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Mission Concepcion, San Antonio, Texas *(See page 1119)*

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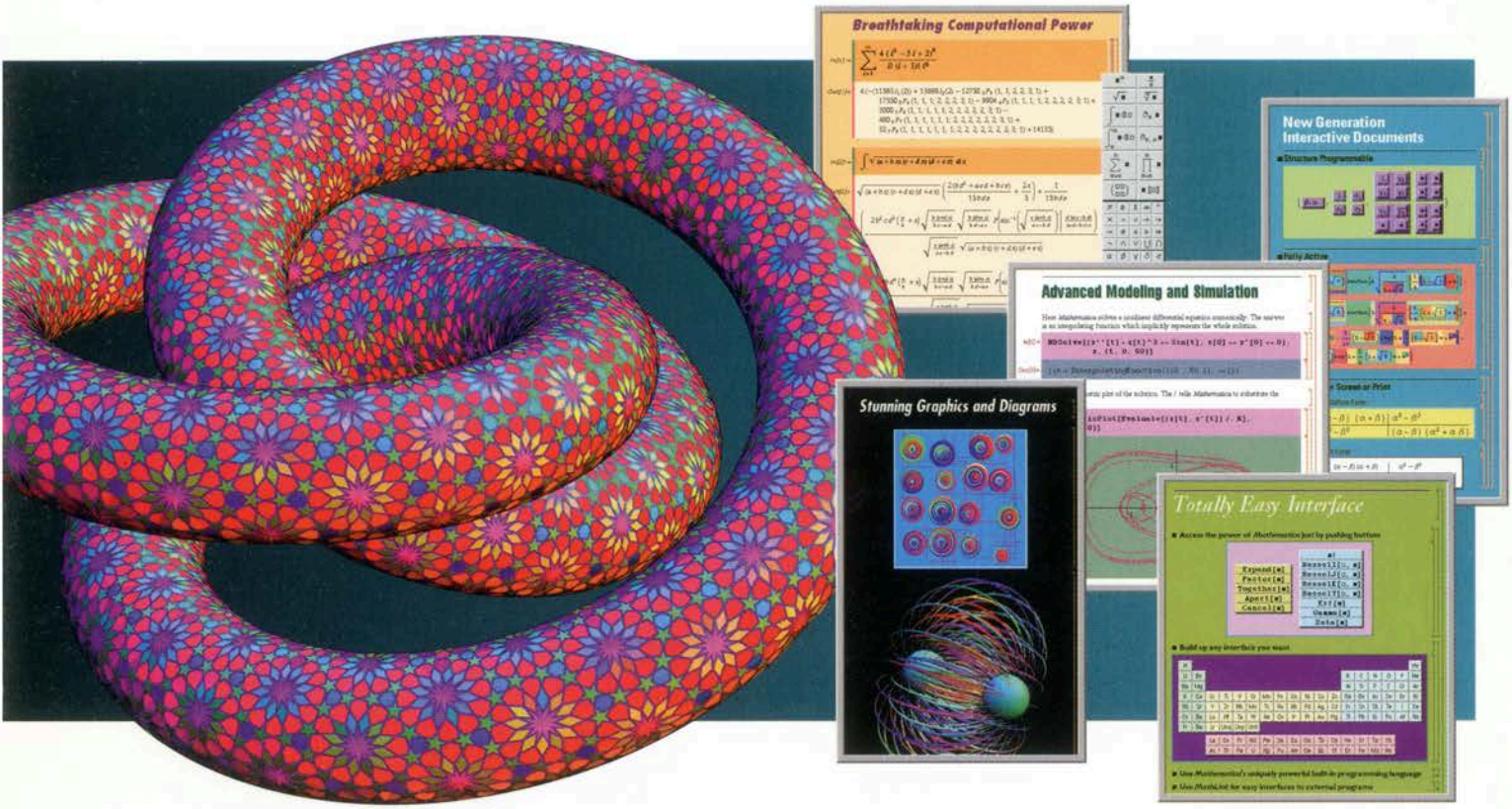

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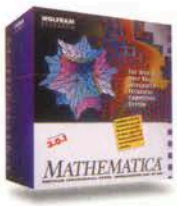

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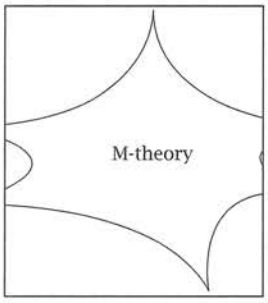

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From the Secretary of the AMS

Challenges for the 21st Century

As a legacy from my ten years of service to the AMS as its secretary, I give you part of my "To Do" list, which I call "Challenges for the 21st Century". Mention of these items here is intended to provoke thought and discussion within the mathematical community and the AMS about the community and the AMS (and not about mathematics).

Challenge I: Merge the AMS and the MAA?

Mathematical research and mathematical education are inextricable. Many people feel that the divorce some eighty years ago that resulted in the two organizations should be annulled. The benefit would be an organization that would speak with a louder voice on all matters affecting the profession. Members who belong to both organizations would realize a saving in membership dues. The Society and Association would realize savings in administrative expenses. With over 50,000 members, the combined AMS/MAA would have a strong voice in all aspects of a mathematician's professional life.

Challenge II: Increase the Society's cooperation with the International Mathematical Union (IMU)?

Whereas Challenge I speaks to the role the profession can play domestically, this item speaks to the role the professional organization can play on the international front. At present the "adhering organization" from the U.S. is the National Academy of Sciences (NAS). I propose that the AMS (or the combined AMS/MAA) be the adhering organization with the International Mathematical Union and should appoint and administer the United States National Committee on Mathematics (USNCM). Indeed, in most countries, the professional mathematical organization *is* the adhering body.

If the NAS remains the adhering organization and continues to appoint the members of the USNCM, I propose that the NAS should ask the AMS to administer and fund the USNCM. The AMS has the resources and know-how to provide total support for committee meetings. It has the resources and will to fund transportation for members to attend IMU General Assembly meetings and Congresses. In fact, the AMS did pay some expenses for the five U.S. representatives to the General Assembly in August 1998, since the Board on Mathematical Sciences (BMS) did not have the wherewithal to fund these representatives fully.

Challenge III: Involve all mathematicians in the affairs of their professional organization(s).

Being invited to join the AMS was, many years ago, a rite of passage into the profession. It was taken seriously—one even had to have a sponsor. Joining the AMS no longer seems to be regarded as so important. It is surprising how many names of eminent American mathematicians do *not* appear in the *Combined Membership List*. Anyone who uses any of the products and services of the Society (the publications, the meetings, the Web site) should be a member in order to help support the efforts.

As for further involvement, the secretary administers the committees of the Society. In the past ten years of writing appointment letters, the names of appointees have hardly changed, just their committee assignments. This year there were just a handful of responses to full-page *Notices* ads requesting suggestions for nominations for office or membership on committees. Membership involvement must come from everywhere. Each person can make a difference.

Join and participate!

Conclusions: The Society's administration is in excellent hands. The AMS now has a publication program that is the envy of any publishing house. MathSciNet is the standard for delivery of review material. The AMS is out in front as we move into the age of electronic delivery of mathematics. It has been a real pleasure working with the staff and members throughout these ten years. I thank everyone for the support they have given to the leaders, officers, and staff, and especially to me.

—Robert M. Fossum

Commentary

In My Opinion

See No Evil, Hear No Evil, Speak No Evil

The art of discourse is alive and well in the theater. Producers and directors and actors develop new productions of old classics; some of these productions work and some fail. The audiences and the critics publicly debate what is good and what is not, and they interact with the creators as they do so. Everyone learns from the process, and the theater continues to grow.

Not so in mathematics. Many mathematicians will not offer public opinions about mathematics; other mathematicians are disinclined to listen to such opinions or seem to prefer an artificial conformity of opinion. All these practices reflect an unwillingness or inability to exercise critical thinking skills. Consider three examples of these phenomena:

1. In the 1970s there was a fad of catastrophe theory. It was claimed that catastrophe theory could be used to predict election outcomes and to analyze prison riots and to understand the temperaments of dogs. The subject of singularities of C^∞ functions (the math behind the hype) is excellent mathematics having interesting applications. By contrast, fitting a cusp to a finite set of experimental data is about as sophisticated and insightful as fitting an Nth degree polynomial to $N+1$ data points; yet few mathematicians of the time questioned the more improbable applications.

2. For the past fifteen years we have been hearing that chaos and cellular automata *might* provide paradigms for the way the world works. These theories *suggest* the mechanism by which protoplasm multiplies or the manner in which weather systems move and change.

   But they might not provide any of the claimed insights; nobody knows whether they do or not. There is not one example of any scientific problem that has been solved (not just *described*) using these theories. Still—both in the media and in science—chaos and cellular automata continue to flourish.

3. In the October 1996 issue of the *Bulletin of the AMS* Irving Segal gave a review of A. Connes's book *Noncommutative Geometry*. Regardless of what I think of Segal's ideas, I consider his review to be a sterling piece of scientific exposition. Near the end of his piece Segal offered a few mild criticisms of the tract under review, taking particular note of the book's repeated imprecision with respect to physical applications. The response was mass outrage and the writing of several "counter-reviews"; two of these appeared in the August 1997 issue of these *Notices*. The counter-reviews endeavored, without saying so, to answer questions that were raised by Segal. Neither cited the Segal review to which it was responding. It is typical, but disheartening, that the counterreviewers left it to the reader to figure out what they were *really* talking about.

My first two examples are of opinions that could have been expressed, but which generally were not; my third is of a nice, crisp opinion that was indeed expressed, but which few people heard or appreciated. Because our subject does not have a healthy marketplace for opinions, we suffer from an embarrassing myopia. I know of mathematicians who have quit mathematics altogether because a piece of their work received a negative review. Were we more accustomed to discourse, these mathematicians might have taken the criticism in stride.

Because we do not have a vigorous discussion of ideas, passing fads and mathematics of inflated value sometimes stand shoulder to shoulder with deep subjects that have withstood the test of time. Mathematicians today have paid too much attention to their beloved specialties and not enough to good writing, good exposition, incisive judgment, and the overall health of the discipline.

The common wisdom among mathematical mandarins is that mathematics is a process that tends to work itself out: in the end we all know who did what and what is of value. Woe betide that intrepid soul who actually calls into question a piece of ongoing research. It is all right to criticize *The Bible Code*, because that does not pretend to be mathematics done by mathematicians. But suggest that Fields Medalist A fails to live up to the usual standard, or hint that Theorem B of mathematician C should not have appeared in the *Annals*, or imply that mathematical subject D may be just so much doubletalk, and you had better look out.

As Aldous Huxley observed, "That men do not learn very much from the lessons of history is the most important of all the lessons that history has to teach." Scholars should fight that trend. We should occasionally step back and take stock of what we are doing. We owe it to ourselves, we owe it to our subject, and we owe it to future generations of mathematicians.

—Steven G. Krantz
Contributing Editor

Letters to the Editor

Address the Demand Problem

In March 1998 a panel commissioned by the NSF warned that the U.S.'s dominant position in mathematics was threatened. This report is available on the Web at `http://www.nsf.gov/pubs/1998/nsf9895/start.htm`, and it is entitled "Report of the Senior Assessment Panel of the International Assessment of the U.S. Mathematical Sciences".

The report states that "the U.S. enjoys a position of world leadership in the mathematical sciences. But this position is fragile." Concerns are raised that "young Americans do not see careers in the mathematical sciences as attractive [in part because] funding for graduate study is scarce and ungenerous."

The panel recommended that the NSF encourage programs that "broaden graduate and undergraduate education in the mathematical sciences", "provide support for full-time graduate students in the mathematical sciences comparable with the other sciences", and "provide increased opportunity for postdoctoral study for those who wish to become academic researchers as a means to broaden and strengthen their training as professional mathematicians," among other initiatives.

A similar report was released by the NSF in 1986. That report warned of an impending shortage of scientists and mathematicians in the United States, in part due to an expected large wave of retirements. As a consequence of that report, the NSF substantially increased its funding support for graduate students in mathematics and science. This action addressed the "supply" problem in mathematics, but it assumed that there was no "demand" problem.

Most of us know what happened next. By 1990 there were more new Ph.D.s in the job market than there were jobs for them, particularly in academia. One could blame the economic slowdown at that time for the lack of jobs. One could also cite the end of the Soviet Union as leading to an increase of those searching for jobs. However, the problem has continued into the later 1990s, even as the economy has grown and Eastern Europe has stabilized. They say in the new report that "young Americans do not see careers in the mathematical sciences as attractive." Since a good explanation has not been given as to why the future will be different from the past, it is understandable why young Americans feel this way.

As in 1986 the "supply" problem has been raised as the main issue, without much focus on the "demand problem". So how does more federal money for mathematics address the problem that research departments of mathematics have not been replacing their retiring mathematicians, leading to disappearing tenure-track positions?

It is not the case that universities have grown less willing to make a lifelong commitment to a mathematician simply because the NSF has been less generous. There are other reasons (e.g., tight funding from state legislatures and a new focus by some universities on undergraduate education) that have made administrations less likely to hire permanent research positions. If the U.S. is to retain its leadership in mathematics, then there need to be more tenure-track positions in universities. More money for graduate students might attract more young Americans to a career in mathematics, but these people need permanent jobs after they complete their Ph.D.s. This is what the NSF should be addressing if they wish to promote mathematical research in the U.S.

As we should be learning from the engineering profession, an abundance of well-paying jobs, more than anything else, will attract young Americans to mathematics.

—Edward Aboufadel
Grand Valley State University

(Received June 8, 1998)

Editor's Note: Aspects of the report mentioned in the above letter are discussed in the article "Reports Assess U.S. Standing in Mathematics" by Allyn Jackson in the August *Notices*, pages 880–882.

Mathematicians May Not Always Know Best

I salute Warren Page and Mark Saul for their astute commentary "Collaboration and Respect" in the June/July 1998 *Notices*. They ably delineate many of the distinctions between mathematical and educational research.

I take partial issue, however, with their statement that "mathematicians are our best source of information about what should be taught and with what emphases." Although many mathematicians may know best what mathematics a future research mathematician should learn, not all may be well informed on what mathematics the average citizen needs to know, or even on what is needed by people working with mathematics in a professional setting other than mathematics research, and hence they may not be "our best source of information" in as broad a way as Page and Saul's statement might suggest. Certainly mathematicians have much to contribute to the discussion of what should be taught and with what emphases, but their perspective, as with that of any specialist, can fail to take into account all the dimensions of these questions.

So while I welcome the increased involvement of mathematicians as participants in the making of educational decisions, I think we need to recognize that the subject-matter expert does not always know best.

—Dan Fendel
San Francisco State University

(Received June 23, 1998)

Teaching or Cheating?

In his article "It's WHAT they teach, STUPID!", John Elson writes in *Time/the Princeton Review* (Spring 1997), p. 14:

> In a new book called *Generation X Goes to College* pseudonymous author Peter Sacks tells of quitting his job at a newspaper to teach writing at a suburban junior college. What he found was discouraging: intellectually incurious students and time-serving professors

who cynically condoned grade inflation to please administrative bureacrats. The result, charges Sacks, is the classroom equivalent of consumer fraud.

This paragraph reminded me and a few colleagues of mine time and again of many cases or many actions of mathematics administrators which seem to border on cheating. Let us omit a long list of their strange actions in this category.

But I will mention one example which goes beyond any anecdotal evidence and provides statistics with thousands of students involved: In the years 1995 and 1996 at the start of a quarter at Ohio State University (OSU), the Math-148 class's students went to the President's Building (or other COPEZ locations) and paid $1.06 for a special booklet (a good value for $1 spent!). This booklet listed the problems which would be offered (with slight variation: Terry's typing service becoming, for example, Rose's catering services) on their three midterm tests and final exam. It was not a collection of 200 or 300 exercises to practice before tests; no, just 10 or 12 problems for each midterm and final —neither more nor less.

Is this testing system

(a) a smart pedagogical method to focus students' attention on important concepts and skills,

(b) an institutionalized fraud (in a system closely coordinated by the administration, without any participation of regular faculty) which cannot be tolerated any more,

(c) something else?

To make this question and answer easier, I will give more information. Under pressure from some faculty, in winter 1997 the Midterm-1 set of exercises was different from the booklet's; students were told in advance about this change.

The table below, formed from data obtained from the OSU Mathematics Department Course Office, gives the (ranges of) results of Midterm-1 in AU'96 quarter (Column (1)) when the assignment followed the booklet, and in WI'97 quarter (Column (2)) when the assignment followed the syllabus, the material taught in the previous weeks, and the stated course objectives as required by the OSU Bylaws, Rule 7-19—but not the booklet.

Quarter	(1) AU'96	(2) WI'97
A	16.38%	0.44%
B	20.09%	2.73%
C	20.01%	7.21%
D	16.75%	12.02%
E	26.76%	77.60%
Number of Students	1,349	915

Did the Mathematics Department administration set up the Math-148 instruction and grading in 1995 and 1996 as—in John Elson's and Peter Sack's terminology—"the classroom equivalent of consumer fraud"?

—Boris Mityagin
Ohio State University

(Received June 25, 1998)

Math Education Is Not Mathematics

I am canceling my membership in the AMS immediately. Some administrators of the AMS have decreed that math education is a branch of math which should have major input in teaching matters. They further decreed that no questioning of this premise would be permitted (see *Notices*, February and August editorials and the June/July "Commentary").

In requesting discussion about educational matters, with the restriction I mention above, the AMS is in the position of the lawyer who asks, "When did you stop beating your wife?" Sometimes an assumption implicit in a discussion needs to be questioned.

—Ralph deLaubenfels
Scientia Research Institute

(Received July 19, 1998)

Encourage and Recognize DMS Service

I am writing as a member of the mathematics community, as a former member of the National Science Board, and as director of the Institute for Advanced Study, which has had an important historic role in supporting mathematics.

The Division of Mathematical Sciences within the National Science Foundation is critically important to the mathematics community, as I think we all recognize. By far the largest amount of support for mathematics comes from DMS, and probably no other field is as dependent as we are on the National Science Foundation. It is obvious that in order to make the most effective use of the available funding, the DMS needs the benefit of the most professional and knowledgeable staff. While DMS now has a very good staff, due to natural turnover and to upcoming retirements, they currently face an especially acute challenge in finding staffing for the Division. It is of course highly desirable that the staff to be recruited be active in research and have good knowledge of mathematics and the mathematics community.

I believe it is our responsibility as a community to encourage colleagues to consider serving on the staff of DMS and to provide good recognition for those who choose to do so.

—Phillip A. Griffiths
Institute for Advanced Study

(Received August 13, 1998)

About the Cover

Mission Concepcion, San Antonio, Texas. San Antonio is the site of the 1999 Joint Mathematics Meetings, January 13–16. Photograph by Doug Wilson, courtesy of the San Antonio Convention and Visitors Bureau.

Forum

Computer Simulation and Beyond—for the 21st Century

John Guckenheimer

Computers have become powerful tools to simulate natural and artificial phenomena. Industry, science, economic affairs, and national security have come to rely upon simulation as an essential technology. We bet our lives on devices like fly-by-wire aircraft and digitally controlled pacemakers that require digital computation to function properly. We have replaced testing of nuclear weapons with an aggressive program of computer simulation, and international treaties on carbon dioxide emissions are based upon computer predictions of long-term effects of human activity on global climate. The fidelity and reliability of computer simulation is a critical issue for many endeavors. As our computers become faster and cheaper, simulations become larger, more complex, and more difficult to evaluate. The process of simulation itself becomes more diverse in ways that I discuss in this "Forum". I begin by stating briefly a conventional view of simulation. Then I discuss issues that extend beyond this traditional view.

John Guckenheimer is professor of mathematics at Cornell University. His e-mail address is gucken@cam.cornell.edu.

Simulation Dichotomies

The starting point for fluid simulation—and many other problems—is frequently expressed as the solution of systems of partial differential equations. We assume that these equations give a correct "first principles" description of a fluid flow. The key mathematical problems are the creation of algorithms that approximate the solutions of PDEs as the scale of discretizations tends to zero. As the resolution of the calculations becomes finer and more computational resources become available, we are able to solve these problems more accurately. This viewpoint is very prevalent, but it applies fully to only a limited set of problems. These are problems in which

- a precise description of the problem can be given with a data set of fixed size, including boundary and initial conditions;
- the problems have solutions that are stable to perturbations of the magnitude of the errors inherent in the calculations;
- the simulation results are readily compared with test data.

Many simulations do not satisfy these constraints. Nonetheless, we make large investments in simulation. To cite but one example, the Department of Energy Advanced Strategic Computing Initiative is a simulation project for stockpile stewardship of nuclear weapons that spends more today than the entire federal expenditures for mathematics research. We need to broaden the scope of the mathematical theories that provide foundations for the analysis of simulations. We present below five dichotomies, each pointing to a different aspect of simulation where more mathematics research is needed. Precise mathematical questions are not given here, but we suggest that the is-

sues present challenges to twenty-first century mathematics:

First principles vs. data driven models
Determinism vs. indeterminism
Continuous vs. discrete models
Special structure vs. genericity
Complexity vs. aggregation

Following discussion of these issues, we describe aspects of numerical analysis that are important for simulation.

First Principles vs. Phenomenology

Computational neuroscience is growing rapidly. Our efforts to model the brain are rooted firmly in biophysical models of membranes and the channels they contain, but there is a vast difference between compartmental Hodgkin-Huxley models of neurons and the Navier-Stokes equations of fluid dynamics. The Hodgkin-Huxley models are based upon sound biophysical principles, but these principles do not constrain the models to a definite set of equations in the same manner that a few assumptions about fluid properties lead to the Navier-Stokes equations. Instead, many aspects of the models depend upon approximations, choices of parametric relationships among quantities, and measurements that fit data to these relationships. The assumptions oversimplify and distort information that we know about these systems. However, when we try to increase the resolution of the models, then we increase the number of parameters that must be measured to fit finer models. This creates the need for more measurements, more than we may be able to perform. Those that can be made create voluminous data sets that need to be analyzed to extract useful information for parametrizing and initializing the models. Thus, it is hardly clear that efforts to increase resolution in these models will lead to higher fidelity. Uncertainty about the values of additional parameters may prevent us from obtaining the improved fits to data that we expect to obtain from finer resolution models.

When data for initializing high-resolution models can be collected, it is usually expensive to do so. Some databases are maintained by the federal government at great cost and made partially available for scientific purposes. However, large scientific collaborations like the human genome project or those centered around the NSF Long-Term Ecological Research sites are required to lay the substrate for detailed simulation of many natural processes. Building high-fidelity models from data using phenomenological models requires planning and coordination greater than has been customary in most research areas. Successful efforts will require data standards and computational tools that are accepted by researchers. Agreement on such standards is likely to increase scientific orthodoxy, perhaps at the risk of thwarting individual creativity. Thus, simulation may bear cultural costs as well as those of money and effort. This is not an argument that we should avoid a focus on simulation, but rather a plea that we should examine the enterprise. As with large telescopes in astronomy, many areas of science stand to reap enormous benefits from thoughtful planning and investment in technology that will help simulation efforts.

Determinism

Is the weather predictable? There is abundant evidence that global forecast models display sensitive dependence to initial conditions. Perturbations well within the measurement errors of current observations lead to different forecasts. It is likely that this sensitivity is not an artifact, but an inherent property of atmospheric circulation. Let us assume here that the atmospheric flow is turbulent and that disturbances grow to effect global circulation. What are the implications for simulation? Dynamical systems analysis of chaotic systems gives insight into the answer to this question. It clarifies how unpredictability can arise in a deterministic, clockwork universe. Sensitive dependence to initial conditions is a property of many dynamical systems, from simple nonlinear mechanical linkages to population models. The chaotic nature of such systems has been studied extensively, to the point that there are solid mathematical foundations for quantifying their unpredictability in terms of invariant measures, entropies, Lyapunov exponents, and fractal dimensions. Still, the application of these concepts to the simulation of complex systems remains problematic.

In the face of systems that display sensitive dependence to initial conditions, long-term prediction of the full state of the system as a function of time is simply impossible. Weather forecasts five weeks in advance, let alone five years, can specify at best average properties of the weather. Operational weather forecasts have begun to employ ensemble forecasting based on simulations of several initial states. The usefulness of dynamical systems methods is problematic for simulations with attractors whose dimensions are large. Probabilistic methods about system behavior seem more suited to these situations, but assumptions about underlying statistical distributions are hard to verify. For example, the statistical properties of turbulent fluid flows related to coherent geometric structures remain a controversial subject.

Monte Carlo methods employ systematic approaches to the modeling of stochastic systems. Producing high-fidelity simulations in complex systems with many parameters using Monte Carlo methods is an even larger task than it is for deterministic models with stable asymptotic states. When we are faced with noisy, unpredictable systems like the brain, our understanding of which aspects of dynamical behavior of complex systems we can hope to simulate is primitive.

From Model Architecture to Dynamics

Modern molecular biology has invested great effort to elucidate the reaction pathways of living organisms. These pathways are embodied in graphs that show intermediate steps in the production of important biological molecules. Frequently missing from this work is an understanding of the kinetics of the pathways. We see information about the structure of the pathway, but we do not understand how it works. In particular, we have difficulty predicting the functional consequences of drugs, mutations, or other modulatory effects on the network. For example, deleterious side effects of calcium blockers used as cardiac drugs were unpredicted. Molecular biologists have assumed that function will be evident from structure and have made the de-

termination of structure the principal goal of the subject. However, data from neural networks demonstrate that a single morphological network may support a diverse set of behaviors. Biologists increasingly recognize that systems modeling will facilitate their understanding of complex biological processes.

Apart from considerations of symmetry, we have had little success in relating system structure to function. Dynamical systems theory provides a context for guiding our intuition of dynamical phenomena that we expect to observe in generic systems. Using results from differential topology and singularity theory, we have a coherent view of phenomena that we regard as typical and phenomena that are exceptional. When there is symmetry in a system, we know how to modify the theory to see the consequences of the symmetry. We believe that there are architectural principles which are important in building robust complex systems, but there is little theory to support our intuition in this domain. In the context of specific applications such as electronic circuit design, we build hierarchical systems of astounding complexity with millions of elements. Concepts such as hierarchy and feedback control have not been incorporated into a general theory of nonlinear dynamical systems. Our lack of insight into how system architecture constrains dynamical behavior limits the power of simulation as a tool for studying complex systems.

Continuous, Discrete, and Hybrid Models

High-fidelity simulation of human walking is a demanding task. We perceive small variations in gait and readily distinguish departures from normality. Attempts to build two-legged locomotion machines have floundered over the issue of maintaining balance in dynamically unstable states. Computational models of walking must contend with impacts. These break stride into phases in which the primary physical forces acting on the body differ. Dynamical systems in which there are discrete events in the phase space that result in discontinuous changes of the underlying model are called hybrid systems. Hybrid models can have continuous and discrete components in both space and time. For example, the engagement of gears changes the dimension of the phase space of a model of two rotating shafts. Most of the machines that we build are hybrid systems. The construction of full system simulations from simulations of components frequently introduces the need for hybrid models.

Theoretical models and computational tools for studying dynamical systems that include both continuous and discrete time are in their infancy. Theory and numerical methods that apply to discontinuous or singular systems are more limited than those that treat analytic or smooth systems. Consequently, the foundations for simulations of hybrid systems are shaky. Dynamical systems theory has sharpened our intuition about what types of phenomena we should expect to see in continuous phase spaces of systems that operate in continuous or in discrete time. Extending that understanding to hybrid systems is a barrier to confident simulation of hybrid systems. We are left with weaker intuition to guide design of machines and industrial processes that meet our desired specifications.

Scales and Aggregation

Decomposition of natural systems into different "scales" is one of the central tasks in producing high-fidelity simulations. We seek to understand how macroscopic behavior results from physical laws that operate on smaller scales. For example, we would like to understand fracture in terms of atomistic properties of materials. Reducing all complex phenomena to atomic interactions is clearly a hopeless task. It is preposterous to model the effects of global climate change on natural populations and agriculture on an atomic scale. Recognizing when we can separate physical scales and encapsulate smaller-scale information in models that operate at larger scales has been a central issue within condensed matter physics. In studying population biology, economies, or the brain, the issue of aggregating small scales is fuzzier and more challenging.

Only recently have we acquired the computing resources required to simulate detailed multiscale models. One of the areas that is growing rapidly is the simulation of models with large numbers of components. In applications as varied as molecular dynamics, battlefield simulations, and traffic flow, we build stochastic models from which we seek to observe emergent behavior at the system level. The challenge with these efforts is to obtain results that fit the real world. We seldom know which details of component behavior are most significant for determining system properties, so it would be prudent to have systematic ways of evaluating the effects of uncertainty in model components upon system behavior. Such methods hardly exist at this time.

Numerical Analysis

Numerical implementation of dynamical systems models depends upon approximations that are subtle. The simplest, most direct numerical integration algorithm (the Euler method) is subject to substantial errors. These errors can accumulate to give qualitatively incorrect predictions about long-time dynamics, as happens with the harmonic oscillator. Accurate and stable methods motivated by historic limitations on the speed and cost of performing arithmetic have been developed for solving these problems. The dramatic improvements of digital computers during the past fifty years have completely transformed these parts of mathematics. The speed of computation as a limiting factor in simulating physical systems has largely been replaced by the constraints of memory hierarchies, round-off errors inherent in floating-point arithmetic, and the difficulty of extracting useful information from large data sets.

Consider the problem of simulating electric power systems. Reliable electric power produced with minimal environmental impact is vital to the world today. Adequate capacity to handle anticipated loads and real-time monitoring of operations are essential for these systems. Simulating network models at first sight seems like a straightforward task in numerical integration. However, when we look a bit closer, we find technical issues that are bothersome. One issue is that the equations for a network are naturally expressed as differential-algebraic equations rather

than as ordinary differential equations. The mathematical theory of DAEs is more complex than that of ODEs. For DAEs, not all initial conditions in the phase space are consistent with the equations. Moreover, there are points in phase space where the algebraic constraints inherent in the equations are satisfied, but there still are no solutions (or multiple solutions) with these initial conditions. The mathematical underpinnings of the theory of DAEs remain incomplete, and restrictive assumptions on models are required to guarantee that the available simulation algorithms will work. Still, DAEs are common in engineering applications and cannot be ignored, even when the models appear to be internally inconsistent. For some classes of DAEs (such as those arising in models of mechanical systems) there are hidden dependencies of the solutions on derivatives of the initial data that make stable computation difficult.

Beyond Simulation

Simulation viewed as the evolution of specific initial conditions for a dynamical computer model is unlikely to answer directly many of the questions that we ask. For example, consider the problem of fitting parameters to experimental data. In Hodgkin-Huxley models for neurons a typical vector field may have a ten-dimensional phase space and forty parameters. The model of a network of ten neurons built from single-compartment Hodgkin-Huxley neurons will have a phase space of dimension approximately one hundred with several hundred parameters. If there are many model parameters that cannot be measured directly, then we are left with a complex "inverse" problem of using simulation data to optimize the parameters. In the case of the neural network, the problem is further complicated by the distortion of the primary voltage measurements that occurs due to unmodeled spatial effects in the system. This means that the most useful data for model comparisons are likely to be related to properties such as the period of oscillations or the stability boundaries for different dynamical states as physical parameters are varied. Obtaining this information by sampling trajectories can only be done for a small number of parameters, because the number of required trajectories grows exponentially with the number of parameters. Thus, solution of these parameter identification problems seems to require algorithms that go beyond simulation. The problems of fitting model parameters inhibit the creation of high-fidelity models. As described previously, increasing model resolution to include smaller scales in a problem may increase the number of parameters that must be determined faster than the fidelity of the models improve.

Bifurcation theory for dynamical systems provides a framework for direct determination of information about how system behavior changes qualitatively with parameter variations. Implementation of algorithms based on this theory is a step towards computing parameter ranges that produce desired behavior. For bifurcations of equilibria, stability boundaries can be determined without numerical integration by formulating defining equations for bifurcations from the derivatives of the vector field. These methods have been implemented in a continuation setting to compute curves of codimension-one Hopf and saddle-node bifurcations in two-parameter families of vector fields and curves of codimension-two bifurcations in three-parameter families of vector fields. We need better algorithms to compute multidimensional continuation of submanifolds of bifurcations and to treat bifurcations of periodic orbits reliably.

There are additional geometric questions about dynamical systems that are important for varied applications. Computation of mixing properties of fluid flows has been greatly facilitated by regarding the instantaneous velocity fields as generating a dynamical system of streamlines and computing invariant manifolds of these dynamical systems. The stagnation points of the fluid flow are saddle points of the dynamical system, and their stable and unstable manifolds give separation boundaries for the fluid flow. Computing the intersections of these manifolds and the evolution of their turnstile structures gives approximations to the mixing properties of these fluids. These techniques have been used to investigate the design of industrial reactors, chemical reaction rates, and fluid transport of ocean eddies. Because invariant manifolds become highly convoluted with sharp bends, substantial care is need to compute them accurately.

We desire the ability to compute robustly and routinely far more about the qualitative properties of dynamical systems than we can today. There are phenomena that play a prominent role in the qualitative theory that occur on very fine scales in many examples. Developing consistent, converged calculations requires that these scales be resolved. Since the phenomena often involve singularities and bifurcations, classical algorithms need to be modified and extended to work with these problems. Mathematical theory has guided this work, leading to the creation of algorithms that solve challenging problems. Unlike prevailing trends in computational science, the problems have often been small and the computing highly interactive. The interplay among classical and modern mathematics, geometry and numerical analysis and computational science will continue to be important to progress in the use of simulation as a powerful scientific tool.

Magic, Mystery, and Matrix

Edward Witten

In the twentieth century, the quest for deeper understanding of the laws of nature has largely revolved around the development of two great theories: namely, general relativity and quantum mechanics.

General relativity is, of course, Einstein's theory according to which gravitation results from the curvature of space and time; the mathematical framework is that of Riemannian geometry. While previously spacetime was understood as a fixed arena, given ab initio, in which physics unfolds, in general relativity spacetime evolves dynamically, according to the Einstein equations. Part of the problem of physics, according to this theory, is to determine, given the initial conditions as input, how spacetime will develop in the future.

The influence of general relativity in twentieth-century mathematics has been clear enough. Learning that Riemannian geometry is so central in physics gave a big boost to its growth as a mathematical subject; it developed into one of the most fruitful branches of mathematics, with applications in many other areas.

While in physics general relativity is used to understand the behavior of astronomical bodies and the universe as a whole, quantum mechanics is used primarily to understand atoms, molecules, and subatomic particles. Quantum theory has had a much more complex history than general relativity, and in some sense most of its influence on mathematics belongs to the twenty-first century. The quantum theory of particles—which is more commonly called nonrelativistic quantum mechanics—was put in its modern form by 1925 and has greatly influenced the development of functional analysis, and other areas.

But the deeper part of quantum theory is the quantum theory of fields, which arises when one tries to combine quantum mechanics with special relativity (the precursor of general relativity, in which the speed of light is the same in every inertial frame but spacetime is still flat and given ab initio). This much more difficult theory, developed from the late 1920s to the present, encompasses most of what we know of the laws of physics, except gravity. In its seventy years there have been many milestones, ranging from the theory of "antimatter", which emerged around 1930, to a more precise description of atoms, which quantum field theory provided by 1950, to the "standard model of particle physics" (governing the strong, weak, and electromagnetic interactions), which emerged by the early 1970s, to new predictions in our own time that one hopes to test in present and future accelerators.

Quantum field theory is a very rich subject for mathematics as well as physics. But its development in the last seventy years has been mainly by physicists, and it is still largely out of reach as a rigorous mathematical theory despite important efforts in constructive field theory. So most of its impact on mathematics has not yet been felt. Yet in many active areas of mathematics, problems are

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studied that actually have their most natural setting in quantum field theory. Examples include Donaldson theory of four-manifolds, the Jones polynomial of knots and its generalizations, mirror symmetry of complex manifolds, elliptic cohomology, and many aspects of the study of affine Lie algebras.

To a certain extent these problems are studied piecemeal, with difficulty in understanding the relations among them, because their natural home in quantum field theory is not now part of the mathematical theory. To make a rough analogy (Figure 1), one has here a vast mountain range, most of which is still covered with fog. Only the loftiest peaks, which reach above the clouds, are seen in the mathematical theories of today, and these splendid peaks are studied in isolation, because above the clouds they are isolated from one another. Still lost in the mist is the body of the range, with its quantum field theory bedrock and the great bulk of the mathematical treasures.

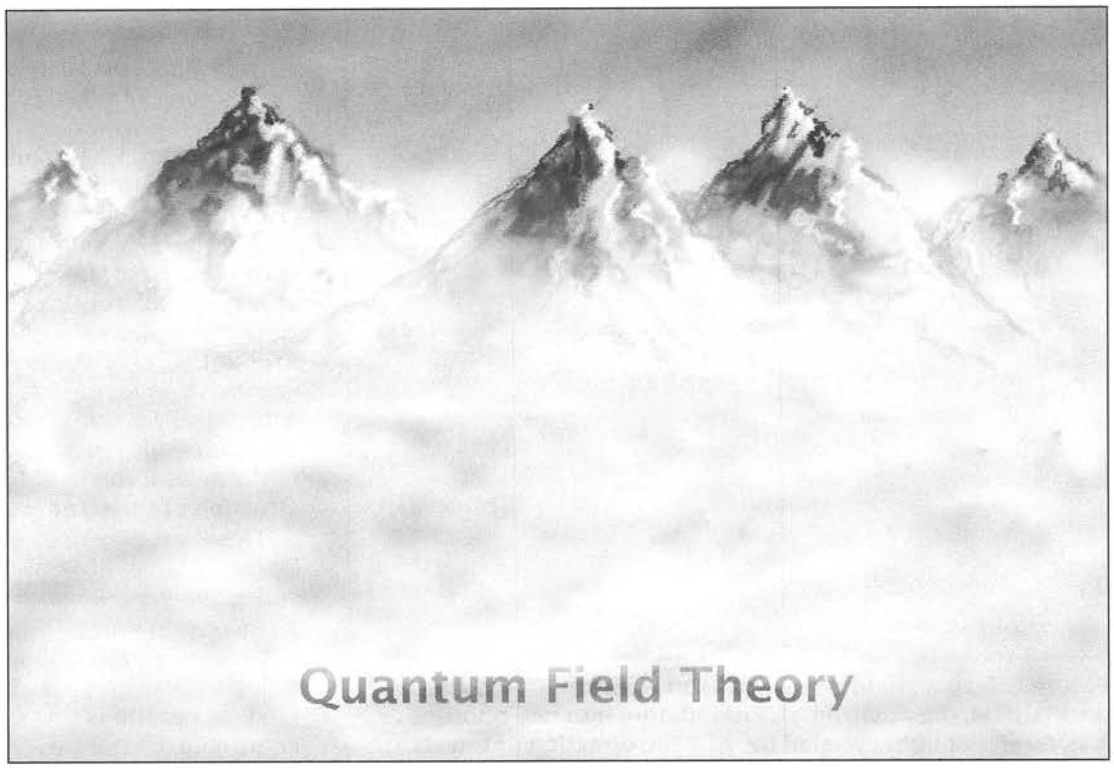

Figure 1.

So there is one rather safe, though perhaps seemingly provocative, prediction about twenty-first century mathematics: trying to come to grips with quantum field theory will be one of the main themes.

The $1/r^2$ Singularity

To see a little further than this, we must discuss quantum mechanics in a little more depth. The origin and subsequent development of quantum mechanics depended a lot on the "inverse square law" of gravity and electricity. The gravitational forces between two masses M_1 and M_2 separated a distance r is

$$-\frac{GM_1M_2}{r^2}$$

(with G being Newton's constant), and the electrical force between two charges q_1 and q_2 separated a distance r is likewise

$$\frac{q_1q_2}{r^2}.$$

For elementary particles one typically has $q_1q_2 > GM_1M_2$, which is why gravity can generally be ignored on an atomic scale and below, but for astronomical bodies typically $GM_1M_2 > q_1q_2$, so gravity dominates on large scales.

Obviously, the inverse square law means that the force becomes infinite for $r \to 0$. This singularity did not cause great difficulties for Newton, since (for instance) the Moon was always at a safe distance from the Earth, far from $r = 0$. However, once the electron and atomic nucleus were discovered almost a century ago, the $1/r^2$ singularity did become a severe problem. A simple calculation based on nineteenth-century physics showed that, because of the strong force at small r, the electron should spiral into the nucleus in about 10^{-9} seconds. This was obviously not the case.

To cure this problem, quantum mechanics was invented. In quantum mechanics the position x and momentum p of a particle do not commute, but obey Heisenberg's relation

$$[p, x] = -i\hbar,$$

with $\hbar$ being Planck's constant. This relation gives a sort of "fuzziness" to the electron and other particles. Because of this fuzziness, one never really gets to $r = 0$, and the problem is averted.

What I have just described is nonrelativistic quantum mechanics—or quantum mechanics of particles, as I called it before. This theory was developed by about 1925 and has long since been more or less assimilated mathematically. The whole theory of elliptic operators on manifolds is a kind of mathematical counterpart of nonrelativistic quantum mechanics; group representation theory is also a close cousin.

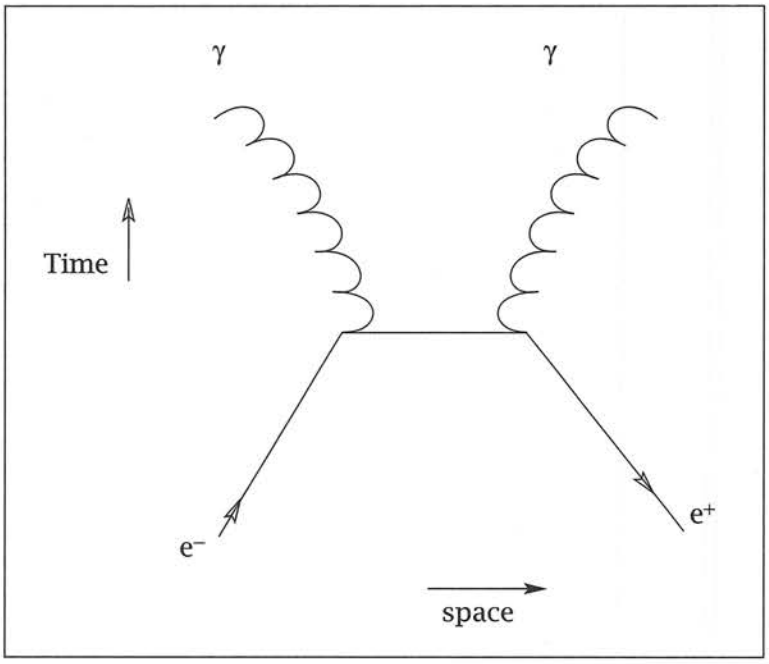

Figure 2. A spacetime history with an electron e^- and its antiparticle, the positron e^+, annihilating into two photons or basic units of light (labeled by γ). If the direction of time is reversed, one gets a process in which incoming light waves combine to create a charged particle-antiparticle pair. Such phenomena occur all the time in quantum field theory.

Quantum Field Theory

But trying to allow for special relativity makes things much more challenging. In special relativity one cannot assume the "instantaneous action at a distance" that is implicit in the inverse square laws of gravity and electricity. Instead, the force must be mediated by a field, and consistency of the whole setup requires that an uncertainty relation analogous to the Heisenberg formula $[p, x] = -i\hbar$ must be applied to the field. Then things become much more complicated and much more interesting. From the uncertainty relation one deduces that the field comes in "quanta", which are observed as particles of a new kind—photons in the case of the electromagnetic field. The more familiar particles, like the electron, must likewise be reinterpreted as quanta of a field. One soon learns that, like classical electromagnetic waves, these quanta can be created and annihilated (Figure 2). This leads to the concept of antimatter and the prediction of matter-antimatter creation and annihilation. By this time one is living in a world that is much more surprising and interesting and certainly much more challenging mathematically.

Though quantum mechanics was invented because of the $1/r^2$ singularity, it turned out that once special relativity was included, quantum mechanics did not automatically cure all of the problems associated with that singularity. Much of the development of physics since 1930 had to do with the $1/r^2$ problem in the light of quantum mechanics plus special relativity. Among the milestones, some of which I alluded to before, were the following:

- By about 1950, renormalization theory and quantum electrodynamics gave a much more precise theory of electrons and atoms.
- In 1967–73 nonabelian gauge theories were incorporated in the description of nature (giving the electroweak part of the standard model) to overcome the problem of the $1/r^2$ singularity in the case of the weak interactions.
- In 1973 asymptotic freedom of nonabelian gauge theories was discovered and used to overcome and fully tame the $1/r^2$ problem in the case of the nuclear force. This also completed the construction of the standard model.

Those last developments set the stage for a new kind of interaction between quantum field theory and geometry. Nonabelian gauge theories, supplemented in time by other ingredients that I have not yet mentioned, notably supersymmetry and string theory, led physicists to gradually ask new kinds of questions that involved geometrical concepts and techniques not previously used in physics. In time it was realized that things could be turned around and that the quantum field theory methods could be used to draw inferences about geometry. And so it is that although quantum field theory is a rather old subject, its mathematical influence is in many respects rather recent and still lies mainly in the future.

Quantum Gravity

The developments that I have already mentioned, leading to the standard model of particle physics, put most of the known phenomena in physics, except gravity, more or less under one roof. The main hurdle that remains is to include gravity, but this involves problems of a quite different nature. At first sight, gravity presents us with just another instance of the familiar $1/r^2$ singularity. Gravity and electricity are indeed very similar in many ways, but the relation between them is not nearly as straightforward as is suggested by the fact that in classical physics they are both governed by inverse square laws. Relativistically, for instance, the field equations of electromagnetism (Maxwell's equations) are linear, while Einstein's equations for the gravitational field are highly nonlinear. Quantum fuzziness, springing from the uncertainty relation $[p, x] = -i\hbar$, is apparently not enough to deal with the $1/r^2$ singularity in the gravitational force. Overcoming this problem—combining quantum mechanics and gravity—is probably the main obstacle to unifying the forces of nature.

Making sense of quantum gravity is essential as well for addressing many commonplace questions that one might well ask with no special training in physics. Astronomers, for example, see that the universe is expanding today, and as far as we can tell

this expansion began in an explosion, often called the big bang. But contemplation of the big bang may seem to present paradoxes. What started the clocks? What was there before the big bang? Gravity and quantum mechanics were both important near the big bang, so the answers must depend on how gravity and quantum mechanics work together.

Physicists learned rather unexpectedly, beginning in the early 1970s, that the problem of quantum gravity could be overcome by introducing a new sort of fuzziness. One replaces "point particles" by "strings". Of course, the point particles and strings must both be treated quantum mechanically. Quantum effects are proportional to Planck's constant $\hbar$, and stringy effects are proportional to a new constant α' (equal to approximately $(10^{-32}\,\mathrm{cm})^2$) that determines the size of strings. In this theory stringiness and quantum uncertainty both contribute to smearing things out; together they tame the $1/r^2$ singularity of gravity.

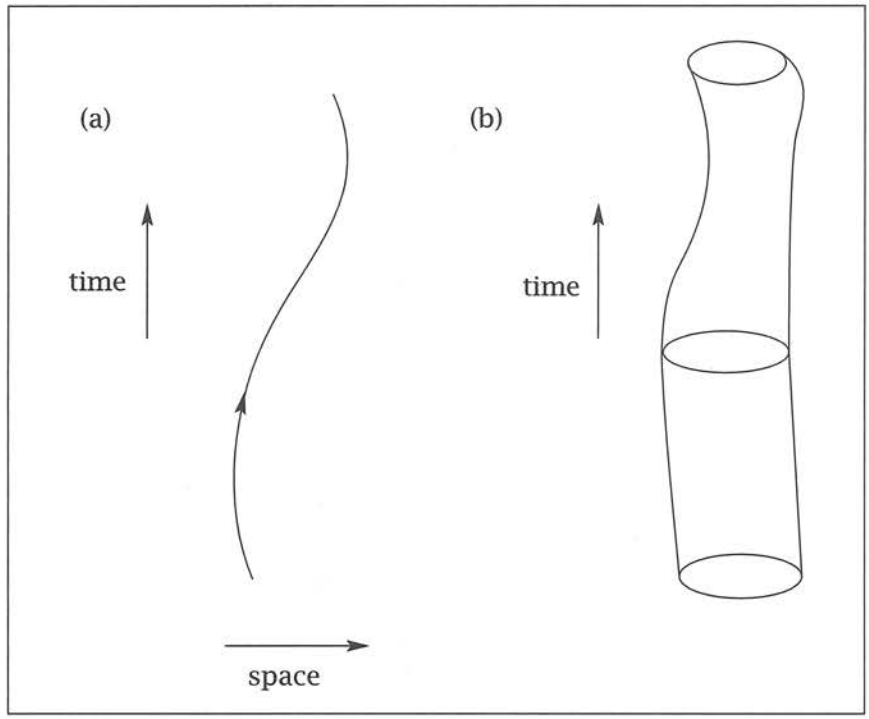

Figure 3. The spacetime orbit of a point particle (a) or a string (b) is a manifold of real dimension 1 or 2.

If string theory is correct, then α' is just as fundamental in physics as $\hbar$, and its effects are at least as interesting. The $\hbar$ and α' deformations both involve fundamental new tools and ideas in geometry. About the $\hbar$ deformation we have ample experience and fairly extensive nonrigorous knowledge concerning some of the geometrical applications, though, as I explained before, the mathematical development still lies largely in the future. The α' deformation is far more mysterious and challenging even for physicists, as the basic tools and concepts have not yet been unearthed. Seeking to do so is perhaps the most exciting adventure in theoretical physics for the next few decades. The mathematical questions posed by the $\hbar$ deformation are at least beginning to be asked, though answers still lie mainly ahead, but the equally exciting mathematical questions associated with the α' deformation are for the most part not yet even being asked. The reason for this is simply that the basic prerequisite for understanding what the α' deformation is supposed to mean is a thorough familiarity with the $\hbar$ deformation, and this is not yet available mathematically.

The idea of replacing point particles by strings sounds so naive that it may be hard to believe that it is truly fundamental. But in fact this naive-sounding step is probably as basic as introducing the complex numbers in mathematics. If the real and complex numbers are regarded as real vector spaces, one has $\dim_{\mathbf{R}}(\mathbf{R}) = 1$, $\dim_{\mathbf{R}}(\mathbf{C}) = 2$. The orbit of a point particle in spacetime (Figure 3) is one-dimensional and should be regarded as a real manifold, while the orbit of a string in spacetime is two-dimensional (over the reals) and should be regarded as a complex Riemann surface. Physics without strings is roughly analogous to mathematics without complex numbers.

The String Theories

The requirements of quantum mechanics plus special relativity are so tight that historically constructing string theories was very difficult. The conditions that must be obeyed are highly overdetermined. A vast effort went into the construction of string theories, and by the time the dust cleared in 1984–85 it was found that there were five of them. They differ by very general properties of the strings:

- In two theories (the Type IIA and Type IIB theories, which differ by whether there is invariance under reversal of the orientation of spacetime) the strings are closed and oriented and are electrical insulators.
- In two theories (the heterotic superstrings with gauge groups $SO(32)$ and $E_8 \times E_8$) the strings are closed, oriented, and superconducting.
- In the last case (Type I) the strings are unoriented and insulating and can have boundaries, in which case they carry electric charges on their boundaries.

Because there are so few string theories, the general framework of string theory makes certain general predictions that are out of reach without string theory:

1. *Gravity.* Each of the five string theories predicts gravity (plus quantum mechanics): that is, these theories predict a structure that looks just like general relativity at long distances, with corrections (unfortunately unmeasurably small in

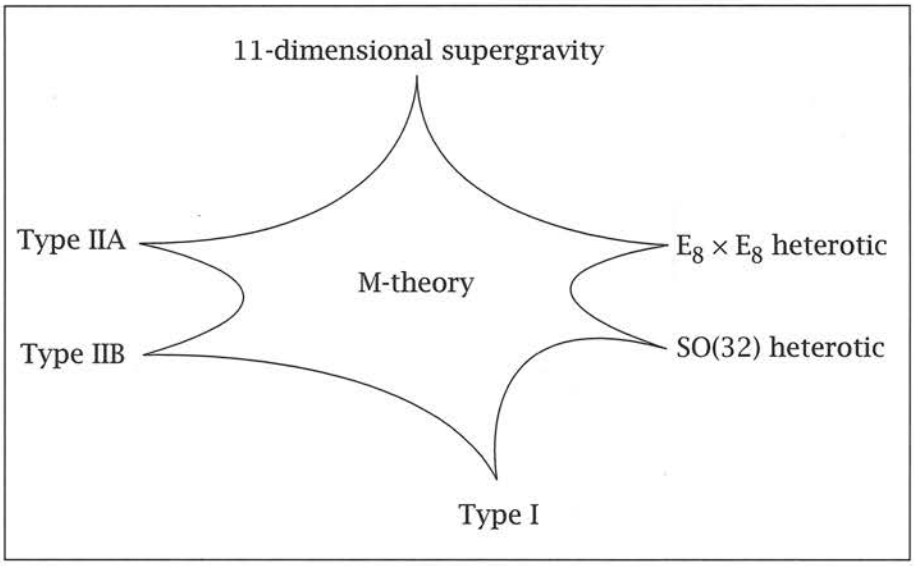

Figure 4. The five string theories—and a wild card, eleven-dimensional supergravity, that has proved to be important in getting a systematic understanding—are now understand as different limiting cases of a more comprehensive (and little understood) theory known as M-theory. The figure is meant to suggest a family of physical situations that are possible in M-theory. With some oversimplification one can think of the parameters in the figure as $\hbar$ and α'.

practice) proportional to α'. This is very striking, since, as I have stressed, standard quantum field theory makes gravity impossible. It is the single most important reason for the intensive study of string theory in the last generation.

2. *Nonabelian Gauge Symmetry.* The second general prediction is nonabelian gauge symmetry (again with unmeasurably small corrections proportional to α'), which is of course the bread and butter of particle physics.

3. *Supersymmetry.* The last general prediction is "supersymmetry", a subtle new kind of symmetry of elementary particles. We do not yet know if nature is supersymmetric, but there are hints (for instance, from accurate measurements of the low-energy gauge couplings) that it is. There is a good chance that we will know for certain from accelerator experiments within about a decade. The fact that we do not yet really know if it is right means that supersymmetry (which historically was discovered at least in part because of its role in string theory) is a genuine prediction of string theory, while gravity and nonabelian gauge symmetry (which were already known before they were seen to be consequences of string theory) might better be called postdictions.

To properly explain supersymmetry requires assuming some familiarity with quantum field theory and so is beyond our scope here. But as a very rough analogy, supersymmetric quantum theory is to ordinary quantum theory as differential forms on a manifold are to functions on a manifold. A very large fraction of geometrical applications of quantum field theory found in the eighties and nineties depend on supersymmetry. (Examples include the supersymmetric proofs of the positive energy theorem, the Atiyah-Singer index theorem, and the Morse inequalities, and the quantum field theory approaches to elliptic cohomology and to Donaldson theory.) This, along with its beauty and the boost its discovery would give to string theory, is yet another reason to hope that supersymmetry will be found! Surely, if supersymmetry is confirmed in accelerators, mathematical attention will be focussed on this fruitful branch of quantum field theory roughly as the discovery of general relativity focussed attention on Riemannian geometry.

Apart from the general predictions that I have stressed, string theory also leads in a simple way to elegant and qualitatively correct models that combine quantum gravity and the other known forces in nature, recovering the main features of the standard model. To improve these constructions further, the most vital need is probably to understand the vanishing (or extreme smallness) of the cosmological constant (the energy density of the vacuum) after supersymmetry breaking. That remains out of reach.

Although physicists do not have any systematic understanding of the new geometrical ideas associated with the α' deformation, powerful methods using two-dimensional conformal field theory are available for exploring some of the associated phenomena. In the late 1980s and early 1990s much effort in string theory was focussed on describing some of these phenomena. An example is mirror symmetry, a relation between two spacetimes that are different in classical geometry but are equivalent for $\alpha' \neq 0$. This symmetry has attracted much mathematical interest because it has striking consequences, some of which can be extracted from their natural conformal field theory setting and stated in isolation. Closely related is the phenomenon of topology change. In general, in string theory the question, What is the topology of spacetime? does not make sense, because in general for $\alpha' \neq 0$ classical ideas in geometry are not valid. But in a suitable limit, upon varying a parameter, classical ideas may be a good approximation. It was found that one can perfectly well have a family of string theory states depending on a real parameter t that interpolate between two different spacetimes in the following sense. For $t \to \infty$, classical ideas in geometry are a good approximation, and one observes a spacetime X. For $t \to -\infty$, classical geometry is again a good approximation and one observes a different (and perhaps topologically

distinct) spacetime Y. Somewhere in between large positive t and large negative t one passes through a "stringy" region in which classical geometry is not a good description and the interpolation from X to Y takes place.

M-Theory

While understanding the new geometrical ideas that prevail for $\alpha' \neq 0$ remains in all likelihood a problem for the next century, the problem has lately been recast in a much wider context. For years the existence of five string theories, though it represented a dramatic narrowing of the possibilities that existed in prestring physics, posed a puzzle. It is rather strange to be told that there is a rich new framework for physics which unifies quantum mechanics and gravity and that in this new framework there are five possible theories. If one of those theories describes our universe, who lives in the other four worlds?

By learning something about what happens when α' and $\hbar$ are *both* nonzero, we have learned a very satisfying answer to this question. The five string theories traditionally studied are different limiting cases of one richer and still little-understood theory. For $\hbar = 0$ these theories are really different, but with $\hbar$ and α' both nonzero one can interpolate between them. The relation between them (Figure 4) is rather like the relation between the classical spacetimes X and Y mentioned two paragraphs ago. These are distinct in classical geometry—that is, for $\alpha' = 0$—but for $\alpha' \neq 0$ they are two different limiting cases of a more subtle structure.

The richer theory, which has as limiting cases the five string theories studied in the last generation, has come to be called M-theory, where M stands for magic, mystery, or matrix, according to taste. The magic and mystery are clear enough, while "matrix" refers to a new noncommutativity, roughly analogous to $[p, x] = -i\hbar$ but very different, that seems to enter the theory. Physicists and mathematicians are likely to spend much of the next century trying to come to grips with this theory.

Reading Suggestions: For an introduction to quantum field theory and perturbative string theory, the reader might consult *Quantum Fields and Strings: A Course for Mathematicians*, P. Deligne, P. Etinghof, D. Freed, L. Jeffrey, D. Kazhdan, D. Morrison, and E. Witten, eds. (American Mathematical Society, to appear). A recent string theory text (for physicists) treating some of the nonperturbative as well as perturbative developments is *String Theory*, Vols. I and II, by Joseph Polchinski (Cambridge University Press, 1998).

Singular Integrals: The Roles of Calderón and Zygmund

Elias M. Stein

Editor's Note: Alberto Pedro Calderón died on April 16, 1998. A memorial article appears elsewhere in this issue.

The subject matter of this essay is Alberto Calderón's pivotal role in the creation of the modern theory of singular integrals. In that great enterprise Calderón had the good fortune of working with Antoni Zygmund, who was at first his teacher and mentor and later his collaborator. For that reason any account of that theory has to be in part the story of the efforts of both Zygmund and Calderón. With this in mind, I shall explain the various goals that motivated them, describe some of their shared accomplishments and later work of Calderón, and discuss briefly the wide influence of their achievements.

Zygmund's Vision: 1927–1949

In the first period of his scientific work, from 1923 to the middle 1930s, Zygmund devoted himself to what is now called "classical" harmonic analysis: that is, Fourier and trigonometric series of the circle, related power series of the unit disc, conjugate functions, Riemannian theory connected to uniqueness, lacunary series, etc. An account of much of what he did, as well as the work of his contemporaries and predecessors, is contained in his famous treatise *Trigonometrical Series*, published in 1935. The time in which this took place may be viewed as the concluding decade of the brilliant century of classical harmonic analysis: the approximately one hundred-year span which began with Dirichlet and Riemann, continued with Cantor and Lebesgue among others, and culminated with the achievements of Kolmgorov, M. Riesz, and Hardy and Littlewood.

It was during that last decade that Zygmund began to turn his attention from the one-dimensional situation to problems in higher dimensions. At first this represented merely an incidental interest, but then later he followed it with increasing dedication, and eventually it was to become the main focus of his scientific work. I want now to describe how this point of view developed with Zygmund.

In outline, the subject of one-dimensional harmonic analysis as it existed in that period can be understood in terms of what were then three closely interrelated areas of study and which in many ways represented the central achievements of the theory: real-variable theory, complex analysis, and the behavior of Fourier series. Zygmund's first excursion into questions of higher dimensions dealt with the key issue of real-variable theory, the averaging of functions. The question was as follows. The classical theorem of Lebesgue guaranteed that for almost every x

$$\lim_{\substack{x\in I\\ \operatorname{diam}(I)\to 0}} \frac{1}{|I|}\int_I f(y)\,dy = f(x), \tag{1.1}$$

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This essay, published in the Notices *by arrangement with the University of Chicago Press, is a modified version of the article entitled "Calderón and Zygmund's theory of singular integrals", to appear in the proceedings of the 1996 conference in honor of Calderón's seventy-fifth birthday held at the University of Chicago. That article also contains an extended list of references and further bibliographical notes which have been omitted from the present version.*

where I ranges over intervals and when f is an integrable function on the line $\mathbb{R}^1$.

In higher dimensions it is natural to ask whether a similar result holds when the intervals I are replaced by appropriate generalizations in $\mathbb{R}^n$. The fact that this is the case when the I's are replaced by balls (or more general sets with bounded "eccentricity") was well known at that time. What must have piqued Zygmund's interest in the subject was his realization (in 1927) that a paradoxical set constructed by Nikodym showed that the answer is irretrievably false when the I's are taken to be rectangles (each containing the point in question) but with arbitrary orientation. To this must be added the counterexample found by Saks several years later, which showed that the desired analogue of (1.1) still failed even if we now restricted the rectangles to have a fixed orientation (e.g., with sides parallel to the axes) as long as one allowed f to be a general function in L^1.

It was at this stage that Zygmund effectively transformed the subject at hand by an important advance: he proved that the wished-for conclusion (when the sides are parallel to the axes) held if f was assumed to belong to L^p, with $p > 1$. He accomplished this by proving an inequality for what is now known as the "strong" maximal function. The original Hardy-Littlewood maximal function involved a supremum over the averages in (1.1); in the definition of the strong maximal function the intervals containing x are replaced by rectangles with sides parallel to the axes. Shortly afterwards in Jessen, Marcinkiewicz, and Zygmund (1935) this was refined to the requirement that f belong to $L(\log L)^{n-1}$ locally.

This study of the extension of (1.1) to $\mathbb{R}^n$ was the first step taken by Zygmund. It is reasonable to guess that it reinforced his fascination with what was then developing as a long-term goal of his scientific efforts: the extension of the central results of harmonic analysis to higher dimensions. But a great obstacle stood in the way: it was the crucial role played by complex function theory in the whole of one-dimensional Fourier analysis, and for this there was no ready substitute.

In describing this special role of complex methods we shall content ourselves with highlighting some of the main points. The theory can be formulated equally in the unit disc or the upper half-plane, and we shall freely pass back and forth between these settings.

(i) *The conjugate function and its basic properties*

As is well known, the Hilbert transform comes directly from the Cauchy integral formula. Closely connected with this is the fact that the Hilbert transform of a function f is obtained by passing to the Poisson integral of f in the upper half-plane, taking the conjugate harmonic function and passing back to boundary values. We also recall the fact that M. Riesz proved the L^p boundedness properties of the Hilbert transform

$$f \mapsto H(f) = \frac{p.v.}{\pi} \int_{-\infty}^{\infty} f(x-y)\frac{dy}{y}$$

by applying a contour integral to $(F)^p$, where F is the analytic function whose boundary limit has f as its real part. It should be noted that the Hilbert transform has a simple expression as a Fourier multiplier, that is,

$$H(f)\hat{}(\xi) = \frac{sign(\xi)}{i}\hat{f}(\xi),$$

where $\hat{}$ denotes the Fourier transform; from this the L^2 boundedness is an immediate consequence via Plancherel's theorem.

(ii) *The theory of the Hardy spaces H^p*

These arose in part as substitutes for L^p, when $p \le 1$, and were by their very nature complex-function-theory constructs. (It should be noted, however, that for $1 < p < \infty$ they were essentially equivalent with L^p by Riesz's theorem.) The classical space H^p consists of analytic functions F in the unit disc for which

$$\sup_{r<1} \int_0^{2\pi} |F(re^{i\theta})|^p \, d\theta < \infty.$$

The main tool used in their study was the Blaschke product of their zeroes in the unit disc. Using it, one could reduce matters to elements $F \in H^p$ with no zeroes, and from these one could pass to $G = F^{p/2}$; the latter was in H^2 and hence could be treated by more standard (L^2) methods.

(iii) *The Littlewood-Paley theory*

This proceeded by studying the dyadic decomposition in frequency space and had many applications; among them was the Marcinkiewicz multiplier theorem. This gave conditions on a Fourier multiplier, in terms of certain differential inequalities, that were sufficient to guarantee that it defined a bounded operator on L^p. The theory initiated and exploited certain basic "square functions", and these we originally studied by complex-variable techniques closely related to what were used in H^p spaces.

(iv) *The boundary behavior of harmonic functions*

The main result obtained here (Privalov (1923), Marcinkiewicz and Zygmund (1938), and Spencer (1943)) stated that for any harmonic function $u(re^{i\theta})$ in the unit disc the following three properties are equivalent for almost all boundary points $e^{i\theta}$:

(1.2) u has a nontangential limit at $e^{i\theta}$,

(1.3) u is nontangentially bounded at $e^{i\theta}$,

the "area integral" $(S(u)(\theta))^2 =$

$$\iint_{\Gamma(e^{i\theta})} |\nabla u(z)|^2 \, dx\, dy \text{ is finite,} \tag{1.4}$$

where $\Gamma(e^{i\theta})$ is a nontangential approach region with vertex $e^{i\theta}$.

The crucial first step in the proof was the application of the conformal map (to the unit disc) of the famous saw-tooth domain in Figure 1.[1] This mapping allowed one to reduce the implication (1.3) ⇒ (1.2) to the special case of bounded harmonic functions in the unit disc (Fatou's theorem) and also played a corresponding role in the other parts of the proof.

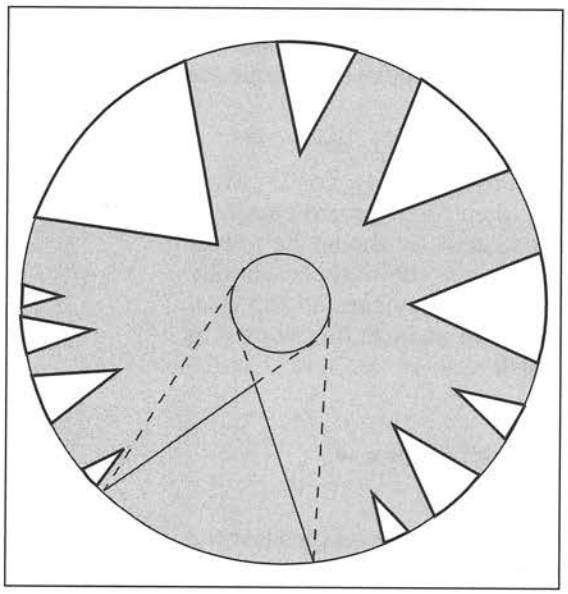


Figure 1. Saw-tooth domain.

It is ironic that complex methods with their great power and success in the one-dimensional theory actually stood in the way of progress to higher dimensions and appeared to block further progress. The only way past, as Zygmund foresaw, required a further development of "real" methods. Achievement of this objective was to take more than one generation and in some ways is not yet complete. The mathematician with whom he was to initiate the effort to realize much of this goal was Alberto Calderón.

Calderón and Zygmund: 1950–1957

Zygmund spent the academic year 1948–49 in Argentina, and there he met Calderón. Zygmund brought him back to the University of Chicago, and soon thereafter (in 1950), under his direction, Calderón obtained his doctoral thesis. The dissertation contained three parts, the first about ergodic theory, which will not concern us here. It is the second and third parts that interest us, and these represented breakthroughs in the problem of freeing oneself from complex methods and, in particular, in extending to higher dimensions some of the results described in (iv) above. In a general way we can say that his efforts here already typified the style of much of his later work: he begins by conceiving some simple but fundamental ideas that go to the heart of the matter and then develops and exploits these insights with great power.

In proving (1.3) ⇒ (1.2) we may assume that u is bounded inside the saw-tooth domain Ω that arose in (iv) above: this region is the union of approach regions $\Gamma(e^{i\theta})$, ("cones") with vertex $e^{i\theta}$, for points $e^{i\theta} \in E$, and E a closed set. Calderón introduced the auxiliary harmonic function U, with U the Poisson integral of $\chi_{\underline{c}E}$, and observed that all the desired facts flowed from the dominating properties of U: namely, u could be split as $u = u_1 + u_2$, where u_1 is the Poisson integral of a bounded function (and hence has nontangential limits a.e.), while by the maximum principle $|u_2| \le c\,U$, and therefore u_2 has (nontangential) limits = 0 at a.e. point of E.

The second idea (used to prove the implication (1.2) ⇒ (1.4)) has as its starting point the simple identity

$$\Delta u^2 = 2|\nabla u|^2 \tag{2.1}$$

valid for any harmonic function. This can be combined with Green's theorem

$$\iint_{\Omega} (B\Delta A - A\Delta B)\, dx\, dy = \int_{\partial\Omega} \left(B\frac{\partial A}{\partial n} - A\frac{\partial B}{\partial n}\right) d\sigma,$$

where $A = u^2$ and B is another ingeniously chosen auxiliary function depending on the domain Ω only. This allowed him to show that $\iint_{\Omega} y|\nabla u|^2\, dx\, dy < \infty$, which is an integrated revision of (1.4).

It may be noted that the above methods and the conclusions they imply make no use of complex analysis and are very general in nature. It is also a fact that these ideas played a significant role in the later real-variable extension of the H^p theory.

Starting in the year 1950, a close collaboration developed between Calderón and Zygmund which lasted almost thirty years. While their joint research dealt with a number of different subjects, their preoccupying interest and most fundamental contributions were in the area of singular integrals. In this connection the first issue they addressed was—to put the matter simply—the extension to higher dimensions of the theory of the Hilbert transform. A real-variable analysis of the Hilbert transform had been carried out by Besicovitch, Titchmarsh, and Marcinkiewicz, and this is what needed to be extended in the $\mathbb{R}^n$ setting.

A reasonable candidate for consideration presented itself. It was the operator $f \mapsto Tf$, with

$$T(f)(x) = p.v. \int_{\mathbb{R}^n} K(y) f(x-y)\, dy, \tag{2.2}$$

[1] *Figure 1 is based on a diagram in Zygmund [1959], Vol. II, p. 200.*

when K was homogeneous of degree $-n$, satisfied some regularity, and in addition satisfied the cancellation condition $\int_{|x|=1} K(x)\,d\sigma(x) = 0$.

Besides the Hilbert transform (which is the only real example when $n = 1$), higher-dimensional examples include the operators that arise as second derivatives of the fundamental solution operator for the Laplacian (which can be written as $\frac{\partial^2}{\partial x_2 \partial x_j}(\Delta)^{-1}$), as well as the related Riesz transforms $\frac{\partial}{\partial x_j}(-\Delta)^{-1/2}$. For the Hilbert transform, n is equal to 1 and $K(x)$ is equal to $\frac{1}{\pi x}$; the Riesz transforms are given (up to a constant multiple) by $K(x) = x_j/|x|^{n+1}$, $j = 1, \ldots, n$.

All of this is the subject matter of their historic memoir "On the existence of singular integrals", which appeared in *Acta Mathematica* in 1952. There is probably no paper in the last fifty years which had such widespread influence in analysis. The ideas in this work are now so well known that I will only outline its contents. It can be viewed as having three parts.

First, there is the Calderón-Zygmund lemma and the corresponding Calderón-Zygmund decomposition. The main thrust of the former is as a substitute for F. Riesz's "rising sun" lemma, which F. Riesz used in re-proving Lebesgue's theorem about the almost everywhere differentiability of monotone functions and which had implicitly played a key role in the earlier treatment of the Hilbert transform. A schematic representation of their decomposition is given in Figure 2.[2]

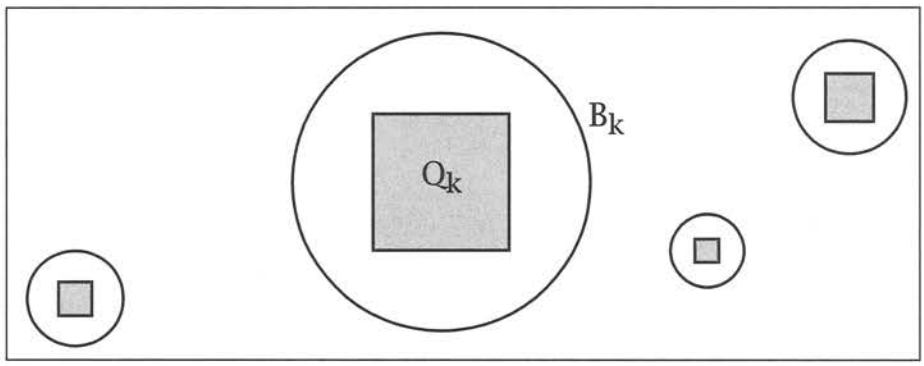


Figure 2. Calderón-Zygmund decomposition of a nonnegative function f at altitude α. The cubes $Q = Q_k$ have the property that $\alpha < |Q|^{-1} \int_Q f\,dx \le 2^n \alpha$. In the complement of the balls B_k, a favorable L^1 estimate holds.

Second, using their decomposition, they then proved the weak-type L^1 and L^p, $1 < p < \infty$, estimates for the operator T in (2.2). As a preliminary step they disposed of the L^2 theory of T using Plancherel's theorem.

Third, they applied these results to the examples mentioned above, and in addition they proved a.e. convergence for the singular integrals in question.

It should not detract from one's great admiration for this work to note two historical anomalies contained in it. The first is the fact that there is no mention of Marcinkiewicz's interpolation theorem or of the paper in which it appeared (Marcinkiewicz [1939a]), even though its ideas play a significant role. In the Calderón-Zygmund paper the special case that is needed is in effect reproved. The explanation for this omission is that Zygmund had simply forgotten about the existence of Marcinkiewicz's note. To make amends, he published (in 1956) an account of Marcinkiewicz's theorem and various generalizations and extensions he had since found. In it he conceded that the paper of Marcinkiewicz "... seems to have escaped attention and does not find allusion to it in the existing literature."

The second point, like the first, also involves important work of Marcinkiewicz. He had been Zygmund's brilliant student and collaborator until his death at the beginning of World War II. It is a mystery why no reference was made to the paper by Marcinkiewicz [1939b] and the multiplier theorem in it. This theorem had been proved by Marcinkiewicz in an n-dimensional form (as a product "consequence" of the one-dimensional form). As an application the L^p inequalities for the operators $\frac{\partial^2}{\partial x_i \partial x_j}(\Delta^{-1})$ were obtained[3]; these he had proved at the behest of Schauder.

As has already been indicated, the n-dimensional singular integrals had their main motivation in the theory of partial differential equations. In their further work, Calderón and Zygmund pursued this connection, following the trail that had been explored earlier by Giraud, Tricomi, and Mihlin. Starting from those ideas (in particular the notion of "symbol"), they developed their version of the symbolic calculus of "variable-coefficient" analogues of the singular integral operators. To describe these results, one considers an extension of the class of operators arising in (2.2), namely, of the form

$$(2.3)\quad T(f)(x) = a_0(x)f(x) + p.v. \int_{\mathbb{R}^n} K(x,y)f(x-y)\,dy,$$

where $K(x, y)$ is for each x a singular integral kernel of the type (2.2) in y, which depends smoothly and boundedly on x; also $a_0(x)$ is a smooth and bounded function.

[2] *I still have a graphic recollection of a similar picture shown me by Harold Widom in 1952–53, when we were both graduate students at the University of Chicago.*

[3] *In truth, he had done this for their periodic analogues, but this is a technical distinction.*

To each operator T of this kind there corresponds its symbol $a(x,\xi)$, defined by

$$a(x,\xi) = a_0(x) + \hat{K}(x,\xi), \tag{2.4}$$

where $\hat{K}(x,\xi)$ denotes the Fourier transform of $K(x,y)$ in the y variable. Thus $a(x,\xi)$ is homogeneous of degree 0 in the ξ variable (reflecting the homogeneity of $K(x,y)$ of degree $-n$ in y), and it depends smoothly and boundedly on x. Conversely, to each function $a(x,\xi)$ of this kind there exists a (unique) operator (2.3) for which (2.4) holds. One says that a is the symbol of T and also writes $T = T_a$.

The basic properties that were proved were, first, the regularity properties

$$T_a : L_k^p \to L_k^p, \tag{2.5}$$

where L_k^p are the usual Sobolev spaces, involving L^p norms of the function and its partial derivatives through order k, with $1 < p < \infty$.

Also proved were the basic facts of symbolic manipulations

$$T_{a_1} \cdot T_{a_2} = T_{a_1 \cdot a_2} + Error \tag{2.6}$$

$$(T_a)^* = T_{\bar{a}} + Error \tag{2.7}$$

where the *Error* operators are smoothing of order 1, in the sense that $Error : L_k^p \to L_{k+1}^p$.

A consequence of the symbolic calculus is the factorizability of any linear partial differential operator L of order m,

$$L = \sum_{|\alpha| \le m} a_\alpha(x) \left(\frac{\partial}{\partial x}\right)^\alpha,$$

where the coefficients a_α are assumed to be smooth and bounded. On can write

$$L = T_a(-\Delta)^{m/2} + (Error)' \tag{2.8}$$

for an appropriate symbol a, where the operator $(Error)'$ refers to an operator that maps $L_k^p \to L_{k-m+1}^p$, for $k \ge m-1$. It seemed clear that this symbolic calculus should have wide applications to the theory of partial differential operators and to other parts of analysis. This was soon to be borne out.

Acceptance: 1957–1965

At this stage of my narrative I would like to share some personal reminiscences. I had been a student of Zygmund at the University of Chicago, and in 1956 at his suggestion I took my first teaching position at MIT, where Calderón was at that time. I had met Calderón several years earlier when he came to Chicago to speak about the "method of rotations" in Zygmund's seminar. I still remember my feelings when I saw him there; these first impressions have not changed much over the years: I was struck by the sense of his understated elegance, reserve, and quiet charisma.

At MIT we would meet quite often, and over time an easy conversational relationship developed between us. I do recall that we, in the small group who were interested in singular integrals then, felt a certain separateness from the larger community of analysts—not that this isolation was self-imposed, but more because our subject matter was seen by our colleagues as somewhat arcane, rarefied, and possibly not very relevant. However, this did change, and a fuller acceptance eventually came. I want to relate now how this occurred.

Starting from the calculus of singular integral operators that he had worked out with Zygmund, Calderón obtained a number of important applications to hyperbolic and elliptic equations. His most dramatic achievement was in the uniqueness of the Cauchy problem (Calderón [1958]). There he succeeded in a broad and decisive extension of the results of Holmgren (for the case of analytic coefficients) and Carleman (in the case of two dimensions). Calderón's theorem can be formulated as follows.

Suppose u is a function which in the neighborhood of the origin in $\mathbb{R}^n$ satisfies the equation of mth order:

$$\frac{\partial^m u}{\partial x_n^m} = \sum_\alpha a_\alpha(x) \frac{\partial^\alpha u}{\partial x^\alpha}, \tag{3.1}$$

where the summation is taken over all indices $\alpha = (\alpha_1, \dots, \alpha_n)$, with $|\alpha| \le n$ and $\alpha_n < m$. We also assume that u satisfies the null initial Cauchy conditions

$$\left.\frac{\partial^j u(x)}{\partial x_n^j}\right|_{x_n=0} = 0, \qquad j = 0, \dots, m-1. \tag{3.1$'$}$$

Besides (3.1) and (3.1′) it suffices that the coefficients a_α belong to $C^{1+\epsilon}$, that the characteristics are simple, and that $n \ne 3$ or $m \le 3$. Under these hypotheses u vanishes identically in a neighborhood of the origin.

Calderón's approach was to reduce matters to a key "pseudo-differential inequality" (in a terminology that was used later). This inequality is complicated but somewhat reminiscent of a differential inequality that Carleman had used in two dimensions. The essence of it is that

$$\begin{aligned} &\int_0^a \phi_k \left\| \frac{\partial u}{\partial t} + (P + iQ)(-\Delta)^{1/2} u \right\|^2 dt \\ &\qquad \le c \int_0^a \phi_k \|u\|^2 \, dt, \end{aligned} \tag{3.2}$$

where $u(0) = 0$ implies $u \equiv 0$ if (3.2) holds for $k \to \infty$.

Here P and Q are singular integral operators of the type (2.3), with real symbols and P invertible; we have written $t = x_n$, and the norms are L^2

norms taken with respect to the variables $x_1, \ldots, x_{n-1}$. The function ϕ_k is meant to behave like t^{-k}, which, when $k \to \infty$, emphasizes the effect taking place near $t = 0$. In fact, in (3.2) we can take $\phi_k(t) = (t + 1/k)^{-k}$.

The proof of assertions like (3.2) is easier in the special case when all the operators commute; their general form is established by using the basic facts (2.6) and (2.7) of the calculus.

The paper by Calderón was at first not well received. In fact, I learned from him that it was rejected when submitted to what was then the leading journal in partial differential equations, *Communications of Pure and Applied Mathematics.*

At about that time, because of the applicability of singular integrals to partial differential equations, Calderón became interested in formulating the facts about singular integrals in the setting of manifolds. This required the analysis of the effect coordinate changes had on such operators. A hint that the problem was tractable came from the observation that the class of kernels, $K(y)$, of the type arising in (2.2) was invariant under linear (invertible) changes of variables $y \mapsto L(y)$. (The fact that $K(L(y))$ satisfied the same regularity and homogeneity that $K(y)$ did was immediate; that the cancellation property also holds for $K(L(y))$ is a little less obvious.)

R. Seeley was Calderón's student at that time, and he dealt with this problem in his thesis (1959). Suppose $x \mapsto \psi(x)$ is a local diffeomorphism. Then the result is that modulo error terms (which are "smoothing" of one degree) the operator (2.3) is transformed into another operator of the same kind,

$$T'(f)(x) \cdot a_0'(x) = f(x) + p.v. \int K'(x, y) f(x - y)\, dy,$$

but now

$$a_0'(x) = a_0(\psi(x))$$

and

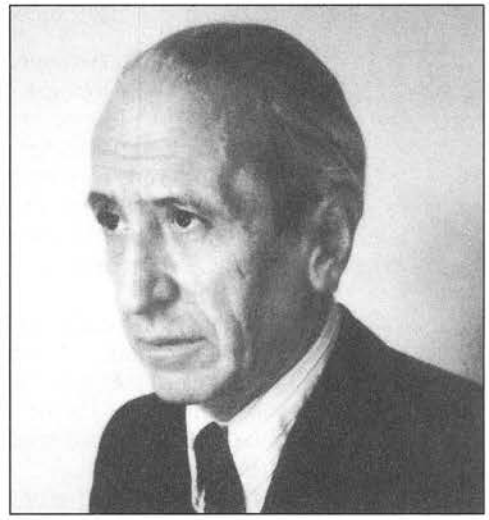
$$K'(x, y) \;=\; K'(\psi(x), L_x(y)),$$

where L_x is the linear transformation given by the Jacobian matrix $\frac{\partial \psi(x)}{\partial x}$. On the level of symbols this meant that the new symbol a' was determined by the old symbol according to the formula

$$a'(x, \xi) = a(\psi(x), L_x'(\xi)),$$

with L_x' the transpose inverse of L_x. Hence the symbol is actually a function on the cotangent space of the manifold.

The result of Seeley was not only highly satisfactory as to its conclusions, it was also very timely in terms of events that were about to take place. Following an intervention by Gelfand (1960), interest grew in calculating the "index" of an elliptic operator on a manifold. This index is the difference of the dimension of the null space and the codimension of the range of the operator and is an invariant under deformations. The problem of determining it was connected with a number of interesting issues in geometry and topology. The result of the "Seeley calculus" proved quite useful in this context: the proofs proceeded by appropriate deformations, and matters were facilitated if these could be carried out in the more flexible context of "general" symbols instead of restricting attention to the polynomial symbols coming from differential operators. A contemporaneous account of this development (during the period 1961–64) may be found in the notes of the seminar on the Atiyah-Singer index theorem (see Palais [1965]); for an historical survey of some of the background, see also Seeley [1967].



Alberto Pedro Calderón, circa 1979

Antoni Zygmund, circa 1979.

With the activity surrounding the index theorem, it suddenly seemed as if everyone was interested in the algebra of singular integral operators. However, one further step was needed to make this a household tool for analysts: it required a change of point of view. Even though this change of perspective was not major, it was significant psychologically and methodologically, since it allowed one to think more simply about certain aspects of the subject and because it suggested various extensions.

The idea was merely to change the role of the definitions of the operators, from (2.3) for singular integrals to pseudo-differential operators

$$T_a(f)(x) = \int_{\mathbb{R}^n} a(x, \xi) \hat{f}(\xi) e^{2\pi i x \cdot \xi}\, d\xi, \tag{3.3}$$

with symbol a. (Here $\hat{f}$ is the Fourier transform $\hat{f}(\xi) = \int_{\mathbb{R}^n} e^{-2\pi i x \cdot \xi} f(x)\, dx$.)

Although the two operators are identical (when $a(x,\xi) = a_0(x) + \hat{K}(x,\xi)$), the advantage lies in the emphasis in (3.3) on the L^2 theory and Fourier transform and the wider class of operators that can be considered, in particular, differential operators. The formulation (3.3) allows one to deal more systematically with the composition of such operators and incorporate the lower-order terms in the calculus.

One way of doing this was to adopt a wider class of symbols of "homogeneous type": roughly speaking, $a(x,\xi)$ belongs to this class (and is of *order m*) if $a(x,\xi)$ is for large ξ asymptotically the sum of terms homogeneous in ξ of degrees $m-j$, with $j = 0, 1, 2, \ldots$.

The change in point of view described above came into its full flowering with the papers of Kohn and Nirenberg (1965) and Hörmander (1965), (after some work by Unterberger and Bokobza (1964) and Seeley (1965)). It is in this way that singular integrals were subsumed by pseudo-differential operators. Despite this, singular integrals, with their formulation in terms of kernels, still retained their primacy when treating real-variable issues, issues such as L^p or L^1 estimates (and even for some of the more intricate parts of the L^2 theory). The central role of the kernel representation of these operators became, if anything, more pronounced in the next twenty years.

Calderón's New Theory of Singular Integrals: 1965–

In the years 1957–58 there appeared the fundamental work of DeGiorgi and Nash dealing with smoothness of solutions of partial differential equations, with minimal assumptions of regularity of the coefficients. One of the most striking results, for elliptic equations, was that any solution u of the equation

$$(4.1) \qquad L(u) \equiv \sum_{i,j} \frac{\partial}{\partial x_i}\left(a_{ij}(x)\frac{\partial u}{\partial x_j}\right) = 0$$

in an open ball satisfies an a priori interior regularity as long as the coefficients are uniformly elliptic, i.e.,

$$(4.2) \qquad c_1|\xi|^2 \le \sum_{i,j} a_{ij}(x)\xi_i\xi_j \le c_2|\xi|^2.$$

In fact, no regularity is assumed about the a_{ij} except for the boundedness implicit in (4.2), and the result is that u is Hölder continuous with an exponent depending only on the constants c_1 and c_2.

Calderón was intrigued by this result. He initially expected, as he told me, that one could obtain such conclusions and others by refining the calculus of singular integral operators (3.2), making minimal assumptions of smoothness on $a_0(x)$ and $K(x,y)$. While this was plausible—and indeed in his work with Zygmund they had already derived properties of the operators (2.3) and their calculus when the dependence on x was e.g. of class $C^{(1+\epsilon)}$—this hope was not to be realized. Further understanding about these things could be achieved only if one were ready to look in a somewhat different direction. I want to relate now how this came about.

The first major insight arose in answer to the following:

Question: Suppose M_A is the operator of multiplication (by the function A),

$$M_A : f \mapsto A \cdot f.$$

What are the least regularity assumptions on A needed to guarantee that the commutator $[T, M_A]$ is bounded on L^2 whenever T is of order 1?

In $\mathbb{R}^1$ if T happens to be $\frac{d}{dx}$, then $[T, M_A] = M_{A'}$, and so the condition is exactly

$$(4.3) \qquad A' \in L^\infty(\mathbb{R}^1).$$

In a remarkable paper Calderón [1965] showed that this is also the case more generally. The key case, containing the essence of the result he proved, arose when $T = H\frac{d}{dx}$, with H the Hilbert transform. Then T is actually $\left|\frac{d}{dx}\right|$, its symbol is $2\pi|\xi|$, and $[T, M_A]$ is the "commutator" C_1,

$$(4.4) \qquad C_1(f)(x) = \frac{1}{\pi}\, p.v. \int_{-\infty}^{\infty} \frac{A(x)-A(y)}{(x-y)^2} f(y)\, dy.$$

Calderón proved that $f \mapsto C_1(f)$ is bounded on $L^2(\mathbb{R})$ if (4.3) holds.

There are two crucial points that I want to emphasize about the proof of this theorem. The first is the reduction of the boundedness of the bilinear term $(f,g) \to \langle C_1(f), g\rangle$ to a corresponding property of a particular bilinear mapping, $(F,G) \to B(F,G)$, defined for (appropriate) holomorphic functions in the upper half-plane $\{z = x+iy, y > 0\}$ by

$$(4.5) \qquad B(F,G)(x) = i\int_0^\infty F'(x+iy)G(x+iy)\, dy.$$

This B is a primitive version of a "para-product" (in this context, the justification for this terminology is the observation that $F(x)\cdot G(x) = B(F,G)(x) + B(G,F)(x)$). It is, in fact, not too difficult to see that $f \mapsto C_1(f)$ is bounded on $L^2(\mathbb{R}^1)$ if B satisfies the Hardy-space estimate

$$(4.6) \qquad \|B(F,G)\|_{H^1} \le c\|F\|_{H^2}\|G\|_{H^2}.$$

The second major point in the proof is the assertion needed to establish (4.6). It is the converse part of the equivalence

$$(4.7) \qquad \|S(F)\|_{L^1} \sim \|F\|_{H^1}$$

for the area integral S (which appeared in (1.4)).

