NOTICES
OF THE
AMERICAN MATHEMATICAL SOCIETY

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Johan Håstad

MAY/JUNE 1988, VOLUME 35, NUMBER 5
Providence, Rhode Island, USA
ISSN 0002-9920

Calendar of AMS Meetings and Conferences

This calendar lists all meetings which have been approved prior to the date this issue of *Notices* was sent to the press. The summer and annual meetings are joint meetings of the Mathematical Association of America and the American Mathematical Society. The meeting dates which fall rather far in the future are subject to change; this is particularly true of meetings to which no numbers have been assigned. *Programs* of the meetings will appear in the issues indicated below. *First* and *supplementary* announcements of the meetings will have appeared in earlier issues.

Abstracts of papers presented at a meeting of the Society are published in the journal *Abstracts of papers presented to the American Mathematical Society* in the issue corresponding to that of the *Notices* which contains the program of the meeting. Abstracts should be submitted on special forms which are available in many departments of mathematics and from the headquarters office of the Society. Abstracts of papers to be presented at the meeting must be received at the headquarters of the Society in Providence, Rhode Island, on or before the deadline given below for the meeting. Note that the deadline for abstracts for consideration for presentation at special sessions is usually three weeks earlier than that specified below. For additional information, consult the meeting announcements and the list of organizers of special sessions.

Meetings

Meeting #		Date	Place	Abstract Deadline	Program Issue
844		August 8–12, 1988† (AMS Centennial Celebration)	Providence, Rhode Island	Expired	July/August
845	*	October 28–30, 1988	Lawrence, Kansas	August 23	October
846	*	November 12-13, 1988	Claremont, California	August 23	October
847	*	January 11–14, 1989 (95th Annual Meeting)	Phoenix, Arizona	October 12	December
		April 15–16, 1989	Worcester, Massachusetts	January 25,1989	March, 1989
		May 19–20, 1989	Chicago, Illinois	March 1, 1989	April,1989
		October 21–22, 1989	Hoboken, New Jersey	August 30,1989	October, 1989
		October 27–28, 1989	Muncie, Indiana	August 30,1989	October, 1989
		January 17–20, 1990 (96th Annual Meeting)	Louisville, Kentucky		
		January 16–19, 1991 (97th Annual Meeting)	San Francisco, California		

* Please refer to pages 721 - 722 for listing of special sessions

† Preregistration/Housing deadline is June 1

Conferences

May 29–June 3, 1988: Symposium on The Legacy of John von Neumann, Hofstra University, Hempstead, New York

June 4–August 11, 1988: Joint Summer Research Conferences in the Mathematical Sciences, Bowdoin College, Brunswick, Maine

July 3–23, 1988: Summer Research Institute on Operator Theory/Operator Algebras and Applications, University of New Hampshire, Durham, New Hampshire

July 18–29, 1988: AMS-SIAM Summer Seminar on Computational Solution of Nonlinear Systems Equations, Colorado State University, Fort Collins, Colorado

August 6–7, 1988: AMS Short Course: Chaos and Fractals: The mathematics behind the computer graphics

September 6–10, 1988: International Neural Network Society, 1988 Annual Meeting, Boston, Massachusetts (see news item, page 269, February issue)

Deadlines

	September Issue	October Issue	November Issue	December Issue
Classified Ads*	Aug 1, 1988	Aug 31, 1988	Oct 3, 1988	Oct 31, 1988
News Items	Aug 5, 1988	Sept 6, 1988	Oct 7, 1988	Nov 4, 1988
Meeting Announcements**	Jul 28, 1988	Aug 24, 1988	Sept 26, 1988	Oct 24, 1988

* Please contact AMS Advertising Department for an Advertising Rate Card for display advertising deadlines.

** For material to appear in the Mathematical Sciences Meetings and Conferences section.

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NOTICES OF THE AMERICAN MATHEMATICAL SOCIETY

SUBSCRIPTION INFORMATION
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[*Notices of the American Mathematical Society* is published ten times a year (January, February, March, April, May/June, July/August, September, October, November, December) by the American Mathematical Society at 201 Charles Street, Providence, RI 02904. Second class postage paid at Providence, RI and additional mailing offices. POSTMASTER: Send address change notices to *Notices of the American Mathematical Society*, Membership and Sales Department, American Mathematical Society, P. O. Box 6248, Providence, RI 02940.] Publication here of the Society's street address, and the other information in brackets above, is a technical requirement of the U. S. Postal Service. All correspondence should be mailed to the Post Office Box, NOT the street address.

Notices Schedule

With the increased frequency of the *Notices* and a more regular mailing schedule, certain features that readers have associated with specific issues may now be appearing in a different issue. The following are some of these items and the issues in which they will appear under the new schedule.

- **NSF Budget Request**

A description of the NSF's proposed budget request for the following fiscal year as it relates to the mathematical sciences. *April issue*

- **AMS-MAA Annual Survey, First Report**

A report of the portion of the AMS-MAA Annual Survey which deals with faculty salaries and presents a report on the statistical profile of new doctorates in the mathematical sciences. Included with this report is a listing of new doctorates and their theses titles. *November issue*

- **AMS-MAA Annual Survey, Second Report**

The employment picture in the mathematical sciences is presented through an update on the new doctorates and an analysis of faculty size and mobility. Information on course enrollment, department size and number of graduate students and undergraduate majors is also presented. *April issue*

- **Reciprocity Agreements**

Listing of all foreign mathematical societies with which the AMS has a reciprocity agreement. *July/August issue*

- **Acknowledgement of Contributions**

Listing of the AMS members who have made contributions to the Society in the past year. *July/August issue*

- **AMS Prizes**

The announcement of the presentation of AMS Prizes at Annual and Summer Meetings including biographical information about the recipients. Annual Meeting, *February issue*; Summer Meeting, *September issue*

- **Statistics on Women Mathematicians Compiled by the AMS**

A report on the breakdown by sex of AMS members in the United States, AMS Invited Speakers, AMS Officers, and AMS Editorial Boards, along with new doctorates awarded to United States citizens. *September issue*

- **Call for Topics**

Suggestions are invited for topics for various conferences which are organized by the Society. *February, April, and July/August issues*

- **Meeting Programs**

Three announcements are normally given for each meeting held by the Society. The first announcement contains information about invited speakers, special sessions, and other highlights along with registration information. The second announcement updates this information. The third announcement, or program, contains a complete description of the scientific program and other events of interest. The issue containing the first announcement for Joint Meetings (Annual and Summer) also contains the preregistration and housing forms for those meetings as well as forms for the Employment Register. The first and second announcements for these meetings appear in the two issues immediately preceding the program. For your ease in locating the Meetings and Conferences section of each issue, the contents page for this section is marked by a black bar which extends to the edge of the page. Programs of meetings and Mathematical Sciences Meetings and Conferences are also marked in this manner. Annual Meeting Program, *December issue*; Summer Meeting Program, *July/August issue*

- **Assistantships and Fellowships**

The information on assistantships and fellowships that formerly appeared in the special December issue will be presented in a publication separate from *Notices*. The new December issue will be a regular *Notices* issue. Information on special fellowships, instructorships, and postdoctoral positions will continue to appear in *Notices* since it is of interest to the general mathematical community. *October issue*

- **Bylaws of the American Mathematical Society**

The bylaws of the Society are printed in their entirety in odd-numbered years. The bylaws are accompanied by a listing of AMS Funds, Prizes, Officers, and Lecturers. *November issue, in alternate years*

AMS publication order forms, membership application forms, and change of address forms appear in the back of every issue for the convenience of Society members and their associates.

Letters to the Editor

Referendum

The AMS referendum on issues in federal support of mathematics has been a resounding success. All motions passed, most by very large margins. After considerable discussion last year over the wording of the motions, the final formulation was recognized as permitting a sounding of members' preference in this area. The unprecedented extent of debate in the *Notices* and at meetings led to an unprecedented volume of voting (more than twice as large as in an election of officers) and the outcome can be accepted without reservation as Society policy.

In our view, there is no doubt about a few immediate consequences. In particular, the Society representatives should now reorder their approach to the seeking of funding for mathematics. Mathematics has many actual and potential areas of application. Correspondingly, there are many agencies where we can seek funding while avoiding SDI and deemphasizing military work. Following the members' wishes in this regard will benefit both the profession and society.

Chandler Davis
University of Toronto

Lucy Garnett
Baruch College

Linda Keen
Lehman College

Lee Mosher
Rutgers University
at Newark

Michael Shub
IBM Thomas J. Watson
Research Center

Jean Taylor
Rutgers University
at New Brunswick

William Thurston
Princeton University

(Received March 26, 1988)

Mathematics and the AMS

Based on my recent impressions I doubt whether the American Mathematical Society is still a mathematical society.

I attended the Atlanta meeting and expected to meet many mathematicians there. Someone in your journal wrote the meeting was very enjoyable—perhaps he meant the Peachtree center. I was eager to talk mathematics with anyone (my own research is on mathematical crossroads) and was rebuffed with expressions like "I don't know," "I never heard of this before," "Send a preprint to me"—as if I was talking to clerks. Instead, those "mathematical" people around were busy with numerous conversations concerning Star Wars, Women's troubles in mathematics, appointments and promotions. None would like to try posing or solving a mathematical problem—with one exception. A nononsense man from Naval Research caught me after my talk and said ≈ "If you proved that, then maybe you can do the following problem...."; and we found a quieter room, sat and proved together a nice statement on algebraic relations between some analytic functions. It looks as if I met only 1 (one) mathematician at that crowded Atlanta meeting.

Another reason for my doubts is the contents of the *Notices*. When I was entering the AMS, the *Notices* were thoroughly mathematical: even the topics related to general politics were discussed in exact manner and within the competence of mathematicians. Recently I read in your journal that one does not need to know physics to judge a very large engineering project (the author suggests that it's enough to be literate) and that somebody is "right wing." If a mathematical journal prints "right wing" then no doubt the editor is on *the wrong wing*. This change was gradual and now I am fed up. Perhaps you cannot withstand the bullying of the "mathematical" politicians. So, I have a suggestion. I remember a discussion on whether one should receive the *Bulletin* as a part of the AMS membership (I always enjoyed the *Bulletin*)—now it's the time to discuss whether one should receive the *Notices* as a part of the AMS membership. I am tired of paying for garbage.

R. Gurevič
University of Illinois
at Urbana-Champaign

(Received March 21, 1988)

Policy on Letters to the Editor

Letters submitted for publication in *Notices* are reviewed by the Editorial Committee, whose task is to determine which ones are suitable for publication. The publication schedule requires from two to four months between receipt of the letter in Providence and publication of the earliest issue of *Notices* in which it could appear.

Publication decisions are ultimately made by majority vote of the Editorial Committee, with ample provision for prior discussion by committee members, by mail or at meetings. Because of this discussion period, some letters may require as much as seven months before a final decision is made. Letters which have been, or may be, published elsewhere will be considered, but the Managing Editor of *Notices* should be informed of this fact when the letter is submitted.

The committee reserves the right to edit letters.

Notices does not ordinarily publish complaints about reviews of books or articles, although rebuttals and correspondence concerning reviews in *Bulletin of the American Mathematical Society* will be considered for publication.

Letters should be typed and in legible form or they will be returned to the sender, possibly resulting in a delay of publication.

Letters should be mailed to the Editor of *Notices*, American Mathematical Society, P.O. Box 6248, Providence, RI 02940, and will be acknowledged on receipt.

Lower Bounds in Computational Complexity Theory

Johan Håstad

Suppose somebody gives you a 400-digit decimal number and asks you to factor it. Suppose furthermore that you are given the friendly advice that this number is the product of two primes, one with 212 digits and the other with 188 digits.

Faced with this formidable task you exclaim "I cannot do this in my lifetime!". This statement is correct in so far that even though mathematicians have studied the problem of factorization for centuries, nobody has discovered an algorithm which is efficient enough to factor a general 400-digit number in reasonable time even on today's fastest computers. This fact, however, does not convince a mathematician that factoring cannot be done efficiently. To do this one would have to *prove* that any factoring algorithm necessarily would have to take a long time.

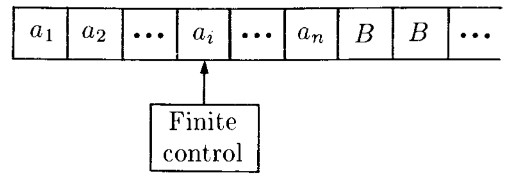
Given a computational problem we would like to prove lower bounds on the time needed to solve this problem. Obtaining any kind of non-trivial lower bound on the computational complexity of specific problems has proved very difficult; the notorious $P \neq NP$? problem would be settled by a super polynomial lower bound on the complexity of some function in the complexity class NP. While we are still far from settling this question or proving any good lower bounds for factoring some significant progress on lower bounds has been obtained recently, and the purpose of this article is to describe these results. Since the area has only been developed to a limited extent we will be reasonably complete.