The theorem of Calderón, and in particular the methods he used, inspired a number of significant developments in analysis. The first came because of the enigmatic nature of the proof: a deep L^2 theorem had been established by methods (using complex function theory) that did not seem susceptible to a general framework. In addition, the non-translation-invariance character of the operator C_1 made Plancherel's theorem of no use here. It seemed likely that a method of "almost-orthogonal" decomposition—pioneered by Cotlar for the classical Hilbert transform—might well succeed in this case also. This led to a reexamination of Cotlar's lemma (which had originally applied to the case of commuting self-adjoint operators). A general formulation was obtained as follows: Suppose that on a Hilbert space $T = \sum T_j$. Then

$$\|T\|^2 \le \sum_k \sup_j \{\|T_j T_{j+k}^*\| + \|T_j^* T_{j+k}\|\}. \tag{4.8}$$

Despite the success in proving (4.8) this alone was not enough to re-prove Calderón's theorem. As understood later, the missing element was a certain cancellation property. Nevertheless, the general form of Cotlar's lemma, (4.8), quickly led to a number of highly useful applications, such as singular integrals on nilpotent groups (intertwining operators), pseudo-differential operators, etc.

Calderón's theorem also gave added impetus to the further evolution of the real-variable H^p theory. This came about because the equivalence (4.7) and its generalizations allowed one to show that the usual singular integrals (2.2) were also bounded on the Hardy space H^1 (and in fact on all H^p, $0 < p < \infty$). Taken together with earlier developments and some later ideas, the real-variable H^p theory reached its full flowering a few years later. One owes this long-term achievement to the work of G. Weiss, C. Fefferman, Burkholder, Gundy, and Coifman, among others.

It became clear after a time that understanding the commutator C_1 (and its "higher" analogues) was in fact connected with an old problem that had been an ultimate but unreached goal of the classical theory of singular integrals: the boundedness behavior of the Cauchy integral taken over curves with minimal regularity. The question involved can be formulated as follows: in the complex plane, for a contour γ and a function f defined on it form the Cauchy integral

$$F(z) = \frac{1}{2\pi i} \int_\gamma \frac{f(\zeta)}{\zeta - z}\, d\zeta,$$

with F holomorphic outside γ. Define the mapping $f \to C(f)$ by $C(f) = F_+ + F_-$, where F_+ are the limits of F on γ approached from either side. When γ is the unit circle, or real axis, then $f \to C(f)$ is essentially the Hilbert transform. Also, when γ has some regularity (e.g., γ is in $C^{(1+\epsilon)}$), the expected properties of C (i.e., L^2, L^p boundedness, etc.) are easily obtained from the Hilbert transform. The problem was what happened when, say, γ was less regular, and here the main issue that presented itself was the behavior of the Cauchy integral when γ was a Lipschitz curve.

If γ is a Lipschitz graph in the plane, $\gamma = \{x + iA(x), x \in R\}$, with $A' \in L^\infty$, then up to a multiplicative constant,

$$C(f)(x) = p.v. \int_{-\infty}^{\infty} \frac{1}{x - y + i(A(x) - A(y))} f(y) b(y)\, dy \tag{4.9}$$

where $b = 1 + iA'$. The formal expansion

$$\begin{aligned} &\frac{1}{x - y + i(A(x) - A(y))} \\ &\quad = \frac{1}{x - y} \cdot \sum_{k=0}^{\infty} (-i)^k \left(\frac{A(x) - A(y)}{x - y} \right)^k \end{aligned} \tag{4.10}$$

then makes clear that the fate of Cauchy integral C is inextricably bound up with that of the commutator C_1 and its higher analogues C_k given by

$$C_k f(x) = \frac{p.v.}{\pi} \int_{-\infty}^{\infty} \left(\frac{A(x) - A(y)}{x - y} \right)^k \frac{f(y)}{x - y}\, dy.$$

The further study of this problem was begun by Coifman and Meyer in the context of the commutators C_k, but the first breakthrough for the Cauchy integral was obtained by Calderón [1977] (using different methods) in the case where the norm $\|A'\|_{L^\infty}$ was small. His proof made decisive use of the complex-analytic setting of the problem. It proceeded by an ingenious deformation argument, leading to a nonlinear differential inequality; this nonlinearity accounted for the limitation of small norm for A' in the conclusion. But even with this limitation the conclusion obtained was stunning.

The crowning result came in 1982 when Coifman and Meyer, having enlisted the help of McIntosh and relying on some of their earlier ideas, together proved the desired result without limitation on the size of $\|A'\|_{L^\infty}$. The method they used was operator-theoretic, emphasizing the multilinear aspects of the C_k, and in distinction to Calderón's approach was not based on complex-analytic techniques.

The major achievement represented by the theory of the Cauchy integral led to a host of other results, either by a rather direct exploitation of the conclusions involved or by extensions of the techniques that were used. I will briefly discuss two of these developments.

The first was a complete analysis of the L^2 theory of "Calderón-Zygmund operators". By this terminology is meant operators of the form

$$T(f)(x) = \int_{\mathbb{R}^n} K(x,y)f(y)\,dy, \tag{4.11}$$

initially defined for test functions $f \in S$, with the kernel K a distribution. It is assumed that away from the diagonal, K agrees with a function that satisfies familiar estimates such as

$$\begin{aligned} |K(x,y)| &\le A|x-y|^{-n}, \\ |\nabla_{x,y}K(x,y)| &\le A|x-y|^{-n-1}. \end{aligned} \tag{4.12}$$

The main question that arises (and is suggested by the commutators C_k) is, what are the additional conditions that guarantee that T is a bounded operator on $L^2(\mathbb{R}^n)$ to itself? The answer, found by David and Journé (1984), is highly satisfying: a certain "weak boundedness" property, namely, $|(Tf,g)| \le Ar^n$ wherever f and g are suitably normalized bump functions, supported in a ball of radius r; also, that both $T(1)$ and $T^*(1)$ belong to BMO. (Here BMO denotes the space of functions of bounded mean oscillation. This space first arose in partial differential equations as a useful substitute for the space L^∞ and later played a key role in H^p theory.) These conditions are easily seen to also be necessary.

The argument giving the sufficiency proceeded in decomposing the operator into a sum $T = T_1 + T_2$, where for T_1 the additional cancellation condition $T_1(1) = T_1^*(1) = 0$ held. As a consequence the method of almost-orthogonal decomposition, (4.8), could be successfully applied to T_1. The operator T_2 (for which L^2 boundedness was proved differently) was of para-product type, chosen so as to guarantee the needed cancellation property.

The conditions of the David-Journé theorem, while applying in principle to the Cauchy integral, are not easily verified in that case. However, a refinement (the "$T(b)$ theorem"), with $b = 1 + iA'$, was found by David, Journé, and Semmes, and this does the job needed.

A second area that was substantially influenced by the work of the Cauchy integral was that of second-order elliptic equations in the context of minimal regularity. Side by side with the consideration of the divergence-form operator L in (4.1) (where the emphasis is on the minimal smoothness of the coefficients), one was led to study also the potential theory of the Laplacian (where the emphasis was now on the minimal smoothness of the boundary). In the latter setting a natural assumption to make was that the boundary is Lipschitzian. In fact, by an appropriate Lipschitz mapping of domains, the situation of the Laplacian in a Lipschitz domain could be realized as a special case of the divergence-form operator (4.1) where the domain was smooth, say, a half-space.

The decisive application of the Cauchy integral to the potential theory of the Laplacian in a Lipschitz domain was in the study of the boundedness of the double-layer potential (and the normal derivative of the single-layer potential). These are $n-1$ dimensional operators, and they can be realized by applying the "method of rotations" to the one-dimensional operator (4.9). One should mention that another significant aspect of Laplacians on Lipschitz domains was the understanding brought to light by Dahlberg of the nature of harmonic measure and its relation to A_p weights. These two strands, initially independent, have been linked together, and with the aid of further ideas a rich theory has developed, owing to the added contributions of Jerison, Kenig, and others.

Finally, we return to the point where much of this began—the divergence-form equation (4.1). Here the analysis growing out of the Cauchy integral also had its effect. Here I will mention only the usefulness of multilinear analysis in the study of the case of "radially-independent" coefficients, also in the work on the Kato problem: the determination of the domain of $\sqrt{L}$ in the case where the coefficients can be complex-valued.

Some Perspectives on Singular Integrals: Past, Present, and Future

The modern theory of singular integrals, developed and nurtured by Calderón and Zygmund, has proved to be a very fruitful part of analysis. Beyond the achievements described above, a number of other directions have been cultivated with great success, with work being vigorously pursued up to this time. In addition, here several interesting open questions present themselves. I want to allude briefly to three of these directions and mention some of the problems that arise.

1. *Method of the Calderón-Zygmund lemma.* As is well known this method consists of decomposing an integrable function into its "good" and "bad" parts, the latter being supported on a disjoint union of cubes and having mean value zero on each cube. Together with an L^2 bound and estimates of the type (4.12), this leads ultimately to the weak-type (1,1) results, etc.

It was recognized quite early that this method allowed substantial extension. The generalizations that were undertaken were not so much pursued for their own sake, but rather were motivated in each case by the interest of the applications. Roughly, in order of appearance, here were some of the main instances:

(i) *The heat equation and other parabolic equations.* This began with the work of F. Jones (1964) for the heat equation, with the Calderón-Zygmund cubes replaced by rectangles whose dimensions reflected the homogeneity of the heat operator. The theory was extended by Fabes, Rivière, and Sadosky to encompass more general singular inte-

grals respecting "nonisotropic" homogeneity in Euclidean spaces.

(ii) *Symmetric spaces and semisimple Lie groups.* To be succinct, the crucial point was the extension to the setting of nilpotent Lie groups with dilations ("homogeneous groups"), motivated by problems connected with Poisson integrals on symmetric spaces, and construction of intertwining operators.

(iii) *Several complex variables and subelliptic equations.* Here we return again to the source of singular integrals, complex analysis, but now in the setting of several variables. An important conclusion obtained was that for a broad class of domains in $\mathbb{C}^n$ the Cauchy-Szegö projection is a singular integral susceptible to the above methods. This was realized first for strongly pseudo-convex domains, next weakly pseudo-convex domains of finite type in $\mathbb{C}^2$, and more recently convex domains of finite type in $\mathbb{C}^n$.

Connected with this is the application of the above ideas to the $\bar{\partial}$-Neumann problem, and its boundary analogue for certain domains in $\mathbb{C}^n$, as well as the study solving operators for subelliptic problems, such as Kohn's Laplacian, Hörmander's sum of squares, etc. These matters also involved using ideas originating in the study of nilpotent groups as in (ii).

The three kinds of extensions mentioned above are prime examples of what one may call "one-parameter" analysis. This terminology refers to the fact that the cubes (or their containing balls) which occur in the standard $\mathbb{R}^n$ setup have been replaced by a suitable one-parameter family of generalized "balls" associated to each point. While the general one-parameter method clearly has wide applicability, it is not sufficient to resolve the following important question:

Problem. Describe the nature of the singular integral operators that are given by Cauchy-Szegö projection, as well as those that arise in connection with the solving operators for the $\bar{\partial}$ and $\bar{\partial}_b$ complexes for general smooth finite-type pseudo-convex domains in $\mathbb{C}^n$.

Some speculation about what may be involved in resolving this question can be found below.

2. *The method of rotations.* The method of rotations is both simple in its conception and far-reaching in its consequences. The initial idea was to take the one-dimensional Hilbert transform, induce it on a fixed (subgroup) $\mathbb{R}^1$ of $\mathbb{R}^n$, rotate this $\mathbb{R}^1$, and integrate in all directions, obtaining in this way the singular integral (2.2) with odd kernel, which can be written as

$$T_\Omega(f)(x) = p.v. \int_{\mathbb{R}^n} \frac{\Omega(y)}{|y|^n} f(x-y)\,dy \tag{5.1}$$

where Ω is homogeneous of degree 0, integrable in the unit sphere, and odd.

In much the same way the general maximal operator

$$M(f)(x) = \sup_{r>0} \frac{1}{r^n} \left| \int_{|y|\le r} \Omega(y) f(x-y)\,dy \right| \tag{5.2}$$

arises from the one-dimensional Hardy-Littlewood maximal function.

This method worked very well for L^p estimates for $p > 1$, but not for L^1 (since the weak-type L^1 "norm" is not subadditive). The question of what happens for L^1 was left unresolved by Calderón and Zygmund. It is now to a large extent answered: we know that both (5.1) and (5.2) are indeed of weak-type (1,1) if Ω is in $L(\log L)$. This is the achievement of a number of mathematicians, in particular Christ and Rubio de Francia.

When the method of rotations is combined with the singular integrals for the heat equation (as in 1(i) above), one arrives at the "Hilbert transform on the parabola". Consideration of the Poisson integral on symmetric spaces leads one also to inquire about some analogous maximal functions associated to homogeneous curves. The initial major breakthroughs in this area of research were obtained by Nagel, Rivière, and Wainger. The subject has since developed into a rich and varied theory, beginning with its translation invariant setting on $\mathbb{R}^n$ (and its reliance on the Fourier transform), and then prompted by several complex variables, to a more general context connected with oscillatory integrals and nilpotent Lie groups, where it was rechristened as the theory of "singular Radon transforms".

A common unresolved enigma remains about these two areas that have sprung out of the method of rotations. This is a question that has intrigued workers in the field and whose solution, if positive, would be of great interest.

Problem

(a) Is there an L^1 theory for (5.1) and (5.2) if Ω is merely integrable?[4]

(b) Are the singular Radon transforms, and their corresponding maximal functions, of weak-type (1,1)?

3. *Product theory and multiparameter analysis.* To oversimplify matters, one can say that "product theory" is that part of harmonic analysis in $\mathbb{R}^n$ which is invariant with respect to the n-fold dilations: $x = (x_1, x_2, \ldots, x_n) \to (\delta_1 x_1, \delta_2 x_2, \ldots, \delta_n x_n)$, $\delta_j > 0$. Another way of putting it is that its initial concern is with operators that are essentially products of operators acting on each variable separately and then more generally with operators (and associated function spaces) that retain some of these characteristics. Related to this is the multiparameter theory, standing partway between the one-parameter theory discussed above and product theory: here the emphasis is on operators

[4] *For (5.1) we assume also that Ω is odd.*

which are "invariant" (or compatible with) specified subgroups of the group of n-parameter dilations.

The product theory of $\mathbb{R}^n$ began with Zygmund's study of the strong maximal function, continued with Marcinkiewicz's proof of his multiplier theorem, and has since branched out in a variety of directions where much interesting work has been done. Among the things achieved are an appropriate H^p and BMO theory and the many properties of product (and multiparameter) singular integrals that have came to light. This is due to the work of S. Y. Chang, R. Fefferman, and Journé, to mention only a few of the names.

Finally, I want to come to an extension of the product theory (more precisely, the induced "multiparameter analysis") in a direction that has particularly interested me recently. Here the point is that the underlying space is no longer Euclidean $\mathbb{R}^n$, but rather a nilpotent group or another appropriate generalization. On the basis of recent but limited experience, I would hazard the guess that multiparameter analysis in this setting could well turn out to be of great interest in questions related to several complex variables. A first vague hint that this may be so came with the realization that certain boundary operators arising from the $\bar{\partial}$-Neumann problem (in the model case corresponding to the Heisenberg group) are excellent examples of multiple-parameter singular integrals (in the work of Müller, Ricci, and the author (1995)). A second indication is the description of Cauchy-Szegö projections and solving operators for $\bar{\partial}_b$ for a wide class of quadratic surfaces of higher codimension in $\mathbb{C}^n$ in terms of appropriate quotients of products of Heisenberg groups (in yet unpublished joint work with Nagel and Ricci). And even more suggestive are recent calculations (made jointly with A. Nagel) for such operators in a number of pseudo-convex domains of finite type. All this leads one to hope that a suitable version of multiparameter analysis will provide the missing theory of singular integrals needed for a variety of questions in several complex variables. This is indeed an exciting prospect.

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The Autobiography of Laurent Schwartz

K. Chandrasekharan

The romantic poet Keats (1795–1821) compared human life to a large mansion of many apartments, only two of which he could describe, the doors of the rest being as yet shut upon him. Laurent Schwartz's autobiography, written at the age of eighty-two, has just appeared and describes more than two apartments, not romantically but in limpid prose. Its gripping interest derives from the richness of events that have filled his career—as a creative mathematician of the first rank, an educationalist of renown, and a political activist grappling with the burning issues of his time—and from the searching honesty and lack of egotism in their description. Some of those events are so painful as to have daunted any lesser spirit. With remarkable courage, Schwartz is willing to look at his earlier selves, and look at them hard. He has the generosity to show in his book his true self, with its humane impulses and moral commitment. His analytical mind is subtle and penetrating, and he articulates his thoughts on mathematics or music, Beethoven or butterflies, Mahatma Gandhi or Ho Chi Minh, Bertrand Russell or Jean Paul Sartre, communism or colonialism, the persecution of Jews or the repression of dissidents with such clarity and with such well-balanced reasoning that one is inevitably reminded of the writings of Gandhi in *Young India* (who called his autobiography *My Experiments with Truth*).

The book opens with a description of the country home at Autouillet (40 kilometres from Paris), which his father acquired in 1926 when he was just eleven and his brothers Bertrand and Daniel were just nine and seven. His father was a famous surgeon in Paris who helped him overcome the poliomyelitis which he had contracted the same year, and his mother's love of nature, which was transmitted to all her children, found its fulfilment at Autouillet. It is the anchorage of Schwartz's childhood memories, his Garden of Eden. He recalls its sights and sounds with an unassumed tenderness: the fruit trees (especially the figs), the flower beds, the herb garden, the fishing pond, the French lawns, the birds and insects and their behaviour patterns. He seems to lend support to George Orwell's observation that "by retaining one's childhood love of such things as trees, fishes, butterflies, and toads, one makes a peaceful and decent future a little more probable," and that "life is frequently more worth living because of a blackbird's song, a yellow elm tree in October, or some other natural phenomenon." It is in the shade of a giant chestnut tree at Autouillet, within earshot of birdsong, that many of his manuscripts took shape. His fascination with butterflies, which evolved into a lifelong hobby, began when he was barely five and became serious at Autouillet, which was the centre of reunion of family and friends. To the young and intellectually acute but physically fragile Schwartz, Autouillet offered the joy and happiness of Paradise. No doubt that experience helped

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to sustain his spirit in the difficult and painful years that lay ahead.

At school Schwartz excelled in Latin and Greek and mathematics. Thanks to the advice proffered to his mother by a discerning professor of literature (Thoridenet) and by his uncle (mother's brother) Robert Debré, mathematics was the course he finally followed, which in retrospect seems entirely justified. Preparing to enter the École Normale Supérieure (ENS), admission to which is by competitive examination, he fell in love with his schoolmate Marie-Hélène Lévy, daughter of the famous mathematician Paul Lévy (who was then a professor at the École Polytechnique (EP)). They became engaged in April 1935, when both of them were at the ENS, and intended to get married in December 1935. But in October that year she contracted a pulmonary tubercular infection and had to move to a sanatorium (at Passy, in Haut Savoie). Eighteen excruciating months of separation followed, during which they stayed in touch by correspondence. Schwartz's unswerving devotion to her during that period showed his mettle. (They got married in May 1938. They have had two children: Marc André, a poet and writer, who passed away suddenly in 1971; and Claudine, married to Raoul Robert, both of them professors of mathematics now at Grenoble. Marie-Hélène herself, overcoming all obstacles, wrote her doctoral thesis in 1953 and accepted a professorship at Lille in 1963.) Schwartz observes drily: "We have not even celebrated our silver wedding in 1963, or our golden wedding in 1988." Marie-Hélène, according to Schwartz, has the seeing eye for geometry, which he himself lacks, even though projective geometry was his first love. Her mathematical vision complemented his, and her strength of character reinforced his. His interests turned to analysis and probability. His great uncle Jacques Hadamard was a great inspiration, also Paul Lévy. Both of them lived to see his own work on distributions crowned with the award of a Fields Medal in 1950.

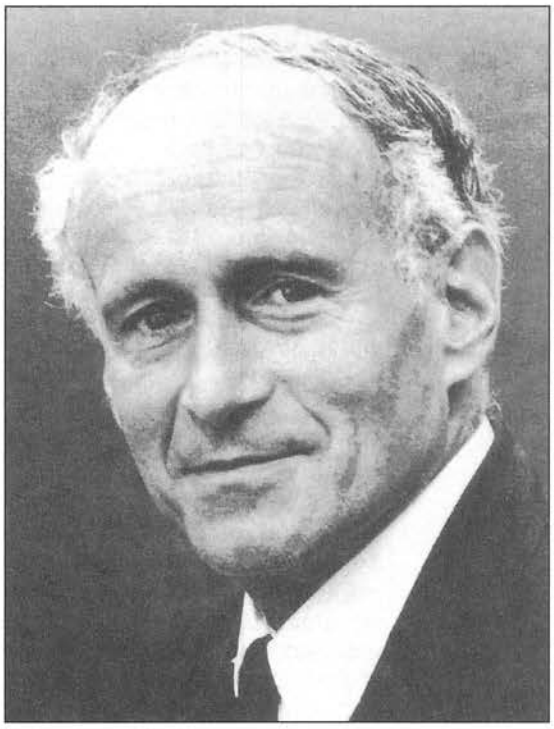
The years spent at the ENS were not only decisive for his mathematical career (as well as his wife's) but also for his political involvement. By instinct an internationalist and anticolonialist, his deep and extensive study of economic geography and political literature led him to the conviction that the policy of "nonintervention" (1936–38) practised in France by Leon Blum's government in the face of Hitler's rise to power in Germany, Stalin's purges, and the Spanish civil war was totally ineffective, if not extremely dangerous, and that the benefits of colonialism were far outweighed by the exploitation of peoples. He decided to seek some answer in Trotskyist theory. It took him a while (1931–47) to conclude that Trotskyism was divorced from reality, and he has remained independent of any political party ever since (except for a few years in the sixties when he belonged to the PSU, Parti Socialiste Unifié, as a secondary activity). The chapter on his years as a Trotskyist, written with the advantage of hindsight, goes to the heart of his political credo—his nonviolent approach, his moral commitment, his resolute will to oppose oppression, his desire to serve humanity, above all his intellectual honesty. (Aung San Suu Kyi, asked recently what "political integrity" meant to her, replied, "Just plain honesty in politics.") Gandhi would have welcomed his affirmation that "the end not only does not justify the means, but the means are an intrinsic part of the end, which they ineluctably influence."

Soon after leaving the ENS, with an excellent record, Schwartz decided to do his (obligatory) military service of two years (1937–39) as an officer, followed by a third year of active service (1939–40) during the war; thereafter he remained an officer in the reserves. His lecturing skill, later to become legendary, was already in evidence during the service and helped him avert getting into scrapes; so was his capacity for decision making. These years witnessed the unrelenting march of tragic events: the annexation of Austria (1938), the Munich pact (30 September 1938), the occupation of Czechoslovakia (March 1939), the Nazi-Soviet pact (August 1939), the victory of Franco in Spain (1939), the German (and Soviet) invasion of Poland leading to World War II (September 1939). Following France's defeat by the Germans, Vichy became (July 1940) the seat of government of the capitulationist French regime headed by Marshal Petain, which administered the southern, unoccupied half of France. Demobilised in August 1940, Schwartz went to Toulouse, where his parents were staying. His father, who was a reserve colonel in the medical service, was working, on a voluntary basis, as a surgeon in a hospital. Schwartz applied for, and obtained, a membership in the Caisse National des Sciences (the future CNRS) till the end of 1942. A stipend from the ARS (Aid à la Recherche Scientifique), founded by Michelin, kept him going from 1943 until the end of the war. Chance intervened to rescue him from the scientific desert in Toulouse in which he found himself. Henri Cartan happened to go to Toulouse to conduct the orals for admission to the ENS. Marie-Hélène, who was in need of advice about how to resume her work (after a three-year interruption, 1935–38), took the initiative to meet Cartan, who advised them strongly to move to the University of Clermont-Ferrand, which had a faculty of its own, combined with that of the University of Strasbourg, which had been withdrawn (from Strasbourg) and posted there. The change proved highly beneficial. It was at Clermont that Schwartz had his first encounter with André Weil and (the mathematical collective) Bourbaki, stimulating enough to let him finish his doctoral thesis in two years

(by January 1943, with the translated title *Real Exponential Sums*).

While his research progressed, the flames of war spread worldwide and brought new dangers ever closer. Hitler failed to subdue Britain with his air attacks on London (September 1940) and invaded the Soviet Union (June 1941). Japan declared war against the U.S. and U.K. (December 1941). The Germans occupied the whole of France (November 1942). His physical frailty precluded Schwartz from joining the Resistance movement. He risked deportation as a Trotskyist; being of Jewish origin (though an avowed atheist) added to the peril. In March 1943 Marie-Hélène gave birth to a son, Marc-André, and the young family was in multiple jeopardy. The ineffectiveness of the Trotskyist party filled him with frustration: "Trotskyism gave me, during my years at the ENS, a remarkable education, clearly more advanced and sophisticated than that of most youngsters of my age. But by the extremism and sectarianism of its ideas, and by its stereotyped language, it neutralised me during the occupation." Some in the Trotskyist party were engaged in converting German soldiers into anti-Nazis, even Trotskyites. Most of them were arrested and deported. "My judgment remains extremely severe on my own actions as well as those of the majority of the Trotskyist party during that period."

It was not just a question of personal frustration, but one of life and death. Two of his contemporaries working for their doctorates at Clermont were Feldbau, a student of Ehresmann, and Gorny, a Polish refugee working with Mandelbrojt. Feldbau was deported to Auschwitz (November 1943), and Gorny to Drancy, never to reappear. A leading article from the *Times* of London (3 November 1997) recalls: "From Drancy 76,000 Jews were deported between 1942 and 1944, rounded up by the French police acting on the orders of the Vichy government. At the war's end, 2,600 returned. Many more French, including clergy, sheltered Jews than did so in other Nazi-occupied countries." The crimes of the Nazis and of the Vichy regime became palpable realities. Deportations and disappearances increased even as military defeat stared them in the face (Stalingrad, February 1943; North Africa). The extermination of European Jewry seemed to have become Hitler's principal aim; that of the Allies was his destruction. They never allowed themselves to be preoccupied by what now seems to be the genocide that was being perpetrated (and they are still undergoing atonement). Schwartz always entertained the idea that it would be very useful to create a Jewish army, partly recruited in Israel, with a massive stock of weapons, to show the German soldiers what it would be like to fight against a race that they misrepresented as inferior and submissive, which could have tipped the balance psychologically. But he well knew that a good many geopolitical reasons operated against the idea. It becomes clear in retrospect that the Allies could have acted to halt the deportations, at the minimum, but failed to do so. How he had to adopt a false identity (Laurent-Marie Sélimartin, a high society Protestant name, instead of Laurent-Moïse Schwartz, and Marie-Hélène Lengé) and cover his tracks well enough to escape detection seems *now* like the stuff of fiction, but the anguish and the danger present at the time could have broken the spirit of any person who did not have the clear-headedness, courage, and presence of mind that Schwartz possessed, and the sheer luck that came his way. His good humour, adaptability, and his capacity to welcome with a smile the smaller pleasures of life kept him sane and relatively safe, with some hairbreadth escapes, near St. Pierre-de-Paladru, a little hamlet north of Grenoble (in the Italian occupied zone). He plainly and tellingly describes the texture of his daily life during those years of personal peril: the rooms one lived in, the food one ate, often with an air of detachment, as if one was describing someone else. Celebrities appear, but it is the vignettes of the uncelebrated (like Mme. Martha Carus, the restauratrice at Paladru) which stick in the memory. (She is now eighty-eight, and her daughter, who once got a few piano lessons from Schwartz, is now a professor of music). It is the ordinary occurrences of life where the distinctive features of character and psychology emerge most clearly that catch attention. A police superintendent who questioned Marie-Hélène about their suspected contacts with Trotskyists concludes with the comment: "You Alsatians, you are like us Corsicans, we are patriots."



Photograph on cover of autobiography, courtesy of Laurent Schwartz.

Laurent Schwartz

It is an extraordinary instance of cerebral percolation that, after such a trying period entirely taken up with problems of survival rather than mathematics, Schwartz should have come up with his idea of distributions (in 1944–45, just as the war was ending and normality returning, while

still carrying his false identity), which, in one go, cleared up the mystery of the Heaviside "function" (1893), renamed Dirac's "delta function" (1926), and opened the way to the theory of Fourier transforms of (tempered) distributions, which has proved so fruitful in the study of partial differential equations, exemplified by his own work, that of his distinguished pupils, and notably that of Lars Hörmander (Fields Medal, 1962). Schwartz's idea has all the simplicity and inevitableness one associates with work of the highest class. His chapter on the "Invention of Distributions" is an example of his extraordinary skill in the presentation of mathematics; it is also a model of fairmindedness in its coverage of the work of his predecessors, contemporaries, and students. Particularly touching is his reference to Georges de Rham and *his* theory of "currents" (p. 240). According to the citation for his Fields Medal, Schwartz has "clearly seen, and been able to shape, the new ideas in their purity and generality," adapted to the needs of further research. Bourbaki's influence on the process of percolation clearly is a moot point. Scattered throughout are his remarks, with concrete examples, on the nature of research, its joys and sorrows, its zigzag turns and deviations, the partial successes followed by the sudden illuminations. If cast on a desert island, Schwartz would like not only to do research but to teach.

After a one-year appointment in Grenoble (fall 1944), Schwartz joined the Faculty of Science at Nancy (fall 1945), on the initiative of Delsarte and Dieudonné, and stayed there for seven very fruitful years, fruitful both in research and teaching, attracting such brilliant students as B. Malgrange, J.-L. Lions, F. Bruhat, and A. Grothendieck, who in their turn have enriched mathematics in unforeseen ways. Politics still had its claim on his time, as evidenced by his unsuccessful candidacy as a Trotskyist in the French legislative elections in 1945 from Grenoble and in 1946 from Nancy. But his mathematical achievement attracted international attention, beginning with Harald Bohr's invitation for him to visit Copenhagen in October 1947 to give a series of lectures on his work. It was Bohr who was to present him with a Fields Medal three years later at the International Congress of Mathematicians at Harvard (1950). He was one of the four invited speakers (along with Dirac, Zygmund, and Bhabha) at the First Canadian Mathematical Congress (of a month's duration) in Vancouver in 1949. Notes of his lectures in English received wide circulation. His two volumes entitled *Théorie des distributions* were published in 1950–51.

Although he bade goodbye to Trotskyism in 1947, it clung to him like a limpet when he was to go to Harvard (August 1950) to receive the Fields Medal. The Trotskyist party was listed as a "prohibited" organization by the U.S. Government, and members were precluded by law from entering the U.S. unless a waiver was granted by the U.S. State Department. In response to pressure from his hosts, a waiver was indeed granted at the last minute, though his movements within the U.S. were sought to be restricted. It was the time of the Korean War, with McCarthyism at its peak in the U.S. He went to Berkeley in 1960 for two months, again with a waiver. The denial of easy entry to the U.S. (until 1962–63, when he spent a sabbatical year at New York University) meant a gain to other countries anxious to have him, such as India, Brazil, Mexico. His visits to India gave an impetus of inestimable value to the development of mathematical research in that country and brought lasting benefit.

On Denjoy's initiative he moved from Nancy to the Sorbonne in 1952, and in 1958 he became a professor at the École Polytechnique (EP) as well. With tremendous energy, clarity of vision, and skill in handling human relations, he brought about fundamental reforms in such a classic and staid institution as the EP by modernizing its programme for the training of engineers and by making it a flourishing centre of mathematical research in its broadest sense. His achievement was acknowledged by the French public and by successive French governments when he was appointed president of the National Committee for the Evaluation of French Universities (1985–89).

His rise to fame as a mathematician on the international stage and his thumping success as a reformer of the EP on the national stage did not by any means diminish his political commitment. As a confirmed anticolonialist, he was a keen observer of political developments that led to the decolonisation of Vietnam (Geneva Agreement, 1954), Tunisia, and Morocco (1956), made possible by the statesmanship of Pierre Mendes-France. Algeria presented a special problem, because (around 1960) it had a French population of a million living alongside nine million Algerians. Schwartz was appalled by the cycle of terrorism and repression which developed there, and the widespread use of torture posed a challenge to his deeply held beliefs. While he sympathised with the goal of self-determination, he kept his distance from the nationalist movement. Matters came to a head in an unexpected fashion, and he was inexorably drawn into the political vortex. Maurice Audin, a graduate student from Algeria, who was to have completed his doctoral thesis in Paris under his supervision, was suddenly arrested (11 June 1957) in Algeria and disappeared. Audin was French, not a Muslim, but a communist. It turned out that he had been tortured and murdered at the hands of the forces of law and order (on 21 June). There was no official response to numerous inquiries. This cut Schwartz to the quick, outraged his sense of justice, and triggered his determination to galvanize public opin-

ion against the practice of torture, and especially against the abuse of the special powers invoked by the government for the use of third-degree methods to put down the rebels in Algeria. Schwartz focussed on the case of Audin (as Gandhi did on the salt tax), founded the Audin Committee (fall 1957) to demand a clarification of the circumstances surrounding his death, arranged for the award of a doctor's degree, in absentia, for Audin's nearly, but not quite, complete thesis (December 1957), and wrote a famous article in *L'Express* on "the revolt of the universities" against the practice of torture by governments. His photograph appeared on the cover, and the article gained the attention and support of a wide public and made him a national political figure. Protests and demonstrations followed. The Algerian War became increasingly unpopular, especially after the failed Anglo-French military expedition to control the Suez canal and the Soviet occupation of Hungary. There was unrest among the youth who were subject to conscription. And in 1960 Schwartz was a signatory of the famous manifesto signed by 121 French intellectuals, including Jean-Paul Sartre and Simone de Beauvoir, which proclaimed solemnly the right of the French youth morally to rebel against the Algerian War. This resulted in his dismissal from his professorship at the EP by the defence minister. Schwartz went to the Administrative Tribunal to challenge the legality of the decision; the Tribunal did find it illegal, but on the technical ground that he had not been given the opportunity to see the file containing the grounds for action. The minister appealed, this time showed him the file, and repeated the dismissal. Schwartz went on appeal to the Council of State on the ground that the file had, in fact, been empty. While the case was pending, it proved difficult to find a successor, except on a stop-gap basis, for one year at a time, because of the solidarity of the professors in confronting the authorities on the question of academic freedom without political shackles. Schwartz left to spend the year 1962–63 in New York University. A compromise was reached out of court with the minister, according to which he would be reinstated if he reapplied for the post, which he did in 1963–64.

Meanwhile, beginning in 1961, bombings with plastic explosives organized by extreme right-wing elements began to take place near the apartments of those fighting against torture. Roger Godement's apartment came under attack; so did Sartre's, and Kastler's, and several others; there was one in the garden opposite Schwartz's fifth-floor apartment. Clearly present was also the threat of assassination; an armed policeman in mufti was assigned by the government for the protection of Schwartz's family. Nevertheless, (in February 1962) his son, Marc-André, was kidnapped, held in a forest for two nights, and then released. Interested parties tried to make a mystery out of this tragic episode, but such machinations were countered in a famous article by Alfred Kastler in *Le Monde* in which he warned the public against being taken in. This horrible experience obviously took a heavy emotional toll of Marc-André, for even as he was recognized as a writer of talent for his novel *L'Automne* (1970), he developed a psychosis of suicide and ended his life (21 March 1971)—a terrible blow to his family and friends, who had always known him as a bright, alert, jolly child, with his collection of butterflies, his understanding of science, and his bent for poetry. The suicide of a son touches many hearts. The view of life expressed by Ted Hughes (now England's Poet Laureate) in the context of (his wife) Sylvia Plath's suicide (herself a poet) comes to mind: "Human beings have always been dwarfed by the elemental power-circuit of the universe." During those troubled times the Schwartz Seminar at the university very kindly was conducted for a year by Bernard Malgrange. Nobody forgets a good teacher, they say. Even after the Evian Agreement (March 1962), which brought about a ceasefire in Algeria, Schwartz had occasion to protest against torture practised by those who took over power, and he is aghast at the political catastrophe now facing that country. But one cannot rewrite history.

Schwartz's political activity reached a crescendo during the Vietnam War. The longest chapter of his autobiography deals with Vietnam's struggle for independence and his own part in it, a worthy and honourable part, "more than a drop in the ocean." He meticulously describes that struggle, beginning with the civil war between Vietnamese nationalists led by Ho Chi Minh (the "Viet Minh") and the French, which ended with the Geneva Agreement (April–July 1954) concluded by Pierre Mendes-France. That Agreement provided for the recognition of North Vietnam (north of the 17th parallel) and South Vietnam, with free elections to be held, within two years, under the supervision of an International Control Commission (Canada, Poland, India), for a unified Vietnam. The Agreement was never fully implemented by the South, which was backed by the U.S. against the communist North. When military pressure from the North increased, the civilian regime in the South was ousted by a military coup (1963) backed by the U.S. On the excuse that the North Vietnamese had attacked the U.S. Navy, American Marines landed there, and the U.S. Air Force began bombing raids on North Vietnam. As the bombings reached ever new heights of ferocity, causing immense destruction and enormous suffering of the civilian population, Schwartz founded, along with Sartre, Kastler, Vidal-Naquet, and Bartoli, a National Committee for Vietnam (NCV) to rouse public opinion to protest against the undeclared, heinous war with its appalling brutalities (1966). Schwartz was also a member of the Russell Tribunal, which was set up by the

Bertrand Russell Foundation to act as an international jury (without a judge) to hear and examine evidence of indiscriminate attacks against civilian targets, like churches, schools, hospitals, and dikes, and the effect of the use of napalm, defoliants, phosphorous and antipersonnel bombs on the civilian population, especially children. The Tribunal heard the evidence provided by observers whom it had sent to Vietnam for a first-hand investigation of the facts. The crucial question before the Tribunal was whether genocide had taken place in Vietnam, and its unanimous answer was yes. Schwartz says he is still bothered by that answer, though the assembled evidence was appalling. The work of the Tribunal received worldwide publicity, not necessarily always followed by approval.

Soon after the sittings of the Russell Tribunal, Schwartz received an invitation to visit North Vietnam for three weeks. Towards the end of August 1968, he went to Hanoi via Pnom Penh (a few days after the Soviet invasion of Czechoslovakia). "My window gave on to a lake, unveiling a part of Hanoi. Like some graceful shadows, beautiful Vietnamese girls in black silk dresses rode past on bicycles." He had meetings with the prime minister, Pham Van Dong, lasting three hours, and talked also to Ho Chi Minh for about an hour (which, according to American diplomats, was rare). The message he got was that Vietnam would concentrate on winning the war and would make no concessions and that negotiations should be concerned only with the cessation of all bombing everywhere. Though few at home believed the message that he had brought back from Hanoi, events have vindicated Ho Chi Minh. Schwartz did not fail to convey to his hosts his disapproval of their nonobservance of the Geneva Convention on prisoners of war, since they never gave the names of prisoners, nor reported on their condition, nor allowed any access to them. Seemingly as a recompense, they arranged for him to meet and talk to an American pilot who had been shot down and taken prisoner. His family was pleased to get news of him from Schwartz. He says of his first visit: "That trip has left an indelible impression on me because of its diversity and intensity. I became forever closely linked to Vietnam. I have since returned there several times, but for purely scientific reasons, at the invitation of the École Polytechnique in Hanoi, or the Ministry of Higher Education and Training." Even on his later visits (1976, '79, '84, '90) he continued to intervene with the Vietnamese authorities on behalf of dissidents.

President Johnson, who had announced in March 1968 that he would not seek reelection, halted the bombing of the North in October 1968. His successor, Nixon, expanded U. S. involvement in Vietnam by secretly invading Cambodia and renewing large-scale bombing of major North Vietnamese cities (1970). But the Viet Cong rebels continued to gain in the South, and the North Vietnamese succeeded in shooting down American high-altitude bombers (34 in all, or so). A shaky ceasefire was reached in 1973. But Nixon had to resign in 1974, and in 1975 the war ended, as Saigon fell, and the South surrendered to communist North Vietnam. A unified Vietnam finally emerged. Schwartz concludes: "Vietnam has left its mark on my life. I knew about colonial Indo-China from the book of André Viollis, written in 1931, which I read sixty years ago, when I was twenty. My fight for the freedom of that country is the longest in my life. I have been, and shall always be, fond of Vietnam, its landscape, its extraordinary people, and its bicycles. I am something of a Vietnamese. When I run into a Vietnamese, or hear Vietnamese spoken in a bus, I feel inexplicably happy, even though I do not know the language. My sentimental chord vibrates for that country. Many on the left share those feelings. The Vietnamese, moreover, don't forget about me, and numerous students from there write to me, calling me 'godfather of all the Vietnamese'. Sartre also had a right to the title, but I do not believe he would have remained still attached to Vietnam as I am."

The Soviet invasion of Afghanistan, a nonaligned, developing country, in December 1979 led to the creation in Paris of an International Bureau for Afghanistan (IBA), of which Schwartz was president. "For reasons of notoriety I was, more or less, the only possible choice." The purpose of the Bureau was "to defend the independence of Afghanistan against Soviet aggression, without having any illusions about the future of the country after the war." The Bureau's work was supported by the European Parliament, the French Ministry of External Affairs, many Western countries, and Japan. The massacres, executions, and tortures that were taking place in that (culturally) remote country were exposed and condemned by the Bureau, and the resulting publicity strengthened, in some measure, the resistance which began to build up, especially in the countryside and in the mountains, with the generous supply of arms and equipment by the United States. Soviet troops had finally to withdraw in February 1989. In a country of twenty million people, one million were dead, and six million were refugees. Schwartz considers this invasion a major historical event of the last quarter of the twentieth century, inasmuch as it brought in its wake the collapse of the Soviet Union. In his view it is Soviet repression which has engendered the civil wars that still rage in Afghanistan. He will not hazard a guess about its future. Interesting is the fact that this was academically the busiest period for him. He collaborated in producing a volume of 570 pages with the translated title *Education and Scientific Development in France* (1981); he was chairing (1985–89)

the Board for the Evaluation of French Universities and was working regular hours in his office four days a week while doing mathematics at home the rest of the time; published seven research articles; and wrote a report on the University of Strasbourg. The style is the man.

The withdrawal of Soviet forces from Afghanistan did not diminish Schwartz's concern for the repression of individuals, particularly mathematicians, in the Soviet Union. The consignment of Leonid Pliousch to a psychiatric clinic on the spurious grounds that he was psychologically disturbed was a blatant attempt to break his will as a dissident, and it redounds to the credit of Laurent Schwartz, Henri Cartan, and Marcel Broué—the Committee of Mathematicians—that they mustered the support of a wide circle of leading mathematicians internationally to press for his release. He was arrested in January 1972 and was finally allowed to leave the country in 1976. Youri Chikanovitch, who had translated a Bourbaki volume into Russian, was another such case: arrested in September 1972 and, after public agitation, released in February 1974. The Committee's efforts extended also to mathematicians in other countries; for example, Sion Assidon in Morocco, Vaclav Benda in Czechoslovakia, Jose Luis Massera in Uruguay. Well may Schwartz conclude with the words: "Mathematicians carry the rigour of scientific reasoning into everyday life. Mathematical discovery is subversive, and is ever ready to break taboos, and depends very little on established authorities. Many today tend to consider scientists, whether mathematicians or not, as people little concerned with moral standards, harmful, shut up within their ivory tower, and indifferent to the world outside. The Committee of Mathematicians is a brilliant illustration of the contrary."

Laurent Schwartz is a strategist of ideas, within mathematics and without. He is a great communicator who has drawn huge audiences and conveyed to them the fragrance of research, or the joy of teaching, or the value of freedom. His is a mind whose company is never dull. He belongs to the great libertarian tradition of France. And his book has the very French characteristic of giving serious consideration to the life of the intellect. No man's life can be encompassed in one telling, yet the spirit of the man and his times is well caught in the *Autobiography*.

Alberto Pedro Calderón (1920–1998)

Michael Christ, Carlos E. Kenig, Cora Sadosky, and Guido Weiss

Alberto Pedro Calderón, who died April 16, 1998, was one of this century's leading mathematicians. His work (mainly in the field of mathematical analysis) was characterized by its tremendous originality and depth and its remarkable power. His contributions have been of extremely wide scope and have changed the way researchers approach, and think of, a wide variety of areas in both pure mathematics and its applications to science. His fundamental influence is felt strongly in abstract fields, such as harmonic analysis, partial differential equations, complex analysis, and geometry, as well as in more concrete areas, such as signal processing, geophysics, and tomography.

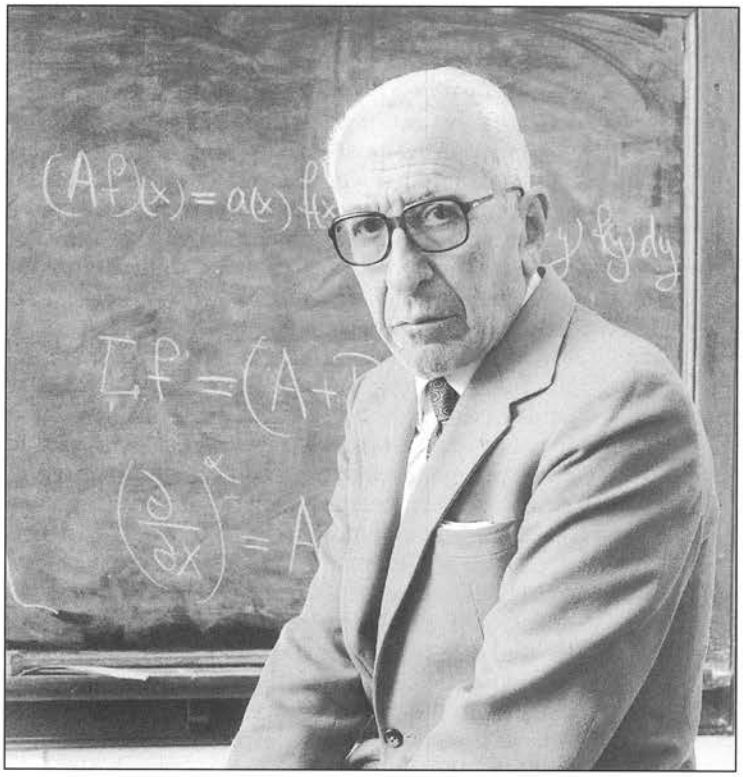
Calderón was born in Mendoza, Argentina, on September 14, 1920. He received his early education there and in Switzerland. His initial professional training was as a civil engineer at the University of Buenos Aires (graduated 1947), and he worked as an engineer for a few years. He simultaneously nurtured his passion for mathematics, partly under the guidance of Dr. Alberto Gonzalez Dominguez. Two events changed his future: His supervisor at YPF (the state-owned petroleum company) made his life very difficult, and around the same time, Antoni Zygmund, one of the world's leading mathematical analysts of the time and a professor at the University of Chicago, visited Argentina in 1948 at the invitation of Dr. Gonzalez Dominguez. Zygmund immediately recognized Calderón's brilliance, and he invited Calderón to come to Chicago to work with him. Calderón arrived in Chicago in 1949, as a Rockefeller Fellow, and by 1950 he had obtained his Ph.D. in mathematics under Zygmund's supervision. Calderón's dissertation was marvelous. In it he solved three separate and longstanding problems. From this point on, Calderón and Zygmund started one of the most successful collaborations in mathematical history. Together they created the modern theory of singular integrals, which has had enormous consequences for many areas of mathematics. They developed what has become known as the "Chicago school of analysis", one of the most influential forces in pure mathematics, which has also had a great impact on applications to science and engineering. Calderón went on to apply systematically the theory of singular integrals (and the important refinements that he obtained) to the study of partial differential equations. Calderón's contributions to their study have completely changed the landscape of that field. He not only solved fundamental specific problems but, in addition, developed a host of techniques that are now basic to the subject. Among his influential achievements were works on the boundary behavior of harmonic functions, ergodic theory, the Calderon-Zygmund decomposition, the real-variable theory of singular integral operators, complex interpolation, uniqueness in the Cauchy problem, boundary value problems for elliptic equations, commutators of operators having minimally regular coefficients, L^2 boundedness of pseudodifferential operators, real variable Hardy space theory, the Cauchy integral, and an inverse boundary problem in electrical prospection.

The biographical segment is adapted from an article written by Carlos Kenig for the British newspaper The Independent *(April 27, 1998).*

Besides his remarkable research accomplishments, Calderón was also a gifted teacher. During his career he taught at Ohio State University, MIT, the University of Buenos Aires, and the University of Chicago. He had many Ph.D. students, both in the U.S. and in Argentina. In Argentina he also served for several years as director of the Instituto Argentino de Matematica (IAM).

Calderón was recognized all over the world for his outstanding contributions to mathematics. He was a member of the National Academy of Sciences of the U.S., Argentina, Spain, and France; of the Latin American Academy of Sciences; of the Academy of Sciences of the Third World; and of the American Academy of Arts and Sciences. He received honorary doctorates from the University of Buenos Aires, the Technion (Israel), the Ohio State University, and the Universidad Autonoma de Madrid. He gave many invited addresses to universities and to learned societies, and he was awarded many prizes. Among these are the Bôcher Prize (1979) and the Steele Prize (1989) from the American Mathematical Society, and the Wolf Prize in Mathematics (1989) from Israel. In 1992 President Bush awarded him the National Medal of Science, the U.S.'s highest award for scientific achievement.

—*Carlos E. Kenig*



Photograph courtesy of the University of Chicago.

Alberto P. Calderón, September 1991.

Michael Christ

On a warm Chicago afternoon in the late summer of 1977 a class of new graduate students awaited their first lecture on real analysis. With naive curiosity I awaited the appearance of Professor Zygmund, author of the fattest mathematics book I had yet encountered. Instead, a distinguished-looking gentleman entered and quietly announced, "I am Alberto Calderón," substituting for Zygmund. The simple greeting still resonates in memory; its tone was not that of a teacher addressing a class, but of a man addressing colleagues.

Later, having demonstrated a disinclination towards algebra and disintuition towards geometry, I gravitated towards analysis and was urged by R. Fefferman to attend Professor Calderón's lectures. These treated primarily his own work: complex interpolation, the Cauchy integral, the commutators, the real variable theory of parabolic Hardy spaces, boundary value problems for elliptic PDE, algebras of pseudodifferential/singular integral operators with low regularity coefficients. Related work of others, such as R. Coifman and Y. Meyer, was also presented. Theorems and full details of proofs were given, with only occasional motivation and no editorializing. While Calderón was both architect and bricklayer, his lectures emphasized the bricks. The pace was decidedly slow; the thoughts of a young student wandered.

Rarely had he visible lecture notes. During one memorable long stretch the notes consisted solely of his four-page paper on the Cauchy integral, carried in an inside coat pocket and seldom consulted. The lectures were clear yet unpolished, with occasional retreats and emendations. Once in a great while the argument would founder. An irked but calm Calderón, along with the audience, would seek to bridge the gap. When one such breakdown led to a spirited discussion among Calderón, W. Beckner, and P. W. Jones, I finally understood: the lectures were planned in barest outline. Calderón was rethinking the theorems on the blackboard before us; we were expected to think along with him. Much later he confirmed this, explaining that meticulous preparation early in his career had produced lectures too rapid for his audience; he had resolved to be understood despite the occasional blow to his pride.

Those were glorious days for analysis in Chicago. Calderón's magnetism had attracted a remarkable group of young visitors, postdocs, and junior faculty, including Beckner, R. Fefferman, D. Geller, S. Janson, D. Jerison, Jones, R. Latter, P. Tomas, A. Uchiyama, D. Ullrich, M. Wilson, and T. Wolff. There were exciting lectures by Coifman, C. Fefferman, J. Garnett, Meyer, J. J. Kohn, and others and a lecture course by Zygmund. Spectacular developments included the decisive work of Coifman,

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A. McIntosh, and Meyer on the Cauchy integral; the arrival of a photocopied letter from A. B. Aleksandrov on inner functions; Uchiyama's constructive decomposition of BMO; G. David's dissertation; and the work of S. Bell and E. Ligocka on biholomorphic mappings. Calderón rarely spoke out in seminars, but in private conversation afterwards he sometimes revealed thoughts which went well beyond the lecture.

After auditioning in an oral examination, I asked for a dissertation problem. Calderón suggested the boundedness of the Cauchy integral on Lipschitz curves of large constant—long the main focus of his own research. While I half-listened in shock, he generously shared an idea for a line of attack, offered encouragement, and promised an alternative problem if I made no headway, as indeed I did not. The shock was unwarranted, for this merely illustrated both the attitude of genuine respect with which Professor Calderón invariably treated others and his concentration on the most fundamental problems. To me he later mentioned two other potential research topics: the restriction of the Fourier transform to curved submanifolds of $\mathbf{R}^n$, and L^p estimates for solutions of subelliptic partial differential equations. Today both remain major, fundamental open problems, despite the fascinating results obtained by many investigators.

Calderón's high standards for himself prevented some of his work from ever seeing the light of day. He once asked about the $\bar{\partial}$-Neumann problem, explaining that he had obtained results different from those he had found in the literature. His influential paper on an inverse boundary problem in electrostatics apparently languished for decades before finally being published.

Calderón rarely offered advice. Perhaps he considered it a presumption, feeling that others should be left free to attack problems on their own terms, just as he himself wished to be. Once, unable to supply even a single background reference for a problem he suggested, he apologetically explained that studying the literature could be confining; he felt more likely to find original ideas by working independently in complete freedom.

Despite his rigorous personal standards, Professor Calderón encouraged a young student struggling to find himself. After suggesting a problem and offering an initial suggestion, he allowed me to work in complete independence, but was genuinely pleased to hear reports of even minor progress. A long and sometimes chaotic presentation of a dissertation was endured with unflagging courtesy.

I was too overawed and too naturally reticent to glean more than rare glimpses of his personal life. Introducing his son, Pablo, he glowed with simple pride. The death of his first wife was, in his words, a terrible blow; for a time it was difficult to continue to work. Years later, resurrected in the company of Alexandra Bellow, Calderón was relaxed and full of good humor.

In his lectures Professor Calderón taught one to work with the bricks and mortar and to appreciate their beauty. But in his quiet way, by example through his own life, he taught deeper lessons.

Carlos E. Kenig

I was one of Alberto Calderón's graduate students at the University of Chicago from 1975 to 1978. This was a period of intense mathematical activity. During the 1976 Christmas break Calderón obtained his remarkable result on the boundedness of the Cauchy integral for Lipschitz curves with small constant. (The general case was obtained by Coifman-McIntosh-Meyer in 1981.) As soon as classes started in the winter quarter, I went to see Calderón in his office, where he was explaining his proof to Bill Beckner. There was real excitement in the air, which even I, a mere graduate student, could feel. Soon after, the annual meeting of the AMS took place in St. Louis in the midst of a terrifying cold spell and a terrible winter storm. In connection with the AMS meeting there was a conference in harmonic analysis at Washington University, the very first conference I attended. At this conference Calderón explained his proof with his usual elegance. One could also sense his pleasure in having finally made a dent in this problem, which he had thought about for so long. This work opened up entire new vistas of research, which are still being explored.

Shortly after our return from St. Louis, I asked Calderón for a thesis problem. His response was this: Find a problem yourself, and let's discuss it afterwards. Fortunately for me, the recent work on the Cauchy integral had opened up many new possibilities. I chose to explore the theory of Hardy spaces on Lipschitz domains and went on to obtain my degree in 1978.

Calderón was a mathematician of deep and original insights and also of great generosity with both his ideas and his time. I count myself as extremely fortunate to have been his student, especially at such a highly significant moment—an experience that greatly influenced much of my ensuing research.

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Cora Sadosky

Professor Antoni Zygmund visited Buenos Aires twice, in 1948 and in 1959. The first visit, when he met Calderón, shaped the development of real analysis for the following fifty years; the second one shaped my life. In 1948 Zygmund and Calderón started what was to become one of the most influential partnerships in mathematical analysis. Ten years later Zygmund returned to Argentina to help build a mathematical school in a land where he knew mathematical talent flourished. Calderón also started to make periodic visits to the University of Buenos Aires, where I was then an undergraduate. It was at that time that I became one of the first students of both Calderón and Zygmund. Two years later I arrived at the University of Chicago to pursue a doctorate, with Calderón as dissertation advisor and under the close supervision of Professor Zygmund.

What a privilege it was! Although I had missed Calderón's seminal course on singular integrals and its applications to hyperbolic PDE in Buenos Aires, by the time I arrived in Chicago I had already been the sole beneficiary of a course on his new theory of interpolation of operators, later published in *Studia Mathematica*. The final articles were difficult and dense, but his lectures and the notes I took from his course were crystalline. The extraordinary opportunity of discussing ideas in the making with such a profoundly original mathematician was a unique gift. At the time I did not understand, and therefore failed to appreciate fully, how unusual Calderón's openness was, and I marvel now in retrospect. I think this was one of his most remarkable traits of character: he would talk mathematics openly, sharing freely all of his thoughts, ideas, and insights.

During my years at Chicago we had long mathematical talks. Unfortunately I was too stubborn and inexperienced to pay as much attention as I should have. For instance, when Atiyah and Singer proved the index theorem, Calderón was quite excited, but told me he did not grasp the proof. His usual way to grasp a proof was to work another one for himself, so he told me he was interrupting research to study algebraic topology and advised me to join him. I did not, giving priority to my exams and losing a great opportunity to study alongside him. After a few months he announced happily that he could resume work, having understood the index theorem!

When I started on my thesis project, I met weekly with Professor Zygmund to report on my work, but I also talked with Calderón almost daily on our way home from Eckhart Hall. Many a time I was invited to stay at his home for dinner, and while I helped his wife, Mabel, to set the table, he played the piano. We shared a delight in Mozart, and after dinner sometimes he played some more for me. Other times I joined his children, Pachita and Pablo, in the basement to watch Calderón work very seriously with a large setup of electric trains he had given Pablo. He was an eager engineer and became totally absorbed in the task of constructing and managing the intricate model railway.

I was not tempted by the dissertation problem proposed by my great teachers (quite foolish of me, since it was interesting enough to be developed by themselves later) because I was obsessed with parabolic singular integrals, which seemed the natural object to study after Calderón's success with elliptic and hyperbolic PDEs. Calderón encouraged me in that interest, and, as the problem was in the air, very soon afterwards a first paper on the subject appeared by B. Frank Jones. This did not discourage me, since I came up with a notion of principal value for the integral through a nonisotropic distance, an idea which Calderón thought was "the right one". In 1963–64 he left Chicago for a sabbatical year, partly spent in Argentina, and I joined him for a three-month period at the Instituto Balseiro in Bariloche. I completed there the research for my thesis, while in the evenings Calderón, his lifelong friend Alberto Gonzalez Dominguez, and

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Ph.D. Students of Alberto Calderón

Robert T. Seeley, MIT (1958)
Irwin S. Bernstein, MIT (1959)
I. Norman Katz, MIT (1959)
Jerome H. Neuwirth, MIT (1959)
Earl Robert Berkson, Chicago (1960)
Evelio Oklander, Chicago (1964)
Cora S. Sadosky, Chicago (1965)
Stephen Vagi, Chicago (1965)
Umberto Neri, Chicago (1966)
John C. Polking, Chicago (1966)
Nestor Marcelo Rivière, Chicago (1966)
Carlos Segovia-Fernandez, Chicago (1967)
Miguel S. J. de Guzman, Chicago (1968)
Daniel Fife, Chicago (1968)
Alberto Torchinsky, Chicago (1971)
Keith W. Powls, Chicago (1972)
Josefina Dolores Alvarez Alonso, Buenos Aires (1976)
Telma Caputti, Buenos Aires (1976)
Robert Richard Reitano, MIT (1976)
Carlos E. Kenig, Chicago (1978)
Angel Bartolome Gatto, Buenos Aires (1979)
Cristian Enrique Gutierrez, Buenos Aires (1979)
Kent G. Merryfield, Chicago (1980)
F. Michael Christ, Chicago (1982)
Gerald M. Cohen, Chicago (1982)
Maria Amelia Muschietti, Buenos Aires (1984)
Marta Susana Urciolo, Buenos Aires (1985)

François Treves tried, mostly in vain, to teach me how to play billiards. There, through C-Z correspondence, we found out that Zygmund had assigned one of his students, Eugene Fabes, a problem close to mine and that we had both proved the pointwise convergence of parabolic singular integrals (by different methods)! Panic struck; Calderón defended my priority on the problem, but all was solved amicably, and upon my return Gene and I wrote our first result as a joint paper. Shortly afterwards I defended my thesis and left for Argentina, while Gene started a fruitful collaboration with Nestor Rivière, another Argentine student of Calderón, who had been an eager listener of our first results and who later became key to the development of the subject.

What a happy time that had been! I returned to Buenos Aires, leaving behind an ambience I cherished and some very interesting problems on parabolic maximal functions Calderón had suggested for working together. A loss to me, but not to mathematics, since those problems were successfully solved by Calderón and Alberto Torchinsky, another Argentine student of Calderón, who came to Chicago later. In the meantime, Calderón had directed the thesis of Carlos Segovia, one of the students selected by Zygmund in Buenos Aires, who is now a professor there. While Calderón also had, in later years, several doctoral students in Buenos Aires, the majority of his Argentine students received their Ph.D.s from the University of Chicago. Although both Calderón and Zygmund devoted themselves to strengthening analysis in Argentina and later in Spain, the results of their efforts, due to political and other circumstances, were very different in the two countries. Nowadays only one of Calderón's Argentine students is on the faculty of the University of Buenos Aires.

After graduation I did not hesitate to go back home, since the opportunities for research and teaching in Argentina were good. The flourishing of intellectual life under democracy, however, lasted only one more year. In 1966, after a bloodless military coup, the School of Sciences of the University of Buenos Aires was brutally attacked by the police, four hundred faculty members left, and our scientific dreams were shattered. In the following years tolerance decreased as military repression increased. Unable to find another academic job in Argentina, I was forced out of mathematics for some years, and to return to it I had to leave the country. In the meanwhile, Calderón's family had settled in Buenos Aires, where he stayed for longer periods after the onset of his wife's eventually fatal illness. For several years he was director of the IAM (Argentine Institute of Mathematics). In these years we had hardly any contact.

The circumstances of Argentina changed for the better in the mid-1980s, and we met again in Buenos Aires, but for a time we did not know how to renew our friendship. Then Calderón found a way in the understated mode so typical of him. One day at his IAM office he handed me a cassette, saying, "This is some of the Mozart you used to love when I played it years ago, only better played. I copied it for you." We were friends again. That gave me the joy of sharing some of the wonderful moments of his last years, when he basked in the happiness of being with Alexandra, his second wife.

Alberto Calderón was a very unassuming man of natural charm, a person of great elegance and restraint, and wonderful company. Mathematically Calderón was exceptional not only for the strength of his talent but for his peculiar way of grasping mathematics. He redid whole theories by himself, got to the core of what he wanted to know by himself, found always his own way. His ideas and the methods he developed were always extremely original and powerful. Although he was an individualist to the core, he influenced profoundly the work of others, who developed what is known as the "Calderón program". He shared his knowledge freely with his students, yet did not closely follow their careers. Calderón was modest, sure of himself, and quite indifferent to competition. He was always happy to have been an engineer and conserved a real interest in applications. In one of our last conversations he told me how intrigued he was that his work was perceived to be in the foundation of wavelet theory. I think this pleased Calderón very much.

Guido Weiss

I began my graduate studies in mathematics in the early 1950s and wrote my Ph.D. thesis under the direction of Antoni Zygmund. The graduate program offered by the University of Chicago was excellent. But I really learned most by attending and participating in the legendary "Zygmund seminar". It was there that I learned the various topics in harmonic analysis that formed the basis of what is now known as the "Calderón-Zygmund School". Alberto Calderón had received his Ph.D. at the University of Chicago before I started my studies with Zygmund and had left to join the faculty at Ohio State University and, a short time later, at MIT. I felt his presence at the University of Chicago, however, in practically every session of the Zygmund seminar. He had made important contributions in each topic we discussed: interpolation of operators, potential theory and the boundary behavior of harmonic functions, ergodic theory, and, of course, singular integrals. I was surrounded by not only a remarkable faculty but also by a large number of

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very talented graduate student colleagues who have by now made important contributions in mathematics. I could not help, however, having a feeling of great awe for this individual who was capable of making so many important contributions in such a large number of topics. As I stated above, he was an ever present participant of the Zygmund seminar.

I first met Alberto shortly before I finished my thesis in the mid-1950s. He visited the University of Chicago, and after presenting a beautiful talk on singular integrals and their connection with partial differential equations, Zygmund, the young group that was working with him, and Alberto met in Zygmund's office and discussed various topics in harmonic analysis. I remember vividly the impressions Alberto made on me. He had unique insights and ways of looking into the various subjects we discussed and in a very friendly, open, and generous way shared this knowledge with us. I began to realize what was his main strength: he made special efforts to reduce each concept he considered to clear, simple components, and from this understanding he was able to arrive at methods for solving a problem that often were applicable to many other fields in mathematics. His considerable contributions in analysis are being described elsewhere in these *Notices*; I will not try to give such a description. I do want to emphasize, however, this important feature that is ever present in his research: The methods he discovered often go way beyond the results he obtained. Ideas he used in his study of the interpolation of operators have had an important impact in fields that seem totally different. One of the important equations that characterize wavelets, for example, is really a discrete version of what is known as the "Calderón Reproducing Formula".

Since this first meeting I have had several opportunities to be with Alberto, and on each occasion all the feelings I described above were strengthened. I was asked by the mathematics department of the University of Chicago to give the "Zygmund lectures", and I presented them in March of this year. Recently I became interested in the mathematical theory of wavelets and chose this topic for the three lectures I gave. Alberto attended these lectures and expressed an interest in the subject; in particular, he asked me to send him what I had written. I was very excited at the prospect of establishing an area of common interest with him. I obtained a copy of a book on wavelets I had recently coauthored with Eugenio Hernández and put it together with a collection of papers I thought might interest Alberto, but then I heard the sad news of his passing away. Along with many others, I will miss him very much.

Book Review

Paul Dirac: The Man and His Work

Reviewed by Clifford H. Taubes

Review of Paul Dirac: The Man and His Work
Abraham Pais, Maurice Jacob, David I. Olive, and Michael F. Atiyah
Cambridge University Press, 1998
ISBN 0-521-58382-9
Hardcover, $19.95

This review concerns the book *Paul Dirac: The Man and His Work*, which consists of a collection of four essays on the life and work of Paul Dirac. The book also contains a short address by Stephen Hawking on the occasion of the dedication of a plaque at Westminster Abbey in honor of Dirac. The essayists are Abraham Pais (a physicist and historian of physics), Maurice Jacob (a physicist), David Olive (a mathematical physicist), and Sir Michael Atiyah. Peter Goddard served as the book's editor. The book is short and wonderful.

The essays describe Dirac's influence in both physics and mathematics. The list of Dirac's fundamental ideas is simply stunning. One might ask which physicists of the twentieth century will be remembered in the thirtieth? Surely Dirac and Einstein and perhaps a few more. In any event, Dirac is truly one of the heroes of twentieth-century physics. The essay by Pais consists of a concise biography of Dirac, and so describes Dirac's most profound scientific achievements. Pais's essay is full of charming quotes from and about Dirac, who was an iconoclast, to say the least.

Dirac is most famous for his celebrated differential equation, which revolutionized both physics and mathematics. This equation is simplest in the case where the space in question is the circle parameterized by an angle t between 0 and π. In this context the Dirac equation is defined by the operator

$$D = i\frac{d}{dt}$$

on complex valued functions. In higher dimensions the analogous operator D acts on certain vectors of complex valued functions, the ever mysterious spinors. Here are D's salient features: This operator is first order, it is symmetric, and its square is minus the standard Laplacian. In a Lorentz signature metric, the square is the wave operator.

In physics the operator D was used by Dirac to predict the behavior of relativistic electrons, and it led directly to Dirac's prediction of the existence of antiparticles. (I will explain this below.) These days the Dirac operator and the notion of an antiparticle are fundamental to physics's description of all elementary, spin 1/2 particles. Thus, Dirac's equation profoundly changed humanity's view of physical reality. Jacob's essay describes the influence in modern physics of Dirac's equation and his ideas about antiparticles.

In mathematics Dirac's operator lies at the very heart of a great deal of late twentieth-century geometry; moreover, it still regularly delivers profound surprises (as this writer can avidly attest). And the Dirac operator promises to deliver surprises into the twenty-first century. The Dirac operator bewitches more than just analysts, because some version can be written down on any Riemannian (in fact, conformal) manifold. In this context it is completely natural yet still mysterious. The Dirac operator sees something very deep about manifolds, and the nature of its vision is still beyond our ken. Atiyah's essay sketches the mathematics behind Dirac's operator while describing some of its mathematical incarnations and applications.

Less well known to mathematicians is Dirac's work on magnetic monopoles. These are hypothetical particles which consist of a single magnetic pole, solely "north" or solely "south". Their existence restores to Maxwell's equations for electric-

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ity and magnetism a fundamental symmetry which is lost in the presence of charges and currents. (Modulo a sign, this symmetry interchanges the electric and magnetic fields.) In spite of some serious searching (in laboratories, on earth, and in space), no monopoles have been found to date. In any event, Dirac pointed out that the fact that all electric charges are integer multiples of a single constant is a direct consequence of the existence in this universe of a single monopole. There are those who speculate that Dirac's work on magnetic monopoles will prove as central to twenty-first century geometry as the Dirac equation is to geometry of today. The essay by Olive describes Dirac's work on monopoles and its current remarkable incarnations in certain supersymmetric field theories.

The essays of both Olive and Atiyah sparkle to the eyes, and I finished each wishing for more. Meanwhile, Pais's essay was entertaining and very touching, for I still have heroes and Dirac is one of them. Finally, Jacob's lecture was fascinating, but probably dry without prior knowledge of the physics or, at minimum, the mathematics of antiparticles. For those lacking this knowledge, what follows is a brief introduction to the subject.

Roughly the antiparticle story is as follows. In the absence of interparticle forces, the dynamics of a single electron moving in space is controlled by the Dirac operator in the following sense: The possible states of the electron at a given time t are described by a spinor (which is to say a vector of functions on which the Dirac operator can act) whose absolute value squared integrates to one. Then the function which is the square of the absolute value of the spinor is meant to be the probability distribution for finding the electron at points in space.

Here is how dynamics enters the story: Having described the electron state at time t by a certain vector of functions whose norm square integrates to one, one can obtain the state at any later time from the original via a certain unitary action of the group of translations on the line. The key point here is that the generator of this unitary action is supposed to be the operator D. In particular, the eigenvalues of D are to be interpreted as the allowed energies of electrons whose probability distributions are time independent.

So far so good, except that D's spectrum is not bounded from below. For example, the eigenvalues of D for the case where space is the 1-dimensional unit radius circle have the form n where n can be any integer. The fact that D has accessible states which have arbitrarily negative eigenvalues renders D useless for the description of our universe. Indeed, such a universe would not last long, since the slightest generic perturbation would send all the electrons pathologically cascading ever deeper into the negative energy states.

Of course, Dirac was aware of the negative energy problem. But still, his D explained various major paradoxes about the behavior of electrons, and so he was not quick to abandon it. And after a time Dirac resolved the negative energy problem, and this resolution leads unavoidably to the antielectron. (This particle is now called the "positron".) To explain, understand first that the resolution invokes an extra feature of electrons that was well known to Dirac but not yet introduced here. This feature is the "exclusion principle", which was first enunciated by Pauli and which leads to the explanation of chemistry. The exclusion principle asserts that no two electrons can occupy the same quantum state. (Chemistry appears here for the following reason: The chemical properties of an atom are essentially determined by the states of its orbital electrons. Meanwhile, the exclusion principle prevents all but one of the electrons in an atom from occupying any given orbital state. Thus, atoms with different numbers of electrons must have different chemical properties.)

With the exclusion principle understood, Dirac made the audacious proposal that essentially all of the negative energy states in the universe are already filled with electrons. Then, Pauli's exclusion principle makes these states inaccessible to the remaining electrons, and the negative energy instability disappears. Of course, in making such a proposal Dirac was forced to consider the observational consequences of the occupation of essentially all of the negative energy states. What Dirac realized was that this assumption is essentially unobservable when all negative energy states are filled. Moreover, an empty negative energy state is essentially indistinguishable from a particular positive energy state which is filled by the antiparticle. The idea here is that a missing negative charge is indistinguishable from a present positive charge. (Since interparticle interactions would unavoidably knock electrons from filled negative energy states into positive energy states, Dirac was forced to consider the observational consequences of a relatively small number of negative energy states.)

The filling of the negative energy states led Dirac to the antielectron. Remarkably enough, the first observations of the particle occurred only a few years later.

As I remarked at the outset, this book is quite short; it is not a text to learn a great deal about either Dirac's physics or math, or even about his life. Rather, this book is a small gem of an introduction to all three of these subjects.

Book Review

The Man Who Loved Only Numbers

Reviewed by Paul Halmos

The Man Who Loved Only Numbers
Paul Hoffman
Hyperion Books, 1998
289 pages
Hardcover $22.95
ISBN 0-786-86362-5

This book is about Paul Erdős (who lived from March 26, 1913 to September 30, 1996). He was a mathematician who lived and loved and breathed and thought mathematics and almost nothing else. The author obviously loves his subject; he writes with care and affection. Much of what he writes consists of quotations or paraphrases of what Erdős wrote and said. A fair way to review such a book seems to be to quote or paraphrase what's in it, and what follows is written in that spirit.

The book tells us to pronounce Erdős's name as "air-dish", but I don't agree. In some languages, including English and Hungarian, vowels can be short or long, as in word pairs such as "foot" and "boot". In Hungarian the distinction is indicated by diacritical marks on long vowels, so that "foot" would be "fut" and "boot" would be "bút". The accented o in Erdős's name is the so-called long Hungarian umlaut; it should be pronounced the way most people pronounce the ö in Gödel.

I don't know all the Erdős stories, but all the ones I know are reported in this book just the way I had heard them.

Erdős spoke English well and fast, but his pronunciation was idiosyncratic—it was difficult for

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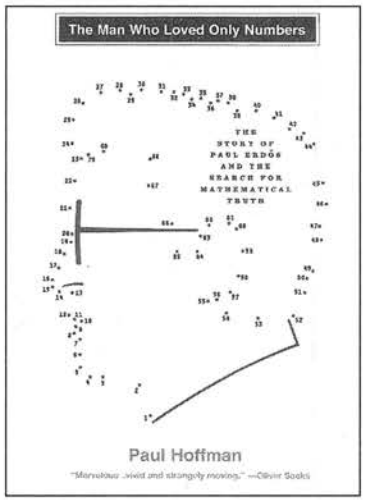


some people to understand, especially the first time. One time when he was asked what he was doing just then, he said, "I am sinking on a seorem." When he allowed himself to talk about things other than mathematics, he used a language of his own: women were "bosses", children were "epsilons", and alcohol was "poison".

He loved children, and he fussed over them when he met them, but not for long—his patience was quickly exhausted. And he loved all children, not just the mathematically precocious, and doted on the epsilons of his collaborators. "People are always taking pictures of me holding babies," said Erdős. In one photo "the baby looked so content that somebody said, 'Uncle Paul is nursing.'" The younger the child was, the deeper his connection.

He liked to discover young geniuses, and he did. For instance, he discovered Pósa at age fourteen, Pelikán at fifteen, and Lovász at seventeen. One of his good friends and frequent collaborators was Béla Bollobás, who was fourteen when he met Erdős, who was forty-four. They had a forty-year collaboration that resulted in fifteen papers.

Erdős loved to invent jokes and then to make exhaustive use of them. One that he was fond of telling was about his age: "When I was a child, the earth was said to be two billion years old. Now scientists say it's four and a half billion. So that makes me two and a half billion." In the early 1970s he started appending the initials P.G.O.M. to his name, which stood for Poor Great Old Man, and then kept expanding that initialized reference to his great age for the next quarter of a century.

With more than 484 coauthors, Erdős collaborated with more people than any other mathematician in history. Those lucky 484 are said to have an Erdős number 1, a coveted code phrase in the mathematics world for having written a paper with the master himself. If your Erdős number is 2, it means you have published with someone who has published with Erdős. If your Erdős number is 3, you have published with someone who has published with someone who has published with Erdős. Einstein had an Erdős number of 2, and the highest known Erdős number of a working mathematician is 7.

An important person in Erdős's life was Ron Graham, who handled many of Erdős's affairs—such as making sure that the visa on his passport was up to date, and managing his income, which dribbled in from four continents. "I signed his name on checks and deposited them," Graham said. "I did this so long I doubted the bank would have cashed a check if he had endorsed it himself." In 1970 Graham bet Erdős that he couldn't stop taking amphetamines for a month. Erdős accepted the challenge and went cold turkey for thirty days. After Graham paid up—and wrote the $500 off as a business expense—Erdős said, "You've showed me I'm not an addict. But I didn't get any work done. I'd get up in the morning and stare at a blank piece of paper. I'd have no ideas, just like an ordinary person. You've set mathematics back a month." He promptly resumed taking pills, and mathematics was better for it.

Back in the early 1950s Erdős started spurring on his collaborators by putting out contracts on problems he wasn't able to solve. By 1987 the outstanding rewards totalled about $15,000 and ranged from $10 to $3,000, reflecting his judgment of the problems' difficulty.

Near the end of his life he appreciated that his explanations were sometimes hard to follow. He realized this when he looked back at his old papers and was impressed by how hard it was for him to understand his own arguments of thirty or forty years earlier.

He was twenty-one when he buttered his first piece of bread, his mother or a domestic servant having always done it for him. "I remember clearly," he said. "I had just gone to England to study. It was tea time, and bread was served. I was too embarrassed to admit I had never buttered it. I tried. It wasn't so hard."

Erdős certainly didn't look like an athlete, but he was more athletic than he appeared. He was, for instance, an excellent ping-pong player—he played to win—fast and hard.

An ingrained characteristic of Erdős was his insistence on travel: if he spent as much as two weeks in the same town, or even in the same country, he became restless. As a result he frequently had visa problems, especially with the United States. In the early 1960s he repeatedly petitioned the U.S. Government to allow him re-entry, but his requests were rejected again and again. His comment: "The foreign policy of the State Department was adamant on two points: nonadmission of Red China to the United Nations and of Paul Erdős to the United States."

"When I first met Landau in 1935 in Cambridge," Erdős liked to recall, "he told me, 'Wir mathematiker sind alle ein bißchen meschugge.'"[1]

Ralph Faudree, one of his hosts, recalled: "One day when I came down to the kitchen, there was cereal, lots of cereal, all over the floor. I didn't understand how it got there. Even if he opened a new box and had to struggle to rip the plastic, that much cereal couldn't have shot out. I couldn't figure it out, so I just swept it up. The next morning I came down and there was cereal all over the floor again. Erdős was sitting there, dropping fistfuls of cereal, trying to feed the dogs."

One of Erdős's rare feminine contacts was Jo Bruening, who was his platonic friend and chauffeur for a while in the early 1960s, but she got tired of that and disappeared from his life.

His mother was a big part of his life. She was always on his mind, and he phoned her every day from everywhere. "Erdős mama" was famous in the mathematical world. "No son loved his mother more than Paul," said John Selfridge. "I got to know her well during the spring of 1966. She was a kind woman. We called her *Anyuka* [not "mother" but "mommy"] like Paul. ... When Paul died, I went to his funeral in Budapest. I hate funerals, but I am glad I went. The official memorial service ... was one of the largest ever held in Hungary, with more than five hundred people in attendance, as if it were the funeral of a head of state."

[1] "We mathematicians are all a bit nutty."

1997 AMS-IMS-MAA Annual Survey

(Second Report)

Report on the 1997 Survey of New Doctoral Recipients, Starting Salary Survey of New Doctoral Recipients, Faculty Characteristics, Enrollment Profile, Undergraduate Majors, and Graduate Student Profile

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

This is the Second Report of the 1997 Survey, which includes analysis of data on departmental enrollments, majors, and faculty size as well as an update of the First Report, which appeared in the *Notices of the AMS* in January 1998, pages 33–44. It included a report on the 1996–97 new doctoral recipients and salary data on faculty members in four-year colleges and universities.

The 1997 AMS-IMS-MAA Annual Survey represents the forty-first in an annual series begun in 1957 by the Society. The 1997 Survey was under the direction of the AMS-IMS-MAA Data Committee, whose members were 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. Comments or suggestions regarding the Annual Survey may be directed to the Committee.

Highlights

The final count of 1,174 new doctorates awarded July 1, 1996, through June 30, 1997, is a slight increase over the previous year's final count of 1,154. The number (and proportion) of 1996–97 doctoral recipients who were female was up significantly from last year: 294 (25.0%) compared with 250 (21.7%) last year.

The final fall 1997 unemployment rate was 3.8%, a significant decline from the previous year's final figure of 8.1%. This is the lowest reported final rate since fall 1990. The drop is due primarily to increased nonacademic employment in the U.S. Of the new doctoral recipients who found employment in the U.S., 286 (35.5%) found employment in government, business, or industry for fall 1997. This is a 22.7% increase over the previous year's figure of 233, and more than double the figures reported in the late 1980s.

Using data collected from 583 of the 1996–97 doctoral recipients employed in the U.S., 318 reported obtaining a permanent position and 264 a temporary position. (One did not respond to this question.) Of the 264 in temporary positions, 156 reported taking temporary employment because a suitable permanent position was not available.

The median age of the 675 doctoral recipients who responded to the individual survey was 31, and the first and third quartiles were 29 and 35 respectively.

The fall 1997 median starting salary for a 9–10-month appointment, teaching or teaching and research, was $36,600, up just $600 from the fall 1996 figure.

Within mathematics departments, the total full-time doctoral faculty for fall 1997 increased 1.5% over fall 1996 counts, based on the reports from the departments responding to the Departmental Profile Survey. However, the number of untenured but tenure-track faculty declined 1.3%, and the number of non-tenure-track faculty increased almost 13%. This continues a steady trend through the 1990s.

The 4.7% increase in first-year graduate students reported by the Ph.D.-granting mathematics departments was the first increase reported since fall 1991. It is the largest one-year percentage increase since 1986. These same departments reported a 3.4% drop in first-year U.S. citizen graduate students. Female first-year graduate students were up 8.1% in Ph.D.-granting mathematics departments. The responding departments in Group V reported a 50% increase in first-year female students and just over a 10% increase overall.

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.*[1] These rankings update those reported in a previous study published in 1982.[2] Consequently, the departments that now comprise Groups I, II, and III differ significantly from those used in prior surveys. The reader should keep this in mind when attempting to make comparisons by group with previous Annual Survey reports.

The subdivision of the Group I institutions into Group I Public and Group I Private was new with the 1996 Annual 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 I Public and **Group I Private** are Group I departments at public institutions and private institutions respectively.

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 of 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.

Listings of the departments which comprise groups I through V are available through the AMS's Web site at www.ams.org/membership/survey.html.

[1] *Research-Doctorate Programs in the United States: Continuity and Change*, edited by Marvin L. Goldberger, Brendan A. Maher, and Pamela Ebert Flattau, National Academy Press, Washington, DC, 1995.

[2] These findings were published in *An Assessment of Research-Doctorate Programs in the United States: Mathematical and Physical Sciences*, edited by Lyle V. Jones, Gardner Lindzey, and Porter E. Coggeshall, National Academy Press, Washington, DC, 1982. The information on mathematics, statistics, and computer science was presented in digest form in the April 1983 issue of the *Notices*, pages 257–67, and an analysis of the classifications was given in the June 1983 *Notices*, pages 392–3.

Paul W. Davis is professor of mathematics at Worcester Polytechnic Institute. James (Jim) W. Maxwell is AMS associate executive director for Professional Programs and Services. Kinda M. Remick is AMS survey specialist.

Introduction

The AMS-IMS-MAA Annual Survey collects information each year about departments, faculties, and students in the mathematical sciences at four-year colleges and universties in the United States. This article reports results from three parts of the 1997 AMS-IMS-MAA Annual Survey. First, we update information about new doctoral recipients reported earlier in the January 1998 issue of the *Notices of the American Mathematical Society* (see pages 33–44). Second, we present the starting salaries of the new doctoral recipients who responded to a follow-up survey. Third, we present results about the characteristics of faculties and of instructional programs at the undergraduate and graduate levels.

In the interest of continuity in the analysis and presentation and to make year-to-year comparisons possible, we report the same kinds of information that were included in last year's Second Report. Details are presented concerning employment patterns for new doctoral recipients, department faculty characteristics, and distribution of enrollments in different types of departments. As explained in the 1997 First Report section "Revised Procedure for Survey of Employment Status" (*Notices of the AMS*, January 1998, page 33), individual recipients of new doctorates formerly reported their employment status for the upcoming fall during the summer following the academic year in which the degree had been awarded. For this year's survey, all doctoral recipients were sent the revised and expanded questionnaire Employment Experiences of New Doctoral Recipients in October. They were asked to report their employment status as of the week of October 13, 1997, and to report additional details on their employment experiences as of that week. In spite of this change in procedure, comparisons with prior years of the key employment indicators remain valid. In addition, use of the survey form and procedures allows the employment experiences of the 1996–97 doctoral recipients in the mathematical sciences to be compared with those of doctoral recipients in a number of other academic disciplines. An initial report on this comparative data is available through *Science* magazine's Next Wave Web site at `www.nextwave.org/`.

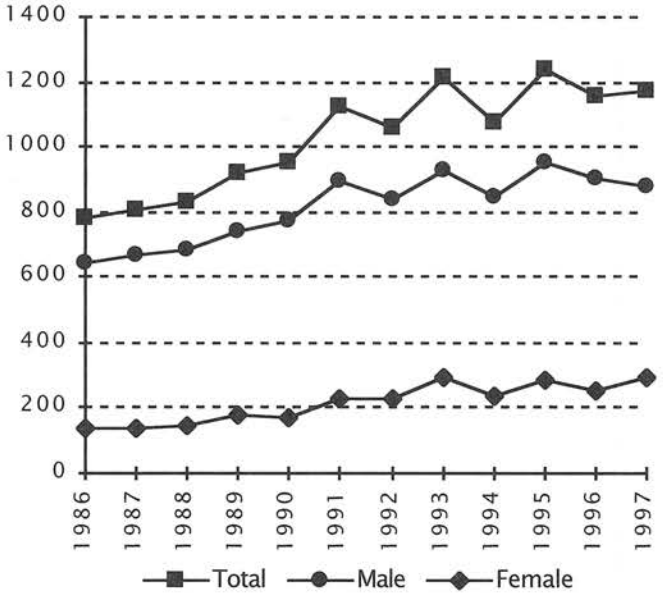
We follow the procedure started in the 1991 Second Report of reporting projections of survey responses to the entire population of mathematical sciences departments. The projections of survey responses to the entire population are done within strata defined by the survey groups. For example, on the part of the Departmental Profile Survey concerned with faculty, there were 22 usable responses from the 25 departments in Group I Public (see Table 3A). The 22 responding departments reported 24 full-time faculty to have retired or died, and this tally was multiplied by 25/22 to obtain the projected value of 27 for the group as a whole.

We caution the reader that survey responses and the proportional projections are potentially biased due to (i) selection bias of the responding departments and (ii) inhomogeneity of departments within the survey groups. The responses and projections for total faculty size are slightly affected by this bias. Nonetheless, the problems of a possible selection bias are mitigated by the generally high re-

Table 1A: U.S. New Doctoral Recipients, Fall and Final Counts, 1991–1997

Year	Fall	Final
1991–1992	1050	1062
1992–1993	1202	1214
1993–1994	1059	1076
1994–1995	1226	1237
1995–1996	1153	1154
1996–1997	1158	1174

Table 1B: Trend Chart of Final Count of New Doctoral Recipients, 1986–1997



sponse rates to the Annual Survey. In groups with lower response rates (e.g., Groups M and B) there is greater risk of biased projections.

Update on the 1997 Survey of New Doctoral Recipients

Information about recipients of doctoral degrees awarded between July 1, 1996, and June 30, 1997, was collected from doctorate-granting departments in late spring 1997 and from a follow-up census of individual degree recipients beginning in October. The "1997 AMS-IMS-MAA Annual Survey First Report" (*Notices of the AMS*, January 1998, pages 33–44) presents the survey results obtained about new doctoral recipients from the departments. Here we update the earlier figures on the basis of the follow-up census.

The names of the 1996–97 doctoral recipients and their thesis titles were published in "Doctoral Degrees Conferred" (*Notices of the AMS*, January 1998, pages 45–63).

The final count of new doctoral recipients (Table 1A) shows a total of 1,174 doctorates in mathematical sciences awarded by U.S. institutions. This number represents an increase of 1.7% from the 1,154 doctorates awarded during 1995–96. Table 1B shows the overall and by-gender trends in the final counts of new doctoral recipients from 1985–86 through 1996–97.

Citizenship status is known for all of the 1,174 new doctoral recipients. The final count of new doctoral recipients who are U.S. citizens is 522. The percentage of 1996–97 new doctoral recipients who are U.S. citizens is 44.5%, up slightly from the reported 44.0% of the past year and down from the high of 47.9% of 1994–95. The final count of new doctoral recipients who are non-U.S. citizens increased slightly from 646 to 652, but was still below the record high of 679 reported in the final count four years ago. Pages 37–38 of the First Report present further information related to the citizenship of the 1996–97 new doctoral recipients.

Of the 522 U.S. citizen new doctoral recipients, 150 are women and 372 are men. The 150 women new doctoral recipients comprise 28.7% of the U.S. citizen total for 1996–97, a significant increase over last year's count of 118 (23.4%). The number of U.S. citizen men who were awarded Ph.D. degrees in mathematical sciences during 1996–97, 372, decreased by 3.9% from 1995–96.

Tables 2A and 2B display updates of employment data for the fall count of 1996–97 doctoral recipients, partitioned by field of thesis research and by the survey group of their degree department. At the time of the Second Report, the fall 1997 employment status of 1,008 of the 1,158 doctoral recipients was known. Of the 1,008, 48.7% assumed academic employment in the U.S., and 61.5% took academic employment in the U.S. or other countries. Both of these percentages are slightly below equivalent percentages reported the last three years, but down more sharply from their 1992–93, 1991–92, and 1990–91 levels.

Employment of 1996–97 doctoral recipients by U.S. Ph.D.-granting institutions decreased by 10.3% from the corresponding figure for 1995–96. Employment of the 1996–97 doctoral recipients by research institutes, government, and business and industry increased by 24.6% (including a 22.2% increase in employment by business and industry).

Among those 1996–97 doctoral recipients taking employment in the U.S., 35.5% took nonacademic employment (government or business and industry). This percentage was 4.6 percentage points more than for the 1995–96 doctoral recipients and accelerates the steady growth throughout the 1990s of employment in this U.S. employment sector of mathematical scientists. The corresponding figure for 1990–91 was 21.0%. The fraction of the 1996–97 doctoral recipients taking nonacademic employment varied significantly by field of thesis. Of those whose field of thesis was either algebra/number theory, real or complex analysis, or geometry/topology, 21.6% took nonacademic employment. For probability or statistics the analogous figure is 49.8%; and for applied math, discrete math/combinatorics/logic/computer science, numerical analysis/approximations, or linear/nonlinear optimization the analogous figure is 42.2%.

Group I departments continued to award the most doctorates. Of the 1,158 doctoral degrees awarded in the mathematical sciences between July 1, 1996, and June 30, 1997, 41.8% (484) were awarded by Group I departments, more than double the number of any other group.

Table 2A: Fall 1997 Employment Status of 1996–97 U.S. Doctoral Recipients in the Mathematical Sciences, Updated May 1998

TYPE OF EMPLOYER		FIELD OF THESIS												TOTAL
		Algebra Number Theory	Real or Complex Analysis	Geometry/ Topology	Discr. Math./ Combin./ Logic/ Comp. Sci.	Probability/ Statistics	Applied Math.	Numerical Analysis Approxi-mations	Functional Analysis	Linear Nonlinear Optim./ Control	Differential Integral and Difference Equations	Harmonic Analysis and Topological Groups	Other/ Unknown	
Group I (Public)		11	5	18	5	4	5	2	4		6	3		63
Group I (Private)		11	3	12	3	4	5			1	5	3		47
Group II		10	3	5	3	5	1	2	2	1	4	3	2	41
Group III		6	2	1	2	3	3	2	2	1	2	1	2	27
Group IV		1				29	1							31
Group V						3	4				1			8
Master's		9	2	9	7	15	3	2	3		5	3	2	60
Bachelor's		22	6	22	19	8	5	2	6	3	15	4	7	119
Two-Year College		3			3	1	1	2		1	5		2	18
Other Academic Dept.		1	3	8	7	27	14	4		4	5	1	3	77
Research Inst./Nonprofit		4		4	4	9	4				1	2		28
Government		5	2	2	2	13	5	5			3	1		38
Business/Industry		21	3	17	17	94	37	20	8	6	15	10		248
Foreign, Academic		21	3	15	15	21	14	11	7	6	12	4		129
Foreign, Nonacademic		2	1			6	2		1			1	1	14
Not seeking employment		3	2	3	4		2	3	1	1	1	1	1	22
Still seeking employment		9	2	4	7	7	2		1	1	4	1		38
Unknown (U.S.)		10	0	8	8	21	9	1	2		5	2	2	68
Unknown (non-U.S.)*		11	2	15	3	21	5	5	4	2	9	4	1	82
Column Total		**160**	**39**	**143**	**109**	**291**	**122**	**61**	**41**	**27**	**98**	**44**	**23**	**1158**
Column Subtotals	Male	122	32	118	82	193	94	48	35	22	74	37	12	869
	Female	38	7	25	27	98	28	13	6	5	24	7	11	289

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

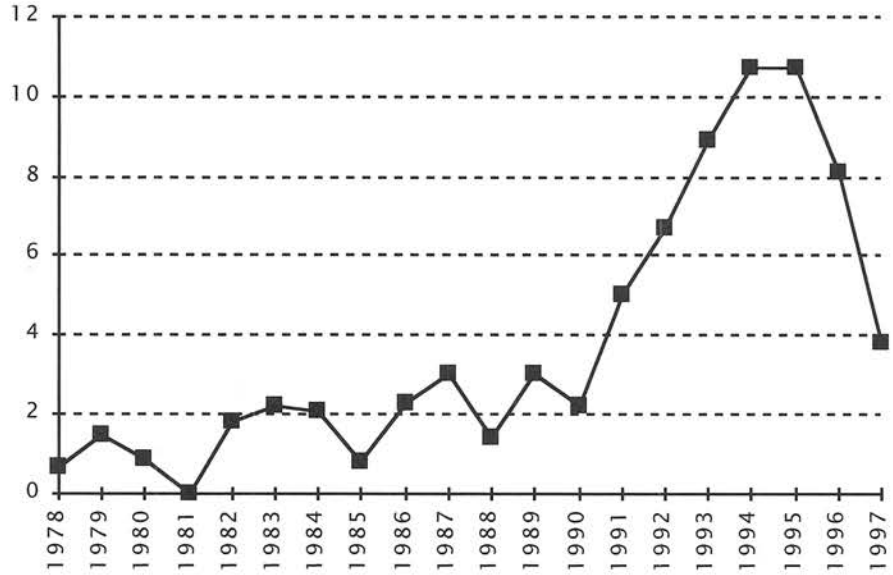
Table 2B: Fall 1997 Employment Status of 1996–97 U.S. Doctoral Recipients by Type of Granting Department, Updated May 1998

TYPE OF EMPLOYER		TYPE OF DOCTORAL DEGREE-GRANTING DEPARTMENT						ROW TOTAL	ROW SUBTOTAL	
		Group I (Public) Math	Group I (Private) Math	Group II Math	Group III Math	Group IV Statistics	Group V Applied Math/OR		Male	Female
Group I (Public)		34	20	5	1	1	2	63	52	11
Group I (Private)		11	31	2	1	1	1	47	38	9
Group II		14	7	15	3	2		41	33	8
Group III		2	3	6	11	4	1	27	18	9
Group IV		2	1	1		27		31	21	10
Group V		1	2		2		3	8	8	
Master's		17	3	14	17	6	3	60	47	13
Bachelor's		31	7	47	23	6	5	119	74	45
Two-Year College		2		11	4		1	18	12	6
Other Academic Dept.		12	8	13	7	21	16	77	55	22
Research Inst./Nonprofit		6	11	4	1	6		28	23	5
Government		12	3	6	5	9	3	38	26	12
Business/Industry		45	34	34	33	68	34	248	187	61
Foreign, Academic		42	24	26	8	14	15	129	112	18
Foreign, Nonacademic		2	2	1	2	3	4	14	11	2
Not seeking employment		10	2	6	3	1		22	13	9
Still seeking employment		15	3	9	2	5	4	38	31	7
Unknown (U.S.)		15	14	13	5	10	11	68	49	19
Unknown (non-U.S.)*		24	12	25	4	13	4	82	69	23
Column Total		**297**	**187**	**238**	**132**	**197**	**107**	**1158**	**869**	**289**
Column Subtotals	Male	238	157	175	95	123	81	869		
	Female	59	30	63	37	74	26	289		

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

Table 2C: Percentage of New Doctoral Recipients Unemployed, As Reported in the Respective Annual Survey Second Reports, 1978–1997

Year	Unemployed
1978	0.7
1979	1.5
1980	0.9
1981	0.0
1982	1.8
1983	2.2
1984	2.1
1985	0.8
1986	2.3
1987	3.0
1988	1.4
1989	3.0
1990	2.2
1991	5.0
1992	6.7
1993	8.9
1994	10.7
1995	10.7
1996	8.1
1997	3.8



The fall 1997 unemployment rate for new doctoral recipients, based on information gathered by the time of the Second Report, increased significantly from 6.7% for fall 1992 to 8.9% for fall 1993 to 10.7% for fall 1994 and fall 1995. Continuing last year's decline to 8.1%, the fall 1997 unemployment rate made a significant drop to 3.8%, the best reported rate since fall 1990. The counts on which these rates are determined do not include those new doctoral recipients whose fall employment status was unknown at the time of the Second Report.

Table 2C presents the fall 1978 through fall 1997 trend in the final fall unemployment rate of new doctoral recipients.

There were 675 individuals who responded to the Employment Experiences of New Doctoral Recipients (EENDR) survey out of the 1,158 doctoral recipients reported in the First Report, an overall response rate of 58.3%. The response rates varied considerably among the various subgroups of new doctorates defined by their employment status as reported by departments. Among those reported by the departments as employed in the U.S., the response rate was 69.5%. The response rate was 78.7% for those employed in academia in the U.S., but for those employed in business and industry in the U.S. the response rate dropped to 50.9%. The response rate was 42.4% for the 118 individuals in the U.S. whose employment status was unknown to the department. Females were slightly more likely to respond than males: 61.7% for females versus 57.2% for males. The response rates for U.S. citizens, permanent residents, and temporary residents were 69.4%, 52.9%, and 48.2% respectively.

The EENDR gathered details on employment experiences not available through departments and not gathered in previous Annual Surveys. The rest of this section presents the additional information available on this subset of the 1996–97 doctoral recipients.

Of the 675 total respondents to the EENDR, 583 were employed in the U.S., 70 were employed outside the U.S., and 22 were unemployed in the U.S. as of the week of October 13, 1997. Among those employed in the U.S., 555 were employed full-time and 28 were employed part-time. Of the 28 reporting part-time employment, 13 reported that they were working part-time because a suitable full-time job was not available. Five also reported they were working part-time while they pursued additional education.

Among the 583 employed in the U.S., 318 reported obtaining a permanent position, 264 a temporary position, and one did not respond to this question. Of the 264 in temporary positions, 156 reported taking temporary employment because a suitable permanent position was not available—64.2% of those who responded to this question. Of those in a temporary position, 146 classified their position as postdoctoral—56.8% of those responding to this question. Furthermore, among those in postdoctoral positions, 55.3% responded that they took the position because a suitable permanent position was not available.

Among the 318 who reported obtaining a permanent position in the U.S., 50.9% were employed in academia, 38.7% in business or industry, 7.2% in government, and the remaining 3.2% in other nonprofits or self-employed. Women held 31.1% of the permanent positions.

Among the 264 individuals with temporary employment in the U.S., 88.6% were employed in academia, 3.0% in business or industry, 2.6% in government, and the remaining 5.8% in other nonprofits, typically a research institute.

Among the 70 individuals employed outside the U.S., 85.7% were employed in academia, 4.3% in business or industry, 5.7% in government, and 4.3% in other nonprofits. Twelve of those employed outside the U.S. were U.S. citizens, and one was a U.S. permanent resident.

The most frequently used job search resources were electronic at 58.1%, publications at 51.1%, informal channels (networking with colleagues or friends) at 44.7%, and faculty advisor at 41.9%. The remaining types of resources are used much less often, each below 20.0%. When asked to indicate the single most effective job search resource, 39.6% chose electronic resources. The next highest was informal channels at 19.1%, followed by faculty advisor at 10.7%. Not surprisingly, 79.0% reported using two or more of these methods. The AMS's Web site, e-MATH, was the most frefrequently mentioned electronic resource. The *Notices of the AMS* was the most frequently mentioned publication, followed by the *Chronicle of Higher Education*, *Amstat News*, and then the publications of other mathematical societies.

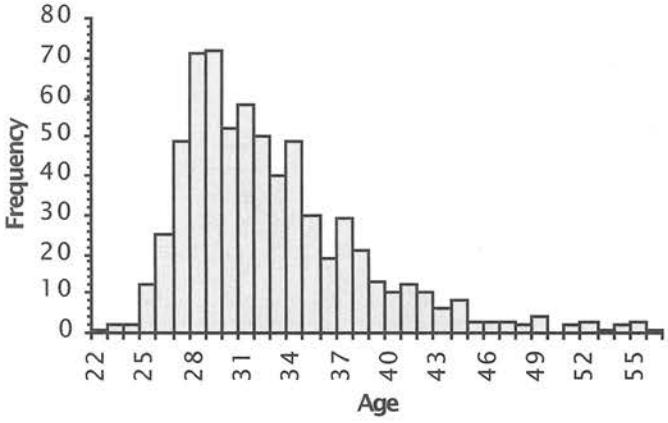
Doctoral recipients who found employment were asked to indicate their agreement or disagreement with the following four questions.

1. The position is related to my field.
2. The position is commensurate with my education and training.
3. The position is similar to what I expected to be doing when I began my doctoral program.
4. The position is professionally challenging.

Response options ranged from 5 for "strongly agree" down to 1 for "strongly disagree". The distribution of responses was very similar for questions 1, 2, and 4, and each distribution indicates strong agreement with these three statements. Between 75 and 80 percent responded with either a 4 or a 5. For question 3, the response indicated less overall agreement, with 59.7% responding 4 or 5 and 23.2% responding 1 or 2. In summary, the positions obtained were appropriate for the type of education, but not always what was expected at the outset of the doctoral program.

Table 2D shows the age distribution of new doctoral recipients. The median age was 31, while the mean age was 32.6. The first and third quartiles were 29 and 35 respectively.

Table 2D: Age Distribution of New Doctoral Recipients



Starting Salary Survey of New Doctoral Recipients

The salary figures for 1997 were compiled from information gather on the EENDR questionnaires sent to individuals who received doctoral degrees in the mathematical sciences during the 1996–97 academic year from universities in the United States (see previous section for more details).

The questionnaires were distributed to 1,124 recipients of degrees using addresses provided by the departments granting the degrees; 675 individuals responded between late October and mid-May. Responses with insufficient data or from individuals who indicated they had part-time employment were considered unusable. Numbers of usable responses for each salary category are reported in the following tables.

Readers should be warned that the data in this report are obtained from a self-selected sample, and inferences from them may not be representative of the population.

Key to Tables. *Salaries* are listed in hundreds of dollars. Nine-month salaries are based on 9–10 months' teaching and/or research, not adding extra stipends for summer grants or summer teaching or the equivalent. *Years* listed refer to the academic year in which the doctorate was received. *M* and *F* are male and female respectively. Some persons receiving a doctoral degree had been employed in their present position for several years. Quartile figures are given only in cases where the number of responses is large enough to make them meaningful. In addition, the "Research, 9–10 Month Salaries" table was dropped this year. No recipients responded as being within this category in 1996–97, and so few responded in prior years that the data were not considered meaningful. Starting salaries for those reporting a postdoctoral position are available for the first time this year.

Note that salaries for teaching or teaching and research have yet to return to their high point of 1970, although considerable progress has been made since 1980.

Academic Postdoctorates
9–10 Month Salaries
(47 men/14 women)

Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 1997 $
1997	180	350	385	410	450	385
1997M	250	350	380	405	446	
1997F	180	350	385	408	450	

Teaching or Teaching and Research
9–10 Month Salaries
(199 men/73 women)

Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 1997 $
1960	49		65		80	314
1965	70		80		105	360
1970	85		110		195	404
1975	90	120	128	135	173	341
1980	105	155	171	185	250	318
1985	170	230	250	270	380	358
1990	230	305	320	350	710	384
1994	150	330	350	375	730	375
1995	220	320	350	382	640	366
1996	240	333	360	400	636	367
1997	180	340	366	400	840	366
1994M	150	329	350	378	730	
1994F	270	330	348	370	520	
1995M	220	320	350	388	640	
1995F	240	323	350	380	525	
1996M	240	330	360	400	636	
1996F	270	345	365	399	500	
1997M	180	340	367	400	571	
1997F	180	340	366	396	840	
One year or less experience (168 men/59 women)						
1997M	180	340	370	400	560	
1997F	180	340	367	398	840	

Teaching or Teaching and Research
11–12 Month Salaries
(25 men/12 women)

Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 1997 $
1960	.....No data.....					
1965	78		104		121	468
1970	95		128		200	470
1975	87		145		204	386
1980	143		195		350	363
1985	220	230	273	300	470	391
1990	225	318	365	404	670	438
1994	365	391	480	503	510	514
1995	300	354	410	478	600	428
1996	150	302	340	390	720	347
1997	260	370	400	497	650	400
1994M	365	401	455	510	510	
1994F	370	380	480	500	505	
1995M	300	380	420	490	600	
1995F	-----	-----	-----	-----	-----	
1996M	150	280	330	460	720	
1996F	330	340	358	368	400	
1997M	260	360	400	420	635	
1997F	260	393	447	505	650	
One year or less experience (21 men/9 women)						
1997M	260	360	400	420	635	
1997F	260	370	400	500	650	

Research
11–12 Month Salaries
(29 men/12 women)

Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 1997 $
1960	97		105		140	507
1965	81		93		107	418
1970	90		120		205	441
1975	90		119		180	317
1980	120		180		321	335
1985	190	295	342	400	520	490
1990	180	280	300	365	546	360
1994	210	330	350	400	490	375
1995	196	280	340	370	587	355
1996	192	270	330	400	585	336
1997	190	300	350	400	600	350
1994M	210	300	340	433	490	
1994F	330	340	365	400	400	
1995M	196	280	350	370	587	
1995F	200	-----	287	-----	400	
1996M	210	273	330	360	585	
1996F	192	265	390	455	500	
1997M	210	300	350	406	500	
1997F	190	313	350	386	600	
One year or less experience (29 men/12 women)						
1997M	210	300	350	406	500	
1997F	190	313	350	386	600	

Government
11–12 Month Salaries
(18 men/10 women)

Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 1997 $
1960	72		93		130	449
1965	70		126		160	567
1970	100		150		223	551
1975	78		182		247	485
1980	156		244		501	454
1985	263	294	325	381	440	465
1990	320	345	378	430	587	454
1994	250	355	455	530	576	488
1995	370	440	494	507	650	516
1996	360	420	427	504	650	435
1997	350	454	573	600	750	600
1994M	250	350	423	550	576	
1994F	-----	-----	-----	-----	-----	
1995M	440	-----	499	-----	650	
1995F	-----	-----	-----	-----	-----	
1996M	360	405	427	500	650	
1996F	-----	-----	-----	-----	-----	
1997M	370	476	573	608	750	
1997F	350	465	560	586	680	
One year or less experience (14 men/9 women)						
1997M	390	546	573	596	640	
1997F	350	510	570	590	680	

Business and Industry
11-12 Month Salaries
(93 men/25 women)

Ph.D. Year	Min	Q_1	Median	Q_3	Max	Reported Median in 1997 $
1960	78		110		150	531
1965	100		136		180	612
1970	96		170		235	624
1975	114		187		240	498
1980	190		284		400	529
1985	260	360	400	420	493	573
1990	320	438	495	533	700	594
1994	200	418	525	600	750	563
1995	288	480	568	690	1250	593
1996	250	510	580	610	1000	591
1997	300	483	600	658	1000	600
1994M	200	405	490	600	750	
1994F	-----	-----	-----	-----	-----	
1995M	288	480	550	690	1250	
1995F	397	550	630	680	1000	
1996M	250	480	580	610	1000	
1996F	520	-----	590	-----	650	
1997M	300	490	600	670	1000	
1997F	400	460	540	620	900	
One year or less experience (64 men/16 women)						
1997M	300	468	600	662	100	
1997F	420	475	545	603	650	

Faculty Characteristics

The Departmental Profile Survey, sent in fall 1997 to mathematical sciences departments at four-year colleges and universities as part of the Annual Survey, provided information about faculty and instructional programs. In order that more reliable year-to-year comparisons could be made, data for fall 1996 and fall 1997 were gathered, except for data on retirement, deaths, and faculty recruitment. The percent change figures reported in Tables 3E and 3F, Tables 4A and 4D, and Tables 5A, 5C, and 5D are based on these two years of data. The First Report presented information collected earlier about faculty salaries (pages 33–44 of the January 1998 issue of the *Notices of the AMS*).

Table 3A displays losses of full-time mathematical sciences faculty due to retirements or deaths. The fall 1997 mathematical sciences faculty attrition rate for mathematics departments (Groups I, II, III, M & B combined) was 2.4%, compared with fall 1996, 1995, and 1994 figures of 2.3%, 2.2%, and 2.3% respectively. These rates are significantly ahead of the rates prior to 1992 and may, to some extent, reflect the numerous early retirement incentive programs which have occurred in academic institutions during these years. Table 3B depicts the trend in the faculty attrition rates for mathematics departments during the years 1986–97.

Table 3C displays Departmental Profile Survey information on the number of full-time faculty positions in mathematical sciences departments under recruitment in 1996–97. The number of positions in mathematics departments under recruitment increased 4.8% from 1995–96. Table 3D presents the positions under recruitment in mathematics departments for the years 1989–90 through 1996–97. Although there was a steady decrease from 1990 to 1994, recruitment appears to have leveled off in the past few years with only slight fluctuations. Table 3C of this report as compared with Table 3C of the 1996 Second Report shows that declines in the number of positions under recruitment in Groups I and II were more than offset by increases in Groups M and B.

Table 3C indicates that 89.6% of the positions under recruitment in 1996–97 by mathematics departments were available to new doctoral recipients, but of these only 67.2% were tenured/tenure-track. The number of tenured/tenure-track positions under recruitment by mathematics departments increased by 7.5% from last year's count.

Tables 3E and 3F describe the makeup of faculties by sex, tenure status, and doctoral/nondoctoral degree in the different groups. Table 3E indicates that the total number of full-time faculty in mathematics departments increased slightly from fall 1996 to fall 1997. After the 1995 reported decrease of 6.5%, the number of non-tenure-track, doctoral, full-time faculty in mathematics departments increased by 5.7% in 1996 and by 12.8% in 1997. The increase for 1997 was produced by large proportional increases in Groups I Public, III, B, and especially M. This increase in non-tenure-track full-time positions continues a disturbing trend reported in "Changes in Mathematics Faculty Composition, Fall 1990 to Fall 1996" (*Notices of the AMS*, November 1997, pages 1321–3). There was a small overall increase in the untenured, tenure-track doctoral faculty in mathematics departments. However, there were significant proportional decreases in Groups I Public, II, and III. Offsetting these decreases was a small proportional increase in Group B. (Note that Group B accounts for 47.7% of the total of these positions within mathematics departments.) There was an overall increase of 5.6% in part-time faculty in mathematics departments. This increase was due primarily to an 8.2% increase in Group B. (Group B accounts for 54.9% of all the reported part-time faculty.) Overall in mathematics departments, the number of female non-tenure-track, doctoral, full-time faculty increased by 11.4%, following the fall 1996 increase of 15.1%.

Table 3A: Faculty Attrition*

	GROUP									
	I Public	I Private	II	III	I, II, & III	IV	V	M	B	I, II, III, M & B
Full-time faculty who retired or died										
Total number	27	15	58	41	141	21	14	140	185	466
Percentage (%)	1.8	1.8	2.7	2.1	2.2	1.7	2.9	2.7	2.5	2.4
Usable responses**										
Total number	22	19	46	56	144	51	17	117	410	671
Percentage (%)	88	83	82	78	82	63	50	50	41	47

* Number and percentage of full-time faculty who were in the department in fall 1996 but were reported to have retired or died by fall 1997.
** All counts are projected from the survey response to the respective group as a whole. The number of usable responses varies for different sections of the Departmental Profile Survey. The response rates reported here apply to faculty size and recruitment data only.

Table 3B: Percent of Full-Time Doctoral Faculty Who Retired or Died in Groups I, II, III, M & B Combined

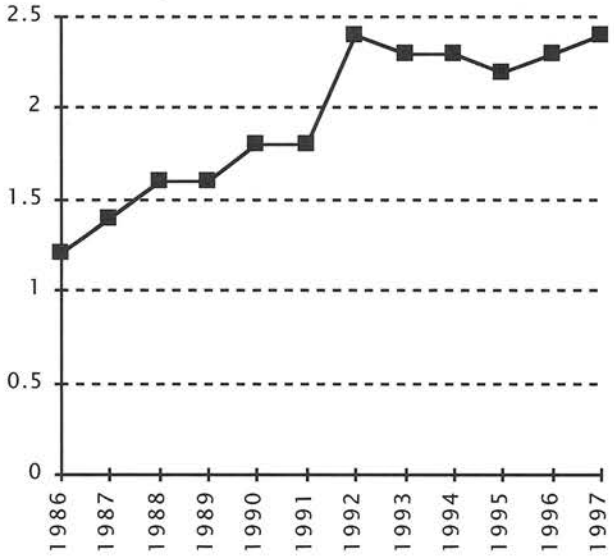


Table 3D: Number of Full-Time Doctoral Positions under Recruitment in Groups I, II, III, M & B Combined

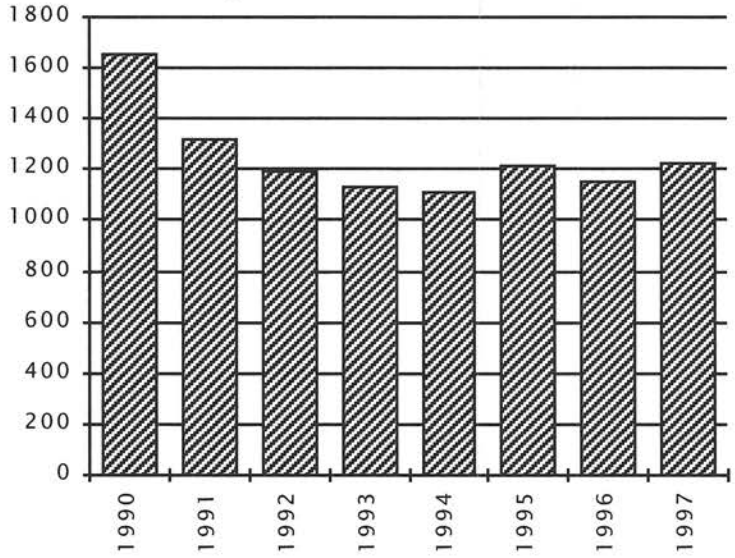


Table 3C: Recruitment of Doctoral Faculty

	GROUP									
	I Public	I Private	II	III	I, II, & III	IV	V	M	B	I, II, III, M & B
Open doctoral positions										
Total number*	108	87	122	107	424	81	30	268	542	1235
Tenured/tenure-track	55	25	73	81	234	60	30	208	375	817
Open to new doctoral recipients	81	70	105	95	350	75	22	240	515	1106
Tenured/tenure-track	43	15	63	76	197	57	22	194	353	743
Male doctoral hires	80	63	75	59	277	33	10	132	293	703
Female doctoral hires	23	16	26	16	80	17	6	72	133	286
Male nondoctoral hires	0	0	1	0	1	2	0	4	37	42
Female nondoctoral hires	0	0	0	3	3	0	0	16	15	33
Unfilled positions	6	8	19	29	63	29	14	44	64	171

*Number of full-time doctoral positions under recruitment in 1996–97 to be filled for 1997–98. Subtotals of rounded table values may exhibit rounding errors.

Table 3E: Faculty Size, Fall 1997, and Percentage Change in Size, Fall 1996 to Fall 1997

	GROUP									
	I Public	I Private	II	III	I, II, & III	IV	V	M	B	I, II, III, M & B
Full-time faculty										
Total number	1558	797	2163	1945	6476	1213	470	5260	7306	19042
Percentage change (%)	2.2	0.2	-3.8	2.5	-0.2	0.9	-7.1	1.7	0.6	0.7
Doctoral full-time faculty										
Total number	1515	788	2033	1719	6071	1186	459	4324	5639	16035
Percentage change (%)	1.8	0.0	-1.4	2.7	0.6	1.4	-7.2	2.1	1.9	1.5
Tenured doctoral full-time faculty										
Total number	1231	506	1669	1291	4714	785	314	3320	3908	11943
Percentage change (%)	0.1	-0.2	0.2	4.4	1.2	-0.8	-7.1	1.3	0.6	1.0
Untenured, tenure-track doctoral full-time faculty										
Total number	126	62	194	306	688	229	84	788	1346	2823
Percentage change (%)	-5.1	4.1	-10.7	-7.8	-7.4	1.4	2.0	-2.2	2.8	-1.3
Non-tenure-track doctoral full-time faculty										
Total number	158	220	170	122	669	173	60	216	385	1269
Percentage change (%)	25.2	-0.5	-4.8	15.9	5.7	12.4	-18.1	42.1	13.0	12.8
Part-time faculty										
Total number	211	29	306	402	941	94	32	1612	3107	5660
Percentage change (%)	2.8	14.3	1.6	2.6	2.6	-3.3	77.9	2.5	8.2	5.6

Table 3F: Female Faculty Size, Fall 1997, and Percentage Change in Size, Fall 1996 to Fall 1997

	GROUP									
	I Public	I Private	II	III	I, II, & III	IV	V	M	B	I, II, III, M & B
Full-time female faculty										
Total number	144	71	306	366	886	224	46	1296	2084	4266
Percentage change (%)	6.7	9.3	-0.8	6.7	3.9	4.4	-3.4	4.9	4.2	4.3
Doctoral full-time female faculty										
Total number	116	69	191	242	619	206	40	820	1295	2733
Percentage change (%)	6.3	11.8	0.0	12.6	6.6	7.4	-4.0	5.7	6.9	6.5
Tenured doctoral full-time female faculty										
Total number	63	22	99	122	305	73	12	470	725	1500
Percentage change (%)	5.8	-5.3	1.3	17.3	7.4	15.0	22.0	2.6	6.5	5.4
Untenured, tenure-track doctoral full-time female faculty										
Total number	18	12	56	80	167	75	16	286	469	922
Percentage change (%)	6.7	66.7	4.5	3.3	6.1	0.0	13.3	3.6	8.6	6.6
Non-tenure-track doctoral full-time female faculty										
Total number	35	35	37	40	146	59	12	64	101	311
Percentage change (%)	6.9	11.5	-9.1	19.2	5.3	8.8	-32.0	52.4	2.5	11.4
Part-time female faculty										
Total number	74	2	114	159	347	33	6	734	1430	2512
Percentage change (%)	22.6	-60.0	13.3	9.7	12.0	40.0	0.0	7.0	8.4	8.5

Enrollment Profile and Undergraduate Majors

The Departmental Profile Survey obtains information about enrollments and distribution of instructional effort in mathematical sciences departments.

Table 4A indicates that undergraduate mathematical sciences course enrollments increased by 2.7% from fall 1996 to fall 1997. In addition, graduate course enrollments increased by 1.2% over the same period. A comparison of this year's Table 4B with Table 4B from last year's Second Report (page 918 of the September 1997 *Notices of the AMS*) shows a similar pattern of enrollment distributions for mathematics departments.

Table 4D reports that the total number of junior/senior majors in mathematics departments (Groups I, II, III, M & B combined) increased by 3.7% from fall 1996 to fall 1997. The number of female junior/senior majors increased by 3.1% during the same period. In fact, all Groups reported at least slight increases in female majors, with Groups I Private and II showing sizable increases.

Table 4A: Undergraduate and Graduate Enrollments (thousands), Fall 1997, and Percentage Change in Enrollments, Fall 1996 to Fall 1997

	GROUP									
	I Public	I Private	II	III	I, II, & III	IV	V	M	B	Total
Undergraduate course enrollments										
Total number (thousands)	172	42	248	219	681	69	28	560	701	2039
Percentage change (%)	3.5	-2.4	1.4	4.9	2.8	0.5	0.8	2.1	3.5	2.7
Graduate course enrollments										
Total number (thousands)	7	3	8	7	26	19	8	13		67
Percentage change (%)	1.2	-2.7	-1.7	-5.0	-2.0	7.4	-2.6	1.6		1.2
Usable responses*										
Total number	22	15	44	54	135	49	11	107	386	688
Percentage (%)	88	65	79	75	77	61	38	46	38	45

* The number of usable responses varies for different sections of the Departmental Profile Survey. The response rates reported here apply to Tables 4A through 4C on enrollments only. All counts are projected from the survey response to the respective group as a whole.

Table 4B: Distribution of Undergraduate Enrollments (thousands), Fall 1997

	GROUP								
	I Public	I Private	II	III	I, II, & III	IV	V	M	B
Remedial mathematics*									
Total number (thousands), %**	17 10	0 0	19 8	33 15	69 10	0 0	0 1	104 19	101 14
Precalculus									
Total number (thousands), %	28 16	2 5	51 21	42 19	123 18	0 0	0 2	88 16	92 13
1st-year Calculus (mainstream)									
Total number (thousands), %	47 28	17 41	52 21	36 16	152 22	0 0	0 2	64 11	93 13
1st-year Calculus (nonmainstream)									
Total number (thousands), %	19 11	4 9	28 11	22 10	72 11	0 0	1 4	35 6	38 5
Statistics									
Total number (thousands), %	4 2	3 6	10 4	17 8	33 5	69 100	8 27	49 9	74 11
Computer Science									
Total number (thousands), %	1 1	1 1	1 1	4 2	7 1	0 0	0 3	31 6	75 11
Other courses for majors									
Total number (thousands), %	34 20	7 18	35 14	26 12	102 15	0 0	10 35	51 9	70 10
Other undergraduate courses									
Total number (thousands), %	23 13	8 20	51 21	40 18	122 18	0 0	7 26	139 25	158 23

*Arithmetic, high school algebra, geometry.
**Percents are "column percents" describing relative enrollments within the respective survey groups of the different types of undergraduate courses.

Table 4C: Undergraduate and Graduate Enrollments per Full-Time Faculty Member, Fall 1997

	GROUP							
	I Public	I Private	II	III	IV	V	M	B
Undergraduate course enrollments per full-time faculty member	110	52	115	113	57	59	106	96
Graduate course enrollments per full-time faculty member	4	4	5	8	16	17	2	
Total course enrollments per full-time faculty member	115	56	120	121	73	76	109	96

Table 4D: Undergraduate Junior/Senior Majors and Undergraduate Female Junior/Senior Majors (hundreds), Fall 1997, and Percentage Change in Majors, Fall 1996 to Fall 1997

	GROUP								
	I Public	I Private	II	III	IV	V	M	B	I, II, III, M & B
Junior/senior majors									
Total number (hundreds)	41	13	56	46	6	28	174	260	590
Percentage change (%)	-1.8	2.0	13.1	3.7	-6.5	-2.2	-1.4	6.6	3.7
Female junior/senior majors									
Total number (hundreds)	16	4	23	21	3	10	80	111	255
Percentage change (%)	2.6	9.6	12.4	1.7	0.7	4.9	1.4	2.6	3.1
Usable responses*									
Total number	21	17	41	48	31	7	94	313	553
Percentage (%)	88	74	75	68	53	28	40	34	39

* The number of usable responses varies for different sections of the Departmental Profile Survey. The response rates reported here apply to undergraduate majors data only. All counts are projected from the survey response to the respective group as a whole.

Graduate Student Profile

Tables 5A, 5C, and 5D summarize population statistics for graduate students gathered by the 1997 Departmental Profile Survey. Table 5A indicates that the total number of full-time graduate students in mathematics departments (Groups I, II, III & M combined) declined by 2.3% from fall 1996 to fall 1997 and declined in every group except Group V. Following a five-year decline, the Ph.D.-granting mathematics departments (Groups I, II & III combined) reported an increase of 4.7% in the number of full-time, first-year graduate students. This is the first increase reported since fall 1991 and the largest one-year increase since 1986. In addition, the number of full-time, first-year female graduate students in Ph.D.-granting mathematics departments increased by 8.1%. However, Table 5D indicates a decline of 3.4% in the total number of U.S. citizen full-time first-year mathematics graduate students from fall 1996 to fall 1997 for these same departments. Table 5B presents the trend in annual percentage change of first-year graduate students in Ph.D.-granting mathematics departments during the years 1986 to 1997. For the first year since 1991, the number of first-year graduate students increased.

Table 5A: Full-Time Graduate Students, Fall 1997, and Percentage Change in Graduate Students, Fall 1996 to Fall 1997

	GROUP								
	I Public	I Private	II	III	I, II, & III	IV	V	M	I, II, III, & M
Full-time graduate students									
Total number	2620	945	2764	2069	8399	2791	1958	2316	10715
Percentage change (%)	-4.8	-3.6	-0.5	-0.8	-2.3	-5.4	4.9	-2.1	-2.3
First-year graduate students									
Total number	559	184	853	633	2229	802	613	831	3060
Percentage change (%)	-3.4	-13.1	19.2	1.5	4.7	2.2	13.3	-0.3	3.3
Usable responses*									
Total number	23	19	44	54	140	51	19	98	238
Percentage (%)	92	83	79	75	80	63	51	42	58

* The number of usable responses varies for different sections of the Departmental Profile Survey. The response rates reported here apply to Tables 5A through 5C on graduate student enrollments only. All counts are projected from the survey response to the respective group as a whole.

Table 5B: Annual Percentage Change in Full-Time, First-Year Graduate Students in Groups I, II & III Combined, 1986 to 1997

Table 5C: Full-Time Female Graduate Students, Fall 1997, and Percentage Change in Female Graduate Students, Fall 1996 to Fall 1997

	GROUP								
	I Public	I Private	II	III	I, II, & III	IV	V	M	I, II, III, & M
Full-time female graduate students									
Total number	688	202	883	731	2504	1199	536	957	3462
Percentage change (%)	-5.7	1.2	-0.9	5.0	-0.5	-8.5	10.7	-1.2	-0.7
First-year female graduate students									
Total number	167	56	321	241	785	372	191	384	1170
Percentage change (%)	5.5	31.4	15.1	-2.2	8.1	0.0	50.4	11.0	9.0

Table 5D: Full-Time U.S. Citizen Graduate Students, Fall 1997, and Percentage Change in U.S. Citizen Graduate Students, Fall 1996 to Fall 1997

	GROUP								
	I Public	I Private	II	III	I, II, & III	IV	V	M	I, II, III, & M
Full-time U.S. citizen grad. students									
Total number	1385	410	1699	1113	4608	1402	894	1757	6365
Percentage change (%)	-7.0	-6.4	-1.5	-7.7	-5.2	-10.8	-3.5	-2.0	-4.3
First-year U.S. citizen grad. students									
Total number	288	77	537	316	1219	419	277	597	1816
Percentage change (%)	-9.2	-22.0	15.0	-16.3	-3.4	5.6	10.7	-9.1	-5.3

Acknowledgments

The Annual Survey of the Mathematical Sciences 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 Annual Survey Data Committee and the Annual Survey staff, I thank the many secretarial and administrative staff members in the mathematical sciences departments for their cooperation and assistance in responding to the survey questionnaires.

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Mathematics People

NSF Graduate Fellowships Announced

The National Science Foundation has announced awards in its Graduate Fellowship Program for fiscal year 1998. This program provides support for students pursuing doctoral study in all areas of science and engineering. Listed below are the names of the 1998 awardees in the mathematical sciences, followed by their undergraduate institutions (in parentheses) and the institutions where they plan to pursue graduate work.

AARON FRANCIS ARCHER (Harvey Mudd College) Cornell University; ERIC BAIR (Utah State University) Stanford University; JEREMY DAVID LIPSITZ BEM (Cornell University) University of California, Berkeley; DANIEL KALMAN BISS (Harvard University) Massachusetts Institute of Technology; KARIANE CALTA (Williams College) Harvard University; AMY ELLEN MAINVILLE COHN (Harvard University) Massachusetts Institute of Technology; MOON DUCHIN (Harvard University) Cornell University; PAUL JOSEPH ELLIS (Princeton University) Harvard University; TAMAR FRIEDMANN (Princeton University) Princeton University; SAMUEL GRUSHEVSKY (Harvard University) Harvard University; TIVON ELAN JACOBSON (University of Arizona) Cornell University; DAVID YEN JAO (Massachusetts Institute of Technology) Massachusetts Institute of Technology; CHRISTOPHER DAVID JERIS (University of Chicago) Harvard University; RAMESH OM JOHARI (Harvard University) Massachusetts Institute of Technology; NICHOLAS ANTHONY LOEHR (Virginia Polytechnic Institute and State University) Massachusetts Institute of Technology; BRIAN OLIVEIRA LUCENA (Harvard University) Brown University; LOUIS ARI MERLIN (Yale University) Stanford University; ANDREW M. NEITZKE (Princeton University) Harvard University; TREVOR HOWARD PARK (University of Arizona) Cornell University; SETH S. PATINKIN (Indiana University, Bloomington) Princeton University; JACOB ANDREW RASMUSSEN (Princeton University) Harvard University; LAWRENCE PIERCE ROBERTS (Washington University) University of California, Berkeley; JESSICA ANN SHEPHERD (University of Utah) Princeton University; SUDHEER POORNACHANDRA SHUKLA (University of Maryland, College Park) University of Chicago; JOHN DAVID STOREY (North Carolina State University) North Carolina State University; HUA TANG (Harvard University) Stanford University; CHRISTOPHER RYAN VINROOT (North Carolina State University) Massachusetts Institute of Technology; RONALD ALLEN WALKER (University of Richmond) Princeton University; BENJAMIN CHARLES WALTER (Rice University) Massachusetts Institute of Technology; DAVID BRIAN WALTON (Brigham Young University) University of Arizona; STEPHEN SOONG WANG (Harvard University) Princeton University; LEAH JEANNINE WELTY (University of Chicago) Washington University; and ALEKSEY ZINGER (Massachusetts Institute of Technology) Massachusetts Institute of Technology.

Editor's note: The institutions of graduate study listed here are from the students' original applications. In some cases students will have switched institutions by the time the fellowship tenure begins.

—NSF announcement

NSF Minority Graduate Fellowships Announced

The National Science Foundation has announced awards in its Minority Graduate Fellowship Program for fiscal year

1998. This program provides support for students who are members of minority groups and who are pursuing doctoral study in science and engineering. Listed below are the names of the 1998 awardees in the mathematical sciences, followed by their undergraduate institutions (in parentheses) and the institutions where they plan to pursue graduate work. DUANE DAVID GILYOT (Rice University) University of California, Berkeley; MONICA THERESA GREENWOOD (St. Bonaventure University) University of Maryland, College Park; SHARON ANN LOZANO (University of Texas, Austin) University of Texas, Austin; FRANCISCO RAMON RIOS (California State University, San Bernardino) University of California, Berkeley; JORGE FEDERICO RODRIGUEZ (Massachusetts Institute of Technology) University of California, San Diego; and NIKKI LATRINA WILLIAMS (Spelman College) Rice University.

Editor's Note: The institutions of graduate study listed here are from the students' original applications. In some cases students will have switched institutions by the time the fellowship tenure begins.

—NSF announcement

Aumann Awarded Nemmers Prize in Economics

Northwestern University has awarded its 1997-98 Erwin Plein Nemmers Prize in economics to ROBERT J. AUMANN, a mathematical economist and professor of mathematics and economics at The Hebrew University of Jerusalem.

The Nemmers Prizes, awarded for work of lasting significance in economics and mathematics, are given every other year to scholars who display "outstanding achievement in their discipline as demonstrated by major contributions to new knowledge or the development of significant new modes of analysis." The prizes each carry a $100,000 stipend.

In connection with the award, Aumann will spend a period of residence at Northwestern University, during which he will present a public lecture and will interact with students and members of the faculty.

Aumann has taught at The Hebrew University of Jerusalem since 1956. He has been one of the leaders in revolutionizing economics and other social sciences by expanding their analysis to issues of strategies, coalitions and information. His contributions include substantial discoveries about large competitive markets and games with a continuum of players, the development of the general model of coalitional games, and the first studies of dynamic strategic interaction with differential information. He founded the subject of interactive epistemology and established the logical foundation of rational correlated behavior.

Aumann received his bachelor of science degree from the City College of New York and his master's and doctoral degrees from the Massachusetts Institute of Technology. He is a past president of the Israel Mathematics Union. He has received the Harvey Prize in Science and Technology from the Technion (Israel Institute of Technology) and the Israel Prize in Economics.

Aumann has written four books and dozens of scientific publications, has founded and edited leading scientific publications, and has organized some of the earliest conferences in game theory and economics.

The Nemmers Prizes, initiated in 1994, were made possible by bequests from the late Erwin P. Nemmers, a former member of the Northwestern University faculty, and his brother, the late Frederic E. Nemmers, both of Milwaukee, Wisconsin. The 1998 selection committees were composed of faculty members from the University of California at Berkeley, Harvard University, Massachusetts Institute of Technology, Yale University, and Northwestern University.

—Northwestern University announcement

Erdős Awards Presented

The Paul Erdős National Awards of the World Federation of National Mathematics Competitions (WFNMC) for 1998 have been presented to MARK SAUL of Bronxville High School in Bronxville, New York; AGNIS ANDJANS of Latvia; and WOLFGANG ENGEL of Germany. Saul is an associate editor of the *Notices*.

The Erdős Award was established to recognize contributions by mathematicians who have played a significant role in developing mathematical challenges at the national level and who have been a stimulus for enriching mathematics learning.

The World Federation of National Mathematics Competitions is an organization of national mathematics competitions affiliated as a special interest group of the International Commission for Mathematical Instruction (ICMI). Its purpose is to provide a focal point for those interested in and concerned with conducting national mathematics competitions to stimulate mathematics learning.

The Erdős Awards were presented at the international conference of the WFNMC, held in July in ZhongShan, China.

—from the WFNMC

Boltzmann Prize to Widom and Lieb

The 1998 Boltzmann Prize has been awarded to BENJAMIN WIDOM of Cornell University and ELLIOTT LIEB of Princeton University.

Widom was cited "for his illuminating studies of the statistical mechanics of fluids and fluid mixtures and their interfacial properties, especially his clear and general formulations of scaling hypotheses for the equation of state and surface tensions of fluids near critical points." Lieb was cited "for his outstanding mathematical investigations of fundamental problems in classical and quantum statisti-

cal physics, including exact solutions of a wide range of models with important applications."

The Boltzmann Prize is given every three years by the Commission on Statistical Physics in the name of the International Union of Pure and Applied Physics.

—Elaine Kehoe

Lieb Awarded Onsager Medal

ELLIOTT LIEB of Princeton University has been awarded the Lars Onsager Medal from the Norwegian University of Science and Technology for his contributions to statistical and mathematical physics.

Previous recipients of the Onsager Medal are Michael Fisher, Benjamin Widom, Walter Ebeling, Russell Donnelly, and Pierre-Gilles de Gennes.

—Helge Holden
Norwegian University of Science and Technology

Mathematicians Elected to Royal Society of Canada

Four mathematicians have been elected as Fellows of the Royal Society of Canada. They are MARTIN T. BARLOW, University of British Columbia; VICTOR IVRII, University of Toronto; SCOTT A. VANSTONE, University of Waterloo; and ALFRED WEISS, University of Alberta.

They will be inducted in November.

The Royal Society of Canada emcompasses a broad range of disciplines and is dedicated to promoting and developing learning and research in the arts and sciences.

—from a Royal Society of Canada press release

Benguria Wins Guggenheim Fellowship

RAFAEL D. BENGURIA of the Pontifical Catholic University of Chile has been awarded a John Simon Guggenheim Fellowship for his work in spectral properties of linear and nonlinear boundary value problems. Benguria was selected as Fellow in Mathematics by the 1998 Latin American and Caribbean Committee of the Foundation.

The Foundation offers fellowships to scholars and artists to aid their research in all fields of knowledge and creation in any of the arts under the freest possible conditions and irrespective of race, color, or creed.

—Guggenheim Foundation

B. H. Neumann Awards Given

The B. H. Neumann Awards for 1998 have been awarded by the Board of the Australian Mathematics Trust to DAVID C. HUNT, University of New South Wales; NATHAN HOFFMAN, retired from the Western Australian Department of Education and Edith Cowan University, and HANS LAUSCH, Monash University.

The awards, named for Bernhard H. Neumann, are presented each year to mathematicians who have made important contributions over many years to the enrichment of mathematics learning in Australia and its region.

—Board of the Australian Mathematics Trust

Sloan Dissertation Fellowships

The Alfred P. Sloan Foundation has announced the names of the 1998 recipients of Sloan Dissertation Fellowships. Fifty fellowships are awarded on a national competitive basis in two fields: mathematics and economics. In each field, leading doctoral departments are invited to nominate candidates. The Foundation does not accept applications from individual students. The awards provide full tuition and a stipend for the dissertation year.

The following lists the names and affiliations of those receiving Sloan Dissertation Fellowships in mathematics.

JINHO BAIK, New York University; MATTHEW BAKER, University of California, Berkeley; SERGEY BARANNIKOV, University of California, Berkeley; MIRA BERNSTEIN, Harvard University; DANIEL K. DUGGER, Massachusetts Institute of Technology; NATHAN DUNFIELD, University of Chicago; SIDDHARTHA GADGIL, California Institute of Technology; JONATHAN P. HANKE, Princeton University; DENIS HIRSCHFELDT, Cornell University; ALEXANDRU DAN IONESCU, Princeton University; ADAM LOGAN, Harvard University; PAUL A. LOOMIS, Purdue University; BENJAMIN MCKAY, Duke University; WAI YAN PONG, University of Illinois at Chicago; VICTOR SCHARASCHKIN, University of Michigan; KRISHNAN SHANKAR, University of Maryland; CHAD SPROUSE, University of California, Los Angeles; DMITRY TAMARKIN, Pennsylvania State University; TITUS TEODORESCU, Columbia University; GUOLING TON, Johns Hopkins University; JEREMY TYSON, University of Michigan; JEFF ALAN VIACLOVSKY, Princeton University; MAXIM VYBORNOV, Yale University; HANS ULRICH WALTHER, University of Minnesota; and CHIU-KWONG WONG, University of California, Los Angeles.

—Alfred P. Sloan Foundation

AMS Menger Awards at the International Science and Engineering Fair

The 1998 International Science and Engineering Fair (ISEF) was held May 10–16, 1998, in the Tarrant County Convention Center in Fort Worth, Texas. Student winners were among 1,012 ninth- through twelfth-graders who earned

AMS Menger Awards.
Back row, left to right: M. Y. Lee, R. L. Barnes, A. E. Eroshin, J. R. Rahe; middle row: J. A. Goldstein, D. Yamins, J. A. Kelner, M. C. Ong, D. C. Rennard; front row: J. R. Walk, S. Flannery, H. Yu, and A. W. Salamon.

the right to compete by winning top prizes at local, regional, state, or, in the case of some foreign students, national science fairs to reach the finals at ISEF. Prizes included plaques, certificates, T-shirts, books, magazine/journal subscriptions, organizational memberships, and cash awards. In addition to ISEF recognition, there were special awards made by other groups, including professional and educational organizations, industry, branches of the military, and colleges and universities. In particular, millions of dollars of scholarship funds were awarded.

For the eleventh time the American Mathematical Society presented the Karl Menger Memorial Awards at the ISEF. This year's AMS judging panel consisted of eight mathematicians: Victor A. Belfi and Robert S. Doran (Texas Christian University), Neal Brand, John W. Neuberger, and Henry A. Warchall (University of North Texas), Jerome A. Goldstein, chair (University of Memphis), Marius N. Nkashama (University of Alabama, Birmingham), and Julian Palmore (University of Illinois at Urbana-Champaign). The panel considered 65 projects, including all 52 projects entered in mathematics. Each panel member inspected each project, and each student was interviewed by at least two panel members. The winners (one first-place winner, two second-place winners, four third-place winners) were given cash prizes, and they and the five honorable-mention winners were given copies of *What's Happening in the Mathematical Sciences* by Barry Cipra (published by the AMS) and a short intellectual biography of Karl Menger, in whose honor the awards are named. The Karl Menger Memorial prize winners were as follows:

First Place ($1,000): Jonathan Adam Kelner, "The Universality of the Near-Zero Microscopic Eigenvalue Spectrum of Random Matrix Ensembles of Infinite Variance", Senior, The Wheatley School, Old Westbury, New York.

Second Place ($500 each): Michael Yanchee Lee, "Algebraic Generalizations of Van der Waerden's Theorem on Arithmetic Progressions", Senior, Norman High School, Norman, Oklahoma; Daniel Yamins, Senior, Great Neck South High School, Great Neck, New York.

Third Place ($250 each): Alexey Evgenjevitch Eroshin, "Several Properties of Periodic Fractions", Junior, Moscow Chemical Lyceum, Moscow, Russia; Sarah Flannery, "Cryptography: Science of Secrecy", Senior, Scoil Mhuire Gan Smal, Blarney, County Cork, Ireland; Jeremy Ryan Rahe, "Prime Factorials! 2", Junior, Bellaire High School, Houston, Texas; Jennifer Rose Walk, "Did Pythagoras Know Everything? A Three-Year Study", Sophomore, Suncoast Community High School, Riviera Beach, Florida.

Honorable Mention: Richard Lee Barnes, "Seeking the Center: Determining the Minimum Value of C in a Trifocal Curve", Sophomore, E. C. Glass High School, Lynchburg, Virginia; Matthew Christopher Ong, "A Polynomial-Based Approach to Mapping Multi-valued Propositional Logics", Junior, Cheyenne Central High School, Cheyenne, Wyoming; David Carl Rennard, "An Identity Expressing n! as a Combination of nth Powers of Consecutive Integers from the nth Row of Pascal's Triangle", Junior, Central High School, Omaha, Nebraska; Anna Welling Salamon, "What Patterns Exist in the Factors of the Fibonacci Numbers?", Senior, San Diego High School, San Diego, California; Hui Yu, "Yu's First Theorem", Junior, El Cerrito High School, El Cerrito, California.

Within each category, the names above were listed alphabetically. The titles indicate the breadth and scope of the projects. But the panel was mainly impressed with the enthusiasm and quality of the work done by these twelve winners and numerous other talented youngsters as well. Our first prize went to a student who classified his project as physics. Our winners included two 16-year-olds from abroad, a woman from Blarney (Cork), and a man from Moscow. It was quite interesting to have John Neuberger serve on the panel. John was Karl Menger's colleague at the Illinois Institute of Technology in the 1960s.

The Society's participation in ISEF is supported in part by income from the Karl Menger Fund, which was established by the family of the late Karl Menger. For more information about this program, contact Timothy Goggins, AMS Development Officer, by e-mail (`tjg@ams.org`) or by telephone (401-455-4110).

—Jerome A. Goldstein

Students Receive Awards for Outstanding Paper Presentations

The AMS sponsors an annual prize that is awarded by Pi Mu Epsilon. The prize was instituted in 1989, in honor of PME's seventy-fifth anniversary. PME administers the prize and uses it to recognize the best student papers presented at a PME student paper session. Each recipient of the AMS Award for Outstanding Pi Mu Epsilon Student Paper Presentation receives a check for $100. Following is a list of the recipients for this award during the last five years.

1993 Awards

VLADIMIR DIMITRIJEVIC, Youngstown State University, "A Marble Drop Method for Solving Linear Programs"; JENNIFER GARRETT, Miami University, "Bayesian Probability and Credibility Theory in Insurance Ratemaking"; LAUREN D. HARTMAN, Washington and Lee University, "Differential Hyperbolic Geometry"; JON HESTER, Hendrix College, "Data Structures in the Implementation of the Huffman Algorithm"; and JOEL M. WISDOM, University of Tennessee, Chattanooga, "A Study of the Representations of Even Numbers as the Sum of Two Primes".

1994 Awards

ANDREW DOUGLASS, Miami University, "The Problems of Scale in the Hyperbolic World"; ALLEN HARBAUGH, Boston University, "The Number Theoretic Properties of the Dynamical System Known as Rigid Rotation"; KATHRYN NYMAN, Carthage College, "Quantum Cryptography"; SONNY VU, University of Illinois, "On (B, n)-Happiness Sequences"; and JEB F. WILLENBRING, North Dakota State University, "The Combinatorics of Semi-Direct Products of Cyclic Groups".

1995 Awards

ARON ATKINS, Worcester Polytechnic Institute, "The Traveling Salesman Returns Home" and "A Non-heuristic Minimum Cycle Algorithm"; ASHLEY CARTER, University of Wisconsin, Parkside, "Applications of the Polya-Burnside Theorem to Teaching, Toys and Jewelry"; ALAYNE CLARE, Youngstown State University, "Check Digits and License Numbers"; and SCOTT CLARK, Youngstown State University, "The Triangle Peg Game".

1996 Awards

SCOTT CLARK, Youngstown State University, "Extensions of the Tower of Hanoi"; STEPHEN HAPTONSTAHL, Louisiana State University, "Computing Integrals for the Invariant Measure of Elementary Fractals"; KIM JORDAN, Youngstown State University, "Graceful Creatures of the Sea"; PI-YEH LIU, Clarion University, "Two-Color Radio Numbers for Some Inequalities"; VINCENT LUCARELLI, Youngstown State University, "Qualitative Analysis of Dynamical Systems"; and EUGENE SY, University of California, Davis, "Pipeflow in the Region of a Bifurcation".

1997 Awards

JEFF CLOUSE, Youngstown State University, "Is Coca-Cola an Underachiever?"; JOSHUA HORTSMAN and JAYME MOORE, Rose-Hulman Institute of Technology, "Meetings, Bloody Meetings"; VINCENT LUCARELLI, Youngstown State University, "Why Is 9 Prime?"; MICHAEL PERRY, University of Akron, "On the Brink of Bankruptcy: A Mathematical Model Describing the Social Security System in the United States"; and SHERYLE PROPER, Allegheny College, "Symmetry Structure Analysis of Finite Designs and Infinite Patterns in Decorative Art Work: Amish Quilt Patterns and Other Rural Designs".

—Allyn Jackson

Visiting Mathematicians

(Supplementary List)

Mathematicians visiting other institutions internationally during the 1998–99 academic years were listed in the June/July 1998 issue of the *Notices*, pp. 730–31; August 1998 issue of the *Notices*, p. 885; and the September 1998 issue of the *Notices*, p. 994. The following is an update (home country is listed in parentheses).

ANDRZEJ CZYGRINOW (Poland), Arizona State University, Discrete Math, 8/98–5/99.

SERGEI SUSLOV (Russia), Arizona State University, Classical Analysis and Approximation Theory, Orthogonal Polynomials and q-Special Functions, Theory of Group Representations, Integral Transformations and Their Applications in Theoretical and Mathematical Physics, 5/98–8/99.

XIAO-QIANG ZHAO (China), Arizona State University, Differential Equations, Dynamical Systems, and Mathematical Biology, 8/98–5/99.

Mathematics Opportunities

Guggenheim Memorial Foundation Fellowships

The John Simon Guggenheim Memorial Foundation provides fellowships to individuals in the natural sciences who have demonstrated exceptional capacity for productive scholarship. The purpose of the fellowships is to further the development of scholars by allowing them to engage in research under the freest possible conditions and irrespective of race, color, or creed.

Fellowships are awarded through two annual competitions. One competition is open to citizens and permanent residents of the United States and Canada, the other to citizens and permanent residents of Latin America and the Caribbean. They are awarded to advanced professionals only and are not intended to be used for training or immediate postgraduate work.

Grants are made for a minimum of six months, although one year is the most common length of appointments. Amounts of the grants are dependent on the needs of the recipients; other available resources and the purpose and scope of the fellows' plans are taken into consideration. The average grant amount in 1998 was approximately $31,000. The purpose of the program is to provide fellows with blocks of time in which they can work with as much creative freedom as possible; therefore, grants are made without special conditions, and recipients may spend their grant funds in any way that is necessary to their work.

Scholars must apply directly to the Guggenheim Foundation for both the United States and Canada competition and the Latin America and Caribbean competition. Applicants are compared with others working in their fields and with all others in the competition. Each application is reviewed by advisers who work in the same field as the applicant. A final Committee of Selection for each competition determines the number of awards made in each field.

Application forms for the 1999 fellowship competitions are available from the John Simon Guggenheim Memorial Foundation, 90 Park Avenue, New York, NY 10016; telephone 212-687-4470; fax 212-697-3248; e-mail: `fellowships@gf.org`. When requesting an application by mail, applicants should use their institutional letterhead, include their academic title, and indicate their field of scholarship. The deadline for receipt of applications for the United States and Canada competition is **October 1, 1998.** The deadline for receipt of applications for the Latin America and Caribbean competition is **December 1, 1998.** Application forms may also be requested and further information obtained through the Foundation's Web site, `http://www.gf.org/`.

—Elaine Kehoe

Quantitative Approaches to Complex Biological Problems

The National Institute of General Medical Sciences (NIGMS) of the National Institutes of Health (NIH) is looking to support research projects that develop quantitative approaches to describe, analyze, and predict the behavior of complex biological systems. The projects are expected to be of a collaborative and cross-disciplinary nature, involving individuals with diverse expertise who can work in research areas in which systems approaches are likely to make significant contributions.

Five related initiatives have been formulated in part from recommendations made at workshops held in late 1997 on "New Approaches to the Study of Complex Biological Processes" and "The Genetic Architecture of Complex Traits". The reports of these workshops can be found on the NIGMS Web site at `http://www.nih.gov/nigms/news/reports/`, `http://www.nih.gov/nigms/news/reports/complexbio.html`, and `http://www.nih.gov/nigms/news/reports/genetic_arch.html`.

The workshop participants recommended three classes of initiatives: (1) the support of interdisciplinary research with the specific objective of attracting investigators trained in the mathematically based disciplines (physics, engineering, computer science, applied mathematics, and chemistry) to the study of biomedical problems; (2) the development of workshops and other vehicles to train established biomedical scientists in new, quantitative approaches to their fields of study and, reciprocally, to acquaint established, mathematically expert nonbiologists with biological problems; and (3) the promotion of interdisciplinary training for scientists at the pre- and postdoctoral levels.

The initiatives and the Web sites where the full text of each program announcement can be found are the following: Supplements for the Study of Complex Biological Systems, PA-98-024, January 16, 1998, `http://www.nih.gov/grants/guide/pa-files/PA-98-024.html`; Quantitative Approaches to the Analysis of Complex Biological Systems, PA-98-077, June 4, 1998 (cosponsored with the National Institute of Mental Health [NIMH]), `http://www.nih.gov/grants/guide/pa-files/PA-98-077.html`; Genetic Architecture of Complex Phenotypes, PA-98-078, June 9, 1998 (cosponsored with NIEHS, NIAMS, NIA, NIMH, NIDA, NIAAA, NICHD, NHGRI, NHLBI), `http://www.nih.gov/grants/guide/pa-files/PA-98-078.html`; Fellowships in Quantitative Biology, PA-98-082, June 23, 1998, `http://www.nih.gov/grants/guide/pa-files/PA-98-082.html`; Short Courses on Mathematical and Statistical Tools for the Study of Complex Phenotypes and Complex Systems, PA-98-083, June 23, 1998 (cosponsored with NIMH, NIDA, NIDDK, NHGRI), `http://www.nih.gov/grants/guide/pa-files/PA-98-083.html`.

Eligibility requirements and more information about each initiative, as well as application procedures and award criteria, can be found on the individual program announcement Web pages. Inquiries are welcome and should be directed to the contact people listed in the program announcements.

—from an NIGMS announcement

NCTM 2001 Yearbook

Students express mathematical concepts in a variety of ways. How do these expressions, or representations, affect their understanding of mathematics? To provide a forum for sharing research, thoughts, and anecdotes, the National Council of Teachers of Mathematics (NCTM) will publish the *2001 Yearbook, the Roles of Representation in School Mathematics.* The NCTM's Educational Materials Committee is now inviting manuscripts for this volume, which will be edited by Al Cuoco, senior scientist and codirector of the Mathematics Initiative at Education Development Center, Newton, Massachusetts.

The goal of this yearbook is to create a forum for current thinking and practice related to the representations (such as graphs, tables, diagrams, manipulatives, equations, and so forth) used to record and communicate mathematical ideas and for developing mathematical thinking throughout the grades K–14. In particular, the yearbook editorial panel is interested in papers addressing instructional implications for using various representations of mathematical ideas and contexts, the use and construction of symbol systems in school mathematics, and the tools students use for thinking mathematically. The panel also welcomes brief articles on classroom experiences with representations that reflect cultural, affective, and linguistic influences.

Author guidelines are now available and include a complete description of topics to be addressed and instructions for preparing manuscripts. For a copy of the guidelines, write to General Editor Frances R. Curcio, Department of Teaching and Learning, School of Education, New York University, 239 Greene Street, Mail Code 4741, Washington Square, New York, NY 10003, USA; e-mail: `frc1@is2.nyu.edu`. The guidelines may also be obtained from NCTM's Fax on Demand service, 800-220-8483, document #852; or from NCTM's Web site (`www.nctm.org/`) under "Publications". The deadline for receiving manuscripts is March 1, 1999.

—Frances R. Curcio

Correction

The August 1998 issue of the *Notices* contained an error in the news item on deadlines and target dates for programs in the Division of Mathematical Sciences (DMS) of the National Science Foundation. The corrected dates are as follows:

October 9, 1998 (target date): Foundations

November 4 (target date): Topology

Both target dates were incorrectly listed as November 7.

All DMS deadlines and target dates are listed on the DMS Web site, `www.nsf.gov/mps/dms/`.

For Your Information

13th BMS Annual Department Chairs' Colloquium

Each fall the Board on Mathematical Sciences (BMS) of the National Research Council (NRC) holds the Mathematics Department Chairs' Colloquium. This year's colloquium will be held Friday and Saturday, November 13 and 14, at the Hyatt Regency Washington Hotel in Washington, DC. The theme is "Leading, Innovating, and Succeeding".

There will be plenary sessions and workshops on new federal funding programs; issues that concern small colleges; valuable lessons from statistics departments; innovative curricula; creative department programs; faculty issues such as preparing TAs for teaching, using adjuncts, and posttenure review; and collaboration between mathematical and other sciences.

At this time the scheduled organizers and speakers are: Steven Altschuler, Microsoft Corporation; Lynne Billard, University of Georgia; Richard Brualdi, University of Wisconsin; Tony Chan, University of California, Los Angeles; Phyllis Chinn, Humboldt State University; Kevin Clancey, University of Georgia; George Cobb, Mount Holyoke College; John B. Conway, University of Tennessee; Pamela Cook, University of Delaware; Heidi Davis, National Research Council; Robert Fefferman, University of Chicago; Joan Ferrini-Mundy, Mathematical Sciences Education Board; Joan Garfield, University of Minnesota; James Keener, University of Utah; Douglas Kelly, University of North Carolina, Chapel Hill; Timothy Lance, State University of New York, Albany; Jim Lewis, University of Nebraska; George McCabe, Purdue University; Douglas Ravenel, University of Rochester; William Rundell, Texas A&M University; Christine Stevens, St. Louis University; and John Tucker, BMS. Speakers are subject to change.

The National Science Foundation Divisions of Mathematical Sciences; Undergraduate Education; and Elementary, Secondary, and Informal Education will host an open house on Thursday, November 12, to announce new opportunities, answer questions, and speak informally with chairpersons.

Chairpersons attending the colloquium who are interested also in meeting with congressional representatives or staff or in learning more about how to ensure that such meetings (either in Washington or in their home districts) are most effective should contact Samuel Rankin at the AMS Washington office: 202-588-1100, e-mail: `smr@ams.org`.

The registration fee is $175. Registration forms must be sent by **October 30, 1998**. For further information contact: Board on Mathematical Sciences, National Research Council, Room NAS 340, 2101 Constitution Avenue, NW, Washington, DC 20418-0001; telephone 202-334-2421; e-mail: `bms@nas.edu`.

—from a BMS announcement

John A. Thorpe Named NCTM Executive Director

JOHN A. THORPE of Queens College of the City University of New York has been named executive director of the National Council of Teachers of Mathematics. He succeeds Linda Rosen, who left the NCTM in 1997.

Thorpe received his Ph.D. degree in mathematics from Columbia University. He has been professor of mathematics and vice-provost for undergraduate education at the State University of New York at Buffalo, as well as director of the undergraduate programs in mathematics at the State Uni-

versity of New York at Stony Brook. While at Stony Brook he received the Chancellor's Award for Excellence in Teaching. He served as senior vice president and provost, as well as professor of mathematics, at Queens College from 1993 to 1998. He has also directed the Instructional Materials Development Program at the National Science Foundation and chaired the Science Policy Committee of the Mathematical Association of America. He is the author of four books on elementary topology and geometry, differential geometry, and linear algebra.

"NCTM plays an important advocacy role for excellence in mathematics teaching and learning," Thorpe said. "I am delighted to be able to make a contribution to the work of the Council and its members." Thorpe assumed his duties as executive director on April 13.

—from an NCTM Announcement

NCTM Standards To Be Revised

Since 1996 the National Council of Teachers of Mathematics (NCTM) has been working on a revision of the Standards that it initiated in 1989. The updated Standards will incorporate the advances and experiences of the past ten years and will combine the three sets of Standards for curriculum, teaching, and assessment into one volume. A draft of the updated Standards will be available for public review in the fall of 1998, and the final version will be released in the spring of 2000.

The basic premise of the Standards is that all students should be provided with the opportunity to learn significant and sound mathematics. In view of that goal, the revision will include a more cohesive discussion of the development of students' mathematical knowledge across the grade span, from prekindergarten to grade 12, and will incorporate new knowledge about the ways students learn mathematics, as well as advice from mathematicans about the content development of mathematics. The new Standards will focus on the classroom and will be designed to cover four grade bands: prekindergarten to grade 2, grades 3 through 5, grades 6 through 8, and grades 9 through 12.

The revised Standards are expected to contain the following: a set of principles for instructional programs in mathematics that address necessary elements of effective mathematics education at the classroom, school, district, and national levels; content and process standards for all grade levels; and one chapter specifically addressing each grade band that explains and elaborates the standards and associated key ideas for each band.

The members of the Commission on the Future of the Standards, which has been charged with the revision, are: Mary Lindquist (chair), Columbus State University, Georgia; Fred Crouse, Annapolis Valley Regional School Board, Nova Scotia; Portia Elliott, University of Massachusetts; Mazie Jenkins, Madison, Wisconsin, school system; Jeremy Kilpatrick, University of Georgia; Michael Koehler, Overland Park, Kansas, school system; Marilyn Mays, North Lake College, Texas; Richard Schoen, Stanford University; Bonnie Walker, Texas ASCD; and Gary Martin, NCTM staff liaison. The ex officio members of the Commission are Glenda Lappan, president of NCTM; Gail Burrill, past president of NCTM; and John Thorpe, executive director of NCTM.

A copy of the revised Standards may be requested from the NCTM and will also be available on the Web. Further information is available on the Council's Web site, `http://www.nctm.org/`. The Council may be contacted by e-mail at `future@nctm.org` or by telephone at 703-620-9840.

Issues related to the NCTM Standards revision were discussed in an article "The AMS and Mathematics Education: The Revision of the NCTM Standards" in the February issue of the *Notices*, page 243.

—Elaine Kehoe

Cryptologia Sponsors Undergraduate Paper Competition

The journal *Cryptologia* sponsors an annual Undergraduate Paper Competition in cryptology. The purpose of the competition is to encourage the study of all aspects of cryptology in undergraduate curricula. Undergraduate students are encouraged to enter; faculty are urged to inform their students about the competition. The topic may cover any technical, historical, or literary area of cryptology. First prize is $300 and publication of the winning paper in the journal. Three copies of the paper should be sent to: *Cryptologia*, Department of Mathematical Sciences, United States Military Academy, West Point, NY, 10996. Further information about the journal and the competition may be found at `http://www.dean.usma.edu/math/resource/pubs/cryptolo/index.htm`.

Cryptologia is a scholarly journal devoted to all aspects of cryptology; it has been published as a quarterly since 1977. Topics covered include computer security, history, codes and ciphers, mathematics, military science, espionage, cipher devices, literature, and ancient languages.

—Brian Winkel, Editor
Cryptologia

Correction

The information about the institutional affiliation of 1997 Ostrowski Prize winner Gilles Pisier in the August 1998 *Notices* was incomplete. In addition to being a professor at the University of Paris VI, Pisier is a tenured faculty member at Texas A&M University, a position he has held since 1985. His position at A&M is Distinguished Professor of Mathematics A. G. & M. E. Chair of Mathematics.

Reference

Upcoming Deadlines

October 1, 1998: Deadline for nominations for the Louise Hay Award. For details see "Mathematics Opportunities" in the September *Notices* or write to The Hay Award Selection Committee, Association for Women in Mathematics, 4114 Computer & Space Sciences Building, University of Maryland, College Park, MD, 20742-2461; call 301-405-7892; or send e-mail to `awm@math.umd.edu`.

October 1, 1998: Deadline for receipt of applications for the United States and Canada competition for the Guggenheim Memorial Foundation Fellowships. For details see "Mathematics Opportunities" in this issue.

October 15, 1998: Deadline for submission of grant proposals to the National Security Agency. For further information consult the NSA Web site at `http://www.nsa.gov:8080/programs/msp/grants.html`, call 301-688-0400, send e-mail to `msp@math13.math.umbc.edu`, or write to Director, Mathematical Sciences Program, Attn: R51A, National Security Agency, Ft. George R. Meade, MD 20755-6000.

October 16, 1998: Deadline for applications for the NSF Mathematical Sciences Postdoctoral Research Fellowship Program. More information will be available at the NSF Web site: `http://www.nsf.gov/mps/dms/dmsdead/` or from the Infrastructure Program, Room 1025, Division of Mathematical Sciences, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230; telephone 703-306-1870; e-mail `msprf@nsf.gov`.

October 30, 1998: Deadline for registration for the BMS Annual Department Chairs' Colloquium. For details, see "For Your Information" in this issue.

December 1, 1998: Deadline for receipt of applications for the Latin American and Caribbean competition for the Guggenheim Memorial Fellowships. For details, see "Mathematics Opportunities" in this issue.

DoD Mathematics Staff

Five agencies of the Department of Defense fund research in the mathematical sciences. The names, addresses, and telephone numbers of the pertinent staff members are listed below.

Advanced Research Projects Agency

Applied and Computational Mathematics Program

ARPA

Defense Sciences Office
3701 North Fairfax Drive
Arlington, VA 22203-1714
`http://www.darpa.mil`

Anna Tsao, Director
703-696-2287
Fax: 703-696-3999
`atsao@darpa.mil/`

Air Force Office of Scientific Research

Directorate of Mathematics and Geosciences

AFOSR/NM
110 Duncan Avenue
Suite B115
Bolling AFB, DC 20332-8080
Fax: 202-404-7496
`http://web.fie.com/htest/fed/afosr/org.htm`

Charles J. Holland, Director
202-767-5025
`charles.holland@afosr.af.mil`

More detailed contact information for the Air Force Office of Scientific Research will be provided in a future issue of the *Notices*.

Army Research Office

Mathematical and Computer Sciences Division

P.O. Box 12211

Research Triangle Park, NC
27709-2211

919-549-4321
Fax: 919-549-4354
http://www.aro.army.mil/
Robert L. Launer, Associate Director

Applied Analysis
John Lavery
919-549-4253
lavery@aro-emh1.army.mil

Computational Mathematics
Stephen Davis
919-549-4284
sdavis@aro-emh1.army.mil

Probability, Statistics, and Stochastic Analysis
Robert Launer
919-549-4309
launer@aro-emh1.army.mil

Software and Knowledge-Based Systems
David Hislop
919-549-4255
hislop@aro-emh1.army.mil

Systems and Control
Linda Bushnell
919-549-4319
bushnell@aro-emh1.army.mil

Discrete Mathematics and Computer Science
Vacant
919-549-4256

National Security Agency
Mathematical Sciences Program
Attn: R51A
Ft. George G. Meade, MD 20755-6557

Charles F. Osgood, Director
301-688-0400
msp@math13.math.umbc.edu

Office of Naval Research
Mathematical, Computer, and Information Sciences Division

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800 N. Quincy St.
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Fax: (703) 696-2611
http:// www.onr.navy.mil/

Andre van Tilborg, Director
703-696-4312
avantil@itd.nrl.navy.mil

Operations Research
Don Wagner
703-696-4313
wagnerd@onr.navy.mil

Probability and Statistics
Wendy Poston
703-696-4320
postonw@onr.navy.mil

Numerical Analysis
Richard Lau
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Applied Analysis
Wen Masters
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Robotics
Teresa McMullen
703-696-3163
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Neurally-Inspired Systems
Clifford Lau
703-696-4961
lauc@onr.navy.mil

Command, Control, and Combat Systems
Paul Quinn
703-696-5753
quinnp@onr.navy.mil

David Jakubek
703-696-0872
jakubed@onr.navy.mil

Computer and Software Systems
Ralph Wachter
703-696-4304
wachter@onr.navy.mil

Intelligent Systems
Michael Shneier
703-696-4303
shneiem@onr.navy.mil

Scientific Visualization
Larry Rosenblum
202-767-5333
rosenblj@itd.nrl.navy.mil

DoE Mathematics Program

The Department of Energy (DoE) funds research in the mathematical sciences in a number of areas, particularly applied mathematics and areas connected with the High Performance Computing and Communications (HPCC) initiative. The names of the directors of the relevant programs are given below.

Applied Mathematics
Frederick A. Howes
301-903-3166
howes@er.doe.gov

Computer Science and HPCC
Daniel Hitchcock
301-903-5800
hitchcock@er.doe.gov

These programs are managed by the Mathematical, Information, and Computational Sciences Division of DoE. The telephone number for the Division is 301-903-5800, and the fax number is 301-903-7774. The mailing address is the Mathematical, Information, and Computational Sciences Division, Department of Energy, ER-31, 19901 Germantown Road, Germantown, MD 20874. The URL for the Division's World Wide Web page is http://www.er.doe.gov/production/octr/mics/index.html.

NSF Division of Mathematical Sciences

Listed below are names, e-mail addresses, and telephone numbers for the program directors for the coming academic year in the Division of Mathematical Sciences of the National Science Foundation.

Algebra and Number Theory
Ann K. Boyle
703-306-1875
aboyle@nsf.gov

Daniel Madden
703-306-1870
dmadden@nsf.gov

Lance Small
703-306-1884
lsmall@nsf.gov

Murray Schacher
703-306-1876
mschacher@nsf.gov

Analysis Program
Joe Jenkins
703-306-1879
jjenkins@nsf.gov

Carlos Berenstein
703-306-1992
cberenst@nsf.gov

Bruce Palka
703-306-1994
bpalka@nsf.gov

Applied Mathematics
Hans Engler

703-306-1870
hengler@nsf.gov
Deborah F. Lockhart
703-306-1882
dlockhar@nsf.gov

Jong-Shi Pang
703-306-1877
jpang@nsf.gov

John Strikwerda
703-306-1870
jstrikwe@nsf.gov

Computational Mathematics
Michael Steuerwalt
703-306-1878
msteuer@nsf.gov

John Strikwerda
703-306-1870
jstrikwe@nsf.gov

Infrastructure Program
Lloyd Douglas
703-306-1874
ldouglas@nsf.gov

Alvin Thaler
703-306-1880
thaler@nsf.gov

Statistics and Probability
Keith Crank
703-306-1885
kcrank@nsf.gov

Javier Rojo
703-306-1870
jrojo@nsf.gov

James L. Rosenberger
703-306-1883
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Topology and Foundations
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Where to Find It

A brief index to information that appears in this and previous issues of the *Notices*.

Stipends for Study and Travel

Graduate Support

American Association for the Advancement of Science

Summer Fellowship

Description: Fellows will work for radio and television stations, newspapers, and magazines and will have their travel expenses and stipends paid by the AAAS. Fellows will have the opportunity to: observe and participate in the process by which events and ideas become news, improve their communication skills by teaming to describe complex technical subjects in a manner understandable by the public, and increase their understanding of editorial decision making and the manner in which information is effectively disseminated. Each fellow will: attend an orientation and evaluation session in Washington, DC; begin the internship in mid-June; and submit an interim and final report to AAAS to help evaluate the program.
Eligibility: Provides support for twenty-five outstanding graduate students in mathematics, the natural and social, sciences and engineering as reporters, researchers, and production assistants in the mass media. (Exceptional undergraduate or postdoctoral students will also be considered.)
Grant amount: $400/week stipend for ten weeks.
Deadline: January 15, 1998.
Application information: Amie E. Hubbard, Coordinator, Mass Media Science and Engineering Fellows Program, American Association for the Advancement of Science, 1333 H Street, NW, Washington, DC 20005.

American Association of University Women (AAUW) Educational Foundation

American Fellowships

Description: Postdoctoral, dissertation, and summer postdoctoral faculty fellowships for women fulfilling eligibility requirement. Applicants for the postdoctoral fellowships must hold a doctoral degree by the application deadline. An applicant must have completed all course work, passed all examinations, and have had the dissertation proposal or plan approved by the application deadline.
Eligibility: Women who are citizens or permanent residents of the U.S.
Grant amount: The postdoctoral fellowships provide $27,000 and some have disciplinary restrictions. The summer postdoctoral faculty fellowships provide stipends of $5,000. The dissertation fellowships provide stipends of $15,000 for the final year of writing the dissertation.
Deadline: November 15 (postmark).
Application information: AAUW Educational Foundation, American Fellowships, P.O. Box 4030, Iowa City, IA 52243-4030; telephone: 319-337-1716; fax: 319-337-1204.

Associated Western Universities, Inc.

Description: AWU, in partnership with federal laboratories, industry, and other cooperating facilities, provides fellowships for science and engineering research participation. Fellowship participants are hosted by nearly sixty federal and industrial facilities.
Eligibility: Faculty, advanced-degree graduates, graduate, and undergraduate students in discipline areas including the physical and biological sciences, mathematics, computer science, engineering, and technology.
Application information: Associated Western Universities, Inc., 4190 S. Highland Drive, Suite 211, Salt Lake City, UT 84124; tel: 801-273-8900; fax: 801-277-5632; e-mail: `info@awu.org`; home page: `http://www.awu.org/`.

Bunting-Cobb Graduate Residential Fellowships for Women

Description: Douglass College, the largest women's college in the nation, offers the Bunting-Cobb Graduate Residential Fellowship program. Bunting-Cobb Fellows serve as mentors to the undergraduates in the residence hall. The hall is equipped with a microcomputer room and a resource library.

Items marked with a • are repeated from the October 1997 issue with only a change in the year; the resulting announcement has not yet been confirmed by the sponsoring agent.

Eligibility: Women graduate students enrolled in math, science, or engineering programs at Rutgers University's Graduate School on its New Brunswick campus.
Grant amount: $3,000 to $4,000, depending on duties, as well as room and board for the academic year in the Bunting-Cobb Math, Science, and Engineering Hall.
Application information: For information about the Bunting-Cobb Fellowship, please contact Dr. Ellen F. Mappen, Director, Douglass Project for Rutgers Women in Math, Science, and Engineering at 732-932-9197, ext. 10; or e-mail at `dougproj.rutgers.edu`. For information about graduate study at Rutgers, please contact Ms. Beverly Tarter at 732-932-7711.

East Tennessee State University

Assistantships

Description: East Tennessee State University offers the M.S. in mathematics and has a variety of assistantships available with stipends from $7,200–$10,250 per academic year plus a tuition waiver. Duties are primarily grading responsibilities for the first year and teaching for the second. Some assistantships are for the mathematics laboratory. ETSU is located in upper east Tennessee in an area known for its natural beauty and recreational facilities.
Application information: James W. Boland, e-mail: `BOLAND@access.etsu.edu`.

Fellowships in Mathematics and Molecular Biology

Description: The Program in Mathematics and Molecular Biology (PMMB), with support from the National Science Foundation and the Burroughs Wellcome Fund, offers graduate and postdoctoral fellowships for training and research at the interface between mathematics and molecular biology. Current fellowship research topics include geometry and topology of nucleic acids, mathematical analysis of protein structure and dynamics, radiation hybrid mapping of the human genome, physical studies of single DNA molecules, and algorithms for biomolecular design. Applicants must propose a project with both a mathematical and a biological component in order to be considered. PMMB fellowships can be held at any university or college in the United States.
Deadline: Application deadline is February 1, 1998. Women and minorities are encouraged to apply. Funding can begin between July 1, 1998, and November 1, 1998.
Application information: For information and application materials contact: Program in Mathematics and Molecular Biology, Department of Mathematics, Florida State University, Tallahassee, FL 32306; tel: 850-644-8710; fax: 850-644-6612; e-mail: `pmmb@math.fsu.edu`.

Florida Education Fund

The McKnight Doctoral Fellowship Program

Description: A McKnight Doctoral Fellowship provides funds to twenty-five African American citizens to pursue Ph.D. degrees at participating Florida universities. Contingent upon successful academic progress, the maximum length of the award is five years. The Florida Education Fund provides the first three years, and the student's university continues funding at the same level of support for an additional two years.
Eligibility: Applicants must hold or be receiving a bachelor's degree from a regionally accredited college or university.
Grant amount: Up to $5,000 in tuition and fees plus an annual stipend of $11,000.
Deadline: The deadline for applications for fall 1999 is January 15, 1999.
Application information: Detailed information and application packets can be obtained by writing or calling: The Florida Education Fund, 201 E. Kennedy Boulevard, Suite #1525, Tampa, FL 33602; 813-272-2772. Or visit our Web site at: `http://www.fl-educ-fd.org/`.

Ford Foundation Predoctoral and Dissertation Fellowships for Minorities

Description: Predoctoral and dissertation fellowships.
Eligibility: Available to minorities enrolled in research-based doctoral programs in mathematics, engineering, and other fields. These will be offered on a competitive basis to individuals who are citizens or nationals of the U.S. and who are members of the following groups: Alaskan Natives (Eskimo or Aleut), Native American Indians, Black/African Americans, Mexican Americans/Chicanos, Native Pacific Islanders (Polynesian or Micronesian), and Puerto Ricans.
Grant amount: Annual stipends of $14,000 and $18,000 respectively. The predoctoral awards also include an allowance of $7,500 to the awardee's university in lieu of tuition and fees.
Deadline: The deadline for applications is early November 1998.
Application information: Students interested in the 1999 doctoral fellowships may obtain application materials from the Fellowship Office, National Research Council, 2101 Constitution Avenue, NW, Washington, DC 20418; telephone: 202-334-2872.

Georgia Institute of Technology

President's Fellowships

Description: These stipends are awarded to a selected number of highly qualified U.S. nationals who intend to pursue doctoral degrees. The fellowships are intended to supplement other forms of support and can be extended for three additional years based on academic performance and research potential.
Eligibility: The awards are highly competitive; selection is based on academic criteria and evidence of scholarship. Participants are expected to maintain high academic standing.
Grant amount: $5,000 for twelve months.

Graduate Research/Teaching Assistantships

Eligibility: Appointments are based primarily on scholarship and ability to contribute to ongoing programs of the school.

Grant amount: $15,600 per twelve months, plus waiver of all tuition and fees.
Application information: Prospective students who consider themselves highly qualified for an award should include with their application for admission a letter describing in as much detail as possible their qualifications and needs. Write to the Ph.D. Coordinator, College of Computing, Georgia Institute of Technology, Atlanta, GA 30332-0280, or e-mail to `phd-info@cc.gatech.edu`.

Daniel and Florence Guggenheim Foundation

Description: Fellowships for U.S. and Canadian residents interested in jet propulsion, energy conversion, fluid mechanics, and flight structures.
Application information: For information on flight structures, write to the Department of Civil Engineering and Engineering Mechanics, Columbia University. For information on applied physics and materials science; dynamics and control systems; energy conversion, propulsion, and combustion; energy and environmental policy; flight science and technology; and fluid mechanics and computational and experimental fluid mechanics, write to the Director of Graduate Studies, Department of Mechanical and Aerospace Engineering, Princeton University, Princeton, NJ 08544.

Fannie and John Hertz Foundation Fellowships

Description: For the support of personal and institutional expenses during graduate education directed toward the Ph.D. degree in applied physical sciences. Tenable at the Department of Applied Science of the Davis Campus and at all campuses of the University of California; California Institute of Technology; Carnegie-Mellon University; The University of Chicago; Cornell University; Courant Institute of Mathematical Sciences, New York University; Georgia Institute of Technology; Harvard University; Johns Hopkins University; University of Illinois at Urbana-Champaign; Massachusetts Institute of Technology; University of Minnesota; Polytechnic Institute of New York; Princeton University; Purdue University; Rensselaer Polytechnic Institute; Rice University; University of Rochester; Stanford University; University of Texas at Austin; Texas A&M University; Vanderbilt University; University of Michigan, Ann Arbor; University of Washington, Seattle; University of Wisconsin, Madison; and Yale University.
Eligibility: Offered on the basis of academic (A-undergraduate GPA) and research performance, recommendations, and personal technical interview.
Grant amount: The stipend is $25,000, plus a cost-of-education allowance which is accepted at all of the tenable schools in lieu of fees and tuition per nine-month year.
Deadline: Application deadline is second to last Friday in October each year.
Application information: Applicants should write to the Office of the Graduate Dean at these institutions or write directly to the Hertz Foundation, Box 5032, Livermore, CA 94551-5032.

• National Science Foundation

Graduate Research Fellowships

Description: Three-year awards available to citizens or nationals of the U.S. and permanent residents for full-time study leading to master's or doctoral degrees in science (including mathematics) and engineering.
Eligibility: Awards made only to students who have completed no more than twenty semester-hours or thirty quarter-hours of graduate study in science or engineering.
Grant amount: Stipends of $14,400 proposed for 1997–98 for a 12-month tenure. No dependency allowances. Education allowance paid to fellowship institution.
Deadline: Application deadline is early November.
Application information: Mail request to: NSF Graduate Research Fellowship Program, Oak Ridge Associated Universities (ORAU), P.O. Box 3010, Oak Ridge, TN 37831-3010; 423-241-4300; e-mail: `nsfgrfp@orau.gov`. Materials available in early September 1997.