The computational problems we consider are those of computing functions $f\colon \{0,1\}^* \mapsto \{0,1\}$. We do not lose generality by this requirement since a more general function can be represented as a collection of functions each taking the value 0 or 1. We will call a problem of the above type a *decision problem* or a *language recognition problem*, with the associated language being $\{x \mid f(x) = 1\}$. Sometimes it will be convenient to think of f as a collection $(f_n)_{n=1}^{\infty}$ where $f_n\colon \{0,1\}^n \mapsto \{0,1\}$ is the restriction of f to strings of length n. The length of a string x will be denoted by $|x|$.

We also need to make the notion of an algorithm precise. We will use the model of a one-tape Turing machine (TM), introduced by Alan Turing [18]. A one-tape TM consists of a finite control which is called the head and an infinite tape divided into cells which serves as memory. At each point in time the head is located at one cell and is in one of a finite number of states. During each time step, the head reads the content of the cell where it is located, writes a new content, enters a new state and moves either left or right. Initially the input is given in the first n cells of the tape, while the rest of the cells contain the symbol B (blank). At the end of the computation the

This article is the eighteenth in the series of Special Articles published in *Notices*. The author, Johan Håstad, is Associate Professor of Computer Science at the Royal Institute of Technology in Sweden. He received his Ph.D. in mathematics from M.I.T. in 1986. His thesis, "Computational Limitations of Small-Depth Circuits", received an ACM Distinguished Doctoral Award. His research interests include Complexity Theory and the design and analysis of algorithms.

TM writes the output in a given square and then halts. We have the following schematic picture of a TM:



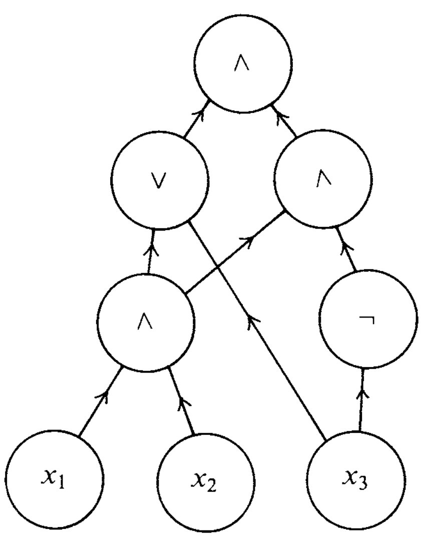
The running time of a TM on input x is the number of time steps the TM takes before it halts on input x. We say that the machine runs in time $T(n)$ if the running time on any input of size n is bounded by $T(n)$.

Let us start by giving a simple lower bound. Let $\{x|x = ww^R\}$ be the palindrome language. Here w^R is the reversal of the string w. For notation let $\Omega(g(n))$ denote a function which grows at least as fast as $cg(n)$ for some positive constant c.

Theorem: *The palindrome language requires $\Omega(n^2)$ time.*

Sketch of Proof: Suppose n is divisible by 4 and look at how the machine behaves on inputs of the form $a0^{\frac{n}{2}}b$ where $|a| = |b| = \frac{n}{4}$. It is not hard to see that to recognize the language correctly the head has to move $\Omega(n)$ times from the a-region to the b-region and back. Since the head moves at most one square per time step this takes $\Omega(n^2)$ time. ∎

As is clear from the above sketch of the proof, the theorem does not rely on the fact that the function in question is hard to compute but rather relies on bounds for information transfer. The lower bound is for this reason heavily oriented towards the given model, and one gets the feeling that we have not proved anything really related to computing. Unfortunately the shocking state of affairs is that the above theorem gives essentially the best lower bound proved by combinatorial methods* for a language recognition problem.



To describe the progress that has been made we need the notion of a circuit. A *Boolean Circuit* is a directed acyclic graph, which has its internal nodes labeled $\wedge$ (and), $\vee$ (or) or $\neg$ (negation). It has one sink which we will call the output node, and the sources are labeled with the variables x_i, $i = 1, \ldots, n$. The nodes of the graph will often be referred to as gates and the indegree of a node is called the *fanin*. We will in general not restrict the fanin of $\wedge$ and $\vee$ gates, while the $\neg$ gates are restricted to fanin 1. By letting x_i take the value of the i'th coordinate the circuit computes in a natural way a function $\{0,1\}^n \mapsto \{0,1\}$. A function f is computed by a sequence $(C_n)_{n=1}^{\infty}$ of circuits if C_n computes f_n.

The crucial parameter of a circuit will be its size (number of nodes) and depth (length of the longest path from input to output). Thus the above circuit has size 8 and depth 3.

It is not hard to prove that any function which can be computed by a TM in time $T(n)$ can also be computed of a family of circuits of size $O(T^2(n))$. Simply let the value of a node in the circuit correspond to the content of a particular square at a particular time. In fact, using subtler observations, $T^2(n)$ can be improved to $T(n) \log T(n)$ [11].

In view of this fact, lower bounds on the running time of TMs follow if we can prove lower bounds on the size of circuits. This is presently the common approach since it seems easier to work with a circuit which is a static object

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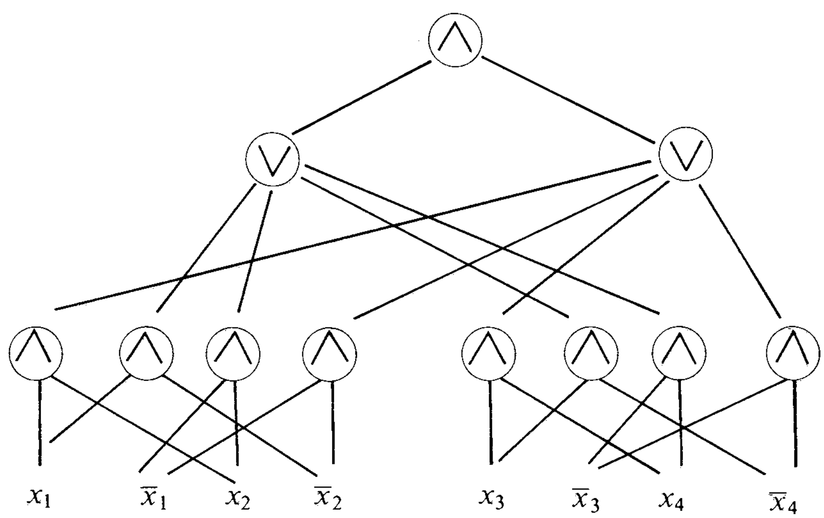
* It is possible to prove better lower bounds by diagonalization techniques. For instance for function g defined as follows. On input i run the TM with encoding i, $f(|i|)$ steps. If it halts and accepts reject the input otherwise accept. This function cannot be computed in time $f(n)$.

than with a TM which is dynamic. However, the success in proving lower bounds for general Boolean circuits has been very limited and the best lower bound for any reasonably simple function is $3n$, a result obtained by Norbert Blum [5].*

The difficulty in proving bounds on the size of general circuits led researchers to study restricted circuit-models. The idea is that if we cannot prove that a full powered computer cannot do something, let's tie its hands and feet together and see if we are more successful. The two models where the most progress has been made are circuits of small depth and monotone circuits (circuits which do not contain negations). We start by describing the results obtained concerning circuits of small depth.

Small-Depth Circuits. In dealing with small-depth circuits we will assume that the negations only appear as negated inputs. Using de Morgan's laws it is easy to see that this can be achieved by at most doubling the size of the circuit. Consider for example the following circuit of depth 3:



Observe that the circuit contains alternating levels of $\wedge$ and $\vee$. This will always be the case since we can collapse two adjacent gates of the same type.

The first two results proving lower bounds for small-depth circuits were by Ajtai [1] and Furst, Saxe and Sipser [7], independently. The techniques of the second paper have since been refined and together with a method by Razborov [13] has proved to be most successful at proving lower bounds for small-depth circuits. We start by describing the approach of Furst, Saxe and Sipser.

Definition: A *restriction* ρ is a mapping of the variables to the set $\{0, 1, *\}$.
$\rho(x_i) = 0(1)$ means that we substitute the value $0(1)$ for x_i
$\rho(x_i) = *$ means that x_i remains a variable.

Given a function f_n we will denote by $f_n\lceil_\rho$ the function of the variables given the value $*$ we get by making the substitutions prescribed by ρ. Given a circuit C_n computing f_n, we can similarly convert it to a circuit $C_n\lceil_\rho$ which computes $f_n\lceil_\rho$. The key to this technique of proving lower bounds for small-depth circuits is the fact that for a suitably chosen restriction, $C_n\lceil_\rho$ is considerably simpler than C_n. In fact $C_n\lceil_\rho$ will be a circuit of about the same

* One can prove that functions which are exponential space complete require large circuits.

size but of depth one less. The only known way to construct such a restriction which does not set too many variables to constants is by using randomness.

Definition: A random restriction $\rho \in R_p$ satisfies
$\rho(x_i) = 0(1)$ each with probability $\frac{1}{2} - \frac{p}{2}$
$\rho(x_i) = *$ with probability p, independently for different x_i.

Furst, Saxe and Sipser's original analysis of how much $\rho \in R_p$ simplifies C_n was substantially improved by Yao [19] and later Håstad [8] simplified and improved Yao's analysis. The essential part of Håstad's proof is contained in the following lemma.

Lemma: *Let g be computed by a depth 2 circuit which is an $\wedge$ of $\vee$'s where each $\vee$ has at most t inputs and let ρ be a random restriction from R_p. Then the probability that $g\lceil_\rho$ cannot be computed by a depth 2 circuit which is an $\vee$ of $\wedge$'s where each $\wedge$ has at most $s-1$ inputs is bounded by $(5pt)^s$.*

Let us see how to use this lemma. Let f be computed by a small-depth circuit C_n. Since for suitable chosen parameters the probability of failure of the lemma is exponentially small, it is possible to find a restriction such that the lemma applies to all depth 2 subcircuits of C_n simultaneously. Thus one can interchange the two lowest layers of $\vee$ and $\wedge$. If the depth of C_n is at least 3 this gives two adjacent layers of the same type which can be collapsed and the depth is decreased by 1. If the depth of C_n is k then after applying $k-2$ restrictions the circuit can be converted into a depth 2 circuit which is easy to analyze.

This procedure enables one to prove lower bounds for any function which even after applying restrictions cannot be computed by a small depth 2 circuit. A prime example is the parity function, i.e. $f(x) = \sum_{i=1}^{n} x_i \pmod 2$ which after restrictions still remains a parity function (of fewer variables).

Theorem: *A circuit of depth k which computes parity of n inputs requires size $\geq 2^{c_k n^{\frac{1}{k-1}}}$ for $n > n_0^k$ where $c_k = 10^{-\frac{k}{k-1}}$.*

This lower bound is actually quite close to optimal since there is a family C_n of circuits of depth k computing parity where C_n has size $n2^{n^{\frac{1}{k-1}}}$.

Sipser [14] also studied how much more powerful depth k was compared to depth $k-1$. Also these results were improved by Yao [19] and Håstad [8][9]. The best known bounds are:

Theorem: *For every k there is a family of functions g_k^n of n variables which can be computed by circuits of depth k and size n but not any $\varepsilon > 0$ requires circuits of size $2^{cn^{\frac{1-\varepsilon}{2(k-1)}}}$ for sufficiently large n when the depth is restricted to $k-1$.*

Let us now proceed to describe Razborov's approach [13] to the problem of proving lower bounds for small depth circuits. Razborov was interested in allowing parity-gates (gates outputting the sum modulo 2 of the inputs) as well as $\wedge$-gates and $\vee$-gates. In particular, he wanted to prove lower bounds for computing the majority function in this model. Here the majority function is the function which takes the value 1 if at least half the inputs are 1 and otherwise takes the value 0. Razborov made the circuit simpler by converting large $\wedge$'s ($\vee$'s) to small $\wedge$'s ($\vee$'s). He did not do this by using restrictions and instead of paying the price of giving values to some of the variables he allowed the circuit to make errors on a small fraction of the inputs. He obtained the following key lemma.

Lemma: *If f can be computed by a depth k circuit containing $\wedge$-gates, $\vee$-gates and parity-gates, of size S, then there is a polynomial over $GF(2)$ of degree l^k which agrees with f except for $S2^{n-l}$ inputs.*

All that remains to prove lower bounds for a function is to prove that a function is not close to any low degree polynomial. By doing this for a function closely related to majority Razborov obtained the following theorem.

Theorem: *A circuit of depth k which contains* $\wedge, \vee \neg$ *and parity gates and computes majority is of size* $\geq 2^{cn^{\frac{1}{k+1}}}$

Smolensky [15] extended Razborov's result and considered circuits which contained gates which computed the sum modulo p of the inputs where p is a prime.* Using a similar lemma but a different technique for the second step he proved essentially the above lower bound for the size of circuits computing the sum modulo m for any $m \neq p^i$.

To summarize these results we introduce a partial order $\leq_{cd}$ on functions where $f \leq_{cd} g$ iff f can be computed by polynomial size circuits of constant depth containing $\wedge, \vee \neg$ and gates computing g. In this partial order we know that $0 <_{cd}$ *parity* $<_{cd}$ *majority* while sum modulo p and sum modulo q are incomparable for different primes p and q. Additional information about this partial order would be very interesting.