• National Science Foundation

Minority Graduate Research Fellowships

Description: Awarded for study or work leading to the master's or doctoral degrees, these fellowships are granted for periods of three years.
Eligibility: Open to U.S. citizens or nationals or permanent residents who are members of an ethnic minority group underrepresented in the advanced levels of the U.S. science personnel pool, i.e., American Indian, Native Alaskan (Eskimo or Aleut), Black/African American, Hispanic, or Native Pacific Islander (Polynesian or Micronesian). Awards made only to students who have completed no more than thirty semester-hours or forty-five quarter-hours, or equivalent, of graduate study in science or engineering.
Grant amount: The stipend is $14,400 proposed for 1997–98 for 12-month tenures. No dependency allowances. Education allowance paid to fellowship institution.
Deadline: The deadline for applications is early November.
Application information: Mail request for application materials to: Oak Ridge Associated Universities (ORAU), P.O. Box 3010, Oak Ridge, TN 37831-3010.

• National Security Agency

Description: Standard research proposals designed principally to provide summer salary for professors and support for graduate students in areas of interest listed below. The National Security Agency (NSA) awards grants to universities in support of self-directed research in the following areas of mathematics (including possible computational aspects): algebra, number theory, discrete mathematics, probability, and statistics. The NSA also accepts proposals for small grants for conferences, workshops, and special academic endeavors. These proposals will be accepted, reviewed, and funded as they are received at NSA. Those submitting the proposals should

allow eight months of review time before grants can be made.
Deadline: October 15, 1997. Grants awarded from this funding can expect to incur expenses by January 1999.
Application information: For further information about the program, please call 301-688-0400. All correspondence should be addressed to Dr. Charles F. Osgood, Director, Mathematical Sciences Program, National Science Agency, ATTN: R51A, Ft. George G. Meade, MD 20755-6557. Queries can also be made by e-mail at `msp@math13.math.umbc.edu`.

• State of California

California State Graduate Fellowships

Eligibility: Residents of California who attend accredited graduate or professional schools located in California with the intent to become college or university faculty members.
Grant amount: Up to $6,490 to cover tuition and fees only.
Deadline: March 2, 1997, for 1997–98 awards.
Application information: California Student Aid Commission, Graduate Fellowship Program, P.O. Box 510621, Sacramento, CA 94245-0621.

• University of California, Los Angeles

Biostatistical Training in AIDS

Description: The UCLA Department of Biostatistics has traineeships in AIDS. We offer support to both predoctoral and postdoctoral students. Training leading to the doctorate includes courses in biostatistics, mathematical statistics, and AIDS and provides collaboration experiences with AIDS researchers. Postdoctoral fellowship training is arranged specifically for each Fellow. Fellows with doctorates in biostatistics or statistics will take the AIDS courses, collaborate with AIDS researchers, and work on their own statistical research projects. Postdoctoral Fellows with a doctorate in other fields will take biostatistics courses, AIDS courses, and work on their own research projects.
Eligibility: This federally funded program requires permanent residence in the U.S. or U.S. citizenship. We encourage applications from qualified women and minority candidates. AA/EOE.
Grant amount: All tuition fees and a monthly stipend.
Application information: Contact: Dr. Jeremy M. G. Taylor, UCLA Department of Biostatistics, Los Angeles, CA 90095-1772.

Zonta International Foundation

Amelia Earhart Fellowship Awards

Description: Established in honor of Amelia Earhart, Zonta member from 1928–1937, the fellowships recognize excellence and encourage and support women in aerospace-related science and engineering.
Eligibility: To qualify for the fellowship, a woman must have by the time of her application: a bachelor's degree in a qualifying area of science or engineering which is closely related to advanced studies in the aerospace-related sciences; a superior academic record and evidence of potential at a recognized institution of higher learning as demonstrated by transcripts, recommendations, and acceptance or verification by an institution of higher learning with accredited courses in aerospace-related studies; and completion of one year of graduate school at a well-recognized institution of higher learning or evidence of a well-defined research and development program as demonstrated by publications or a senior research project.
Grant amount: Thirty-three to thirty-five $6,000 grants to women for graduate study in aerospace-related science or engineering are awarded annually.
Deadline: Application forms must be postmarked by November 1, 1998, and received by November 7, 1998.
Application information: Announcements of awards will be made by May 15, 1999. For more information: Zonta International, ATTN: Ana Ubides, 557 W. Randolph St., Chicago, IL 60661-2206; 312-930-5848; fax: 312-930-0951.

Postdoctoral Support

• Air Force Office of Scientific Research

Research Contracts and Grants

Description: Mathematicians and computer scientists are encouraged to submit proposals for research support through their organizations. Research areas include mathematics of dynamics and control, physical mathematics and applied analysis, computational mathematics, optimization and discrete mathematics, signal processing, probability and statistics, software and systems, artificial intelligence, and electromagnetics.
Application information: Research proposals should be forwarded to the Mathematics and Geosciences Directorate, Air Force Office of Scientific Research (AFOSR NM), 110 Duncan Avenue, Suite B115, Bolling AFB, DC 20332-8080.

American Association for the Advancement of Science

1998–1999 Congressional Science and Engineering Fellowships

Description: Fellows spend one year working as special legislative assistants on the staffs of members of Congress or congressional committees, beginning in September 1998. The program includes an orientation on congressional and executive branch operations and a year-long seminar program on issues involving science and public policy to provide a unique public policy learning experience, to demonstrate the value of such science-government interaction, and to make practical contributions to the more effective use of scientific and technical knowledge in government. AAAS will sponsor two Fellows.

Eligibility: A prospective Fellow must demonstrate exceptional competence in some area of science or engineering, have a good scientific and technical background, and have a strong interest and some experience in applying personal knowledge toward the solution of societal problems. Candidates should be postdoctoral-to-midcareer scientists or engineers.
Grant amount: The stipend is $43,000 plus an allowance for relocation and travel expenses.
Deadline: Deadline for receipt of applications by AAAS is January 15, 1999.
Application information: For additional information and application instructions, write: AAAS Fellowship Programs, 1200 New York Avenue, NW, Washington, DC 20005; 202-326-6700; fax: 202-289-4950; e-mail: `science_policy@aaas.org`.

American Association for the Advancement of Science

Technology Policy Science and Engineering Fellows Program

Description: Fellows spend one or two years working at the RAND Critical Technologies Institute, providing expertise in research and development, technology transfer, international competitiveness, and related issues.
Eligibility: Applicants must have a Ph.D. or equivalent doctoral level degree and at least five years of industrial experience at the managerial level. Persons with a master's degree in engineering and at least six-years of post-degree professional experience may apply.
Grant amount: Stipends are negotiable, depending on qualifications and experience.
Deadline: The deadline for receipt of applications is January 15, 1999.
Application information: For additional information and application instructions, write: AAAS Fellowship Programs, 1200 New York Ave., NW, Washington, DC 20005; 202-326-6700; fax: 202-289-4950; e-mail: `science_policy@aaas.org`.

American Association for the Advancement of Science

Risk Assessment Science and Engineering Fellowships

Description: One-year fellowships are available for work at the U.S. Food and Drug Administration or the U.S. Department of Agriculture on issues relating to risk assessment.
Eligibility: Applicants must have a Ph.D. or equivalent degree at the time of application. Persons with a master's degree in engineering and three years of post-degree experience may also apply. All applicants must be U.S. citizens.
Grant amount: The stipend is $42,000 for the one-year program.
Deadline: The deadline for receipt of applications is January 15, 1999.
Application information: For additional information and application instructions, write: AAAS Fellowship Programs, 1200 New York Ave., NW, Washington, DC 20005; 202-326-6700; fax: 202-289-4950; e-mail: `science_policy@aaas.org`.

American Association for the Advancement of Science

Science, Engineering, and Diplomacy Fellowships

Description: Fellows work in international affairs on scientific and technical subjects for one year, either in foreign policy at the U.S. Department of State or in international development for the U.S. Agency for International Development. One Fellow will be selected at State, and approximately twelve Fellows will be selected at USAID.
Eligibility: The Fellow must demonstrate exceptional competence in some area of science or engineering, be flexible, and have a strong interest or some experience in applying knowledge toward the solution of problems in the area of foreign affairs.
Grant amount: Stipends start at approximately $47,000, depending upon education and experience.
Deadline: Deadline for receipt of applications is January 15, 1999.
Application information: For additional information and application instructions, write: AAAS Fellowship Programs, 1200 New York Ave., NW, Washington, DC 20005; 202-326-6700; fax: 202-289-4950; e-mail: `science_policy@aaas.org`.

American Association for the Advancement of Science

Environmental Science and Engineering Fellows Program

Description: Fellows work for one year at the U.S. Environmental Protection Agency's (EPA) headquarters in Washington, DC, on an array of issues relating to science, policy, and the environment. The program is coordinated by EPA's National Center for Environmental Research and Quality Assurance (NCERQA) within the Office of Research and Developement (ORD).
Fellows will work in offices throughout the Agency on projects of mutual interest to the Fellows and the hosting offices. The program includes an orientation on congressional and executive branch operations, with special emphasis on environmental issues, and a year-long seminar program on topics relating to science, technology, and public policy.
Eligibility: Prospective Fellows must be postdoctoral-to-midcareer professionals, show exceptional competence in a relevant professional area, have a broad professional background, and have a strong interest and some experience in applying scientific or other professional knowledge toward the identification and assessment of future environmental problems. Persons may apply from any physical, biological, or behavioral science field; any field of engineering; or any other relevant professional field. Applicants must be U.S. citizens.
Grant amount: The stipend is $43,000.

Deadline: The deadline for receipt of applications is January 15, 1999.
Application information: For additional information and application instructions, write: AAAS Fellowship Programs, 1200 New York Ave., NW, Washington, DC 20005; 202-326-6700; fax: 202-289-4950; e-mail: science_policy@aaas.org.

American Association for the Advancement of Science

Defense Policy Science and Engineering Fellows Program

Description: Fellows will work on issues related to defense policy, technology applications, defense systems analysis, and program oversight and management in one-year assignments in the offices of the Under Secretary of Defense for Acquisition and Technology or the Office of the Army Deputy Assistant Secretary for Research and Development. Assignments may involve interagency, congressional, or international activity.
Eligibility: Applicants must have a Ph.D. or equivalent doctoral-level degree at the time of application. Persons with a master's degree in engineering and at least three years of postdegree experience may also apply. All applicants must be U.S. citizens.
Grant amount: The stipend is $45,000.
Deadline: All applications must be postmarked by January 15, 1999.
Application information: For additional information and application instructions, write: AAAS Fellowship Programs, 1200 New York Avenue, NW, Washington, DC 20005; tel: 202-326-6700; fax: 202-289-4950; e-mail: science_policy@aaas.org. Minorities and persons with disabilities are especially encouraged to apply.

American Association for the Advancement of Science

Roger Revelle Fellowship in Global Stewardship

Description: The Revelle Fellow will work for one year, beginning in September 1998, in the Congress, an executive brance agency, or elsewhere in the Washington, DC, policy community, on domestic or international environmental issues encompassed under the umbrella of "global stewardship." The focus will be on human interaction with ecosystems, which includes, but is not limited to, population, sustainable development, food, oceans, global climate change and related environmental concerns. The program includes an orientation on congressional and executive branch operations and a year-long seminar program on issues involving science and public policy.
The Roger Revelle Fellowship in Global Stewardship was established in recognition of Roger R. D. Revelle, who was an internationally respected statesman of science. His interests were broad, and he excelled across several fields of study. He was president of AAAS in 1974; he died in 1991.
Eligibility: Prospective Fellows must demonstrate exceptional competence in some area of science or engineering; have a good scientific and technical background; be cognizant of many matters in nonscientific areas; demonstrate sensitivity toward political and social issues; and, perhaps most importantly, have a strong interest and some experience applying personal knowledge toward the solution of societal problems. Fellows are expected to be critical thinkers who are articulate, adaptable, and able to work with a variety of people from outside the scientific and engineering communities.
All applicants must have a Ph.D. or equivalent doctoral level degree at the time of application, and at least three years of post-degree professional experience. Persons with a master's degree in engineering and six years of professional experience may apply. All applicants must be U.S. citizens. Federal employees are not eligible for the fellowships.
Grant amount: AAAS will select and sponsor one Revelle Fellow for 1998–99. The fellowship stipend is $45,000.
Deadline: January 15, 1999.
Application information: AAAS Fellowship Programs, 1200 New York Avenue NW, Washington, DC 20005; 202-326-6700; fax: 202-289-4950; e-mail: science_policy@aaas.org.

American Association of University Women (AAUW) Educational Foundation

American Fellowships

Application information: See the listing in the "Graduate Support" section for information.

American Mathematical Society Centennial Fellowships

Postdoctoral Fellowships

Description: The AMS Centennial Fellowship program makes awards annually to outstanding mathematicians to help further their careers in research. The number of fellowships to be awarded is small and depends on the amount of money contributed to the program. The trustees have arranged a matching program from general funds in such a way that funds for at least one fellowship are guaranteed. Because of the generosity of the AMS membership, it has been possible to award two to four fellowships a year for the past five years.
Eligibility: Applicants: (1) must be citizens or permanent residents of a country in North America, (2) must have held their doctoral degrees for at least two years at the time of the award, (3) must not have permanent tenure, and (4) must have held less than two years of research support at the time of the award. (Each year of a full-time teaching appointment with teaching load less than four (respectively, five) courses per year on the semester (respectively, quarter) system will count in this respect as one half a year of research support.) Recipients may not hold the Centennial Fellowship concurrently with other research fellowships (e.g., Sloan Foundation Fellowships or National Science Foundation Postdoctoral Fellowships), they may not use the stipend solely to reduce teaching at the home institution, and they are expected to spend some of the fellowship period at another institution

which has a stimulating research environment suited to the candidates' research development. Applications should include a short research plan describing both an outline of the research to be pursued and a program for using the fellowship, including institutions at which it will be used and reasons for the choices. The selection committee will base its decision on the research potential of the applicant based upon track record, letters of recommendation, and on the quality and feasibility of the research plan.

Grant amount: The stipend for fellowships awarded for 1999–2000 is expected to be approximately $37,000, with an additional expense allowance of about $1,500. Acceptance of the fellowship cannot be postponed. Fellowship holders may use their stipend as full support for a year or may combine it with half-time teaching and use it as half support over a two-year period.

Deadline: The deadline for receipt of applications is December 1, 1998. Awards will be announced in February 1999 or earlier if possible.

Application information: For application forms, write to the Executive Director, American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248, or send electronic mail to `ams@ams.org`, or call 401-455-4103. Application forms are also available via the Internet at URL `http://www.ams.org/committee/employment/`. *Please note that completed applications and references should not be sent to the AMS, but to the address given on the forms.*

American Philosophical Society

Description: Postdoctoral research grants to aid specific research projects. The purpose of the program is to connect scholars with the objects of their research. Tenable abroad and in U.S. The Committee on Research meets in January, March, and June.

Eligibility: For candidates with Ph.D. for at least one year.

Grant amount: Up to $6,000 (averaging $2,000). Grants contribute toward travel expenses, food and lodging, and photoduplication. No funds are available for attending conferences or consulting with colleagues.

Application information: For application forms please briefly describe your project and proposed budget in a letter to: Committee on Research, American Philosophical Society, 104 South Fifth Street, Philadelphia, PA 19106. Include self-addressed mailing label; or consult the Website at `http://www.amphilsoc.org/`.

American Society for Engineering Education

Navy-ASEE Sabbatical Leave Program

Description: This program allows science and engineering faculty the opportunity to conduct research at Navy laboratories while on sabbatical leave. Appointments must be for at least one quarter or semester.

Grant amount: Participants in the program will receive a monthly stipend making up the difference between salary and sabbatical leave pay from their home institution. In addition, participants will receive reimbursement for travel to and from the laboratory site and a relocation allowance for those who must relocate their residence during their sabbatical leave tenure.

Deadline: Applications for the program will be accepted at any time.

Application information: For information write to: Navy-ASEE Faculty Research Programs Director, 1818 N St., NW, Suite 600, Washington, DC 20036-2479; 202-331-3525; e-mail: `projects@asee.org`.

Brown University

J. D. Tamarkin Assistant Professorship

Description: This is a three-year nonrenewable appointment, beginning July 1, 1999. The teaching load consists of two courses per semester (6 hours per week).

Eligibility: Ph.D. degree must be received before start of appointment, but we will not consider applicants who will have held an academic or posdoctoral position for more than two years after their Ph.D. by June 1999. Applicants should have strong research potential and a commitment to teaching. Field of research should be consonant with the current research interests of the department.

Application information: Applicants should submit a curriculum vitae, a completed application form, and three letters of recommendation by December 1, 1998. Requests for application forms and all other inquiries should be addressed to Tamarkin Search Committee, Department of Mathematics, Brown University, Providence, RI 02912. Application forms are also available from the Web site `http://www.math.brown.edu/tamarkin.shtml`. Brown University is an Equal Opportunity/Affirmative Action Employer and encourages applications from women and minorities.

The Bunting Institute of Radcliffe College

Science Scholar Fellowships

Description: The Bunting Institute provides fellowships to postdoctoral scientists who have received the Ph.D. two years prior to appointment.

Eligibility: Open to women scientists who are U.S. citizens in the fields of astronomy, molecular and cellular biology, biochemistry, chemistry, cognitive and neural science, computer science, electrical engineering, aerospace/mechanical engineering, geology, materials science, mathematics, physics, naval architecture and ocean engineering, oceanography, and all fields that relate to the study of oceans.

Grant amount: Office space, stipend of $37,800 plus up to $3,000 in research expenses, one-year appointment, access to Harvard/Radcliffe libraries and facilities.

Deadline: Deadline for applications is October 15, 1998 (postmarked).

Application information: Write or call for application and information to: Science Scholar Fellowship Program, The Bunting Institute of Radcliffe College, 34 Concord Avenue, Cambridge, MA 02138; 617-495-8212; Website: `http://www.radcliffe.edu./bunting/`.

California Institute of Technology

Harry Bateman Research Instructorships

Description: Offered by The Division of Physics, Mathematics, and Astronomy at the California Institute of Technology. Appointments are for one year and are renewable for one additional year.
Eligibility: Open to persons who have recently received their doctorate in mathematics.
Grant amount: The annual salary for academic year 1998-99 is $42,500. Duties include teaching one course for the full academic year.
Deadline: January 1, 1999.
Application information: Please send applications to Instructorship Search Committee, 253-37 Sloan Laboratory, Pasadena, CA 91125. Include c.v. and a statement of anticipated research. The candidate is requested to ensure that at least three letters of recommendation are sent to Caltech. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky & John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

California Institute of Technology

Olga Taussky and John Todd Instructorships in Mathematics

Description: Initial appointments are for two years, with a one-year terminal extension expected. There are three terms in the Caltech academic year, and instructors are expected to teach one course in all but two terms of the total appointment.
Eligibility: Offered to recent Ph.D. recipients who show strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.
Grant amount: The annual salary for 1998-99 is $45,500 per year plus a $2,000 per year research fund.
Deadline: January 1, 1999.
Application information: Apply to the Instructorship Search Committee, 253-37 Sloan Laboratory, Pasadena, CA 91125. Include c.v. and a statement of anticipated research. The candidate is requested to ensure that at least three letters of recommendation are sent directly to Caltech. To avoid duplication of paperwork, your application may also be considered for a Harry Bateman Research Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

Carnegie Mellon University

Center for Nonlinear Analysis Postdoctoral Fellowships

Description: The Center for Nonlinear Analysis expects to make several appointments for 1999-2000. These are two-year appointments by the Center and the Department of Mathematics. Recipients will teach at most one course per semester. The Center engages in research in partial differential equations, the calculus of variations, nonlinear continuum mechanics, stochastic differential equations, stochastic control, numerical analysis, and scientific computation. The Center is primarily supported by the National Science Foundation, with additional support provided by the Army Research Office and NASA. Applicants should submit a vita, list of publications, a statement describing current and planned research, and at least three letters of recommendation.
Eligibility: The chief applications are to materials science, fluid dynamics, and stochastic models for production and communication processes.
Deadline: The deadline for application is January 18, 1999.
Application information: All communications should be addressed to: Postdoctoral Appointments Committee, Department of Mathematics, Carnegie Mellon University, Pittsburgh, PA 15213. Carnegie Mellon is an Affirmative Action/Equal Opportunity Employer.

Centre de Recerca Matematica, Barcelona

Description: The Centre de Recerca Matematica, Barcelona, offers two postdoctoral fellowships for the academic year 1999-2000. Fellowships are for eleven months, unextendable. Successful candidates will be able to take up their fellowships between October 1, 1999, and January 1, 2000.
Eligibility: Applicants should have a Ph.D. in mathematics, obtained after December 31, 1996.
Grant amount: The amount of the fellowship is 180.000 pta per month. Travel expenses to Barcelona will be paid. The Fellow will be provided with medical and accident insurance.
Deadline: All applications arriving at the CRM before February 10, 1999, will be considered.
Application information: Applicants should send the following documents to the Centre de Recerca Matematica (Apartat 50, E-08193 Bellaterra): (a) proof of Ph.D. degree, (b) curriculum vitae and list of publications, (c) copies of published and not-yet-published papers, (d) description of research project (of no more than 1,000 words), (e) two letters of reference to be sent directly to the director, (f) complete address and telephone number. For further information telephone 343/581.10.81 from 9 a.m. to 4 p.m., or e-mail: `crm@crm.es`.

• Cornell University

Possible H. C. Wang Assistant Professorship

Description: During one semester, the holder of a Wang Assistant Professorship will teach only one course; otherwise the teaching load will be two courses per semester. The assistant professorship is nonrenewable after a three-year term.
Eligibility: Candidates must possess a Ph.D.
Grant amount: Salary $38,600.
Deadline: December 15, 1997.
Application information: Send c.v. and three letters of reference to the Recruiting Committee, Department of Mathematics, White Hall, Cornell University, Ithaca, NY 14853-7901.

Courant Institute

K.O. Friedrichs Fellowship

Description: The Courant Institute of Mathematical Sciences at New York University is seeking applications for the K.O. Friedrichs Fellowship, a postdoctoral research fellowship in computational mathematics. The fellowship is supported by the MICS of the Department of Energy. The appointment is for two years starting September 1997.
Eligibility: Specific areas of interest include combustion, computational fluid dynamics, parallel computing, or other areas of application. Candidates must be U.S. citizens or permanent residents.
Deadline: The deadline for applications is February 1998.
Application information: Interested candidates should send a résumé, research statement, preprints or thesis if available, and the names of three references to: Marsha Berger, K.O. Friedrichs Fellowship Committee, Courant Institute, 251 Mercer Street, New York, NY 10012.

Courant Institute

Visiting Memberships and Courant Institute Instructorships

Description: The Courant Institute is a center for advanced training and research in the mathematical sciences. It has long been a leader in mathematical analysis, applied mathematics, and computational science, with special emphasis on partial differential equations and their applications. Its scientific activities include an extensive array of research seminars and advanced graduate courses. Each year a limited number of positions are awarded to postdoctoral scientists. Courant Institute Instructorships and Visiting Memberships are primarily for recent Ph.D.s. Candidates must have a degree in mathematics or an affiliated field. These appointments carry a light teaching load and have a tenure of one or two years.
Eligibility: Applicants must have a Ph.D. in mathematics or an affiliated discipline. Preference is given to individuals not more than four years beyond the Ph.D.
Deadline: Applications for the 1998–99 academic year are due by December 15, 1998.
Application information: For an application form and further information write to: Visiting Membership Committee, Courant Institute of Mathematical Sciences, New York University, 251 Mercer Street, New York, NY 10012-1185. Forms may also be obtained by sending e-mail to `vm-apply@cims.nyu.edu`. NYU is an Equal Opportunity/Affirmative Action Employer.

Dartmouth College

John Wesley Young Research Instructorships

Description: Two instructorships are normally awarded by Dartmouth College each year. Teaching duties are one course for two quarters and two courses for one quarter (or two courses for two quarters) and are of a varied and nonroutine nature. Appointments are for two years and are not renewable.
Grant amount: The academic-year salary of $40,000 is supplemented by a two-month resident research stipend of $8,889, for a total of $48,889.
Deadline: Applicants are advised to apply promptly and no later than January 15, 1999.
Application information: Applicants should write to Department of Mathematics, Dartmouth College, Hanover, NH 03755-3551 (Attention: Recruiting).

• Fellowships in Mathematics and Molecular Biology

Application information: See listing in the "Graduate Support" section for information.

Ford Foundation Postdoctoral Fellowships for Minorities

Description: Administered by the National Research Council, these fellowships are sponsored by the Ford Foundation. Tenure of the one-year fellowship provides postdoctoral research experience at an appropriate nonprofit institution of the Fellow's choice.
Eligibility: Applicants must be U.S. citizens who are members of one of the designated minority groups: Native American Indians and Alaskan Natives (Eskimo or Aleut), Black/African Americans, Mexican Americans/Chicanos, Native Pacific Islanders (Micronesians and Polynesians), or Puerto Ricans who are engaged in college or university teaching and research (or planning such a career) and hold a doctoral degree. Supported fields include: behavioral and social sciences, humanities, engineering, mathematics, physical sciences, life sciences, education, and interdisciplinary programs composed of two or more eligible research-based disciplines.
Grant amount: The stipend is $25,000, with a travel and relocation allowance of $3,000. No dependency allowance is available. The employing institution is encouraged to supplement the Fellow's stipend. The program will also provide a cost-of-research allowance of $2,000 for each Fellow in residence that is meant as partial support for the Fellow's study and research program.
Deadline: The deadline for the submission of applications is January 1999.
Application information: For revised eligibility guidelines and application materials for the 1999 program, please contact the NRC Fellowship Office in September 1998. National Research Council, 2101 Constitution Avenue, NW, Washington, DC 20418; 202-334-2872.

John Simon Guggenheim Memorial Foundation Fellowships

Description: Fellowships are on an advanced professional level. Approximately 195 awards are made.
Eligibility: U.S. or Canadian citizenship or permanent residence is required. Fellowships are also offered to citizens or permanent residents of Latin America and the Caribbean.
Grant amount: Approximately $31,000.

Deadline: Application deadline: October 1 for the U.S. and Canada competition, December 1 for the Latin American and Caribbean competition.
Application information: For more information write to John Simon Guggenheim Memorial Foundation, 90 Park Avenue, New York, NY 10016.

Institute for Advanced Study Memberships

Description: The School of Mathematics will grant a limited number of memberships, some with financial support, for research in mathematics at the Institute during the academic year 1999–2000.
Eligibility: Candidates must give evidence of ability in research comparable at least with that expected for the Ph.D. degree.
Deadline: December 1, 1998.
Application information: Application blanks may be obtained from The School of Mathematics, Institute for Advanced Study, Princeton, NJ 08540, and should be returned (whether or not funds are expected from some other source). Forms may also be downloaded but not submitted via Web connection at `http://www/math.ias.edu/`. An Equal Opportunity/Affirmative Action Employer.

Institute for Mathematics and its Applications (IMA)

Postdoctoral Memberships

Senior Visiting Memberships

Reactive Flow & Transport Phenomena 1999–2000

Description: The IMA announces two-year postdoctoral research memberships. The postdoctoral terms will include the academic-year program on Reactive Flow and Transport Phenomena in 1999–2000. The second year of the appointment will provide a variety of options to enhance career development, including participation in the 2000–2001 annual program on *Mathematics in Multi-Media.*
Eligibility: All requirements for a doctorate should be completed by September 1, 1999. Applicants must show evidence of mathematical excellence, but they do not need to be a specialist in the field. The following materials must be submitted: (1) personal statement of scientific interest, research plans, and reasons for wishing to participate in the Reactive Flow & Transport Phenomena Program (this is an essential part of the application); (2) curriculum vitae and a list of publications; (3) three letters of recommendation, to be sent directly to the IMA. **Senior memberships are also available.** Preference will be given to supplementary support for persons with sabbatical leaves, fellowships, or other stipends.
Deadline: All material should arrive by January 15, 1999.
Application information: All correspondence should be sent to: Visiting Membership Committee, Institute for Mathematics and its Applications, University of Minnesota, 514 Vincent Hall, 206 Church Street SE, Minneapolis, MN 55455-0436. The University of Minnesota is an Equal Opportunity Educator and Employer.

Institute for Mathematics and its Applications (IMA)

Postdoctorates in Industrial Mathematics

Description: The IMA announces two-year positions in industrial mathematics effective September 1, 1999. These appointments are in addition to the regular IMA 1999–2000 postdoctoral program in Reactive Flow & Transport Phenomena and are funded jointly by the NSF and by industry. They are designed to prepare mathematicians for research careers involving industrial interaction.
Eligibility: Applicants should have received their Ph.D. in mathematics, applied mathematics, or statistics by September 1, 1999. Postdoctorates will spend 50 percent effort in the IMA program and 50 percent effort working with scientists from industry. The following materials must be submitted: (1) personal statement of scientific interests, research plans, and reasons for wishing to participate in the Industrial Mathematics program (this is an essential part of the application); (2) curriculum vitae and a list of publications; (3) three letters of recommendation, to be sent directly to the IMA.
Deadline: All material should arrive by January 15, 1999.
Application information: All correspondence should be sent to: Industrial Mathematics Postdoctorate Membership Committee, Institute for Mathematics and its Applications, University of Minnesota, 514 Vincent Hall, 206 Church Street SE, Minneapolis, MN 55455-0436. The University of Minnesota is an Equal Opportunity Educator and Employer.

Los Alamos National Laboratory

Postdoctoral Appointments

Description: Research opportunities are granted in many areas of chemistry, mathematics, computer science, materials science, biological sciences, environmental science, geoscience, and many engineering fields. Appointments are available for two years, subject to renewal for a third year. A postdoctoral committee meets to review candidates for postdoctoral appointments in February, May, August, and December.
Eligibility: Candidates must be recipients of a doctoral degree within the past three years.
Grant amount: Starting salary: $45,700–$49,300.
Application information: Los Alamos National Laboratory is an Equal Opportunity Employer. For more information: e-mail: `postdoc-info@lanl.gov`; phone: 505-667-0872; fax: 505-665-4562.

Los Alamos National Laboratory

J. Robert Oppenheimer Research Fellowship

Description: Research opportunities are granted in many areas of chemistry, mathematics, computer science, materials science, biological sciences, environmental science,

geoscience, and many engineering fields. Appointments are for two years, subject to renewal for a third year.
Eligibility: Candidates must be recipients of a doctoral degree within the past five years and must show clear and definite promise of becoming outstanding leaders in scientific research.
Grant amount: Starting salary: $70,000.
Deadline: Application deadline: mid-November each year.
Application information: Los Alamos National Laboratory is an Equal Opportunity Employer. For initial consideration send résumé with publication listing to Postdoctoral Program Office, Mail Stop P-290, Los Alamos National Laboratory, Los Alamos, NM 87545.

Massachusetts Institute of Technology

C. L. E. Moore Instructorships in Mathematics

Description: Offered by the Department of Mathematics at the Massachusetts Institute of Technology. The teaching load is six hours per week in one semester and three hours per week in the other. Appointments are for one year and are renewable for two additional years.
Eligibility: Open to mathematicians with doctorates who show definite promise in research. Applicants please send (a) a vita, (b) a description of the research in your thesis and other work you have done (1–3 pages), and (c) the research which you plan for next year.
Deadline: December 1, 1998.
Application information: Application should be sent to the Pure Mathematics Committee, Department of Mathematics, Room 2-263, Massachusetts Institute of Technology, Cambridge, MA 02139-4307. M.I.T. is an Equal Opportunity Employer.

Mathematical Sciences Research Institute (MSRI)

Hewlett Packard Postdoctoral Grants

Description: The Mathematical Sciences Research Institute announces the availability of several postdoctoral fellowhips combined with internships at Hewlett Packard Laboratories in Palo Alto, to commence in the academic year 1998–99. The Laboratories pursue a wide range of mathematical work, from counting points on elliptic curves over finite fields to the mechanics of ink droplets. Because of the great variety of work done at the HP Labs, no particular fields of mathematics have been specified. However, an essential prerequisite is a strong interest in the applications of mathematics and in working in the laboratory setting as well as in the research environment of MSRI. These postdocs will join an active research group at the HP Labs for two months prior to the start of their year or semester at MSRI and will consult three days a month with that group during their tenure at MSRI. Two further months at HP Labs at the end of their time at MSRI is optional. They will be paid for this work at HP Labs in addition to the standard MSRI postdoctoral fellowship, thus gaining first-hand knowledge of mathematical work at a major industrial lab as well as the independent research experience at MSRI.
Eligibility: Applicants for these fellowships must have received their doctorates in 1993 or later and should apply through the usual process for MSRI postdoctoral fellowships, indicating their interest in these internship/fellowships and adding relevant documentation. Applications indicating interest in the internship program will be reviewed by Hewlett Packard as well as the MSRI directorate.
Deadline: The deadline for postdoctoral and general membership applications for the 1998–99 programs is November 30, 1997.
Application information: Application forms are available on the Web at `http://www.msri.org/sched/application/`. Inquiries may be directed to the Deputy Director, MSRI, 1000 Centennial Drive, Berkeley, CA 94720, or by e-mail to `rossi@msri.org`.

• Mathematical Sciences Research Institute (MSRI)

Postdoctoral Fellowships

Description: The Institute will award about twenty-one postdoctoral fellowships during 1998–99, with starting date August 1998. The year 1998–99 features two half-year programs during fall 1998 in Symbolic Computation in Geometry and Analysis and Foundations of Computational Mathematics and one half-year program during spring 1999 in Random Matrix Models and Their Applications. Some awards will be made in other areas, so applications from candidates in all fields are welcome.
Eligibility: For new and recent Ph.D.s (Ph.D. earned in 1993 or later).
Grant amount: The stipend will be at least $32,000.
Deadline: Files must be complete by November 30, 1997.
Application information: Application forms can be obtained by writing to the Mathematical Sciences Research Institute, 1000 Centennial Drive, Berkeley, CA 94720-5070; e-mail: `send-application@msri.org`; `http://www.msri.org/`; or by calling 510-642-0143.

• Mathematical Sciences Research Institute (MSRI)

Research Professorships

Description: The Institute will award six to eight research professorships during academic year 1998–99. The year 1998–99 features two half-year programs during fall 1998 in Symbolic Computation in Geometry and Analysis and Foundations of Computational Mathematics and one half-year program during spring 1999 in Random Matrix Models and Their Applications. Some awards will be made in other areas, so applications from candidates in all fields are welcome.
Eligibility: For midcareer mathematicians (Ph.D. earned in 1992 or earlier).
Grant amount: The stipend will be limited to a ceiling of $40,000 and normally will not exceed half the applicant's salary.
Deadline: Files must be complete by September 30, 1997.
Application information: Application forms can be obtained by writing to the Mathematical Sciences Research Institute, 1000 Centennial Drive, Berkley, CA 94720-5070; e-mail: `send-application@msri.org`; `http://www.msri.org/`; or by calling 510-642-0143.

The Michigan Society of Fellows

Horace H. Rackham School of Graduate Studies, The University of Michigan

Description: The Michigan Society of Fellows was founded in 1970 through grants from the Ford Foundation and Horace H. Rackham Graduate School for the purpose of promoting academic and creative excellence in the arts, sciences, and professions. The objective of the program is to support individuals selected for outstanding achievement, professional promise, and interdisciplinary interests. We invite applications from qualified candidates for three-year postdoctoral fellowships at the University of Michigan. Fellows are appointed as assistant professors/postdoctoral scholars with departmental affiliations. They spend the equivalent of one academic year teaching; the balance of time is devoted to their own scholarly research and creative work. Applications will be screened by faculty in relevant University of Michigan departments. Final selections will be made by the senior Fellows of the Society. New Fellows will be selected for three-year terms beginning September 1999.

Eligibility: Candidates must have received the Ph.D. degree between June 1, 1996, and September 1, 1999.

Grant amount: The annual stipend will be $36,000.

Deadline: Completed applications are due October 9, 1998.

Application information: Please send requests for application materials to Michigan Society of Fellows, 3030 Rackham Building, University of Michigan, 915 E. Washington St., Ann Arbor, MI 48109-1070; 734-763-1259; e-mail: `society.of.fellows@umich.edu`.

Michigan State University

MSU Postdoctoral Instructorships

Description: Pending funding, several two-year positions will be available for new or recent Ph.D.s who show strong promise in research and teaching. These positions will begin in the fall of 1999. The teaching load is at most four semester courses per year, and participation in the research activities of the department is expected. NSF postdoctoral fellowships or other awards may be held concurrently for a further reduction in teaching load. An applicant should send a vita as well as a brief statement of research interests and three letters of recommendation commenting on the applicant's research and teaching abilities.

Grant amount: A starting salary of at least $36,500.

Deadline: The deadline for applications is December 1, 1998.

Application information: Application via e-mail is strongly encouraged. Contact `jobs@math.msu.edu` with a message containing "send application-info". All application materials can also be addressed to The Hiring Committee, Department of Mathematics, Michigan State University, East Lansing, MI 48824-1027. MSU is an Affirmative Action/Equal Opportunity Institution.

National Center for Atmospheric Research

Advanced Study Program

Description: Postdoctoral fellowships are offered for highly qualified atmospheric scientists and scientists from related disciplines who wish to continue basic research in the atmospheric sciences. Appointments are for a one-year period with a possible extension for an additional year.

Eligibility: For recent recipients of the Ph.D.

Grant amount: Stipends are $35,000 and are adjusted annually in June.

Deadline: The application deadline is January 5, 1999.

Application information: Contact: 303-497-1601; e-mail: `barbm@ncar.ucar.edu`; or Barbara Hansford, NCAR, ASP, P. O. Box 3000, Boulder, CO 80307-3000; fax: 303-497-1646.

National Science Foundation

Mathematical Sciences Postdoctoral Research Fellowships (with Research Instructorship Option)

Description: The format of the 1999 Fellowship program has not been changed from that of 1998. The stipend portion of the awards will consist of support for eighteen academic-year months or their equivalent and six summer months. Awardees have two options for academic year stipends, subject to the constraints that their academic-year support begin by October 1 of the award year and be configured in intervals no shorter than three consecutive months. An awardee may have full-time support for any eighteen academic-year months in a three-year period (the Research Fellowship Option) or have a combination of full-time and half-time support over a period of three academic years, usually as one academic year full-time and two academic years half-time (the Research Instructorship Option). Summer month stipends are limited to two per calendar year.

Grant amount: Stipend amounts are $3,250 per full-time month and $1,625 per half-time month, for a total award of $78,000 to be used within 48 months.

Deadline: Deadline for applications is October 17, 1998; applicants will be notified of decisions on or about March 1, 1999.

Application information: For further details write to the Mathematical Sciences Infrastructure Program, Division of Mathematical Sciences, Room 1025, National Science Foundation, 4201 Wilson Boulevard, Arlington, VA 22230; call 703-306-1870; or send an inquiry to e-mail: `msprf@nsf.gov` (Internet).

• National Science Foundation

Professional Opportunities for Women in Research and Education (POWRE)

Description: POWRE is a Foundation-wide program with activities designed to increase women's prominence in science and engineering and to enhance their professional advancement by providing women with funding opportunities not ordinarily available through regular

research and education grants. The former Visiting Professorships for Women, Faculty Awards for Women, Research Planning Grants for Women, and Career Advancement Awards for Women programs have been integrated and incorporated into the POWRE program. Objectives of the program are: (1) to provide opportunities for further career advancement, professional growth, and increased prominence of women in engineering and in the disciplines of science supported by NSF; and (2) to encourage more women to pursue careers in science and engineering by providing greater visibility for women scientists and engineers in academic institutions and industry. The following categories of activities will be supported:

Visiting Professor—supports activities at a host academic institution for the conduct of research projects and/or for engaging in innovative educational activities that have promise beyond the home institution's traditional education approaches.

Visiting Researcher—supports activities for academically employed women to conduct research and development projects at an industrial or non-federal organization.

Research/Educational Enhancement—supports opportunities to enhance the applicant's research and/or educational activities at the home institution or at an external site through: (1) access and utilization of new and/or special facilities, skills, or methodologies; or (2) exploratory or pilot work to determine feasibility of a new line of inquiry or educational activity.

Supplements—support additional research and/or education activities for women principal investigators or coprincipal investigators under existing NSF grants to (1) take advantage of a special opportunity (e.g., pursuit of a promising new direction in research or education, an international collaboration, an innovative idea for integrating research and education) or (2) provide extra support at a critical career stage (e.g., after major administrative demands, after a career interruption to accommodate family responsibilities or relocation requirements). Potential supplement applicants should contact the cognizant program officer; directorate-specific information may be available on the home page of the appropriate NSF directorate/office.

Eligibility: Eligibility is limited to women scientists and engineers who: (1) hold a doctorate at the time of submission in a field of research supported by NSF (in exceptional circumstances, experience equivalent to the Ph.D. degree will be accepted); (2) are a U.S. citizen, national, or permanent resident at the time of the proposal submission; and (3) hold, or have held, a faculty or research-related position in a U.S. college, university, or other nonprofit institution. Alternately, applicants for the Visiting Professor position may be currently employed in industry or be on the staff of a scientific or engineering professional organization.

Additional eligibility requirements may have been established in specific directorates. Applicants for POWRE supplements should consult the cognizant program officer or the home page of the appropriate NSF directorate/office.

The Foundation is particularly interested in increasing the participation of minority women, women with disabilities, and women whose careers have been interrupted. Proposals from members of these groups are especially encouraged.

Grant amount: Awards for the Visiting Professor, Visiting Researcher, and Research/Educational Enhancement categories of the program will be made for up to 18 months' duration and for up to the following maximum budget amounts (which include both direct and indirect costs):

Visiting Professor—up to $150,000
Visiting Researcher—up to $150,000
Research/Educational Enhancement—up to $75,000

Award sizes for POWRE proposals and supplement requests will vary based on the activities proposed and the priorities of the NSF disciplinary directorates.

Deadline: POWRE proposals must be received no later than December 9, 1997; requests for POWRE supplemental funding must be received by February 17, 1998.

Application information: The NSF Grant Proposal Guide (GPG), NSF 95-27, provides a detailed description of proposal preparation, review criteria, and proposal processing. The GPG may be obtained without charge from Forms and Publications Unit, Room P-15, National Science Foundation, 4201 Wilson Blvd., Arlington, VA 22230; telephone: 703-306-1130; e-mail: `pubs@nsf.gov`. In your request be sure to include the publication number and title, your name, and a complete mailing address. A Grant Proposal Forms Kit is available on WWW at `http://www.nsf.gov/bfa/cpo/gpg/fkit.htm`.

• National Security Agency

Sabbatical Program

Description: The National Security Agency (NSA) has a program supporting sabbaticals for academic mathematical scientists to visit NSA, usually for nine or twelve months.

Eligibility: American citizenship for the applicant and all immediate family members is required. Because a complete background investigation is required, applications should be submitted as soon as possible.

Grant amount: A supplement to the university's stipend to bring the visitor's salary up to his or her regular monthly salary, a choice of either an allowance for moving expenses or a housing supplement.

Application information: For further information on the sabbatical program, contact: Dr. Charles F. Osgood, Director, Mathematical Sciences Program, National Security Agency, ATTN: R51A, Ft. George G. Meade, MD 20755-6557; telephone: 301-688-0400; e-mail: `msp@math13.math.umbc.edu`.

• National Security Agency

Description: Standard research proposals designed principally to provide summer salary for professors and support for graduate students in areas of interest listed below. The National Security Agency (NSA) awards grants to universities in support of self-directed research in the following areas of mathematics (including possible

computational aspects): algebra, number theory, discrete mathematics, probability, and statistics. The NSA also accepts proposals for small grants for conferences, workshops, and special academic endeavors. These proposals will be accepted, reviewed, and funded as they are received at NSA. Those submitting the proposals should allow eight months of review time before grants can be made.

Deadline: October 15, 1997. Grants awarded from this funding can expect to incur expenses by December 1, 1998.

Application information: For further information about the program, please call 301-688-0400. All correspondence should be addressed to Dr. Charles F. Osgood, Director, Mathematical Sciences Program, National Science Agency, ATTN: R51A, Ft. George G. Meade, MD 20755-6557. Queries can also be made by e-mail at `msp@math13.math.umbc.edu`.

Office of Naval Research

Description: Supports research over a wide range of areas including applied analysis, numerical analysis, operations research, software research, scientific visualization, statistics, and probability.

Application information: Information regarding proposal submission can be found at `http://www.onr.navy.mil/`.

President's Commission on White House Fellowships

Description: The White House Fellowships offer outstanding Americans early in their careers the opportunity to serve for one year, September through August, as special assistants to Cabinet officers, to the vice president, or to members of the president's senior staff.

Eligibility: The fellowships are open to all U.S. citizens, with the exception of civilian employees of the Federal Government.

Grant amount: Salary: $71,000.

Deadline: The application postmark date is February 1, 1999.

Application information: Applications for the 1999–2000 fellowships may be obtained from The President's Commission on White House Fellowships, 712 Jackson Place, NW, Washington, DC 20503; 202-395-4522; `http://www.whitehouse.gov/WH_Fellows/`.

Purdue University

Research Assistant Professorship

Description: These positions are intended for recent Ph.D.s who can benefit from and contribute to an active research environment.

Eligibility: Candidates are expected to have a Ph.D. degree in mathematics prior to September 1999.

Deadline: Preference will be given to completed applications received by December 15, 1998.

Application information: Applications, including a vita; brief description of research interests; and at least three letters of recommendation, one of which addresses teaching, should be sent to Carl Cowen, Head, Department of Mathematics, Purdue University, West Lafayette, IN 47907-1395. Purdue University is an Equal Opportunity/Affirmative Action Employer.

Rice University

Griffith Conrad Evans Instructorships

Description: Postdoctoral appointments for two to three years for promising research mathematicians with research interests in common with the active research areas at Rice. Rice University encourages applications from women and minority group members.

Deadline: Applications received by December 31, 1998, will receive thorough consideration.

Application information: Inquiries and applications should be addressed to Chairman, Evans Committee, Department of Mathematics, Rice University, 6100 Main St.-MS 136, Houston, TX 77005.

Sloan Foundation

Research Fellowships

Description: Unrestricted grants made to selected university scientists in the physical sciences, mathematics, applied mathematics, computer science, economics, and neuroscience. Candidates do not apply but are nominated by their department chairmen or other scientists.

Eligibility: Candidates must be members of the regular (i.e., tenure-track) faculty, though not necessarily in a tenured position, at a recognized college or university in the United States or Canada.

Deadline: Nominations are due by September 15 for awards to begin the following September.

Application information: For information write to the Sloan Research Fellowships, Alfred P. Sloan Foundation, Suite 2550, 630 Fifth Avenue, New York, NY 10111; e-mail: `gassman@sloan.org`; `http://www.sloan.org/`.

The U.S. Arms Control and Disarmament Agency (ACDA)

William C. Foster Fellows Visiting Scholars Program

Description: The purpose of the program is to give specialists in the physical sciences and other disciplines relevant to the Agency's activities an opportunity for active participation in the arms control and disarmament activities of the Agency and to gain for the Agency perspective and expertise such persons can offer. ACDA is an Equal Opportunity Employer. Selections will be made without regard to race, color, religion, sex, national origin, age, or physical handicap that does not interfere with performance of duties. Prior to appointment, applicants will be subject to a full-field background security investigation for a Top Secret security clearance as required by Section 45 of the Arms Control and Disarmament Act.

Eligibility: Visiting scholars must be citizens of the United States, on the faculty of a recognized institution of higher learning, and tenured or on a tenure-track or

equivalent; they must also have served as a permanent career employee of the institution for at least ninety days before selection for the program.
Deadline: January 30, 1999.
Application information: Send applications and any requests for additional information to: Visiting Scholars Program, Office of Intelligence, Technology and Analysis Division, Room 4930, ATTN: Kimberly Solomon, U.S. Arms Control and Disarmament Agency, Washington, DC 20451, or call 202-647-4153.

U.S. Department of Energy (DOE)

Special University–Laboratory Cooperation

Description: Participants engage in laboratory-approved projects in a program designed to increase the interactions and flow of information between universities and DOE laboratories. Included is research in applied mathematics and computer science.
Application information: Inquiries should be addressed to the director at any of the following organizations: Associated Western Universities, 4190 South Highland Drive, Suite 211, Salt Lake City, UT 84124; Argonne Division of Educational Programs, 9700 South Cass Avenue, Argonne, IL 60439; Brookhaven National Laboratory, Upton, NY 11973; Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, TN 37831-0117.

U.S. Department of Health and Human Services, National Institutes of Health

Description: Supports postdoctoral training in specified areas of biomedical and behavioral research.
Eligibility: Applicant must have earned an appropriate degree and arranged for appointment to an institution and acceptance by a sponsor who will supervise the training research experience. U.S. citizenship or lawful admittance to the U.S. for permanent residence is required.
Application information: To obtain application kits with instructions and forms, please contact your institutional office of sponsored research. If application kits are not available at the institution, they may be requested from the Division of Extramural Outreach and Information Resources, Office of Extramural Research, National Institutes of Health. For fastest service, e-mail: `asknih@odrockm1.od.nih.gov` or fax: 301-402-0525.

USIA Fulbright Senior Scholar Program

Description: The Fulbright Scholar Program awards approximately 700 grants for research and university lecturing for periods ranging from two months to a full academic year. There are openings in over 120 countries with some opportunity for multicountry research. Fulbright awards are granted in virtually all disciplines. Scholars in all academic ranks, retired faculty, and independent scholars are eligible to apply.
Eligibility: The basic eligibility requirements are U.S. citizenship, Ph.D. or comparable professional qualifications, university or college teaching experience for lecturing awards, and, for selected assignments, proficiency in a foreign language.
Grant amount: Benefits include a base stipend plus allowances for housing, subsistence, travel, and other benefits.
Deadline: Application deadline is August 1.
Application information: For further information and application materials, contact the USIA Fulbright Senior Scholar Program, Council for International Exchange of Scholars, 3007 Tilden St., N.W., Suite 5L, Box GNEWS, Washington, DC 20008-3009. Telephone: 202-686-7877; Web page (online materials): `http://www.cies.org/`; e-mail: `apprequest@cies.iie.org` (requests for mailing of application materials only).

University of California

President's Postdoctoral Fellowship Program

Description: The University of California offers postdoctoral fellowships to enhance the competitiveness of outstanding scholars for academic appointments at major research universities such as the University of California. Awards are for one academic year with the possibility of renewal for a second year pending demonstration of satisfactory progress.
Eligibility: Applicants must be U.S. citizens or permanent residents and hold a Ph.D. degree from an accredited university. Preference is given to minority and women candidates historically underrepresented in higher education. Applications are encouraged from African Americans, American Indians, Asian Americans, Filipinos, Mexican Americans and Latinos, and from white women in physical sciences, mathematics, and engineering.
Grant amount: Stipends start at $28,536 plus health benefits and up to $4,000 for research expenses.
Deadline: The application deadline is December 1, 1998.
Application information: Further information and application materials may be obtained from: President's Fellowship Program, University of California, 300 Lakeside Drive, 18th Floor, Oakland, CA 94612-3550; 510-987-9500; `http://www.ucop.edu/acadadv/fgsaa/`. Application and information materials will be available in the fall. An Equal Opportunity/Affirmative Action Employer.

• University of California, Los Angeles

Biostatistical Training in AIDS

See listing in the "Graduate Support" section for information.

University of California, Los Angeles

Earle Raymond Hedrick Assistant Professorships in Mathematics

Description: The Department of Mathematics, University of California, Los Angeles, announces the availability of three appointments for the year 1999–00. The appointments will be for three years. The teaching load will be three hours per week for two quarters and six hours per week for one quarter.

Eligibility: These awards will be made to mathematicians with recent Ph.D.s who show strong promise in research.
Grant amount: Annual salary of $47,100 in the first year.
Deadline: Preference will be given to applications completed by January 8, 1999.
Application information: Requests for application forms should be sent by electronic mail to `search@math.ucla.edu` or in writing to Department of Mathematics, University of California, 405 Hilgard Avenue, Los Angeles, CA 90095-1555, Attn: Staff Search. Web site: `http://www.math.ucla.edu`. UCLA is an Equal Opportunity/Affirmative Action Employer.

University of California, San Diego

S. E. Warschawski Assistant Professorship

Description: The S. E. Warschawski Assistant Professorship is a special two-year position. All areas of specialization will be considered. Selection will be based primarily on demonstrated research achievement. In compliance with the Immigration Reform and Control Act of 1986, individuals offered employment by the University of California will be required to show documentation to prove identity and authorization to work in the United States before hiring can occur. UCSD is an Equal Opportunity/Affirmative Action Employer.
Eligibility: Candidates (of any age) should possess a recent Ph.D. degree (received no earlier than 1996) in mathematics or expect to receive one prior to July 1999. Teaching experience is desirable.
Grant amount: The nine-month salary is $44,000.
Deadline: All applications received by January 1, 1999, will receive thorough consideration. All supporting material must be received no later than January 8, 1999.
Application information: To apply, please submit your placement file, including vita and publications, and three letters of reference to the Faculty Search Committee, Department of Mathematics, 0112, University of California, San Diego, 9500 Gilman Dr., La Jolla, CA 92093-0112. Please indicate primary research area (field and #) using the AMS Mathematical Review Classification List.

University of Chicago

L.E. Dickson Instructorships and Assistant Professorships in Mathematics

Description: The Dickson Instructorships appointment is for two years. The Assistant Professorships appointment is 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 Felloships may be held concurrently with a reduced teaching load.
Eligibility: The Dickson Instructorships are intended for persons who have recently completed the doctorate in mathematics, or soon will, and whose work shows remarkable promise in mathematical research and teaching. The Assistant Professorships are intended for persons further along in their careers, typically two or three years past the doctorate and whose work has been of outstandingly high caliber.
Deadline: January 2, 1999.
Application information: Further information and application forms may be obtained from the Appointments Secretary, Department of Mathematics, University of Chicago, 5734 S. University Avenue, Chicago, IL 60637; e-mail: `apptsec@math.uchicago.edu`; tel: 773-702-0965; fax: 773-702-9787. 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.

University of Georgia

Description: One two-year postdoctoral position in number theory with the title part-time instructor postdoctoral associate, offered by the Department of Mathematics beginning in the 1999–2000 academic year. The department especially encourages applications from women and minorities. Duties consist of teaching three courses per year and conducting original research. Applicants are suggested to identify a member of the current faculty with whom they would like to work.
Eligibility: Applicants must exhibit potential for significant research and the skills necessary to be an excellent teacher.
Deadline: Review of applications will begin on December 1, 1998, and continue until the position is filled.
Application information: To apply, send a vita with a list of publications and four letters of recommendation to Kevin Clancey, Head, Department of Mathematics, University of Georgia, Athens, GA 30602. The University of Georgia is an Equal Opportunity/Affirmative Action Employer.

University of Illinois at Urbana-Champaign

J. L. Doob Research Assistant Professor

Description: The Department of Mathematics of the University of Illinois at Urbana-Champaign is soliciting applications for postdoctoral positions. Two appointments will be made starting August 21, 1998; each appointment is for three years and is not renewable. The Department of Mathematics will provide an excellent scientific environment to pursue research in pure and applied mathematics.
Eligibility: These positions are for recent Ph.D. recipients (with a strong preference for those not more than one year past the Ph.D. degree).
Grant amount: The position carries a salary of $39,000 per year.
Deadline: For full consideration, the application must be received by December 7, 1998.
Application information: Applications should include a curriculum viate and a brief statment of research interests and activities. The use of the AMS Cover Sheet will be appreciated. Applications should be sent by regular mail to the Postdoctoral Search Committee, Department of Mathematics, University of Illinois at Urbana-Champaign, 1409 W. Green St., Urbana, Illinois 61801-2975. Applicants should arrange for at least three

letters of recommendation to be sent to the same address. For more information, visit our Web page at `http://www.math.uiuc.edu/`. Inquiries may be sent to `postdocs@math.uiuc.edu`. The University of Illinois is an Affirmative Action/Equal Opportunity Employer. Women and minorities are strongly encouraged to apply.

University of Michigan, Ann Arbor

Assistant Professorships and T. H. Hildebrandt Research Assistant Professorships

Description: Designed to provide mathematicians with favorable circumstances for academic career development including research and teaching. The teaching load is two courses per term for Assistant Professorships and one and one-half courses per term for the Hildebrandt Professorships. Appointments are for three years. NSF postdoctoral fellowships may be held simultaneously, providing a reduction in teaching load. Applicants should submit a completed application form, a research plan, a statement describing their teaching experience, and an indication of senior faculty at Michigan with whom they have a common research interest and who might mentor them. They should also arrange to have at least three letters of recommendation sent to the department. Letters should address the applicant's mathematical promise, teaching ability, and collegiality. One letter should specifically address the applicant's teaching capability and experience.
Eligibility: Preference is given to persons of any age having their Ph.D. less than two years.
Grant amount: The salary for the academic year 1999–2000 will be $39,700. There is a good possibility of additional income during the summer.
Deadline: First preference will be given to applications completed before December 18, 1998.
Application information: Applications should be made to Chair, Department of Mathematics, University of Michigan, Ann Arbor, MI 48109-1109. Affirmative Action Employer. Application forms and information also available on the departmental Web page, `http://www.math.lsa.umich.edu/`.

University of Pennsylvania

Hans Rademacher Instructorship

Description: This postdoctoral position is in honor of Hans Rademacher, a member of the department from 1934 to 1962. Appointment will be for two years, possibly renewable for a third, beginning July 1, 1999. The position carries a reduced academic-year teaching load.
Eligibility: Applicants should have received a Ph.D. in mathematics before start of the appointment, but no earlier than 1997, and are expected to show promise of significant accomplishment.
Grant amount: The stipend will be competitive and there is an additional discretionary research fund of $1,500.
Deadline: January 1, 1999.
Application information: A letter of application, vita and publications, and three letters of recommendation should be sent. Write to: Personnel Committee, Department of Mathematics, University of Pennsylvania, Philadelphia, PA 19104-6395. The University of Pennsylvania is an Equal Opportunity/Affirmative Action Employer.

University of Utah

Instructorship in Mathematics

Description: *Instructorship in Mathematics.* One or more nonrenewable three-year instructorship(s). Teaching duties for the entire three-year instructorship are nine one-semester courses. Availability of positions is contingent upon funding. The hiring committee will select candidates based on their teaching experience and research record.
Eligibility: Persons of any age receiving Ph.D. degrees in 1998 or 1999 are eligible.
Grant amount: Starting salary will be $40,000. Increases are given annually but amounts vary from year to year.
Deadline: The deadline for applications is January 15, 1999. However, applications may be accepted until all positions are filled.
Application information: To apply for any of these positions, you are strongly encouraged to fill out an application at `http://www.math.utah.edu/jobs/` or send the AMS cover sheet. To complete your application, send a curriculum vitae, bibliography, and three letters of recommendation. Incomplete files will not be considered. Please send this information to Committee on Staffing, Department of Mathematics, University of Utah, 155 S. 1400 E. JWB 233, Salt Lake City, UT 84112. The University of Utah is an Equal Opportunity, Affirmative Action Employer and encourages applications from women and minorities, and provides reasonable accommodation to the known disabilities of applicants and employees.

University of Wisconsin-Madison

Van Vleck Assistant Professorship

Description: The Department of Mathematics invites applications for possible Van Vleck assistant professorships to begin on August 24, 1999. Appointments are for a fixed term of two or three years. The usual teaching load is two courses per semester.
Eligibility: Ordinarily only those applicants who have received their doctorates since 1996 will be considered. Promise of excellence in research and teaching is important. Preference will be given to candidates who are likely to interact well with other members of the department.
Deadline: The application deadline is January 15, 1999, although applications will continue to be considered until all available positions are filled.
Application information: Applicants should send a completed AMS Standard Cover Sheet, a curriculum vitae which includes a publication list, and a brief statement of research plans to: Hiring Committee, Dept. of Mathematics, Van Vleck Hall, University of Wisconsin-Madison, 480 Lincoln Drive, Madison, WI 53706-1388. Applicants should also arrange to have three or four

letters of recommendation sent to the above address. At least one of these letters must discuss the applicant's teaching experience and capabilities. Other evidence of good teaching will be helpful. The University of Wisconsin is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minorities.

Washington University

William Chauvenet Assistant Professorship

Description: This is a two-year nontenure-track faculty appointment beginning August, 1999, with a possibility of renewal for a third year. The teaching load consists of three courses per year, two in one semester and one in the other semester. Teaching assignments normally include introductory courses for undergraduates and specialized graduate courses.
Eligibility: To be eligible for a fall 1999 appointment, a candidate must complete all requirements for the Ph.D. by September 1999. Those receiving the Ph.D. prior to 1995 and those currently holding tenure-track faculty positions are ineligible to apply. The applicant's research interests should match those of one or more or our faculty. Current research interests are: algebraic geometry, commutative algebra, foliations, functional analysis, low-dimensional manifolds, mathematical biology, probability, real and complex analysis, Riemannian geometry, and wavelets. Applications from analysts are especially encouraged.
Deadline: First consideration will be given to applications received by February 1, 1999, but applications will be reviewed until available positions are filled.
Application information: Applicants should submit a curriculum vitae, thesis abstract, statement of research plans and interest, and arrange to have sent three or four letters of recommendation. At least one referee must address the applicant's teaching abilities. Application materials and inquiries should be sent to Chauvenet Search Committee, Department of Mathematics, Washington University, Campus Box 1146, One Brookings Drive, St. Louis, MO 63130. E-mail inquiries may be addressed to `terri@math.wustl.edu`. Washington University is an Affirmative Action/Equal Opportunity Employer and specifically invites and encourages women and minorities to apply.

Yale University

Josiah Willard Gibbs Instructorships/Assistant Professorships

Description: Offered to men and women with the doctorate who show definite promise in research in pure mathematics. Applications from women and members of minority groups are welcome. Appointments are for two/three years. The teaching load is kept light to allow ample time for research. This will consist of three one-semester courses. Part of the teaching duties over the term of the appointment may consist of a one-semester course at the graduate level in the general area of the instructor's research.
Grant amount: The 1999–00 salary will be at least $44,200.
Deadline: January 1, 1998.
Application information: Inquiries and applications should be addressed to the Gibbs Committee, Department of Mathematics, Yale University, Box 208283, New Haven, CT 06520-8283. Yale University is an Affirmative Action/Equal Opportunity Employer.

Travel and Study Abroad

Alexander von Humboldt Foundation

Bundeskanzler (Federal Chancellor) Scholarship

Description: Ten Federal Chancellor scholarships are awarded annually to exceptionally able young Americans for study in such fields as the humanities, social sciences, law and economics at academic or other appropriate institutions in Germany. The objective of this program is to maintain and foster a close relationship between the U.S. and Germany by providing young scholars and practicing professionals the opportunity to obtain substantial professional and personal knowledge of Germany.
Grant amount: Monthly stipends will vary between DM 2,500 and DM 5,500 net; travel and language training expenses will be reimbursed. In addition, the stay will include an introductory seminar, a study tour and a final meeting in Bonn. The scholarship period is normally one year beginning about September 1, preceded by language classes which commence in August and are held in Germany.
Application information: Applications must be submitted to the Foundation office in Bonn, Germany, by October 31 (postmark). Finalists will be invited to an interview with the U.S. selection committee in January. The Foundation will announce results in February. Interested persons may be nominated by a senior academic official or other prominent person with knowledge of the nominee's achievements; individuals may also submit applications directly to the Foundation. Applicants must be U.S. citizens under 32 years of age and should have at least a bachelor's degree by the time the award begins. U.S. Liaison Office: 1055 Thomas Jefferson St. N.W., Suite 2030, Washington, DC 20007; tel: 202-296-2990; fax: 202-833-8514; e-mail: `info@humboldtfoundation.org`; Main office: Jean-Paul-Str. 12, 53173 Bonn, Germany; tel: +49-228-833-0; fax: +49-228-833-199.

Alexander von Humboldt Foundation

Research Fellowships

Description: The Humboldt Foundation grants some 500 Humboldt Research Fellowships annually to highly qualified foreign scholars holding doctorates up to the age of 40, enabling them to undertake long-term periods of research (6–12 months) in the Federal Republic of Germany. Applications are decided upon by a Selection Committee, which is chaired by the president of the German Research Society and composed of eminent German scholars from all disciplines. Candidates' academic

attainments are the only criterion for selection; there are no limitations in respect of specific countries or subjects.

Eligibility: Application requirements include high academic qualifications, academic publications, a specific research plan, and for humanities scholars a good command of the German language.

Grant amount: Monthly stipends range from DM 3,200 to DM 4,000 net. Family allowances, travel expenses, and language courses are covered by the fellowship.

Deadline: Applications may be submitted at any time; however, the actual selection committees meet in March, July, and November. Applications should be submitted 5–6 months before the meeting at which the candidate wishes to be considered.

Application information: Interested scholars may contact the Alexander von Humboldt Foundation, Jean-Paul-Str. 12, D-53173 Bonn, Federal Republic of Germany; tel: +49-228-833-0; fax: +49-228-833-199; e-mail: `post@avh.de`, homepage: `http://www.avh.de/`.

Alexander von Humboldt Foundation

Research Awards

Description: Provides prominent scholars in the natural sciences with the opportunity to carry out research at a university or other research institute within the Federal Republic of Germany. Nominations for awards must be made by eminent German scholars; direct applications are not accepted. Award winners are invited to spend a research stay of 4–12 months in Germany.

Eligibility: Scholars must have a position as a full/associate professor and an internationally recognized research record.

Application information: Nominators may contact the Alexander von Humboldt Foundation, Jean-Paul-Str. 12, D-53173 Bonn, Federal Republic of Germany; tel.: +49-228-833-0; fax: +49-228-833-199; e-mail: `post@avh.de`; Homepage: `http://www.avh.de/`.

American-Scandinavian Foundation

Description: Grants and fellowships for study or research in Scandinavia (Denmark, Finland, Iceland, Norway, and Sweden). Necessary language competence, financial need, and merit in pursuing the study program in Scandinavia are considered in making these awards. Applications must be on official ASF forms, available on request. Only applications on the current forms will be considered.

Eligibility: Applicants must be U.S. citizens or permanent residents and have completed their undergraduate education by the time the overseas project is to begin.

Deadline: The deadline for completed applications is November 1, 1998.

Application information: Write to the Exchange Division, The American-Scandinavian Foundation, 725 Park Avenue, New York, NY 10021; tel: 212-879-9779; fax: 212-249-3444; Web site: `http://www.amscan.org/`.

Centro de Investigación y de Estudios Avanzados del IPN

Solomon Lefschetz Research Instructorships

Description: Appointments are for one year with a possibility of renewal for another year. The principal duties will be to do research and to teach a graduate course in the area of your specialty.

Eligibility: Offered to young mathematicians with doctorates who show definite promise in research. Knowledge of Spanish is desirable.

Grant amount: Salary equivalent to that of assistant professor in the mathematics department. An allowance for moving expenses.

Deadline: Deadline for applications is December 31, 1998.

Application information: Inquiries should be addressed to: Solomon Lefschetz Instructorships, Mathematics Department, CINVESTAV del IPN, Apartado Postal 14-740, 07000, México, D.F., México; phone (52-5) 747-7103; fax (52-5) 747-7104.

• The Chateaubriand Fellowship

Science and Technology Program

Eligibility: If you are currently working towards your Ph.D. in science or engineering, including biomedical and agricultural sciences, or if you have completed it in the last three years, you may qualify for a fellowship from the French Government to conduct research in France. Some of the fellowships are cosponsored by French companies. Candidates must be accepted by a French laboratory in order to be eligible for this fellowship program. Candidates may use existing contacts between own laboratory and a French research institution. If candidate does not have such contacts, he/she may register on the Web (`http://www.chateaubriand.amb-wash.fr`). In this case, the candidate's file will be submitted to directors of various laboratories in France who will be able to contact them directly. Applicants must be U.S. citizens and registered in a university in the U.S. or in a U.S. national laboratory.

Grant amount: Starting in September 1998, fellowships are available for a six- to twelve-month period, with a monthly stipend of $1,800 for a doctoral fellow and $2,200 for a postdoctoral fellow. Health insurance and a round-trip ticket are also provided.

Deadline: Only completed applications received before December 1, 1997, will be accepted.

Description: The fellowships are given to conduct research in a French university, a school of engineering or in a public or private laboratory. (For example, the Laboratoire de Physique Corpusculaire de Clermont-Ferrand, supported by the Blaise Pascal Université and the CNRS, is ready to accept candidates. The activities of the Laboratory are in hadronic physics field with strong activity at TJNAF (CEBAF), and in elementary particle at CERN, where there are teams in ATLAS and ALICE. For further information please contact Pierre-Yves Bertin at `bertin@jlab.org` or `bertin@clermont.in2p3.fr`).

Application information: The Embassy of France, Office for Science and Technology, Chateaubriand Fellowship,

4101 Reservoir Road, NW, Washington, DC 20007-2176; tel: 202-944-6261; fax: 202-944-6244; http://www.chateaubriand.amb-wash.fr/; e-mail: chateaubriand@amb-wash.fr.

• Fulbright Teacher Exchange Program

Description: Sponsored by the United States Information Agency, this program offers international exchange opportunities for two-year community college faculty members and elementary and secondary school teachers and administrators. Currently the program conducts exchanges with twenty-three countries in Eastern and Western Europe, Latin America, Africa, and Canada. (The list of countries is subject to change.) Most exchanges are for the full academic year; however, some are for a semester or six weeks. A few one-way assignments are also available. In most cases both the U.S. and international teacher remain on the payroll of their respective home institutions. The Fulbright Teacher Exchange Program also offers an eight-week summer seminar in Italy which is open to college and university faculty and teachers (grades 9–12) of Latin, Greek, and the Classics.

Eligibility: Eligibility requirements are U.S. citizenship, fluency in English, a bachelor's degree or higher, three years' full-time teaching/administrative experience, a current full-time teaching/administrative position, approval of school administration, and no participation in a Fulbright Teacher Exchange Program longer than eight weeks in the last two years. In addition to the general eligibility requirements, each applicant must meet the specific subject, level, and language fluency requirements for the countries to which he/she applies; these requirements are detailed in the application booklet.

Grant amount: Grants to teach abroad may include round-trip transportation for the participant (except Canada and the United Kingdom).

Deadline: The application deadline is October 15 for the following year's program.

Application information: The application booklet should be requested from the Fulbright Teacher Exchange Program, 600 Maryland Ave., SW, Room 140, Washington, DC 20024-2520; 800-726-0479.

International Research and Exchanges Board (IREX)

Description: Programs administered by IREX include exchanges from two weeks to one academic year with Central and Eastern Europe, Eurasia, and Mongolia; grants to promote new exchanges; collaborative projects in the social sciences and humanities; and short-term travel grants for postdoctoral scholars in social sciences and humanities. The IREX programs provide access at the predoctoral and postdoctoral levels to East European and Eurasian universities and academies of sciences.

Application information: For a program announcement describing the full range of IREX programs, write to the International Research & Exchanges Board, 1616 H Street, NW, Washington, DC 20006; 202-628-8188; fax: 202-628-8189; e-mail: irex@irex.org; or visit the IREX Web site at http://www.irex.org/.

Marshall Scholarships

Description: Up to forty scholarships are offered by the British Government to U.S. graduates; tenable at any university in the United Kingdom. Fields unrestricted.

Eligibility: Recipients of awards are required to take a degree at their British university. Age limit: 25 years.

Deadline: Deadline: October 13, to commence the following September.

Application information: Apply through British Consulates General in the following regions: (1) Northeast: Federal Reserve Plaza, 600 Atlantic Avenue, 25th Floor, Boston, MA 02210; (2) Mideast: British Embassy Cultural Dept., 3100 Massachusetts Avenue, NW, Washington, DC 20008; (3) South: Suite 2700, Marquis One Tower, 245 Peachtree Center Avenue, Atlanta, GA 30303; (4) Midwest: Suit 1300, The Wrigley Building, 400 N. Michigan Avenue, Chicago, IL 60611; (5) Pacific: 1 Sansome Street, Suite 850, San Francisco, CA 94104; (6) Southwest: First Interstate Bank Plaza Bldg., Suite 1900, 1000 Louisiana, Houston, TX 77002.

National Academy of Sciences (NAS)

Collaboration in Basic Science and Engineering (COBASE)

Description: The NAS invites applications from American scientists who wish to make visits to or to host foreign scientists from Armenia, Azerbaijan, Belarus, Bosnia, Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Macedonia, Moldova, Poland, Romania, Russia, Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan. The program of individual exchanges will support 1- to 6-month research visits. The project development grants will support two-week visits. Applicants for the project development visits need to demonstrate that a joint proposal for collaborative research will be prepared during their visit for submission to the National Science Foundation for funding.

Eligibility: Applicants must be U.S. citizens or permanent residents and have doctoral degrees or their equivalent. Acceptable topics include physics; chemistry; mathematics and computer sciences; earth, atmospheric, and oceanographic sciences; biological sciences; environmental sciences; engineering; archaeology and anthropology; geography; psychology; science and technology policy; economics; linguistics; or the history and philosophy of science. There is special emphasis on young investigators in each program.

Application information: Address application requests to: Office for Central Europe and Eurasia, National Academy of Sciences, 2101 Constitution Ave., NW, Washington, DC 20418; e-mail: ocee@nas.edu; tel: 202-334-3680; http://www2.nas.edu/oia/22da.html.

National Science Foundation

International Research Fellow Awards

Description: The International Division of the National Science Foundation administers a program to introduce scientists and engineers in the early stages of their careers to research opportunities abroad. The program provides support to carry out research at science and engineering establishments in foreign countries for periods of three to twenty-four months. Support for short-term visits, in order to plan research abroad, is also available. Applications from women and minorities and for work in developing countries are especially encouraged. Research may be done in any field of science and engineering supported by the National Science Foundation. Appropriate host institutions are institutions of higher education, science and engineering centers, and nonprofit industrial and government research institutes.
Eligibility: Eligible applicants, in addition to being citizens or permanent residents of the United States, must have earned a doctoral degree within six years of the date of application or expect to receive their degree by the award date.
Grant amount: Awards will consist of round-trip economy airfare, in-country travel, a modest living allowance, health insurance, and dependent allowance for visits of six months or more. Support for language training is also available.
Deadline: November 1. Decisions will be announced the following March.
Application information: Interested persons should contact the National Science Foundation for details and application materials. Applications must include a letter of invitation from the proposed host institution. Address inquiries to NSF, Division of International Programs, 4201 Wilson Blvd., Arlington, VA 22230; telephone: 703-306-1706; fax: 703-306-0474; e-mail: `sparris@nsf.gov`; TDD: 703-360-0090. Guidelines to the program may be obtained by anonymous ftp to `stis.nsf.gov`, using anonymous for the user name and e-mail address for password. Retrieve publication NSF9588.txt. World Wide Web: Using a "Web browser" software, access the NSF home page. The URL is `http://www.nsf.gov/`.

Natural Sciences and Engineering Research Council of Canada

Visiting Fellowships

Description: The Government of Canada offers fellowships on behalf of the following Canadian Government departments and agencies: Agriculture and Agri-Food Canada, Canadian Space Agency, Industry Canada, National Defence, Natural Resources Canada, Environment Canada, Fisheries and Oceans, Health Canada, National Research Council Canada, Canadian Museum of Nature. The initial appointment is for one year, with a possibility of renewal for a second year.
Eligibility: The applicant should hold a recent doctoral degree (within the last five years).
Grant amount: The annual value of the fellowships is $35,184, subject to Canadian income tax.
Deadline: The closing dates for applications are November 15, March 15, and July 15 each year.
Application information: Write to the Visiting Fellowships Office, Natural Sciences and Engineering Research Council of Canada, 350 Albert Street, Ottawa, Ontario, Canada K1A 1H5.

Social Science Research Council

International Dissertation Research Fellowship Program (IDRF)

Description: The program provides support to advanced doctoral candidates at U.S. universities for dissertation research outside the U.S.
Application information: Full information on this program may be obtained by writing to the Social Science Research Council, IDRF Program, 810 Seventh Ave., New York, NY 10019; 212-377-2700.

USIA Fulbright Program

Fulbright and Related Grants for Graduate Study and Research Abroad.

Description: For graduate study or research in any field in which the project can be profitably undertaken abroad. If an applicant is already enrolled in a U.S. university, he must apply directly to the Fulbright Program Adviser on his campus. Unenrolled students may apply to the Institute of International Education.
Eligibility: Applicant must be a U.S. citizen, hold a B.A. degree or the equivalent, and have language proficiency sufficient to carry out the proposed study and to communicate with the host country.
Application information: Further details may be obtained from the USIA Fulbright Student Program, U.S. Student Programs Division, Institute of International Education, 809 United Nations Plaza, New York, NY 10017; 212-984-5330.

Winston Churchill Foundation of the United States

Description: A scholarship program for graduate work in engineering, mathematics, and science at Churchill College, Cambridge University.
Grant amount: Tuition and living allowance worth approximately $25,000, depending upon course of study.
Application information: Application forms are available from representatives on campuses of colleges and universities participating in the program. For further information write to the Winston Churchill Foundation, P.O. Box 1240, Gracie Station, New York, NY 10028.

Weizmann Institute of Science

Feinberg Graduate School Postdoctoral Fellowships

Description: The fellowships provide a 12-month stipend (with possible renewal for a second year), a small relocation allowance, and a one-way air ticket. Round-trip airfare is provided if the fellowship is extended for a second year.

Eligibility: The fellowships are intended mainly for scientists who have recently obtained their Ph.D. degree.
Grant amount: The annual stipend is adjusted periodically in accordance with living costs.
Deadline: The review of applications is held twice a year, on January 1 and May 15.
Application information: Application forms and additional information may be obtained from the Feinberg Graduate School, The Weizmann Institute of Science, P.O. Box 26, Rehovot 76100, Israel. World Wide Web: `http://www.weizmann.ac.il/`; e-mail: `NFINFO@WEIZMANN.weizmann.ac.il`.

Study in the U.S. for Foreign Nationals

Many of the programs in the "Graduate Support" and "Postgraduate Support" sections are also applicable to foreign nationals.

American-Scandinavian Foundation

Description: Scandinavian scholars are awarded graduate fellowships to study in the U.S.
Application information: For information write to the appropriate society in Scandinavia cooperating with The American-Scandinavian Foundation (The Denmark-America Foundation, Fiolstraede 24, 3.sal DK-1171, Copenhagen K, Denmark; The League of Finnish-American Societies, Mechelininkatu 10, SF-001 00 Helsinki, Finland; The Icelandic-American Society, c/o The US-Iceland Educational Commission, Laugavegi 26, 101 Reykavík, Iceland; The Norway-America Association, Drammensveien 20C, 0255 Oslo 2, Norway; The Sweden-America Foundation, Box 5280, S-102 46 Stockholm, Sweden) or to the Exchange Division, The American-Scandinavian Foundation, 725 Park Avenue, New York, NY 10021; tel: 212-879-9779; fax: 212-249-3444; Web site: `http://www.amscan.org/`.
Grant amount: The number of awards varies each year according to total funds available.

American Association of University Women (AAUW) Educational Foundation

International Fellowships

Description: These are awarded to women of outstanding academic ability who are not citizens or permanent residents of the U.S. for full-time graduate or postgraduate study in the U.S. Upon completion of studies, fellowship recipients must return to their home countries to pursue professional careers. Previous and current recipients of AAUW fellowships are not eligible.
Eligibility: Applicants must hold the equivalent of a U.S. bachelor's degree by December 1.
Grant amount: The fellowships provide $16,000 each.
Deadline: The deadline is January 15 (receipt).
Application information: For more information contact: AAUW Educational Foundation, P.O. Box 4030, Iowa City, IA 52243-4030; telephone: 319-337-1716; fax: 319-337-1204.

Fulbright Program

Description: Grants under the Fulbright Act for study, research, teaching, and lecturing in the United States are available to nationals of many countries. The number of grants for each academic year will depend on funds available.
Application information: Information regarding these opportunities may be secured from the Cultural Affairs Officer of the United States Embassy or from the Binational Educational Commission or Foundation, if there is one in the inquirer's own country.

International Research and Exchanges Board (IREX)

Description: Programs administered by IREX include exchanges from two weeks to one academic year with Central and Eastern Europe, Eurasia, and Mongolia; grants to promote new exchanges; collaborative projects in the social sciences and humanities; and short-term travel grants for postdoctoral scholars in social sciences and humanities. The IREX programs provide access at the predoctoral and postdoctoral levels to East European and Eurasian universities and academies of sciences.
Application information: For a program announcement describing the full range of IREX programs, write to the International Research & Exchanges Board, 1616 H Street, NW, Washington, DC 20006; 202-628-8188; fax: 202-628-8189; or visit the IREX Web site at `http://www.irex.org/`; e-mail: `irex@irex.org`.

Kennedy Scholarships

Description: These grants are for postgraduate study at Harvard University or the Massachusetts Institute of Technology.
Eligibility: For citizens of the United Kingdom.
Deadline: Application deadline is October 28, 1998.
Application information: Write to Secretary, Kennedy Memorial Trust, 48 Westminster Palace Gardens, Artillery Row, London SWIP 1RR, England.

Sources of Fellowship Information

Some of the publications listed below are available at school or college and university libraries or in the reference room of a good public library.

Academic Year Abroad 1998/99

Describes 2,491 academic-year and semester-length programs, offered by U.S. and foreign university and private

organizations. Key information on application procedures and requirements, academic credit, addresses and phone contacts, costs, fields of study, languages of instruction, housing, travel and orientation. Introductory section on planning study abroad and on how to read study-abroad literature. Indexes to sponsor institutions, consortia, fields of study, cost ranges, and special options such as internships, student teaching, and independent study. 2,081 program-specific Web addresses give students and study-abroad advisers immediate access to additonal guidance on 80 percent of programs described. Annual. $44.95 (plus $6.00 postage and handling). ISBN 0-87206-241-4. IIE Books, Institute of International Education, P. O. Box 371, Annapolis Junction, MD 20701-0371.

Annual Register of Grant Support, 1999

R.R. Bowker, a unit of Canners Business Information, 121 Chanlon Rd., New Providence, NJ 07974. Directory of fellowships, grant support programs of government agencies, foundations, corporations, and business and professional organizations. Annual. $199.95 plus $14.40 postage and handling.

Basic Facts on Study Abroad in the 21st Century

Designed to guide U.S. students to information on the broad range of practical considerations that accompany study abroad. Valuable advice on the choice of program, definition of terms, and financial consideration. An extensive bibliography lists other sources of information. Single copy free: $25.00 per 50 plus $6.00 shipping and handling. IIE Books, Institute of International Education, P. O. Box 371, Annapolis Junction, MD 20701-0371.

The Big Book of Minority Opportunities: The Directory of Special Programs for Minority Group Members

(6th Edition, 1997, 450 pages), Garrett Park Press, Garrett Park, MD 20896. $39.95

Chronicle Financial Aid Guide, 1998/1999

Order #502A. ISBN 1-55631-288-1. $22.47 plus $2.25 postage and handling. Revised annually. Chronicle Guidance Publications, Inc., 66 Aurora Street, P. O. Box 1190, Moravia, NY 13118-1190; 1-800-622-7284; fax: 315-497-3359; Web site: `http://www.chronicleguidance.com/`. Provides information on over 1,850 financial aid programs available to high school students, college undergraduates, and graduates, including programs sponsored by private organizations and foundations; state and federal government sources; and national and international labor unions, both AFL-CIO affiliated and independent. A Subject Index to Programs gives easy access to programs for which a student may be eligible. A bibliography of resources is also listed.

Chronicle Four-year College Databook, 1998–1999

Lists 2,160 colleges and 790 majors. Data covered include degrees, accreditation, enrollment, admissions, Internet addresses, costs, and aid. Order #502CM4, ISBN 1-55631-286-5, $22.49 plus $2.25 shipping and handling. Chronicle Guidance Publications, Inc., 66 Aurora Street, P. O. Box 1190, Moravia, NY 13118-1190; 1-800-622-7284; fax: 315-497-3359; Web site: `http://www.chronicleguidance.com/`.

Chronicle Two-Year College Databook, 1998–1999

Provides information on over 2,400 colleges, 760 occupational-career programs, nondegree and degree programs, accreditation, enrollment, admissions, costs, and financial aid. Order #502CM2, ISBN 1-55631-287-3, $22.46 plus $2.25 shipping and handling. Chronicle Guidance Publications, Inc., 66 Aurora Street, P. O. Box 1190, Moravia, NY 13118-1190; 1-800-622-7284; fax: 315-497-3359; Web site: `http://www.chronicleguidance.com/`.

Directory of Computer and High Technology Grants

Richard M. Eckstein, Publisher. This directory lists 500 funding sources for computers, software, and hightech-related grants and provides extensive profiles on foundations. 3rd Edition cost is $59.50 plus $6.00 for shipping and handling. Research Grant Guides, Dept. 3A, P. O. Box 1214, Loxahatchee, FL 33470; 407-795-6129. Please Note: Directories are for nonprofit organizations only.

Directory of Graduate Programs, 15th Edition

Four volumes categorized by discipline, $20.00 each. Volume A: Natural Sciences; Volume B: Engineering, Business; Volume C: Social Sciences, Education; Volume D: Arts, Humanities, Other Fields. Educational Testing Service, P. O. Box 6014, Princeton, NJ 08541-6014. Includes graduate programs in United States and Canada.

Dollars for College: The Quick Guide to Financial Aid for Science and Mathematics

(1997, 75 pages), Garrett Park Press, Garrett Park, MD 20896. $7.95 + $1.50 postage.

Financial Aid for Minorities in Engineering and Science

Financial assistance, scholarship and fellowship programs, resources for further information, 1995, Garrett Park Press, P. O. Box 190, Garrett Park, MD 20896. $5.95 + $1.50 shipping.

Financial Resources for International Study: A Guide for U.S. Students and Professionals

Grant listings include award-granting agency's name, address, phone, fax and e-mail. Amount and type of award. Purpose and geographic location for its use. Eligibility, application deadline and notification dates. Indexes organize grants by sponsor, field of study, academic level, and type of award, amount of support, destination. Identifies awards targeted for women, for minorities, and for other specific populations. 1996. 8.5 x 11. Indexes. ISBN 0-87206-220-1. $39.95 pb. plus $6.00 shipping and handling. IIE Books, Institute of International Education, P. O. Box 371, Annapolis Junction, MD 20701-0371.

The Foundation Center

The Foundation Center, 79 Fifth Avenue, New York, NY 10003, provides free library service through over 200 libraries across the country and publishes information about U.S. foundations and the grants they award, including the publication *Foundation Grants to Individuals* (10th edition, 1997, $65.00). Call toll-free 800-424-9836 for further information.

Fulbright Scholar Program Grants for Faculty and Professionals: Research and Lecturing Awards

(Current Edition) Available from the Council for International Exchange of Scholars, 3007 Tilden St., NW, Suite 5M, Box NEWS, Washington, DC 20008-3009; 202-686-7877; e-mail: `cies1@ciesnet.cies.org`; World Wide Web: `http://www.cies.org/`.

Fulbright and Other Grants for Graduate Study Abroad

List of grants for graduate study and research abroad, administered by the IIE for U.S. citizens. Request copy of brochure from U.S. Student Programs, Institute of International Education, 809 United Nations Plaza, New York, NY 10017; 212-984-5330.

Funding for U.S. Study

Features detailed descriptions of more than 600 fellowships, grants, scholarships and paid internships. For undergraduates, graduate students and postdoctoral students as well as working professionals. Sponsors of all awards welcome applications from foreign nationals. A substantial number of awards are intended specifically for international use. Sponsors are US and foreign governments, colleges and universities, educational associations, libraries, research center, foundations, corporations and other organizations. Descriptions include contacts, number and purpose of awards, amount and type of financial support, eligibility, restrictions, duration, and how to apply. 1996. 8.5 x 11. Indexes. ISBN 0-87206-219-8. $39.95 pb. plus $6.00 shipping and handling. IIE Books, Institute of International Education, P. O. Box 371, Annapolis Junction, MD 20701-0371.

Graduate School and You: A Guide for Prospective Graduate Students

Council of Graduate Schools, 5th Edition, 1996. Available from the Council of Graduate Schools, 1 Dupont Circle, NW, Suite 430, Washington, DC 20036-1173, or call 202-223-3791. This publication is $5.00 plus S&H. It can be obtained by calling CGS for an order form.

• The Grants Register

1997–1998. Ruth Austin (ed.), St. Martin's Press, 175 Fifth Avenue, New York, NY 10010. Lists scholarships, fellowships, and grants at all levels of graduate study, all over the world, available from government agencies and international, national, and private organizations. List price $115.00. Annual.

International Exchange Locator

A publication of the Liaison Group for International Education Exchange distributed through IIE Books, this book includes nearly 200 pages of key information on more than 100 organizations responsible for the exchange of over 100,000 U.S. and foreign nationals annually. Provides contact data on twelve committees and twenty-four subcommittees of the House and Senate that deal with exchange issues, as well as a listing of over 400 federal agency officials in twenty-one agencies with complete address and fax information. 1998. ISBN 0-87206-244-9. $11.95 pb. plus $3.00 shipping and handling. IIE Books, Institute of International Education, P. O. Box 371, Annapolis Junction, MD 20701-0371.

• The Prentice Hall Guide to Scholarships and Fellowships for Math and Science Students

(*A Resource for Students Pursuing Careers in Mathematics, Science, and Engineering*), by Mark Kantrowitz and Joann P. DiGennaro. This resource book focuses on the more than 250 scholarships and fellowships available to math and science students at the high school, undergraduate, and graduate levels. It also provides the latest information on over eighty contests and competitions, internships, summer employment offerings, and opportunities to study abroad. Included are financial aid programs that span the whole range of careers open to students in science, math, and engineering. Programs directed toward female and minority students can be found, as well as programs of a more general nature that do not restrict the student's field of study. The guide supplies information on: (1) how to uncover all possible sources of financial aid, assess career goals, obtain useful letters of recommendation, and get nominated for scholarships and fellowships; (2) how to choose an undergraduate school; and (3) how to improve one's chances of getting accepted to a graduate school. Information:

Simon & Schuster, Mail Order Customer Service, Rt. 59 at Brook Hill Dr., West Nyack, NY 10994; 800-288-4745; fax: 800-495-6991; e-mail: `books@prenhall.com`; ISBN 0-13-045345-5 (paper), 325 pp., $19.95; ISBN 0-13-045337-4 (cloth), 325 pp., $29.95.

U.K. Central Bureau Publications

The Central Bureau is the agency funded by the education ministries of the U.K. to provide the most-needed information on international education. IIE is the U.S. distributor for five Central Bureau books most widely used by U.K. students, librarians, and campus professionals in planning study and work abroad. IIE Books, Institute of International Education, P. O. Box 371, Annapolis Junction, MD 20701-0371.

Vacation Study Abroad 1998/99

A guide to 2,008 short-term and summer programs offered by U.S. and foreign higher education institutions, language schools, and private agencies. Programs listed are open to U.S. undergraduates, graduate students, and adult learners. Contains information on courses, costs, scholarships, and accommodations. 1998/1999. Annual. $39.95 (plus $6.00 postage and handling). ISBN 0-87206-242-2. IIE Books, Institute of International Education, P. O. Box 371, Annapolis Junction, MD 20701-0371.

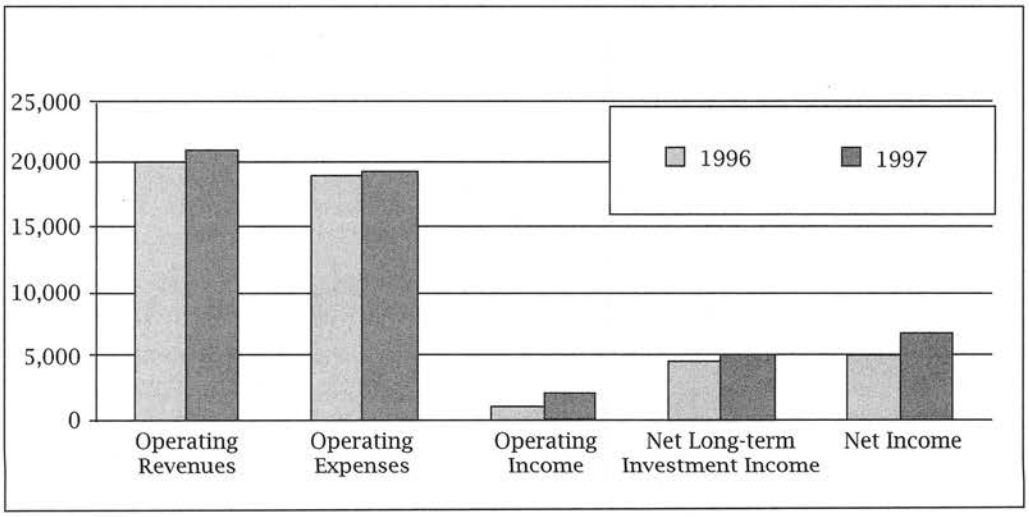
Report of the Treasurer (1997)

I. Introduction

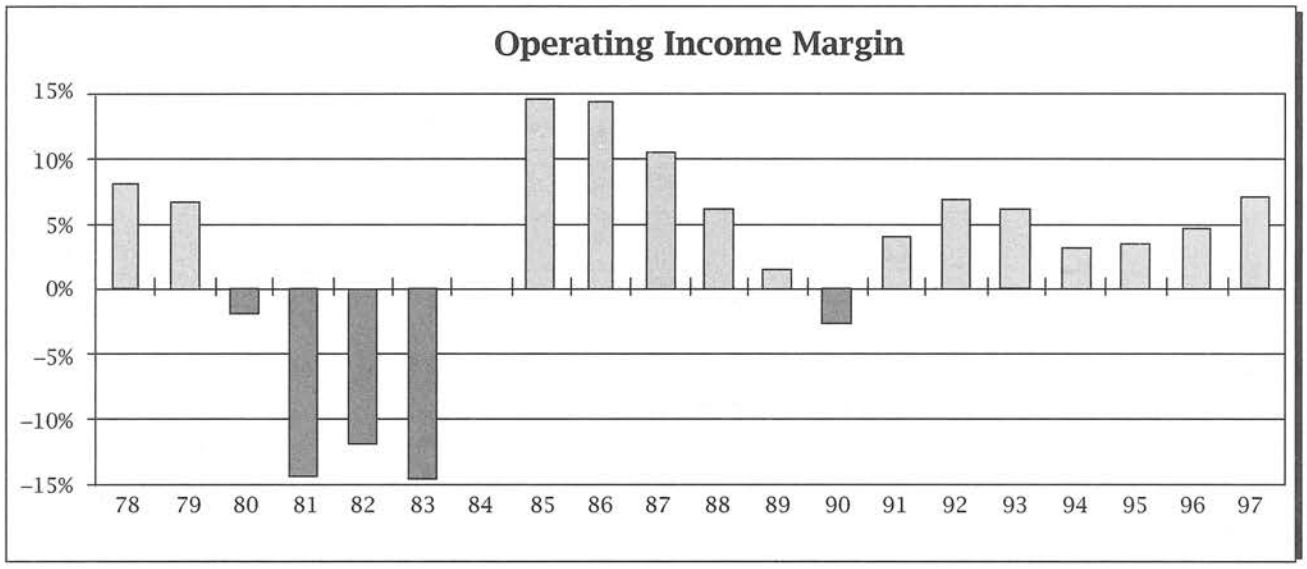
The Report of the Treasurer is presented annually and discusses the financial condition of the Society as of the immediately preceding fiscal year-end and the results of its operations for the year then ended. This section contains summary information regarding the operating results and financial condition of the Society for 1997. Section II, "Review of 1997 Operations", contains more detailed information regarding the Society's operations. Section III discusses the assets and liabilities of the Society. Section IV, "Summary Financial Information", presents information regarding the operations, financial condition, and long-term investments of the Society in financial statement format.

The Society segregates its net assets, and the activities that increase or decrease net assets, into three types. **Unrestricted net assets** are those which have no requirements as to their use placed on them by donors outside the Society. A substantial majority of the Society's net assets and activities are in this category. **Temporarily restricted net assets** are those with donor-imposed restrictions or conditions that will lapse upon the passage of time or the accomplishment of a specified purpose. Examples of the Society's temporarily restricted net assets and related activities include grant awards and the spendable income from prize and other income-restricted endowment funds. **Permanently restricted net assets** are those that must be invested in perpetuity and are commonly referred to as endowment funds. The accompanying financial information principally relates to the unrestricted net assets, as this category includes the operating activities of the Society.

Unrestricted revenue in excess of unrestricted expenses for the year ended December 31, 1997, totaled approximately $6,335,000. Of this amount, net returns on the unrestricted portion of the long-term investment portfolio totaled $4,580,000, and net income from operations totaled $1,755,000. Exceptionally strong financial markets in the U.S. during the year contributed to returns on our long-term portfolio that approximated 19%, a return which is comparable to the very highest of university endowments. These and other matters are discussed in more detail in the following sections.



The Society's net assets totaled $36,074,000 at December 31, 1997. $1,296,000 is permanently restricted, consisting principally of donor restricted gifts and bequests received by the Society; $1,670,000 is temporarily restricted by donor-imposed limitations that will



lapse upon the passage of time or the use of the asset for its intended purpose; $33,108,000 is unrestricted, of which $25,391,000 has been designated by the Board of Trustees, principally in the form of the Economic Stabilization Fund. This fund's purpose is to provide a source of cash in the event of a financial crisis. It has met the target established by the Board of Trustees of 75% of operating expenses plus the unfunded liability for post-retirement benefits. Assets underlying this fund are long-term investments whose performance is monitored to ensure that the target is maintained. The remaining unrestricted net assets consist of $5,934,000 invested in fixed assets and undesignated net assets of $1,783,000.

II. Review of 1997 Operations

Financially, 1997 was the Society's best year since the mid-1980s. In terms of operating income and total revenues over expenses (the equivalent of a for-profit's net income), the Society exceeded its expectations.

1997 operating revenues exceeded 1996 and operating expenses were about the same as in 1996, resulting in increased operating income. In addition to these good operating results, the Society's long-term investments had another outstanding year, generating about $4,580,000 of unrestricted investment income.

When reflecting on a year with good operating results, it is instructive to review the Society's record for a somewhat longer period. The chart above shows operating income as a percentage of operating revenues. Two observations are noteworthy. First, the margin achieved in 1997 is high for the most recent ten years, but not so high compared with the first ten years presented. Second, the variation in margin over the most recent ten years is smaller than the variation in the first ten years.

Sales Trends

The graphs on the following page show sales trends from 1992 through 1997, first in historical dollars and second in constant dollars (using 1997 as the base year and adjusting other years for inflation).

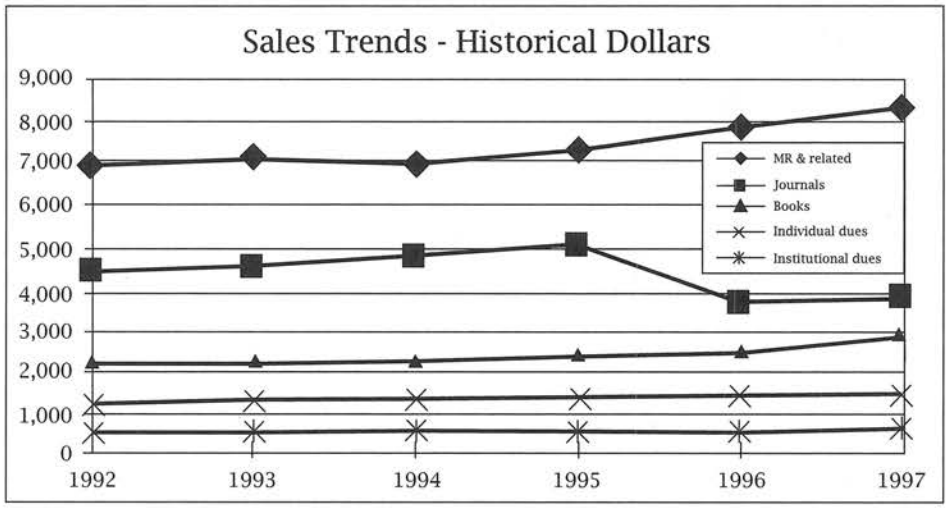
Sales Trends - Historical Dollars shows sales trends from 1992 through 1997. Some of the trends are mildly upward, and this may be due to the effects of inflation. Below, the chart is repeated with the underlying data converted to constant dollars.

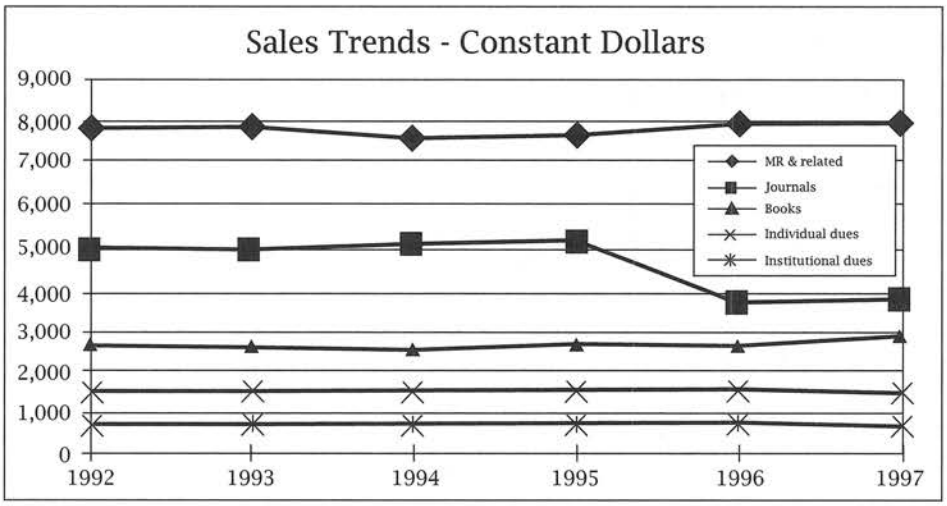
Mathematical Reviews. Once again, MR shows a good sales trend. Total MR revenues continue to grow. In addition, more institutions are taking advantage of consortium pricing, and we expect this trend to help stabilize the revenues from MR while providing a means for more institutions to access MR.

Journals. Journal revenues have held reasonably constant for 1997. The drop in 1996 resulted from decisions made by those in control of four Russian journals (*Izvestiya*, *Sbornik*, *Steklov*, and *Doklady*) to use sources other than AMS for translation into English and distribution of the resulting translation journals. The Society continues to keep annual price increases well below those reported for most scientific and technical journals, and there have been only small losses of subscribers.

Books. Book revenues have been somewhat level historically. There was a slight increase in 1996, with a steeper increase in 1997. The Society continues to increase sales in bookstores, has introduced an online bookstore (accessible through the e-MATH home page or directly at `www.ams.org/bookstore/`), and has worked to improve distribution arrangements around the world.

Dues. Dues, both individual and institutional, have shown a slight upward slope on the historical dollars chart and a nearly flat line in constant dollars. This is expected for institutional dues, as the number of members varies little from year to year and the dues rates have been set so that dues will increase at about the same level as inflation. Individual membership has not risen at the rate we would like. The organization is working on ways to make membership more attractive.





Major Expense Categories

	1997		1996	
Personnel Costs	$10,942	61%	$10,808	60%
Building and Equipment Related	1,642	9%	1,679	9%
Postage	813	4%	900	5%
Outside Printing	998	6%	1,034	6%
Travel-Staff and Volunteers	509	3%	532	3%
All Other Expenses	3,109	17%	3,151	17%
TOTAL	$18,103	100%	$18,104	100%

The table above shows the major expenses for 1996 and 1997 in thousands of dollars. In terms of how expense dollars are allocated, there is not much change from year to year. Remarkably, total expenses excluding interest on unfunded retirement benefits and expenses such as commissions that directly offset revenues decreased from 1996 to 1997.

III. Assets and Liabilities

So far, this report has dealt with revenues and expenditures that affect unrestricted net assets. Another aspect of the Society's finances is what it owns and owes, or its assets and liabilities, which are reported below in the balance sheets. As discussed previously, the Society's net assets and activities that increase or decrease net assets are classified as unrestricted, temporarily restricted, or permanently restricted. A majority of the assets and liabilities detailed on the accompanying balance sheets relate to the unrestricted net assets. The permanently restricted net assets are supported by investments in the long-term investment portfolio, and the temporarily restricted net assets are supported by investments in the long-term and short-term investment portfolios. The Market Value of Invested Funds shows the market value of each endowment and Board-designated (quasi-endowment) fund, including any reinvested earnings.

The Society's fiscal year coincides with the period covered by subscriptions and dues. Since dues and subscriptions are generally received in advance, the Society reports a large balance of cash and short-term investments on its financial statements at year-end. This amounted to about $11,069,000 and $8,647,000 at December 31, 1997 and 1996, respectively. The recorded liability for the revenues received in advance was about $11,112,000 and $10,553,000 at December 31, 1997 and 1996, respectively. The difference can be thought of as having been invested in the Society's other assets, principally the long-term investment portfolio. Effectively, the Society borrows from its subscribers to finance current operations and long-term investments. This is a common practice in the publishing industry and allows the Society to operate free of short-term or long-term bank debt.

The Society's property and equipment include land, buildings and improvements, office furniture and equipment, as well as software. The Society also owns a small amount of transportation equipment. The land, buildings, and improvements include the Society's Rhode Island headquarters, with buildings in Providence and Pawtucket, and the Mathematical Reviews offices in Ann Arbor. The largest part of the Society's office equipment is its investment in computer facilities.

The Society's endowment is managed under the "total return concept". Under this management policy, income in excess of a reasonable amount (set by the Board of Trustees) is reinvested and added to the principal of the fund. This allows for growth in income over time. Because of good investment returns, endowment funds have increased more than 30% over the past two years.

IV. Summary Financial Information

The Treasurer presents to the membership the following financial information of the Society. A copy of the Society's audited financial statements, as submitted to the Trustees and the Council, will be sent from the Providence office to any member who requests it from the Treasurer. The Treasurer will be happy to answer any questions members may have regarding the financial affairs of the Society.

BALANCE SHEETS (in 000's)
December 31, 1997 and 1996

Assets	1997		1996	
Cash and cash equivalents	$800	2%	$708	2%
Short-term investments	10,269	19%	7,939	17%
Receivables:				
Customers, less allowance	1,164	2%	1,052	2%
Grants and other	406	1%	527	1%
Deferred prepublication costs	428	1%	397	1%
Completed books	1,143	2%	982	2%
Prepaid expenses and deposits	892	2%	832	2%
Land, buildings and equipment, net	5,934	11%	6,117	14%
Long-term investments	31,205	60%	26,347	59%
Total assets	**$52,241**	**100%**	**$44,901**	**100%**
Liabilities and Net Assets				
Liabilities:				
Accounts payable	$1,225	2%	$1,285	3%
Accrued expenses:				
Severance and study leave pay	969	2%	878	2%
Vacation and sick pay	557	1%	508	1%
Payroll, benefits & other	782	1%	710	2%
Deferred revenue:				
Subscriptions	9,053	17%	8,533	19%
Dues	1,471	3%	1,444	3%
Other	588	1%	576	1%
Post-retirement benefit obligation	1,522	3%	1,375	3%
Total liabilities	**16,167**	**31%**	**15,309**	**34%**
Net Assets (deficit):				
Unrestricted:				
Undesignated	1,783	3%	(679)	-2%
Designated	25,391	49%	21,335	48%
Invested in fixed assets	5,934	11%	6,117	14%
Temporarily restricted	1,670	3%	1,540	3%
Permanently restricted	1,296	2%	1,279	3%
Total net assets	**36,074**	**69%**	**29,592**	**66%**
Total liabilities and net assets	**$52,241**	**100%**	**$44,901**	**100%**

STATEMENTS OF ACTIVITIES (in 000's)

Unrestricted Net Assets
Years Ended December 31, 1997 and 1996

Operating Revenue	1997		1996	
Publication:				
Mathematical Reviews and related activities	$8,161	39%	$7,894	40%
Journals (excluding MR)	3,803	18%	3,658	19%
Books	2,799	13%	2,462	12%
Sale of services	330	2%	275	1%
Other	62	- %	64	- %
Total publication revenue	**15,155**	**72%**	**14,353**	**72%**
Membership and professional services:				
Meetings	684	3%	730	4%
Dues and membership services	3,433	17%	3,266	16%
Grants, prizes and awards	950	5%	1067	6%
Total membership and professional services revenue	**5,067**	**25%**	**5,063**	**26%**
Short-term investment income	472	2%	239	1%
Other	218	1%	207	1%
Total operating revenues	**$20,912**	**100%**	**$19,862**	**100%**
Operating Expenses				
Publication:				
Mathematical Reviews and related activities	$5,178	27%	$5,224	27%
Journals (excluding MR)	933	5%	1,101	6%
Books	2,589	13%	1,919	10%
Publication—divisional indirect	889	5%	1,088	6%
Warehousing and distribution	595	3%	598	3%
Sale of services	227	1%	244	1%
Total publication expense	**10,411**	**54%**	**10,174**	**53%**
Membership and professional services:				
Dues and member services	2,628	14%	2,534	13%
Grants, prizes and awards	910	5%	1,020	6%
Meetings	764	4%	724	4%
Governance	363	2%	427	2%
Divisional indirect	289	2%	273	1%
Total membership and professional services expense	**4,954**	**27%**	**4,978**	**26%**
Interest portion of post-retirement benefits	98	- %	96	- %
Miscellaneous	203	1%	316	2%
Membership and customer services	805	4%	853	4%
General and administrative	2,686	14%	2,650	15%
Total operating expenses	**$19,157**	**100%**	**$19,067**	**100%**
Excess of operating revenue over operating expenses	1,755		795	
Total operating expenses	**$19,157**	**100%**	**$19,067**	**100%**

From the AMS—1997 Treasurer's Report

MARKET VALUE OF INVESTED FUNDS
December 31

	1997	1996	1995
Endowment Funds			
Prize Funds:			
Steele	$578,047	$503,595	$431,544
Birkhoff	34,969	30,114	25,455
Veblen	11,809	10,288	8,816
Wiener	11,809	10,288	8,816
Bôcher	8,589	7,482	6,412
Conant	38,551	33,586	28,780
Cole	19,042	16,589	14,216
Satter	30,702	26,748	22,921
Morgan	41,952	36,549	31,320
Albert Whiteman	8,798	0	0
Arnold Ross Lectures	23,134	11,161	0
Pooled Income	0	9,280	7,952
Trjitzinksky	464,475	404,651	346,756
C. V. Newsom	216,274	188,418	161,460
Centennial	106,643	92,907	79,615
Menger	5,769	5,026	3,362
Total (income restricted)	**1,600,563**	**1,386,682**	**1,177,425**
Endowment	609,767	526,377	448,809
Henderson	3,343,009	2,885,828	2,460,569
Ritt	186,577	154,048	106,014
Moore	17,587	14,808	12,266
Total (income unrestricted)	**4,156,940**	**3,581,061**	**3,027,658**
Total Endowment Funds	**5,757,503**	**4,967,743**	**4,205,083**
Quasi-endowment Funds:			
Friends of Math	123,572	123,572	123,572
Russian Royalties	17,829	17,829	17,945
Journal Archive Fund	68,842	23,500	0
Economic Stabilization Fund	25,165,477	21,158,630	17,502,715
Charitable Gift Annuities	27,857	23,455	0
Total Quasi-endowment Funds	**25,403,577**	**21,346,986**	**17,644,232**
Total funds	**$31,161,080**	**$26,314,729**	**$21,849,315**

Respectfully submitted,

Franklin P. Peterson
Treasurer

Officers and Committee Members

Numbers to the left of headings are used as points of reference in an index to AMS committees which follows this listing. Primary and secondary headings are:

1. Officers
   1.1. Liaison Committee
2. Council
   2.1. Executive Committee of the Council
3. Board of Trustees
4. Committees
   4.1. Committees of the Council
   4.2. Editorial Committees
   4.3. Committees of the Board of Trustees
   4.4. Committees of the Executive Committee and Board of Trustees
   4.5. Internal Organization of the AMS
   4.6. Program and Meetings
   4.7. Status of the Profession
   4.8. Prizes and Awards
   4.9. Institutes and Symposia
   4.10. Joint Committees
5. Representatives
6. Index

Terms of members expire on January 31 following the year given unless otherwise specified.

1. Officers

President	Arthur M. Jaffe	1998
President-Elect	Felix E. Browder	1998
Vice-Presidents	Michael Aschbacher	1998
	Jennifer Tour Chayes	2000
	H. Blaine Lawson, Jr.	1999
Secretary	Robert M. Fossum	1998
Associate Secretaries	Robert J. Daverman	1998
	Susan J. Friedlander	1999
	Bernard Russo	2001
	Lesley M. Sibner	1998
Treasurer	Franklin P. Peterson	1998
Associate Treasurer	B. A. Taylor	1998

1.1. Liaison Committee

All members of this committee serve *ex officio*.

	Robert M. Fossum
Chair	Arthur M. Jaffe
	Donald E. McClure
	Franklin P. Peterson

2. Council

2.0.1. Officers of the AMS

President	Arthur M. Jaffe	1998
President-Elect	Felix E. Browder	1998
Vice-Presidents	Michael Aschbacher	1998
	Jennifer Tour Chayes	2000
	H. Blaine Lawson, Jr.	1999
Secretary	Robert M. Fossum	1998
Associate Secretaries*	Robert J. Daverman	1998
	Susan J. Friedlander	1999
	Bernard Russo	2001
	Lesley M. Sibner	1998
Treasurer	Franklin P. Peterson	1998
Associate Treasurer	B. A. Taylor	1998

2.0.2. Representatives of Committees

Bulletin	Haynes R. Miller	1999
Colloquium	Susan J. Friedlander	1998
Executive Committee	John B. Conway	2000
Executive Committee	Steven George Krantz	1998
Executive Committee	Andrew M. Odlyzko	1999
Journal of the AMS	Benedict H. Gross	2000
Mathematical Reviews	Hugh L. Montgomery	1998
Mathematical Surveys and Monographs	Tudor Stefan Ratiu	2000
Mathematics of Computation	Lars B. Wahlbin	1997
Proceedings	Clifford J. Earle, Jr.	2000
Transactions and Memoirs	Peter B. Shalen	1999

2.0.3. Members-at-Large

Francis Bonahon	1999	Andrew M. Odlyzko	1998
David M. Bressoud	1998	Karen Parshall	2000
Robert L. Bryant	2000	Gail D. L. Ratcliff	1999
Gail A. Carpenter	1998	M. Beth Ruskai	2000
John B. Conway	1998	Joel H. Spencer	1999
Frederick P. Gardiner	1999	Michael Starbird	2000
Jane M. Hawkins	2000	Karen Vogtmann	1999
Krystyna M. Kuperberg	1998		

* Only one Associate Secretary at a time is a voting member of the Council, namely the cognizant Associate Secretary for the scientific sessions.

2.1. Executive Committee of the Council

	Felix E. Browder	*ex officio*
	John B. Conway	2000
	Robert M. Fossum	*ex officio*
	Arthur M. Jaffe	*ex officio*
	Steven George Krantz	1998
	Andrew M. Odlyzko	1999
	Joel Spencer	2001

3. Board of Trustees

	Roy L. Adler	2002
	Hyman Bass	1998
	Michael G. Crandall	2000
	Arthur M. Jaffe	*ex officio*
Secretary	Andy R. Magid	2001
Chair	Donald E. McClure	1999
	Franklin P. Peterson	*ex officio*
	B. A. Taylor	*ex officio*

4. Committees

4.1. Committees of the Council

Standing Committees

4.1.1. Editorial Boards

Chair	Eric D. Bedford	1999
	Sun-Yung Alice Chang	1998
	Andrew J. Granville	1998
	David Jerison	2000
	Abel Klein	2000
	Richard S. Palais	1999

4.1.2. Nominating Committee

Terms begin on January 1

	Sylvain E. Cappell	1998
	Eric M. Friedlander	1998
	Jane P. Gilman	1998
	Barbara L. Osofsky	1999
	John C. Polking	1999
	Paul H. Rabinowitz	2000
Chair	James D. Stasheff	1999
	Elias M. Stein	2000
	Sylvia M. Wiegand	2000

4.2. Editorial Committees

4.2.1. Abstracts Editorial Committee

All members of this committee serve *ex officio.*

	Robert J. Daverman
Chair	Robert M. Fossum
	Susan J. Friedlander
	Bernard Russo
	Lesley M. Sibner

4.2.2. Bulletin (New Series)

	David Eisenbud	1998
Chair	Haynes R. Miller	1999
	Bhama Srinivasan	2000

Associate Editors for Book Reviews

Martin D. Davis	1998	Ruth J. Williams	1999
Jim Douglas	1999	Wolfgang Ziller	1998
Alex J. Wilkie	2000	_____	2000

Associate Editors for Research Reports

John M. Franks	1998	Richard M. Schoen	1998
Eric M. Friedlander	1998	David A. Vogan, Jr.	1998
Barry Mazur	1998	Robert J. Zimmer	1999
Daniel Ruberman	1998		

Associate Editors for Research – Expository Surveys

John C. Baez	1998	Karen Vogtmann	1999
Bruce K. Driver	1998	Nolan R. Wallach	1998
Kenneth Ribet	1999		

4.2.3. Collected Works

	Jonathan Alperin	2000
	Elliott H. Lieb	1999
	Cathleen S. Morawetz	2000

4.2.4. Colloquium

	Joan S. Birman	2000
Chair	Susan J. Friedlander	1998
	Stephen Lichtenbaum	1999

4.2.5. Contemporary Mathematics

	Andreas Blass	2001
Chair	Dennis DeTurck	1998
	Andy R. Magid	1998
	Michael Vogelius	2001

4.2.6. Electronic Research Announcements

	Stuart Antman	1999
	Douglas N. Arnold	2000
	Hyman Bass	1998
	Dimitri Burago	2000
	Alexandre J. Chorin	1999
	Mark Freidlin	1999
	James G. Glimm	2000
	Ronald L. Graham	2000
Chair	Svetlana R. Katok	2000
	Yitzhak Katznelson	1998
	David Kazhdan	1998
	Alexander S. Kechris	1999
	Alexandre A. Kirillov	1999
	Frances C. Kirwan	1999
	Krystyna M. Kuperberg	1999
	Robert K. Lazarsfeld	1998
	Grigorii A. Margulis	1999
	Hugh L. Montgomery	2000
	Walter David Neumann	2000
	Klaus Schmidt	2000
	Richard M. Schoen	1998
	Masamichi Takesaki	2000
	Michael E. Taylor	1998
	Thomas H. Wolff	1999
	Zhihong (Jeff) Xia	2000
	Don Zagier	1998
	Efim Zelmanov	2000
	Robert J. Zimmer	1998

4.2.7. Graduate Studies in Mathematics

Chair	James E. Humphreys	2000
	David J. Saltman	1999
	David Sattinger	1998
	Julius L. Shaneson	1998

4.2.8. Journal of the AMS

	William Fulton	1998
Chair	Benedict H. Gross	2000
	Carlos E. Kenig	2000
	Bernd Sturmfels	2001
	Clifford Taubes	2000

Associate Editors

James G. Arthur	1999	Robert K. Lazarsfeld	1999
Alexander Beilinson	2001	Grigorii A. Margulis	2000
Ingrid Daubechies	2000	Curtis McMullen	1999
Michael J. Hopkins	1999	Marina Ratner	2000
Ehud Hrushovski	2000	Richard M. Schoen	2000
Henryk Iwaniec	1999	Richard P. Stanley	2000
Sergio Klainerman	1998	W. Hugh Woodin	1999

4.2.9. Mathematical Reviews

AMS staff contact: Jane E. Kister.

	Jonathan L. Alperin	1997
	Yuji Ito	2000
	Jean-Louis Loday	1999
	Joyce McLaughlin	1999
Chair	Hugh L. Montgomery	1998
	Clarence Wilkerson	1998

4.2.10. Mathematical Surveys and Monographs

	Georgia Benkhart	2000
	Peter Landweber	2000
Chair	Tudor Stefan Ratiu	2000
	Michael Renardy	1998

4.2.11. Mathematics of Computation

	Andrew M. Odlyzko	1997
	Stanley J. Osher	1998
	G. W. Stewart	1998
Chair	Lars B. Wahlbin	1997

Associate Editors

David D. Boyd	2000	Roswitha März	1999
James Bramble	2000	Harald Niederreiter	1999
Susanne C. Brenner	1998	John E. Osborn	1998
Richard P. Brent	2000	René Schoof	1998
Joe P. Buhler	2000	Ridgway Scott	1998
Carsten Carstensen	2000	Chi-Wang Shu	1998
Arjeh M. Cohen	1999	Frank Stenger	1998
Howard Elman	2000	Nico M. Temme	1998
Richard Falk	1998	Vidar Thomée	2000
Walter Gautschi	1998	Joseph D. Ward	2000
Daniel W. Lozier	1998	Hugh C. Williams	2000
James N. Lyness	1999	Stephen J. Wright	2000

4.2.12. Notices Editorial Board

Editor	Anthony Knapp	2000

Associate Editors

Robert M. Fossum	*ex officio*	Susan Landau	2000
Susan J. Friedlander	2000	Andy R. Magid	2000
Martin Golubitsky	2000	Judith Roitman	2000
Victor W. Guillemin	2000	M. Beth Ruskai	2000
David Jerison	2000	Mark E. Saul	2000

4.2.13. Proceedings

	Dale Alspach	1999
	Albert Baernstein	1999
Coordinating	Eric D. Bedford	2000
	Steven R. Bell	2000
	John Burns	1999
	Suncica Canic	2000
	Ralph Cohen	2000
	Christopher Croke	1999
	J. Dodziuk	2000
	Ron Donagi	1999
	Alan Dow	1999
Chair	Clifford J. Earle, Jr.	2000
	Ronald A. Fintushel	1999
Coordinating	James G. Glimm	1999
	Kenneth R. Goodearl	2000
	Roe Goodman	1999
	Michael Handel	2001
	Dennis A. Hejhal	1999
	Carl Jockusch, Jr.	2000
Coordinating	Linda Keen	2001
	David R. Larson	2000
Coordinating	Peter W. K. Li	1998
	Wei Y. Loh	1999
	David Rohrlich	2000
	Leslie Saper	1999
	Stanley A. Sawyer	1998
	David Sharp	1999
	Lesley M. Sibner	2001
Coordinating	Lance W. Small	1999
	Hal L. Smith	1999
	Christopher D. Sogge	2001
	Ronald M. Solomon	1998
	John Stembridge	2001
	Wolmer V. Vasconcelos	1999

4.2.14. Proceedings of Symposia in Applied Mathematics

	Marsha J. Berger	2000
Chair	Peter S. Constantin	1998
	Eitan Tadmor	1999

4.2.15. Transactions and Memoirs

	Rodrigo Banuelos	1999
	William Beckner	1998
	Bruce Blackadar	2001
	Daniel M. Burns	1998
	Charles W. Curtis	2001
	Lawrence Ein	1998
	Philip J. Hanlon	1999
	Barbara L. Keyfitz	2001
	John Luecke	2000
	John J. Mallet-Paret	1999
	Stewart B. Priddy	1999
Chair	Peter B. Shalen	1999
	Alice Silverberg	1999
	Theodore Slaman	2000
	Robert J. Stanton	2001
	Chuu-Lian Terng	2000
	Robert F. Williams	2001

4.2.16. Translation from Chinese

	Sun-Yung Alice Chang
	S.-Y. Cheng
Chair	Tsit-Yuen Lam
	Tai-Ping Liu
	Chung-Chun Yang

4.2.17. Translation from Japanese

Chair	Shoshichi Kobayashi	1998
	Masamichi Takesaki	1998

Standing Committees

4.2.18. Conformal Geometry and Dynamics

	Kari Astala	2000
	Frederick W. Gehring	2000
Chair	Linda Keen	1999
	Misha Lyubich	1999
	Howard Masur	1998
	Mitsuhiro Shishikura	1998

4.2.19. History of Mathematics

	George E. Andrews	1999
	Bruce Chandler	1999
	Karen Parshall	2000
Chair	George B. Seligman	1998

4.2.20. Representation Theory

	Anthony Knapp	2000
	James Lepowsky	1998
	George Lusztig	2000
	Dragan Milicic	1998
	Birgit Speh	1999
Chair	David Vogan	1999

4.2.21. Reprinted Books

	Charles W. Curtis	1998
Chair	Oscar S. Rothaus	2000
	Guido Weiss	1999

4.2.22. Undergraduate Book Series

	David Bressoud	2001
Chair	Robert Devaney	2001
	Carl Pomerance	2001
	Hung-Hsi Wu	2001

4.2.23. University Lecture Series

	Jerry L. Bona	1999
	Nicolai Reshetikhin	1999
Chair	Leonard L. Scott	1999

4.3. Committees of the Board of Trustees

4.3.1. Agenda and Budget

All members of this committee serve *ex officio.*

Robert M. Fossum
Arthur M. Jaffe
Steven George Krantz
Donald E. McClure
Franklin P. Peterson
B. A. Taylor

4.3.2. Appeals Committee on Discounted Subscriptions

AMS staff contact: Cheryl Marino.

	Michael G. Crandall	
	John H. Ewing	*ex officio*
Chair	Morton Lowengrub	
Consultant	Cheryl Marino	
Consultant	Hugh L. Montgomery	
	Franklin P. Peterson	

4.3.3. Audit

All members of this committee serve *ex officio.*
AMS staff contact: Gary G. Brownell.

Donald E. McClure
Franklin P. Peterson

4.3.4. Endowment and Planned Giving

AMS staff contact: Timothy J. Goggins.

	Roy L. Adler	2000
	Arthur M. Jaffe	2000
Chair	Donald E. McClure	*ex officio*
	Cathleen S. Morawetz	2000
	T. Benny Rushing	2000

4.3.5. Investment

AMS staff contact: Gary G. Brownell.

	Roy L. Adler	*ex officio*
	John M. Franks	2000
Chair	Franklin P. Peterson	*ex officio*
	T. Benny Rushing	2000
	B. A. Taylor	*ex officio*

4.3.6. Salaries

All members of this committee serve *ex officio.*

Michael G. Crandall
Chair Donald E. McClure
Franklin P. Peterson
B. A. Taylor

4.3.7. Staff and Services

All members of this committee serve *ex officio.*

Roy L. Adler
Franklin P. Peterson
Chair B. A. Taylor

4.4. Committees of the Executive Committee and Board of Trustees

4.4.1. Long Range Planning

All members of this committee serve *ex officio.*
AMS staff contact: Raquel E. Storti.

John B. Conway
John H. Ewing
Robert M. Fossum
Arthur M. Jaffe
Donald E. McClure
Chair Andrew M. Odlyzko
Franklin P. Peterson

4.4.2. Nominating

All members of this committee serve *ex officio.*

John B. Conway
Chair Michael G. Crandall
Steven George Krantz
Andy R. Magid
James D. Stasheff

4.5. Internal Organization of the American Mathematical Society

Standing Committees

4.5.1. Archives

	Robert M. Fossum	2001
Chair	Karen Parshall	1999
	Everett Pitcher	2000

4.5.2. Committee on Committees

	Felix E. Browder	*ex officio*
	Sun-Yung Alice Chang	1998
	Robin Forman	1998
	Robert M. Fossum	*ex officio*
	Arthur M. Jaffe	*ex officio*
	Andrew M. Odlyzko	1998
	Marc A. Rieffel	1998
	Iakov G. Sinai	1998
Chair	Daniel W. Stroock	1998
	Floyd Williams	1998
	Ruth J. Williams	1998

4.5.3. Library Committee

Co-chair	Bruce C. Berndt	2000
	R. Keith Dennis	2000
	Lawrence S. Husch	1999
Co-chair	Carol Hutchins	1999
	Robert Seeds	2000
	Martha Tucker	1999
	Molly White	2000
	Hung-Hsi Wu	1999

4.5.4. Publication

AMS staff contact: Donald G. Babbitt.

	Donald G. Babbitt	*ex officio*
	Robert L. Bryant	2000
	John B. Conway	1998
	Michael G. Crandall	1998
	John H. Ewing	*ex officio*
	Robert M. Fossum	*ex officio*
	Arthur M. Jaffe	*ex officio*
Chair	M. Susan Montgomery	1999
	Robert O'Malley	1998
	Richard S. Palais	1998
	Gail D. L. Ratcliff	1999
	Srinivasa S. R. Varadhan	1999
	_____	1998

4.6. Program and Meetings

Standing Committees

4.6.1. Meetings and Conferences

AMS staff contact: H. Hope Daly.

	Roy L. Adler	1998
	John H. Ewing	*ex officio*
	Robert M. Fossum	*ex officio*
	Isom H. Herron	1998
	Evan G. Houston	1998
	Arthur M. Jaffe	*ex officio*
	Karen Parshall	2000
Chair	Joel H. Spencer	1999
	Michael Starbird	2000
	Karen Vogtmann	1999
	Sylvia M. Wiegand	1999
	_____	2000

4.6.2. Program Committee for National Meetings

	Robert M. Fossum	*ex officio*
	Daniel S. Freed	2000
	Carolyn S. Gordon	1998
	Isom H. Herron	1999
Chair	Linda Rothschild	2000
	Leon Takhtajan	2000
	Dan Voiculescu	1999

4.6.3. Short Course Subcommittee

	Mark J. Ablowitz	1998
	Lenore Blum	1998
	Michael J. Kallaher	1998
	Svetlana Katok	2000
	Jane Cronin Scanlon	1998
	Bertram Schreiber	2000
	James A. Sethian	1999

4.6.4. Central Section Program Committee

	Brian Conrey	1998
	Susan J. Friedlander	*ex officio*
	Jerry Kaminker	1999
	Henri Moscovici	1999
Chair	Michael I. Weinstein	1998

4.6.5. Eastern Section Program Committee

	Paul Baum	1999
	Anthony Knapp	1998
Chair	Yanyan Li	1998
	Mikhail Shubin	1999
	Lesley M. Sibner	*ex officio*

4.6.6. Southeastern Section Program Committee

	Eric Carlen	1999
	Robert J. Daverman	*ex officio*
	Andrew J. Granville	1999
	James D. Stasheff	1998
Chair	Lawrence E. Thomas	1998

4.6.7. Western Section Program Committee

	Bruce Blackadar	1998
	William Faris	1999
	Sorin Popa	1999
Chair	Nicolai Reshetikhin	1998
	Bernard Russo	*ex officio*

4.6.8. Agenda for Business Meetings

	James A. Donaldson	1998
Chair	Robert M. Fossum	*ex officio*
	John M. Franks	1998

4.6.9. Arnold Ross Lecture Series Committee

Chair	Kenneth I. Gross	2000
	Deborah Haimo	2000
	Robert Osserman	1999
	Paul J. Sally, Jr.	1998
	Andre Toom	2000

4.6.10. Colloquium Lecture

	William Browder	1998
	_____	1999
	_____	2000

4.6.11. Gibbs Lecturer for 1999 and 2000, Committee to Select

	George Mackey
Chair	David Ruelle
	Clarence Eugene Wayne

4.6.12. Program Committee for the Year 2000 Meeting on Problems, Programs, and Prospects of 21st Century Mathematics

	Richard A. Askey	1999
	Spencer Bloch	1999
Chair	Felix E. Browder	1999
	Charles L. Fefferman	1999
	Peter D. Lax	1999
	Robert D. MacPherson	1999
	David Mumford	1999
	Gian-Carlo Rota	1999
	Peter Sarnak	1999
	Audrey A. Terras	1999
	Srinivasa S. R. Varadhan	1999
	Edward Witten	1999

4.6.13. Progress in Mathematics

	Michael Aschbacher	1997
	Constantine M. Dafermos	1998
	Richard M. Schoen	1997

4.7. Status of the Profession

Standing Committees

4.7.1. Academic Freedom, Tenure, and Employment Security

	William Abikoff	1999
	Murray Gerstenhaber	1998
	Rhonda J. Hughes	1998
	Irwin Kra	2001
	Robert Eugene Megginson	1998
Chair	Arlan B. Ramsay	1999
	Seymour Schuster	2000

4.7.2. Education

AMS staff contact: Samuel M. Rankin III.

	Michael Aschbacher	1999
	Richard A. Askey	2000
Chair	Hyman Bass	1999
	Francis Bonahon	1999
	Robert E. Bozeman	1998
	David M. Bressoud	1998
	Jere Confrey	2000
	John H. Ewing	*ex officio*
	Robert M. Fossum	*ex officio*
	Arthur M. Jaffe	*ex officio*
	Harvey B. Keynes	1998
	Andy R. Magid	1998
	Cathleen S. Morawetz	*ex officio*
	Judith Roitman	1998
	Alan H. Schoenfeld	1998
	Alan C. Tucker	1999

4.7.3. Human Rights of Mathematicians

	Francis Bonahon	2000
	Shiu-Yuen Cheng	1998
	Susan Friedlander	2000
	Troels Jorgensen	1998
Chair	Neal I. Koblitz	1999
	Tsit-Yuen Lam	1998
	Joel L. Lebowitz	1999
	Robert D. MacPherson	1999
	Alice T. Schafer	2000

4.7.4. Profession

AMS staff contact: James W. Maxwell.

	M. Salah Baouendi	1999
	Curtis D. Bennett	1998
	Gail A. Carpenter	1998
	Jennifer Chayes	2000
	Annalisa Crannell	1999
	John H. Ewing	*ex officio*
	Robert M. Fossum	*ex officio*
	Frank L. Gilfeather	1998
	Arthur M. Jaffe	*ex officio*
	Krystyna M. Kuperberg	1998
	H. Blaine Lawson, Jr.	1999
	Joseph Lipman	1999
Chair	Donald E. McClure	1998
	Ronald J. Stern	1998
	Steven H. Weintraub	1998

4.7.5. Professional Ethics

	Donald Burkholder	2000
	Simon Hellerstein	1998
	Lee Mosher	2000
	Christel Rotthaus	2000
Chair	Claude L. Schochet	1999
	Hale F. Trotter	1998

4.7.6. Science Policy

AMS staff contact: Samuel M. Rankin III.

	Hyman Bass	*ex officio*
	Felix E. Browder	*ex officio*
	John H. Ewing	*ex officio*
	Robert M. Fossum	*ex officio*
	Susan Friedlander	1999
	Frederick P. Gardiner	1999
	Jane M. Hawkins	2000
	Roger Howe	2000
	William H. Jaco	1998
	Arthur M. Jaffe	*ex officio*
	William A. Massey	1998
Chair	Cathleen S. Morawetz	2000
	Daniel W. Stroock	2000

4.7.7. World Mathematical Year 2000, Blue Ribbon Committee for

Chair	Felix E. Browder
	Robert M. Fossum
	Ronald L. Graham
	Peter D. Lax
	Cathleen S. Morawetz
	Peter Sarnak
	Audrey A. Terras
	William P. Thurston

Special Committee

4.7.8. Task Force on Excellence in Mathematics Scholarship

AMS staff contact: Raquel E. Storti.

	Thomas R. Berger
Project Director	John H. Ewing
	John B. Garnett
	Ettore Infante
	Raymond L. Johnson
	Barbara L. Keyfitz
	Joan P. Leitzel
	William James Lewis
	Douglas Lind
Chair	Morton Lowengrub
	Donald E. McClure
	Alan Newell
	Alan C. Tucker
	David A. Vogan, Jr.

4.8. Prizes and Awards

Standing Committees

4.8.1. Award for Public Service, Committee to Select the Winner of the

	Frederick W. Gehring	2002
Chair	Ronald L. Graham	2000
	Peter D. Lax	2001
	Everett Pitcher	1999
	Isadore M. Singer	1998

4.8.2. Centennial Fellowships

Terms expire on June 30

	Richard Durrett	2000
	Fanghua Lin	1999
	Leon Simon	1999
	Richard Stanley	2000
	Nancy Stanton	2000
Chair	Paul Vojta	1999
	Steven Weintraub	2000

4.8.3. Menger Prize Committee

Terms expire on May 31

	Gisele Goldstein	1999
	Peter V. O'Neil	2000
Chair	Julian Palmore	1998

4.8.4. National Awards and Public Representation

	Felix E. Browder	*ex officio*
	Robert M. Fossum	*ex officio*
	Melvin Hochster	1999
Chair	Arthur M. Jaffe	*ex officio*
	Cathleen S. Morawetz	1999

4.8.5. Satter Prize for 1998, Committee to Select the Winner of the

	Sun-Yung Alice Chang	2000
	Peter Sarnak	1999
Chair	Carol S. Wood	1998

4.8.6. Steele Prizes

	Richard A. Askey	1998
	Ciprian Foias	1999
	Bertram Kostant	2000
	H. Blaine Lawson, Jr.	1998
	Andrew J. Majda	1998
	Louis Nirenberg	1999
	Marc A. Rieffel	2000
Chair	Jonathan M. Rosenberg	2000
	John T. Tate	1999

Special Committee

4.8.7. Automatic Theorem Proving, Committee to Recommend Winners of Prizes for

Chair	Ronald L. Graham
	Oscar Lanford
	David Mumford

4.8.8. Bôcher Prize

Chair	James Glimm
	_____
	_____
	_____

4.8.9. Cole Prize

	Simon Donaldson
	William Fulton
Chair	Efim Zelmanov

4.9. Institutes and Symposia

Standing Committees

4.9.1. Liaison Committee with AAAS

	Hyman Bass	*ex officio*
	Lenore Blum	*ex officio*
	Ronald G. Douglas	*ex officio*
	John H. Ewing	1999
	Robert M. Fossum	*ex officio*
	Evans M. Harrell	*ex officio*
	Warren Page	*ex officio*
	Yum Tong Siu	1999
	_____	1999

4.9.2. Summer Institutes and Special Symposia

Terms expire on February 28

	Michael D. Fried	1999
	Robert Osserman	1999
	Jeffrey B. Rauch	2000
Chair	Leon Takhtajan	2000
	Clarence Eugene Wayne	2001
	Ruth J. Williams	1999

4.10. Joint Committees

4.10.1. AMS-ASA-AWM-IMS-MAA-NCTM-SIAM Committee on Women in the Mathematical Sciences

NCTM members' terms expire April 1 of the year given.

Susan Ackerman (ASA)	2000
Ann S. Almgren (SIAM)	1999
Stella Roberson Ashford (AMS)	1998
Mary Flahive (MAA)	2000
Ena Gross (NCTM)	1999
Diane L. Herrmann (AWM)	2000
Erica Jen (AMS)	2000
Deborah Lockhart (SIAM)	1998
Harriett M. Lord (MAA)	2000
Mina Ossiander (IMS)	1997
Connie Page (IMS)	1998
Tamar Schlick (SIAM)	1999
Sanford Segal (MAA)	1998
Robert J. Sibner (AMS)	1998
Tara L. Smith (AWM)	1999
Berit Stensones (AMS)	1998
Patricia Wozniak (ASA)	1999

4.10.2. AMS-ASL-IMS-SIAM Committee on Translations from Russian and Other Slavic Languages

ASL Subcommittee Members

Terms expire on January 1

	Marat Arslanov	1999
	Sergei Artemov	1999
	Oleg Belegradek	1999
	Peter Komjath	1999
	Jan Krajicek	1999
Chair	Steffen Lempp	1999

IMS Subcommittee Members

Chair	M. I. Freidlin
	B. Pittel
	A. Rukhin
	W. J. Studden

4.10.3. AMS-IMS-SIAM Committee on Joint Summer Research Conferences in the Mathematical Sciences

Terms expire on June 30

Alejandro Adem (AMS)	2000
David Brydges (AMS)	2001
Percy Alec Deift (AMS)	1998
James W. Demmel (AMS)	2000
Dipak Dey (IMS)	2000
Tom DiCiccio (IMS)	2000
Steven Hurder (AMS)	2001
Alan F. Karr (AMS)	2000
Barbara L. Keyfitz (SIAM)	2000
W. Brent Lindquist (AMS)	2001
Andrzej Manitius (SIAM)	2000
Bart S. Ng (SIAM)	2000

4.10.4. AMS-MAA Committee on Cooperation

All members of this committee serve *ex officio.*

	Gerald L. Alexanderson (MAA)	
	Thomas F. Banchoff (MAA)	
	Felix E. Browder (AMS)	
	John H. Ewing (AMS)	
	Robert M. Fossum (AMS)	
	Arthur M. Jaffe (AMS)	
	Martha J. Siegel (MAA)	
	Marcia P. Sward (MAA)	

4.10.5. AMS-MAA Committee on Mathematicians with Disabilities

	Robert Coleman (AMS)	2000
	John Fulton (MAA)	2000
	David M. James (AMS)	1998
Chair	Carlos E. Kenig (AMS)	1999
	Eileen Poiani (MAA)	2000
	Jon Wilkin (MAA)	1999

4.10.6. AMS-MAA Committee on Research in Undergraduate Mathematics Education (CRUME)

	George E. Andrews (AMS)	2000
	Hyman Bass (AMS)	1999
Chair	Thomas P. Dick (MAA)	1998
	Ed Dubinsky (MAA)	2000
	Joan Ferrini-Mundy (NCTM)	1998
	Daniel L. Goroff (AMS)	1999
	James J. Kaput (MAA)	1999
	R. Bruce Lind (MAA)	2000
	Warren Page (AMATYC)	1998
	Alan H. Schoenfeld (AMS)	1998

4.10.7. AMS-MAA Committee on Teaching Assistants and Part-time Instructors (TA/PTI)

	Curtis D. Bennett (AMS)	1999
	Neil Calkin (AMS)	2000
	Reuben Drake (MAA)	1998
	James Kister (AMS)	2000
Chair	Suzanne Lenhart (AMS)	1998
	Teri Murphy (MAA)	2000
	Stephen B. Rodi (MAA)	2000
	Raymond O. Wells (MAA)	1998

4.10.8. AMS-MAA Joint Archives Committee

	Robert M. Fossum (AMS)	2001
Chair	Victor Katz (MAA)	2000
	John McCleary (MAA)	1999
	Karen Parshall (AMS)	1999
	Everett Pitcher (AMS)	2000
	James J. Tattersall (MAA)	1998

4.10.9. AMS-MAA Joint Meetings Committee

All members of this committee serve *ex officio.*

Consultant	H. Hope Daly
	John H. Ewing
Chair	Robert M. Fossum
	Marcia P. Sward
	Donovan H. Van Osdol

4.10.10. AMS-MAA Exhibits Advisory Subcommittee

	Donald J. Albers
	Elizabeth Carey
	H. Hope Daly
	Louise Decker
	Annette Emerson
	Catherine Faduska
Chair	Robert M. Fossum
	Debbie Hamar
	Martin Lapidus
	Elaine Pedreira-Sullivan
	Penny Pina
	James J. Tattersall
	David Tranah

4.10.11. AMS-MAA Arrangements Committee for the San Antonio Meeting January 13–16, 1999

	Loran W. Gierhart
Chair	Gregory P. Wene
	Lawrence R. Williams

4.10.12. AMS-MAA Joint Program Committee for the San Antonio Meeting

	Luis Caffarelli (AMS)
	Karen Parshall (MAA)
	Carl Pomerance (MAA)
	Linda Rothschild (AMS)

4.10.13. AMS-MAA-SIAM Joint Administrative Committee

All members of this committee serve *ex officio.*

	Gerald L. Alexanderson (MAA)
	James M. Crowley (SIAM)
	John H. Ewing (AMS)
Chair	Robert M. Fossum (AMS)
	Samuel Gubins (SIAM)
	John Guckenheimer (SIAM)
	Franklin P. Peterson (AMS)
	Martha J. Siegel (MAA)
	Marcia P. Sward (MAA)

4.10.14. AMS-MAA-SIAM Joint Committee on Employment Opportunities

AMS staff contact: James W. Maxwell.

	William G. Bade (AMS)	2000
Chair	James W. Bond (AMS)	1999
	Neil Calkin (AMS)	2000
	J. Kevin Colligan (MAA)	2000
	James W. Daniel (MAA)	2000
	David Field (SIAM)	2000
	James W. Maxwell	*ex officio*
	Thomas W. Rishel (MAA)	1999
	David Ross (SIAM)	2000

4.10.15. AMS-MAA-SIAM Joint Policy Board for Mathematics (see 1998 Mathematical Sciences Professional Directory, page 30)

4.10.16. AMS-MAA-SIAM Morgan Prize Committee for Outstanding Research in Mathematics by an Undergraduate Student

	George Andrews (AMS)	2000
Chair	Kelly J. Black (SIAM)	2000
	Catherine A. Roberts (SIAM)	1999
	Robert O. Robson (MAA)	1999
	Martha J. Siegel (MAA)	2000
	Trevor Wooley (AMS)	1999

4.10.17. AMS-SIAM Committee on Applied Mathematics

	James W. Demmel	1998
	Tai-Ping Liu	1998
	Juan C. Meza	1997
	Tamar Schlick	1997
	_____	1999
	_____	1999

4.10.18. AMS-SIAM-SMB Committee on Mathematics in the Life Sciences

	Stephen Ellner	2000
	Lisa Fauci	2000
	Michael C. Mackey	1999
	John M. Rinzel	1999
	Michael S. Waterman	1998
Chair	Carla Wofsy	1998

4.10.19. Annual Survey Data Committee

AMS staff contact: James W. Maxwell.

Chair	Paul W. Davis (AMS)	1999
	Malay Ghosh (IMS)	1998
	Mary W. Gray (MAA)	1999
	Alfred W. Hales (AMS)	2000
	Don Loftsgaarden (MAA)	1999
	James W. Maxwell (AMS)	*ex officio*
	M. Beth Ruskai (AMS)	1998
	Ann K. Stehney (AMS)	1998
	Ann E. Watkins (MAA)	1999
	_____(AMS)	1999

Special Committees

4.10.20. AMS-SMM Joint Program Committee for the Denton Meeting May 19–22, 1999

Alfonso Castro
Monica Clapp
David McLaughlin
Rick Miranda
Victor Perez-Abreu
Eduardo Rivera-Campo
Ronald J. Stern
Rafael H. Villarreal

4.10.21. Program Committee for the Joint AMS-AMS (American Mathematical Society-Australian Mathematical Society) Meeting in Australia July 5–9, 1999

Ezra Getzler
William H. Jaco
Chair Richard Melrose
Ruth J. Williams

4.10.22. Program Committee for the Joint AMS-Nordic Mathematics Meeting in Denmark June 12–15, 2000

William Browder
Robert M. Fossum
Karsten Grove
Berit Stensones

5. Representatives

5.0.1. American Association for the Advancement of Science

Terms expire on February 21

Section A	Robert M. Fossum	2000
Section Q	Evans M. Harrell	2000

5.0.2. Commission on Professionals in Science and Technology

Ann K. Stehney	1999

5.0.3. Committee on the American Mathematics Competition

Term expires on June 30

Noam Elkies	2000

5.0.4. Conference Board of the Mathematical Sciences

Arthur M. Jaffe	1998

5.0.5. Fulkerson Prize Committee

Ronald L. Graham

5.0.6. MAA Committee on Undergraduate Program in Mathematics

Peter Hinman	1999
Judith Roitman	1999

5.0.7. MAA-NCTM Task Force on Mathematical Competitions

Peter W. Shor

5.0.8. U.S. National Committee on Theoretical and Applied Mechanics

Term expires on October 31

Philip John Holmes	2000

6. Index

Mathematics Calendar

The most comprehensive and up-to-date Mathematics Calendar information is available on e-MATH at `http://www.ams.org/mathcal/`.

October 1998

*8-11 **Dynamical Systems and Related Topics Workshop**, Penn State University, State College, Pennsylvania.

Program: A regular meeting dedicated to recent results in the theory of smooth dynamical systems, ergodic theory, symbolic dynamics, topological dynamics, Hamiltonian mechanics and related areas in differential geometry, differential equations, and Lie theory. 15-20 one-hour and 45-minute talks are expected.

Information: `http://www.math.psu.edu/dynsys/`.; conference questions e-mail: `dswk@math.psu.edu`; A. Katok, organizer, 814-865-2266. Deadline for lodging is September 4, 1998, send e-mail to: `manning@math.psu.edu`.

*23-25 **The Midwest Geometry Conference**, Louisiana State University, Baton Rouge, Louisiana.

Aim: The Midwest Geometry Conference is an annual meeting dedicated to the dissemination of important recent advances in Differential Geometry, Geometric Analysis, and Integral Geometry to the community of Midwestern mathematicians. The aim is to create a focused environment, bringing together leading mathematicians, young professionals and students.

Topics: Twelve invited speakers will talk on the following topics: Integral Geometry, Geometric Inequalities, Integrable Systems, and Low Dimensional Gauge Theory.

Speakers: M. Adler (Brandeis Univ.), A. Ashtekar (Penn State Univ.), W. Beckner (Univ. of Texas), R. Forman (Rice Univ.), B. Hall (Univ. of California), S. Helgason (MIT), E. Lieb (Princeton), M. Loss (Georgia Tech), A. McDaniel (Georgetown Univ.), E. T. Quinto (Tufts Univ.), I. M. Singer (MIT), C.-L. Terng (Northeastern Univ.).

Organizers: T. Branson (Univ. of Iowa), G. Olafsson (LSU), A. Sengupta (LSU) and L. Smolinsky (LSU).

Support: The conference is supported by the NSF and Louisiana State University. Some partial support is available. Students, recent graduates, women and minorities are encouraged to apply. Please contact the organizers at `mgc98@math.lsu.edu` or by mail at Dept. of Math., Louisiana State Univ., Baton Rouge, LA 70803.

Information: Further information about the conference, hotels and other practical information can be found at the web side `http:///math.lsu.edu/~mgc/`.

*26-27 **NVH: Source, Path and Receiver Modeling Symposium**, Novi, Michigan.

Description: Noise, vibration and harshness are important design considerations for aircraft, automobiles, home appliances and work and living spaces. This unique meeting brings together the leading experts and practitioners of NVH technology to discuss the current analysis capapbilities and experimental techniques in the field.

Topics: Topics in this symposium include: Transfer path analysis/noise path analysis route tracking; Application of sound quality techniques in NVH design and development; Variability and statistical methods; Squeak and rattle.

Information: The preliminary technical program and registration form are available on SEM's Web site: `http://www.sem.org/`. Contact SEM for more information: 7 School Street, Bethel, CT 06801; tel: 203-790-6373; fax: 203-790-4472; e-mail: `meetings@sem1.com`.

November 1998

*5-7 **Workshop on Geometric Scattering**, University of Aarhus, Aarhus, Denmark.

Sponsor: MaPhySto - Centre for Mathematical Physics and Stochastics.

Principal Speakers: R. Melrose (MIT), A. Vasy (Univ. of California, Berkeley) and M. Zworski (Univ. of Toronto)

Organizers: A. Jensen (Aalborg) and E. Skibsted (Aarhus).

Deadline: Registration before September

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/` (or `http://www.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.)

15, 1998.
Information: For further information see the web page located at http:///www.maphysto.dk/events/GeomScat98/.

December 1998

*17–19 **International Symposium on Recent Advances in Mathematics and Applications (ISRAMA 98)**, Calcutta, India.
Organizers: M. R. Adhikari and A. P. Baisnab, Calcutta Mathematical Society, AE-374, Sector 1, Saltlake City, Calcutta 700064, India.
Scope: The symposium will be held on occasion oc the 90th Foundation Anniversary of the Calcutta Mathematical Society and 90 years of continuous publication of the Bulletin of the Calcutta Mathematical Society. The symposium will highlight the recent advances in geometry, topology and mathematical physics.
Call for Papers: Abstract of papers in English not exceeding 500 words should be sent to the organizers by October 15, 1998. Acceptance of the same shall be communicated to the respective author within a month from the date of their receipt.
Registration Fee: RS. 400.00 for each participant from India and US$200 for each participant from other countries with a provision of 50% concession for members of the Calcutta Mathematical Society.
Information: Send e-mail to: H. P. Majumder at hpm@isical.ac.in; http://php.iupui.edu/~rgompa/israma.htm.

January 1999

*4–9 **National Academy of Sciences Colloquium on Nonlinear Partial Differential Equations**, Irvine, California.
Organizing Committee: H. Brezis, F. Browder, L. Nirenberg (chairman), and J. Serrin.
Focus: This is one of a series of colloquia in various fields of science and engineering, the second in mathematics (the first in 1996 was devoted to elliptic curves and modular forms). As contrasted with all the previous NAS colloquia, this particular meeting will also serve as a school on recent developments in the field for younger mathematicians, graduate students, and post-docs.
Program: The program of the meeting will consist of three expository lecture series of three lectures each, as well as eighteen one-hour research lectures. Partial support for some of the younger participants is available from a grant from the National Science Foundation. Due to relatively restricted facilities at the Beckman Center, all participants must receive invitations from the organizers.
Applications: To apply for an invitation and/or support, please contact nascol@math.rutgers.edu by November 15, 1998.
Topics: The lectures will be given in four general areas as follows: 1) PDE and geometry: R. Hamilton, R. Schoen, G. Tian, S. T. Yau; 2) PDE and material science: F. Bethuel, H. Brezis, F. H. Lin, V. Sverak, J. Taylor; 3) Topological methods (including Hamiltonian systems and symplectic geometry): A. Ambrosetti, V. Benci, H. Hofer, Y. Y. Li, E. Zehnder; 4) Nonlinear elliptic and evolution equations: H. Berestycki, J. Bourgain, L. Caffarelli, L. C. Evans, C. Kenig, S. Klainerman, M. Struwe.
Speakers: The expository lecture series will be given by H. Brezis, R. Hamilton, and S. Klainerman.
Information: Contact nascol@math.rutgers.edu.

*7–9 **Semidefinite Programming and its Applications to Large Scale Discrete Optimization**, Computer Science Dept., Princeton University, Princeton, New Jersey.
Sponsor: DIMACS Center.
Organizers: R. J. Vanderbei (Princeton Univ.), rvdb@princeton.edu, and Y. Ye (Univ. of Iowa), yinyu-ye@uiowa.edu.
Focus: Semidefinite Programming has been a major research topic in the past several years. It was mainly a theoretical model for proving, e.g. bounds or showing desirable properties of certain mathematical problems. With the extension of the theory and practice of interior point methods from linear programming to semidefinite programming—many of these semidefinite programs exhibited desired computational complexity and tractability. This spurred interest and results in the field and development of approaches to solve large-scale semidefinite programs. It seems time to summarize all theoretical results, review various algorithmic approaches, demonstrate available implementation codes, explore important applications, and recommend future research directions of semidefinite programming. The workshop will consist of six invited presentations and about thirty talks on special issues.
Support: Limited support for participants is available, graduate students are particularly encouraged to participate.
Contacts: Y. Ye (Univ. of Iowa), yinyu-ye@uiowa.edu.
Local Arrangements: S. Barbu (Princeton Univ.), barbu@cs.princeton.edu, tel: 609-258-1771.
Information: WWW: http://dimacs.rutgers.edu/Workshops/index.html.

*15–16 **ASL Winter Meeting (in conjunction with AMS annual meeting)**, San Antonio, Texas.
Program Notes: In the AMS meeting there will be an ASL/AMS Special Session on Model Theory and its Applications, organized by A. Pillay. Other AMS special sessions include: Commutative Algebra and Algebraic Geometry, Compuational Algebraic Geometry for Curves and Surfaces, Singularities in Algebraic and Analytic Geometry, Mathematics and Education Reform, History of Mathematics, and Mathematics Education and Mistaken Philosophies of Mathematics.
Submission: Abstracts of contributed papers from ASL members should be sent by the deadline of October 9, 1998, to the ASL office.
Local Arrangements: Registration and hotel arrangements through the AMS.
Information: Association for Symbolic Logic, 1409 West Green Street, Urbana, Illinois 61801; tel: 217-244-7902; fax: 217-333-9576; e-mail: asl@math.uiuc.edu; http://www.math.uiuc.edu/~asl/.

*18–21 **DMTCS'99, Discrete Mathematics and Theoretical Computer Science and CATS'99, Computing: The Australasian Theory Symposium**, University of Auckland and CDMTCS, Auckland, New Zealand.
Topics: Original papers are solicited in all areas of discrete mathematics and theoretical computer science. Typical, but not exclusive, topics of interest include: abstract data types and specification, algorithms and data structures, automata and formal languages, computability and complexity, computational algebra, biology, geometry, logic and number theory, concurrecy, distributed systems and parallel computing, constructive mathematics, discrete mathematics, combinatorial computing and category theory, formal semantics, specification, sythesis and verification, hybrid systems and nonmonotonic logic.
Call for Papers: Authors are invited to submit papers either in hard copy by post, or electronically by e-mail, to the address below. Electronic submissions should be in PostScript format, printable in a standard Unix environment. LaTeX source of final version of accepted papers will be required. Submissions should not exceed 15 pages and include an e-mail address of the corresponding author. Joint submissions to other conferences are not permitted. At least one author of each accepted paper is expected to register by November 6, 1998 and present their work at the conference. The proceedings will be published by Springer-Verlag, Singapore, in the DMTCS Series, and will be made available during the conference. Send submissions to: DMTCS'99 + CATS'99 (Attn: M. Dinneen), Department of Computer Science, University of Auckland, Private Bag 92019, Auckland, New Zealand, e-mail: mjd@cs.auckland.ac.nz.
Invited Speakers: R. Downey (UVW, NZ), J. Goguen (UCSD, USA), A. Nerode (Cornell, USA), J. Pach (Hungarian Academy of Sciences), A. Restivo (U. Palermo, Italy), G. Walsh (U. Ottawa).
Fee: The registration fee is A$400 (which includes the dinner, excursion and proceedings) or A$100 for students (including only the proceedings).
Information: See the home-page of the conference http://www.tcs.auckland.ac.nz/~acsw99/, or contact the local chair, B. Khoussainov, e-mail: bmk@cs.auckland.ac.nz.

March 1999

*13–15 **International Conference on Scientific Computations**, Beirut Arab University, Beirut, Lebanon.

Organizers: D. Callebaut(chair, Antwerp Univ.), S. Doma (Beirut Arab Univ.), S. L. Kalla (Kuwait Univ.), N. L.Tsinstadze (Tbilisi Univ.), I. Moughrabi (Lebanese American Univ.).

Call for Papers: We invite submissions for 30-minute presentations on any aspect of scientific computations. Deadline for submitting papers is November 31, 1998. Papers will be refereed by an international committee. The proceeding is planned to be published soon after the conference. Send submissions to A. N. El-Kassar, Faculty of Science, Beirut Arab University, P.O.Box 15-5020, Beirut, Lebanon; e-mail: `Science@bau.edu.lb` or fax: 961-1-818402.

Information: For further information call 0961-03-534843 or email and fax above.

13–17 **1999 Arizona Winter School: Local-to-Global Principles in Arithmetical Algebraic Geometry**, University of Arizona, Tucson, Arizona.

Overview: This conference is the second Arizona Winter School on Arithmetical Algebraic Geometry.

Topics: Lecture series are planned on the following topics: descent, the Shafarevich-Tate group, obstructions to the Hasse Principle, and the method of Coleman and Chabauty.

Graduate Student Sessions: Graduate student participants will each be assigned an advisor from one of the speakers and will be expected to report on their advisor's research talk during special sessions devoted to graduate student presentations.

Professional Development: There will be a professional development component focusing on the use of computers to make explicit calculations.

Organizers: W. McCallum, W. Raskind, and D. Ulmer.

Confirmed Speakers: J.-L. Colliot-Thelene, J. Cremona, W. G. McCallum, K. Rubin.

Funding: We expect to be able to provide financial support for accommodations and airfare to approximately 30 eligible graduate students and reseachers within a few years of receiving their degrees. In any case, the workshop is open to the mathematical public, not just the funded participants.

Applications: Applications for funding, consisting of a CV, publication record, and (for graduate students) a letter of recommendation, should be sent by November 30, 1998, to: W. McCallum, Attn: SWCAAG Workshop, Department of Mathematics, Univ. of Arizona, Tucson, AZ 85721.

Information: See `http://www.math.arizona.edu/~swcenter/aws99/index.html` or send an e-mail message to `majordomo@swc.math.arizona.edu` with "subscribe aws99" in the body.

20–23 **ASL Annual Meeting**, San Diego, California.

Program Notes: The program will represent a broad perspective of modern logic, and will include the Tenth Annual Gödel Lecture.

Submission: Abstracts of contributed papers from ASL members should be sent by the deadline of January 15, 1999, to the Program Chair: S. Buss, Department of Mathematics, Univ. of California at San Diego, La Jolla, CA 92093-0112; e-mail: `sbuss@ucsd.edu`.

Program Committee: S. Buss (chair), B. Hart, C. G. Jockusch Jr., V. McGee, and W. H. Woodin.

Travel Grants: Travel grants (partly supported by an NSF grant) are available to graduate students in logic. Applications should be sent by January 15, 1999, to S. Buss at the address above.

Information: Association for Symbolic Logic, 1409 West Green Street, Urbana, IL 61801; tel: 217-244-7902; fax: 217-333-9576; e-mail: `asl@math.uiuc.edu`; `http://www.math.uiuc.edu/~asl/`.

*24–26 **DIMACS Workshop on Mobile Networks and Computing**, DIMACS Center, Rutgers University, Piscataway, New Jersey.

Organizers: B. R. Badrinath (Dept. of CS, Rutgers Univ.), F. Hsu (Dept. of CIS, Fordham Univ.), P. Pardalos (Univ. of Florida), and S. Rajasekaran (Univ. of Florida).

Aim: The new challenges in designing software systems for mobile networks include location and mobility management, channel allocation, power conservation, among some others. This workshop is aimed at bringing together researchers from academia as well as the industry who are working on various aspects of mobile computing.

Topics: Topics will include sensor networks, smart spaces, field computing, channel allocation, etc.

Local Arrangements: P. Pravato, DIMACS Center, `pravato@dimacs.rutgers.edu`, tel: 732-445-5929.

Information: WWW: `http://dimacs.rutgers.edu/Workshops/Mobile/index.html`. Contact `raj@cise.ufl.edu`.

*25–28 **International Conference on Algebra and its Applications**, Ohio University, Athens, Ohio.

Topics: Theory of Rings and Modules, Coding Theory, and Applied Linear Algebra.

Invited Speakers: R. B. Bapat, R. Brualdi, R. Calderbank, M. P. Drazin, N. V. Dung, C. Faith, K. Fuller, J. L. Gomez-Pardo, K. Goodearl, B. Huisgen-Zimmermann, C. Johnson, T. Y. Lam, L. Levy, C. Moreno, O. Moreno, M. Neumann, B. Osofsky, J. Park, V. S. Pless, L. Rowen, S. Sehgal, P. F. Smith, H. Tapia-Recillas, M. Teply, R. Wisbauer, J. Wolfmann, and J. Zelmanowitz.

Keynote Speaker: E. Zelmanov.

Funding: This conference is supported by funding from the National Security Agency and Ohio University.

Information: Those interested please e-mail `algebra@bing.math.ohiou.edu` and send a hard copy of the abstract (if you wish to contribute) so as to reach us by November 15, 1998. For more updates and additional information, please visit our webpage at `http://www.bing.math.ohiou.edu/~algebra`.

April 1999

*6–9 **London Mathematical Society Invited Lecture Series**, University of Bath, Bath, United Kingdom.

Topic: Reduction methods for differential equations.

Lecturer: A. Mielke (Hanover).

Forum: Ordinary and partial differential equations near steady states can often be reduced to equivalent but more accessible problems using implicit-function-theorem-type arguments. Often reduction is to finite-dimensional problems but sometimes, as in the case of Ginzburg-Landau theory, it leads to another partial differential equation.

A. Mielke will present a unified treatment of these approaches, which include Lyapunov-Schmidt procedures, invariant manifold theory, centre manifolds and amplitude equations (as in Ginzburg-Landau theory).

Support: These Invited Lectures, which are open to all, will be valuable for research students, and the LMS has provided funds to help support postgraduates who attend. It intends in each case that up to half the costs can be met, and it expects that the other half should be met by the student's department from RTSG or other funds. The fund will however be administered flexibly as needs dictate.

Information: For further details contact J. Toland, Department of Mathematical Sciences, Univ. of Bath, Bath BA2 7AY (`jft@maths.bath.ac.uk`).

May 1999

*7–8 **1999 ASL Spring Meeting**, New Orleans, Louisiana (in conjunction with a meeting of the Central Division of the American Philosophical Association, May 5–8, 1999).

Program Notes: The APA meeting will include a symposium on Frege and Russell, with speakers P. Hylton and I. Rumfitt.

Submission: Abstracts of contributed papers from ASL members should be sent by the deadline of February 26, 1999, to the ASL office. For any abstract submitted before November 6, 1998, the contributed talk will be scheduled and announced in the meeting program published by the APA.

Program Committee: G. Forbes and C. Parsons, co-chairs.

Local Arrangements: Registration and hotel arrangements through APA.

Information: Association for Symbolic Logic, 1409 West Green Street, Urbana, IL 61801; tel: 217-244-7902; fax: 217-333-9576; e-mail: `asl@math.uiuc.edu`; WWW `http://www.math.uiuc.edu/~asl/`.

*26–29 **Twelfth Biennial Conference of the Association of Christians in the Mathematical Sciences**, Gordon College, Wenham, MA.

Invited Speaker: W. Dunham (Muhlenberg College).

Call for Papers: Abstract deadline is December 1, 1998.
Information: R. Stout, Gordon College, Wenham, MA 01984-1895; e-mail: stout@faith.gordonc.edu.

* 27–29 **Mathematics Towards The Third Millennium**, Accademia Nazionale dei Lincei, Rome, Italy.
Aim: The aim of the conference is to present a wide spectrum of trends of current research that might serve as a guideline for future developments.
Organizers: S. Abeasis, V. Baldoni, G. M. Piacentini Cattaneo, E. Prestini, C. Rossi, E. Strickland, G. Tarantello (Dipartimento di Matematica, Univ. di Roma Tor Vergata, Italia).
Speakers: V. Arnold (Paris, Steklov), E. Bombieri (I.A.S.), A. Connes (College de France), C. Fefferman (Princeton Univ.), P. Griffiths (I.A.S.), M. Gromov (I.H.E.S.), M. Kontsevitch (I.H.E.S.), E. Lieb (Princeton Univ.) D. McDuff (SUNY at Stony Brook), D. Mumford (Brown Univ.), M. Talagrand (Paris 6), K. Uhlenbeck (Austin), D. Vogan (M.I.T.).
Information: For future information use the Web site: http://www.mat.uniroma2.it/ and click on Scienza & Cultura.

June 1999

* 7–9 **Theoretical, Experimental & Computational Mechanics**, Cincinnati, Ohio.
Theme: The theme for the 1999 SEM (Society for Experimental Mechanics, Inc.) Conference is the interdependence between theoretical, experimental and computational mechanics. This international conference draws attendees from around the world to participate in technical presentations, workshops, symposia, product displays and roundtable discussions on a variety of topics related to the field of experimental and applied mechanics.
Call for Papers: Papers are solicited for the following thematic tracks: Experimental verification of computational models; Materials behavior: Experiments and models; Verifying structural design integrity and performance; Experimental and applied mechanics.
Submissions: All those interested in submitting a paper to the conference are encouraged to submit via SEM's Web site: http://www.sem.org/. Abstracts for the conference are due by October 9, 1998.
Information: Conference overview, full track descriptions, important dates and location information may also be found on the SEM Web site. For more information, contact SEM at: 7 School Street, Bethel, CT 06801; tel: 203-790-6373; fax: 203-790-4472; e-mail: meetings@sem1.com.

July 1999

* 13–16 **International Conference on Applied Partial Differential Equations**, Tongji University, Shanghai, China.
Organizers: This conference is jointly organized by Tongji Univ. and City Univ. of Hong Kong.
Presentations: Presentations in all areas of applied partial differential equations are welcomed.
Information: Details of the conference are available on the Web page: http://www.cityu.edu.hk/ma/conference/tongji/. For further information, please contact H. Ziping at: Department of Applied Mathematics, Tongji Univ., 200092 Shanghai, P. R. China. E-mail: hzpsyhk@online.sh.cn; fax: +86-21-65150645.

August 1999

* 1–6 **1999 ASL European Summer Meeting (Logic Colloquium '99)**, Utrecht, The Netherlands.
Program Notes: The program will represent logic broadly; a featured topic will be computational logic. ESSLLI-99 will take place in Utrecht during the two following weeks, August 8–20, 1999.
Submission: Abstracts of contributed papers must be submitted by the deadline of April 2, 1999, to the Program Chair: W. Hodges, School of Mathematical Sciences, Queen Mary and Westfield College, Mile End Rd., London E1 4NS, England; e-mail: w.hodges@qmw.ac.uk.
Program Committee: E. Barendsen, J. van Eijck, S. Goncharov, W. Hodges (chair), D. de Jongh, A. Kechris, P. Koepke, M. Lerman, D. Marker, J. van Oosten, A. Pitts, and A. Visser.
Local Arrangements: P. Blok, P. Dekker, J. van Eijck (chair), M. de Rijke, and Y. Venema.
Travel Grants: Travel grants (partly supported by an NSF grant) are available to graduate students in logic and recent Ph.D.s. Applications should be sent by April 2, 1999, to W. Hodges at the address above.
Information: Association for Symbolic Logic, 1409 West Green Street, Urbana, IL 61801; tel: 217-244-7902; fax: 217-333-9576; e-mail: asl@math.uiuc.edu; WWW: http://www.math.uiuc.edu/~asl/.

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.

June 2000

* 3–7 **1999–2000 ASL Annual Meeting**, University of Illinois at Urbana-Champaign, Illinois.
Program Notes: The program will reflect the accomplishments and future prospects of modern logic, in recognition of the new millennium.
Local Arrangements: L. van den Dries, C. W. Henson, C. G. Jockusch Jr., and A. Pillay.
Information: Association for Symbolic Logic, 1409 West Green Street, Urbana, IL 61801; tel: 217-244-7902; fax: 217-333-9576; e-mail: asl@math.uiuc.edu; WWW: http://www.math.uiuc.edu/~asl/.

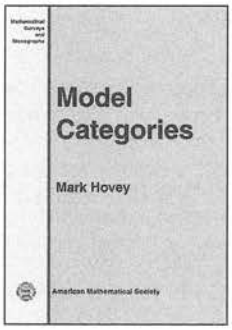
July 2000

* 3–7 **ANTS IV (Algorithmic Number Theory Symposium IV)**, Korteweg de Vries Institute for Mathematics, University of Amsterdam, The Netherlands.
Organizing Committee: W. Bosma, H.J.J. te Riele, B. de Smit, P. Stevenhagen, J. Top.
Information: http://www.wins.uva.nl/research/math/ants/ or contact P. Stevenhagen, Korteweg de Vries Institute for Mathematics, Univ. of Amsterdam, Plantage Muidergracht 24, 1018 TV Amsterdam, The Netherlands; e-mail: psh@wins.uva.nl.

* 21–31 **2000 ASL European Summer Meeting (Logic Colloquium 2000)**, Paris, France.
Program Notes: The program will reflect the accomplishments and future prospects of modern logic, in recognition of the new millennium.
Program Committee: D. Andler, C. Berline, B. Cooper, D. van Dalen, A. Kanamori, A. Razborov, H. Schwichtenberg, J. Steel, S. Todorčevic, A. Wilkie, and C. Wood (chair).
Local Arrangements: R. Cori, Z. Chatzidakis, M. Dickmann, D. Lascar, L. Pacholski, J. P. Ressayre, and B. Velickovic.
Information: Association for Symbolic Logic, 1409 West Green Street, Urbana, IL 61801; tel: 217-244-7902; fax: 217-333-9576; e-mail: asl@math.uiuc.edu; WWW: http://www.math.uiuc.edu/~asl/.

New Publications Offered by the AMS

Algebra and Algebraic Geometry



Model Categories

Mark Hovey, *Wesleyan University, Middletown, CT*

Model categories are a tool for inverting certain maps in a category in a controllable manner. As such, they are useful in diverse areas of mathematics. The list of such areas is continually growing.

This book is a comprehensive study of the relationship between a model category and its homotopy category. The author develops the theory of model categories, giving a careful development of the main examples. One highlight of the theory is a proof that the homotopy category of any model category is naturally a closed module over the homotopy category of simplicial sets.

Little is required of the reader beyond some category theory and set theory, making the book accessible to graduate students. The book begins with the basic theory of model categories and proceeds to a careful exposition of the main examples, using the theory of cofibrantly generated model categories. It then develops the general theory more fully, showing in particular that the homotopy category of any model category is a module over the homotopy category of simplicial sets, in an appropriate sense. This leads to a simplification and generalization of the loop and suspension functors in the homotopy category of a pointed model category. The book concludes with a discussion of the stable case, where the homotopy category is triangulated in a strong sense and has a set of small weak generators.

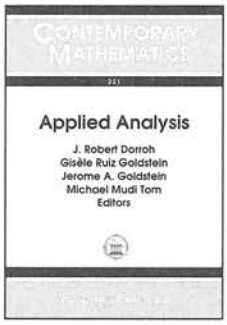
This text will also be of interest to those working in geometry and topology.

Contents: Model categories; Examples; Simplicial sets; Monoidal model categories; Framings; Pointed model categories; Stable model categories and triangulated categories; Vistas; Bibliography; Index.

Mathematical Surveys and Monographs

November 1998, 207 pages, Hardcover, ISBN 0-8218-1359-5, LC 98-34539, 1991 *Mathematics Subject Classification*: 55U35; 13D25, 16W30, 18G55, 20J05, **Individual member $32**, List $54, Institutional member $43, Order code SURV-HOVEYN

Analysis



Applied Analysis

J. Robert Dorroh, *Louisiana State University, Baton Rouge*, **Gisèle Ruiz Goldstein** and **Jerome A. Goldstein**, *University of Memphis, TN*, and **Michael Mudi Tom**, *Louisiana State University, Baton Rouge*, Editors

This volume contains proceedings from the AMS conference on Applied Analysis held at LSU (Baton Rouge) in April 1996. Topics include partial differential equations, spectral theory, functional analysis and operator theory, complex analysis, numerical analysis and related mathematics. Applications include quantum theory, fluid dynamics, control theory and abstract issues, such as well-posedness, asymptotics, and more.

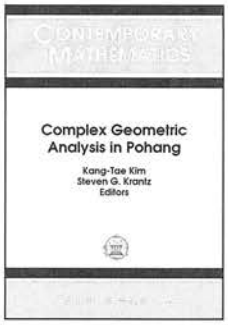
The book presents the scope and depth of the conference and its lectures. The state-of-the-art surveys by Jerry Bona and Fritz Gesztesy contain topics of wide interest. There have been a number of good conferences on related topics, yet this volume offers readers a unique, varied viewpoint. The scope of the material in the book will benefit readers approaching the work from diverse perspectives. It will serve those seeking motivational scientific problems, those interested in techniques and subspecialties and those looking for current results in the field.

Contents: **J. P. Albert**, Concentration compactness and the stability of solitary-wave solutions to nonlocal equations; **T. Bhattacharya** and **A. Weitsman**, Estimates for Green's function in terms of asymmetry; **J. L. Bona** and **L. Luo**, A generalized Korteweg-de Vries equation in quarter plane; **A. Castro** and **J. W. Neuberger**, An inverse function theorem; **F. Gesztesy** and **R. Weikard**, Toward a characterization of elliptic solutions of hierarchies of soliton equations; **K. A. Grasse** and **J. R. Bar-on**, Regularity of the value function for constrained optimization problems; **V. Liskevich** and **A. Manavi**, On perturbations of dominated semigroups; **M. A. Park**, On some nonlinear dispersive equations; **Yu. A. Semenov**, On perturbation theory for linear elliptic and parabolic operators; The method of Nash.

Contemporary Mathematics, Volume 221

Continued

November 1998, 284 pages, Softcover, ISBN 0-8218-0673-4, LC 98-34483, 1991 *Mathematics Subject Classification*: 34-XX, 35-XX, 47-XX, 35B40, 35Q55, 35Q53, 35Q35, 76B15, 76B25, **Individual member $35**, List $59, Institutional member $47, Order code CONM/221N



Complex Geometric Analysis in Pohang

Kang-Tae Kim, *Pohang University of Science and Technology (POSTECH), Korea*, and **Steven G. Krantz**, *Washington University, St. Louis, MO*, Editors

This volume comprises the proceedings of a conference on the geometric analysis of several complex variables held at POSTECH in June 1997. The conference was attended by scientists and students from around the globe.

Each of the five plenary speakers at the conference gave a short course on a topic of current interest in the field. The lecture write-ups contain cogent and accessible information intended for a broad audience. The volume also includes a tutorial in several complex variables given by Kim and Krantz at the conference. This tutorial is geared toward helping the novice to understand the rest of the material in the book.

The bibliographies of the papers give students and young mathematicians a valuable resource for future learning on the topic. This book provides a substantial overview on areas of current activity. Required background for understanding the text is a solid undergraduate education in mathematics and familiarity with first-year graduate studies in real and complex analysis. Some exposure to geometry would be helpful. The book is also suitable for use as a supplemental course text.

Contents: *Survey:* **K.-T. Kim** and **S. G. Krantz**, A crash course in the function theory of several complex variables; *Plenary Lectures:* **E. Bedford** and **J. Smillie**, External rays in the dynamics of polynomial automorphisms of $\mathbf{C}^2$; **N. Mok**, G-structures on irreducible Hermitian symmetric spaces of rank ≥ 2 and deformation rigidity; **J. Noguchi**, Value distribution theory of holomorphic mappings; **J.-P. Rosay**, Automorphisms of $\mathbb{C}^n$, a survey of Andersén-Lempert theory and applications; *Short Talks:* **M. Abate** and **G. Patrizio**, Convex-like properties of the Teichmüller metric; **M. Abate** and **R. Tauraso**, The Julia-Wolff-Carathéodory theorem(s); **U. Backlund** and **A. Fällström**, Maximal ideals in $A(\Omega)$; **Z. B łocki**, On the regularity of the complex Monge-Ampère operator; **H. R. Cho**, L^p and H^p extensions of holomorphic functions from subvarieties; **H. Derksen** and **F. Kutzschebauch**, Global holomorphic linearization of actions of compact Lie groups on $\mathbb{C}^n$; **P. M. Gauthier**, Covering properties of holomorphic mappings; **A. Hayashimoto**, On the relations between the holomorphic extendability theorems and the finiteness properties; **K.-T. Kim** and **A. F. Spiro**, Moduli space of ramified holomorphic coverings of B^2; **S. Ko łodziej**, A sufficient condition for solvability of the Dirichlet problem for the complex Monge-Ampère operator; **M. Landucci**, Γ-invariant polynomials and proper maps; **J.-P. Rosay**, A simple proof of uniqueness for perturbations of the Mizohata operator.

Contemporary Mathematics

November 1998, approximately 264 pages, Softcover, ISBN 0-8218-0957-1, LC 98-29259, 1991 *Mathematics Subject Classification*: 32A15, 32B10, 32B20, 32C15, 32C16, 32D05, 32D15, 32E05; 32F05, 32F20, 32G08, 32H02, 32H15, 32J05, 32J15, 32L05, **Individual member $33**, List $55, Institutional member $44, Order code CONM-KRANTZN

Applications

Randomization Methods in Algorithm Design

Panos Pardalos and **Sanguthevar Rajasekaran**, *University of Florida, Gainesville*, and **Jose Rolim**, *University of Geneva, Switzerland*, Editors

This volume is based on proceedings held during the DIMACS workshop on Randomization Methods in Algorithm Design in December 1997 at Princeton. The workshop was part of the DIMACS Special Year on Discrete Probability. It served as an interdisciplinary research workshop that brought together a mix of leading theorists, algorithmists and practitioners working in the theory and implementation aspects of algorithms involving randomization.

Randomization has played an important role in the design of both sequential and parallel algorithms. The last decade has witnessed tremendous growth in the area of randomized algorithms. During this period, randomized algorithms went from being a tool in computational number theory to finding widespread applications in many problem domains.

Major topics covered include randomization techniques for linear and integer programming problems, randomization in the design of approximate algorithms for combinatorial problems, randomization in parallel and distributed algorithms, practical implementation of randomized algorithms, derandomization issues, and pseudo-random generators. This volume focuses on theory and implementation aspects of algorithms involving randomization. It would be suitable as a graduate or advanced graduate text.

This text will also be of interest to those working in probability.