Connections to Relativized Complexity: An important tool in recursion theory is to study relativized computation. This means that as a computational aid the Turing machine is given the ability to ask a question "$x \in A$" for a specific language A called the *oracle language*. These questions are answered correctly in one time timestep. It is straightforward to define the usual complexity classes relative to an oracle and a fair amount of work as been done to study these classes.

As was first proved by Furst, Saxe and Sipser [7] and Sipser [14] lower bounds for small-depth circuits can be used to construct oracles achieving new separations. It is possible to construct an oracle B such that $\sum_i^B \neq \sum_{i+1}^B$ for all i and $PH^B \neq PSPACE^B$. Here *PSPACE* is the set of languages recognizable in polynomial space, *PH* is the polynomial time hierarchy [16] $PH = \bigcup_{i=1}^{\infty} \sum_i$ where $\sum_i$ are languages recognizable by TMs which run in polynomial time and have i alternations [6]. In particular $\sum_1 = NP$. An oracle such that $P^A = PH^A = PSPACE^A$ was known previously [4]. A selfcontained proof on how to construct these oracles and some explanation of the implication of these results are given in [9]. After this detour let us return to lower bounds for circuits.

Monotone Circuits. Recall that a monotone circuit is a circuit which does not contain negations. This restricts the functions which can be computed to be monotone i.e. changing an input from 0 to 1 cannot change the function from 1 to 0.

The basic technique for proving lower bounds on the size of monotone circuits was introduced by Razborov [12] and Andreev [3].

Let Clique(n, k) denote the set of graphs on n nodes which contain as a subgraph the complete graph on k vertices. This language is NP-complete for suitable choice of k and hence a nonpolynomial lower bound for general circuits computing this language would prove that $NP \neq P$. Alon and Boppana [2] extended Razborov's result to get the following.

Theorem: *For* $k < \left(\frac{n}{8 \log n}\right)^{\frac{2}{3}}$ *Clique(n,k) requires monotone circuits of size* $2^{\frac{(\sqrt{k}-5)}{2}}$.

Let us give a brief outline of the proof. The main idea is to construct a family $\mathcal{F}$ of functions with the following properties.

1) $x_i \in \mathcal{F}$ for all i.
2) For $f_1, f_2 \in \mathcal{F}$ there exists $f_3 \in \mathcal{F}$, $f_3 \leq f_1 \wedge f_2$ and $d_1(f_3, f_1 \wedge f_2) \leq \delta_1$.
3) For $f_1, f_2 \in \mathcal{F}$ there exists $f_3 \in \mathcal{F}$, $f_3 \geq f_1 \vee f_2$ and $d_2(f_3, f_1 \vee f_2) \leq \delta_2$.

* To make this a Boolean function define the value of the gate to be 0 iff the sum is 0 modulo p.

Here the metric d_i corresponds to the number of inputs from a set S_i two functions take different values at and δ_1 and δ_2 are two constants. Using these properties it is easy to prove.

Lemma: If g is computed by a monotone circuit of size S, then there exists $f \in \mathcal{F}$, with $d_1(g, g \wedge f) \leq S\delta_1$ and $d_2(g, g \vee f) \leq S\delta_2$.

The punchline of the proof is of course dealt by providing a family $\mathcal{F}$ such that for $f \in \mathcal{F}$ either $d_1(f, Clique(n, k))$ or $d_2(f, Clique(n, k))$ is large.

It may seem as if restricting a circuit which computes a monotone function to be monotone is not such a severe restriction. This is not correct since Razborov [12] proved that there is a monotone function which has polynomial size general circuits but requires superpolynomial size monotone circuits. The gap was widened by Tardos [17] who gave a function which has polynomial size circuits but requires exponential size monotone circuits.

Finally we mention a recent result by Karchmer and Wigderson [10]. Let the problem of st-connectivity be: Given an undirected graph G and two nodes s and t in G. Is there a path between s and t?

Theorem: *If we restrict the fanin of each gate to be at most* 2, *st-connectivity requires* $\Omega(\log^2 n)$ *depth monotone circuits.*

The idea of this proof is different from the other proofs for the reason that it starts from the outputs and works towards the inputs. They prove that there is a path which starts at the output and ends up at one input such that the functions computed at the nodes along this path are in a technical sense approximations of an st-connectivity problem. This is obvious for the output and is established by induction. To finish the proof one needs only to verify that an input variable is not an approximation of an st-connectivity function in the required sense.

In view of the results presented one can ask if we have made any progress towards the original question; proving lower bounds for general circuits. If one takes that question as "Will any of the above methods extend to the general case", then the answer probably has to be negative and probably some new idea is required. Whether this idea will be inspired by the set of ideas presented here remains to be seen. Even if this is not the case, I feel that the presented results are very much interesting in their own right.

The series of Special Articles was created to provide a place for articles on mathematical subjects of interest to the general membership of the Society. The Editorial Committee of the *Notices* is especially interested in the quality of exposition and intends to maintain the highest standards in order to assure that the Special Articles will be accessible to mathematicians in all fields. The articles must be interesting and mathematically sound. They are first refereed for accuracy and (if approved) accepted or rejected on the basis of the breadth of their appeal to the general mathematical public.
Items for this series are solicited and, if accepted, will be paid for at the rate of $250 per page up to a maximum of $750. Manuscripts to be considered for this series should be sent to Ronald L. Graham, Associate Editor for Special Articles, *Notices of the American Mathematical Society*, Post Office Box 6248, Providence, Rhode Island 02940.

References

[1] Ajtai M. "$\sum_1^1$-Formulae on Finite Structures", *Annals of Pure and Applied Logic* 24 (1983) 1–48.

[2] Alon N. and Boppana R. "The Monotone Circuit Complexity of Boolean Functions", *Combinatorica* 7:1 (1987) pp 1–22.

[3] Andreev A. E. "On one method of obtaining lower bounds of individual monotone function complexity", *Dokl. Ak. Nauk.* 282 (1985), pp 1033–1037.

[4] Baker T., Gill J., and Solovay R. "Relativizations of the $P =?NP$ question" *SIAM J. on Computing*, 4 (1975), pp 431–442.

[5] Blum N. "A Boolean function requiring $3n$ network size", *Theor. Comp. Sci.* 28 (1984) 337–345.

[6] Chandra A. K., Kozen D. C., and Stockmeyer L. J. "Alternation", *Journal of the ACM 28*, 1 (January 1981), pp 114–133.

[7] Furst M., Saxe J., and Sipser M. "Parity, Circuits, and the Polynomial Time Hierarchy" *Math. System Theory* 1984 Vol. 17 pp 13–27.

[8] Håstad J. "Almost Optimal Lower Bounds for Small-Depth Circuits", *Proceedings of 18th Annual ACM Symposium on Theory of Computing*, 1986, 6–20.

[9] ——— "Computational Limitations of Small-Depth Circuits", MIT PRESS, 1986.

[10] Karchmer M. and Wigderson A. "Monotone Circuits for Connectivity Require Super-logarithmic Depth", manuscript 1987.

[11] Pippenger N. and Fischer M. J. "Relationships Among Complexity Measures", IBM Research Report RC-6569 (1977), Yorktown Heights.

[12] Razborov A. A. "Lower Bounds for the Monotone Complexity of some Boolean Functions", *Dokl. Ak. Nauk.* 281 (1985), pp 798–801.

[13] ——— "Lower Bounds for the Size of Circuits of Bounded Depth with basis $\wedge, \oplus$" preprint (in Russian). To appear in *Matem. Zam.*

[14] Sipser M. "Borel Sets and Circuit Complexity", *Proceedings of 15th Annual ACM Symposium on Theory of Computing*, 1983, 61–69.

[15] Smolensky R. "Algebraic Methods in the Theory of Lower Bounds for Boolean Circuit Complexity", *Proceedings of 19th Annual ACM Symposium on Theory of Computing*, 1987, 77–82.

[16] Stockmeyer L. J. "The Polynomial-Time Hierarchy", *Theoretical Computer Science 3*, 1987, pp 1–22.

[17] Tardos E. "The Gap Between Monotone and Non-Monotone Circuit Complexity is Exponential", to appear in *Combinatorica.*

[18] Turing A. "On computable numbers with an application to the Entscheidungsproblem", *Proc. London Math. Soc.*, 2: 42 pp 230–265.

[19] Yao A. "Separating the Polynomial-Time Hierarchy by Oracles", *Proceedings 26th Annual IEEE Symposium on Foundations of Computer Science*, 1985, 1–10.

AMERICAN MATHEMATICAL SOCIETY
1888 - 1988

100 YEARS OF AMERICAN MATHEMATICS

THE AMS CENTENNIAL

This year the American Mathematical Society is celebrating its 100th Anniversary. It is a time to look back with pride to our historic past and to look forward to a future of growth and increased service to the mathematical community.

American Mathematical Society
Centennial Celebration – August 8-12, 1988
Providence, Rhode Island

William H. Jaco
New Executive Director of the AMS

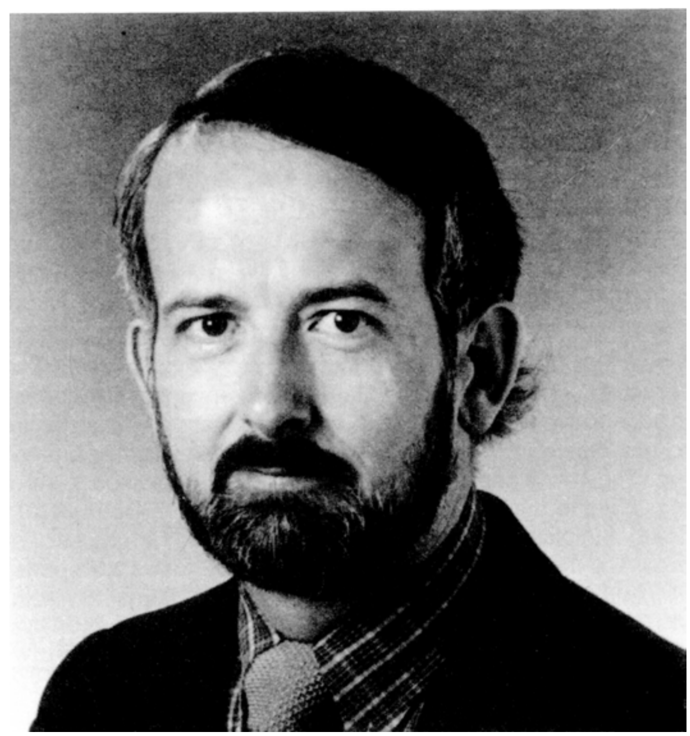
William H. Jaco has been appointed as the next Executive Director of the AMS. He will succeed William J. LeVeque, who, after eleven years as Executive Director, will retire on September 9, 1988.

Currently on leave from Oklahoma State University, Jaco holds the position of Professorial Research Fellow at the University of Melbourne in Australia. He has served as Professor and Head of the Department of Mathematics at Oklahoma State University since 1982. Before that, he was at Rice University, where he began as Assistant Professor in 1970 and advanced to the rank of Professor in 1978.

Jaco has distinguished himself for his research in topology, combinatorial group theory and differential geometry. He has published books in two AMS book series: *Lectures on Three-Manifolds* in the CBMS Regional Conference Series and *Seifert Fibered Spaces in 3-Manifolds*, co-authored with Peter Shalen, in the *Memoirs* of the AMS series.

Jaco was a member of the Institute for Advanced Study in Princeton, New Jersey during 1971-1972, 1978-1979, and the summers of 1973 and 1986. In 1984-1985, he was a senior research fellow at the Mathematical Sciences Research Institute in Berkeley, California. He has held visiting appointments at Columbia University (1976-1977) and Michigan State University (1982). Jaco has presented a number of invited addresses at various mathematical conferences in the U.S., Canada, Europe, and Australia, including invited lectures for the International Mathematical Union in Geneva, Switzerland in 1981. He presented a one-hour Invited Address before the Society and has been an invited speaker at two AMS sectional meetings.

His professional activities include membership in the AMS, the Mathematical Association of America, the Houston Philosophical Society, the National Council of Teachers of Mathematics, and the Oklahoma Council of Teachers of Mathematics. Jaco has served on the AMS Committee to Select Hour Speakers and is currently chairman of the AMS Committee on Committees. Jaco is also an editor of the AMS book series, *Contemporary Mathematics*. His concern with the health of the profession is reflected in his membership on the Task Force for Collegiate Mathematics in the Year 2000 (MS2000) and on the Board on Mathematical Sciences, both at the National Research Council.



William H. Jaco

Jaco looks forward to his new position with enthusiasm. "This is a very interesting time to be in such a position," he says. "The Society is moving into its second century and the issues facing professional mathematicians today call for the active and comprehensive involvement of the AMS." He sees the Society functioning as a focal point for issues facing the mathematical community. "The AMS can be a mechanism through which mathematicians function collectively when individual effort is not or cannot be effective."