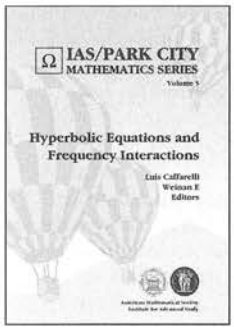
Contents: **R. D. Barve**, **E. F. Grove**, and **J. S. Vitter**, Simple randomized Mergesort on parallel disks; **R. Battiti**, **A. Bertossi**, and **R. Rizzi**, Randomized greedy algorithms for the hypergraph partitioning problem; **G. Cooperman** and **G. Havas**, Elementary algebra revisited: Randomized algorithms; **O. Goldreich**, Combinatorial property testing (a survey); **J. Gu**, Randomized and deterministic local search for SAT and scheduling problems; **K. Jansen**, An approximation scheme for scheduling of malleable parallel tasks; **D. S. Kim**, Blocking behaviors of broadcast switching networks in random traffics; **S. L. Martins**, **P. M. Pardalos**, **M. G. C. Resende**, and **C. C. Ribeiro**, Greedy randomized adaptive search procedures for the Steiner problem in graphs; **L. McShine** and **P. Tetali**, On the mixing time of the triangulation walk and other Catalan structures; **J. Mockus**, **A. Mockus**, and **L. Mockus**, Bayesian approach for randomization of heuristic algorithms of discrete

programming; **M. Molloy**, **B. Reed**, and **W. Steiger**, On the mixing rate of the triangulation walk; **I. Pak**, When and how n choose k; **S. Rajasekaran**, Computing on optical models; **A. Sahai** and **S. Vadhan**, Manipulating statistical difference; **A. Srinivasan**, A survey of the role of multicommodity flow and randomization in network design and routing; **T. V. Theodosopoulos**, Some remarks on the optimal level of randomization in global optimization.

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science, Volume 43

November 1998, 318 pages, Hardcover, ISBN 0-8218-0916-4, LC 98-34537, 1991 *Mathematics Subject Classification*: 03B05, 90A05, 68T15, 68Q42, 90C27, 90C30, 90B40, 68T01, 68Q15; 68Q22, 68Q25, 68P10, **Individual member $41**, List $69, Institutional member $55, Order code DIMACS/43N

Differential Equations



Hyperbolic Equations and Frequency Interactions

Luis Caffarelli and **Weinan E**, *Courant Institute, New York University, NY*, Editors

The research topic for this IAS/PCMS Summer Session was nonlinear wave phenomena. Mathematicians from the more theoretical areas of PDEs were brought together with those involved in applications. The goal was to share ideas, knowledge, and perspectives.

How waves, or "frequencies", interact in nonlinear phenomena has been a central issue in many of the recent developments in pure and applied analysis. It is believed that wavelet theory—with its simultaneous localization in both physical and frequency space and its lacunarity—is and will be a fundamental new tool in the treatment of the phenomena.

Included in this volume are write-ups of the "general methods and tools" courses held by Jeff Rauch and Ingrid Daubechies. Rauch's article discusses geometric optics as an asymptotic limit of high-frequency phenomena. He shows how nonlinear effects are reflected in the asymptotic theory. In the article "Harmonic Analysis, Wavelets and Applications" by Daubechies and Gilbert the main structure of the wavelet theory is presented.

Also included are articles on the more "specialized" courses that were presented, such as "Nonlinear Schrödinger Equations" by Jean Bourgain and "Waves and Transport" by George Papanicolaou and Leonid Ryzhik. Susan Friedlander provides a written version of her lecture series, "Stability and Instability of an Ideal Fluid", given at the Mentoring Program for Women in Mathematics, a preliminary program to the Summer Session.

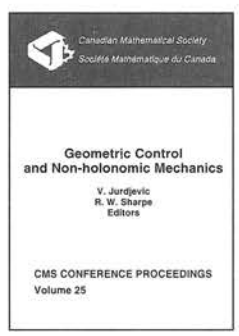
This Summer Session brought together students, fellows, and established mathematicians from all over the globe to share ideas in a vibrant and exciting atmosphere. This book presents the compelling results.

This text will also be of interest to those working in mathematical physics.

Contents: Introduction; **Jean Bourgain**, *Nonlinear Schrödinger Equations:* Introduction; Generalities and initial value problems; The initial value problem (continued); A digression: The initial value problem for the KdV equation; 1D invariant Gibbs measures; Invariant measures (2D); Quasi-periodic solutions of Hamiltonian PDE; Time periodic solutions; Time quasi-periodic solutions; Normal forms; Applications of symplectic capacities to Hamiltonian PDE; Appendix; **Ingrid C. Daubechies** and **Anna C. Gilbert,** *Harmonic Analysis, Wavelets and Applications:* Introduction; Constructing orthonormal wavelet bases: Multiresolution analysis; Wavelet bases: Construction and algorithms; More wavelet bases; Wavelets in other functional spaces; Pointwise convergence for wavelet expansions; Two-dimensional wavelets and operators; Wavelets and differential equations; References; **Susan Friedlander,** *Lectures on Stability and Instability of an Ideal Fluid:* Introduction; Equations of motion; Initial-boundary value problem; The type of the Euler equations; Vorticity; Steady flows; Stability/instability of an equilibrium state; Two-dimensional spectral problem; "Arnold" criterion for nonlinear stability; Plane parallel shear flow; Instability in a vorticity norm; Sufficient condition for instability; Exponential stretching; Integrable flows; Baroclinic instability; Nonlinear instability; References; **George Papanicolaou** and **Leonid Ryzhik,** *Waves and Transport:* Introduction; The Schrödinger equation; Symmetric hyperbolic systems; Waves in random media; The diffusion approximation; The geophysical applications; References; **Jeffrey Rauch (with the assistance of Markus Keel)**, *Lectures on Geometric Optics:* Introduction; Basic linear existence theorems; Examples of propagation of singularities and of energy; Elliptic geometric optics; Linear hyperbolic geometric optics; Basic nonlinear existence theorems; One phase nonlinear geometric optics; Justification of one phase nonlinear geometric optics; References.

IAS/Park City Mathematics Series, Volume 5

November 1998, 466 pages, Hardcover, ISBN 0-8218-0592-4, LC 98-30060, 1991 *Mathematics Subject Classification*: 35Lxx, 35Qxx, 42-XX, 73Dxx, 76-XX, **All AMS members $55**, List $69, Order code PCMS/5N



Geometric Control and Non-holonomic Mechanics

V. Jurdjevic and **R. W. Sharpe**, *University of Toronto, ON, Canada*, Editors

Control theory, a synthesis of geometric theory of differential equations enriched with variational principles and the associated symplectic geometry, emerges as a new mathematical subject of interest to engineers, mathematicians, and physicists. This collection of articles focuses on several distinctive research directions having origins in mechanics and differential geometry, but driven by modern control theory.

The first of these directions deals with the singularities of small balls for problems of sub-Riemannian geomtery and provides a generic classification of singularities for two-dimensional distributions of contact type in a three-dimensional ambient space.

The second direction deals with invariant optimal problems on Lie groups exemplified through the problem of Dublins

extended to symmetric spaces, the elastic problem of Kirchhoff and its relation to the heavy top. The results described in the book are explicit and demonstrate convincingly the power of geometric formalism.

The remaining directions deal with the geometric nature of feedback analyzed through the language of fiber bundles, and the connections of geometric control to non-holonomic problems in mechanics, as exemplified through the motions of a sphere on surfaces of revolution.

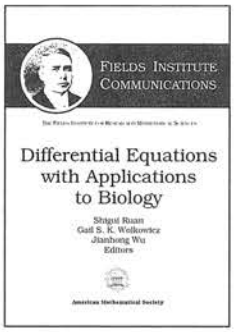
This book provides quick access to new research directions in geometric control theory. It also demonstrates the effectiveness of new insights and methods that control theory brings to mechanics and geometry.

Members of the Canadian Mathematical Society may order at the AMS member price.

Contents: V. Jurdjevic, Lie determined systems and optimal problems with symmetries; **A. A. Agrachev**, **El-H. C. El-A.**, and **J. P. Gauthier**, Sub-Riemannian metrics on $\mathbb{R}^3$.; **B. Bonnard** and **M. Chyba**, Sub-Riemannian geometry: the Martinet case; **D. Mittenhuber**, Dubins' problem in hyperbolic space; **D. Mittenhuber**, Dubins' problem in the hyperbolic plane using the open disc model; **F. Monroy-Pérez**, Three dimensional non-Euclidean Dubins' problem; **B. Jakubczyk**, Symmetries of nonlinear control systems and their symbols; **J. L. F. Chapou**, The motion of a sphere on a surface of revolution: a geometric approach; **J. C. Martínez-García**, Geometry and structure in the control of linear time invariant systems; Index.

Conference Proceedings, Canadian Mathematical Society, Volume 25

October 1998, 239 pages, Softcover, ISBN 0-8218-0795-1, LC 98-29718, 1991 *Mathematics Subject Classification*: 49-XX; 22-XX, 53-XX, **Individual member $29**, List $49, Institutional member $39, Order code CMSAMS/25N



Differential Equations with Applications to Biology

Shigui Ruan, *Dalhousie University, Halifax, NS, Canada*, **Gail S. K. Wolkowicz**, *McMaster University, Hamilton, ON, Canada*, and **Jianhong Wu**, *York University, North York, ON, Canada*, Editors

This book presents the proceedings from the International Conference held in Halifax, NS in July 1997. Funded by The Fields Institute and Le Centre de Recherches Mathématiques, the conference was held in honor of the retirement of Professors Lynn Erbe and Herb I. Freedman (University of Alberta). Featured topics include ordinary, partial, functional, and stochastic differential equations and their applications to biology, epidemiology, neurobiology, physiology and other related areas.

The 41 papers included in this volume represent the recent work of leading researchers over a wide range of subjects, including bifurcation theory, chaos, stability theory, boundary value problems, persistence theory, neural networks, disease transmission, population dynamics, pattern formation and more. The text would be suitable for a graduate or advanced undergraduate course study in mathematical biology.

Features:

- An overview of current developments in differential equations and mathematical biology.
- Authoritative contributions from over 60 leading worldwide researchers.
- Original, refereed contributions.

This text will also be of interest to those working in applications.

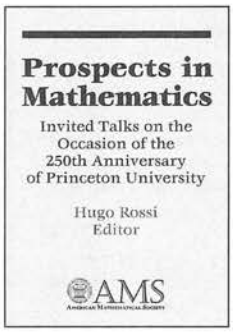
Contents: W. Allegretto and **P. Nistri**, On a class of nonlocal problems with applications to mathematical biology; **L. J. S. Allen**, **E. J. Allen**, and **D. N. Atkinson**, Integrodifference equations applied to plant dispersal, competition, and control; **M. Benaïm** and **M. W. Hirsch**, Differential and stochastic epidemic models; **F. Brauer**, General recruitment models for sexually transmitted diseases; **J. R. Buchanan**, Asymptotic behavior of two interacting pioneer/climax species; **S. A. Campbell**, Stability and bifurcation of a simple neural network with multiple time delays; **D. Chao** and **S. A. Levin**, Herding behavior: The emergence of large-scale phenomena from local interactions; **C. J. Clements**, **J. C. Clements**, and **B. M. Horáček**, On the formation of scroll waves in an anisotropic ventricular myocardium; **J. C. Clements**, An optimal control theory approach to the inverse problem of electrocardiography; **R. Cressman**, Natural selection as an extensive form game; **L. Dung**, **H. L. Smith**, and **P. Waltman**, Growth in the unstirred chemostat with different diffusion rates; **T. Faria**, Bifurcation aspects for some delayed population models with diffusion; **J. E. Franke** and **A.-A. Yakubu**, Extinction and persistence in a size-structured, discrete competitive system with dispersion; **H. I. Freedman** and **X.-Q. Zhao**, Global attractivity in a nonlocal reaction-diffusion model; **P. Freitas**, Nonlocal reaction-diffusion equations; **T. C. Gard**, Practical persistence in stochastic population models; **T. Gedeon**, Stucture and dynamics of artificial neural networks; **T. Gedeon** and **L. Glass**, Continuity of resetting curves for FitzHugh-Nagumo equations on the circle; **L. Genik** and **P. van den Driessche**, An epidemic model with recruitment-death demographics and discrete delays; **K. P. Hadeler**, Nonlinear propagation in reaction transport systems; **U. an der Heiden**, On the dynamics of nonlinear feedback loops in cell membrane, neural and sensory systems; **Y. Hino** and **S. Murikami**, Skew product flows of quasi-processes and stabilities; **Y. S. Huang**, Periodic solutions to system of globally coupled oscillators; **Y. Kan-on**, Bifurcation structure of stationary solutions of a Lotka-Volterra competition model with density-dependent diffusion; **J. Kato** and **J. Pan**, Stability domain of a chemostat system with delay; **Q. Kong**, Oscillation criteria for second order half-linear differential equations; **Y. Kuang**, Rich dynamics of Gause-type ratio-dependent predator-prey system; **L. A. C. Ladeira**, Differentiability with respect to delays for a neutral differential-difference equation; **J. P. Lampreia**, **R. Severino**, and **J. Sousa Ramos**, Renormalizations for trimodal maps; **A. Lasota** and **M. C. Mackey**, Statistical stability of strongly perturbed dynamical systems; **X. Liu**, A generalization of variation of parameters and Lyapunov's method; **J. Milota**, Persistence in an epidemiological model; **Y. Morita**, **M. Pernarowski**, and **J. Dockery**, Homoclinic bifurcations in a diffusively coupled excitable system; **H. Petzeltová**, Compactness and asymptotic spatial homogeneity in conservation laws with memory; **K. Schmitt**, On boundary value problems for quasilinear elliptic equations; **J. F. Selgrade** and **P. M. Schlosser**, A model for the production of ovarian hormones during the menstrual cycle; **J. W.-H. So** and **J. S. Yu**, Global stability for a general population model with time delays; **H. R. Thieme** and **P. van den Driessche**,

Global stability in cyclic epidemic models with disease fatalities; **B. Toni**, **D. Thieffry**, and **R. Bulajich**, Feedback loops analysis for chaotic dynamics with an application to Lorenz system; **W. Wu** and **Z. Deng**, Absolute stability of the second canonical form of control systems; **D. Xiao** and **S. Ruan**, Bogdanov-Takens bifurcations in predator-prey systems with constant rate harvesting; List of participants.

Fields Institute Communications, Volume 21

November 1998, approximately 528 pages, Hardcover, ISBN 0-8218-0944-X, 1991 *Mathematics Subject Classification*: 34-XX; 92-XX, 35-XX, 58-XX, **Individual member $77**, List $129, Institutional member $103, Order code FIC/21N

General and Interdisciplinary



Prospects in Mathematics

Invited Talks on the Occasion of the 250th Anniversary of Princeton University

Hugo Rossi, *Mathematical Sciences Research Institute, Berkeley, CA*, Editor

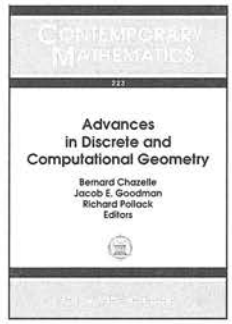
In celebration of Princeton University's 250th anniversary, the mathematics department held a conference entitled "Prospects in Mathematics". The purpose of the conference was to speculate on future directions of research in mathematics.

This collection of articles provides a rich panorama of current mathematical activity in many research areas. From Gromov's lecture on quantitative differential topology to Witten's discussion of string theory, new ideas and techniques transfixed the audience of international mathematicians. The volume contains 11 articles by leading mathematicians, including historical presentations by J. Milnor and D. Spencer. It provides a guide to some of the most significant mathematical work of this decade.

Contents: J. Milnor, Growing up in the Old Fine Hall; **D. Spencer**, Old memories and an old problem; **J. Fröhlich**, The electron is inexhaustible; **M. Gromov**, Quantitative homotopy theory; **H. Iwaniec**, Harmonic analysis in number theory; **D. McDuff**, Symplectic topology and capacities; **M. Struwe**, Evolution problems in geometry and mathematical physics; **E. Witten**, Small instantons in string theory; **T. Wolff**, Recent work connected with the Kakeya problem.

October 1998, 154 pages, Hardcover, ISBN 0-8218-0975-X, LC 98-36451, 1991 *Mathematics Subject Classification*: 00B20, **All AMS members $23**, List $29, Order code PIM-ROSSIN

Geometry and Topology



Advances in Discrete and Computational Geometry

Bernard Chazelle, *Princeton University, NJ*, **Jacob E. Goodman**, *City University of New York*, and **Richard Pollack**, *Courant Institute, New York University*, Editors

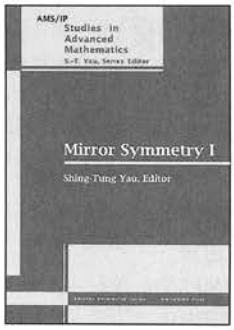
This volume is a collection of refereed expository and research articles in discrete and computational geometry written by leaders in the field. Articles are based on invited talks presented at the AMS-IMS-SIAM Summer Research Conference, "Discrete and Computational Geometry: Ten Years Later", held in 1996 at Mt. Holyoke College (So. Hadley, MA). Topics addressed range from tilings, polyhedra, and arrangements to computational topology and visibility problems. Included are papers on the interaction between real algebraic geometry and discrete and computational geometry, as well as on linear programming and geometric discrepancy theory.

This text will also be of interest to those working in applications.

Contents: P. K. Agarwal and **J. Erickson**, Geometric range searching and its relatives; **N. Amenta** and **G. M. Ziegler**, Deformed products and maximal shadows of polytopes; **L. J. Billera**, **C. S. Chan**, and **N. Liu**, Flag complexes, labelled rooted trees, and star shellings; **B. Chazelle**, Discrepancy bounds for geometric set systems with square incidence matrices; **T. K. Dey**, **H. Edelsbrunner**, and **S. Guha**, Computational topology; **G. F. Tóth**, Recent progress on packing and covering; **B. Grünbaum**, Acoptic polyhedra; **F. Holt** and **V. Klee**, A proof of the strict monotone 4-step conjecture; **I. Itenberg** and **M.-F. Roy**, Interactions between real algebraic geometry and discrete and computational geometry; **J. O'Rourke**, Open problems in the combinatorics of visibility and illumination; **J. Pach** and **J. Solymosi**, Halving lines and perfect cross-matchings; **J. Pach**, **T. Thiele**, and **G. Tóth**, Three-dimensional grid drawings of graphs; **M. Pocchiola** and **G. Vegter**, On polygonal covers; **J. Richter-Gebert**, The universality theorems for oriented matroids and polytopes; **M. Senechal**, Periodic and aperiodic tilings of E^n; **M. I. Shamos**, The early years of computational geometry–A personal memoir; **M. Sharir**, Arrangements of surfaces in higher dimensions; **J. Spencer**, Geometric discrepancy theory; **H. Tverberg**, Proof of Reay's conjecture on certain positive-dimensional intersections; **R. Wenger**, Progress in geometric transversal theory; **G. M. Ziegler**, Recent progress on polytopes; **B. Chazelle**, **J. E. Goodman**, and **R. Pollack**, Application challenges to computational geometry (CG impact task force report).

Contemporary Mathematics, Volume 223

November 1998, 463 pages, Softcover, ISBN 0-8218-0674-2, LC 98-34538, 1991 *Mathematics Subject Classification*: 52-XX, 68-XX, **Individual member $59**, List $99, Institutional member $79, Order code CONM/223N



Mirror Symmetry I

Shing-Tung Yau, *Harvard University, Cambridge, MA*, Editor

This volume is an updated edition of *Essays on Mirror Manifolds*, the first book of papers published after the phenomenon of mirror symmetry was discovered. The two major groups who made the discovery reported their papers here.

Greene, Plesser, and Candelas gave details on their findings; Witten gave his interpretation which was vital for future development. Vafa introduced the concept of quantum cohomology. Several mathematicians, including Katz, Morrison, Wilson, Roan, Tian, Hübsch, Yau, and Borcea discussed current knowledge about Calabi-Yau manifolds. Ferrara and his coauthors addressed special geometry and $N = 2$ supergravity. Roček proposed possible mirrors for Calabi-Yau manifolds with torsion. This collection continues to be an important book on this spectacular achievement in algebaic geometry and mathematical physics.

This text will also be of interest to those working in mathematical physics.

Titles in this series are co-published with International Press, Cambridge, MA.

Contents: B. R. Greene and **M. R. Plesser**, An introduction to mirror manifolds; **P. Candelas, X. C. de la Ossa, P. S. Green,** and **L. Parkes**, A pair of Calabi-Yau manifolds as an exactly soluble superconformal theory; **C. Vafa**, Topological mirrors and quantum rings; **E. Witten**, Mirror manifolds and topological field theory; **Y. Kawamata**, Rational curves and classification of algebraic varieties; **S. Katz**, Rational curves on Calabi-Yau threefolds; **D. R. Morrison**, Picard-Fuchs equations and mirror maps for hypersurfaces; **P. M. H. Wilson**, Kähler classes on Calabi-Yau threefolds—An informal survey; **S. Ferrara, C. Kounnas, D. Lüst,** and **F. Zwirner**, Automorphic functions and special Kähler geometry; **S. Ferrara** and **J. Louis**, Picard-Fuchs equations and flat holomorphic connections from $N = 2$ supergravity; **P. S. Aspinwall** and **C. A. Lutken**, A new geometry from superstring theory; **S.-S. Roan**, The geometry of Calabi-Yau orbifolds; **A. Giveon** and **D.-J. Smit**, Properties of superstring vacua from (topological) Landau-Ginzburg models; **T. Hübsch** and **S.-T. Yau**, An $SL(2,\mathbb{C})$ action on certain Jacobian rings and the mirror map; **P. Berglund** and **T. Hübsch**, A generalized construction of mirror manifolds; **B. R. Greene, M. R. Plesser,** and **S.-S. Roan**, New constructions of mirror manifolds: Probing moduli space far from Fermat points; **Z. Ran**, Deformations of Calabi-Yau Kleinfolds; **G. Tian**, Smoothing 3-folds with trivial canonical bundle and ordinary double points; **M. Roček**, Modified Calabi-Yau manifolds with torsion; **C. Borcea**, Calabi-Yau threefolds and complex multiplication.

AMS/IP Studies in Advanced Mathematics, Volume 9

October 1998, 444 pages, Hardcover, ISBN 0-8218-0665-3, LC 98-35520, 1991 *Mathematics Subject Classification*: 14-XX; 32-XX, 81-XX, **All AMS members $39**, List $49, Order code AMSIP/9N

Classified Advertisements

Positions available, items for sale, services available, and more

ALABAMA

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Applications are invited for two tenure-track positions to begin September 1, 1999. One position is at the level of associate professor and one position is at the level of assistant professor. Applicants should have demonstrated strong potential in research commensurate with the level of the position and a commitment to excellent teaching. Postdoc experience is desirable for candidates applying for the position of assistant professor. All qualified candidates are encouraged to apply. We are especially interested in candidates whose research is compatible with the department's current research expertise in differential equations, differential geometry, dynamical systems, mathematical physics, and topology, including the computational aspects of these research areas. Our home page can be found at `http://www.math.uab.edu/`.

In order to apply, please send a completed AMS standard cover sheet (available from the AMS - `http://www.ams.org/employment/coversheet-info.html`) and a curriculum vita. Review of applications will begin November 15, 1998, and will continue until the positions are filled. Please arrange for at least three letters of reference to be sent. Applications and letters of reference should be sent to the following address: Search Committee, Department of Mathematics, UAB, Birmingham, AL 35294-1170. UAB is an AA/EO Employer.

CALIFORNIA

UNIVERSITY OF CALIFORNIA AT BERKELEY
Tenured or Tenure-track Position
Department of Mathematics
Berkeley, CA 94720

Pending budget approval, we invite applications for one or more positions effective July 1, 1999, at either the tenure-track (assistant professor) or tenured (associate or full professor) level, in the general areas of pure or applied mathematics.

Tenure-track applicants are expected to have demonstrated outstanding research potential, normally including major contributions beyond the doctoral dissertation. Such applicants should send a résumé, and reprint or preprints, and/or dissertation abstract, and ask three people to send letters of evaluation to the Vice Chair of Faculty Affairs at the above address. It is the responsibility of the tenure-track applicants to make sure that letters of evaluation are sent. All letters of evaluation are subject to Berkeley campus policies on confidentiality of letters of evaluation, a summary of which can be found on our home page (`http://math.berkeley.edu/` by clicking on People, then Faculty Positions at Berkeley).

Tenure applicants are expected to demonstrate leadership in research and should send a curriculum vitae, list of publications, a few selected reprints or preprints, and the names and addresses of three references to the Vice Chair of Faculty Affairs at the above address. The applicant should indicate whether they are applying for an associate professor or full professor position. The department will assume responsibility to solicit letters of evaluation and will provide evaluators with a copy of the summary of policies on confidentialtiy of letters of evaluation.

All applicants are requested to use the AMS standardized application form and to indicate their subject area using the AMS subject classification numbers. The form is the *Academic Employment in Mathematics, Application Cover Sheet.* It is available courtesy of the American Mathematical Society.

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 1998 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: November issue–August 20, 1998; December issue–September 18, 1998; January issue–October 26, 1998; February issue–November 12, 1998; March issue–December 21, 1998; April issue–January 16, 1999.

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 `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.

We should receive material for both tenure-track and tenure applications no later than November 15, 1998. Applications postmarked after the deadline will not be considered. The University of California is an Equal Opportunity, Affirmative Action Employer.

UNIVERSITY OF CALIFORNIA AT BERKELEY
Temporary Postdoctoral Positions
Department of Mathematics
Berkeley, CA 94720

Several temporary positions beginning in fall 1999 are anticipated for new and recent Ph.D.s of any age, in any area of pure or applied mathematics. The terms of these appointments may range from one to three years. Applicants for NSF or other postdoctoral fellowships are encourage to apply for these positions. Mathematicians whose research interests are close to those of regular department members will be given some preference. Applicants should send a résumé and reprints, preprints, and/or dissertation abstract, and ask three people to send letters of evaluation to the Vice Chair for Faculty Affairs at the above address. All letters of evaluation are subject to Berkeley campus policies on confidentiality of letters of evaluation, a summary of which can be found on our home page (`http://math.berkeley.edu/` by clicking on People, and then Faculty Positions at Berkeley). We request that applicants use the AMS standardized application form and indicate their subject area using the AMS subject classification numbers. The form is the *Academic Employment in Mathematics, Application Cover Sheet.* It is available courtesy of the American Mathematical Society.

We should receive this material no later than December 1, 1998. The University of California is an Equal Opportunity, Affirmative Action Employer.

UNIVERSITY OF CALIFORNIA AT BERKELEY
Charles B. Morrey Jr.
Assistant Professorships
Department of Mathematics
Berkeley, CA 94720

We invite applications for these special (nontenure-track) positions effective July 1, 1999. The terms of these appointments may range from two to three years. Applicants should have a recent Ph.D., or the equivalent, in an area of pure or applied mathematics. Applicants should send a résumé, reprints, preprints and/or dissertation abstract, and ask three people to send letters of evaluation to the Vice Chair for Faculty Affairs at the above address. All letters of evaluation are subject to Berkeley campus policies on confidentiality of letters of evaluation, a summary of which can be found on our home page (`http://math.berkeley.edu/` by clicking on People, and then Faculty Positions at Berkeley). We request that applicants use the AMS standardized application form and indicate their subject area using the AMS subject classification numbers. The form is the *Academic Employment in Mathematics, Application Cover Sheet.* It is available courtesy of the American Mathematical Society.

We should receive this material no later than December 1, 1998. Applications postmarked after the deadline will not be considered. The University of California is an Equal Opportunity, Affirmative Action Employer.

UNIVERSITY OF CALIFORNIA, DAVIS
Regular Faculty Positions in Mathematics

The UC Davis Department of Mathematics invites applications for four positions at either the assistant (tenure-track) or associate professor (tenured) level in the following areas: (1) analysis/partial differential equations, (2) geometry/topology, and (3) applied mathematics, effective July 1, 1999.

Appointments will be made commensurate with qualifications. Minimum qualifications include a Ph.D. degree in mathematical sciences and great promise in research and teaching. Duties include mathematical research, undergraduate and graduate teaching (4.0 quarter courses per year), and service. Candidates for the associate professor position must have demonstrated outstanding attainment in research and teaching.

The application deadline is October 15, 1998, or until positions are filled. To initiate the application process, request an application package by sending an e-mail message to `forms@math.ucdavis.edu` or by writing to:

Chair of Search Committee
Department of Mathematics
University of California
Davis, California 95616-8633

The University of California, Davis, is an Affirmative Action/Equal Opportunity Employer with a strong institutional commitment to the achievement of diversity among its faculty and staff.

For more information regarding the position or institution: `http://math.ucdavis.edu/`.

UNIVERSITY OF CALIFORNIA, RIVERSIDE
Department of Mathematics
Assistant Professor
Position in Analysis

Applications and nominations are invited for an entry level, assistant professor position in analysis beginning July 1, 1999. A doctorate in mathematics is required as is demonstrated excellence or strong promise in research and teaching. Responsiblities include teaching undergraduate and graduate level courses and seminars, conducting scholarly research, and participating in service activities. Established criteria of the University of California determine salary and level of appointment. To assure full consideration, applicants should send their curriculum vitae, including a list of publications, and have at least three letters of recommendation sent to:

Analysis Search Committee
Department of Mathematics
University of California, Riverside
Riverside, CA 92521-0135

by Tuesday, December 1, 1998. UCR is an Affirmative Action/Equal Opportunity Employer.

GEORGIA

UNIVERSITY OF GEORGIA
Department of Mathematics
Assistant Professor Positions

Applications are invited for two tenure-track positions at the rank of assistant professor, to begin in August, 1999. Candidates should have a Ph.D. in mathematics or applied mathematics and should exhibit outstanding research potential as well as a commitment to excellence in teaching. The area of priority for one of the positions is harmonic analysis. This area is broadly defined to include the following research areas: classical harmonic analysis, analysis on Lie groups, analysis of partial differential equations, and the theory of wavelets.

Applications from all areas of pure and applied mathematics will be considered for the second position.

Applicants should send a completed AMS Standard Cover Sheet, a curriculum vitae, and a brief statement about their current and future research plans to: Dr. Kevin Clancey, Head, Department of Mathematics, University of Georgia, Athens, GA 30602. They should also arrange to have three letters of recommendation concerning research and one concerning teaching sent directly to the above address. Review of applications will begin December 1, 1998; applications received by this date are assured of consideration.

The University of Georgia is an Affirmative Action/Equal Opportunity Employer which is committed to increasing the diversity of its faculty. We especially encourage applications from women, minorities and underrepresented groups.

ILLINOIS

ILLINOIS WESLEYAN UNIVERSITY

The Department of Mathematics and Computer Science at Illinois Wesleyan University invites applications for a full-time, tenure-track position in computer science

to begin August 1999. Candidates must have a Ph.D. in computer science or a closely related field. The position is open to all areas of specialization in CS; however, preference may be given to those who could teach courses in network theory and design, software engineering, simulation, or theory of computation in addition to the core CS curriculum.

Illinois Wesleyan is a highly selective undergraduate liberal arts university of 1,900 students located in Bloomington, Illinois, a community of about 100,000. The Department of Mathematics and Computer Science is located in the new Center for Natural Science Learning and Research. This $25 million facility is equipped with over ninety Sun SPARC stations for student and faculty use. For additional information on the computer science curriculum and facilities see `http://www.iwu.edu/~cs/`.

Send a letter of application and résumé, and have three letters of reference sent under separate cover, to: Dr. Melvyn Jeter, Chair, Department of Mathematics and Computer Science, Illinois Wesleyan University, P.O. Box 2900, Bloomington, IL 61702-2900.

IWU is an Equal Opportunity Employer. Applications will be reviewed beginning November 2, 1998. Preference may be given to those completed by this date. Acceptance and review of applications will continue until the position is filled. Interviews for this position may be held at the Joint AMS-MAA Mathematics Meetings in San Antonio, Texas (January 1999).

ILLINOIS WESLEYAN UNIVERSITY

The Department of Mathematics and Computer Science at Illinois Wesleyan University invites applications for a full-time, tenure-track position jointly in both mathematics and computer science to begin August 1999. Candidates must have a Ph.D. in computer science or mathematics and possess considerable expertise in both areas. The position is open to all areas of specialization in mathematics and CS.

Illinois Wesleyan is a highly selective undergraduate liberal arts university of 1,900 students located in Bloomington, Illinois, a community of about 100,000. The Department of Mathematics and Computer Science is located in the new Center for Natural Science Learning and Research. This $25 million facility is equipped with over ninety Sun SPARC stations for student and faculty use. For additional information on the computer science curriculum and facilities see `http://www.iwu.edu/~cs/`. Send letter of application, AMS cover sheet, and résumé, and three letters of reference under separate cover, to: Dr. Melvyn Jeter, Chair, Department of Mathematics and Computer Science, Illinois Wesleyan University, P.O. Box 2900, Bloomington, IL 61702-2900.

Illinois Wesleyan University is an Equal Opportunity Employer. Applications will be reviewed beginning January 31, 1999. Preference may be given to those completed by this date. Preliminary interviews for this position will be held at the Joint Mathematics Meetings in San Antonio, Texas (January 1999). Review of applications will continue until the position is filled.

NORTHWESTERN UNIVERSITY
Department of Mathematics
2033 Sheridan Road
Evanston, Illinois 60208-2730
Boas Assistant Professor

Applications are solicited from people whose research is related to probability for two Ralph Boas assistant professorships of three years each starting in September 1999. These positions are part of the Emphasis Year in Probability which the department will be sponsoring in 1999–2000.

Applications should be sent to the Emphasis Year Committee at the department address and include: (1) the American Mathematical Society's Application Cover Sheet for Academic Employment, (2) a curriculum vitae, and (3) three letters of recommendation including one which discusses in some detail the candidate's teaching qualifications. Inquiries may be sent via e-mail to `hiring@math.nwu.edu`. In order to ensure full consideration, applications should be received by December 1, 1998. Northwestern University is an Affirmative Action, Equal Opportunity Employer committed to fostering a diverse faculty; women and minority candidates are especially encouraged to apply.

NORTHWESTERN UNIVERSITY
Department of Mathematics
2033 Sheridan Road
Evanston, Illinois 60208-2730

Applications are invited for anticipated tenure-track or tenured positions starting September 1999. Priority will be given to exceptionally promising research mathematicians. Fields of interest within the department include algebra, algebraic geometry, analysis, dynamical systems, probability, partial differential equations, and topology.

Application material should be sent to Personnel Committee, at the department address and include: (1) the American Mathematical Society's Application Cover Sheet for Academic Employment, (2) a curriculum vitae, and (3) at least four letters of recommendation including one which discusses in some detail the candidate's teaching qualifications. Inquiries may be sent via e-mail to `hiring@math.nwu.edu`. Applications are welcome at any time, but the review process starts in November 1998. Northwestern University is an Affirmative Action/Equal Opportunity Employer committed to fostering a diverse faculty; women and minority candidates are especially encouraged to apply.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Mathematics
Postdoctoral Positions
J. L. Doob Research Assistant Professor

The Department of Mathematics of the University of Illinois at Urbana-Champaign is soliciting applications for postdoctoral positions. Two appointments will be made starting August 21, 1999; each appointment is for three years and is not renewable. These positions are for recent Ph.D. recipients (with a strong preference for those not more than one year past the Ph.D. degree). The Department of Mathematics will provide an excellent scientific environment to pursue research in pure and applied mathematics. The position carries a salary of $40,000 per year.

Applicants should send a letter of application, a curriculum vitae and publication list, and three letters of reference to the address below. It is the responsibility of the applicants to make sure that letters of recommendation are sent.

Postdoctoral Search Committee
Department of Mathematics
University of Illinois
at Urbana-Champaign
1409 West Green Street
Urbana, IL 61801-2975
e-mail: `postdocs@math.uiuc.edu`

To insure full consideration, all materials, including letters of reference, should be received by December 1, 1998. We will review later applications until the search is closed. We encourage use of the application cover sheet provided by the American Mathematical Society and the indication of the subject area using the AMS subject classification numbers. Applications from women and minority candidates are especially encouraged. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Mathematics
Tenured Position

Applications are invited for one or more full-time tenured faculty positions to commence August 21, 1999. Those faculty will be expected to pursue an outstanding research program and teach graduate students as well as undergraduate students. The department will consider applicants in all fields of mathematics, but we intend to show preference in applied mathematics, partial differential equations and global analysis, number theory, algebraic geometry, combinatorics, computational mathematics, and probability theory. Salary and teaching load are competitive.

Applicants are expected to have a Ph.D. and a documented record of leadership in research as well as of excellence in teaching. They should send a curriculum vitae, a list of publications, a few selected reprints or preprints, and the names and addresses of three references to the address below. The department will solicit letters for the finalists for the tenured positions.

Philippe Tondeur, Chair
Department of Mathematics
University of Illinois
at Urbana-Champaign
1409 West Green Street
Urbana IL 61801
tel. (217) 333-3352
e-mail: tenure@math.uiuc.edu

We anticipate an ongoing search, but will begin considering applications and conducting interviews on October 5, 1998. We encourage use of the application cover sheet provided by the American Mathematical Society and the indication of the subject area using the AMS subject classification numbers. Applications from women and minority candidates are especially encouraged. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Mathematics
Tenure-Track position

Applications are invited for one or more full-time faculty positions to commence August 21, 1999, at the tenure-track (assistant professor) level. Those faculty will be expected to pursue a vigorous research program and teach graduate as well as undergraduate students. The department will consider applicants in all fields of mathematics, but we intend to show preference in applied mathematics, partial differential equations and global analysis, number theory, algebraic geometry, combinatorics, computational mathematics, and probability theory. Salary and teaching load are competitive.

Applicants should have completed the Ph.D. (or equivalent) by the time the appointment begins and are expected to present evidence of excellence in research and teaching. Applicants should send a letter of application, a curriculum vitae and publication list, and three letters of reference to the address below. It is the responsibility of the tenure-track applicants to make sure that letters of recommendation are sent.

Philippe Tondeur, Chair
Department of Mathematics
University of Illinois
at Urbana-Champaign
1409 West Green Street
Urbana, IL 61801
tel. (217) 333-3352
e-mail: search@math.uiuc.edu

For fullest consideration, all materials, including letters of reference, should be received by December 1, 1998; however, applications will be accepted and interviews conducted until the positions are filled. We encourage use of the application cover sheet provided by the American Mathematical Society. Applications from women and minority candidates are especially encouraged. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN
Department of Mathematics
Faculty Position in Actuarial Science

Applications are invited for a full-time faculty position in actuarial science to commence August 21, 1999 or 2000, rank depending on qualifications. The person selected will be expected to teach graduate and advanced undergraduate students and to pursue professional activity through research and professional committee work. He or she should also have the potential to assume direction of the Actuarial Program after several years. This involves increased responsibilities in advising and placing students, maintaining relations with our alumni and with insurance companies and consulting firms, and raising funds to enhance the operation of the program. Salary and teaching load are competitive.

Applicants for a tenured position are expected to be Fellows of either the Society of Actuaries or the Casualty Actuarial Society, with a documented record of leadership in the actuarial field. A Ph.D. is desirable. Applications for a tenure-track position should be associates of one of the professional societies, should have completed the Ph.D. (or equivalent) by the time the appointment begins, and should present evidence of excellence in teaching. Preference will be given to candidates with outstanding credentials in actuarial science from academia or business and a strong commitment to teaching.

All applicants should send a letter of application with a curriculum vitae and publication list, plus the names and addresses of three references to:

Philippe Tondeur, Chair
Department of Mathematics
University of Illinois
at Urbana-Champaign
1409 West Green Street
Urbana, IL 61801
tel. (217) 333-3352
e-mail: search@math.uiuc.edu

All applications received by December 1, 1998, will receive full consideration. We will review later applications until the search is closed. Applications from women and minority candidates are especially encouraged. The University of Illinois is an Affirmative Action/Equal Opportunity Employer.

MARYLAND

UNIVERSITY OF MARYLAND AT COLLEGE PARK
Department of Mathematics

Applications are invited for tenured and tenure-track positions in the Department of Mathematics. Strong preference will be given to applicants whose primary interest is in one of the following categories: (1) algebra, number theory, and algebraic geometry; (2) applied and computational harmonic analysis; (3) probability and statistics, with an emphasis on applications, including applications to financial mathematics.

Candidates at all levels will be considered. Priority will be given to applications received by November 1, 1998. Appointments will commence in fall 1999.

The University of Maryland is an Equal Opportunity and Affirmative Action Employer that strongly encourages applications from female and minority candidates.

Please send a curriculum vitae and AMS Standard Cover Sheet, and three letters of recommendation to:

The Hiring Committee
Department of Mathematics
University of Maryland
College Park, Maryland 20742

MASSACHUSETTS

BOSTON COLLEGE
Department of Mathematics
Assistant Professor of Mathematics

Applications are invited for a tenure-track assistant professor position in mathematics which will begin on September 1, 1999. Under exceptional circumstances we would consider hiring at a higher level. Necessary requirements include a doctoral degree, demonstrated success or strong potential in research, and a commitment to effective teaching at the undergraduate and graduate levels. At least two years teaching experience beyond the doctoral degree are preferred.

Boston College is a Jesuit university enrolling approximately 8,500 full-time undergraduate students and 4,300 graduate students. The Department of Mathematics has twenty-one full-time faculty. It grants approximately fifty B.A. degrees in mathematics, and approximately ten M.A. degrees and five M.S.T. degrees (in the teaching of mathematics) annually. Current research interests include algebra, analysis, applied mathematics, dynamical systems, geometry, number theory, probability, statistics, and topology.

Applicants should include with their cover letter and résumé a description of their research plans and a statement of teaching philosophy, and should arrange to have at least four letters of reference

sent to the department. At least one of the letters should focus on teaching effectiveness and potential. Send all materials to:

C.K. Cheung, Search Committee
Department of Mathematics
Boston College
Chestnut Hill, MA 02467-3806

E-mail inquiries may be directed to: search.math@bc.edu or may be answered at our Web page http://fmwww.bc.edu/MT/. Electronic applications will NOT be accepted. Review of applications will begin on December 1, 1998, and continue until the position is filled. Boston College is an Affirmative Action/Equal Opportunity Employer.

WILLIAMS COLLEGE
Department of Mathematics
Williamstown, Massachusetts 01267

Anticipated tenure-eligible position in statistics, beginning fall 1999, probably at the rank of assistant professor. In exceptional cases, however, more advanced appointments may be considered. Excellence in teaching and statistics, including scholarship and consulting, and Ph.D. required. Applicants with emphasis in operations research will also be considered.

Please have a vita and three letters of recommendation on teaching and research sent to 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.

NEW JERSEY

Associate Examiner
Assessment Math Group

Educational Testing Service (ETS) is the nation's leading educational assessment organization and a leader in educational research. We develop and administer achievement, occupational, and admission tests, such as the SAT for the College Board, for clients in education, government, and business. We have an excellent opportunity for an Associate Examiner at our corporate offices located in Princeton, New Jersey.

Responsibilities include developing, assembling, and critically reviewing mathematics tests by involvement with the test development process from inception through final printing and post-administration follow-up. Specifically, you will research and write items for the GRE, GMAT, PRAXIS, SAT and AP programs, recommend resolutions for problems with test items, and develop test-related surveys and studies. A Master's degree in mathematics and four years of related work experience is required. Teaching at the college level would be an asset.

ETS offers competitive salaries, an excellent benefits package, and an ideal environment for professional growth. Please send résumé, along with cover letter which MUST state salary requirements, to Bert D. Newton, Educational Testing Service, Rosedale Road, Princeton, NJ 08541; fax to 609-497-6022, or via Internet to bnewton@ets.org. We regret we are unable to respond to each résumé. Only those selected for an interview will be contacted. We are dedicated to Equal Opportunity/Affirmative Action in the workplace.

NEW YORK

NATIONAL RESEARCH COUNCIL
Teaching/Research
Postdoctoral Awards
in Mathematical Sciences or Physics
at the United States Military Academy
and the Army Research Laboratory

Description: The U.S. Military Academy (USMA) at West Point, New York, and the U.S. Army Research Laboratory (ARL) invite applications for postdoctoral teaching and research associateships to be administered by the National Research Council (NRC). Applicants who are considered by USMA as qualified for teaching appointments in mathematics or physics will be invited to choose a research project and develop a proposal based on NRC approved research opportunities at ARL. The program provides three years of a combination of teaching and research during the academic year and research in the summers. Each associate has a teaching mentor and selects an advisor from the Army Research Laboratory to serve as a mentor and host for the postdoctoral research. The teaching requirement in mathematics at USMA involves teaching two sections (thirty-four students) per semester in an undergraduate mathematics course (calculus, differential equations, dynamical systems, probability and statistics, etc.). Eligibility: The award competition is open to U.S. citizens who have earned a Ph.D. within the 5-year period preceding the award starting date, which should not be later than July 1, 1999. Award amount: The award includes a beginning annual stipend of $40,000, reimbursement for initial relocation to West Point, an allowance for professional travel, and subsidized health insurance. Application information: Applicants should send a curriculum vitae, graduate and undergraduate transcripts, a statement of teaching philosophy and career goals and research interests, and three Reference Reports with letters of recommendation by November 1, 1998, to: Department of Mathematical Sciences, ATTN: Personnel Officer, United State Military Academy, West Point, NY 10996-1786. Applicants selected by the Department of Mathematical Sciences will be asked to submit research proposals for review by the National Research Council and the Army Research Laboratory.

Overviews of USMA and ARL are available on the Web: USMA: http://www.usma.edu/ ARL: http://info.arl.mil/

Questions: Mathematics: Call LTC Gary Krahn, Department of Mathematical Sciences, USMA: 914-938-5870, or e-mail: gary-krahn@usma.edu. Physics: Call COL Thomas Lainis, Department of Physics, USMA, 914-938-3014.

NORTH CAROLINA

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
Department of Mathematics

Applications are invited for a faculty appointment in applied mathematics at the senior level, effective January 1, 1999. The successful candidate will assume the duties of the Associate Chair of Applied Mathematics, with leadership responsibility for the group currently consisting of four tenured/tenure-track faculty and two research assistant professors. The other duties consist of coordinating the applied mathematics course offerings in the graduate program, the applied mathematics seminar, supervising a full- time systems programmer and administrative assistant, recruitment, and oversight of the program resources. The term as Associate Chair is three years, after which the successful candidate will assume regular faculty duties in the Department of Mathematics. Rank and salary depend on qualifications and budget considerations. Ph.D. in mathematics or closely related field and exceptionally strong research record and commitment to excellent teaching required. Persons with established expertise in scientific computation and physical applied mathematics will be given highest priority in the search. Evidence of extramural funding, either from federal agencies or industry, is expected. Some experience with administration is desirable, though not necessary. A copy of this ad may be found on our World Wide Web page at http://www.math.unc.edu/General/Job.announcements/. Send curriculum vitae, abstract of current research program, and four letters of recommendation to Applied Search Committee, Senior Position, Math. Dept., CB #3250 Phillips Hall, UNC at Chapel Hill, Chapel Hill, NC 27599-3250. EO/AA Employer. Women and minorities are encouraged to identify themselves voluntarily. Applications will be accepted until the position is filled.

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
Tenure-Track Position in Mathematics

Applications are invited for one tenure-track assistant or associate professor position in applied mathematics, with employment to begin fall 1999. Preference

will be given to an exceptional candidate in applied scientific computation. A strong research record and doctorate in mathematics, applied mathematics or a closely related field are required. Preference is given to candidates with a commitment to interdisciplinary university research, collaborations with industry or government, and teaching including development of applied math curricula at undergraduate and graduate levels. This position contributes toward an aggressive plan to build a strong applied and computational mathematics group interacting with existing strengths at UNC in mathematics and its applications in materials, marine, biomedical, life, environmental, and the computational sciences. A copy of this ad may be found on our World Wide Web page at `http://www.math.unc.edu/General/Job.announcements/`, and further information about the Applied Mathematics Program may be found at the website `http://www.math.unc.edu/Applied/`. Send curriculum vitae, abstract of current research, and four letters of recommendation to Applied Search Committee, Tenure Track Position, Dept. of Mathematics, CB #3250, Phillips Hall, UNC-Chapel Hill, Chapel Hill, NC 27599-3250. EO/AA Employer. Women and minorities are encouraged to apply and to identify themselves. Applicants are encouraged to submit a concise statement of current research plans and teaching interests. Completed applications received by December 1, 1998, are assured of full consideration.

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL
Research Assistant Professor Position(s)

Applications are invited for one, possibly two, term 3-year research assistant professor positions in applied mathematics. The successful candidate(s) will begin duties effective fall 1999. A strong thesis and research promise, and a doctorate in mathematics, applied mathematics, or closely related field are strongly preferred. Preference is given to candidates whose area of specialization is complementary to that of the existing faculty in applied mathematics, or in areas of applied science which have direct ties to applied and computational mathematics, e.g., materials science, environmental sciences, biomedical sciences, atmospheric or geophysical science. Computational science and/or physical modeling are two areas of high priority. These positions are term appointments, with a maximum teaching load of three courses per year. A copy of this ad may be found on our website at `http://www.math.unc.edu/General/Job.announcements/`. Further information about the Applied Mathematics Groups may be found at the math website `http://www.math.unc.edu/`. Send curriculum vitae, abstract of current research, and four letters of recommendation to, Applied Search Committee, Research Assistant Professor Position, Dept. of Mathematics, CB #3250 Phillips Hall, UNC-Chapel Hill, Chapel Hill, NC 27599-3250. EO/AA Employer. Women and minorities are encouraged to apply and to identify themselves. Completed applications received by December 1 are assured of full consideration.

OHIO

OBERLIN COLLEGE
Department of Mathematics

Full-time, tenure-track position beginning the 1999–2000 academic year. Responsibilities include teaching undergraduate courses in statistics and mathematics (5/year), supervising honors students, and sustained scholarly production. Ph.D. degree in statistics or mathematics (in hand or expected by August 31, 1999) required. All research specialties in statistics and related fields considered. Candidates must demonstrate potential excellence in teaching. Send letter of application, *curriculum vitae*, academic transcripts (graduate and undergraduate), and three letters of reference to Jeffrey Witmer, Department of Mathematics, Oberlin College, Oberlin, OH 44074 by November 15, 1998. Oberlin College has admitted women since its founding in 1833 and has been historically a leader in the education of blacks. AA/EOE.

OKLAHOMA

SAXON PUBLISHERS, INC.
Secondary Mathematics Assistant Editor

One year assignment (with possible opportunity of renewal in one year increments). Saxon Publishers, Inc., a K–12 textbook publisher, is seeking an assistant secondary math editor to assist a senior editor in revising a 2nd year algebra text. Candidate must be willing to relocate and work onsite. Qualifications: excellent writing and editing skills, solid mathematics background as evidenced by graduate studies and advanced degree. Preferred: familiarity with the Saxon pedagogy, classroom experience with secondary students teaching high school level math, editing experience in the publishing industry. Salary commensurate with experience. Please send résumé, transcript and salary requirements to Saxon Publishers, Inc., Attn: Human Resources, 1320 W. Lindsey, Norman, OK 73069.

PENNSYLVANIA

CARNEGIE MELLON UNIVERSITY
Department of Mathematical Sciences
Lecturer Track Positions

The Department of Mathematical Sciences at Carnegie Mellon University expects to make several lecturer track appointments for 1999-00. These are three-year appointments, with possible renewal, but are not eligible for indefinite tenure. Qualifications: doctorate, established success in education, familiarity with computer use in mathematics education. One of these positions will, in addition to having responsibility for undergraduate teaching, be to support the CMAP Program at Carnegie Mellon. Detailed descriptions of all of these positions may be found on our Website: `http://www.math.cmu.edu/`. The deadline for applications is February 1, 1999. To apply send a letter of application and vitae to Lecturer Track Appointments Committee, Department of Mathematical Sciences, Carnegie Mellon University, Pittsburgh, PA 15213. Letters of reference may be requested. Carnegie Mellon University is an Affirmative Action/Equal Opportunity Employer.

RHODE ISLAND

BROWN UNIVERSITY

One professorship at the associate professor level with tenure, to begin July 1, 1999. Preference to be given to applicants with research interests consonant with those of the present members of the department. We are especially looking for candidates in the general area of analysis, but exceptional candidates in all fields will be seriously considered. Candidates should have a distinguished research record and a strong commitment to undergraduate and graduate teaching. Qualified individuals are invited to send a vita and at least five letters of recommendation to Senior Search Committee, Department of Mathematics, Box 1917, Brown University, Providence, Rhode Island 02912. Applications must be received by November 9, 1998, in order to receive consideration. E-mail inquiries can be addressed to `srsearch@math.brown.edu`. Brown University is an Equal Opportunity/Affirmative Action Employer and encourages applications from women and minorities.

BROWN UNIVERSITY
J. D. Tamarkin Assistant Professorship

One or more three-year nontenured nonrenewable appointments, beginning July 1, 1999. Teaching load: two courses per semester (6 hours per week). Candidates are required to have received a Ph.D. degree by the start of this appointment, and they may have up to two years of academic

and/or postdoctoral research experience by then. Applicants should have strong research potential and a commitment to teaching. Field of research should be consonant with the current research interests of the department. For full consideration, a curriculum vitæ, a completed application form, and three letters of recommendation must be received by December 1, 1998. Requests for application forms and all other inquiries should be addressed to Tamarkin Search Committee, Department of Mathematics, Brown University, Providence, RI 02912. Application forms are also available from our Website: `http://www.math.brown.edu/tamarkin.shtml`, and standard AMS application forms are accepted. E-mail inquiries can be addressed to `tamsearch@math.brown.edu`. Please do not request application forms by e-mail. Brown University is an Equal Opportunity/Affirmative Action Employer and encourages applications from women and minorities.

TEXAS

TEXAS A&M UNIVERSITY
Department of Mathematics

Applications are invited for tenured and tenure-eligible as well as visiting faculty positions beginning fall 1999. The field is open, but we particularly seek applications from individuals whose mathematical interests would augment and build upon existing strengths both within the Mathematics Department as well as other departments in the University.

For a tenured position the applicant should have an outstanding research reputation and would be expected to fill a leadership role in the department. An established research program, including success in attracting external funding and supervision of graduate students, and a demonstrated ability and interest in teaching are required. Informal inquiries are welcome.

For an assistant professorship, we seek strong research potential and evidence of excellence in teaching. Research productivity beyond the doctoral dissertation will normally be expected.

The department expects to have several visiting appointments available: senior positions may be for a semester or one year period while junior positions will be for a two year period. The latter are intended for those who have recently received their Ph.D. and the expectation is for collaborative efforts with our existing faculty. The application letter should identify those permanent department members or groups with which they have close research interests.

In order to expedite the application process we request that the AMS Application Cover Sheet be used. Applicants should send the completed form, a vita, and arrange to have letters of recommendation sent to:

Faculty Hiring
Department of Mathematics
Texas A&M University
College Station, Texas 77843-3368

For full consideration, the complete dossier should be received by January 15, 1999. Further information can be obtained from our Website: `http://www.math.tamu.edu/hiring/`.

Texas A&M University is an EOE/AA Employer and the department encourages applications from women and minorities.

TRINITY UNIVERSITY

The Department of Mathematics invites applications for two tenure-track positions at the assistant professor level starting in August 1999. Excellence in teaching is essential, and strong potential in research is expected. Exceptional candidates in any area of mathematics will be considered. However, the department is particularly interested in filling one position in analyis and one in discrete mathematics. Applicants should provide a curriculum vitae, three letters of reference, transcripts, and a professional statement describing their philosophy about both teaching and research. Applications received by December 4, 1998, will be given full consideration. Send all materials to: Chair of the Search Committee, Department of Mathematics, Trinity University, San Antonio, Texas 78212; Phone: 210-736-8205, e-mail: `math@trinity.edu`.

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.

Applicants should have a doctorate in mathematics or statistics, should qualify for a full professorship at USU, and should enjoy an outstanding and current record of research, excellent teaching credentials at the undergraduate and graduate levels, and an established record of university and professional service. Applicants must possess demonstrated administrative skills and leadership abilities necessary to promote the development of a growing department with diverse research, teaching, and service responsibilities and goals. A strong commitment to support scholarly activity in pure and applied mathematics, statistics, and mathematics education, and to undergraduate and graduate education is required.

Utah State University is a Carnegie I, Land-Grant institution with an enrollment of 16,000 undergraduate and 4,000 graduate students. The Department of Mathematics and Statistics offers the Ph.D. degree in mathematical sciences and various degree programs at the masters and bachelor levels. The department has approximately thirty-five faculty members with research interests in pure mathematics, applied mathematics, mathematical physics, computational mathematics, mathematics education, and statistics.

Utah State University is located in Cache Valley, just north of the Wasatch Range of the Rocky Mountains. More information about the university and department can be found at `http://www.usu.edu/`.

The committee will begin screening applications on December 15, 1998, and continue until the position is filled. Send a letter of application, vita, telephone number and e-mail address, and a list of names, mailing addresses, and e-mail addresses of five references to:

Chairman, Screening Committee
Mathematics and Statistics Head
Utah State University
Logan, Utah 84322-3900

Two references should be able to evaluate administrative and leadership skills and one reference should address teaching credentials. For further information, please direct inquires to `headsrch@math.usu.edu`.

Utah State University is an Equal Opportunity/Affirmative Action Employer.

WISCONSIN

UNIVERSITY OF WISCONSIN - MADISON

The Department of Mathematics invites applications for one or more positions to begin August 23, 1999, at either the assistant professor (tenure-track) or associate professor (tenured) level. Applications are invited in all areas of mathematics. Among the department's priorities are partial differential equations, and real and harmonic analysis. Candidates should exhibit evidence of outstanding research potential, normally including significant contributions beyond the doctoral dissertation. A strong commitment to excellence in instruction is also expected. Additional departmental information is available on our WWW site, `http://www.math.wisc.edu/`.

Applicants should send a completed AMS Standard Cover Sheet, a curriculum vitae that includes a publication list, and brief descriptions of research and teaching to:

Hiring Committee
Dept. of Mathematics, Van Vleck Hall
University of Wisconsin-Madison
480 Lincoln Drive
Madison, WI 53706-1388

Applicants should also arrange to have sent to the above address three or four letters of recommendation, at least one of which addresses the applicant's teaching

experiences and capabilities. Completed applications received by November 15, 1998, will be assured full consideration. Additional letters will be solicited by the department for candidates who are finalists for a tenured position.

The University of Wisconsin is an Affirmative Action/Equal Opportunity Employer and encourages applications from women and minorities. Unless confidentiality is requested in writing, information regarding the applicants must be released upon request. Finalists cannot be guaranteed confidentiality.

UNIVERSITY OF WISCONSIN - MADISON

The Department of Mathematics invites applications for possible Van Vleck Visiting Assistant Professorships to begin August 23, 1999. Appointments are for a fixed term of two or three years. The usual teaching load is two courses per semester. Ordinarily only those applicants who have received their doctorate since 1996 will be considered. Promise of excellence in research and teaching is important. Preference will be given to candidates who are likely to interact well with other members of the department.

Applicants should send a completed AMS Standard Cover Sheet, a curriculum vita which includes a publication list, and a brief statement of research plans to:

Hiring Committee
Dept. of Mathematics, Van Vleck Hall
University of Wisconsin-Madison
480 Lincoln Drive
Madison, WI 53706-1388.

Applicants should also arrange to have sent to the above address, three to four letters of recommendation, at least one of which must discuss the applicant's teaching experiences and capabilities. Other evidence of good teaching will be helpful. The deadline for completed applications is January 31, 1999.

The University of Wisconsin is an Affirmative Action, Equal Opportunity Employer and encourages applications from women and minorities. Unless confidentiality is requested in writing, information regarding the applicants must be released upon request. Finalists cannot be guaranteed confidentiality.

PUBLICATIONS FOR SALE

H. Pogorzelski et. al., **Transtheoretic Foundations of Mathematics**: Vol IA **Foundations** (175 pp.); Vol IB **Arithmetics** (217 pp.); Vol IC **Goldbach Conjecture** (301 pp.). Softcover, typewriter print. Each volume $29.99. May be ordered **post-free** directly from: Research Institute for Mathematics, 383 College Ave., Orono, Maine 04473.

PUBLICATIONS WANTED

MATHEMATICS BOOKS PURCHASED

Pure & appl. adv. & research level, any age, usable cond. Reprints OK. One box to whole libraries sought. Contact: Collier Brown or Kirsten Berg @ **Powell's Technical Bks.**, Portland, OR. Call 800-225-6911, fax 503-228-0505, or e-mail: `kirsten@technical.powells.com`.

AMERICAN MATHEMATICAL SOCIETY

Please read the "Membership Categories" section of this form to determine the membership category for which you are eligible. Then fill out this application and return it as soon as possible.

. . . . . .
Family Name ***First*** ***Middle***

Place of Birth . . . . . .
City ***State*** ***Country***

Date of Birth . . . . . .
Day ***Month*** ***Year***

If formerly a member of AMS, please indicate dates . . . . . .

Check here if you are now a member of either MAA ☐ or SIAM ☐

Degrees, with institutions and dates . . . . . .

. . . . . .

. . . . . .

Present position . . . . . .

Firm or institution . . . . . .

. . . . . .
City ***State*** ***Zip/Country***

Primary Fields of Interest (choose five from the list at right)

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Secondary Fields of Interest (choose from the list at right)

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Address for all mail

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Telephone number(s) . . . . . .

Electronic address . . . . . .

. . . . . .
Signature

Prepayment Methods and Mailing Addresses

All prices quoted in U.S. dollars.
Payment by check must be drawn on U.S. bank if paid in U.S. dollars.

Send checks, money orders, UNESCO coupons to American Mathematical Society, P.O. Box 5904, Boston, MA 02206-5904

To use credit cards, fill in information requested and mail to American Mathematical Society, P.O. Box 6248, Providence, RI 02940-6248 or call (401) 455-4000 or 1-800-321-4AMS.

For Foreign Bank Transfers: American Mathematical Society, State Street Bank and Trust Company, 225 Franklin St., ABA #011000028, Account #0128-262-3, Boston, MA 02110.

American Express ☐ *Discover* ☐ *VISA* ☐ *MasterCard* ☐

. . . . . .
Account number ***Expiration date***

M8NO

Application for Membership 1998

(January–December)

Date . . . . . 19 . . . . . .

Fields of Interest

If you wish to be on the mailing lists to receive information about publications in fields of mathematics in which you have an interest, please consult the list of major headings below. These categories will be added to your computer record so that you will be informed of new publications or special sales in the fields you have indicated.

EME	Education/Mathematics Education
00	General
01	History and biography
03	Mathematical logic and foundations
04	Set theory
05	Combinatorics
06	Order, lattices, ordered algebraic structures
08	General algebraic systems
11	Number theory
12	Field theory and polynomials
13	Commutative rings and algebras
14	Algebraic geometry
15	Linear and multilinear algebra; matrix theory
16	Associative rings and algebras
17	Nonassociative rings and algebras
18	Category theory, homological algebra
19	*K*-theory
20	Group theory and generalizations
22	Topological groups, Lie groups
26	Real functions
28	Measure and integration
30	Functions of a complex variable
31	Potential theory
32	Several complex variables and analytic spaces
33	Special functions
34	Ordinary differential equations
35	Partial differential equations
39	Finite differences and functional equations
40	Sequences, series, summability
41	Approximations and expansions
42	Fourier analysis
43	Abstract harmonic analysis
44	Integral transforms, operational calculus
45	Integral equations
46	Functional analysis
47	Operator theory
49	Calculus of variations and optimal control; optimization
51	Geometry
52	Convex and discrete geometry
53	Differential geometry
54	General topology
55	Algebraic topology
57	Manifolds and cell complexes
58	Global analysis, analysis on manifolds
60	Probability theory and stochastic processes
62	Statistics
65	Numerical analysis
68	Computer science
70	Mechanics of particles and systems
73	Mechanics of solids
76	Fluid mechanics
78	Optics, electromagnetic theory
80	Classical thermodynamics, heat transfer
81	Quantum theory
82	Statistical mechanics, structure of matter
83	Relativity and gravitational theory
85	Astronomy and astrophysics
86	Geophysics
90	Economics, operations research, programming, games
92	Biology and other natural sciences, behavioral sciences
93	Systems theory; control
94	Information and communication, circuits

Membership Categories

Please read the following to determine what membership category you are eligible for, and then indicate below the category for which you are applying.

*For **ordinary members** whose annual professional income is below $45,000, the dues are $96; for those whose annual professional income is $45,000 or more, the dues are $128.*

*The **CMS cooperative rate** applies to ordinary members of the AMS who are also members of the Canadian Mathematical Society and reside outside of the U.S. For members whose annual professional income is $45,000 or less, the dues are $82; for those whose annual professional income is above $45,000, the dues are $109.*

*For a **joint family membership,** one member pays ordinary dues, based on his or her income; the other pays ordinary dues based on his or her income, less $20. (Only the member paying full dues will receive the* Notices *and the* Bulletin *as a privilege of membership, but both members will be accorded all other privileges of membership.)*

*Minimum dues for **contributing members** are $192. The amount paid which exceeds the higher ordinary dues level and is purely voluntary may be treated as a charitable contribution.*

*For either **students** or **unemployed individuals,** dues are $32, and annual verification is required.*

*The annual dues for **reciprocity members** who reside outside the U.S. and Canada are $64. To be eligible for this classification, members must belong to one of those foreign societies with which the AMS has established a reciprocity agreement, and annual verification is required. Reciprocity members who reside in the U.S. or Canada must pay ordinary member dues ($96 or $128).*

*The annual dues for **category-S members,** those who reside in developing countries, are $16. Members can chose only one privilege journal. Please indicate your choice below.*

*Members can purchase a **multi-year membership** by prepaying their current dues rate for either two, three, four or five years. This option is not available to category-S, unemployed, or student members.*

1998 Dues Schedule (January through December)

Ordinary member . . . . . ☐ $96 ☐ $128

CMS cooperative rate . . . . . ☐ $82 ☐ $109

Joint family member (full rate) . . . . . ☐ $96 ☐ $128

Joint family member (reduced rate) . . . . . ☐ $76 ☐ $108

Contributing member (minimum $192) . . . . . ☐

Student member (please verify)[1] . . . . . ☐ $32

Unemployed member (please verify)[2] . . . . . ☐ $32

Reciprocity member (please verify)[3] . . . . . ☐ $64 ☐ $96 ☐ $128

Category-S member[4] . . . . . ☐ $16

Multi-year membership . . . . . $ . . . . . for . . . . . years

[1] ***Student Verification*** (sign below)

I am a full-time student at . . . . . .

. . . . . *currently working toward a degree.*

[2] ***Unemployed Verification*** (sign below) *I am currently unemployed and actively seeking employment.*

[3] ***Reciprocity Membership Verification*** (sign below) *I am currently a member of the society indicated on the right and am therefore eligible for reciprocity membership.*

. . . . . .

Signature

[4] ☐ ***send* NOTICES** ☐ ***send* BULLETIN**

Reciprocating Societies

- ☐ Allahabad Mathematical Society
- ☐ Australian Mathematical Society
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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.

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08 General mathematical systems
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12 Field theory and polynomials
13 Commutative rings and algebras
14 Algebraic geometry
15 Linear and multilinear algebra, matrix theory
16 Associative rings and algebras
17 Nonassociative rings and algebras
18 Category theory, homological algebra
19 K-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
39 Finite differences and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
49 Calculus of variations, optimal control
51 Geometry
52 Convex and discrete geometry
53 Differential geometry
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55 Algebraic topology
57 Manifolds and cell complexes
58 Global analysis, analysis on manifolds
60 Probability theory and stochastic processes
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73 Mechanics of solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
83 Relativity and gravitational theory
85 Astronomy and astrophysics
86 Geophysics
90 Economics, operations research, programming, games
92 Biology and other natural sciences, behavioral sciences
93 Systems theory, control
94 Information and communication, circuits

Meetings & Conferences of the AMS

The most comprehensive and up-to-date information on AMS meetings and conferences is available on e-MATH at `http://www.ams.org/meetings/`.

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: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Invited Addresses

Vitaly Bergelson, Ohio State University, *Number theory, combinatorics and ergodic theorems along polynomials.*

Sheldon Katz, Oklahoma State University, *The mathematics and physics of mirror symmetry.*

Ralf J. Spatzier, University of Michigan, *Rigidity phenomena in geometry and dynamics.*

Vladimir Voevodsky, Northwestern University, *Motivic homotopy type?*

Special Sessions

Algebraic Coding, **William C. Huffman**, Loyola University of Chicago, and **Vera S. Pless**, University of Illinois at Chicago.

Algebraic Combinatorics: Association Schemes and Related Topics, **Sung Yell Song**, Iowa State University.

Algebraic Geometry and Mirror Symmetry, **Ezra Getzler** and **Mikhail Kapranov**, Northwestern University, and **Sheldon Katz**, Oklahoma State University.

Commutative Algebra, **Irena V. Peeva**, Massachusetts Institute of Technology, and **Michael Stillman**, Cornell University.

Complex Dynamics, **Shmuel Friedland**, University of Illinois at Chicago.

Complexity of Geometric Structures on Manifolds, **Melvin G. Rothenberg** and **Shmuel A. Weinberger**, University of Chicago.

Ergodic Theory and Topological Dynamics, **Roger L. Jones**, DePaul University, and **Randall McCutcheon**, Wesleyan College.

Fourier Analysis, **Marshall Ash**, DePaul University, and **Mark A. Pinsky**, Northwestern University.

K-Theory and Motivic Cohomology, **Kevin Knudson**, Northwestern University, and **Mark Walker**, University of Nebraska-Lincoln.

Nonlinear Partial Differential Equations, **Gui-Qiang Chen** and **Konstantina Trivisa**, Northwestern University.

Number Theory, **Jeremy T. Teitelbaum** and **Yuri Tschinkel**, University of Illinois at Chicago.

Orthogonal Polynomial Series, Summability and Conjugates, **Calixto P. Calderon**, University of Illinois at Chicago, and **Luis A. Caffarelli**, University of Texas at Austin.

Rigidity in Geometry and Dynamics, **Steven E. Hurder**, University of Illinois at Chicago, and **Ralf J. Spatzier**, University of Michigan.

Stochastic Analysis, **Richard B. Sowers**, University of Illinois-Urbana, and **Elton P. Hsu**, Northwestern University.

Topics in Mathematics and Curriculum Reform, **Richard J. Maher**, Loyola University 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: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Program

The complete program for this meeting is available at `http://www.ams.org/meetings`. Follow the links to the Sectional Meetings to get the most up-to-date information on all speakers, the titles of the talks, and abstracts on line. The December issue will carry the full program of record for this meeting.

Registration and Meeting Information

Registration will take place in the main lobby of Benson University Center from 7:30 a.m. to 4:00 p.m. on Friday and 8 a.m. to noon on Saturday. Sessions will take place in Calloway Hall, Carswell Hall, and Benson University Center.

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.

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

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Invited Addresses

Jeffrey Adams, University of Maryland, College Park, *Title to be announced.*

Nigel D. Higson, Pennsylvania State University, *The Baum-Connes Conjecture.*

Tasso J. Kaper, Boston University, *Title to be announced.*

Kate Okikiolu, University of California, San Diego, and MIT, *Title to be announced.*

Special Sessions

Automorphic Forms and Arithmetic Geometry, **Kevin L. James** and **Wen-Ching Winnie Li**, Pennsylvania State University.

C-Algebraic Methods in Geometry and Topology*, **Nigel D. Higson**, Pennsylvania State University, and **Erik Guentner** and **John D. Trout Jr.**, Dartmouth College.

Least Squares and Total Least Squares, **Jesse L. Barlow**, Pennsylvania State University.

Mathematical Modeling of Inhomogeneous Materials: Homogenizaton and Related Topics, **Leonid Berlyand**, Pennsylvania State University, and **Karl Voss**, Yale University.

Metric Topology, **Steve Armentrout**, **Joseph Borzelino**, **Hossein Movahedi-Lankarani**, and **Robert Wells**, Pennsylvania State University.

Modeling of Phase Transitions of Partially Ordered Physical Systems, **Maria-Carme T. Calderer**, Pennsylvania State University.

Operator Algebras and Noncommutative Geometry, **Victor Nistor**, **Paul F. Baum**, and **Adrian Ocneanu**, Pennsylvania State University.

Partitions and q-Series, **George E. Andrews**, **Ken Ono**, and **Scott D. Ahlgren**, Pennsylvania State University.

Set Theory, **Thomas Jech**, Pennsylvania State University.

Symplectic Geometry and Quantization, **Jean-Luc Brylinski**, **Ranee Brylinski**, **Boris Tsygan**, and **Ping Xu**, Pennsylvania State University.

Tucson, Arizona

University of Arizona-Tucson

November 14–15, 1998

Meeting #938

Western Section
Associate secretary: Robert M. Fossum
Announcement issue of *Notices*: September 1998
Program issue of *Notices*: To be announced
Issue of *Abstracts*: Volume 19, Issue 4

Deadlines

For organizers: Expired

For consideration of contributed papers in Special Sessions: Expired
For abstracts: September 23, 1998

Invited Addresses

Alexandru Buium, University of New Mexico, *Differential algebraic geometry and derivatives of integers.*

Hans Koch, University of Texas at Austin, *Title to be announced.*

Mark Lewis, University of Utah, *Title to be announced.*

Jiang-Hua Lu, University of Arizona, *Title to be announced.*

Special Sessions

Arithmetic Algebraic Geometry (Code: AMS SS H1), **Douglas Ulmer**, University of Arizona.

Classical and Quantum Mechanical Lattice Spin Systems (Code: AMS SS E1), **Tom Kennedy**, University of Arizona.

Conditionally Positive Definite Functions and Interpolation Schemes (Code: AMS SS G1), **Donald Myers**, University of Arizona.

Dynamical Systems (Code: AMS SS F1), **Marek Rychlik** and **Maciej P. Wojtkowski**, University of Arizona.

Filaments, Interfaces and Patterns (Code: AMS SS I1), **Nicholas Ercolani** and **Jerry Moloney**, University of Arizona.

Geometry and Lie Groups (Code: AMS SS B1), **Samuel R. Evens** and **Jiang-Hua Lu**, University of Arizona.

Groups and Computation (Code: AMS SS A1), **Robert Beals**, University of Arizona.

Integrable Systems and Random Matrix Theory (Code: AMS SS K1), **K. T-R McLaughlin**, University of Arizona, and **Craig A. Tracy**, University of California, Davis.

Mathematics and Biology (Code: AMS SS D1), **Jim Cushing** and **Shandelle M. Henson**, University of Arizona.

Spectral Geometry and Its Applications (Code: AMS SS C1), **Xianzhe Dai**, University of Southern California, and **Leonid Friedlander**, University of Arizona.

Striking the Balance: Theory, Technique, and Applications in Lower Division Mathematics Courses (Code: AMS SS J1), **Joseph Watkins**, University of Arizona.

San Antonio, Texas

Henry B. Gonzales Convention Center

January 13–16, 1999

Meeting #939

Joint Mathematics Meetings, including the 105th Annual Meeting of the AMS, 82nd 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: Susan J. Friedlander

Announcement issue of *Notices*: October 1998
Program issue of *Notices*: January 1999
Issue of *Abstracts*: Volume 20, Issue 1

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: October 1, 1998
For summaries of papers to MAA organizers: Expired

AMS-MAA Invited Addresses

Jennifer Tour Chayes, Microsoft, *Title to be announced*, Wednesday, 11:10 a.m.

Joan Feigenbaum, AT&T Labs, *Massive graphs: Algorithms, applications, and open problems*, Friday, 11:10 a.m.

Joint Special Sessions

Geometry in Dynamics (Code: AMS SS F1), **Krystyna Kuperberg**, Auburn University; Friday and Saturday, mornings and afternoons. (AMS-AWM)

Mathematics and Education Reform (Code: AMS SS M1), **William H. Barker**, Bowdoin College, **Jerry L. Bona**, University of Texas at Austin, **Naomi Fisher**, University of Illinois at Chicago, and **Kenneth C. Millett**, University of California, Santa Barbara; Wednesday and Thursday, mornings and afternoons. (AMS-MAA-MER)

Model Theory and Its Applications (Code: AMS SS S1), **Anand Pillay**, MSRI and University of Illinois, Urbana; Wednesday and Thursday, mornings and afternoons. (AMS-ASL)

Research in Mathematics by Undergraduates (Code: AMS SS E1), **John E. Meier**, Lafayette College, and **Leonard A. VanWyk**, James Madison University; Friday and Saturday mornings. (AMS-MAA)

The History of Mathematics (Code: AMS SS L1), **Karen H. Parshall**, University of Virginia, and **Victor J. Katz**, University of the District of Columbia; Friday and Saturday, mornings and afternoons. (AMS-MAA)

Joint Sessions

Prize Session and Reception: In order to showcase the achievements of the recipients of various prizes, the AMS and MAA are cosponsoring this event at 4:25 p.m. on Thursday. A cash bar reception will immediately follow. All participants are invited to attend. The Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student (cosponsored by the AMS, MAA, and the Society for Industrial and Applied Mathematics) will be presented. The AMS will announce the winners of the Leroy P. Steele Prizes, the Bôcher Memorial Prize, and the Ruth Lyttle Satter Prize in Mathematics. The AWM will present the Louise Hay Award for Contributions to Mathematics Education and the Alice T. Schafer Prize for Excellence in Mathematics by an Undergraduate Woman. The MAA prizes include the Deborah and Franklin Tepper Haimo Award for Distinguished College or University Teaching of Mathematics, the Chauvenet Prize, the Yueh-Gin Gung and Dr. Charles Y. Hu Award for Distinguished Ser-

vice to Mathematics, and Certificates of Meritorious Service. The Joint Policy Board for Mathematics Communication Award will also be presented.

The Draft of the Updated NCTM Standards for School Mathematics: An Opportunity for Your Feedback, Friday, 9:35 a.m.–10:55 a.m. The National Council of Teachers of Mathematics (NCTM) released the draft of the *Principles and Standards for School Mathematics* in October. Members of the writing team will share their views and pose questions for the audience. Special attention will be given to the input and feedback received from the Association Review Groups. The panel will be moderated by **Joan Ferrini-Mundy**, National Research Council. Panelists include **Kathleen Heid**, Pennsylvania State University; **Judith Roitman**, University of Kansas; and **Alan Schoenfeld**, University of California, Berkeley. Cosponsored by the MAA, the AMS Committee on Education, and NCTM.

Other AMS-MAA Events

Mathchats and Graduate Student Reception: On Tuesday evening well-known mathematicians representing a wide range of disciplines will join interested graduate students for informal chats on a riverboat cruise, followed by a reception at the Rio Rio Cantina. Complimentary food and beverages will be served. NOTE: This event is only for students who sign up on the Advance Registration/Housing (ARH) Form. There is no charge.

Reception for First-Time Participants: The AMS and the MAA Committee on Membership are cosponsoring a social hour on Wednesday from 6:00 p.m. to 7:00 p.m. All participants (especially first-timers) are encouraged to come and meet some old-timers and pick up a few tips on how to survive the environment of a large meeting. Refreshments will be served.

105th Annual Meeting of the AMS

AMS Invited Addresses

Helmut Hofer, Courant Institute, New York University, *Symplectic geometry from a dynamical systems point of view*, Wednesday, Thursday, and Friday, 1:00 p.m. (AMS Colloquium Lectures)

Nancy J. Kopell, Boston University, *We got rhythm: Dynamical systems of the nervous system*, Wednesday, 8:30 p.m. (AMS Josiah Willard Gibbs Lecture)

Andrea L. Bertozzi, Duke University, *Undercompressive shocks in thin film flow*, Saturday, 2:15 p.m.

Rita Colwell, National Science Foundation, *Title to be announced*, Friday, 4:20 p.m. (Committee on Science Policy Government Speaker)

Sorin Popa, University of California, Los Angeles, *Title to be announced*, Friday, 9:00 a.m.

Chuu-Lian Terng, Northeastern University, *Geometry of soliton equations*, Wednesday, 10:05 a.m.

Alan D. Weinstein, University of California, Berkeley, *Midpoints*, Thursday, 3:20 p.m.

AMS Special Sessions

Banach Spaces of Holomorphic Functions and Operators on These Spaces (Code: AMS SS D1), **Benjamin A. Lotto**, Vassar College, and **Pamela B. Gorkin**, Bucknell University; Wednesday and Thursday, mornings and afternoons.

Bergman Spaces and Related Topics (Code: AMS SS B1), **Peter L. Duren**, University of Michigan, Ann Arbor, and **Michael Stessin**, SUNY at Albany; Friday and Saturday, mornings and afternoons.

Combinatorial Topology (Code: AMS SS K1), **Laura M. Anderson** and **Jonathan P. McCammond**, Texas A&M University; Wednesday and Thursday, mornings and afternoons.

Commutative Algebra (Code: AMS SS G1), **Scott Thomas Chapman**, Trinity University; Wednesday and Thursday, mornings and afternoons.

Commutative Algebra and Algebraic Geometry (Code: AMS SS J1), **Roger A. Wiegand**, University of Nebraska and Purdue University, and **Susan Elaine Morey**, Southwest Texas State University; Friday and Saturday, mornings and afternoons.

Computational Algebraic Geometry for Curves and Surfaces (Code: AMS SS R1), **Mika K. Seppala**, Florida State University, and **Emil J. Volcheck**, National Security Agency; Friday and Saturday, mornings and afternoons.

Development of Electronic Communications in Mathematics (Code: AMS SS N1), **Alfonso Castro**, University of North Texas, and **Rafael De La Llave**, University of Texas at Austin; Wednesday and Thursday, mornings and afternoons.

Discrete Models and Difference Equations (Code: AMS SS T1), **Saber Elaydi**, Trinity University, and **Gerry Ladas**, University of Rhode Island; Wednesday and Thursday, mornings and afternoons.

Dynamical, Spectral, and Arithmetic Zeta-Functions (Code: AMS SS H1), **Michel L. Lapidus**, University of California, Riverside, and **Machiel van Frankenhuysen**, Institut des Hautes Études Scientifiques; Friday and Saturday, mornings and afternoons.

Hamiltonian Mechanics: Applications to Celestial Mechanics and Chemistry (Code: AMS SS Y1), **Michael K. Rudnev**, The University of Texas at Austin, and **Stephen R. Wiggins**, California Institute of Technology; Wednesday and Thursday, mornings and afternoons.

Mathematics Education and Mistaken Philosophies of Mathematics (Code: AMS SS U1), **Saunders Mac Lane**, University of Chicago, and **Richard A. Askey**, University of Wisconsin-Madison; Wednesday and Thursday, mornings and afternoons.

Operator Algebras and Applications (Code: AMS SS P1), **Allan P. Donsig**, University of Nebraska–Lincoln, and **Nik Weaver**, Washington University; Friday and Saturday, mornings and afternoons.

Probabilistic Combinatorics (Code: AMS SS C1), **Béla Bollobás**, University of Memphis, and **Jeong Han Kim**, Microsoft; Friday morning and afternoon.

Recent Developments in Differential Geometry (Code: AMS SS V1), **Huai-Dong Cao** and **Jian Zhou**, Texas A&M University; Wednesday and Thursday, mornings and afternoons.

Several Complex Variables (Code: AMS SS A1), **Emil J. Straube** and **Harold P. Boas**, Texas A&M University; Friday and Saturday, mornings and afternoons.

Singularities in Algebraic and Analytic Geometry (Code: AMS SS X1), **Caroline G. Grant**, U.S. Naval Academy, and **Ruth I. Michler**, University of North Texas; Wednesday and Thursday, mornings and afternoons.

The Functional and Harmonic Analysis of Wavelets (Code: AMS SS Q1), **Lawrence W. Baggett**, University of Colorado, and **David R. Larson**, Texas A&M University; Wednesday and Thursday, mornings and afternoons.

The Mathematics of the Navier-Stokes Equations (Code: AMS SS W1), **Peter A. Perry** and **Zhong-Wei Shen**, University of Kentucky; Friday and Saturday, mornings and afternoons.

There will be **sessions for contributed papers** of ten minutes' duration. Contributed papers will be grouped by related *Mathematical Reviews* subject classifications into sessions insofar as possible. The title, author(s), and affiliation(s) of each paper accepted and the date and time of presentation will be listed in the program. Abstracts must be submitted, preferably electronically. Send a blank message to `abs-submit@ams.org` and type `help` as the message to see your electronic options. See the beginning of this article for pertinent deadlines.

Any presenter who finds it impossible to give the talk after the abstract has been submitted should notify the meeting coordinator at `abs-coord@ams.org` or 401-455-4146.

Other AMS Sessions

Committee on the Profession Presentation, Wednesday, 4:30 p.m.–6:00 p.m.

e-MATH on the World Wide Web, Friday, 8:30 a.m.–9:30 a.m., organized by **Ralph E. Youngen** and **Wendy A. Bucci**, AMS. Discover what's new on e-MATH, the AMS's Web resource for information on the mathematical sciences. Find out about the new services available exclusively to AMS members, new features of MathSciNet and the AMS electronic journals, employment opportunities, the AMS Bookstore, and more.

Math E-Journals and Beyond, Friday, 10:00 a.m.–10:55 a.m., organized by **Ralph E. Youngen** and **Wendy A. Bucci**, AMS. A discussion of the current and projected "value-added" features that are being offered by publishers of electronic math journals. What value do features such as links to cited articles, author commentary, links to Web sites, article-by-article posting, e-mail alerts, etc., bring to the process of using electronic journals for mathematics research? Comments and suggestions from the audience will be encouraged.

Committee on Science Policy Panel, Friday 2:30 p.m.–4:00 p.m.

Committee on Education Panel, Saturday, 8:30 a.m.–10:00 a.m.

Other AMS Events

Council Meeting: Tuesday, 1:00 p.m.–10:00 p.m. N.B. This meeting is not in the Marriotts (headquarters hotels), but will be held in the Hilton Palacio del Rio.

***Mathematical Reviews* (MR) Reception**, Friday, 6:00 p.m.–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.

Business Meeting: Saturday, 11:45 a.m.–12:15 p.m. The secretary notes the following resolution of the Council: Each person who attends a Business Meeting of the Society shall be willing and able to identify himself as a member of the Society. In further explanation, it is noted that each person who is to vote at a meeting is thereby identifying himself as and claiming to be a member of the American Mathematical Society. The Society has a Committee on the Agenda for Business Meetings. The purpose is to make business meetings orderly and effective. The committee does not have legal or administrative power. It is intended that the committee consider what may be called "quasipolitical" motions. The committee has several possible courses of action on a proposed motion, including but not restricted to:

(a) doing nothing,

(b) conferring with supporters and opponents to arrive at a mutually accepted amended version to be circulated in advance of the meeting,

(c) recommending and planning a format for debate to suggest to a business meeting,

(d) recommending referral to a committee, and

(e) recommending debate followed by referral to a committee.

There is no mechanism that requires automatic submission of a motion to the Committee. However, if a motion has not been submitted through the Committee, it may be thought reasonable by a business meeting to refer it rather than to act on it without benefit of the advice of the Committee. The Committee consists of James A. Donaldson, Robert M. Fossum (chair), and John M. Franks.

In order that a motion for this business meeting receives the service offered by the Committee in the most effective manner, it should be in the hands of the secretary by December 10, 1998.

AMS Short Course

Please see the article on this two-day conference on *Nonlinear Control*, organized by **Héctor Sussman**, Rutgers University, and **Kevin Grasse**, University of Oklahoma, elsewhere in this issue.

82nd Annual Meeting of the MAA

MAA Invited Addresses

Jean Pedersen, Santa Clara University, *Extending and generalizing the Pascal triangle: An interplay of algebra and geometry*, Wednesday, 2:15 p.m.–3:05 p.m.

John H. Conway, Princeton University, *The symmetries of things: Real and conceptual*, Wednesday, 3:20 p.m.–4:10 p.m.

John Fauvel, The Open University, *The history of mathematics and its future*, Thursday, 10:05 a.m–10:55 a.m.

Jeremy Kilpatrick, University of Georgia, *The role of research in improving school mathematics*, Friday, 2:15 p.m.–3:05 p.m.

Edward G. Dunne, American Mathematical Society, *Pianos and continued fractions*, Friday, 7:30 p.m.–8:20 p.m. (Student Lecture)

Rodica E. Simion, George Washington University, *Convex polytopes and partially ordered sets*, Saturday, 9:00 a.m.–9:50 a.m.

Jonathan M. Borwein, Simon Fraser University, *Experimental mathematics: Insight from computation*, Saturday, 10:05 a.m.–10:55 a.m.

MAA Minicourses

Minicourse #1: *Mathematics, Calculus, and Modeling Using the TI-92*, organized by **Phoebe T. Judson**, Trinity University; **William C. Bauldry**, Appalachian State University; and **Richard D. West**, U.S. Military Academy. Part A: Wednesday, 8:00 a.m.–10:00 a.m.; Part B: Wednesday, 4:30 p.m.–6:30 p.m. Participants will examine ways in which the symbolic manipulation and data matrix tables of the TI-92 facilitate student understanding of calculus. The basic concepts of the derivative as rate of change, the definite integral as accumulation, and differential equations will be introduced from a modeling perspective. Some familiarity with the TI-92 is essential. TI-92s will be available. The course is based on the text *Calculus, Mathematics, and Modeling* by Ellis, Bauldry, Fiedler et al. Enrollment limit is 40; cost is $55.

Minicourse #2: *Mathematical Finance*, organized by **Walter R. Stromquist**, Berwyn, PA. Part A: Wednesday, 2:15 p.m.–4:15 p.m.; Part B: Thursday, 8:00 a.m.–10:00 a.m. We will cover two main ideas of modern finance: portfolio optimization and option valuation. Portfolio optimization means allocating a fixed investment fund among instruments (e.g., stocks) in order to maximize return and/or minimize risk; the techniques range from matrix algebra to quadratic programming. In option valuation we will derive the Black-Scholes formula under naive assumptions and then show how the modern no-arbitrage theory allows us to apply it more generally. The presenter will draw on practical examples from his consulting work. This minicourse is independent of the MAA Short Course. Enrollment limit is 30; cost is $75.

Minicourse #3: *Developing Materials for Liberal Arts Mathematics That Use Elementary Graph Theory and Emphasize Applications to Everyday Experience*, organized by **Helen Christensen**, Loyola University. Part A: Wednesday, 8:00 a.m.–10:00 a.m.; Part B: Wednesday, 4:30 p.m.–6:30 p.m. Content, techniques, and illustrative problems will be presented, suitable for enabling participants to develop materials for a liberal arts mathematics course appropriate to their student population, using a limited amount of theory, and emphasizing day-to-day applications to which students can readily relate. Included for each type of problem considered will be a synopsis of relevant theory, demonstration problems with solutions, and participant team solutions of similar problems. Enrollment limit is 40; cost is $55.

Minicourse #4: *The Mathematics of the Perfect Shuffle*, organized by **S. Brent Morris**, National Security Agency. Part A: Wednesday, 8:00 a.m–10:00 a.m.; Part B: Thursday, 10:15 a.m.–12:15 p.m. This minicourse is based on *Magic Tricks, Card Shuffling, and Dynamic Computer Memories* published by MAA in January 1998. The focus of the course is the perfect shuffle, a permutation used by mathematicians, magicians, and computer scientists for seemingly different ends. The shuffle and several generalizations will be introduced, the group structure generated by perfect shuffles will be explored, several card tricks will be taught, and the course will conclude with computer circuits using the perfect-shuffle interconnection. Students should bring a new deck of cards, preferably Bicycle or Aviator brands. Enrollment limit is 40; cost is $55.

Minicourse #5: *Building Custom Classroom Capsules with Maple Programming*. organized by **Douglas E. Ensley**, Shippensburg University. Part A: Wednesday, 4:30 p.m.–6:30 p.m.; Part B: Thursday, 10:15 a.m.–12:15 p.m. Computer algebra systems (CAS) should not be limited to the commands that come "built in". With simple programming constructs like loops, conditional statements, and procedures, CAS become highly specialized classroom tools for building connections vital to the learning process. Course participants will learn to program in Maple in order to build custom procedures for exploratory use and will receive specific examples for calculus and discrete math. Some experience with computer programming is required. Enrollment limit is 24; cost is $75.

Minicourse #6: *Cooperative Learning in Undergraduate Mathematics Education*, organized by **Barbara E. Reynolds**, Cardinal Stritch University, and **William E. Fenton**, Bellarmine College. Part A: Friday, 1:00 p.m.–3:00 p.m.; Part B: Saturday, 1:00 p.m.–3:00 p.m. Participants will be introduced to cooperative learning in undergraduate mathematics courses at all levels. Participants will engage in various cooperative learning experiences, work with several different small groups and reflect on ways of forming groups in their own classrooms, discuss issues related to assessment and grading, and talk about potential problems and ways of avoiding or overcoming such problems. No prior experience with cooperative learning is expected. Some readings will be distributed during the course. Enrollment limit is 80; cost is $55.

Minicourse #7: *Finding Motivation for Upper Division Mathematics through Original Sources*, organized by **Jerry M. Lodder** and **David J. Pengelley**, New Mexico State University. Part A: Wednesday, 4:30 p.m–6:30 p.m.; Part B:

Thursday, 2:15 p.m.–4:15 p.m. We will focus on using original historical sources to teach upper-division mathematics in a senior-level capstone course or to enrich existing courses in algebra, analysis, geometry, number theory, or numerical analysis. Participants will receive advance selections from two chapters of our four-author text being written for an established capstone course using original sources. By working with the book materials participants will learn how original sources can be used to enhance motivation in mathematics courses. Enrollment limit is 50; cost is $55.

Minicourse #8: *Teaching a Course in the History of Mathematics*, organized by **Victor J. Katz**, University of the District of Columbia, and **V. Frederick Rickey,** U.S. Military Academy. Part A: Wednesday, 2:15 p.m.–4:15 p.m.; Part B: Thursday, 8:00 a.m.–10:00 a.m. Many colleges and universities are introducing courses in the history of mathematics and asking mathematicians without a strong background in history to teach them. This minicourse will assist those teaching history by introducing participants to numerous resources, discussing differing approaches and sample syllabi, providing suggestions for student projects and course assessments, and, in general, giving those teaching such courses for the first time the confidence to master the subject themselves and to present the material to their students. Enrollment limit is 60; cost is $55.

Minicourse #9: *Exploring Abstract Algebra through Interactive Labs*, organized by **Allen C. Hibbard**, Central College, and **Kenneth M. Levasseur**, University of Massachusetts, Lowell. Part A: Thursday, 2:15 p.m.–4:15 p.m.; Part B: Friday, 8:00 a.m.–10:00 a.m. Using Mathematica, participants will become engaged in examining a series of interactive laboratory activities for groups and rings (including morphisms). The notebooks encourage exploration and investigation and are intended to motivate/expand upon classroom discussions. The labs are independent of any text. No previous experience (or programming) with Mathematica is required, since packages are read-in that define the required functionality. The labs and packages are based on EAAM, the Exploring Abstract Algebra with Mathematica project. See `http://www.central.edu/eaam.html`. Enrollment limit is 30; cost is $75.

Minicourse #10: *Facilitating Active Learning: Concrete Ways to Foster Student Participation*, organized by **Sandra L. Rhoades**, Keene State College. Part A: Wednesday, 2:15 p.m.–4:15 p.m.; Part B: Friday, 8:00 a.m.–10:00 a.m. This minicourse provides a place for hearing about, sharing, and experiencing a broad range of techniques for facilitating learning. No one method or technique is promoted; rather, a number of concrete ways to get students involved in their learning are discussed and illustrated. Participants exchange ideas, discuss and reflect on the techniques being used in the minicourse, as well as those being shared, and consider how to incorporate new techniques into their own classrooms. Enrollment limit is 40; cost is $55.

Minicourse #11: *Creating Interactive Texts in Mathematica*, organized by **John R. Wicks**, North Park University. Part A: Friday, 1:00 p.m.–3:00 p.m.; Part B: Saturday, 8:00 a.m.–10:00 a.m. Participants will create their own lesson on a specific suggested topic by completing an interactive lesson, written as a Mathematica Notebook, geared to their specific level of expertise. One Notebook will be geared to a novice user who is still learning the basics of Mathematica, while another will assume a bit more familiarity, and the third will focus on more advanced features of lesson design. All participants will receive a floppy disk of all materials. Enrollment limit is 30; cost is $75.

Minicourse #12: *Writing and the Teaching of Mathematics*, organized by **John E. Meier**, Lafayette College, and **Thomas W. Rishel**, Cornell University. Part A: Thursday, 2:15 p.m.–4:15 p.m.; Part B: Friday, 1:00 p.m.–3:00 p.m. Carefully designed writing assignments are effective pedagogical tools to help students learn mathematics. We will discuss how to create such assignments, how to evaluate student essays, and the role of writing assignments in the mathematics curriculum. We'll also discuss "narrative", "process writing", and other terminology used by our colleagues in writing departments. This minicourse will be partly based on our book *Writing and the Teaching and Learning of Mathematics*, published by the MAA. Enrollment limit is 30; cost is $55.

Minicourse #13: *Getting Students Involved in Undergraduate Research*, organized by **Joseph A. Gallian**, University of Minnesota-Duluth, and **Aparna W. Higgins**, University of Dayton. Part A: Wednesday, 2:15 p.m.–4:15 p.m.; Part: B: Thursday, 10:15 a.m.–12:15 p.m. We will discuss strategies and give examples for involving undergraduate students in doing research in mathematics. The discussion will include REU year-long projects and short investigations suitable for a variety of levels of student motivation, interest, and talent. Sources for projects will be suggested, as will outlets for the results of undergraduate research. Enrollment limit is 40; cost is $55.

Minicourse #14: *An Introduction to Wavelets*, organized by **Colm K. Mulcahy**, Spelman College. Part A: Friday, 3:15 p.m.–5:15 p.m.; Part B: Saturday, 1:00 p.m.–3:00 p.m. Wavelets are a relatively recent arrival on the scene, and they provide an alternative to classical Fourier methods for one- and multidimensional data analysis and synthesis. This minicourse will introduce the basics of wavelets and some common applications (e.g., to image compression), with the help of several hands-on explorations using Matlab. Prerequisites will be kept to a minimum: in particular, no expertise in Fourier analysis or prior familiarity with Matlab is assumed. Enrollment limit is 30; cost is $75.

Minicourse #15: *Music and Mathematics*, organized by **Leon Harkleroad**, Bard College. Part A: Friday, 3:15 p.m.–5:15 p.m.; Part B: Saturday, 1:00 p.m.–3:00 p.m. Over the years people have used mathematics in various ways to describe, analyze, and create music. This minicourse will explore the applications of mathematical areas such as number theory, probability, and group theory to musical topics like tuning systems, bell-ringing, and twentieth-century compositional technique. Emphasis will be placed on how minicourse participants can incorporate this material into their classes—or even design a service course on music and mathematics. Enrollment limit is 80; cost is $55.

Minicourse #16: *Using Hand-held CAS throughout the Mathematics Curriculum*, organized by **Wade Ellis**, West Valley College; **L. Carl Leinbach**, Gettysburg College; and **Bert K. Waits**, Ohio State University. Part A: Thursday, 2:15 p.m.–4:15 p.m.; Part B: Saturday, 8:00 a.m.–10:00 a.m. The course will begin with an overview of the calculus sequence and the advantages of using computer algebra in presenting the course. However, the major emphasis will be on the use of the TI-92 Plus in doing advanced mathematics. Topics will include graphical techniques in multivariable calculus, advanced algebraic and numerical techniques in linear algebra, and differential equations from a symbolic and graphical point of view. Participants will have access to a TI-92 Plus or TI-89 calculator and will have hands-on experience with the CAS calculator. Enrollment limit is 40; cost is $55.

Minicourses are open only to persons who register for the Joint Meetings and pay the Joint Meetings registration fee in addition to the appropriate minicourse fee. If the only reason for registering for the Joint Meetings is to gain admission to a minicourse, please make a notation on your form. If the minicourse is fully subscribed or cancelled, a full refund will be made of the Joint Meetings advance registration fee (otherwise subject to the 50% rule). The MAA reserves the right to cancel any minicourse which is undersubscribed.

MAA Contributed Paper Sessions

See the complete descriptions and instructions on how to participate in these sessions beginning on p. 798 in the June/July issue of the *Notices* or at `http://www.ams.org/amsmtgs/maacontrib-sat.html`.

The Use of Technology in Teaching Abstract Mathematics, **Douglas E. Ensley**, Shippensburg University; Wednesday and Friday mornings.

Quantitative Literacy, **Barbara A. Jur**, Macomb Community College; **Richard A. Gillman**, Valparaiso University; **Jimmy L. Solomon**, Georgia Southern University; **Allen E. Pulsion**, College of Science and Technology; and **Linda R. Sons**, Northern Illinois University; Wednesday and Friday mornings.

Teaching Statistics: Teaching the Reasoning and New Technological Tools, **Dexter C. Whittinghill**, Rowan University; **Franklin A. Wattenberg**, National Science Foundation; **Mary R. Parker**, Austin Community College; and **Donald L. Bentley**, Pomona College; Wednesday and Friday mornings.

Mathematics Competitions, **Harold B. Reiter**, University of North Carolina, Charlotte; **Stephen B. Maurer**, Swarthmore College; **William P. Fox**, USMA; and **Susan Schwartz Wildstrom**, Montgomery City Schools; Wednesday morning and Thursday afternoon.

Innovations in Teaching Abstract Algebra, **Vesna Kilibarda**, University of Alaska Southeast; **Allen C. Hibbard**, Central College; and **Ellen Maycock Parker**, DePauw University; Wednesday afternoon.

Ethical, Humanistic, and Artistic Mathematics, **Alvin M. White**, Harvey Mudd College; **Robert P. Webber**, Longwood College; and **Stefanos P. Gialamas**, Illinois Institute of Art; Wednesday and Friday afternoons.

Geometry in the Classroom in the Next Millennium, **Colm K. Mulcahy**, Spelman College; **David W. Henderson**, Cornell University; and **Barry Schiller**, Rhode Island College; Thursday and Saturday mornings.

Discrete Mathematics Revisited, **Richard K. Molnar**, Macalester College, and **Suzanne M. Molnar**, College of St. Catherine; Thursday and Saturday mornings.

Projects That Work in Applied Mathematics Courses, **Alexandra Kurepa**, North Carolina A&T State University, and **Henry Warchall**, University of North Texas; Thursday and Saturday afternoons.

Innovative Use of Distance Learning Techniques to Teach Post-secondary Mathematics, **Brian E. Smith**, McGill University, and **Marcelle Bessman**, Jacksonville University; Thursday and Saturday afternoons.

Integrating Mathematics and Other Disciplines, **William G. McCallum**, University of Arizona; **Nicholas T. Losito**, SUNY Farmingdale; and **Yajun Yang**, SUNY Farmingdale; Thursday and Saturday afternoons.

The Integral Role of the Two-Year College in the Preservice Preparation of Elementary School Teachers, **Mercedes A. McGowen**, William Rainey Harper College; **Joanne V. Peeples**, El Paso Community College; and **William E. Haver**, Virginia Collaborative for Excellence in the Preparation of Teachers; Friday morning and Saturday afternoon.

Proof in Mathematical Education, **G. Joseph Wimbish**, Huntingdon College, and **Gary Davis**, University of Southampton; Friday afternoon.

Other MAA Sessions

The Use of History in the Teaching of Mathematics, Wednesday 8:00 a.m.–10:55 a.m., organized by **Florence Fasanelli**, College-University Resource Institute, and **V. Frederick Rickey**, U.S. Military Academy. An NSF-supported MAA Institute on the History of Mathematics and Its Use in Teaching, which began with the first summer session in 1995, deals with the history of mathematics, how it can be used in the classroom, and how to teach history of mathematics courses. This session invites contributions from individuals who have taught history of mathematics in innovative ways or who have used history in their classes to support current changes in curricula, pedagogy, and the mathematical preparation of teachers. Speakers include **Robin Wilson**, The Open University; **Ed Sandifer**, Western Connecticut State University; **V. Frederick Rickey** and **Victor J. Katz**, University of the District of Columbia; and **Shirley B. Gray**, California State University-Los Angeles.

Dean's View of Mathematics Departments, Wednesday, 8:00 a.m.–9:20 a.m., organized by **Bernard L. Madison**, University of Arkansas, and **David J. Lutzer**, College of William and Mary. A panel of (nonmathematician) deans will discuss how mathematics departments are perceived in their institutions. The aim is to investigate how the cultures of mathematics faculties are interacting with shifting priorities in colleges and universities. Declining enrollments, changes in engineering accreditation criteria, and reports of program reductions have raised new concerns and rekindled old ones about the future of the profession. This future will be affected by decisions of college deans. The panel is sponsored by the MAA Committee on the Profession.

Bernard L. Madison, dean, Fulbright College of Arts and Sciences, University of Arkansas, will serve as moderator. Panelists include **Sheryl Smith-Kappus**, dean, Mathematics and Natural Sciences, Collin County Community College District, McKinney, Texas; **Mary Ann Rankin**, dean, College of Natural Sciences, University of Texas at Austin; and **Jane L. Winer**, dean, College of Arts and Sciences, Texas Tech University.

The Mathematics of Lewis Carroll, Wednesday, 7:00 p.m.–8:00 p.m., performed by **Robin Wilson**, The Open University, and friends. This dramatic presentation will contain episodes from the life of Lewis Carroll, with particular reference to his mathematics (both serious and otherwise) gleaned from his texts, mathematical puzzles, the "Alice" books, and university pamphlets. In particular, material relating to his views on algebra, logic, and geometry, and his attitudes toward teaching will be presented.

Summer Research Opportunities for Faculty in Industry and Government, Thursday, 8:00 a.m.-9:30 a.m., organized by **Joseph A. Gallian**, University of Minnesota-Duluth. Summer positions in government and industry provide faculty with unique opportunities for professional development. Such positions permit faculty to participate in research that has "real-world" applications and also provide an enhanced perspective on the teaching of mathematics. Panelists will discuss their own experiences with such positions, including how they found these positions, their advantages and disadvantages, and their impact on both the faculty member and her or his collaborators in government or industry. Included among the panelists are **M. Leigh Lunsford** of Alabama A&M University and **William Velez** of the University of Arizona. The panel will be moderated by **Joseph A. Gallian**. Sponsored by Project NeXT.

Outreach Programs for Women and Girls in Mathematics, Thursday, 8:00 a.m.–10:00 a.m., organized by **Kathleen A. Sullivan**, Seattle University. Advocacy programs for women and girls in mathematics will be showcased at this poster session. Mathematicians with programs which target women and girls are urged to submit an application, preferably by e-mail, to Kathleen Sullivan (`ksulliva@seattleu.edu`). The application should include the name, address and title of the applicant, an e-mail address if available, and a one-page description of the project. Applications should be submitted by October 1. Space is limited, and there is no guarantee that all submissions can be accommodated. Applicants will be notified in November whether or not their proposals have been accepted. The poster session is sponsored by the MAA Women in Mathematics Network.

Involving Undergraduate Students in Industrial Consulting Experiences, Thursday, 2:15 p.m.–3:45 p.m., organized by **Mary R. Parker**, Austin Community College, and **Dexter C. Whittinghill**, Rowan University. Well-designed experiences in industrial consulting provide undergraduate students, even freshmen, with an opportunity to deal with meaningful problems and sample the field for potential careers. The panel will discuss the values of such experiences to students, industry, and faculty. The panel is sponsored by the ASA-MAA Committee on Statistics. Panelists include **Donald L. Bentley**, Pomona College; **Cary Marcot**, Cardio-Genesis Corporation; and **Julie Buring**, Harvard University.

Exemplary Women in Mathematical Careers, Thursday, 2:15 p.m.–3:45 p.m., organized by **Carolyn C. Connell**, Westminster College. In what ways does one's gender affect pursuit of a career in mathematics? Women at various stages in their mathematical careers will offer some insights. The panel is sponsored by the MAA Committee on the Participation of Women.

Using the Web as a Tool for Teaching Calculus: What We've Learned; Successes and Problem Areas, Thursday, 2:15 p.m.–3:45 p.m., **Lawrence S. Husch**, University of Tennessee at Knoxville; **Earl D. Fife**, Calvin College; and **Eugene A. Klotz**, Swarthmore College. Recent Joint Mathematics Meetings have presented sessions featuring uses of the World Wide Web in mathematical instruction. These sessions have included a panel discussion, minicourses, and a contributed paper session. As software packages improve and more faculty have access to high-speed Internet connections, uses of the Web for mathematics instruction have proliferated. Some of these experiences have been highly successful, and others leave both faculty and students with a feeling of disappointment. The time has come for retrospection. This panel discussion will focus on past experiences and what important lessons have been learned from these experiences. The panel is sponsored by the MAA Committee on Computers in Mathematics Education (CCIME).

Discovery-based Teaching of Undergraduate Mathematics Courses, Thursday, 2:15 p.m.–3:45 p.m., organized by **William T. Mahavier**, Nichols State University, and **James P. Ochoa**, Hardin-Simmons University. The purpose of this session is to present ideas for teaching undergraduate mathematics courses using discovery-based methods modeled after the Moore (Texas) Method. Professors who have taught courses using these methods will discuss their theorem sequences, experiences, and insights concerning this style of teaching. **William T. Mahavier** and **James P. Ochoa** will serve as moderators and will compile a proceedings for this session. Panelists include **Stuart J. Anderson**, Texas A&M at Commerce; **Steve Armentrout**, Pennsylvania State University; **Mary Ellen Rudin**, University of Wisconsin, Madison; **Jerome Dancis**, University of Maryland, College Park; and **Tom Ingram**, University of Missouri at Rolla. Contributions are welcome.

College Algebra Reform, Thursday, 2:15 p.m.–3:45 p.m., organized by **Donald B. Small**, U.S. Military Academy. The panelists will discuss their experience in developing and teaching reformed college algebra courses in terms of content, pedagogy, and the use of technology. Reform efforts are addressing the fact that in many schools college algebra has evolved into a "barrier" course rather than a "pump" course. In several schools college algebra is required by all majors and, in addition, enrolls more students than all other mathematics courses combined. Sponsored by the CUPM Subcommittee on Calculus Reform and the First Two Years. Panelists include **Sandi Athanassiou**, University of Missouri-Columbia; **General G. Marshall**, Huston-Tillotson College; **Kathleen Heid**, Pennsylvania State University; and **Philip Quartararo**, Southern University.

Using the Web in Teaching Undergraduate Mathematics, Thursday, 2:15 p.m.–4:10 p.m., organized by **V. S. Ramamurthi**, University of North Florida, and **Rebecca E. Hill**, Rochester Institute of Technology. This poster session provides an opportunity for educators to share their experiences with instructional uses of the Web with other interested educators. Some instructional materials can be described with actual posters, while others might be better shared by presenting the Web site on a laptop computer. Actual Internet access is not needed for this session. An educator's Web site can be presented locally on a laptop. Software such as Web Whacker even allows one to download links to other sites and present this on a laptop. The session is sponsored by the MAA Committee on Computers in Mathematics Education. Applications should be submitted to V. S. Ramamurthi (`ramm@osprey.unf.edu`) or Rebecca E. Hill (`rehsma@rit.edu`) by October 1.

Solving the Two Body Problem, Thursday 7:00 p.m.–8:30 p.m., organized by **Philip E. Gustafson**, Mesa State College, and **Gregory P. Dresden**, Washington and Lee University. This panel focuses on issues of concern to couples, at least one of whom is a career academician. Panelists will give a brief discussion of some of the relevant issues. Audience participation will be encouraged. **Gregory P. Dresden** will serve as moderator. Panelists include **Jean E. Taylor**, Rutgers University; **Elizabeth G. Yanik**, Emporia State University; and **Albert W. Schueller**, Whitman College. Cosponsored by the MAA and the Young Mathematicians Network.

Research on Undergraduate Mathematics Education, Thursday, 7:00 p.m.–9:00 p.m., organized by **Thomas P. Dick**, Oregon State University. The Association for Research on Undergraduate Mathematics Education (ARUME) is being formed for mathematics educators and professional mathematicians interested in research on undergraduate mathematics education. On Thursday evening this group will host a welcoming address, business meeting, election of officers, and several presentations exemplifying research on undergraduate mathematics, followed by a cash bar reception. More presentations will be made on Friday, 7:00 p.m.–9:00 p.m.

Innovations in Mathematics Programs Which Benefit Future Teachers, Thursday, 7:00 p.m.–9:00 p.m., organized by **Marjorie Enneking**, Portland State University. This poster session will provide an opportunity for faculty from community colleges, colleges, universities, and collaboratives of institutions to share their innovations in courses and programs which are designed to benefit students in the courses who plan to become elementary, middle school, or high school teachers. In addition to courses, the session will showcase programs which incorporate diversity, advising, undergraduate research, undergraduate peer teaching experiences, use of technology, or other components which provide exemplary support for future teachers. Applications should be submitted to Marj Enneking (`marj@mth.pdx.edu`) by October 1. The application should include name, address, phone number, e-mail address, and a one-page description of the project. Space is limited and there is no guarantee that all submissions can be accommodated. Applicants will be notified in November whether or not their proposals have been accepted. Sponsored by the MAA Committee on the Mathematical Education of Teachers (COMET).

Eine Kleine (Mathematische) Nachtmusik, Thursday, 7:30 p.m.–9:00 p.m., presented by **Erich Neuwirth**, University of Vienna. Mathematical principles of musical tuning systems will be demonstrated, beginning with simple frequency ratios for musical intervals known to the Greeks. Pythagorean, Mean Tone, and Well Tempered scales with accompanying melodies and chords will be constructed on the piano. A few different pieces by well-known composers will be performed to show the connection between the mathematical and physical aspects of the problem. How much the musical expression of a piece of music changes when played in different tunings will be demonstrated.

Student Reports: Explorations in Using the World Wide Web to Enhance the Teaching of Mathematics, Thursday, 7:30 p.m.–9:00 p.m., organized by **Donald B. Small**, U.S. Military Academy. Teams of students will report on their research that was initiated at the "Explorations in Using the World Wide Web to Enhance the Teaching of Mathematics" workshop held at Carroll College, May 1998. Each team is to complete an undergraduate thesis or capstone project or the equivalent during the 1998–99 academic year based on research stemming from the Carroll workshop. Teams involved in the workshop are from Simmons College, Texas Southern University, Prairie View A&M University, University of Texas at San Antonio, Missouri Western State College, University of Redlands, Oregon State University, Dull Knife Memorial Community College, Stone Child Community College, and Little Big Horn Community College.

Innovations in Teaching Assistant Training, Friday, 8:00 a.m.–10:50 a.m., organized by **Teri Jo Murphy**, University of Oklahoma, and **Suzanne M. Lenhart**, University of Tennessee. This session will showcase a variety of new and ongoing teaching assistant development programs that address the evolving role of the teaching assistant in reform courses. These training programs provide support and guidance to teaching assistants and the future professoriate, who are adjusting to new technologies, content, and instructional strategies. The panel is sponsored by the AMS-MAA Committee on Teaching Assistants and Part-Time Instructors. Panelists include **Patricia Shure**, University of Michigan; **James Epperson**, Texas Tech University; **Ethel Wheland**, University of Akron; and **Iris B. Fetta**, Clemson University.

Dual Credit for Mathematics Courses Taken in High School, Friday 8:00 a.m–9:20 a.m, organized by **Mary Robinson**, University of New Mexico-Valencia Campus Branch. Programs have been established in many places which allow high school students to take college-content mathematics courses to earn credit at both the high school and the college-level. Two- and four-year institutions each are involved in these arrangements. Such dual credit plans seem to be growing in number nationwide and can include courses taught on the high school campus by master-degreed high school faculty. The ways in which such programs are administered across the country vary widely, sometimes falling under state mandate and sometimes existing as ad

hoc arrangements made by individual schools. This panel represents a geographically diverse selection of both two- and four-year college faculty and high school faculty. It will discuss the positive and negative aspects of these dual credit arrangements. The panel is sponsored by the MAA Committee on Two-Year Colleges. **Wade Ellis**, West Valley College, will serve as moderator. Panelists include **Gary L. Britton**, University of Wisconsin-Washington County; **Philip M. Cheifetz**, Nassau Community College; **Ann Davidian**, McArthur High School, Levittown, New York; **Kathleen K. Berver**, New Mexico State University; and **Raymond J. Cannon Jr.**, Baylor University.

Educational Testing Service Open Forum: Testing with Technology—Sharing Ideas To Meet the Challenges That Lie Ahead, Friday, 9:35 a.m–10:55 a.m., organized by **Gloria S. Dion**, Educational Testing Service. During the past decade, College Board programs (SAT I, SAT II, and AP Calculus) initiated the use of calculators on their tests, a practice consistent with recommendations of national mathematics organizations. The panel will address questions that arise when technology is available to students. Participants will be asked to share teaching practices and expectations of students, discuss how students solve problems using technology, evaluate sample questions for appropriateness on a national test, and make recommendations for future directions. Speakers from ETS include **Gloria Dion**, **Carol Jackson**, **Chancey O. Jones**, **Patricia Klag**, and **Craig L. Wright**.

Forming the Crystal Ball for Calculus, Friday, 8:00 a.m.–9:20 a.m., organized by **Donald B. Small**, U.S. Military Academy. The present Calculus Reform Movement was launched with an AMS/MAA panel discussion at the 1985 January Math Meetings in Anaheim, CA. During the last decade, the Movement expanded across the country. Several different types of calculus courses were developed around a changed pedagogy that emphasized active student involvement. The panelists will reflect on the work of the past decade in order to prepare for the next decade of reform. The panel is sponsored by the NSF and CRAFTY. **Chris Arney**, U.S. Military Academy, will serve as moderator. Panelists include **Paul Zorn**, St. Olaf College; **David A. Smith**, Duke University; **Franklin A. Wattenberg**, NSF; and **Donald B. Small**.

Project Next and YMN Poster Session, Friday, 8:00 a.m.–10:00 a.m., organized by **Kenneth A. Ross**, University of Oregon, and **Kevin E. Charlwood**, Washburn University. The session will include exhibits from thirty or so new or recent Ph.D.s in the mathematical sciences or from those still pursuing graduate study. Applications should be submitted to Ken Ross (`ross@math.uoregon.edu`) or Kevin Charlwood (`zzcharlw@acc.wuacc.edu`).

The Effect of Calculus Reform on Student Performance in Subsequent Courses, Friday, 9:35 a.m.–10:55 a.m., organized by **Jack Bookman**, Duke University; **Susan L. Ganter**, Worcester Polytechnic University and AAHE; and **Herbert E. Kasube**, Bradley University. The MAA Committee on Calculus Reform and the First Two Years recognizes that the evaluation of calculus reform involves not only students' performance in the calculus, but also their performance in subsequent courses. This panel will bring together faculty who have spent time evaluating such performance as well as (possibly) faculty from client disciplines to discuss how well students who have completed a reformed calculus sequence perform in later courses as well as those that have traditionally had a calculus prerequisite. Panelists include **Susan L. Ganter**, American Association for Higher Education; **Jack Bookman**, Duke University; **Judith Lee Baxter**, University of Illinois at Chicago; **John C. Polking**, Rice University; **Norman L. Webb**, Wisconsin Center for Educational Research; and **Herbert E. Kasube**, Bradley University.

College Algebra Reform, Friday 1:00 p.m.–3:00 p.m., organized by **Donald B. Small**, U.S. Military Academy; **Sarah Bush**, Wiley College; and **Eugene J. Taylor**, Grambling State University. Instructors and/or developers of College Algebra reform programs are encouraged to share their work and experiences through this poster session sponsored by the CUPM Subcommittee on Calculus Reform and the First Two Years. Applications should be submitted to Sarah Bush, Wiley College, Marshall, TX 75670, or Gene Taylor, Department of Mathematics, Grambling State University, Grambling, LA 71245; e-mail: `taylore@alphao.gram.edu`.

Models for Intervention Projects, Friday, 3:15 p.m.–4:45 p.m., organized by **Robert E. Megginson**, University of Michigan, and **Manuel P. Berriozábal**, University of Texas at San Antonio. As a response to the MAA resolution which encourages mathematics departments throughout the country to organize and conduct intervention programs, models of successful intervention programs will be presented and discussed. Topics will include program content, recruitment of participants, financial and in-kind support, and linkages with local, state, and national public and private sector agencies. Panelists include **Manuel Berriozábal**; University of Texas at San Antonio; **Florence Fasanelli**, director, College-University Resource Institute, Inc.; **William A. Hawkins Jr.**, SUMMA; **Robert E. Megginson**, University of Michigan; **Irvin E. Vance**, Michigan State University; and **Charlene Morrow**, Mount Holyoke College.

Teaching Awards Presentations, Friday, 3:20 p.m.–5:00 p.m. Winners of the Awards for Distinguished College or University Teaching of Mathematics will give presentations on the secrets of their success. Details will be published in the program booklet.

Informal Session on Actuarial Education, Friday, 5:00 p.m.–7:00 p.m., organized by **James W. Daniel**, University of Texas, and **Matthew J. Hassett**, Arizona State University. This informal session sponsored by the Actuarial Faculty Forum provides an opportunity for those involved in actuarial education, interested in it, or interested in learning about it to get together and discuss common concerns such as the upcoming changes in the actuarial examination system.

Research on Undergraduate Mathematics Education, Friday, 7:00 p.m.–9:00 p.m. A continuation of Thursday evening's ARUME program with more presentations on this topic.

Isolated Teachers of Statistics, Friday, 7:00 p.m.–9:00 p.m., organized by **Dexter C. Whittinghill**, Rowan University. This group will meet again in order to discuss an agenda of topics related to the teaching of undergraduate statistics. The agenda will be determined before the meet-

ing (solicited via e-mail) by the organizer, who will also moderate the meeting. Meeting participants who would likely find this meeting helpful are self-labeled as "isolated" because they are the one person who teaches all or most of the statistics in their department or who "coordinates" the statistics curriculum. Especially invited are those interested in teaching statistics well but who may not have formal training in statistics. In many ways the target audience is the same as the audience for the MAA-sponsored STATS workshops of recent years.

An Evening of Poetry, Friday, 7:15 p.m.–9:15 p.m., organized by **Alvin M. White**, Harvey Mudd College. Read your poetry or other poetry that is appropriate for the occasion. The second hour will feature Sandra Coleman and Michael Dutko reading from their translations of the poetry of Sophia Kovalevskaia. Sponsored by the Humanistic Math Network.

State Standards, Saturday, 8:30 a.m.–10:00 a.m., organized by **Kenneth A. Ross**, University of Oregon, and **Joan F. Donahue**, executive director of NASSMC. **Rolf Blank** of the Council of Chief State School Officers will open this panel discussion with a concise description of the nature and purposes of state standards. There will be a representative from each of the three standards-evaluating groups: American Federation of Teachers, the Council for Basic Education, and the Fordham Foundation. **Alice Gill**, AFT, and **Ralph A. Raimi**, professor emeritus at the University of Rochester and coauthor of the report from the Fordham Foundation, have agreed to participate. These panelists will be asked to respond to questions regarding the purpose, criteria, procedures, evaluators, and "grade interpretation" associated with each study. **Joseph Rosenstein**, director of the New Jersey Mathematics Coalition and leader of the group who created the state standards in New Jersey, will present a brief discussion of the New Jersey Mathematics Standards in light of the evaluation procedures described by the panel. **Henry Alder**, University of California-Davis, has kindly agreed to moderate the session. It will be cosponsored by the MAA and the National Alliance of State Science and Mathematics Coalitions (NASSMC).

Life after Retirement, Saturday, 8:00 a.m.–9:20 a.m., organized by **Andrew Sterrett Jr.**, Denison University.

Planning for Retirement, Saturday, 9:30 a.m.–10:50 a.m., organized by **Carol Shaw**, MAA. Planning for retirement includes financial and estate planning. A certified financial planner will discuss ways to plan for and during retirement to maximize your financial results.

Teaching Collaborations between Graduate Departments, in Mathematics at Four-Year Institutions, and Community Colleges, Saturday, 1:00 p.m.–2:20 p.m., organized by **Pamela E. Matthews**, American University. Such collaborations give graduate students teaching experience while meeting community colleges' adjunct needs; schools can work together to improve the graduate students' teaching. The panel is sponsored by the MAA Committee on the Teaching of Undergraduate Mathematics (CTUM). Panelists include **Paul Latiolais**, Portland State University; **Janet P. Ray**, Seattle Central Community College; and **Ginger Warfield**, University of Washington.

SUMMA Special Presentation, Saturday, 1:00 p.m.–2:20 p.m., organized by **William A. Hawkins Jr.**, director of the SUMMA (Strengthening Underrepresented Minority Mathematics Achievement) Program. Presentations will be given on intervention programs for minority precollege students. Speakers to be announced. There will be ample time for questions and interchange with the presenters.

Improved Teacher Preparation: What Mathematics Departments Can Do, Saturday 1:00 p.m.–2:20 p.m., organized by **James Loats**, Metropolitan State College of Denver. This session will open with brief descriptions by the panelists of innovations in the way their departments prepare secondary teachers. Then participants will divide into small groups to share and learn about ideas for change that best fit their own environment. Information will also be available that summarizes changes that have been made at the fifteen NSF-funded Collaboratives for Excellence in Teacher Preparation (CETP). This interactive panel session is sponsored by the MAA Committee on the Mathematical Education of Teachers (COMET).

Integrating Active Learning Techniques into Lectures, Saturday, 1:00 p.m.–3:00 p.m., organized by **Sandra L. Rhoades**, Keene State College. This participatory workshop is for faculty who are interested in learning about and discussing ways to incorporate active learning techniques into lectures. For some people this may be a beginning step towards moving away from lectures; for others, it is simply a way to increase the effectiveness of their lectures. A wide variety of techniques that require minimal in-class time will be presented and discussed. Workshop participants will be actively involved; little or no lecturing will occur during the workshop.

Student Activities

Undergraduate Research: Student Poster Session, Friday, 4:00 p.m.–7:00 p.m., organized by **Aparna W. Higgins**, University of Dayton, and **Mario U. Martelli**, California State University-Fullerton. The CUPM Subcommittee on Research by Undergraduates invites undergraduate students to display posters describing their mathematical research projects. Posters will be judged on their mathematical content and on the presentation, with monetary prizes for the best poster presentations. Poster boards will be provided. A one-page abstract describing the project should be sent by December 1, 1998, to Aparna Higgins, `higgins@saber.udayton.edu`. However, space is limited, and there is no guarantee that all submissions will be accepted.

Joint Pi Mu Epsilon and MAA Student Chapter Advisors' Breakfast, Friday, 7:00 a.m.–8:00 a.m.; contact Richard D. Jarvinen, `richard.d.jarvinen1@jsc.nasa.gov`.

See the details about the MAA Student Lecture under the MAA Invited Addresses section. There will be an ice cream social following this lecture.

MAA Short Course

Mathematics in Finance, Monday and Tuesday, January 11 and 12, organized by **Robert F. Almgren**, University of Chicago, will take place in the Hilton Palacio del Rio. The modern financial industry uses mathematics of ever-increasing sophistication and employs large numbers of our

graduates. The fundamental models can be grasped in a few hours and provide ideal material for undergraduate courses in probability, differential equations, and applied math modeling. At higher levels the field makes challenging demands in stochastic calculus, PDEs with free boundaries, and large-scale computation. We will cover the basic models and the underlying mathematics, present practical methods for their solution, and discuss their use in real life. Speakers and topics include: **Robert F. Almgren**, The University of Chicago, *A program on financial mathematics*; **Ara Pehlivanian**, Morgan Stanley Dean Witter, *Portfolio theory and risk management*; **Yuri Balasanov**, Nations Bank/University of Chicago, *Interest rate modeling and fixed income products*; **Jingyi Zhu**, Salomon Smith Barney, *Calibrating models with market data*; **Neil Chriss**, Goldman Sachs Asset Management/NYU, *Preparing for a career in financial mathematics*; **Steve Allen**, Chase Manhattan Bank/NYU, *A historical overview of mathematics in finance.*

Please note that there is a separate registration fee for this Short Course. To register in advance, please use the Advance Registration/Housing form found at the back of this issue. Advance registration fees are $125/member; $175/nonmember; and $50/student, unemployed, emeritus. On-site registration fees are $140/member; $190/nonmember; and $60/student, unemployed, emeritus.

Other MAA Events

Board of Governors, Tuesday, 8:30 a.m.–4:00 p.m. N.B. This meeting is not in the Marriotts (headquarters hotels), but will be held in the Hilton Palacio del Rio.

Section Officers, Wednesday, 4:30 p.m.–6:30 p.m.

Two-Year College Reception, Thursday, 5:45 p.m.–7:00 p.m.; sponsored by Addison Wesley Longman.

MAA Business Meeting, Saturday, 11:10 a.m.–11:40 a.m.

Activities of Other Organizations

Association for Symbolic Logic (ASL)

This two-day program on Friday and Saturday will include Invited Addresses and sessions of contributed papers. Watch for details in a future issue.

Association for Women in Mathematics (AWM)

Nineteenth Annual Emmy Noether Lecture, Thursday, 9:00 a.m.–9:50 a.m., **Krystyna Kuperberg**, Auburn University, *Aperiodic dynamical systems.* Also see the AMS-AWM Special Session organized by Kuperberg.

Panel Discussion, Wednesday, 3:20 p.m.–4:20 p.m.

Business Meeting, Wednesday, 4:20 p.m.–4:50 p.m.

Workshop, Saturday, 9:00 a.m.–5:00 p.m. With funding from the Office of Naval Research and the National Science Foundation, AWM will conduct its workshop for women graduate students and women who have received the Ph.D. within the last five years.

Twenty women will be selected in advance of the workshop to present their work. The selected graduate students will present posters, and the postdocs will give 20-minute talks. AWM will offer funding for travel and two days' subsistence for the selected participants. The workshop will also include a panel discussion on issues of career development and a luncheon. Participants will have the opportunity to meet with other women mathematicians at all stages of their careers. All mathematicians (female and male) are invited to attend the entire program. Departments are urged to help graduate students and postdocs who do not receive funding to obtain some institutional support to attend the workshop and the associated meetings. The deadline for applications for funding was September 1, 1998. Inquiries may be made to AWM by telephone: 301-405-7892 or by e-mail: `awm@math.umd.edu`.

AWM seeks volunteers to lead discussion groups and to act as mentors for workshop participants. If you are interested in volunteering, please contact the AWM office.

National Association of Mathematicians

Granville-Brown Session of Presentations by Recent Doctoral Recipients in the Mathematical Sciences: Friday, 2:15 p.m.–5:00 p.m., moderated by **William A. Massey**, Lucent Technology, Bell Labs.

Cox-Talbot Address, Friday evening after the banquet, **Johnny L. Houston**, Elizabeth City State University, *The end of one era, the dawn of another.*

Effective Networking and Research Dialogue via Teleconferences/Telecommunication, Saturday, 9:00 a.m.–9:50 a.m. This panel discussion, moderated by **Leon C. Woodson**, Morgan State University, includes **James C. Turner**, Arizona State University, among the panelists.

Business Meeting, Saturday, 10:00 a.m.–10:50 a.m.

William W. S. Claytor Lecture, Saturday, 1:00 p.m., given by **Earl R. Barnes**, Georgia Institute of Technology, on *Maximum cliques and minimum colorings of graphs.*

See the "Social Events" section for details on the NAM Banquet.

National Science Foundation (NSF)

The NSF will be represented at a booth in the exhibit area. NSF staff members will be available to provide counsel and information on NSF programs of interest to mathematicians. The booth is open the same days and hours as the exhibits. Times that staff will be available will be posted at the booth.

Rocky Mountain Mathematics Consortium (RMMC)

Board of Directors Meeting, Friday, 2:15 p.m.–4:10 p.m.

Young Mathematicians Network (YMN)

Concerns of Young Mathematicians: A Town Meeting, Wednesday, 7:15 p.m.–8:15 p.m. This panel discussion will focus on the current primary concerns for young mathematicians, with emphasis on audience participation.

Also see details about the poster session (Friday morning) and panel discussion (Thursday evening) cosponsored by YMN under the MAA's "Other Scientific Events" listings.

Others

Mathematical Sciences Institutes Reception, Wednesday, 5:30 p.m.–7:30 p.m. Meet old friends, reminisce about activities at a research institute, and learn about their future programs. Participating institutes include The Fields Institute for Research in Mathematical Sciences, The Institute

for Mathematics and Its Applications, The Mathematical Sciences Research Institute, The National Institute of Statistical Sciences, and The Center for Discrete Mathematics and Theoretical Computer Science.

University of Illinois Alumni Gathering, Friday, 5:00 p.m.–7:00 p.m.

Other Events of Interest

AMS Information Booth: All meeting participants are invited to visit the AMS Information Booth during the meeting. Complimentary coffee and tea will be served. A special gift will be available for participants, compliments of the AMS. The membership manager of the Society will be at the booth to answer questions about membership.

Book Sales and Exhibits: All participants are encouraged to visit the book, education media, and software exhibits from noon to 5:00 p.m. on Wednesday, 9:30 a.m. to 5:30 p.m. on Thursday and Friday, and 9:00 a.m. to noon on Saturday. Books published by the AMS and MAA will be sold at discounted prices somewhat below the cost for the same books purchased by mail. These discounts will be available only to registered participants wearing the official Meetings badge. Most major credit cards will be accepted for book sale purchases at the Meetings. Also, AMS electronic products and e-MATH will be demonstrated. Participants visiting the exhibits will be asked to display their Meetings badge or acknowledgment of advance registration from the Mathematics Meetings Service Bureau in order to enter the exhibit area.

Mathematical Sciences Employment Register: Those wishing to participate in the San Antonio Mathematical Sciences Employment Register should read carefully the important article about the Register beginning on page 1300 in the October issue of the *Notices* or at `http://www.ams.org/emp-reg/`.

Social Events

It is strongly recommended that tickets for these events be purchased through advance registration, since only a very limited number of tickets, if any, will be available for sale on-site. To get a 50% refund, returned tickets must be received by the Mathematics Meetings Service Bureau (MMSB) by December 30. After that date no refunds can be made. Special meals are available at all banquets upon advance request, but this must be indicated on the Advance Registration/Housing Form.

All participants are invited to a **dinner to honor AWM's Noether Lecturer** on Wednesday. A sign-up sheet for those interested will be located at the AWM table in the exhibit area and also at the AWM panel discussion.

AWM Reception: There is an open reception on Wednesday at 9:30 p.m. This has been a popular, well-attended event in the past.

MER Banquet: The Mathematicians and Education Reform (MER) Network welcomes all mathematicians who are interested in precollege, undergraduate, and/or graduate educational reform to attend the MER banquet on Thursday evening. This is an opportunity to make or renew contacts with other mathematicians who are involved in educational projects and to engage in lively conversation about educational issues. The after-dinner discussion is an open forum for participants to voice their impressions, observations, and analyses of the current education scene. There will be a cash bar beginning at 6:30 p.m. Dinner will be served at 7:30 p.m. Tickets are $39 each, including tax and gratuity.

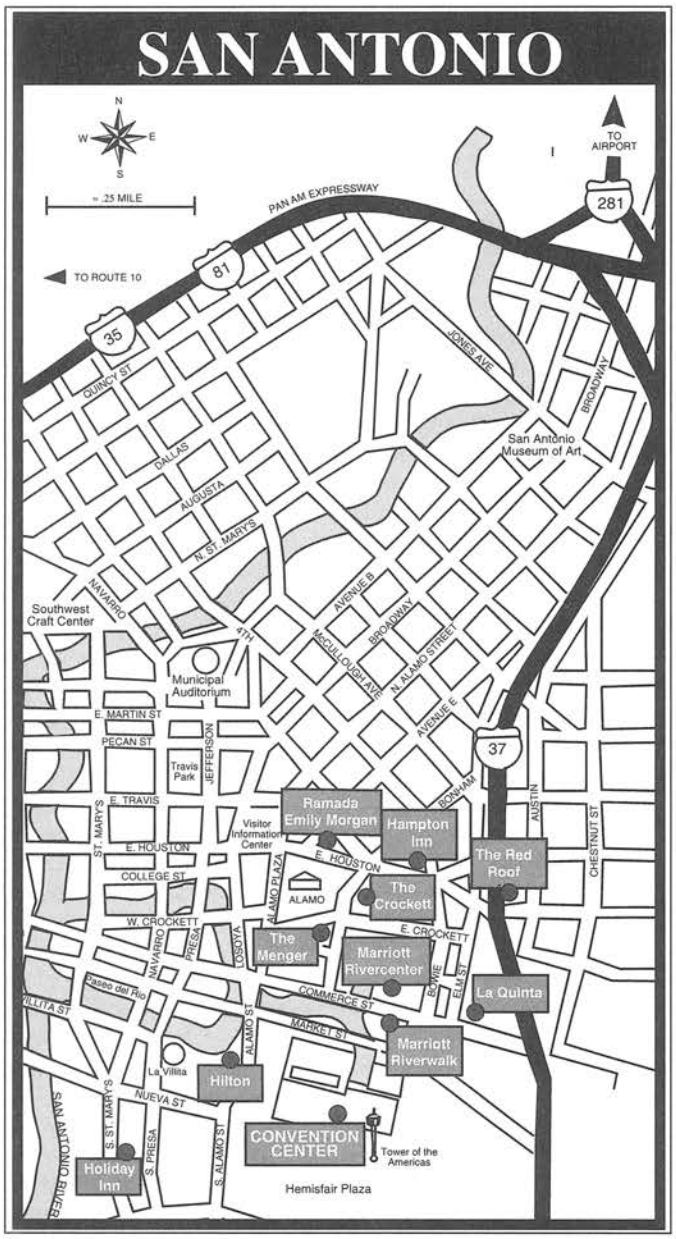
NAM Banquet: The National Association of Mathematicians will host a banquet on Friday evening. A cash bar reception will be held at 5:30 p.m. and dinner will be served at 6:00 p.m. Tickets are $39 each, including tax and gratuity.

AMS Banquet: As a fitting culmination to the meetings, the AMS banquet provides an excellent opportunity to socialize with fellow participants in a relaxed atmosphere. The banquet will honor Franklin P. Peterson and Robert M. Fossum. Peterson is retiring as AMS treasurer, a post he has held since 1973, making him the longest-serving treasurer in the history of the Society. Fossum is retiring as AMS secretary, having held that post since 1989. Please join your fellow meetings participants at the banquet to recognize the service these officers have provided to the Society. The banquet will be held on Saturday, with a cash bar reception at 6:30 p.m. and dinner at 7:30 p.m. Special door prizes will range in value from $50 to $100. Each attendee will receive a memento of the occasion. Tickets are $39 each, including tax and gratuity.

Registering in Advance and Hotel Accommodations

How to Register in Advance: The importance of advance registration cannot be overemphasized. Advance registration fees are considerably lower than the fees that will be charged for registration at the meeting. Participants registering by November 23 will receive their badges, programs, and tickets purchased in advance by mail two to three weeks before the Meetings, unless they check the appropriate box to the contrary on the Advance Registration/Housing Form. Because of delays that occur in U.S. mail to Canada, it is strongly suggested that advance registrants from Canada choose to pick up their materials at the Meetings. Because of delays that occur in U.S. mail to overseas, materials are never mailed overseas. There will be a special Registration Assistance Desk at the Joint Meetings to assist individuals who either do not receive this mailing or who have a problem with their registration. Please note that a $5 replacement fee will be charged for programs and badges that are mailed but not taken to San Antonio. Acknowledgments of registrations will be sent by e-mail to the e-mail addresses given on the Advance Registration/Housing Form. If you do not wish your registration acknowledged by e-mail, please mark the appropriate box on the form.

E-mail Advance Registration: This service is available for advance registration and housing arrangements by requesting the forms via e-mail from `meetreg-request@ams.`



org, or see http://www.ams.org/amsmtgs/2031_registration.html or http://www.ams.org/amsmtgs/2031_intro.html and look for "Registration". VISA, MasterCard, Discover, and American Express are the only methods of payment which can be accepted for e-mail advance registration, and charges to credit cards will be made in U.S. funds. Completed e-mail forms should be sent to meetreg-submit@ams.org. All advance registrants will receive acknowledgment of payment prior to the Meetings.

Internet Advance Registration: This service is available for advance registration and housing arrangements at http://www.ams.org/amsmtgs/2031_registration.html. VISA, MasterCard, Discover, and American Express are the only methods of payment which can be accepted for Internet advance registration, and charges to credit cards will be made in U.S. funds. All Internet advance registrants will receive instantaneous acknowledgment of payment upon submission of this form.

Cancellation Policy: Those who cancel their advance registration for the meeting, MAA Minicourses, or Short Courses by January 9 (the deadline for refunds for banquet tickets is December 30) will receive a 50% refund of fees paid. No refunds will be issued after this date. Requests for special consideration should be sent to the AMS Director of Meetings, P.O. Box 6887, Providence, RI 02940.

Joint Mathematics Meetings Registration Fees

	by Dec. 21	at meeting
Member of AMS, ASL, Canadian Mathematical Society, MAA	$160	$208
Temporarily Employed	120	133
Emeritus Member of AMS, MAA; Graduate Student; Unemployed; Librarian; High School Teacher; Developing Countries Special Rate	35	45
Undergraduate Student	20	26
Nonmember	248	322
High School Student	2	5
One Day Member of AMS, CMS, MAA	n/a	114
Nonmember	n/a	177
Nonmathematician Guest	5	5
Employment Register		
Employer (first table)	$200	$250
Employer (each additional table)	50	75
Applicant	40	75
Employer Posting Fee	50	N/A
AMS Short Course		
Students/Unemployed/Emeritus	$35	$45
All other participants	80	95
MAA Minicourses		
Minicourses #1,3,4,6,7,8,10,12,13,15,16	$55	$55*
Minicourses #2,5,9,11,14	75	75*
*if space is available		
MAA Short Course		
MAA Member	$125	$140
Nonmember	175	190
Students/Unemployed/Emeritus	50	60

Full-Time Students: Those currently working toward a degree or diploma. Students are asked to determine whether their status can be described as graduate (working toward a degree beyond the bachelor's), undergraduate (working toward a bachelor's degree), or high school (working toward a high school diploma) and to mark the Advance Registration/Housing Form accordingly.

Emeritus: Persons who qualify for emeritus membership in either the Society or the Association. The emeritus status refers to any person who has been a member of the AMS or MAA for twenty years or more and who retired because of age or long-term disability from his or her latest position.

Librarian: Any librarian who is not a professional mathematician.

Unemployed: Any person currently unemployed, actively seeking employment, and not a student. It is not intended to include any person who has voluntarily resigned or retired from his or her latest position.

Developing Country Participant: Any person employed in developing countries where salary levels are radically noncommensurate with those in the U.S.

Temporarily Employed: Any person currently employed but who will become unemployed by June 1, 1999, and who is actively seeking employment.

Nonmathematician Guest: Any family member or friend who is not a mathematician and who is accompanied by a participant of the meetings. These official guests will receive a badge and may attend all sessions and the exhibits.

Participants who are not members of the AMS and/or the MAA will receive mailings after the meetings are over with a special membership offer from AMS and MAA.

Advance registration and on-site registration fees only partially cover expenses of holding meetings. All mathematicians who wish to attend sessions are expected to register and should be prepared to show their badge if so requested. Badges are required to enter the exhibit area, to obtain discounts at the AMS and MAA Book Sales, and to cash a check with the Joint Meetings cashier. If a registrant should arrive too late in the day to pick up his/her badge, he/she may show the acknowledgment of advance registration received from the MMSB as proof of registration.

Advance registration forms accompanied by insufficient payment will either be returned, thereby delaying the processing of any housing request, or a $5 charge will be assessed if an invoice must be prepared to collect the delinquent amount. Overpayments of less than $5 will not be refunded.

For each invalid check or credit card transaction that results in an insufficient payment for registration or housing, a $5 charge will be assessed. Participants should check with their tax preparers for applicable deductions for education expenses as they pertain to these Meetings.

If you wish to be included in a **list of individuals sorted by mathematical interest**, please provide the one mathematical subject classification number of your major area of interest on the Advance Registration/Housing Form. (A list of these numbers is available by sending an empty e-mail message to `abs-submit@ams.org`; include the number 939 as the subject of the message.) The master copy of this list will be posted on the Meetings' bulletin board near the registration area.

If you do not wish to be included in any mailing list used for promotional purposes, please indicate this in the appropriate box on the Advance Registration/Housing Form.

Advance Registration Deadlines

There are three separate advance registration deadlines, each with its own advantages and benefits.

EARLY advance registration
(room lottery, inclusion in the Winter Lists for the Employment Register) **November 9**

ORDINARY advance registration
(hotel reservations, materials mailed) **November 23**

FINAL advance registration
(advance registration, Short Courses, Employment Register, MAA Minicourses, banquets) **December 21**

Early Advance Registration: Those who register by the **early** deadline of November 9 will be included in a random drawing to select winners of complimentary hotel rooms in San Antonio. Multiple occupancy is permissible. The location of rooms to be used in this lottery will be based on the number of complimentary rooms available in the various hotels. Therefore, the free room may not necessarily be in the winner's first choice hotel. The winners will be notified by mail prior to December 31. So register early! (See the list of the winners in Baltimore on the hotel page.)

Also, applicant and employer forms must be received by this deadline in order to be reproduced in the *Winter Lists* for the Employment Register.

Ordinary Advance Registration: Those who register after November 9 and by the **ordinary** deadline of November 23 may use the housing services offered by the MMSB but are not eligible for the room lottery.

Final Advance Registration: Those who register after November 23 and by the **final** deadline of December 21must pick up their badges, programs, and any tickets for social events at the meetings. Unfortunately, it is not possible to provide FINAL advance registrants with housing. Please note that the **December 21 deadline is firm**; any forms received after that date will be returned and full refunds issued. Please come to the Registration Desk in the convention center to register on site.

Hotel Reservations

Participants requiring hotel reservations should read the instructions on the following hotel pages. Participants who did not reserve a room during advance registration and would like to obtain a room at one of the hotels listed on the following pages should call the hotels directly after December 23. However, after that date the MMSB can no longer guarantee availability of rooms or special convention rates. Participants should be aware that most hotels are starting to charge a penalty fee to guests for departure changes made after guests have checked into their rooms. Participants should inquire about this at check-in and make their final plans accordingly.

Participants should also be aware that it is general hotel practice in most cities to hold a nonguaranteed reservation until 6:00 p.m. only. When one guarantees a reservation by paying a deposit or submitting a credit card number as a guarantee in advance, however, the hotel usually will honor this reservation up until checkout time the following day. If the individual holding the reservation has not checked in by that time, the room is then released for sale, and the hotel retains the deposit or applies one night's room charge to the credit card number submitted.

If you hold a guaranteed reservation at a hotel but are informed upon arrival that there is no room for you, there are certain things you can request the hotel do. First, they should provide for a room at another hotel in town for that

evening at no charge. (You already paid for the first night when you made your deposit.) They should pay for taxi fares to the other hotel that evening and back to the Meetings the following morning. They should also pay for one telephone toll call so that you can let people know you are not at the hotel you expected. They should make every effort to find a room for you in their hotel the following day and, if successful, pay your taxi fares to and from the second hotel so that you can pick up your baggage and bring it to the first hotel. Not all hotels in all cities follow this practice, so your request for these services may bring mixed results or none at all.

Miscellaneous Information

Audio-Visual Equipment: Standard equipment in all session rooms is one overhead projector and screen. (Invited 50-minute speakers are automatically provided with two overhead projectors.) Blackboards are not available. Organizers of sessions which by their nature demand additional equipment (e.g., VCR and monitor or projection panel) and where the majority of speakers in the session require this equipment should contact the audio-visual coordinator for the meetings at the AMS office in Providence at 401-455-4140 or by e-mail at `wsd@ams.org`, to obtain the necessary approvals. Individual speakers must consult with the session organizer(s) if additional equipment or services are needed. If your session has no organizer, please contact the audio-visual coordinator directly. All requests should be received by November 4.

Requests for equipment made at the Meetings most likely will not be granted because of budgetary restrictions. Unfortunately no audio-visual equipment can be provided for committee meetings or other meetings or gatherings not on the scientific program.

Child Care: The Marriott Rivercenter and Riverwalk hotels will arrange for in-room child care for Marriott guests through their concierge desks. Rates are $7/child with a four-hour minimum and an additional $10 fee to reimburse travel/parking expense for the child care provider. Call 210-223-1000 (Rivercenter) or 210-224-4555 (Riverwalk) at least five hours in advance. Arrangements represent a contractual agreement between each individual and the child care provider. The Joint Meetings assumes no responsibility for the services rendered.

E-mail at the Meeting: The AMS and MAA are grateful for the support of *Mathematica* (a product of Wolfram Research) in underwriting the considerable cost to establish e-mail facilities for Joint Mathematics Meetings participants. This e-mail facility will be available for participants during the meeting.

MATHEMATICA®

Information Distribution: Tables are set up in the exhibit area for dissemination of general information of possible interest to the members and for the dissemination of information of a mathematical nature not promoting a product or program for sale.

If a person or group wishes to display information of a mathematical nature promoting a product or program for sale, they may do so in the exhibit area at the Joint Books, Journals, and Promotional Materials exhibit for a fee of $50 per item. Please contact the exhibits manager, MMSB, P.O. Box 6887, Providence, RI 02940, for further details.

If a person or group would like to display material in the exhibit area separate from the Joint Books table, the proponent must reimburse the AMS and MAA for any extra furnishings requested (tables, chairs, easels, etc.) in addition to payment of the $50 per item fee. (This latter display is also subject to space availability.)

The administration of these tables is in the hands of the AMS-MAA Joint Meetings Committee, as are all arrangements for Joint Mathematics Meetings.

Local Information: The San Antonio Convention and Visitors Bureau maintains a home page on the WWW. Visit it at `http://www.sanantoniocvb.com/`.

Petition Table: At the request of the AMS Committee on Human Rights of Mathematicians, a table will be made available in the exhibit area at which petitions on behalf of named individual mathematicians suffering from human rights violations may be displayed and signed by meetings participants acting in their individual capacities. For details contact the director of meetings in the Providence office at 401-455-4137 or by e-mail at `hhd@ams.org`.

Signs of moderate size may be displayed at the table but must not represent that the case of the individual in question is backed by the Committee on Human Rights unless it has, in fact, so voted. Volunteers may be present at the table to provide information on individual cases, but notice must be sent at least seven days in advance of the Meetings to the director of meetings in the Providence office. Since space is limited, it may also be necessary to limit the number of volunteers present at the table at any one time. The Committee on Human Rights may delegate a person to be present at the table at any or all times, taking precedence over other volunteers.

Any material which is not a petition (e.g., advertisements, résumés) will be removed by the staff. At the end of registration on Saturday any material on the table will be discarded, so individuals placing petitions on the table should be sure to remove them prior to the close of registration.

Telephone Messages: The most convenient method for leaving a message is to do so with the participant's hotel. Another method would be to leave a message at the Meeting Registration Desk from January 13 through 16 during the hours that the desk is open. These messages will be posted on the Math Meetings Message Board; however, staff at the desk will try to locate a participant in the event of a bona fide emergency. The telephone number will be published in the program.

Travel: The San Antonio International Airport is approximately ten miles from downtown San Antonio and is served by several major air carriers.

Delta Air Lines has been selected as the official airline for these meetings because of its generally convenient schedules to San Antonio. Given the volatility in airfares because of "fare wars", we cannot guarantee that these will be the lowest fares when you make your arrangements. However, we strongly urge participants to make use of

How to Obtain Hotel Accommodations

Room Lottery: (See the *How to Register in Advance* section to learn how to qualify for this year's lottery.) Here are last year's winners:

Jeffrey Adler, Li Aihua, Mohammad K. Azarian, Nicole Betsinger, Harvey Blau, Jack Bookman, Cathy Carter, Wayne Cassel, Ellen Cunningham, Randy Crist, Laura Hegerle, Bill Heller, Gene Herman, Shirley Huffman, Erica Johnson, S. Karmakar, Harvey Keynes, Mauricio Mata, Michael Marcozzi, John W. Neuberger, Alice Schaffer, Anurag Singh, Jennifer Slimowitz, Darrin Spiegel

General Instructions: Participants must register in advance in order to obtain hotel accommodations through the Mathematics Meetings Service Bureau (MMSB). Special meeting rates at the hotels listed below can be obtained only by making reservations through the MMSB. Reservations mistakenly taken by hotels directly may be subject to an increased rate. Participants interested in suites are urged to call the hotels directly for details on configurations, prices, etc.; however, all hotel reservations can only be made by completing the Housing section of the **Advance Registration/Housing (ARH) Form** by **November 23**. Hotels will accept reservations, based on availability, directly after **December 23**.

$ Rates:

- subject to 15% sales/occupancy tax
- only certified students or unemployed mathematicians qualify for student rates
- see ARH Form for detailed rate structure of each property

$ Room Payments/Cancellations:

- all major credit cards
- personal checks with personal ID and/or credit card backup at all properties except the Red Roof Inn
- 72-hour cancellation policy for all hotels except both Marriotts and La Quinta (48 hours), Hilton, Red Roof, and Holiday Inn (4:00 p.m. on day of arrival), and Menger (24 hours)

$ Guarantee Requirements:

- one night deposit by check or
- credit card: VISA, MC, AMEX (cards may be charged one night deposit)

☎ Hotel Information:

- children free, where appropriate, in existing beds only
- limited availability of cribs, but provided free unless otherwise noted
- check-in: 3 or 4 p.m. / check-out: 11 a.m. or noon
- distances to north side (where sessions will be) of Henry B. Gonzales Convention Center (CC) indicated under each caption
- parking rates listed below are daily and include in/out privileges
- windows do not open in most hotels unless otherwise indicated
- hotels with no restaurant on property are located within 2 blocks from a restaurant

Special Services:

- all hotels, with the exception of historical hotels, are working toward being in compliance with the Americans with Disabilities Act (ADA); historic properties indicated, where applicable
- special needs should be clearly indicated on the ARH form
- nonsmoking rooms available at all properties

Deadlines:

- room lottery qualification: **November 9**
- reservations through MMSB: **November 23**
- changes/cancellations through MMSB: **December 11**
- convention rates **based on availability only** after December 23

Marriott Rivercenter
(co-headquarters)
(.10 mile to CC)

101 Bowie Street
San Antonio, TX 78205
(210) 223-1000
single - $121, double - $135
student single/double - $95

restaurants; bars/lounges; indoor/outdoor pools; health club; business center; laundry room; connected to Rivercenter Mall; parking - $10 (self), $13 (valet); in all rooms – coffee maker, hair dryer, iron/ironing board, king or queen beds, desk, dataport; children under 18 years free

Marriott Riverwalk
(.06 mile to CC/across the street)

711 East Riverwalk
San Antonio, TX 78205
(210) 224-4555
single/double - $119
student single/double - $91

restaurant; bar/lounge; food court; laundry room; indoor/outdoor pool; health club; parking - $10 (self) & $13 (valet); in all rooms - coffee maker, hair dryer, iron/ironing board, king or double beds, desk, 2 telephones (not 2 lines), windows open; dataport; rooms facing the river have balconies; children under 18 years free

Hilton Palacio Del Rio
(.10 mile CC/across the street from the south side of CC/**location of MAA Board of Governors and AMS Council meetings**)

200 South Alamo
San Antonio, TX 78205-2711
(210) 222-1400
single/double - $119
student single/double - $109

restaurants; bars/lounges; gift shop; business center; laundry room; outdoor pool; fitness room; parking - $8.50 (self) & $19.50 (valet); in all rooms – king or double beds, iron/ironing board, hair dryer, coffee maker, king or double beds, desk, dataport, balcony; checkout penalty - $25; children under 18 years free

Ramada Emily Morgan
(.40 mile to CC)

705 E. Houston Street
San Antonio, TX 78205
(210) 225-8486
Single - $95, double - $105
Student single - $85, double - $95

Restaurant; bar/lounge; gift shop; outdoor pool; health club with dry saunas; parking - $8 (self); business center; in all rooms – hair dryer, coffee maker, iron/ironing board, dataport, desk, king or double beds; most rooms have jacuzzi tubs; rooms with jacuzzi tubs have refrigerators; children under 18 years free

The Menger
(.20 mile to CC)

204 Alamo Plaza
San Antonio, TX 78205
(210) 223-4361
single - $89, double - $99
student single - $79, double - $89

restaurant; bar/lounge; visitor center; outdoor heated pool; fitness center; spa; multiple gift shops; parking - $8 (self) & $12 (valet); in all rooms – king or 2 queen beds, iron/ironing board, hair dryer, windows open, dataport; king rooms very limited and are not wheelchair accessible; children under 18 years free; historical property

(Continued on next page)

How to Obtain Hotel Accommodations (Continued)

La Quinta Convention Center
(.10 mile to CC)

1001 East Commerce Street
San Antonio, TX 78205-3303
(210) 222-9181
single - $89, double - $99

complimentary continental breakfast; outdoor pool; free parking; in all rooms – coffee maker, dataport, king or double beds, windows open; children under 18 years free

The Crockett
(.20 mile to CC/behind the Alamo)

320 Bonham Street
San Antonio, TX 78205-2083
(210) 225-6500, (800) 292-1050
single/double - $85
student single/double - $75

restaurants; bar; outdoor pool; parking - $11 (valet); in all rooms - hair dryer, coffee maker, dataport, iron/ironing board, king or double beds; all children free (maximum of 4 persons in room); some double rooms have pull-out sofas; historical property

Holiday Inn Express & Suites
(.20 mile to CC)

524 S. St. Mary's Street
San Antonio, TX 78205
(210) 354-1333
single/double - $81
student single/double - $79

all suite hotel; 24-hour refreshment center; complimentary continental breakfast; outdoor pool; fitness center; business center; parking - $5 (self & valet); in all suites – microwave, dataport, refrigerator, wet bar, desk, coffee maker, iron/ironing board, king or 2 double beds, windows open; no charge for children or additional persons

Hampton Inn (Riverwalk Area)
(.30 mile to CC/2 blocks from Alamo, Riverwalk, and Rivercenter Mall)

414 Bowie Street
San Antonio, TX 78205
(210) 225-8500
single/double - $75
student single/double - $65

complimentary continental breakfast; complimentary 24-hour coffee/tea in lobby; outdoor pool; free parking; in all rooms – coffee maker, iron/ironing board, dataport, king or 2 double beds, some kings have sofa sleeper; children under 18 years free

Red Roof Inn
(.4 mile to CC/on trolley route)

1011 E. Houston Street
San Antonio, TX 78205
(210) 229-9973
single/double - $64.99

complimentary continental breakfast; outdoor pool; free parking; complimentary 24-hour coffee/tea in lobby; in all rooms – king or 2 double beds, dataport; children under 18 years free; **personal checks not accepted**

Alternative Housing

For your convenience, we also list the following inexpensive properties that can be called directly for reservations:

Days Inn / Downtowner Motel
(.30 mile from CC)
902 E. Houston Street
San Antonio, TX 78205
(210) 227-6233
(800) DAYS-INN

La Quinta Market Square
(1.5 miles to CC)
900 Dolorosa
San Antonio, TX 78207
(210) 271-0001
(800) 531-5900

Super 8 Motel
(1.2 miles to CC)
1614 N. St. Mary's
San Antonio, TX 78215
(210) 222-8833

Attention Students!

As another alternative to housing choices listed above and for your convenience, we list a student hostel located in San Antonio:

San Antonio International AYH-Hostel
(2 miles to CC/on bus route)
621 Pierce Street
San Antonio, TX 78208
(210) 223-9426

Rates, including tax, are $14 per person for AYH members and $17 per person for nonmembers. There is an additional $10 refundable key fee. Please call the number listed above for further information.

this special deal if at all possible, since the AMS and MAA can earn complimentary tickets on Delta. These tickets are used to send meetings' staff (not officers or other staff) to the Joint Mathematics Meetings, thereby keeping the costs of the Meetings (and registration fees) down.

The following specially negotiated rates are available only for these Meetings and exclusively to mathematicians and their families for the period January 10–19, 1999, on Delta Air Lines:

• 5% discount off published round-trip fares within the continental U.S., Hawaii, Alaska, Canada, Mexico, Bermuda, San Juan, Nassau, and the U.S. Virgin Islands. Some restrictions apply and seats are limited (no discounts apply on Delta Express). By purchasing your ticket 60 days or more prior to departure, you can receive an additional 5% bonus discount.

• 10% discount on Delta's domestic system for travel based on the published unrestricted round-trip coach (Y06) rates. No advance reservations or ticketing is required; however, by purchasing your ticket 60 days or more prior to departure, you can receive an additional 5% bonus discount. (No discounts on Delta Express.)

• Special guaranteed round-trip Zone Fares to all cities served by Delta and Delta Express in the continental U.S., Hawaii, Alaska, Canada, Mexico, Bermuda, San Juan, Nassau, and the U.S. Virgin Islands. For savings on midweek travel. Two-day minimum stay; no Saturday night stay required; seven days advanced reservations and ticketed. Fares are fully refundable, less administrative service fee. Zone Fares are not valid for destinations served only by a Delta Connection® carrier.

For reservations call (or have your travel agent call) Delta Meeting Network® Reservations at 800-241-6760 weekdays between 7:30 a.m. and 11:00 p.m. (8:30 a.m.–11:00 p.m. on weekends) Eastern Standard Time. Refer to **file number 117809A**. These discounts are available only through Delta Meeting Network® Reservation toll-free number.

From the Airport to Downtown: Star Shuttle is the official airport shuttle, operating 24 hours a day, departing every 15 minutes. The fare is $7 one way, or $13 round trip. Call 210-341-6000 for reservations; pickup is outside baggage claim.

Cab fare is approximately $13 (plus tip) for from one to four passengers from the airport to the Convention Center.

Alamo Rent-A-Car is offering special convention car rental rates for the Meetings, effective January 4–23, 1999. All Alamo rentals include unlimited free mileage. The following rates are available to renters 25 years and older:

Car Rental Rates	Daily	Weekly
Economy	$28	$120
Compact	31	130
Midsize	34	145
Full size	40	170
Convertible	55	249
Minivan	54	259
Luxury	59	279

Reservations must be made at least 24 hours in advance. Convention rates may be limited. Drop-off charges, fuel, taxes, optional items, and access taxes/fees as imposed by the airport may be assessed. The 24-hour toll-free reservation number is 800-732-3232; cite group **ID#247733** and rate code **GR.**

Driving Directions: From IH-35 North take IH-37 South to the downtown area. Exit Commerce St. and drive west for two blocks. The Marriott Rivercenter is on your right. The Convention Center is one block south of the hotel. From IH-10 West take IH-35 North and follow the directions above. From IH-10 East take IH-37 North to the Commerce St. exit. Drive west on Commerce St. The Marriott Rivercenter is three blocks on your right, and the Convention Center is one block south of the hotel.

Railway Transportation: For information on AMTRAK call 800-872-7245.

Weather: January weather in San Antonio is generally mild. Normal daily maximum and minimum temperatures are 62 ° F (17 ° C) and 42 ° F (5 ° C). Average precipitation is about 1.5 inches.

For more current information use your favorite net search engine or try the sites: `http://www.usatoday.com/weather/basemaps/nw724060.htm` or `http://www.weather.com/us/cities/TX_SanAntonio.html`.

Gainesville, Florida

University of Florida

March 12–13, 1999

Meeting #940

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: Expired
For consideration of contributed papers in Special Sessions: November 25, 1998
For abstracts: January 20, 1999

Invited Addresses

Alexander N. Dranishnikov, University of Florida, *Title to be announced.*

Gregory F. Lawler, Duke University, *Title to be announced.*

Michael P. Loss, Georgia Institute of Technology, *Title to be announced.*

John G. Thompson, University of Florida, *Title to be announced.*

Special Sessions

Algebraic and Geometric Combinatorics (Code: AMS SS P1), **Andrew J. Vince** and **Neil L. White**, University of Florida.

Analytical Problems in Mathematical Physics (Code: AMS SS M1), **Eric A. Carlen**, Georgia Institute of Technology, and **Laszlo Erdos**, Courant Institute, New York University.

Computability Theory (Code: AMS SS G1), **Douglas Cenzer**, University of Florida, **Geoffrey Louis LaForte**, University of West Florida, and **Rick L. Smith**, University of Florida.

Continuum Theory and Dynamical Systems (Code: AMS SS A1), **Philip Boyland** and **Beverly Brechner**, University of Florida, and **John Mayer**, University of Alabama at Birmingham.

Ergodic Theory and Dynamical Systems (Code: AMS SS R1), **Jonathan L. F. King**, University of Florida.

Finite Groups and Their Representations (Code: AMS SS D1), **Alexandre Turull**, University of Florida.

Galois Theory (Code: AMS SS E1), **J. G. Thompson** and **H. Voelklein**, University of Florida.

Geometric Topology (Code: AMS SS H1), **James E. Keesling** and **Alexander N. Dranishnikov**, University of Florida.

Geometry of Interacting Particles, Random Walks, and Brownian Motion (Code: AMS SS N1), **Irene Hueter**, University of Florida, and **Gregory F. Lawler**, Duke University.

Groups and Geometries (Code: AMS SS F1), **Chat Ho** and **Peter Sin**, University of Florida.

Linear Operator Theory (Code: AMS SS J1), **Leiba Rodman**, College of William & Mary, and **Scott A. McCullough**, University of Florida.

Markov Processes and Potential Theory (Code: AMS SS C1), **Joe Glover** and **Murali Rao**, University of Florida.

Partial Differential Equations and Applications (Code: AMS SS K1), **Gang Bao** and **Yun-mei Chen**, University of Florida.

Probability on Algebraic Structures (Code: AMS SS Q1), **Gregory M. Budzban** and **Philip Feinsilver**, Southern Illinois University at Carbondale, and **Arunava Mukherjea**, University of South Florida.

Structure and Representation Theory of Lattice-Ordered Groups and f-Rings (Code: AMS SS L1), **Jorge Martinez**, University of Florida.

The Erdős Legacy and Connections to Florida (Code: AMS SS B1), **Krishnaswami Alladi** and **Jean Larson**, University of Florida.

Urbana, Illinois

University of Illinois, Urbana-Champaign

March 18–21, 1999

Meeting #941

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: Expired
For consideration of contributed papers in Special Sessions: December 2, 1998
For abstracts: January 27, 1999

Invited Addresses

Alexander Beilinson, MIT, *Title to be announced.*

Alexandra Bellow, Northwestern University, *Title to be announced.*

Igor Krichever, Columbia University, *Title to be announced.*

Steven Rallis, Ohio State University, *Title to be announced.*

Trevor Wooley, University of Michigan, *Title to be announced.*

Special Sessions

Algebraic K-Theory (and the 5th Annual Great Lakes K-Theory Conference (Code: AMS SS H1), **Daniel Grayson**, University of Illinois, Urbana.

Combinatorial Designs (Code: AMS SS M1), **Ilene H. Morgan**, University of Missouri-Rolla, and **Walter D. Wallis**, Southern Illinois University-Carbondale.

Commutative Algebra (Code: AMS SS P1), **Joseph Brennan**, North Dakota State University, and **Sankar Dutta**, **Robert Fossum**, and **Phillip Griffith**, University of Illinois, Urbana.

Diophantine Equations, Inequalities and Related Arithmetic Problems (Code: AMS SS F1), **Michael Bennett**, University of Illinois, Urbana, and **Trevor Wooley**, University of Michigan.

Elementary and Analytic Number Theory (Code: AMS SS E1), **Harold G. Diamond** and **A. J. Hildebrand**, University of Illinois, Urbana.

Galois Representations (Code: AMS SS C1), **Nigel Boston**, University of Illinois, Urbana, and **Michael Larsen**, University of Missouri.

Graph Theory (Code: AMS SS G1), **Douglas B. West**, University of Illinois, Urbana.

Holomorphic Vector Bundles and Complex Geometry (Code: AMS SS L1), **Maarten Bergvelt**, **Steven Bradlow**, and **John P. D'Angelo**, University of Illinois, Urbana, and **Lawrence Ein**, University of Illinois, Chicago.

Integrable Equations (Code: AMS SS I1), **Igor Krichever**, Columbia University, and **Kirill Vaninsky**, Kansas State University.

Low-Dimensional Topology (Code: AMS SS O1), **Mark Brittenham**, University of North Texas, **Charles Delman**, Eastern Illinois University, and **Rachel Roberts**, Washington University.

Martingales and Analysis (Code: AMS SS D1), **Joseph Max Rosenblatt**, **Renming Song**, and **Richard B. Sowers**, University of Illinois, Urbana.

Nonstandard Analysis (Code: AMS SS B1), **C. Ward Henson** and **Peter Loeb**, University of Illinois, Urbana.

Operator Spaces and Their Applications (Code: AMS SS J1), **Gilles Pisier**, Texas A&M, and **Zhong-Jin Ruan**, University of Illinois, Urbana.

Optimization Problems in Geometry (Code: AMS SS N1), **Robert Kusner**, University of Massachusetts, Amherst, and **John M. Sullivan**, University of Illinois, Urbana.

Recent Progress in Elementary Geometry (Code: AMS SS A1), **John E. Wetzel**, University of Illinois, Urbana, and **Clark Kimberling**, University of Evansville.

Symplectic Geometry and Topology (Code: AMS SS K1), **Eugene M. Lerman** and **Susan Tolman**, University of Illinois, Urbana.

Wavelet Analysis and Multiresolution Methods (Code: AMS SS Q1), **Tian-Xiao He**, Illinois Wesleyan University.

Las Vegas, Nevada

University of Nevada, Las Vegas

April 10–11, 1999

Meeting #942

Western Section
Associate secretary: Bernard Russo
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 23, 1998
For abstracts: February 17, 1999

Special Sessions

Analysis and Geometry (Code: AMS SS I1), **Peter Li** and **Song-Ying Li**, University of California, Irvine.

Combinatorial Theory (Code: AMS SS G1), **Kequan Ding**, University of Illinois, Urbana, **Peter Shiue**, University of Las Vegas, Nevada, and **Yeong-Nan Yeh**, Academia Sinica.

Control and Dynamics of Partial Differential Equations (Code: AMS SS A1), **Zhonghai Ding**, University of Nevada, Las Vegas.

Diophantine Problems (Code: AMS SS J1), **Arthur Baragar**, University of Nevada, Las Vegas, and **Michael Bennett**, University of Illinois.

Geometric Group Theory (Code: AMS SS H1), **Eric M. Freden**, Southern Utah University, and **Eric Lewis Swenson**, Brigham Young University.

Graph Theory (Code: AMS SS B1), **Hung-Lin Fu**, University of National Chiao, Tung University-Taiwan, **Chris A. Rodger**, Auburn University, and **Michelle Schultz**, University of Nevada, Las Vegas.

Invariants, Distributions, Differential Operators and Harmonic Analysis (Code: AMS SS K1), **Ronald L. Lipsman**, University of Maryland, College Park.

Nonlinear PDEs—Methods and Applications (Code: AMS SS C1), **David Costa**, University of Nevada, Las Vegas.

Number Theory (Code: AMS SS F1), **Gennady Bachman**, University of Nevada, Las Vegas, **Richard A. Mollin**, University of Calgary, and **Peter J. Shiue**, University of Nevada, Las Vegas.

Numerical Analysis and Computational Mathematics (Code: AMS SS E1), **Jun Zhang**, University of Minnesota and University of Kentucky, and **Jennifer Zhao**, University of Michigan, Dearborn.

Set Theory (Code: AMS SS D1), **Douglas Burke** and **Derrick BuBose**, University of Nevada, Las Vegas.

Buffalo, New York

State University of New York at Buffalo

April 24–25, 1999

Meeting #943

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: Expired
For consideration of contributed papers in Special Sessions: January 6, 1999
For abstracts: March 3, 1999

Invited Addresses

Michele M. Audin, University of Louis Pasteur, *Title to be announced.*

Russel Caflisch, University of California, Los Angeles, *Title to be announced.*

Jeff Smith, Purdue University, *Title to be announced.*

Alexander Voronov, MIT, *Title to be announced.*

Gregg J. Zuckerman, Yale University, *Title to be announced.*

Special Sessions

Combinatorics and Graph Theory (Code: AMS SS C1), **Harris Kwong**, SUNY College at Fredonia.

Complex Geometry (Code: AMS SS G1), **Terrence Napier**, Lehigh University, and **Mohan Ramachandran**, State University of New York at Buffalo.

Knot and 3-Manifolds (Code: AMS SS E1), **Thang T.S. Q. Le**, State University of New York at Buffalo, **William W. Menasco**, SUNY at Buffalo, and **Morwen B. Thistlethwaite**, University of Tennessee.

Mathematical Physics (Code: AMS SS D1), **Jonathan Dimock**, SUNY at Buffalo.

Representations of Lie Algebras (Code: AMS SS F1), **Duncan J. Melville**, Saint Lawrence University.

Smooth Categories in Geometry and Mechanics (Code: AMS SS A1), **F. William Lawvere**, SUNY at Buffalo.

Thin Films: Solid and Liquid (Code: AMS SS B1), **E. Bruce Pitman**, SUNY at Buffalo, and **Brian Spencer**, State University of New York at Buffalo.

Denton, Texas

University of North Texas

May 19–22, 1999

Meeting #944

Fourth International Joint Meeting of the AMS and the Sociedad Matemática Mexicana (SMM).
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: January 1999
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: None
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: March 25, 1999

Melbourne, Australia

Melbourne, Australia

July 12–16, 1999

Meeting #945

First International Joint Meeting of the American Mathematical Society and the Australian Mathematical Society
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: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Invited Addresses

Jennifer Chayes, Microsoft, *Title to be announced.*

Michael Eastwood, University of Adelaide, *Title to be announced.*

Vaughan Jones, University of California, Berkeley, *Title to be announced.*

Hyam Rubinstein, Melbourne University, *Title to be announced.*

Richard M. Schoen, Stanford University, *Title to be announced.*

Neil Trudinger, Australian National University, *Title to be announced.*

Special Sessions

Discrete Groups (Code: AMS SS H1), **Marston Conder, Gaven Martin**, and **Eamonn O'Brien**, University of Auckland.

Fluid Dynamics (Code: AMS SS C1), **Susan Friedlander**, Northwestern University, and **Roger H. J. Grimshaw**, Monash University.

Geometric Themes in Group Theory (Code: AMS SS A1), **Gustav I. Lehrer**, University of Sydney, **Cheryl E. Praeger**, University of Western Australia, and **Stephen D. Smith**, University of Illinois, Chicago.

Low Dimensional Topology (Code: AMS SS D1), **William H. Jaco**, Oklahoma State University, and **Hyam Rubinstein**, Melbourne University.

Mathematical Physics: Many Body Systems (Code: AMS SS B1), **Alan L. Carey**, University of Adelaide, **Paul A. Pearce**, University of Melbourne, and **Mary Beth Ruskai**, University of Massachusetts, Lowell.

Mathematics Learning Centers (Code: AMS SS G1), **Judith Baxter**, University of Illinois, Chicago, **Jackie Nicholas**, University of Sydney, and **Jeanne Wald**, Michigan State University.

Moduli Spaces of Riemann Surfaces, Mapping Class Groups and Invariants of 3-Manifolds (Code: AMS SS F1), **Ezra Getzler**, Northwestern University, and **Richard Hain**, Duke University.

Probability Theory and Its Applications (Code: AMS SS E1), **Timothy Brown**, University of Melbourne, **Phil Pollett**, University of Queensland, and **Ruth J. Williams**, University of California, San Diego.

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

Special Sessions

Algebraic and Geometric Combinatorics (Code: AMS SS A1), **Vesselin N. Gasharov**, Cornell University, and **Ira M. Gessel**, Brandeis University.

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

Invited Addresses

Mikhail Kapranov, Northwestern University, *Title to be announced.*

John Roe, Oxford University and Pennsylvania State University, *Title to be announced.*

Catherine Sulem, University of Toronto, *Title to be announced.*

Tatiana Toro, University of Washington, *Title to be announced.*

Special Sessions

Approximation Theory (Code: AMS SS B1), **Michael Prophet**, Murray State University.

The Development of Topology in the Americas (Code: AMS SS A1), **Cameron Gordon**, University of Texas, Austin, and **Ioan Mackenzie James**, University of Oxford.