The AMS is already cooperating with other professional societies in providing government and public representation for the mathematics community, he points out. "The Society is taking a leadership role in seeking more resources for mathematics, in emphasizing the need for research mathematicians to be involved in issues concerning mathematics education, and in improving the flow of young talent into science and mathematics." Jaco states that he looks forward to being involved with such issues at the national level.

In accepting his new position, Jaco recognizes the value of the "hardworking and dedicated AMS staff," who have brought the Society to its present state of financial stability, efficiency, and effectiveness. "Bill LeVeque deserves a great deal of credit for the Society's current position of strength," he says. "The Society is in excellent shape to meet the important challenges of the future and stands at the center of several important directions for the mathematical sciences."

Research Experiences for Undergraduates

NSF Program Stimulates Students' Interest in Mathematical Research

This article highlights an important new program at the National Science Foundation. Entitled Research Experiences for Undergraduates, the program gives undergraduates an opportunity to participate in hands-on research in science and engineering. The two kinds of awards—Sites and Supplements—are explained in the article. The deadline for Sites is **October 10, 1988**. Supplements require two to three months processing time. The 1988 Site awards are listed in **NSF News & Reports** in this issue of *Notices*. For more information, contact William W. Adams, 202-357-3695.

The decline in recent years in the number of mathematics doctorates has been a continuing source of concern within the mathematical community. Many believe that the root of the problem lies at the undergraduate level, where students are rarely exposed to the excitement of mathematical research when they are in the process of choosing a field of study. In the laboratory sciences, students can participate in research in a variety of ways, and even simply observing the laboratory environment can demonstrate how research is conducted in such fields. But in mathematics, it is more difficult to convey the nature of the research process, and the lack of technical background can be a barrier.

Nonetheless, some mathematicians, with the help of a program at the National Science Foundation (NSF), are developing innovative ways of involving undergraduates in research. The program, entitled Research Experiences for Undergraduates (REU), is designed to immerse undergraduates in active research in mathematics, science, and engineering. Now in its second year, the REU program is demonstrating that involving undergraduates in mathematical research is not only possible but also rewarding for both students and faculty.

Purpose of REU

The purpose of REU is to attract talented students into research careers in mathematics, science, and engineering by exposing them to the excitement of research early in their college years. "We want to involve students in mathematical research by showing them it's worthwhile and enriching, as well as enjoyable," says William W. Adams, Program Director for Algebra and Number Theory and REU Coordinator in the Division of Mathematical Sciences (DMS). "We want to build a pool of students going into science and get them interested in research at the Ph.D. level."

According to DMS Director Judith S. Sunley, REU can show students what mathematics is all about.

"Despite all evidence to the contrary, many students still believe mathematics to be a dead subject and feel they are chasing their tails to solve problems whose answers are already known," she says. "The REU program can help us build a core of students who know that there are still challenging questions for mathematicians to solve and that mathematics is much more than using existing methods to solve the problems of other disciplines. Inventing the ideas that answer questions in mathematics or other areas of science and engineering is where the real excitement of our field lies. That is precisely what the REU program can help show undergraduates."

The precursor of REU was the Undergraduate Research Participation (URP) program, which began in the early 1960s in the NSF's education directorate. Though seen as highly successful, URP was eliminated due to budget cuts in the early 1980s. URP was revived as REU at the urging of the National Science Board, the policymaking arm of the NSF.

Because REU is considered a research program, the NSF delegated responsibility for the program to the research divisions. "We want to give the students hands-on mathematical work," says Adams. "They should be given open-ended things to do." While the work the students do may not be at the leading edge of science, it does give them a sense of the nature of scientific research. "You can take a fairly narrow topic that may not be frontier research, but it can be suitable for an undergraduate to work on." Some research questions can be made accessible by reducing them to special cases. In many of the REU projects, the computer can act as a "laboratory," providing a way for students to contribute to the solution of a research problem. "Library research, in which a student locates papers for the professor, or preparation of an expository work on several extant papers are *not* suitable activities for the program," says Adams.

The REU program can provide a very different atmosphere than the classroom. B. Frank Jones of Rice University last year ran a 2-month REU summer program involving ten students. Jones noted that, unlike the classroom situation, there was little sense of competition among the students. "There was nothing to be competitive about—no grades, no evaluation of performance." Nonetheless, he says, "these students were all very excited with that we were doing and I could tell they worked very hard." Jones said he decided against giving course credit for participation in the program because "that's not a research motivation. I am glad we didn't."

Two Kinds of REU Awards

REU makes two kinds of awards: *Sites* and *Supplements*. REU Sites provide research experiences for a group of students, usually over the summer. The Sites must have well-coordinated activities for the students and must emphasize group activity. An REU Supplement allows an NSF-supported researcher to add one or two undergraduates to his or her research grant. Within the DMS, Adams handles the panel review of Site proposals, while requests for Supplements are evaluated by the program officer handling the individual's research grant.

Adams has noticed some common shortcomings in proposals for REU Sites. "Often the principal investigators gave a reasonable description of the mathematics involved, but gave no indication of what they were going to do with the students to give them a coherent program." Simply assigning problems and telling the students to come for help if they need it does not provide enough structure. "There should be evidence of a coherent program, dynamics between the professors and students, and group interactions," says Adams.

While the number of students involved in an REU Site may vary (in 1988, the numbers will range from 4 to 12), the average is around 8. REU award costs, which usually average about $4000 per student for the Sites, and somewhat less for the Supplements, may include stipends for students, salaries of involved faculty, relevant student housing costs, indirect costs, and a modest allowance for supplies. For full-time summer activity, the student stipend must be at least $2000. The total amount of indirect costs allowed for REU projects is limited to 25% of the student stipends.

A major goal of the program is to involve students who come from institutions where research programs are limited, so those projects that include students outside the host institution are encouraged. In addition, the NSF will give special consideration to projects containing plans for involving women, minority, and disabled students.

Last year, the REU program for all disciplines in the NSF had a budget of $10 million. One hundred twenty-eight REU Sites involved over 1200 students in 43 states and the grants averaged $42,000. Approximately the same number of students were supported by Supplements, which averaged $4000-$8000. Within the DMS, the $380,000 REU budget for last year supported 8 Sites and 20–25 Supplements. The DMS-REU budget rose to $500,000 for 1988.

Descriptions of Currently Supported REU Sites

In fiscal year 1987, the first year of the REU program, the DMS had little time to publicize the program, and consequently received few proposals (8 proposals were funded out of 29 received). In fiscal 1988, despite a substantially increased budget and considerably more time for publicity, the DMS received almost the same number of proposals as in 1987 (there were 2 continuing grants, and 12 new grants were awarded out of 28 proposals; 4 of those 12 were from individuals who had run REU Sites the previous summer). The following descriptions of REU Sites that took place in the summer of 1987 may help to give others ideas of the possibilities and benefits of this kind of activity. These Sites are among those receiving grants for 1988.

University of Minnesota at Duluth

Every summer for the past ten years, Joseph A. Gallian has run a program to involve undergraduates in mathematical research in graph theory and combinatorics. Over the years, his program has attracted some of the nation's brightest undergraduates. Last year, with a Site grant from REU, Gallian was able to expand his program to include five students.

Because the research topics are fairly accessible, Gallian does not require previous knowledge of graph theory or combinatorics. Rather, he seeks students who exhibit a combination of talent, creativity, persistence, and motivation. After choosing the students, he matches two problems to each student according to their backgrounds and abilities.

The organization of the six-week program is fairly informal. There are no regular lectures, and a minimum of background is provided—perhaps one paper that has an open problem or a theorem that can be strengthened or generalized. The students share three bedroom apartments on campus, and Gallian often drops by to chat with them.

In individual weekly meetings, the students describe to Gallian what they have done. Frequently these meetings take the form of "pep talks"—if a student is stuck, Gallian offers ideas, hints, and references, and just generally bolsters confidence. "It's common to make no observable progress," he says. "It's easy for even bright kids to get discouraged." Sometimes the problems turn out to be inappropriate—too easy or too hard, or sometimes they have already been solved. It is for these reasons that Gallian finds two problems for each student.

Gallian always invites one or two former participants who can help the students when they get stuck. David S. Witte of Harvard University has returned to the program every year from the start. "The people who come back have done wonders for the program," says Gallian. "It's a blend of personality and talent that suits the program." In addition, speakers are brought in to present general interest, self-contained talks on a variety of topics. These speakers generally spend a week in the program and socialize with the students.

A central goal of the program is to have the students write up their results for publication. At the end of the program, each student gives Gallian a manuscript, and he helps the students with the revisions, which often take two to three years to complete. He says that his follow-up is crucial, because students often lack the motivation to finish their revisions once they leave the program and the academic year begins. His efforts have been very successful: more than 25 papers written by undergraduates under his supervision have been published.

In future years, Gallian hopes to be able to send students to national conferences to present their papers. "It's a big thing for them," he says. "It gives them pride and enthusiasm." Attending these meetings also helps students feel they are part of the mathematical community. "I didn't go to a national meeting until after I'd gotten my Ph.D.," he remarked. "Students drop out of mathematics too early. They make the choice to do other things before they get a chance to see what a mathematician does."

One of the reasons the program is successful is that Gallian targets outstanding students who are all about equally talented. "It would be a disaster to mix these students with less talented students," he says. "Homogeneity is more important than which group you target." In addition, the program has an informal and supportive but nonetheless challenging atmosphere. "I don't consider it a competition. Everybody does as well as they can," says Gallian. "There's mutual respect and mutual support."

University of Tennessee

Lawrence S. Husch at the University of Tennessee last year ran an REU Site which differs from most of the others in the diversity of the topics investigated and in the number of faculty involved. From the fifty students who applied to the program, thirteen were matched with eleven faculty members based on the students' and faculty members' interests. The faculty then chose problems that they felt were accessible to the students.

Husch says that one of the strengths of the six week program was the way it successfully combined the group and individual components. The students were brought together three times each week to hear faculty speak on their research areas. During the first five weeks, Husch taught a course using *An Introduction to Dynamical Systems*, by R. L. Devaney. "I think this book is accessible to undergraduates and presents a topic they might not see in their home institutions," says Husch. The book does not require a great deal of background, and it has "a lot of pretty pictures." The students were divided into three teams to work on problems from the text, and Husch felt this cooperative-competitive aspect of the program was beneficial.

For the individual component of the program, the students worked closely in ones and twos with the faculty members. The students were required to meet with their mentors three hours per week, and this time allotment was often exceeded. The topics investigated ranged from discrete dynamics problems in the plane, to semigroup rings, to control theory, to the Poisson renewal process. Several students were involved in computational aspects of the research. For example, one of the projects focused on a mathematical model of three-species competition. The student and his mentor used computer simulations to examine whether certain combinations of mathematical conditions would result in a stable equilibrium. The simulations confirmed their intuition, and they were eventually able to prove stability.

The faculty took weekend trips and had picnics and other social events with the students. During the final week, each student made an oral presentation on the work he or she had completed. One of the highlights of the program was a visit to the Mathematical Sciences section of Oak Ridge National Laboratory. During the visit, the leaders of the main mathematical research groups presented talks on the type of research in which they were involved, and the students were able to speak with the mathematicians in each of the groups.

Conceding that the program took a great deal of time, Husch is nonetheless enthusiastic. "It was fantastic," he said. "The students developed a fantastic rapport and were a very close-knit group." Husch feels the students learned a great deal about the process of mathematical research. "The students could see where mathematics is going, they could see some of the fundamental questions," he said. "They could see that mathematics is fun and see mathematicians live, at work, enjoying mathematics."

University of Utah

Robert M. Brooks of the University of Utah ran a 7-week REU Site program involving 5 faculty and 11 students and focusing on the analysis of large data sets. Several data sets arising from various branches of biology were to be subjected to a variety of techniques: principal component analysis, linear regression, groupings by discriminant functions, and projection pursuit. The students applied these techniques to the given data sets to search for patterns and relations and to compare the effectiveness of the techniques. The participants worked singly and in groups, sometimes with close supervision and sometimes with none. The program overlapped with the Joint Mathematics Meetings which were held in Salt Lake City in August 1987, so the students were able to attend a number of the sessions at the meeting.

Hugo Rossi, one of the faculty members involved in the project, says that they attempted to create "a working environment rather than a learning environment." "Suppose you had a laboratory, with principal investigators, postdocs, graduate students and so on. How is it run? You don't get everybody together and lecture to them. You just give them things to do."

Because of this approach, the students needed background only to the level of linear algebra. During the first three weeks of the program, the students were given some background lectures, but, as one student participant put it, the lectures were more like "job training lectures" than "classroom lectures." This orientation phase, which included problem seminars led by a graduate student and time in the computer laboratory, made the various tools available to the students. Rossi said that when the students were given problems to work on, at first they just "looked at each other and said, 'What are we going to do?'" But the faculty gave them hints and pointed them in certain directions, and soon the students were able to get started working on the problems. Rossi noted that it is very difficult to take such an approach in a classroom setting.

Rossi says that one of the intentions was to involve students who had talent and interest in mathematics but were not majoring in mathematics. The program succeeded in attracting students from engineering, biology, and physics, as well as mathematics and statistics. As with most of the REU Site programs, the organizers sent out advertisements to various institutions and contacted colleagues who might be able to recommend students, and they ended up with 25-30 applicants.

At the end of the program, the students were asked to prepare reports on their projects. The success of the program can be measured in part by the students' enthusiastic comments. "I would say that this program has been one of my greatest educational experiences to date," wrote one junior in electrical engineering. "Through it I gained an increased appreciation for the broad world of mathematics." A junior in mathematics said that he gained a more complete picture of the field. "The broad picture shows how the different aspects of math are intertwined ... This program was very beneficial in increasing my enthusiasm for math and graduate studies. The environment was much different from that of a classroom." Said one junior, "I was a dual major in math and physics, but after the program I plan to study mathematics in graduate school ... I was pleased to see professors taking such an active role in showing the wonder of mathematics to undergraduates ... this summer we have seen mathematicians who had their own [research] to pursue set [it] aside in favor of showing us some of the complexity and beauty of mathematics."

Allyn Jackson
Staff Writer

Report of the Treasurer (1987)

Franklin P. Peterson

I. Introduction

The most publicized financial event of 1987 was undoubtedly the stock market crash on October 19, "black Monday". Although the Society suffered from the crash, the losses were largely offset by appreciation which had occurred earlier during the year. Investment income for the year amounted to $557,000 after accounting for losses caused by the crash. This income is about the same dollar amount as was earned in 1986, but the rate of return was less as the total investment base was larger. The Investment Committee of the Board of Trustees has met with the Society's investment managers to discuss the risk and rate of return of the Society's portfolio, and the Committee continues to meet regularly to review the investment performance.

During the first five years of this decade (1980–1984), the Society incurred losses totaling $2,548,000. At December 31, 1984, the Society's fund balances (excluding endowments) had declined to $1,688,000, or 17.7% of the Society's total assets (excluding endowments) of $9,555,000. At December 31, 1979, fund balances were about 44% of total assets (excluding endowments) of $6,891,000. Since 1984, the Society has experienced two very good years of earnings, and at the end of 1987, the Society's fund balances (excluding endowments) had increased to $7,088,000 or 42.3% of total assets (excluding endowments). Included in these fund balances is the Future Operations Fund. The Long Range Planning Committee and the Board of Trustees have recommended that the Society build this fund to an amount equal to one year's operating budget. At December 31, 1987, the Future Operations Fund was $3,748,000, about 32% of one year's budget.

The recent improvement in the Society's financial health can be only partially attributed to cost cutting and fiscal restraint. The Society's finances are very greatly affected by the general economy, library budgets, and even foreign exchange rates. These and other factors are very difficult to predict and the Society often finds itself in the position of reacting to these factors. The Future Operations Fund is an attempt to prepare for the inevitable deterioration in these environmental factors.

II. Summary Financial Statements

The Treasurer this year again presents to the membership summary financial statements of the Society. A copy of the Treasurer's Report, 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 wish to put to him concerning the financial affairs of the Society.

SUMMARY STATEMENT OF ACTIVITY
For the Year Ended December 31, 1987
(Thousands of dollars)

Revenue		
Journals	$ 8,456	63%
Books	1,235	9%
Dues	1,285	10%
Membership Activities	181	1%
Meetings	308	2%
Grants and Contracts	950	7%
Investment Income	557	4%
Other	458	4%
Total revenue	$13,430	100%
Expense		
Journals	$ 7,907	67%
Books	878	7%
Marketing	289	3%
Membership Records	300	3%
Membership Activities	210	2%
Meetings	451	4%
Grants and Contracts	1,098	9%
Other	625	5%
Total expense	$11,758	100%
Excess of Revenues over Expenses	$ 1,672	

SUMMARY BALANCE SHEET
December 31, 1987
(Thousands of dollars)

Assets	
Cash and temporary investments	$ 4,795
Other short-term investments	6
Receivables - members and others (less allowance for doubtful accounts)	530
Prepaid expenses and deposits	619
Deferred prepublication costs	738
Inventory of completed books and back volumes of journals	823
Property and equipment (less accumulated depreciation)	5,262
Total operating assets	12,773
Investments	5,990
Total assets	$18,763

Liabilities and fund balances	
Accounts payable	$ 521
Subscriptions, dues, and other revenues received in advance	8,030
Other miscellaneous liabilities	1,106
Total liabilities	9,657
Operating fund balance	3,116
Total operating funds	12,773
Invested fund balances:	
Endowment funds:	
The Endowment Fund	100
Robert Henderson	548
Joseph Fels Ritt	23
Prize funds	169
Pooled Income Fund	5
Eliakim Hastings	3
Undistributed net gains on investment transactions	1170
Funds other than endowments:	
Future operations	3,748
Friends of Mathematics	124
Other	100
Total liabilities and fund balances	$18,763

III. Operations

I now turn to a discussion of the Society's 1987 operations.

Journals. Journals provide the largest fraction of the Society's revenues and expenses. In the past, journals have operated at a net loss. Since 1985, journals have operated in the black and provided a very significant portion of the Society's 1986 surplus (the excess of revenues over expenses in the summary financial statements above). This improvement is the result of a decrease in the rate of attrition in subscribers and a variety of cost-cutting procedures implemented by Society management.

Books. Included in this category are not only books (monographs or collections of articles) but review volumes and indexes to journals. Books, exclusive of the latter, continue to be financially sound, and selling prices of AMS books compare very favorably with other mathematical books.

Review volumes and indexes are very costly to produce, resulting in high prices. Each such planned publication is scrutinized very carefully from both scientific and financial perspectives, and prices are set accordingly. In 1987, indexes and review volumes broke even.

Dues, Membership Activities, and Membership Records. The Society has about 490 institutional members and 20,500 individual members. Of the latter, about 6,000 pay no dues because they are student nominees, emeritus members, or reviewers without convertible currency. Individual member dues are two-tiered to provide some relief to lower paid members. Institutional dues are set, in part, by the number of papers published by authors employed by the institution. Increases in dues for individual members are set annually by a cost-of-living index.

Membership activities include such projects as the Employment Register and the Professional Directory. In total, the activities operate at a deficit, which is considered to be supported by dues. Other costs which can be considered to be covered by dues include the cost of maintaining membership records, the deficits of *Abstracts*, *Bulletin*, *EIMS*, and *Notices*, deficits from meetings, and the AMS support of the Joint Policy Board on Mathematics.

Meetings. Meetings are normally operated at a deficit (1986 was an exception; the regular summer meeting was not held because the International Congress of Mathematicians was held in the United States). The 1987 deficit is comparable to that of 1985.

Grants and Contracts. The amount of money available from the federal government has declined substantially over the years. Currently, support is mainly for travel and subsistence for participants in research conferences, institutes, and seminars, plus the Society's cost in preparing and running these conferences. The money received from government agencies is reimbursement only, with no profit to the AMS. The Society also has contracts to perform services for other nonprofit organizations, and this helps to recover some fixed costs.

Other Revenues and Expenses. The principal components of other revenues and expenses are MathSci (by far the single largest item), TeX related products, and the AMS support of the Joint Policy Board on Mathematics.

IV. Assets and Liabilities

So far, this report has dealt with sources of revenue and applications of expense. Another aspect of the Society's finances is what it owns and owes, or its assets and liabilities, which are reported above in the Summary Balance Sheet. The Society maintains its accounts in fund groups. The operating funds include membership and publications activities; the invested funds include both endowment funds (gifts and bequests whose principal is required to be invested in perpetuity and whose income must be used for the purpose stated by the donor) and quasi-endowment funds (those funds set aside by the Board of Trustees for designated purposes). Most of the quasi-endowment funds have been designated for future operations.

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 temporary investments on its fiscal year-end, December 31. This amounted to about $5,000,000 for 1987. The recorded liability for the revenues received in advance was about $8,000,000 on the same date. The difference can be thought of as having been invested in the Society's other assets. Effectively, the Society borrows from its subscribers to finance current operations. This is a common practice in the publishing industry and allows the Society to maintain a very low amount of bank debt.

The Society's property, plant and equipment includes land, buildings and improvements, and office furniture, equipment and software. The Society also owns a small amount of transportation equipment. The land, buildings, and improvements include the Society's headquarters building in Providence and the Mathematical Reviews offices in Ann Arbor. The appraised value of these facilities currently exceeds $3,000,000. The largest part of the Society's office equipment is its investment in computer facilities.

At the beginning of 1987, the Society had an outstanding mortgage note amounting to $1,268,000. This was paid during 1987.

Computers and Mathematics

Edited by Jon Barwise

As a mathematician, I have found my professional life profoundly influenced by computers. As a researcher, I have seen my own interests gradually shift from model theory as inspired by pure mathematics to model theory as developed for the more concrete needs of computational linguistics and information processing. As a writer, I have completely switched over from writing mathematics papers in longhand and having them typed, to using LaTeX, a version of Knuth's mathematical text processing system TeX. As a correspondent, I discover that the bulk of my mail is in the form of electronic messages – known as email. And as a teacher of mathematical logic, I have worked with a colleague, John Etchemendy, to develop two computer programs, *Tarski's World* having to do with the semantics of first-order logic, and *Turing's World* having to do with *Turing Machines*. With this courseware, I have seen a dramatic change in our ability to teach abstract material to beginners. I can imagine a time when these sorts of programs will completely alter the way we teach logic.

As I survey mathematicians of my acquaintance, I do not find the impact computers have had on me to be unusually large. If anything, just the contrary. I find many who are even more strongly affected by the development of the computer. In addition to the above, today's computers have brought new areas of mathematics into existence, given us new tools for doing mathematical experimentation, provided a tool for use in giving mathematical proofs (thereby raising interesting issues as to just what constitutes a proof), and made obsolete many of the traditional topics we teach and the ways we teach them.

Of course the influence has not been all one way. Mathematicians have played a central role in the development of the computer and computer science, from the time of Turing and von Neumann to the present day. Indeed, many of today's mathematicians find themselves in computer science departments. But as a whole, there is a feeling that many of us are seriously under-informed about the impact of computers on mathematics.

There is one exception to this rule. The impact of computers on the writing of mathematics has been extensively discussed in these pages in recent years, in Richard Palais' excellent column "Mathematical Text Processing." That column has played an important role in this transitional period, as mathematicians attempted, individually and collectively, to find their way through the maze of possibilities open to them, in terms of computers and computer software for producing mathematical text. Palais' column has ended, but the commitment to keep abreast of the issues has not. Rather, it has expanded. With this issue, the *Notices* embarks on a new column, one devoted to all aspects of the interaction between computers and mathematics.

At this stage in the game, the column is very much in its infancy. It will appear as often as is dictated by the material on hand. What appears in its pages will depend on what mathematicians contribute to the column. In the medium run, we anticipate having several short articles each month along the following lines:

- Reviews of mathematical software and hardware, both those used in research and in teaching. These could give a deeper analysis than is ususal in such reviews. For example, they might go into the actual algorithms used. Or they could provide a comparative discussion of what the programs do and how they can aid the mathematician in particular.
- Expository articles about mathematical research topics inspired by computers, as with the work on zero-knowledge interactive proofs of knowledge.
- Articles telling how computers are now being used in traditional branches of mathematics. This includes the role computers now play in doing mathematics, from being a way to run experiments, to being an

aid in coming up with a proof, as in the case of the Four Color Theorem, but no doubt other uses as well.

- Opinion pieces used to give ideas to software and hardware developers, the NSF and other funding agencies, and others about the computational needs and desires of the mathematical community, as these evolve.
- Other sorts of articles about computers and mathematics, on special topics like the following:
- Many math departments are setting up departmental computing facilities. This involves a host of decisions. How should they be organized and paid for? How much staff is required? What sorts of equipment should be purchased? How much? What space is required? It would be very useful to learn how different kinds of departments are answering these questions.
- Someone is already at work on an article about email, that is, electronic mail, aimed at telling mathematicians how the principal email networks work and how they are used.
- Many mathematicians have gained experience in the creation of new software for use in teaching and research. As I know, there are many pitfalls to avoid. Do you do your own programming? What system or systems do you design your software for? Who pays for the development? Is it yet feasiable to write integrated textbook/software packages for use in math courses? It would be useful to have some articles by those with experience to help others just starting out.

This is not meant to be an exhaustive list, but rather, a suggestive one. Above all, the column will reflect the interests of those mathematicians who contribute to it. To help insure quality, all contributions will be refereed.

The column can also serve as a clearinghouse for information about software that people develop and are willing to share with other mathematicians. We don't want to become a classified column, so this would be restricted to shareware, that is, software that the developers are willing to give away free. If you have such software, send me a description of 50 words or less.