Washington, District of Columbia

Marriott Wardman Park 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: Robert M. Fossum
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

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

Lafayette, Louisiana

University of Southwestern Louisiana

April 14–16, 2000

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: July 14, 1999
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Odense, Denmark

Location to be announced

June 12–15, 2000

First AMS-Scandinavian International Mathematics Meeting. Sponsored by the AMS, Dansk Matematisk Forening, Suomen matemaattinen yhdistys, Icelandic Mathematical Society, Norsk Matematisk Forening, and Svenska matematikersamfundet.
Associate secretary: Robert M. Fossum
Announcement issue of *Notices*: To be announced
Program issue of *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Toronto, Ontario, Canada

University of Toronto

September 22–24, 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: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

New York, New York

Columbia University

November 3–5, 2000

Southeastern 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: February 3, 2000
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

Hoboken, New Jersey

Stevens Institute of Technology

April 28–29, 2001

Southeastern 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 28, 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

San Diego, California

San Diego Convention Center

January 6–9, 2002

Joint Mathematics Meetings, including the 108th Annual Meeting of the AMS and 85th Meeting of the Mathematical Association of America (MAA).
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: April 4, 2001
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

San Antonio Timetable

JOINT MATHEMATICS MEETINGS

San Antonio ★ Texas

January 13–16, 1999

NOTE: CC = Henry B. Gonzales Convention Center

MONDAY, JANUARY 11

9:00 a.m. — 5:00 p.m. **AMS SHORT COURSE ON NONLINEAR CONTROL**, Salon del Rey North, Hilton Palacio del Rio

9:00 a.m. — 5:00 p.m. **MAA SHORT COURSE ON MATHEMATICS IN FINANCE**, Salon del Rey Central, Hilton Palacio del Rio

TUESDAY, JANUARY 12

8:30 a.m. — 4:00 p.m. **MAA BOARD OF GOVERNORS**, Salon del Rey South, Hilton Palacio del Rio

9:00 a.m. — 5:00 p.m. **AMS SHORT COURSE ON NONLINEAR CONTROL**, Salon del Rey North, Hilton Palacio del Rio

9:00 a.m. — 5:00 p.m. **MAA SHORT COURSE ON MATHEMATICS IN FINANCE**, Salon del Rey Central, Hilton Palacio del Rio

1:00 p.m. — 10:00 p.m. **AMS COUNCIL**, El Mirador, Hilton Palacio del Rio

3:00 p.m. — 7:00 p.m. **JOINT MEETINGS REGISTRATION**, South Exhibit Hall, CC

5:30 p.m. — 10:00 p.m. **MATHCHATS AND GRADUATE STUDENT RECEPTION**

WEDNESDAY, JANUARY 13

7:30 a.m. — 4:00 p.m. **JOINT MEETINGS REGISTRATION**, South Exhibit Hall, CC

7:30 a.m. — 4:00 p.m. **MATHEMATICAL SCIENCES EMPLOYMENT REGISTER REGISTRATION** *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)*, South Exhibit Hall, CC

8:00 a.m. — 10:55 a.m. **AMS-MAA-MER SPECIAL SESSION ON MATHEMATICS AND EDUCATION REFORM, I**

8:00 a.m. — 10:55 a.m. **AMS-ASL SPECIAL SESSION ON MODEL THEORY AND ITS APPLICATIONS, I**

AMS SPECIAL SESSIONS

8:00 a.m. — 10:55 a.m. *Banach Spaces of Holomorphic Functions and Operators on These Spaces, I*
8:00 a.m. — 10:55 a.m. *Commutative Algebra, I*
8:00 a.m. — 10:55 a.m. *Combinatorial Topology, I*
8:00 a.m. — 10:55 a.m. *Development of Electronic Communications in Mathematics, I*
8:00 a.m. — 10:55 a.m. *The Functional and Harmonic Analysis of Wavelets, I*
8:00 a.m. — 10:55 a.m. *Discrete Models and Difference Equations, I*
8:00 a.m. — 10:55 a.m. *Mathematics Education and Mistaken Philosophies of Mathematics, I*
8:00 a.m. — 10:55 a.m. *Recent Developments in Differential Geometry, I*
8:00 a.m. — 10:55 a.m. *Singularities in Algebraic and Analytic Geometry, I*
8:00 a.m. — 10:55 a.m. *Hamiltonian Mechanics: Applications to Celestial Mechanics and Chemistry, I*

8:00 a.m. — 10:00 a.m. **AMS SESSIONS FOR CONTRIBUTED PAPERS**

8:00 a.m. — 10:00 a.m. **MAA MINICOURSE #1: PART A** *Mathematics, calculus, and modeling using the TI-92.*

8:00 a.m. — 10:00 a.m. **MAA MINICOURSE #3: PART A** *Developing materials for liberal arts mathematics that use elementary graph theory and emphasize applications to everyday experience.*

8:00 a.m. — 10:00 a.m.	**MAA MINICOURSE #4: PART A** *The mathematics of the perfect shuffle.*
	MAA CONTRIBUTED PAPER SESSIONS
8:00 a.m. — 10:55 a.m.	*The Use of Technology in Teaching Abstract Mathematics, I*
8:00 a.m. — 10:55 a.m.	*Quantitative Literacy, I*
8:00 a.m. — 10:55 a.m.	*Teaching Statistics: Teaching the Reasoning and New Technological Tools, I*
8:00 a.m. — 10:55 a.m.	*Mathematics Competitions, I*
8:00 a.m. — 9:20 a.m.	**MAA COMMITTEE ON THE PROFESSION PANEL DISCUSSION** *A dean's view of mathematics departments.*
8:00 a.m. — 10:55 a.m.	**MAA SPECIAL PRESENTATION** *The use of history in the teaching of mathematics.*
10:05 a.m. — 10:55 a.m.	**AMS INVITED ADDRESS** *Geometry of soliton equations.* **Chuu-Lian Terng**
11:10 a.m. — noon	**AMS-MAA INVITED ADDRESS** *Title to be announced.* **Jennifer Tour Chayes**
noon — 5:00 p.m.	**BOOKS SALES AND EXHIBITS**, South Exhibit Hall, CC
1:00 p.m. — 2:00 p.m.	**AMS COLLOQUIUM LECTURES: LECTURE I** *Symplectic geometry from a dynamical systems point of view: Part 1.* **Helmut Hofer**
2:15 p.m. — 3:05 p.m.	**MAA INVITED ADDRESS** *Extending and generalizing the Pascal Triangle: An interplay of algebra and geometry.* **Jean Pedersen**
2:15 p.m. — 6:00 p.m.	**AMS-MAA-MER SPECIAL SESSION ON MATHEMATICS AND EDUCATION REFORM, II**
2:15 p.m. — 6:00 p.m.	**AMS-ASL SPECIAL SESSION ON MODEL THEORY AND ITS APPLICATIONS, II**
	AMS SPECIAL SESSIONS
2:15 p.m. — 6:00 p.m.	*Banach Spaces of Holomorphic Functions and Operators on These Spaces, II*
2:15 p.m. — 6:00 p.m.	*Commutative Algebra, II*
2:15 p.m. — 6:00 p.m.	*Combinatorial Topology, II*
2:15 p.m. — 6:00 p.m.	*Development of Electronic Communications in Mathematics, II*
2:15 p.m. — 6:00 p.m.	*The Functional and Harmonic Analysis of Wavelets, II*
2:15 p.m. — 6:00 p.m.	*Discrete Models and Difference Equations, II*
2:15 p.m. — 6:00 p.m.	*Mathematics Education and Mistaken Philosophies of Mathematics, II*
2:15 p.m. — 6:00 p.m.	*Recent Developments in Differential Geometry, II*
2:15 p.m. — 6:00 p.m.	*Singularities in Algebraic and Analytic Geometry, II*
2:15 p.m. — 6:00 p.m.	*Hamiltonian Mechanics: Applications to Celestial Mechanics and Chemistry, II*
2:15 p.m. — 6:00 p.m.	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
2:15 p.m. — 4:15 p.m.	**MAA MINICOURSE #10: PART A** *Facilitating active learning: Concrete ways to foster student participation.*
2:15 p.m. — 4:15 p.m.	**MAA MINICOURSE #13: PART A** *Getting students involved in undergraduate research.*
2:15 p.m. — 4:15 p.m.	**MAA MINICOURSE #2: PART A** *Mathematical finance.*
2:15 p.m. — 4:15 p.m.	**MAA MINICOURSE #8: PART A** *Teaching a course in the history of mathematics.*
	MAA CONTRIBUTED PAPER SESSIONS
2:15 p.m. — 6:15 p.m.	*Innovations in Teaching Abstract Algebra*
2:15 p.m. — 6:15 p.m.	*Ethical, Humanistic, and Artistic Mathematics, I*
3:20 p.m. — 4:10 p.m.	**MAA INVITED ADDRESS** *The symmetries of things: Real and conceptual.* **John H. Conway**
3:20 p.m. — 4:20 p.m.	**AWM PANEL DISCUSSION**
4:20 p.m. — 4:50 p.m.	**AWM BUSINESS MEETING**
4:30 p.m. — 6:30 p.m.	**MAA MINICOURSE #1: PART B** *Mathematics, calculus, and modeling using the TI-92.*
4:30 p.m. — 6:30 p.m.	**MAA MINICOURSE #3: PART B** *Developing materials for liberal arts mathematics that use elementary graph theory and emphasize applications to everyday experience.*

WEDNESDAY, JANUARY 13 (CONT'D)

4:30 p.m. — 6:30 p.m.	**MAA MINICOURSE #5: PART A** *Building custom classroom capsules with Maple programming.*
4:30 p.m. — 6:30 p.m.	**MAA MINICOURSE #7: PART A** *Finding motivation for upper division mathematics through original sources.*
4:30 p.m. — 6:00 p.m.	**AMS COMMITTEE ON THE PROFESSION PANEL DISCUSSION**
4:30 p.m. — 6:30 p.m.	**MAA SECTION OFFICERS**
6:00 p.m. — 7:00 p.m.	**RECEPTION FOR FIRST-TIME PARTICIPANTS**
7:00 p.m. — 8:00 p.m.	**MAA DRAMATIC PRESENTATION** *The mathematics of Lewis Carroll.*
7:15 p.m. — 8:15 p.m.	**YOUNG MATHEMATICIANS NETWORK DISCUSSION** *Concerns of young mathematicians: A town meeting.*
8:30 p.m. — 9:30 p.m.	**AMS JOSIAH WILLARD GIBBS LECTURE** *We got rhythm: Dynamical systems of the nervous system.* **Nancy J. Kopell**
9:30 p.m. — 11:00 p.m.	**AWM RECEPTION**

THURSDAY, JANUARY 14

7:30 a.m. — 4:00 p.m.	**JOINT MEETINGS REGISTRATION**, South Exhibit Hall, CC
8:00 a.m. — noon	**AMS-MAA-MER SPECIAL SESSION ON MATHEMATICS AND EDUCATION REFORM, III**
8:00 a.m. — noon	**AMS-ASL SPECIAL SESSION ON MODEL THEORY AND ITS APPLICATIONS, III**
	AMS SPECIAL SESSIONS
8:00 a.m. — noon	*Banach Spaces of Holomorphic Functions and Operators on These Spaces, III*
8:00 a.m. — noon	*Commutative Algebra, III*
8:00 a.m. — noon	*Combinatorial Topology, III*
8:00 a.m. — noon	*Development of Electronic Communications in Mathematics, III*
8:00 a.m. — noon	*The Functional and Harmonic Analysis of Wavelets, III*
8:00 a.m. — noon	*Discrete Models and Difference Equations, III*
8:00 a.m. — noon	*Mathematics Education and Mistaken Philosophies of Mathematics, III*
8:00 a.m. — noon	*Recent Developments in Differential Geometry, III*
8:00 a.m. — noon	*Singularities in Algebraic and Analytic Geometry, III*
8:00 a.m. — noon	*Hamiltonian Mechanics: Applications to Celestial Mechanics and Chemistry, III*
8:00 a.m. — noon.	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
8:00 a.m. — 10:00 a.m.	**MAA MINICOURSE #2: PART B** *Mathematical finance.*
8:00 a.m. — 10:00 a.m.	**MAA MINICOURSE #8: PART B** *Teaching a course in the history of mathematics.*
	MAA CONTRIBUTED PAPER SESSIONS
8:00 a.m. — noon	*Geometry in the Classroom in the Next Millennium, I*
8:00 a.m. — 10:55 a.m.	*Discrete Mathematics Revisited, I*
8:00 a.m. — 10:00 a.m.	**MAA WOMEN AND MATHEMATICS NETWORK POSTER SESSION** *Outreach programs for women and girls in mathematics.*
8:00 a.m. — 9:30 a.m.	**PROJECT NEXT-YOUNG MATHEMATICIANS NETWORK PANEL DISCUSSION** *Summer research opportunities for faculty in industry and government.*
8:15 a.m. — 7:30 p.m.	**MATHEMATICAL SCIENCES EMPLOYMENT REGISTER** *Interviews only*, South Exhibit Hall, CC
9:00 a.m. — 9:50 a.m.	**AWM EMMY NOETHER LECTURE** *Aperiodic dynamical systems.* **Krystyna M. Kuperberg**
9:30 a.m. — 5:30 p.m.	**BOOKS SALES AND EXHIBITS**, South Exhibit Hall, CC
10:05 a.m. — 10:55 a.m.	**MAA INVITED ADDRESS** *The history of mathematics and its future.* **John Fauvel**
10:15 a.m. — 12:15 p.m.	**MAA MINICOURSE #13: PART B** *Getting students involved in undergraduate research.*
10:15 a.m. — 12:15 p.m.	**MAA MINICOURSE #4: PART B** *The mathematics of the perfect shuffle.*

10:15 a.m. — 12:15 p.m.	**MAA MINICOURSE #5: PART B** *Building custom classroom capsules with Maple programming.*
1:00 p.m. — 2:00 p.m.	**AMS COLLOQUIUM LECTURES: LECTURE II** *Symplectic geometry from a dynamical systems point of view: Part 2.* **Helmut Hofer**
2:15 p.m. — 4:10 p.m.	**AMS-MAA-MER SPECIAL SESSION ON MATHEMATICS AND EDUCATION REFORM, IV**
2:15 p.m. — 4:10 p.m.	**AMS-ASL SPECIAL SESSION ON MODEL THEORY AND ITS APPLICATIONS, IV**
	AMS SPECIAL SESSIONS
2:15 p.m. — 4:10 p.m.	*Banach Spaces of Holomorphic Functions and Operators on These Spaces, IV*
2:15 p.m. — 4:10 p.m.	*Commutative Algebra, IV*
2:15 p.m. — 4:10 p.m.	*Combinatorial Topology, IV*
2:15 p.m. — 4:10 p.m.	*Development of Electronic Communications in Mathematics, IV*
2:15 p.m. — 4:10 p.m.	*The Functional and Harmonic Analysis of Wavelets, IV*
2:15 p.m. — 4:10 p.m.	*Discrete Models and Difference Equations, IV*
2:15 p.m. — 4:10 p.m.	*Mathematics Education and Mistaken Philosophies of Mathematics, IV*
2:15 p.m. — 4:10 p.m.	*Recent Developments in Differential Geometry, IV*
2:15 p.m. — 4:10 p.m.	*Singularities in Algebraic and Analytic Geometry, IV*
2:15 p.m. — 4:10 p.m.	*Hamiltonian Mechanics: Applications to Celestial Mechanics and Chemistry, IV*
2:15 p.m. — 6:00 p.m.	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
2:15 p.m. — 4:15 p.m.	**MAA MINICOURSE #12: PART A** *Writing and the teaching of mathematics.*
2:15 p.m. — 4:15 p.m.	**MAA MINICOURSE #16: PART A** *Using hand-held CAS throughout the mathematics curriculum.*
2:15 p.m. — 4:15 p.m.	**MAA MINICOURSE #7: PART B** *Finding motivation for upper division mathematics through original sources.*
2:15 p.m. — 4:15 p.m.	**MAA MINICOURSE #9: PART A** *Exploring abstract algebra through interactive labs.*
	MAA CONTRIBUTED PAPER SESSIONS
2:15 p.m. — 4:10 p.m.	*Mathematics Competitions, II*
2:15 p.m. — 4:10 p.m.	*Projects That Work in Applied Mathematics Courses, I*
2:15 p.m. — 4:10 p.m.	*Innovative Use of Distance Learning Techniques to Teach Post-Secondary Mathematics, I*
2:15 p.m. — 4:10 p.m.	*Integrating Mathematics and Other Disciplines, I*
2:15 p.m. — 3:45 p.m.	**MAA CUPM SUBCOMMITTEE ON CALCULUS REFORM AND THE FIRST TWO YEARS PANEL DISCUSSION** *College algebra reform.*
2:15 p.m. — 3:45 p.m.	**MAA PANEL DISCUSSION** *Discovery-based teaching of undergraduate mathematics courses.*
2:15 p.m. — 3:45 p.m.	**MAA COMMITTEE ON THE PARTICIPATION OF WOMEN PANEL DISCUSSION** *Exemplary women in mathematical careers.*
2:15 p.m. — 3:45 p.m.	**ASA-MAA COMMITTEE ON STATISTICS PANEL DISCUSSION** *Involving undergraduate students in industrial consulting experiences.*
2:15 p.m. — 4:10 p.m.	**MAA COMMITTEE ON COMPUTERS IN MATHEMATICS EDUCATION POSTER SESSION** *Using the Web in teaching undergraduate mathematics.*
2:15 p.m. — 3:45 p.m.	**MAA COMMITTEE ON COMPUTERS IN MATHEMATICS EDUCATION PANEL DISCUSSION** *Using the Web as a tool for teaching calculus: What we've learned; successes and problem areas.*
3:20 p.m. — 4:10 p.m.	**AMS INVITED ADDRESS** *Midpoints.* **Alan D. Weinstein**
4:25 p.m. — 6:00 p.m.	**JOINT PRIZE SESSION AND RECEPTION**
5:45 p.m. — 7:00 p.m.	**MAA RECEPTION FOR TWO-YEAR COLLEGES**
6:30 p.m. — 10:00 p.m.	**MER BANQUET**
7:00 p.m. — 9:00 p.m.	**MAA-ARUME SPECIAL PRESENTATION** *Research on undergraduate mathematics education.*

THURSDAY, JANUARY 14 (CONT'D)

7:00 p.m. — 9:00 p.m. **MAA COMMITTEE ON THE MATHEMATICAL EDUCATION OF TEACHERS POSTER SESSION** *Innovations in mathematics programs which benefit future teachers.*

7:00 p.m. — 8:30 p.m. **MAA-YOUNG MATHEMATICIANS NETWORK PANEL DISCUSSION** *Solving the two body problem.*

7:30 p.m. — 9:00 p.m. **MAA MUSICAL PRESENTATION** *Eine Kleine (Mathematische) Nachtmusik.*

7:30 p.m. — 9:00 p.m. **MAA SPECIAL PRESENTATION** *Student reports: Explorations in using the World Wide Web to enhance the teaching of mathematics.*

FRIDAY, JANUARY 15

7:00 a.m. — 8:00 a.m. **JOINT PI MU EPSILON AND MAA STUDENT CHAPTER ADVISORS' BREAKFAST**

7:30 a.m. — 4:00 p.m. **JOINT MEETINGS REGISTRATION**, South Exhibit Hall, CC

AMS-MAA SPECIAL SESSIONS

8:00 a.m. — 10:55 a.m. *Research in Mathematics by Undergraduates, I*
8:00 a.m. — 10:55 a.m. *The History of Mathematics, I*

8:00 a.m. — 10:55 a.m. **AMS-AWM SPECIAL SESSION ON GEOMETRY IN DYNAMICS, I**

AMS SPECIAL SESSIONS

8:00 a.m. — 10:55 a.m. *Several Complex Variables, I*
8:00 a.m. — 10:50 a.m. *Bergman Spaces and Related Topics, I*
8:00 a.m. — 10:55 a.m. *Probabilistic Combinatorics, I*
8:00 a.m. — 10:55 a.m. *Dynamical, Spectral, and Arithmetic Zeta-Functions, I*
8:00 a.m. — 10:50 a.m. *Commutative Algebra and Algebraic Geometry, I*
8:00 a.m. — 10:55 a.m. *Operator Algebras and Applications, I*
8:00 a.m. — 10:55 a.m. *Computational Algebraic Geometry for Curves and Surfaces, I*
8:00 a.m. — 10:55 a.m. *The Mathematics of the Navier-Stokes Equations, I*

8:00 a.m. — 10:55 a.m. **AMS SESSIONS FOR CONTRIBUTED PAPERS**

8:00 a.m. — 10:00 a.m. **MAA MINICOURSE #10: PART B** *Facilitating active learning: Concrete ways to foster student participation.*

8:00 a.m. — 10:00 a.m. **MAA MINICOURSE #9: PART B** *Exploring abstract algebra through interactive labs.*

MAA CONTRIBUTED PAPER SESSIONS

8:00 a.m. — 10:55 a.m. *The Use of Technology in Teaching Abstract Mathematics, II*
8:00 a.m. — 10:55 a.m. *Quantitative Literacy, II*
8:00 a.m. — 10:55 a.m. *Teaching Statistics: Teaching the Reasoning and New Technological Tools, II*
8:00 a.m. — 10:55 a.m. *The Integral Role of the Two-Year College in the Preservice Preparation of Elementary School Teachers, I*

8:00 a.m. — 9:20 a.m. **MAA CUPM SUBCOMMITTEE ON CALCULUS REFORM AND THE FIRST TWO YEARS-NSF PANEL DISCUSSION** *Forming the crystal ball for calculus.*

8:00 a.m. — 9:20 a.m. **MAA COMMITTEE ON TWO-YEAR COLLEGES PANEL DISCUSSION** *Dual credit for mathematics courses taken in high school.*

8:00 a.m. — 10:50 a.m. **MAA PANEL DISCUSSION** *Innovations in teaching assistant training.*

8:00 a.m. — 10:00 a.m. **PROJECT NEXT-YOUNG MATHEMATICIANS NETWORK POSTER SESSION**

8:15 a.m. — 7:30 p.m. **MATHEMATICAL SCIENCES EMPLOYMENT REGISTER** *Interviews only*, South Exhibit Hall, CC

8:30 a.m. — 9:30 a.m. **AMS PRESENTATION** *e-MATH on the World Wide Web.*

9:00 a.m. — 9:50 a.m. **AMS INVITED ADDRESS** *Title to be announced.* **Sorin Popa**

9:30 a.m. — 5:30 p.m.	**BOOK SALES AND EXHIBITS**, South Exhibit Hall, CC
9:35 a.m. — 10:55 a.m.	**MAA COMMITTEE ON CALCULUS REFORM AND THE FIRST TWO YEARS PANEL DISCUSSION** *The effect of calculus reform on student performance in subsequent courses.*
9:35 a.m. — 10:55 a.m.	**MAA OPEN FORUM** *Educational Testing Service: Testing with technology—Sharing ideas to meet the challenges that lie ahead.*
9:35 a.m. — 10:55 a.m.	**MAA-AMS-NCTM PANEL DISCUSSION** *The draft of the updated NCTM standards for school mathematics: An opportunity for your feedback.*
10:00 a.m. — 10:55 a.m.	**AMS PRESENTATION** *Math e-journals and beyond.*
11:10 a.m. — noon	**AMS-MAA INVITED ADDRESS** *Massive graphs: Algorithms, applications, and open problems.* **Joan Feigenbaum**
1:00 p.m. — 2:00 p.m.	**AMS COLLOQUIUM LECTURES: LECTURE III** *Symplectic geometry from a dynamical systems point of view: Part 3.* **Helmut Hofer**
	AMS-MAA SPECIAL SESSION
1:00 p.m. — 6:00 p.m.	*The History of Mathematics, II*
1:00 p.m. — 6:00 p.m.	**AMS-AWM SPECIAL SESSION ON GEOMETRY IN DYNAMICS, II**
	AMS SPECIAL SESSIONS
1:00 p.m. — 6:00 p.m.	*Several Complex Variables, II*
1:00 p.m. — 6:00 p.m.	*Bergman Spaces and Related Topics, II*
1:00 p.m. — 6:00 p.m.	*Probabilistic Combinatorics, II*, Fiesta A, CC
1:00 p.m. — 6:00 p.m.	*Dynamical, Spectral, and Arithmetic Zeta-Functions, II*
1:00 p.m. — 6:00 p.m.	*Commutative Algebra and Algebraic Geometry, II*
1:00 p.m. — 6:00 p.m.	*Operator Algebras and Applications, II*
1:00 p.m. — 6:00 p.m.	*Computational Algebraic Geometry for Curves and Surfaces, II*
1:00 p.m. — 6:00 p.m.	*The Mathematics of the Navier-Stokes Equations, II*
1:00 p.m. — 6:00 p.m.	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
1:00 p.m. — 3:00 p.m.	**MAA MINICOURSE #11: PART A** *Creating interactive texts in Mathematica.*
1:00 p.m. — 3:00 p.m.	**MAA MINICOURSE #12: PART B** *Writing and the teaching of mathematics.*
1:00 p.m. — 3:00 p.m.	**MAA MINICOURSE #6: PART A** *Cooperative learning in undergraduate mathematics education.*
	MAA CONTRIBUTED PAPER SESSIONS
1:00 p.m. — 3:00 p.m.	*Ethical, Humanistic, and Artistic Mathematics, II*
1:00 p.m. — 6:00 p.m.	*Proof in Mathematical Education*
1:00 p.m. — 5:00 p.m.	**ASL SESSION**
1:00 p.m. — 3:00 p.m.	**MAA CUPM SUBCOMMITTEE ON CALCULUS REFORM AND THE FIRST TWO YEARS POSTER SESSION** *College algebra reform.*
2:15 p.m. — 3:05 p.m.	**MAA INVITED ADDRESS** *The role of research in improving school mathematics.* **Jeremy Kilpatrick**
2:15 p.m. — 5:00 p.m.	**NAM GRANVILLE-BROWN SESSION OF PRESENTATIONS BY RECENT DOCTORAL RECIPIENTS IN THE MATHEMATICAL SCIENCES**
2:15 p.m. — 4:10 p.m.	**RMMC BOARD OF DIRECTORS**
2:30 p.m. — 4:00 p.m.	**AMS COMMITTEE ON SCIENCE POLICY PANEL DISCUSSION**
3:15 p.m. — 5:15 p.m.	**MAA MINICOURSE #14: PART A** *An introduction to wavelets.*
3:15 p.m. — 5:15 p.m.	**MAA MINICOURSE #15: PART A** *Music and mathematics.*
3:15 p.m. — 4:45 p.m.	**MAA PANEL DISCUSSION** *Models for intervention projects.*

FRIDAY, JANUARY 15 (CONT'D)

3:20 p.m. — 5:00 p.m. **MAA TEACHING AWARDS PRESENTATIONS**

4:00 p.m. — 7:00 p.m. **MAA POSTER SESSION** *Undergraduate research by students.*

4:20 p.m. — 5:10 p.m. **AMS COMMITTEE ON SCIENCE POLICY GOVERNMENT SPEAKER** *Title to be announced.* **Rita Colwell**

5:00 p.m. — 7:00 p.m. **MAA INFORMAL SESSION** *Actuarial education.*

5:30 p.m. — 8:30 p.m. **NAM BANQUET AND COX-TALBOT ADDRESS** *The end of one era, the dawn of another.* **Johnny L. Houston**

6:00 p.m. — 7:00 p.m. **AMS SPECIAL EVENT** *Mathematical Reviews reception.*

7:00 p.m. — 9:00 p.m. **MAA-ARUME SPECIAL PRESENTATION** *Research on undergraduate mathematics education.*

7:00 p.m. — 9:00 p.m. **MAA FORMAL DISCUSSION** *Isolated teachers of statistics.*

7:15 p.m. — 9:15 p.m. **MAA PRESENTATION** *An evening of poetry.*

7:30 p.m. — 8:20 p.m. **MAA STUDENT LECTURE** *Pianos and continued fractions.* **Edward G. Dunne**

SATURDAY, JANUARY 16

7:30 a.m. — 2:00 p.m. **JOINT MEETINGS REGISTRATION**, South Exhibit Hall, CC

AMS-MAA SPECIAL SESSIONS

8:00 a.m. — 10:55 a.m. *Research in Mathematics by Undergraduates, II*
8:00 a.m. — 10:55 a.m. *The History of Mathematics, III*

8:00 a.m. — 10:55 a.m. **AMS-AWM SPECIAL SESSION ON GEOMETRY IN DYNAMICS, III**

AMS SPECIAL SESSIONS

8:00 a.m. — 10:55 a.m. *Several Complex Variables, III*
8:00 a.m. — 10:55 a.m. *Bergman Spaces and Related Topics, III*
8:00 a.m. — 10:55 a.m. *Dynamical, Spectral, and Arithmetic Zeta-Functions, III*
8:00 a.m. — 10:55 a.m. *Commutative Algebra and Algebraic Geometry, III*
8:00 a.m. — 10:55 a.m. *Operator Algebras and Applications, III*
8:00 a.m. — 10:55 a.m. *Computational Algebraic Geometry for Curves and Surfaces, III*
8:00 a.m. — 10:55 a.m. *The Mathematics of the Navier-Stokes Equations, III*

8:00 a.m. — 10:55 a.m. **AMS SESSIONS FOR CONTRIBUTED PAPERS**

8:00 a.m. — 10:00 a.m. **MAA MINICOURSE #11: PART B** *Creating interactive texts in Mathematica.*

8:00 a.m. — 10:00 a.m. **MAA MINICOURSE #16: PART B** *Using hand-held CAS throughout the mathematics curriculum.*

MAA CONTRIBUTED PAPER SESSIONS

8:00 a.m. — 10:55 a.m. *Geometry in the Classroom in the Next Millennium, II*
8:00 a.m. — 10:55 a.m. *Discrete Mathematics Revisited, II*

8:00 a.m. — 9:20 a.m. **MAA PANEL DISCUSSION** *Life after retirement.*

8:00 a.m. — 10:55 a.m. **ASL SESSION**

8:30 a.m. — 10:00 a.m. **AMS COMMITTEE ON EDUCATION PANEL DISCUSSION**

8:30 a.m. — 10:00 a.m. **MAA-NATIONAL ALLIANCE OF STATE SCIENCE AND MATHEMATICS COALITIONS PANEL DISCUSSION** *State standards.*

9:00 a.m. — 9:50 a.m. **MAA INVITED ADDRESS** *Convex polytopes and partially ordered sets.* **Rodica E. Simion**

9:00 a.m. — 5:00 p.m. **AWM WORKSHOP**

9:00 a.m. — 10:00 a.m. **NAM PANEL DISCUSSION** *Effective networking and research dialogue via*

teleconferences/telecommunication.

9:00 a.m. — noon **MATHEMATICAL SCIENCES EMPLOYMENT REGISTER** *Interviews only*, South Exhibit Hall, CC

9:00 a.m. — noon **BOOK SALES AND EXHIBITS**, South Exhibit Hall, CC

9:30 a.m. — 10:50 a.m. **MAA PRESENTATION** *Planning for retirement.*

10:00 a.m. — 10:55 a.m. **NAM BUSINESS MEETING**

10:05 a.m. — 10:55 a.m. **MAA INVITED ADDRESS** *Experimental Mathematics: Insight from computation.* **Jonathan M. Borwein**

11:10 a.m. — 11:40 a.m. **MAA BUSINESS MEETING**

11:45 a.m. — 12:15 p.m. **AMS BUSINESS MEETING**

1:00 p.m. — 2:00 p.m. **NAM WILLIAM W.S. CLAYTOR LECTURE** *Maximum cliques and minimum colorings of graphs.* **Earl R. Barnes**

AMS-MAA SPECIAL SESSIONS

1:00 p.m. — 5:00 p.m. *The History of Mathematics, IV*

1:00 p.m. — 5:00 p.m. **AMS-AWM SPECIAL SESSION ON GEOMETRY IN DYNAMICS, IV**

AMS SPECIAL SESSIONS

1:00 p.m. — 5:00 p.m. *Several Complex Variables, IV*
1:00 p.m. — 5:00 p.m. *Bergman Spaces and Related Topics, IV*
1:00 p.m. — 5:00 p.m. *Dynamical, Spectral, and Arithmetic Zeta-Functions, IV*
1:00 p.m. — 5:00 p.m. *Commutative Algebra and Algebraic Geometry, IV*
1:00 p.m. — 5:00 p.m. *Computational Algebraic Geometry for Curves and Surfaces, IV*
1:00 p.m. — 5:00 p.m. *The Mathematics of the Navier-Stokes Equations, IV*
1:00 p.m. — 5:00 p.m. *Operator Algebras and Applications, IV*

1:00 p.m. — 5:00 p.m. **AMS SESSIONS FOR CONTRIBUTED PAPERS**

1:00 p.m. — 3:00 p.m. **MAA MINICOURSE #14: PART B** *An introduction to wavelets.*

1:00 p.m. — 3:00 p.m. **MAA MINICOURSE #15: PART B** *Music and mathematics.*

1:00 p.m. — 3:00 p.m. **MAA MINICOURSE #6: PART B** *Cooperative learning in undergraduate mathematics education.*

MAA CONTRIBUTED PAPER SESSIONS

1:00 p.m. — 5:30 p.m. *Projects That Work in Applied Mathematics Courses, II*
1:00 p.m. — 5:30 p.m. *Innovative Use of Distance Learning Techniques to Teach Post-Secondary Mathematics, II*
1:00 p.m. — 5:30 p.m. *Integrating Mathematics and Other Disciplines, II*
1:00 p.m. — 5:30 p.m. *The Integral Role of the Two-Year College in the Preservice Preparation of Elementary School Teachers, II*

1:00 p.m. — 2:20 p.m. **MAA COMMITTEE ON THE TEACHING OF UNDERGRADUATE MATHEMATICS PANEL DISCUSSION** *Teaching collaborations between graduate departments, in mathematics at four-year institutions, and community colleges.*

1:00 p.m. — 2:20 p.m. **MAA COMMITTEE ON THE MATHEMATICAL EDUCATION OF TEACHERS PANEL DISCUSSION** *Improved teacher preparation: What mathematics departments can do.*

1:00 p.m. — 2:20 p.m. **SUMMA SPECIAL PRESENTATION** *Intervention programs for minority precollege students.*

1:00 p.m. — 3:00 p.m. **MAA WORKSHOP** *Integrating active learning techniques into lectures.*

1:00 p.m. — 5:00 p.m. **ASL SESSION**

2:15 p.m. — 3:05 p.m. **AMS INVITED ADDRESS** *Undercompressive shocks in thin film flow.* **Andrea L. Bertozzi**

6:30 p.m. — 10:00 p.m. **AMS BANQUET**

Conferences

Short Course on Nonlinear Control

San Antonio, Texas, January 11–12, 1999

The American Mathematical Society, in conjunction with its 105th Annual Meeting, will present a two-day Short Course on *Nonlinear Control* on Monday and Tuesday, January 11 and 12, 1999, at the Hilton Palacio Del Rio, San Antonio. The program is under the direction of **Hector J. Sussman**, Rutgers University, and **Keven Grasse**, University of Oklahoma.

Synopses and accompanying reading lists follow. Lecture notes will be available to those who register. Advance registration fees: $80 ($35 student/unemployed/emeritus); on-site registration fees $95 ($45 student/unemployed/emeritus). Registration and housing information can be found in this issue of the *Notices*; see the section "Registering in Advance and Hotel Accommodations" in the announcement for the meetings in San Antonio.

Dynamic Programming and Viscosity Solutions

H. Mete Soner, Princeton University

Synopsis

Consider the classical calculus of variations problem to minimize

$$\int_0^T L(\xi(s), \dot{\xi}(s), s)\, ds,$$

over all Lipschitz continuous functions $\xi : [0, T] \to \mathcal{R}^d$.

In the Hamilton-Jacobi approach, one embeds this problem into a family of similar problems

$$v(x, t) := \inf \left\{ \int_0^T L(\xi(t), \dot{\xi}(t), t)\, dt \right\},$$

parametrized by the initial data $\xi(t) = x$. Then, for every $h > 0$, the value function v satisfies

$$v(x, t) = \inf \left\{ \int_t^{t+h} L(\xi(t), \dot{\xi}(t), t) dt \right.$$
$$\left. + v(\xi(t+h), t+h) | \xi : [t, t+h] :\to \mathcal{R}^d \right\}.$$

This minimization principle, called *dynamic programming*, yields a differential equation for the value function. Indeed, if we assume that the value function is continuously differentiable,

$$-\frac{\partial}{\partial t} v(x, t) + H(x, t, \nabla v(x, t)) = 0, \quad (x, t) \in \mathcal{R}^d \times (0, T)$$

where

$$H(x, t, p) := \sup \left\{ -\alpha \cdot p - L(x, t, \alpha) \quad | \quad \alpha \in \mathcal{R}^d \right\}.$$

Moreover, the minimizer ξ^* satisfies the differential equation

$$\dot{\xi}^*(t) = \nabla v(\xi^*(t), t).$$

In the sixties R. Bellman formulated a general stochastic optimal control problem and the corresponding dynamic programming principle. As a corollary, one obtains a nonlinear partial differential equation satisfied by the value function provided that the value function is sufficiently smooth. We will call this equation the *dynamic programming equation.*

This approach provides a very general way of calculating the value function and the minimizing trajectories. However, the value function is generally not smooth enough to justify these calculations. In their celebrated paper, M.
Crandall and P.-L. Lions overcame this difficulty by introducing a weak notion of a solution for the dynamic programming equation called *viscosity solutions.* The main idea is to define super- and subsolutions and then define the solution as a function which is both a sub- and a supersolution. In addition to this definition, Crandall and Lions also proved a uniqueness result. This is particularly important, as one generally calculates the value function using a numerical method. Then the uniqueness guarantees that the solution calculated by the computer well approximates the value function.

In this talk I will first explain the Crandall and Lions theory for dynamic programming. Then I will outline several applications to financial mathematics. In particular, I will use the viscosity solutions to calculate the superreplication cost of a contingent claim in the presence of portfolio constraints. This problem is related to backward-forward stochastic differential equations.

Reading List

[1] G. Barles, *Nonlinear control systems,* 3rd ed., Springer-Verlag, New York, 1995 (see esp. Chaps. 1, 2).
[2] M. Crandall and P.-L. Lions, Trans. Amer. Math. Soc.
[3] M. Crandall, L. C. Evans, and P.-L. Lions, Trans. Amer. Math. Soc.
[4] M. Crandall, H. Ishii, and P.-L. Lions, *User's guide to viscosity solutions*, Bull. Amer. Math. Soc. (N.S.) **27** (1992), 1–67.
[5] W. H. Fleming and H. M. Soner, *Viscosity solutions and controlled Markov processes*, Springer-Verlag, New York, 1991.

Introduction to Differential-Geometric Control

Kevin A. Grasse, University of Oklahoma

Synopsis

A control system can be viewed informally as a dynamical object (e.g., ordinary differential equation) containing a parameter (control) which can be manipulated to influence the evolution of the system's trajectories through its underlying "state space". In particular, from a fixed initial state it is usually possible to reach (or control to) an entire family of other states by varying the control. This lecture will establish the conceptual and notational framework in which a nonlinear control system can be viewed as a collection of vector fields on a finite-dimensional differentiable manifold. Such a collection of vector fields is

sometimes referred to as a *dynamical polysystem*. The control systems considered here are always understood to be finite-dimensional, deterministic, continuous-time systems (thereby excluding other classes of potentially interesting systems, such as stochastic, distributed-parameter, and discrete-time systems). After R. E. Kalman's introduction of the notion of control systems evolving on a state space (circa 1960), it was discovered somewhat later (circa 1970) that linear control systems (whose state space is a finite-dimensional vector space) could be elegantly and effectively studied via "coordinate-free" linear algebra, while for nonlinear control systems the natural coordinate-free setting was a finite-dimensional, differentiable manifold. It must be stressed that the introduction of manifolds is not made simply for the sake of idle generalization. There are several compelling reasons for doing this, among which are the following:

1. In some cases the state of the system evolves on a manifold by virtue of the system's intrinsic nature (viz. a controlled rigid body where a portion of the state is its orientation, which is represented by a three-by-three orthogonal matrix).
2. Even in cases where the state of the system evolves in a euclidean space, the so-called *reachable set* of the system (i.e., the set of states to which the system can be controlled) may be a subset of an immersed submanifold of the ambient euclidean space.
3. When the reachable set of the system is contained in an immersed submanifold of positive codimension in the ambient euclidean space, the necessary conditions for optimal controls (i.e., the Pontryagin Maximum Principle, to be discussed in subsequent lectures) never yield useful information in their classical, euclidean-space formulation, whereas they may yield useful information when formulated in a coordinate-free manner on manifolds.

We assume only a rudimentary familiarity with the theory of differentiable manifolds, vector fields, and ordinary differential equations (specifically conditions for existence and uniqueness of integral curves of vector fields and continuous dependence of solutions on parameters; Chap. 1 of [8] is more than sufficient). After a brief introduction to the concept of a control system, we will develop the connection between control systems and systems of vector fields. The lecture will proceed to discuss the reachable set of a control system and its basic properties. The Lie bracket of vector fields will emerge in a natural way from this discussion and will play a fundamental role throughout. Questions of the structure of the reachable set are most completely answered for so-called "forward-backward" (FB) reachable sets; i.e., the states we can reach going both forward and backward in time. We will see that the collection of FB-reachable sets of a control system partitions the ambient state manifold into a foliation with singularities (so not all leaves may be of the same dimension). Indeed, we will explicate how this "orbit theorem" provides a striking generalization of the traditional theorem of Frobenius studied in differential geometry. Of course, going "backward in time" is not physically meaningful unless the control system exhibits a very strong form of symmetry, but forward (F)-reachable sets are always contained in the FB-reachable sets, so the orbit theorem can still convey useful information about the F-reachable sets. Questions of structure of the F-reachable sets themselves are considerably more delicate and will be touched on in the next lecture. We will also introduce the concepts of *controllability* (the ability to reach any one state from any other) and *accessibility* (the ability to reach an open subset of the state space from any given initial state) and survey basic results that pertain to these important notions.

We conclude with a few comments about the reading list. Any one of the references [1], [2], [3], [4], [6] provides a good overview of the material of this lecture. Reference [4] is also an excellent introduction to the theory of control systems, but perhaps places more emphasis on the system-theoretic considerations than on geometric considerations. Either of references [5] and [7] gives a fairly complete exposition of the above-mentioned orbit theorem.

Reading List

[1] A. Isidori, *Nonlinear control systems*, 3rd ed., Springer-Verlag, New York, 1995 (see esp. Chaps. 1, 2).

[2] V. Jurdjevic, *Geometric control theory*, Cambridge University Press, Cambridge, 1997 (see esp. Chaps. 1–4).

[3] H. Nijmeijer and A. J. van der Schaft, *Nonlinear dynamical control systems*, Springer-Verlag, New York, 1990 (see esp. Chaps. 1, 2).

[4] E. D. Sontag, *Mathematical control theory*, 2nd ed., Springer-Verlag, New York, 1998 (see esp. Chaps. 1–3 for a general introduction to mathematical control theory and Chap. 4 for the more geometric aspects).

[5] ——, *Integrability of certain distributions associated with actions on manifolds and applications to control problems*, Nonlinear Controllability and Optimal Control (H. J. Sussmann, ed.), Marcel Dekker, New York, 1990, pp. 81–131.

[6] H. J. Sussmann, *Lie brackets, real-analyticity, and geometric control*, Differential Geometric Control Theory (R. W. Brockett et al., eds.), Birkhäuser, Boston, 1983, pp. 1–116 (see esp. §§1–3).

[7] ——, *Orbits of families of vector fields and integrability of distributions*, Trans. Amer. Math. Soc. **180** (1973), 171–189.

[8] F. W. Warner, *Foundations of differentiable manifolds and Lie groups*, Scott, Foreman and Co., Glenview, IL. 1971.

Motion Control of Mechanical Systems

Richard M. Murray, California Institute of Technology

Synopsis

Recent advances in geometric mechanics, motivated in large part by applications in control theory, have introduced new tools for understanding and utilizing the structure present in mechanical systems. In particular, the use of geometric methods for analyzing Lagrangian systems with both symmetries and nonintegrable (or nonholonomic) constraints has led to a unified formulation of the dynamics that has important implications for a wide class of mechanical control systems. In this lecture I will introduce some of the fundamental geometric concepts which are basic to nonlinear control of mechanical systems and illustrate their utility on a variety of engineering examples and applications. The focus of the lecture will be on motion control between equilibrium points of the system or along a reference trajectory.

The underlying mechanical structure which one exploits is based on the association of kinetic energy with a natural Riemannian metric for the system. This allows Lagrange's equations to be represented using covariant differentiation with respect to the Levi-Cevita connection given by the kinetic energy. We use this framework to define the symmetric product between vector fields and show how it arises in the characterization of configuration accessibility and equilibrium controllability of general mechanical systems. This allows one to characterize specialized controllability properties for mechanical systems that are required for motion control.

Using this framework, one can undertake a geometric approach to control of locomotion systems, such as mobile robots and highly articulated snake robots. A common feature of these systems is the role of constraints on the behavior of the system. Typically, these constraints force the instantaneous velocities of the system to lie in a restricted set of directions but do not actually restrict the reachable configurations of the system. A familiar example in which this geometric structure can be exploited is parallel parking of an automobile, where periodic motion in the driving speed and steering angle can be used to achieve a net sideways motion. By studying the geometric nature of velocity constraints in a more general setting, it is possible to synthesize gaits for snake-like robots, generate parking and docking maneuvers for automated vehicles, and study the effects of rolling contacts on multifingered robot hands. Simulations and videotape of experiments performed at Caltech will be used to illustrate the main ideas.

Finally, we consider the problem of real-time trajectory generation and tracking for mechanical systems. Using the paradigm of two degrees of freedom control, we illustrate the role of real-time trajectory generation in nonlinear control. Important systems to consider are differentially flat systems, for which the trajectory generation problem is conceptually simple and computationally tractable. We illustrate the use of flatness in two different flight control examples and provide some constructive conditions for checking flatness of mechanical systems. Experimental results using a flight control testbed at Caltech will be presented to demonstrate the performance of flatness-based controllers.

We assume only a rudimetary familiarity with the theory of differentiable manifolds and vector fields, at the level of [1]. A summary of the basic ideas presented in this lecture can be found in a recent review article [2] and the references therein.

Reading List

[1] W. M. Boothby, *An introduction to differentiable manifolds and Riemannian geometry*, 2nd ed., Academic Press, 1986.

[2] R. M. Murray, *Nonlinear control of mechanical systems: A Lagrangian perspective*, Ann. Rev. Control **21** (1997), 31–45.

The Maximum Principle and Reachable Sets—A Classical Perspective

Heinz Schättler, Washington University

Synopsis

We consider a control system of the form $\Sigma : \dot{x} = f(x, u), x \in M, u \in U$ where M is a C^∞ manifold and the control set U is arbitrary. Admissible controls are Lebesgue measurable functions u defined on a compact interval with values in a compact subset of U. A point q is reachable from p in time t if there exists an admissible control u such that the corresponding trajectory x satisfies $q = x(t)$. The set of all points which are reachable in time t is the time-t-reachable set denoted by $Reach_{\Sigma,t}(p)$, and $Reach_{\Sigma,\leq T}(p)$ denotes those points which are reachable in times t, $0 \leq t \leq T$. If T is small, we call this set the small-time reachable set.

The Pontryagin Maximum Principle [1] gives necessary conditions for the endpoint of a trajectory to lie in the boundary of the reachable set. These conditions are obtained by approximating the reachable set with a convex cone. We briefly outline this classical construction, emphasizing its geometric context under sufficiently strong regularity conditions, which allows us to ignore technical aspects. We also show how these constructions can be used to derive the classical necessary conditions for optimality in the optimal control problem. Connections with classical results from calculus of variations will be made [2].

The first-order necessary conditions for optimality of the Maximum Principle provide the fundamental mechanism for restricting the class of trajectories to a smaller family of candidates for optimality. In general, however, the structure of optimal trajectories is left wide open, and further reductions need to be achieved. In the remainder of the lecture we will describe two approaches intended to achieve such restrictions.

The first pursues a precise construction of the small-time reachable set. If it is possible to analyze the boundary of the reachable set directly, no information will be lost and better characterizations of boundary trajectories will be obtained. This idea will be developed for single-input systems in low dimensions which are linear in the control under general conditions that are expressed in terms of the Lie brackets of the control vector fields and their relations at a reference point. The guiding principle in these constructions is to proceed from the "general" to the "specific" [3]. The procedure has proven effective to solve optimal control problems for low-dimensional systems [4, 5].

The second approach which we describe is an adaptation of the method of characteristics. The necessary conditions for optimality of the Maximum Principle also give the characteristic equations for the corresponding Hamilton-Jacobi-Bellman equation. If the flow of extremals covers a region R in the state space diffeomorphically, then a smooth solution to the Hamilton-Jacobi-Bellman equation can be constructed on R, and, very much as in the classical calculus of variations, sufficient conditions for optimality follow. We briefly outline the classical construction but focus on geometric properties of the value function as fold or simple cusp singularities arise in the flow of extremals [7]. The corresponding syntheses of optimal solutions show very close connections with the structure of the reachable sets discussed earlier.

Reading List

[1] L. PONTRYAGIN, V. BOLTYANSKY, R. GAMKRELIDZE, and E. MISHCHENKO, *The mathematical theory of optimal processes*, Wiley-Interscience, New York, 1962.

[2] H. J. SUSSMANN and J. C. WILLEMS, *300 years of optimal control: From the Brachystochrone to the Maximum Principle*, IEEE Control Systems (1997), 32–44.

[3] H. J. SUSSMANN, *The structure of time-optimal trajectories for single-input systems in the plane: The C^∞ nonsingular case*, SIAM J. Control Optim. **25** (1987), 433–465.

[4] B. PICCOLI, *Classification of generic singularities for the planar time-optimal synthesis*, SIAM J. Control Optim. **34** (1996), 1914–1946.

[5] A. J. KRENER and H. SCHÄTTLER, *The structure of small time reachable sets in low dimension*, SIAM J. Control Optim. **27** (1989), 120–147.

[6] H. SCHÄTTLER, *Extremal trajectories, small-time reachable sets and local feedback synthesis: A synopsis of the three-dimensional case*, Nonlinear Synthesis (C. I. Byrnes and A. Kurzhansky, eds.), Birkhäuser, Boston, 1991, pp. 258–269.

[7] M. KIEFER and H. SCHÄTTLER, *Cut-loci and cusp singularities in parametrized families of extremals*, Optimal Control: Theory, Algorithms and Applications (W. W. Hager and P. M. Pardalos, eds.), Kluwer, 1998.

Feedback Stabilization

Eduardo D. Sontag, Rutgers University

Synopsis

This presentation will deal with the problem of stabilization of an equilibrium for finite-dimensional systems $\dot{x} = f(x, u)$ evolving in a Euclidean space. That is, the objective is to find a *feedback law* $u = k(x)$ rendering the origin of the *closed-loop system* $\dot{x} = f(x, (x))$ locally or globally asymptotically stable. The problem of stabilization of equilibria is one of the central issues in control, of interest in itself and also because many other objectives—such as tracking, disturbance rejection, or output feedback—involve stabilizing suitable quantities (such as an error signal). Furthermore, understanding this simpler problem is a first step in dealing with more complicated issues, such as the stabilization of periodic orbits or general invariant sets.

For *linear* control systems the theory of stabilization is well understood, cf. [11], and it will be reviewed in the talk. Examples will be given, and we will explain the implications for local stabilization of nonlinear systems.

For linear systems if stabilizability is at all possible, then there is a linear feedback that achieves the objective. For nonlinear systems it has been known since the late 1970s that, in general, there are topological obstructions to the existence of even continuous stabilizers, cf. [12, 7, 2, 11]. We will discuss these obstructions, stated in terms of degree theory, and also the use of techniques from nonsmooth analysis and differential games, cf. [3], to deal with discontinuous controllers.

On the other hand, it is also known that in those cases in which continuous stabilizers do exist it is then also possible to pick an infinitely differentiable (in the complement of zero) k. This fact follows from the rich theory of *control-Lyapunov functions* (clf) which constitute an extension of the classical concept of Lyapunov functions from dynamical system theory. We will discuss clf, as well as their use in recursive design and the formulation of "universal" formulas for feedback controls, cf. [1, 8, 5, 6, 11].

Finally, the talk will touch upon the existence and genericity of inputs for nonsingular controllability. The results to be covered are proved by an application of techniques from the theory of real-analytic sets. Examples will be given to illustrate the use of these results, which lead to (1) numerical methods for path planning and (2) constructions of time-varying periodic stabilizers $u = k(t, x)$. References for this part include [4, 10, 9].

Several of the main references, which should be consulted for more technical details, can be found at `http://www.math.rutgers.edu/~sontag/`.

Reading List

[1] Z. ARTSTEIN, *Stabilization with relaxed controls*, Nonlinear Anal., Theory, Methods Appl. **7** (1983), 1163–1173.

[2] R. W. BROCKETT, *Asymptotic stability and feedback stabilization*, Differential Geometric Control Theory (R. W. Brockett, R. S. Millman, and H. J. Sussmann, eds.), Birkhäuser, Boston, 1983, pp. 181–191.

[3] F. H. CLARKE, YU. S. LEDYAEV, E. D. SONTAG, and A. I. SUBBOTIN, *Asymptotic controllability implies feedback stabilization*, IEEE Trans. Automat. Control **42** (1997), 1394–1407.

[4] J.-M. CORON, *Global asymptotic stabilization for controllable systems without drift*, Math Control, Signals, and Systems **5** (1992), 295–312.

[5] A. ISIDORI, *Nonlinear control systems: An introduction*, 3rd ed., Springer-Verlag, Berlin, 1995.

[6] M. KRSTIC, I. KANELLAKOPOULOS, and P. KOKOTOVIC, *Nonlinear and adaptive control design*, Wiley, New York, 1995.

[7] E. D. SONTAG and H. J. SUSSMANN, *Remarks on continuous feedback*, Proc. IEEE Conf. Decision and Control (Albuquerque, 1980), pp. 916–921.

[8] E. D. SONTAG, *A "universal" construction of Artstein's theorem on nonlinear stabilization*, Systems Control Lett. **13** (1989), 117–123.

[9] ——, *Control of systems without drift via generic loops*, IEEE Trans. Automat. Control **40** (1995), 1210–1219.

[10] ——, *Spaces of observables in nonlinear control*, Proc. Internat. Congr. Math., 1994, vol. 2, Birkhäuser-Verlag, Basel, 1995, pp. 1532–1545.

[11] ——, *Mathematical control theory: Deterministic finite dimensional systems*, 2nd ed., Springer-Verlag, New York, 1998.

[12] H. J. SUSSMANN, *Subanalytic sets and feedback control*, J. Differential Equations **31** (1979), 31–52.

Recent Results on the Maximum Principle of Optimal Control Theory

Hector J. Sussmann, Rutgers University

Synopsis

The Maximum Principle of Optimal Control Theory is a far-reaching generalization of the necessary conditions for optimality of a trajectory given by the classical Euler-Lagrange equation of the calculus of variations, which applies to many other problems that are not reducible to the calculus of variations setting. As in H. Schättler's lecture, we will deal only with finite-dimensional, deterministic control systems, thereby excluding other classes of potentially interesting problems arising from stochastic or distributed-parameter systems. (The class of problems to be

considered will, however, include discrete-time as well as continuous-time systems.)

The classical version of the Principle was stated and proved in the 1962 book [7] (cf. also [1] and [6]). Since then, the theorem has been extended in several directions, leading to stronger results for wider classes of problems under weaker technical hypotheses. Until recently it was not clear whether these numerous extensions could be unified into a single general result proved by means of a single method. "Nonsmooth" versions (e.g., Clarke [2]), involving dynamical equations with a Lipschitz but not continuously differentiable right-hand side, were proved by successive penalization techniques, whereas classical smooth versions with stronger conclusions (e.g., high-order optimality conditions) were proved by adapting Weierstrass's idea of "needle variations". Moreover, versions applicable to some very nonsmooth (e.g., non-Lipschitz) problems could be derived by ad hoc methods. All this added up to a somewhat chaotic situation, where many different techniques and constructions were needed to prove results that were all clearly closely related. This was obviously undesirable for aesthetic reasons, and in addition had the unpleasant effect that the existing results did not add up to a version that would cover "hybrid" problems: If the dynamics satisfies different technical conditions in different regions of the state space, and an arc ξ visits more than one of these regions, then each of the existing versions would apply to a piece of ξ, but none of them would yield a conclusion valid for the whole arc.

Recent developments have fundamentally changed this state of affairs and brought us very close to a complete unification of the various versions into one single result, proved using a uniform technique that applies in all cases and that works equally well for "hybrid" systems and for many other problems where the previous theorems either fail to apply or do apply but with conclusions that are too weak. The technique is that of "variations, flows, and generalized differentials", which combines (a) the classical needle-variations approach of Weierstrass, (b) the systematic use of a *reference flow* as opposed to a reference vector field, and (c) the use of suitable theories of *generalized differentials.*

The lecture will give a self-contained description of the technique and of the general results that can be proved with it. The main point of the approach involves realizing that the classical method used in [7] applies equally well if the classical notion of differential of a map is replaced by various other multivalued notions. (For example, the "generalized derivative" of the function $f(x) = |x|$ at 0 in the sense of F. Clarke's "generalized gradients" or that of J. Warga's "derivate containers" is the interval $[-1, 1]$.) It then turns out that the various previously existing versions of the Maximum Principle can all be obtained by the same method by just making an appropriate choice of a theory of multivalued differentials. Moreover, there exists a theory that includes all the others (the "multidifferentials", studied in [13]), and using this theory one gets the most general Maximum Principle, a version of which is stated in [14]. Finally, the approach based on using this theory is actually *simpler* than those using more restrictive theories and allows for a presentation with very few prerequisites other than basic calculus (on the level of the implicit and inverse functions) and standard real variables and functional analysis. (A few more sophisticated results, such as Sard's theorem, the Brouwer fixed-point theorem, and Rademacher's theorem on the a. e. differentiablity of Lipschitz functions will be used as well, but no detailed familiarity will be required.)

In the reading list provided below, the books [1], [6], and [7] contain versions of the classical maximum principle, and [2] contains F. Clarke's nonsmooth version. The books [5] and [8] are general introductions to control theory. A brief discussion of what is still missing to achieve complete unification will be given at the end of the lecture. The versions given in the papers [3] and [4] are examples of the kind of result *not* yet covered by the unified framework discussed in the lecture.

The papers by H. J. Sussmann in the reading list are available at the author's Web page: `http://www.math.rutgers.edu/~sussmann/currentpapers.html`.

Reading List

[1] L. D. Berkovitz, *Optimal control theory*, Springer-Verlag, New York, 1974.

[2] F. H. Clarke, *Optimization and nonsmooth analysis*, Wiley, New York, 1983.

[3] A. D. Ioffe and R. T. Rackafellar, *The Euler and Weierstrass conditions for nonsmooth variational problems*, Calc. Var. Partial Differential Equations **4** (1996), pp. 59–87.

[4] A. D. Ioffe, *Euler-Lagrange and Hamiltonian formalisms in dynamic optimization*, Trans. Amer. Math. Soc. **349** (1995), 801–817.

[5] V. Jurdjevic, *Geometric control theory*, Cambridge Univ. Press, 1997.

[6] E. B. Lee and L. Markus, *Foundations of optimal control theory*, Wiley, New York, 1990.

[7] L. Pontryagin, V. Boltianskii, R. Gamkrelidze, and E. Mishchenko, *The mathematical theory of optimal processes*, Wiley-Interscience, New York, 1962.

[8] E. D. Sontag, *Mathematical control theory*, Springer-Verlag, New York, 1990.

[9] H. J. Sussmann, *A strong version of the Lojasiewicz Maximum Principle*, Optimal Control of Differential Equations (N. H. Pavel, ed.), Dekker, New York, 1994.

[10] ____, *A strong version of the Maximum Principle under weak hypotheses*, Proc. 33rd IEEE Conf. Decision and Control (Orlando, FL, 1994), pp. 1950–1956.

[11] ____, *A strong maximum principle for systems of differential inclusions*, Proc. 35th IEEE Conference on Decision and Control (Kobe, Japan, 1996), IEEE Publications, 1996.

[12] H. J. Sussmann and J. C. Willems, *300 years of optimal control: From the Brachystochrone to the maximum principle*, IEEE Control Systems (1974), 32–44.

[13] H. J. Sussmann, *Multidifferential calculus: Chain rule, open mapping and transversal intersection theorems*, to appear in Optimal Control: Theory, Algorithms, and Applications (W. W. Hager and P. M. Pardalos, eds.), Kluwer, 1997.

[14] ____, *Geometry and optimal control*, to appear in Perspectives in Control, a book of essays in honor of Roger W. Brockett on the occasion of his 60th birthday (J. Baillieul and J. C. Willems, eds.), Springer-Verlag.

Mathematical Sciences Employment Register

Henry B. Gonzales Convention Center, San Antonio, Texas

January 13, 14, and 15, 1999

1999 Employment Register Schedule

Wednesday, January 13, 7:30 a.m. Distribution of Employment Register material for on-site registrants and participants registered in advance who did not receive materials by mail.

9:00 a.m. Short (optional) orientation session.

9:30 a.m.–4:00 p.m. Submission of all interview request forms for both Thursday and Friday interviews. Those who do not submit interview request sheets by 4:00 p.m. will be unable to participate in the scheduled Employment Register on Thursday and Friday.

10 a.m.–5 p.m. Interview Center open.

N.B.— No regular Employment Register interviews are scheduled on Wednesday.

Thursday, January 14, 7:00 a.m.–8:15 a.m. Distribution of interview schedules for both Thursday and Friday.

8:15 a.m.–4:40 p.m. Scheduled interviews.

8:15 a.m.–7:30 p.m. Interview Center open.

Friday, January 15, 8:15 a.m.–4:40 p.m. Scheduled interviews.

8:15 a.m.–7:30 p.m. Interview Center open.

Saturday, January 16, 9:00 a.m.–12 noon. Interview Center open.

All participants in the 1999 scheduled Employment Register must submit their Interview Request/Availability Forms between 9:30 a.m. and 4:00 p.m. on Wednesday or they will not be included when the interview scheduling program runs Wednesday night. Should unexpected delays occur while travelling, contact the Employment Register Desk by telephone at 401-455-4107 before 4:00 p.m. EST on Wednesday, January 13.

Overview of the Employment Register

The Mathematical Sciences Employment Register, held annually at the Joint Mathematics Meetings in January, provides opportunities for mathematical scientists seeking professional employment to meet employers who have positions to be filled.

The Employment Register has grown in recent years to house two services: the scheduled employment register tables and the self-scheduled Interview Center. Use of the Register by employers has gone up. At the 1998 Employment Register, 86 employers and 394 applicants participated, giving an overall applicant to employer ratio of 4.6:1. The number of interviews for each applicant is just over three interviews in the scheduled program and just under four interviews in the Interview Center, for an average total of seven interviews. Each employer conducts approximately 30–40 interviews.

This year, one additional option is available for employers: the use of an "Information Booth" table in the center of the Employment Register where employers can distribute information and speak with walk-up candidates about open positions.

The Mathematical Sciences Employment Register is sponsored by the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics; it is managed by members of the AMS staff under the general guidance of the AMS-MAA-SIAM Committee on Employment Opportunities.

Employers: Choose one or more of these tables:

- *traditional Employment Register scheduling system*
- *Interview Center table*
- *centrally located Information Booth*

The **Interview Center** allows any employer to reserve a table in an area adjacent to the Employment Register. You will arrange your own schedule and interviews, either in advance or on site using the Employment Register Message Center. If you have never used the Employment Register before, you might want to try conducting your interviews at this convenient location. Since you will be setting your own schedule, you have complete control over whom you see, for how long, and when you will be interviewing. The Center will be open longer hours: Wednesday, 10:00 a.m.–5:00 p.m.; Thursday and Friday, 8:00 a.m.–7:30 p.m.; and Saturday, 9:00 a.m.–12 noon. The fee for use of this area is the same as the normal employer fee. You will be mailed in advance the *Winter List of Applicants* containing information about the candidates present at the Employment Register.

How to Register for the Interview Center

Register for the Joint Meetings and pay the employer fee by November 9. Indicate on the Meetings Registration Form that you are using the Interview Center. Also, submit an Employer Form (found at `www.ams.org/emp-reg/employer.html`). Call 800-321-4267, ext. 4105, or e-mail `emp-info@ams.org` with any questions.

How to Use the Interview Center

If you are scheduling interviews in advance, tell applicants to find the table with your institution name in the Employment Register Interview Center (not the regular table area). You can schedule any time from 10 a.m.–5 p.m. Wednesday, 8 a.m.–7:30 p.m. Thursday and Friday, and 9:00 a.m.–12 noon Saturday. To schedule interviews yourself after arriving in San Antonio, leave messages for Employment Register applicants in the Employment Register Message Center. Paper forms will be provided to help you leave messages. You will be provided with a box in the Employer Message Center where applicants can leave items for you.

How to Use the Regular Scheduling System at the Employment Register

Employers will choose on Wednesday, January 13, which of the eight sessions to participate in. Submit your availability/interview request forms by 4:00 p.m. Wednesday. You may ask to be scheduled with ten applicants per day. You are virtually assured of those requests being filled by the scheduling algorithm, provided the applicants are present. The rest of your interviews will be with applicants who ask to see you. Employers should be specific about job requirements on the Employer Form to avoid interviews with inappropriate candidates.

Schedules are distributed on Thursday morning for both Thursday and Friday interviews. The schedule allows fifteen-minute interviews, with five minutes between for note taking. One or more interviewers for the same position(s) may interview at the table separately, together, or in shifts.

Employers should bring school catalogs, corporate reports, or more lengthy job descriptions to the Employment Register Desk early on Wednesday for perusal by applicants prior to interviews.

New Information Booths for Informal Discussions

Some employers need to distribute information about open positions during the Joint Meetings and are willing to speak with walk-up applicants in an informal way. The Information Booth tables, located in the center of the Employment Register, provide a perfect setting for this. Normal table fees are charged. Keep in mind, however, only a table and chairs will be provided. No shipping or receiving services, no electrical connections, and no sales of any kind are allowed. Those requiring such services should utilize Joint Meetings exhibit space.

Registering for More Than One Type of Table

Employers can reserve and pay for two tables at the first and second table rates and indicate that they are of different types. Please specify this on the registration form as well as the Employer Form. Interview Request Forms must be turned in on Wednesday by 4:00 p.m. for those who will be using the scheduling system for any portion of their time.

Employers: How to Register

The fee for all employers to register in advance is $200 for the first table and $50 for each additional table. On-site registration fees (any registrations after 12/18/98) are $250 for the first table and $75 for each additional table. Employers must also register for the Joint Meetings and pay the appropriate Joint Meetings fee. Joint Meetings registration forms are available in the back of this issue or on e-MATH in the Meetings section (`http://www.ams.org/amsmtgs/2031_registration.html`).

Employer Forms are available in the back of this issue or electronically on e-MATH, and they can also be submitted electronically. The URL is `http://www.ams.org/emp-reg/`. The Employer Form and registration form must be received by November 9, 1998. Call the Employment Register staff with any deadline problems at 800-321-4267, ext. 4105, or `emp-info@ams.org`. Please indicate on each form which type or types of tables you plan to use. A "second table" fee should be paid for any additional type of table.

It is the policy of some institutions to pay directly for employer fees. If a payment of this type is made separately from the submission of the advance registration materials, it is important that the institution's fiscal department include the name of the department and interviewer with their payment so that proper credit can be made in the Providence office.

About the *Winter List of Applicants*: This booklet contains hundreds of résumés of applicants registered by November 9 for the Employment Register. It will be mailed to ALL employers who register by November 9 who indicate on their Joint Meetings registration form that they would like their materials mailed. Employers should be aware that there will be hundreds of brief résumés to look through and should be sure to obtain the *Winter List of Applicants* as early as possible. This book is also for sale at the Joint Meetings.

Employers Not Planning to Interview: Employers who do not plan to participate in the Employment Register may display a job description. This description must be submitted on the Employer Form which appears in the back of this issue and on e-MATH, with the appropriate indication that no tables will be used. A fee of $50 is charged for this service. If the form is received in the Providence office (with payment) by the November 9 deadline, it will appear in the *Winter List of Employers*. Forms received with payment in the Providence office after that deadline will be displayed at the meeting.

Applicants: How to benefit from your Employment Register experience

Applicants who participate in the 1999 Employment Register will find themselves talking with employers in three different settings. A scheduling program sets brief, fifteen-minute interviews at the Employment Register numbered tables. There is also an Interview Center where employers set their own schedules. These employers do not participate in the scheduling program, so applicants have no automatic access to interviews with them. They determine their own schedules and make their own appointments privately, either in advance or on site using the Employment Register Message Center. The third method of employer participation (which is being tried for the first time in 1999) is an Information Booth area where employers distribute information about open positions and chat with the candidates who approach the table.

There is a certain scheduling burden placed on applicants to juggle these simultaneous services. A step has been taken to alleviate this: scheduled sessions are now in smaller blocks, for a total of eight sessions over the two days of interviews (Thursday and Friday). This allows applicants, once they receive invitations to interview in the Interview Center, to accept them knowing that when they submit the computer schedule request on Wednesday, they can mark that they are unavailable for one or more of these sessions without seriously jeopardizing their chances of obtaining scheduled interviews. Applicants are encouraged to schedule their time in advance in this manner and not wait for the computer schedule to be distributed Thursday morning.

Applicants should understand that the Employment Register provides no guarantees of interviews or jobs. It is simply a convenient meeting place for candidates and employers who are attending the Joint Meetings. Those who have not yet begun their job search efforts may go unnoticed at the Employment Register (although all applicants will likely receive between one and three interviews in the scheduled program). Attention generally goes to candidates who may already have applied for open positions or to those who are well suited for teaching positions at liberal arts colleges.

Candidates just beginning a job search should realize that employers have no method to judge their credentials other than the brief Résumé Form, and they should make an effort to make it distinct and interesting. If time permits, they should apply for suitable open positions they notice in the *Winter List of Employers* after they receive it in December. Also, they should bring enough materials with them to accompany requests for interviews in the Message Center boxes of the Interview Center employers in which they are interested.

The *Winter List of Applicants* is mailed to all employers in advance, so it is vital that your Joint Meetings registration form, Applicant Résumé Form, and payments be received by the November 9 deadline so your form can be printed in the book. This greatly increases your chances of being invited to the Interview Center.

Recent applicant feedback (see the survey results on the Web at `http://www.ams.org/emp-reg/`) shows that applicants strongly preferred the Interview Center interviews, which are longer, more relaxed, and in a less structured setting. On average, last year each applicant was scheduled for slightly over three interviews in the scheduled program and almost four interviews in the Interview Center. Nearly five out of six applicants were invited for at least one interview at the Interview Center. Those who fared better in the computer schedule were those who were more requested by employers. Applicants should keep in mind that they are not required to participate in the scheduled program. They can make themselves available for Interview Center invitations by registering in advance, placing their form in the *Winter List of Applicants*, and utilizing the Employment Register Message Center. By not turning in a computer interview request sheet on Wednesday, applicants will not be included in the scheduled interviews.

Registration on site is allowed, for a higher fee, but is severely discouraged. Most employers will not notice an applicant form that arrives on Wednesday. Therefore, these individuals will receive only a couple of computer-scheduled interviews.

Data from recent Employment Registers shows that women represent about half of the most sought-after applicants, although they make up less than half of the total Employment Register applicant pool. Those without permanent authorization to work in the United States will find themselves far less requested than U.S. citizens or permanent residents. Newer Ph.D.s tend to be invited for more interviews than those who have been working longer. Most jobs listed require a doctorate.

Applicants should keep in mind that interviews arranged by the Employment Register represent only an initial contact with the employers and that hiring decisions are not ordinarily made during or immediately following such in-

terviews. Applicants are advised to bring a number of copies of the vita or résumé in order to leave them with prospective employers. Alerting any employer to whom applications are made in the fall of your plans to be present at the upcoming Joint Meetings is always a good idea.

Applicants: How to Register

Advance registration is an important step in Employment Register participation that offers several advantages.

Advance registration fees for applicants are $40 plus Joint Meetings registration fee vs. $75 on-site registration fee plus Joint Meetings registration fee.

Applicant Forms are available electronically on e-MATH, and they can also be submitted electronically. The Employment Register announcement and forms are located in the Employment section, along with other employment-related items, at `http://www.ams.org/employment/`.

Each applicant's Résumé Form will be reproduced in a booklet, the *Winter List of Applicants*, and distributed to all registered employers. Applicant Résumé Forms received after November 9, 1998, cannot be included in the booklet. The booklet allows employers more time to examine each candidate's qualifications in advance. Advance registration for the Employment Register will continue until the final registration deadline of December 18, 1998; however, the Résumé Form will NOT be included in the *Winter List*, but will be posted on site at the Employment Register. Those who do not register by December 18 must register on site at the Joint Meetings Registration Desk and pay the higher fees.

Applicants registered by November 9 will receive their badges, programs, and Employment Register materials two to three weeks in advance of the meetings, unless they request otherwise. The package will include the complete job announcements received from employers registered by November 9.

Registration on Site: Feel free to enter the Employment Register area first to consult staff about your decision to try late participation and to check which employers are participating. Applicants should keep in mind that on-site registration should be done as early on Wednesday as possible to allow a longer time for your Résumé Form to be viewed by other participants and also to allow time to examine materials before making your own interview requests. There will be no on-site registration for the Employment Register after 4:00 p.m. Wednesday, January 13.

Instructions for Applicant and Employer Forms

Applicant forms submitted for the Employment Register by the November 9 deadline will be reproduced in a booklet titled *Winter List of Applicants*. Employer forms submitted by the November 9 deadline will be reproduced for the *Winter List of Employers*.

Please use the electronic versions of Applicant and Employer forms (`http://www.ams.org/emp-reg/`). Paper forms should be submitted only by those who do not have access to e-MATH.

If submitting a paper form, please type carefully. **Do not type outside the box or beyond the lines indicated. Extra type will be omitted.**

All forms must be received by the Society by **November 9, 1998**, in order to appear in the *Winter List*. If you are attending the meeting, the Advance Registration/Housing Form printed in this issue should accompany the form.

00 General
01 History and biography
03 Mathematical logic and foundations
04 Set theory
05 Combinatorics
06 Order, lattices, ordered algebraic structures
08 General algebraic systems
11 Number theory
12 Field theory and polynomials
13 Commutative rings and algebras
14 Algebraic geometry
15 Linear and multilinear algebra, matrix theory
16 Associative rings and algebras
17 Nonassociative rings and algebras
18 Category theory, homological algebra
19 K-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
39 Finite differences and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
49 Calculus of variations and optimal control; optimization
51 Geometry
52 Convex and discrete geometry
53 Differential geometry
54 General topology
55 Algebraic topology
57 Manifolds and cell complexes
58 Global analysis, analysis on manifolds
60 Probability theory and stochastic processes
62 Statistics
65 Numerical analysis
68 Computer science
70 Mechanics of particles and systems
73 Mechanics of solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
83 Relativity and gravitational theory
85 Astronomy and astrophysics
86 Geophysics
90 Economics, operations research, programming, games
92 Biology and other natural sciences, behavioral sciences
93 Systems theory, control
94 Information and communication, circuits
97 Mathematics education

EMPLOYER FORM
MATHEMATICAL SCIENCES EMPLOYMENT REGISTER
JANUARY 14–16, 1999
SAN ANTONIO, TEXAS

1. Forms should be accessed and submitted electronically if possible. The URL for accessing Employment Register information and forms is `http://www.ams.org/emp-reg/`.
2. Paper or electronic forms are due, along with payment and your Advance Registration/ Housing Form, by November 9 (to AMS, P. O. Box 6887, Providence, RI 02940) in order to be included in the ***Winter List of Employers***.
3. Please list all potential interviewers, for reference by applicants, but pay fees only for each separate table.
4. Forms will not be processed until registration and payment of fees have been received.

EMPLOYER CODE:

Institution _____

Department _____

Mailing address _____

_____

E-mail address (one only) _____

URL (or other contact info) _____

Name(s) of Interviewer(s) 1. _____

2. _____

3. _____

4. _____

Specialties sought _____

_____

Title(s) of position(s) _____

Number of positions _____

Starting date _____ / _____ (Month / Year) Term of appointment _____ (Years)

Renewal ☐ Possible ☐ Impossible Tenure-track position ☐ Yes ☐ No Teaching hours per week _____

Degree preferred _____ Degree accepted _____

Duties _____

_____

_____

Experience preferred _____

_____

_____

Significant other requirements, needs, or restrictions which will influence hiring decisions _____

_____

_____

This position will be subject to a security clearance which will require U.S. citizenship: ☐ Yes ☐ No

THE EMPLOYER PLANS TO USE THE FOLLOWING SERVICES (check all that apply):

☐ Regular scheduled Employment Register table

☐ A second regular scheduled Employment Register table

☐ Interview Center table

☐ Information Booth table

☐ Placing this form for information only (not using a table)

APPLICANT RÉSUMÉ FORM

MATHEMATICAL SCIENCES EMPLOYMENT REGISTER
JANUARY 14–16, 1999
SAN ANTONIO, TEXAS

1. Forms should be accessed and submitted electronically if possible. The URL for accessing Employment Register information and forms is `http://www.ams.org/emp-reg/`.
2. Paper or electronic forms are due, along with payment and your Advance Registration/ Housing Form, by November 9 (to AMS, P. O. Box 6887, Providence, RI 02940) in order to be included in the ***Winter List of Applicants***.
3. Forms will not be processed until registration and payment of fees have been received.

APPLICANT CODE:

Last name _____ First name _____

Mailing address (include zip code) _____

_____

E-mail address (one only) _____

URL (or other contact info) _____

Specialties _____

_____

(use MR classification codes plus text if possible; applicants will be indexed by first number only)

DESIRED POSITION:

Academic: ☐ Research ☐ University Teaching College Teaching: ☐ 4-year ☐ 2-year

Would you be interested in nonacademic employment? ☐ Yes ☐ No

Available mo. _____ /yr. _____

Significant requirements (or restrictions) which would limit your availability for employment _____

_____

PROFESSIONAL ACCOMPLISHMENTS:

Significant achievements, research or teaching interests _____

_____

_____

_____

_____

Paper to be presented at this meeting or recent publication _____

_____

Degree	Year (expected)	Institution

Number of refereed papers accepted/published _____

PROFESSIONAL EMPLOYMENT HISTORY:

	Employer	Position	Years
1.			_____ to _____
2.			_____ to _____
3.			_____ to _____

References (Name and Institution only)

_____

_____

_____

_____

Work authorization status: (check one) ☐ U.S. Citizen ☐ Non-U.S. Citizen, authorized to work permanently in U.S. ☐ Other

Hotel Reservations

To ensure accurate assignments, please rank hotels in order of preference by writing 1, 2, 3, etc., in the spaces at the left of the form and by circling the requested room type and rate. If the rate or the hotel requested is no longer available, you will be assigned a room at a ranked or unranked hotel at a comparable rate. Participants are urged to call the hotels directly for details on suite configurations, sizes, etc. Reservations at the following hotels must be made through the MMSB to receive the convention rates listed. All rates are subject to a 15% sales occupancy tax. **Guarantee requirements: First night deposit by check (add to payment on reverse of form) or a credit card guarantee.**

☐ Deposit enclosed ☐ Hold with my credit card Card Number_____ Exp. Date _____ Signature _____

Date and Time of Arrival _____ **Date and Time of Departure** _____

Name of Other Room Occupant _____ **Arrival Date** _____ **Departure Date** _____ **Spouse** ☐ **Child** ____ **(give age)**

Order of choice	Hotel	Single	Double 1 bed	Double 2 beds	Triple 2 beds	Triple 2 beds w/cot	Quad 2 beds	Quad 2 beds w/cot	Suites Starting rates
	Marriott Rivercenter (co-headquarters)*	$121	$135	$135	$150	$150	$165	$165	$400
	Students	$95	$95	$95	$110	$110	$125	$125	N/A
	Marriott Riverwalk (co-headquarters)*	$119	$119	$119	$134	$134	$149	$149	$500
	Students	$91	$91	$91	$106	$106	$121	$121	N/A
	Hilton Palacio del Rio	$119	$119	$119	$139	$159**	$159	N/A	$500
	Students	$109	$109	$109	$129	$149**	$149	N/A	N/A
	Ramada Emily Morgan Hotel	$95	$105	$105	$115	$125	$125	$135	N/A
	Students	$85	$95	$95	$105	$115	$115	$125	N/A
	The Menger	$89	$99	$99	$99	$99	$99	$99	$186
	Students	$79	$89	$89	$89	$89	$89	$89	N/A
	La Quinta Convention Center	$89	$99	$99	$109	$119	$109	$119	N/A
	The Crockett Hotel	$85	$85	$85	$95	$105**	$95	$105**	$149
	Students	$75	$75	$75	$85	$95**	$85	$95**	N/A
	Holiday Inn Express Hotel & Suites	$81	$81	$81	$81	N/A	$81	N/A	all suites
	Students	$79	$79	$79	$79	N/A	$79	N/A	N/A
	Hampton Inn	$75	$75	$75	$75	$85	$75	$85	N/A
	Students	$65	$65	$65	$65	$75	$65	$75	N/A
	Red Roof Inn	$64.99	$64.99	$64.99	$64.99	$69.99	$64.99	$69.99	N/A

***Please note that the AMS Council and MAA Board of Governors will meet at the Hilton, NOT at the co-headquarters hotels. Please check updated announcements and schedules for locations of other committee meetings.**

****LImited Availability**

Special Housing Requests:.

☐ I have disabilities as defined by the ADA that require a sleeping room that is accessible to the physically challenged. My needs are: _____

☐ Other requests: _____

☐ If you are a member of a hotel frequent-travel club and would like to receive appropriate credit, please include the hotel chain and card number here: _____

If you are not making a reservation, please check off one of the following:

☐ I plan to make a reservation at a later date.

☐ I will be making my own reservations at a hotel not listed. Name of hotel: _____

☐ I live in the area or will be staying privately with family or friends.

☐ I plan to share a room with _____, who is making reservations.

San Antonio Advance Registration/Housing Form

Name _____

Mailing Address _____

_____

Telephone _____ Fax _____

Email Address _____

(Acknowledgment of this registration will be sent to the email address given here, unless you check the box to the right.)

Badge Information: Name to appear on badge _____

Affiliation for badge _____

Nonmathematician guest badge _____ (please note charge below)

Membership
✓ all that apply

- AMS ☐
- ASL ☐
- AWM ☐
- CMS ☐
- MAA ☐
- NAM ☐

JOINT MATHEMATICS MEETINGS
San Antonio ★ Texas
January 13–16, 1999

☐ **I DO NOT want my program and badge to be mailed to me on 12/9/98.**

☐ **I want acknowledgment of this registration sent by U.S. mail, not email.**

Registration Fees

Joint Meetings	**by Dec 21**	**at mtg**	**Subtotal**
☐ Member AMS, ASL, CMS, MAA	$160	$208	
☐ Nonmember	$248	$322	
☐ Graduate Student	$ 35	$ 45	
☐ Undergraduate	$ 20	$ 26	
☐ High School Student	$ 2	$ 5	
☐ Unemployed	$ 35	$ 45	
☐ Temporarily Employed	$120	$133	
☐ Developing Countries Special Rate	$ 35	$ 45	
☐ Emeritus Member of AMS or MAA	$ 35	$ 45	
☐ High School Teacher	$ 35	$ 45	
☐ Librarian	$ 35	$ 45	
☐ Nonmathematician Guest	$ 5	$ 5	
☐ Exhibitor	$ 0	$ 0	
			$ _____

AMS Short Course on *Nonlinear Control (1/11–1/12)*

☐ Member, Nonmember	$ 80	$ 95	
☐ Student, Unemployed, Emeritus	$ 35	$ 45	
			$ _____

MAA Short Course on *Mathematics in Finance (1/11–1/12)*

☐ Member of MAA	$125	$140	
☐ Nonmember	$175	$190	
☐ Student, Unemployed, Emeritus	$ 50	$ 60	
			$ _____

MAA Minicourses (see listing on facing page)

I would like to attend: ☐ One Minicourse ☐ Two Minicourses

Please enroll me in MAA Minicourse(s) #_____ and/or #_____

In order of preference, my alternatives are: #_____ and/or #_____

Prices: $55 for Minicourses # 1, 3, 4, 6, 7, 8, 10, 12, 13, 15, 16

$75 for Minicourses # 2, 5, 9, 11, 14 (computer)

$ _____

Employment Register

Applicant résumé forms and employer job listing forms will be on e-MATH and in *Notices* in September and in *Focus* in October.

Employer—First Table	$200	$250	
☐ Regular ☐ Self-scheduled ☐ Information Table			
Employer—Second Table	$ 50	$ 75	
☐ Regular ☐ Self-scheduled ☐ Information Table			
☐ Employer—Posting Only	$ 50	N/A	
☐ Applicant	$ 40	$ 75	
			$ _____

Events with Tickets				**Price Per**
AMS Banquet	#____Regular	#____Veg	#____Kosher	$ 39
MER Banquet	#____Regular	#____Veg	#____Kosher	$ 39
NAM Banquet	#____Regular	#____Veg	#____Kosher	$ 39

$ _____

Student Activities (no charge):

☐ Mathchats

Total of Fees for Registrations & Events : $ _____

Payment

Registration & Event Total (total from other column) $ _____

Hotel deposit (only if paying by check) $ _____

Total Amount To Be Paid **$** _____

(Note: A $5 processing fee will be charged for each returned check or invalid credit card.)

Method of Payment

☐ Check. Make checks payable to the AMS. Checks drawn on foreign banks must be in equivalent foreign currency at current exchange rates.

☐ Credit Card. VISA, MasterCard, AMEX, Discover (no others accepted).

Card number: _____

Exp. date: _____ Zipcode of credit card billing address: _____

Signature: _____

Name on card: _____

☐ Purchase order # _____ (please enclose copy)

Registration for the Joint Meetings is not required for the Short Courses, but it is required for the Minicourses and the Employment Register.

Other Information

Mathematical Reviews field of interest # _____

How did you hear about this meeting? Check one:

☐ *Focus* ☐ *Notices* ☐ WWW ☐ Colleague(s) ☐ Special mailing

☐ I am a mathematics department chair.

☐ Please do not include my name on any promotional mailing list.

☐ Please ✓ this box if you have a disability requiring special services.

Mail to:

Mathematics Meetings Service Bureau (MMSB)
P. O. Box 6887
Providence, RI 02940-6887
Fax: 401-455-4004
Questions/changes call: 401-455-4143 or 1-800-321-4267 x4143

Deadlines

For room lottery and/or résumés/job descriptions printed in the *Winter Lists*, return this form by:	**Nov. 9, 1998**
For housing reservations, badges/programs mailed:	**Nov. 23, 1998**
For housing changes/cancellations through MMSB:	**Dec. 11, 1998**
For advance registration for the Joint Meetings, Employment Register, Short Courses, MAA Minicourses, & banquets:	**Dec. 21, 1998**
For 50% refund on banquets, cancel by:	**Dec. 30, 1998***
For 50% refund on advance registration, Minicourses & Short Courses, cancel by:	**Jan. 9, 1999***

***no refunds after this date**

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Bernard Russo, Department of Mathematics, University of California, Irvine, CA 92697; e-mail: brusso@math.uci.edu; telephone: 949-824-5505.

Central Section: Susan J. Friedlander, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (M/C 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@magnus.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:

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 150 in the January 1998 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 LaTeX, or AMS-LaTeX 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 Meetings & Conferences Department, 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. Un-

Conferences: (See http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

1999:

January 11–12: Short Course on Nonlinear Control, Hilton Palacio Del Rio, San Antonio, Texas.
(See pages 1262–1266, this issue, for details.)

SPRINGER FOR MATHEMATICS

Third Edition!

JOHN HORTON CONWAY, Princeton University, NJ and **N. J. A. SLOANE,** AT&T Labs Research, Florham Park, NJ

SPHERE PACKINGS, LATTICES AND GROUPS

The third edition of this timely, definitive, and popular book continues to pursue the question: what is the most efficient way to pack a large number of equal spheres in n-dimensional Euclidean space? It examines related problems such as the kissing number problem, the covering problem, the quantizing problem, and the classification of lattices and quadratic forms and describes the applications of these questions to other areas of mathematics and science such as number theory, coding theory, group theory, analog-to-digital conversion and data compression, n-dimensional crystallography, dual theory, and superstring theory in physics. Of special interest to the third edtion is a report on some recent developments in the field and an updated and enlarged supplementary bibliography with over 800 items.

1998/APP. 744 PP., 112 ILLUS./HARDCOVER
$89.00 (TENT.)/0-387-98585-9
GRUNDLEHREN DER MATHEMATISCHEN WISSENSCHAFTEN, VOLUME 290

ROBERT GOLDBLATT, Victoria University, Wellington, New Zealand

LECTURES ON THE HYPERREALS

An Introduction to Nonstandard Analysis

This introduction to nonstandard analysis is suitable for use as a text at the beginning graduate or upper undergraduate level, or for self-study by anyone familiar with elementary real analysis. It presents nonstandard analysis as a radically different way of viewing many standard mathematical concepts and constructions; a source of new ideas, objects, and proofs; and a wellspring of powerful new principles of reasoning (transfer, overflow, saturation, enlargement, hyperfinite approximation, etc.). The book begins with the ultrapower construction of hyperreal number systems, and proceeds to develop one-variable calculus, analysis, and topology from the nonstandard perspective, emphasizing the role of the transfer principle as a working tool of mathematical practice. It then sets out the theory of enlargements of fragments of the mathematical universe, providing a foundation for the full-scale development of the nonstandard methodology. The final chapters apply this to a number of topics, including Loeb measure theory and its relation to Lebesgue measure on the real line, Ramsey's Theorem, nonstandard constructions of p-adic numbers and power series, and nonstandard proofs of the Stone representation theorem for Boolean algebras and the Hahn-Banach theorem. Features of the text include an early introduction of the ideas of internal, external, and hyperfinite sets, and a more axiomatic set-theoretic approach to enlargements than the usual one based on superstructures.

1998/APP. 304 PP./HARDCOVER/$49.95/0-387-98464-X
GRADUATE TEXTS IN MATHEMATICS, VOLUME 188

Springer

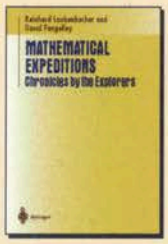
http://www.springer-ny.com

LOOK OUT FOR THE *1998 YELLOW SALE* STARTING OCTOBER 1ST!

REINHARD LAUBENBACHER and **DAVID PENGELLEY,** both of New Mexico State University

MATHEMATICAL EXPEDITIONS

Chronicles by the Explorers



This book contains the stories of five mathematical journeys into new realms, pieced together through the writings of the explorers themselves. Some were guided by mere curiosity and the thrill of adventure, others by more practical motives. In all cases the outcome was a vast expansion to the known mathematical world and the realization that still greater vistas remain to be explored. The authors tell the stories by guiding the reader through the very words of the mathematicians at the heart of these events and thereby help the readers gain insights into the art of approaching mathematical problems. The book can be used in a variety of ways. The five chapters are completely independent and contain varying levels of mathematical sophistication. The book will be enticing to students, instructors, and to the intellectually curious reader. By working through some of the original sources which discuss and solve, or attempt to solve, antecedent problems, this book helps to discover the roots of modern problems, ideas, and concepts, even whole subjects. Students will also see the obstacles that earlier thinkers had to clear in order to make their respective contributions to the five central themes in the evolution of mathematics.

1998/APP. 376 PP., 93 ILLUS./HARDCOVER
$59.95/0-387-98434-8
ALSO AVAILABLE IN SOFTCOVER:
$32.00/0-387-98433-X
UNDERGRADUATE TEXTS IN MATHEMATICS

STERLING K. BERBERIAN, University of Texas at Austin

FUNDAMENTALS OF REAL ANALYSIS

Integration theory and general topology form the core of this textbook for a first-year graduate course in real analysis. After the foundational material in the first chapter (construction of the reals, cardinal and ordinal numbers, Zorn's lemma, and transfinite induction), measure, integral, and topology are introduced and developed as recurrent themes of increasing depth. The treatment of integration theory is quite complete (including the convergence theorems, product measure, absolute continuity, the Radon-Nikodym theorem, and Lebesgue's theory of differentiation and primitive functions), while topology, predominantly metric, plays a supporting role. In the later chapters, integral and topology coalesce in topics such as function spaces, the Riesz representation theorem, existence theorems for an ordinary differential equation, and integral operators with continuous kernel function. In particular, the material on function spaces lays a firm foundation for the study of functional analysis.

1998/APP. 536 PP., 31 ILLUS./SOFTCOVER/$54.95
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UNIVERSITEXT

Second Edition!

JOSEPH ROTMAN, University of Illinois at Urbana-Champaign

GALOIS THEORY

This text offers a clear, efficient exposition of Galois theory with complete proofs and exercises. Topics include: cubic and quartic formulas, fundamental theory of Galois theory, insolvability of the quintic, Galois's great theorem (solvability by radicals of a polynomial is equivalent to solvability of its Galois group), and computation of Galois groups of cubics and quartics. There are appendices on group theory, ruler-compass constructions, and the early history of Galois theory. This book provides a concise introduction to Galois theory suitable for first-year graduate students, either as a text for a course or for study outside the classroom. This new edition has been completely rewritten in an attempt to make proofs clearer by providing more details. The book now begins with a short section on symmetry groups of polygons in the plane, for there is an analogy between polygons and their symmetry groups and polynomials and their Galois groups; this analogy can serve as a guide by helping readers organize the various field theoretic definitions and constructions. The exposition has been reorganized so that the discussion of solvability by radicals now appears later and several new theorems not found in the first edition are included.

1998/APP. 176 PP., 9 ILLUS./SOFTCOVER/$34.95
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HOWARD L. RESNIKOFF, Future WAVE Inc., Cambridge, MA and **RAYMOND O. WELLS, JR.,** Rice University, Houston, TX

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