Eventually this column should be taken over and run by someone for whom it is a more natural extension of their professional interests, someone deeply involved with the interface between computers and mathematics. In the meantime, I have agreed to try to get the column going. However, not much will appear without your help. If you are willing to review hardware or software, send me a note telling me your areas of competence and, in the case of software, what computer systems you have available. If you know of hardware or software that should be reviewed, try to get it sent to me. Or if you want to submit a short article or letter on some aspect of the relation between computers and mathematics, let me know. My address is:

Professor Jon Barwise
CSLI
Ventura Hall
Stanford University
Stanford, CA 94305

Perhaps more to the point, my email address is:

Barwise@csli.stanford.edu.

News and Announcements

William Hicks Pell
1914–1988

William Hicks Pell, retired head of the Mathematical Sciences section of the NSF, died on March 14, 1988, after a varied and distinguished career in government, education, and industry. Born on October 15, 1914 in Lewisport, Kentucky, Pell majored in mathematics and physics at the University of Kentucky, earning his B.S. in 1936 and his M.S. in 1938. Following the advice of his teacher, Leon Cohen, Pell did graduate work at the University of Wisconsin, obtaining his Ph.D. in 1943 for research in thermal stresses of anisotropic thin plates under the supervision of Ivan Sokolnikoff.

As an aerodynamicist at Bell Aircraft in Buffalo, New York, Pell helped to develop the experimental jet aircraft, including the first supersonic plane, the XS-1. He served on the faculty of Brown University's Division of Applied Mathematics from 1947 to 1955, except for a one-year leave of absence (1952-1953) when he served as professor and chairman of the University of Kentucky's Department of Mathematics.

Pell was a visiting fellow at the University of Maryland in 1955 and 1956, and chief of the mathematical physics section at the National Bureau of Standards (1956-1965). From 1965 until 1980 he was the head of the mathematical sciences section at the NSF, serving as the main liaison between the mathematical community and the Federal government. During his tenure at the NSF, the number of NSF programs was increased from three to seven. Also during this time, proposals for new university institutes were solicited and reviewed, leading to the formation of the Mathematical Sciences Research Institute at Berkeley and the Institute for Mathematics and Applications at Minnesota. After his retirement in 1980, Pell taught occasionally at the University of Maryland.

Orrin Frink
1901–1988

Orrin Frink, a well-known mathematician and educator, died on March 4, 1988, at the age of 86. Born in Brooklyn, New York in 1901, Professor Frink received three degrees from Columbia University: an A.B. in 1922, an M.A. in 1923 (Pulitzer scholar), and a Ph.D. in 1926. He did postgraduate work at the University of Chicago.

Professor Frink began his academic career as an instructor of mathematics at Princeton University (1925-1926). He was a National Research Council Fellow at the University of Chicago (1926-1927), before he returned to teach again at Princeton (1927-1928). Frink joined the faculty of Pennsylvania University, State College, in 1928. He became a full professor in 1933 and served as head of the department (1949–1960). While at Pennsylvania State, he held a concurrent position as the chief engineer for the Special Projects Laboratory at Wright Field Air Force Base (1944-1945). He retired from Pennsylvania State in 1967.

Professor Frink was twice a Fulbright Lecturer (1960-1961 and 1965-1966) at University College, Dublin, Ireland. A recipient of an NSF award (1964-1965), he was also a member of the American Mathematical Society and the Mathematical Association of America.

Guggenheim Fellowships Awarded

The John Simon Guggenheim Memorial Foundation has announced the award of 262 fellowships in its sixty-fourth annual competition. The new Guggenheim Fellows were appointed on the basis of unusually distinguished achivement in the past and exceptional promise for future accomplishment. This year's list of awards includes eleven in the mathematical sciences.

The names of these recipients, their positions, institutional affiliations, and their proposed studies are: Richard Cole, Associate Professor of Computer Science, Courant Institute of Mathematical Sciences, New York University (The Design of Efficient Parallel Algorithms); David Paul Dobkin, Professor of Computer Science, Princeton University (Tools for the Visualization of Mathematical Surfaces); Richard Durrett, Professor of Mathematics, Cornell University (Particle Systems and Nonlinear Partial Differential Equations); Gerd Faltings, Professor of Mathematics, Princeton University

(Arithmetic Algebraic Geometry); Victor Guillemin, Professor of Mathematics, Massachusetts Institute of Technology (Studies in the Theory of Group Representations and in the Mathematics of Solid State Physics); John N. Mather, Professor of Mathematics, Princeton University (Stability and Randomness in Dynamical Systems); Jayadev Misra, David Bruton, Jr., Centennial Professor in Computer Science, University of Texas at Austin (A Theory of Program Structuring); Donald G. Saari, Professor of Mathematics and Applied Mathematics, Northwestern University (The Mathematics of Allocation and Decision Procedures); Wilfried Schmid, Dwight Parker Robinson Professor of Mathematics, Harvard University (Studies in Representation Theory); Barry Simon, IBM Professor of Mathematics and Theoretical Physics, California Institute of Technology (Studies in Mathematical Physics); Jeffrey D. Ullman, Professor of Computer Science, Stanford University (Efficient Implementation of Knowledge-base Systems).

Rollo Davidson Trust

Rollo Davidson Prizes have been awarded to I. Z. Rusza, of the Mathematical Institute of the Hungarian Academy of Sciences, Budapest, Hungary, and G. J. Székely, of the Eötvös Loránd University, Mathematical Institute, Department of Probability Theory, Budapest, Hungary (joint award) and to P. H. Baxendale, of the University of Florida, Gainesville.

I. Z. Ruska and G. J. Székely received the award for their contributions to algebraic probability, especially the arithmetic of semigroups of probabilistic objects. P. X. Baxendale was cited for his work on stochastic flows of diffeomorphisms, especially his study of their asymptomatic behavior.

The first Rollo Davidson Prize was awarded in 1976. Since then twenty prizes have been awarded. The work of the Trust is supported by royalties and individual donations. Correspondence relating to the work of the Trust should be addressed to its Secretary, The Bursar, Churchill College, Cambridge, CB3 ODS, England.

Mathematics Lectures for High School Students

About 350 high school students attended a special lecture series sponsored by the AMS and the Boston Museum of Science. Held at the Museum on April 27 as part of National Mathematics Awareness Week, the program featured lectures by Raoul Bott of Harvard University and William P. Thurston of Princeton University. Paul J. Sally, Jr., of the University of Chicago was a principal organizer of the program and acted as introducer and moderator.

The Society is concerned with the declining numbers of degrees in mathematics and believes that an active approach is necessary to reverse this trend. The purpose of the program was to stimulate the interest of mathematically talented students early on by putting high school students into contact with two of the world's leading mathematicians. The program was not intended as an exploration of the career possibilities available in mathematics. Rather, it sought to spark the students' interest in the subject by focusing on the excitement and sense of discovery in mathematics.

Bott drew the students in by proclaiming that there are two kinds of mathematicians—the "dumb" kind and the "smart" kind. Professing himself to be in the former category, he said that the "smart" ones grasp everything immediately, but the "dumb" ones always feel that they never quite understand things completely.

Bott led the students on an "excursion," and to capture their interest, he began with the real numbers, a concept with which the students were familiar. Then, using the practical problem of finding the points of intersection between a line and a circle, he introduced them to the concept of complex numbers. After discussing complex arithmetic, he had the students try to visualize the Riemann surface characterized by $x^3 + y^3 = 1$ and described the connection of this equation to the 2-torus. He spoke about the ideas of genus and Euler characteristic and challenged the students to consider the more general question of the surfaces associated with $x^n + y^n = 1$. After the talk, many students spent the entire half hour break asking Bott questions.

At the beginning of his talk, Thurston claimed, like Bott, to be the "dumb" kind of mathematician. Thurston's talk complemented Bott's by focusing on connections between topology and geometry. He began with two-dimensional surfaces and the idea of deformations and went on to describe to the students the way that a 2-torus can be formed by identifying the sides of a rectangle. He generalized this notion to the 3-torus by vividly explaining to the students how they could visualize a 3-torus by imagining the auditorium to be a cube with the faces identified in the proper way. Thurston also spoke on the connections between hyperbolic geometry and topology, and, although the discussion might have been somewhat mystifying, one thing was clear: the students' were led to these beautiful and fascinating concepts through imagination and geometric intuition and without any formulas or rules to be memorized.

After lunch, Thurston and Sally conducted a discussion session, attended by about 100 students. The discussion was informal and the students asked questions and were encouraged to make conjectures about the ideas presented. The program generated considerable interest among the students and the teachers and may serve as a useful prototype for future Society activities of this kind.

News from the Institute for Mathematics and Its Applications

University of Minnesota

The final preparations for the 1988-1989 program on Nonlinear Waves are under way. The program will begin with a workshop, which will be partly tutorial, on September 12–16 on Solitons in Physics and Mathematics. A follow-up workshop on November 7–11 will concentrate on Solitons in Nonlinear Optics and Plasma Physics. The organizers for the fall quarter are Alan Newell, David Sattinger, Peter Olver, D. Kaup, and Y. Kodama.

The winter quarter will deal with topics of Hyperbolicity, Change of Type and Wave Propagations in Non-Newtonian Fluids, and Multiphase Flows. The organizers Daniel Joseph, Barbara Keyfitz, and David Schaeffer are planning to have three workshops. The first workshop in January will focus on Two Phase Waves in Fluidized Beds, Sedimentation, and Granular Flows. The second workshop on Plasticity will take place on February 6–10. The third workshop on Ellipticity in Evolution Equations will take place on March 6-10. During the spring, the activities will concentrate on multidimensional hyperbolic problems and computations.

The present academic year's activities are coming to an end with a program on Coding Theory which includes two workshops. The first workshop on Coding Theory and Applications, June 12–18, and the second one on Design Theory and Applications, June 19–25, are both organized by Dijen Ray-Chaudhuri. When this program is over, summer activities on Signal Processing are going to begin and will continue for six weeks. The first two weeks of the program will be devoted to a broad range of problems of current interest, followed by periods of concentration on specific topics such as Digital Filter and VLSI Implementation, Aerospace Applications, Radar and Sonar Imaging. (For further details, see the **News and Announcements** section of the January 1988 issue of *Notices.*)

The Fermat Prize for Research in Mathematics

The Fermat Prize will reward the research of mathematicians working in the areas in which the contributions of Pierre de Fermat have been significant: principles of variational theory, the foundations of the calculus of probabilities and of analytic geometry, and number theory. The list, however, is not restrictive; the spirit of the prize is rather to reward the results of research that is accessible to the greatest number of professional mathematicians.

The amount of $10,000 (U.S.) has been designated by MATRA-Espace for the Fermat Prize, which will be awarded every other year in Toulouse. The first award will take place in the spring of 1989.

Further information, such as the rules of the contest and application deadlines, will be available in the fall of 1988 from Prix Fermat de Recherce en Mathématiques, J. B. Hiriart-Urruty, Professeur de Mathématiques, Université Paul Sabatier, 118 route de Narbonne, 31062 Toulouse Cédex, France.

Queries

The following is a response to queries that were received since the February issue of *Notices* was published. As was reported in that issue, the Queries Column will no longer appear in *Notices*, but responses to previously published queries may appear from time to time in this section.

Queries Column: Responses

Although the Queries Column was discontinued as of the February issue, responses are still coming in, and the following appear to merit publication. The editors would like to thank those who sent in the responses.

375. (vol. 34, p. 303, February 1987, Albert A. Mullin) Long-range prediction of perihelia of Halley's Comet. **Reply**: The orbits of comets are only approximately periodic, because of perturbations by planets (especially Jupiter and Saturn) and because of the reaction of the comet to material evaporating under solar heating. (The Vega and Giotto probes in 1986 showed that the evaporation from Comet Halley produced spectacular spurts of gas and dust.) In 1835 Comet Halley returned after 74.4 years, whereas in the sixth century its period was 79.3 years. The effects of gravitational perturbations by the major planets can be predicted to very high accuracy, but the effects of evaporation can only be predicted approximately. The average increase of four days in Comet Halley's period on each return (after allowing for the gravitational perturbations) is attributed to evaporation. When a comet is far enough away from the sun for evaporation to cease, its path can be predicted very accurately. (Contributed by G. J. Tee)

National Science Foundation News & Reports

NSF-NATO Postdoctoral Fellowships Awarded

The NSF has announced the award of fifty-seven National Science Foundation-North Atlantic Treaty (NATO) Postdoctoral Fellowships in Science. These fellowships are awarded to young scientists and engineers for full-time postgraduate study abroad at institutions and laboratories in NATO countries or in neighboring countries that cooperate with NATO.

The seven recipients in the mathematical sciences are listed below (institutions in parentheses are the current institution; those outside the parentheses are those at which the fellowship will be held): Alexander S. Aiken (Cornell University), Oxford University, England; Kirk E. Brattkus (Northwestern University), École Normale Supérieure, Paris, France; David R. Grant (University of Michigan), Cambridge University, England; Sharon L. Pedersen (University of Pennsylvania), Institut des Hautes Études Scientifiques, Bures-Sur-Yvette, France; Igor Reider (University of Oklahoma), University of Paris, France; Jeffrey E. Steif (Stanford University), Stockholm University, Sweden; Jennifer Widom (Cornell University), Oxford University, England.

Graduate Fellowships Announced

Six hundred eighty-five outstanding college and university students are being offered fellowships for graduate study in the natural and social sciences, mathematics, and engineering, the NSF announced recently. Nearly 5,150 students submitted applications in the nationwide competition for the NSF Graduate Fellowships, which are awarded on the basis of merit. As the first step toward an approximate doubling of the number of graduate fellowships planned by the NSF over the next several years, there are 108 more awards this year than were conferred in 1987.

Panels of scientists, assembled by the National Research Council of the National Academy of Sciences, evaluated applications; final selections were made by the NSF. In addition to the fellowship awards offered, the NSF awarded Honorable Mention to 1,613 applicants in recognition of their potential for scientific and engineering careers. Beginning next year, the Foundation is extending to Honorable Mention recipients the opportunity already available to Fellows to obtain, on request, limited use of a supercomputer by any one of the five National Supercomputer Centers supported by the NSF.

NSF Graduate Fellows may attend any appropriate nonprofit U. S. or foreign institution of higher education. Each fellowship is awarded for three years of graduate study. The fellowships may be used over a five-year period to permit students to incorporate teaching or research assistantships into their education during periods in which they are not receiving their fellowship stipends.

The new Fellows come from all 50 states and the District of Columbia. Of the 685 award offers, 245 were made to women. By scientific discipline, the distribution of awards was as follows: 145 in engineering; 28 in mathematics; 17 in applications of mathematics; 40 in computer science; 59 in physics and astronomy; 54 in chemistry; 24 in earth sciences; 186 in the biological sciences, including biochemistry; and 132 in the social sciences and psychology. In addition to the new NSF Graduate Fellowship awards offered this year, 1,050 individuals who received fellowship awards in previous years are eligible to continue their study during the 1988-1989 fellowship year.

The recipients in the mathematical and computer sciences are listed below (institutions listed in parentheses are those awarding bachelor's degrees; those listed outside the parentheses are those at which graduate study will be pursued): Jeffrey Daniel Adler (Princeton University), University of Chicago; Laura Marie Anderson (California Institute of Technology), Massachusetts Institute of Technology; Matthew Aubrey Ando (Princeton University), Massachusetts Institute of Technology; Ann Louise Askew (Brown University), Cornell University; Christopher Norio Avery (Harvard University), Stanford University; Eric Kendall Babson (California Institute of Technology), Massachusetts Institute of Technology; Daniel Wyeth Bair (Pennsylvania State University), California Institute of Technology; ALEXANDER ABRAHAM BALKE (University of California, San Diego), University of California, Berkeley; ERIC DAVID BELSLEY (Yale University), Harvard University; RANJIT SAHAI BHATNAGAR (University of California, Berkeley), University of Pennsylvania; JOHN BARRETT BOYLAND (University of California, Davis), University of California, Berkeley; MATTHEW ELY BRAND (University of Chicago), Massachusetts Institute of Technology; JEAN CAROL CARLETTA (Colgate University), Stanford University; EDWARD CHANG (Brown University), Stanford University; HARRY ALAN CHOMSKY (Harvard University), Massachusetts Institute of Technology; CLINT WAYNE COAKLEY (Virginia Polytechnic Institute and State University), Pennsylvania State University; DAWN MYFANWY COHEN (Columbia University-Barnard College), Rutgers University; CONSTANTINE NICHOLAS COSTES (Harvard University), University of California, Berkeley; MICHAEL JOHN CULLEN (Marquette University), University of California, Los Angeles; GEOFFREY MARK DAVIS (Duke University), New York University; PETER CHRISTIAN DE BOOR (Princeton University), Harvard University; SAMUEL SEAN DOOLEY (Texas A&M University), University of California, Berkeley.

Other recipients are BENJAMIN JAMES Ford (University of Southern Florida), University of Oregon; JILL RENEE GAULDING (Massachusetts Institute of Technology), Massachusetts Institute of Technology; DONALD FITZPATRICK GEDDIS (Stanford University), Stanford University; ROBERT EMERSON GEORGE (Wittenburg University), Ohio State University; STEPHEN M. GLIM (Princeton University), Massachusetts Institute of Technology; KENNETH ALEXANDER GRAVES (Massachusetts Institute of Technology), University of California, Berkeley; JOEL DAVID HAMKINS (California Institute of Technology), University of California, Berkeley; JOHN REID HAUSER, JR. (North Carolina State University), University of Colorado, Boulder; PAUL JAMES HEFFERNAN (Duke University), Cornell University; ALAN BRYANT HEIRICH (University of Michigan), University of California, San Diego; WALDEMAR PETER HORWAT (Massachusetts Institute of Technology), Massachusetts Institute of Technology; WILSON C. HSIEH (Massachusetts Institute of Technology), Massachusetts Institute of Technology; RICHARD ALLEN HUFF (University of California, Santa Barbara), Carnegie-Mellon University; SCOTT BRADLEY HUFFMAN (Carnegie-Mellon University), Stanford University; NARCISCO BATACAN JARAMILLO (University of Notre Dame), Stanford University; JAMES SCOTT JENNINGS (Cornell University), Cornell University; WILLIAM CARL JOCKUSCH (Carleton College), Princeton University; JASON ANDREW JONES (Pennsylvania State University), Yale University.

Other recipients include BRIAN W. KANAGA (Johns Hopkins University), Princeton University; DIKRAN BERNARD KARAGUEUZIAN (Stanford University), Princeton University; KAMAL KHURI-MAKDISI (Yale University), Harvard University; RACHEL ANN KUSKE (University of Wisconsin, Green Bay), Northwestern University; TIMOTHY JEROME LEE (University of California, Berkeley), University of California, Berkeley; JOHN GARRETT LEO (Massachusetts Institute of Technology), Massachusetts Institute of Technology; RICHARD LAWRENCE LEWIS (University of Central Florida), Carnegie-Mellon University; NANCY LEE LIM (University of California, Berkeley), New York University; SHERALYN LISTGARTEN (University of Pennsylvania), Stanford University; MICHAEL JAMES MCGRATH (University of California, Berkeley), Harvard University; MARY SARA MCPEEK (Harvard University), Stanford University; SNINICHI MOCHIZUKI (Princeton University), Princeton University; MARK DAVID MORAN (University of Wisconsin, Madison), University of California, Berkeley; DAT DUY NGUYEN (Massachusetts Institute of Technology), Massachusetts Institute of Technology; GARY HAYATO OGASAWARA (University of California, Berkeley), Stanford University; DAVID ALAN OLSON (Saint Olaf College), New York University; DAVID CLAUDIUS PARKER (University of California, Berkeley), University of California, Berkeley; SAM CLYDE POINTER III (Duke University), Stanford University; RAVI KUMAR RAMAKRISHNA (Cornell University), Princeton University; MICHAEL REID (Harvard University), University of California, Berkeley; MARC B. REIDER (Case Western University), University of Chicago; DANIEL NELS ROPP (Washington University), Stanford University; TODD MICHAEL SANGER (Michigan Technological University), Iowa State University; GREGORY MORRIS SAUNDERS (Ohio State University), Carnegie-Mellon University; WILLIAM JON SCHMIDT (Bethel College), University of Illinois at Urbana-Champaign; DANIEL PAUL SCHROEDER (Moorhead State University), Harvard University; LEONARD JOSEPH SCHULMAN (Massachusetts Institute of Technology), University of California, Berkeley; STEPHEN ALAN SCHWAB (University of California, Berkeley), Carnegie-Mellon University; JONATHAN EDWARD SHAPIRO (University of California, Berkeley), University of California, Berkeley; STEPHEN FREDERICK SIEGEL (University of Chicago), Oxford University, England; JAY MARK SIPELSTEIN (Yale University), Carnegie-Mellon University; KEVIN HERBERT STROBEL (Whitman College), Cornell University; ERIC LEIGH STROMBERG (University of Washington), Harvard University.

Other recipients include SUSAN TOLMAN (University of Chicago), Harvard University; JUDITH LYNNE UNDERWOOD (Oberlin College), Massachusetts Institute of Technology; KATHRYN LOUISE VAN STONE (Harvey Mudd College), Stanford University; ALEXANDER WANG (Massachusetts Institute of Technology), Stanford University; Paul Powen Wang (Massachusetts Institute of Technology), Massachusetts Institute of Technology; Andrew James Ward (Yale University), Harvard University; Erlan E. Wheeler II (Virginia Polytechnic Institute and State University), Massachusetts Institute of Technology; Frederick J. Wicklin (Guilford College), Brown University; Abraham Joshua Wyner (Yale University), Stanford University; Julia Sue Yang (Massachusetts Institute of Technology), Massachusetts Institute of Technology; Jeremy Charles York (University of Illinois at Urbana-Champaign), University of Washington; Christopher Alan Zimmerman (Princeton University), Stanford University.

Minority Graduate Fellowships Awarded

The NSF has announced the award of 75 fellowships to minority students of outstanding ability for graduate study in the sciences, mathematics, and engineering. Nearly 740 students who are Native American, Black, Pacific Islanders, or Hispanic submitted applications in the nationwide competition for these fellowships, which are awarded on the basis of merit.

As the first step toward an approximate doubling of the number of Minority Graduate Fellowships planned by NSF over the next several years, there are 20 more awards this year than last year. Noting the low participation rate of minorities in science and technology, Dr. Bassam Z. Shakhashiri, NSF Assistant Director for Science and Engineering Education, said, "This action stresses the importance of solving the nation's looming shortages of science and technology personnel by expanding opportunities for underrepresented minority groups."

Each new fellowship provides a stipend of $12,300 per year for full-time graduate study. An annual cost-of-education allowance of $6,000 is provided also by NSF in lieu of all tuition and fees to the U. S. institution selected by each fellow. In addition, the appropriate undergraduate departments or colleges of each awardee will be honored with $1,000 Incentives for Excellence Scholarship Prizes in recognition of their efforts to identify and to support the work of these students. The prize goes to one or two minority undergraduates in the department to acknowledge their scholastic excellence and to encourage further development of their academic careers.

NSF Minority Graduate Fellows may attend any appropriate nonprofit U. S. or foreign institution of higher education. Each fellowship supports three years of graduate study. The fellowships may be used over a five-year period, so students can incorporate teaching or research assistantships into their education when they are not receiving their fellowship support.

The 1988 recipients in the mathematical and computer sciences are listed below (institutions listed in parentheses are those awarding bachelor's degrees; those listed outside the parentheses are those at which graduate study will be pursued): Hernan Gustavo Abeledo (Universidad Argentina, Buenos Aires), Rutgers University; Jerome Edward Lengyel (California Institute of Technology), Cornell University; Patrick Denis Lincoln (Massachusetts Institute of Technology), University of Texas at Austin; Sherry Elisabeth Marcus (Cornell University), Harvard University; Amin Amon-Ra Salaam (City University of New York, Queens College), New York University.

Presidential Young Investigators Named

The NSF announced on March 31, 1988 the selection of 148 academic scientists and engineers to receive Presidential Young Investigator Awards.

The awards, which fund research by faculty members near the beginning of their careers, are intended to help colleges and universities attract and retain outstanding young Ph.D.'s who might otherwise pursue nonteaching careers. Each young investigator can receive up to $100,000 per year for five years in a combination of federal and matching private funds.

Initiated in 1983, the awards program addresses growing faculty shortages in the highly competitive scientific and engineering fields and helps universities to improve their scientific and engineering research and training capabilities.

Of the 148 awards, more than five-sixths will go to engineering and the physical sciences. The awards carry an annual base grant from NSF of $25,000. To encourage university-industry cooperation, NSF will provide up to $37,500 per year to match industrial support on a dollar-for-dollar basis, bringing the possible total support to $100,000 per year. Individual colleges and universities provide academic-year salaries and agree to assist the investigator in attracting nonfederal support.

NSF received 1806 eligible nominations for the 148 awards. Eligibility criteria changed this year such that nominees must have begun their first post-Ph.D. tenure-track faculty position after April 30, 1984. The previous stipulation was number of years since receipt of the Ph.D. degree. The new investigators represent 59 academic institutions in 26 states. Two are located at predominantly undergraduate institutions; 21 are women.

The 1988 recipients of the PYI awards in the mathematical sciences, along with their institutional affiliations and research interests, are:

Paul William Beame (University of Washington), Theoretical Computer Science; Hari Bercovici (Indiana University at Bloomington), Operator Theory; Marsha J. Berger (New York University), Numerical

Analysis; MLADEN BESTVINA (University of California, Los Angeles), Geometrically-oriented Topology; CHRISTOPHER S. BRETHERTON (University of Washington), Atmospheric Science; WALTER CRAIG (Stanford University), Mathematical Physics and Continuum Mechanics; JAMES S. FREUDENBERG (University of Michigan, Ann Arbor), Control Theory; JO FRIEDMAN (Princeton University), Theoretical Computer Science; ANDREW V. GOLDBERG (Stanford University), Algorithms and Computational Complexity; JOHN Z. IMBRIE (Harvard University), Physics; GAIL E. KAISER (Columbia University), Software; CHARLES KNESSL, (University of Illinois at Chicago), Applied Mathematics; JANOS KOLLAR (University of Utah), Algebraic Geometry; CHRISTOPHER J. LAWRENCE (University of Illinois at Urbana-Champaign), Fluid Mechanics; CURTIS T. MCMULLEN (Princeton University), Theory of Equations; JOHN C. MITCHELL (Stanford University), Foundations of Programming Languages; JOSEPH S. MITCHELL (Cornell University), Computational/Geometry Optimization; KENNETH G. POWELL (University of Michigan at Ann Arbor), Computational Fluid Dynamics; KARL C. RUBIN (Ohio State University), Algebraic Number Theory; JALAL SHATAH (New York University), Applied Mathematics; CHRISTOPHER D. SOGGE (University of Chicago), Mathematics; MASARU TOMITA (Carnegie Mellon University), Natural Language Processing; JUSTIN D. TYGAR (Carnegie Mellon University), Computer Security; CUN-HUI ZHANG (State University of New York at Stony Brook), Statistics.

A brochure designed to acquaint potential industry donors of matching funds with biographical data and research interests of the new awardees will be available soon after NSF. Copies may be obtained by sending a mailing label to PYI Brochure, Division of Research Career Development, Room 630, National Science Foundation, Washington, D.C. 20550.

Presidential Young Investigators Competition 1989

The NSF is now accepting nominations for one of its most prestigious awards, the Presidential Young Investigator (PYI) award. At the time of this writing, the final program announcement was not available, but it is anticipated that the competition criteria and award size will be the same as last year. The deadline for nominations is **October 1, 1988**.

These awards provide cooperative research support for the nation's most outstanding and promising young science and engineering faculty. With the participation of the industrial sector, the awards are designed to improve the capability of universities to respond to the demand for highly qualified scientific and engineering personnel for academic and industrial research. In addition, the awards are intended to help universities attract and retain outstanding young scientists and engineers who might othewise pursue nonteaching careers.

Some of the rules regarding eligibility were revised in 1987. Below is a description of some of the most important features of the awards.

Award size. The awards provide a base grant of $25,000 per year for 5 years. In addition, the NSF will match, on a dollar-for-dollar basis, donations of up to $37,500 from industry or from nonprofit, private foundations (excluding those associated with particular universities or university systems). The donations may be in the form of cash, grants, research contracts, or permanent research equipment. The equipment must be of a type and quality necessary to carry out the research programs of the awardee.

Eligibility. Eligible institutions may nominate both current and prospective members of their faculty who are holding or have been offered tenure track positions as of the time of nomination. To be eligible, nominees must have begun their first post-Ph.D. tenure-track faculty position after April 30, 1985. Those who have been offered such positions must begin their appointment by October 1, 1989 to activate the award. Nominees must be U.S. citizens or permanent residents as of October 1, 1988.

Nature of activities supported. PYI nominees must have a clearly demonstrated ability to conduct a research program, since the awards must be used to fund research activities. Awardees may conduct research in any branch of science or engineering normally supported by the NSF. They are expected to carry a normal teaching load relative to non-PYI faculty at the nominating institution.

Eligible institutions. Any U.S. institution that awards a baccalaureate, master's or doctoral degree in a field supported by the NSF is eligible to participate in this program.

For more information, contact: Presidential Young Investigators Awards, National Science Foundation, 1800 G Street, NW, Washington, DC 20550; or call 202-357-9466, and ask for the Program Director for PYI awards.

Young Scholars Program for High School Students

The NSF has announced 68 Young Scholars awards to establish science, mathematics, and engineering enrichment projects for more that 2500 high-ability and high-potential secondary school students. The projects will be held in 34 states, the District of Columbia, and Puerto Rico.

Initiated this year with NSF funding of $3.7 million, the Young Scholars Program is designed to excite students about science careers by offering them the opportunity to work side by side with research scientists in ongoing research projects or in projects of their own design.

Bassam Z. Shakhashiri, NSF Assistant Director for Science and Engineering Education, described the new program as "a first step in the NSF's efforts to help talented young men and women in America's schools learn more about the careers that await them if they build on their enthusiasm for science and mathematics. There will be no cripppling shortage of scientists and engineers in the next decade if promising young people see and act on the exciting possiblities of work at the forefront of knowledge."

The program strongly emphasizes student participation in the process of scientific discovery, with projects combining instruction and problem-solving with exposure to the research environment and research methods through laboratory work and field trips. Role modeling is an important component of project activities, and in several projects students will "shadow" industry scientists at work. Project directors will foster lasting mentoring relationships between faculty and students. Some faculty will serve as consultants to students planning projects for science fairs and competitions.

The projects are aimed at students entering grades 8-12, in order to capture their interest before they opt out of science careers. Shakhashiri said the goal of the program is to draw students into the world of science as early as possible. The Young Scholars Program is comprised of residential and commuter projects, conducted during the summer or on weekends, on the campuses of colleges, universities, and research organizations.

Awards are for one year with a second year of support contingent on NSF review of project activities and the availability of funds. With the exception of two large projects budgeted for a total of over $312,000, the average grant size is $41,000. The sponsoring institutions also have made a substantial commitment to these projects as reflected in cost-sharing contributions totaling more than $1.7 million.

Of the Young Scholars awards activities funded in 1988, 30% are in the life sciences, 16% are in engineering, 10% are in mathematics and computer science, 6% each in physics and chemistry, 3% in the earth sciences, and 29% are multidisciplinary in focus. Among the fiscal year 1988 Young Scholars projects, the following are in the areas of mathematics and computer science.

- American Indian Science and Engineering Society: Norbert S. Hill received $51,708 to direct a 3-week summer residential program in mathematics and computer science for 30 students in grades 8 and 9.
- Loyola University of Chicago: Eric R. Hamilton of the Mathematical Sciences Department was granted $34,626 to conduct a 6-week summer commuter program in mathematics and computer science for 16 high school juniors and seniors.
- Northern Michigan University: John O. Kiltinen of the Department of Mathematics/Computer Science has received $34,729 to run a 2-week summer residential program in mathematics for 40 students in grades 11 and 12.
- Southeast Missouri State: Larry A. Lucas of the Center for Science and Mathematics Education was awarded $22,848 to bring in 20 students in grades 9-12 for a 3-week summer residential program in mathematics and computer science.
- University of New Hampshire, Durham: William E. Geeslin of the Department of Mathematics was granted $30,936 to run a 3-week summer commuter program in mathematics and marine science, which will involve 20 tenth-grade students.
- Research Foundation of SUNY at Old Westbury: Jong Pil Lee of the Mathematics Department was awarded a $35,848 grant to involve 50 high school sophomores and juniors in a 3-week academic year program in mathematics.
- University of Texas, San Antonio: Manuel Berriozabal of the Department of Mathematics, Computer Science, and Systems Design was granted $183,513 for a multidisciplinary program in mathematics that will involve 500 students in grades 7-12 in an 8-week summer commuter program.
- University of Washington, Superior: Frances Florey of the Mathematics Department received $49,362 for a 6-week summer residential program in mathematics for 16 high school juniors and seniors.

Undergraduates Participate in Research

The Division of Mathematical Sciences has announced the 1988 awards made in the Research Experiences for Undergraduates (REU) program. REU is designed to give students hands-on experience in research in science and engineering. (For more information on the program, see the article "Research Experiences for Undergraduates," in this issue of *Notices.*)

REU is designed to encourage talented students to pursue careers in research in science and engineering by exposing them to the excitement of research while the students are in the process of making career choices.

The awards provide support for programs to be conducted this summer for undergraduate students to participate in mathematical research. The programs vary in size from 4 to 12 students and generally last from 4 to 6 weeks. The following list gives the names of the principal investigators, their institutions, and the area of emphasis of each program.

- James H. Curry and William E. Briggs, University of Colorado, Boulder: Geometry of iteration and parallel computation
- Charles N. Curtis and James A. Morrow, University of Washington, Seattle: Numerical partial differential equations

- Joseph A. Gallian, University of Minnesota, Duluth: Graph theory
- John Greever, Harvey Mudd College: Applied mathematics
- David L. Housman, Worcester Polytechnic Institute: Discrete and applied mathematics
- Lawrence Husch, University of Tennessee: varied topics
- B. Frank Jones, Rice University: Laplace operator on spheres
- Robert H. Lewis, Fordham University: Matrices for topology applications
- George E. Mitchell and James C. Reber, Indiana University of Pennsylvania: Discrete chaotic dynamical systems
- Donal B. O'Shea et al, Mount Holyoke College: Algebraic geometry, partial differential equations, and statistics
- Robert O. Robson and Paul Cull, Oregon State University: Computational exploration in number theory, dynamics, etc.
- Fred B. Schultheis, Moravian College: Reciprocity laws in algebraic number theory
- Willie E. Taylor and B. Smith, Texas Southern University: Differential and difference equations
- Richard M. Wilson and Fredrick H. Shair, California Institute of Technology: Finite algebra and combinatorics

The deadline to submit proposals for 1989 REU grants is **October 10, 1988**. For more information, contact William W. Adams, Program Director, Research Experiences for Undergraduates, Division of Mathematical Sciences, National Science Foundation, 1800 G Street, NW, Washington, DC 20550; telephone 202-357-3695.

National R and D Funds at Eleven Year Low

The nation is expected to spend $132 billion on research and development (R & D) in 1988, according to *Science Resource Studies Highlights*, published by the NSF. This figure represents a constant-dollar increase of 3% over 1987, the lowest rate of growth since 1977.*

Since 1980, most of the gain in national R & D support is attributable to major increases in federal defense spending. Accounting for approximately half the nation's total R & D expenditures, the federal government spends about 70% of its R & D dollars on defense activities. Increases in DOD expenditures account for 90% of the estimated growth in federal R & D support between 1980 and 1988.

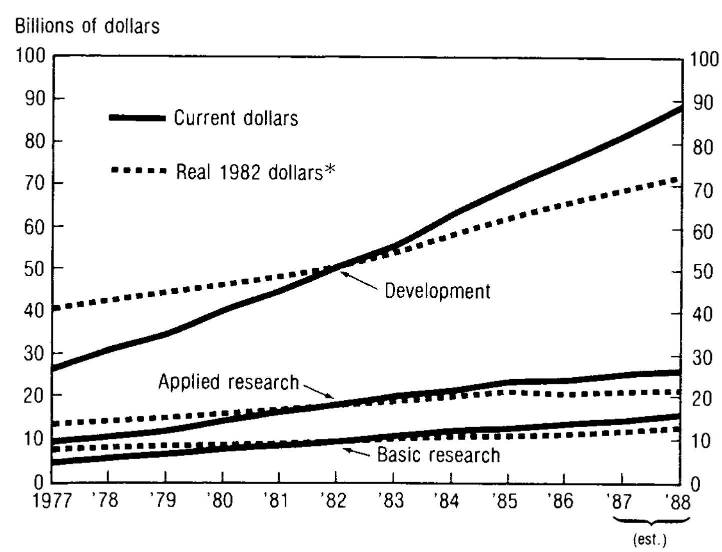
The DOD is expected to continue to shift its R & D emphasis from research to development. In 1980, development accounted for 83% of the DOD's R & D support; in 1988, that figure is expected to rise to 92%.

The nation as a whole is expected to spend $15 billion on basic research in 1988, $27 billion on applied research, and $90 billion on development (see chart). After adjusting for expected inflation, basic research spending is expected to be down slightly from 1987, applied research spending to be unchanged, and development spending to rise 4%.

The federal government continues to support two-thirds of the nation's basic research, with more than half of this support going to universities and colleges. Industry provides an additional 20% of the support for basic research. Basic and applied research each will receive an estimated 14% share of the federal R & D dollar in 1988; in 1980, those percentages were 16% and 23%, respectively.

For the past several years, growth in support for basic and applied research has been slower than for development. Between 1982 and 1987, basic research funding is estimated to have increased at an inflation-adjusted average annual rate of 5%; the corresponding figures for applied research and development are 4% and 6%, respectively. The share of R & D expenditures devoted to development has increased from 64% in 1982 to 68% in 1988, primarily as a result of increased defense development activities.

*The estimated 1987-1988 growth in real R&D expenditures is based on an assumed 4-percent change in the GNP implicit price deflator, as estimated by the Office of Management and Budget.



News from Washington

BMS Activities

The Board on Mathematical Sciences (BMS) was established in 1984 by the National Academy of Sciences/National Research Council (NAS/NRC) in response to the recommendations of the David Report. The objective of the Board is to maintain awareness of and active concern for the health of the mathematical sciences and to serve as the focal point in the NRC for issues connected with the mathematical sciences. The Board is designed to conduct studies for federal agencies and to act as liaison with the mathematical sciences communities. Phillip Griffiths, Provost of Duke University, is Chairman of the BMS, Ronald Pyke of the University of Washington is Chairman of the BMS Committee on Applied and Theoretical Statistics (CATS), and Lawrence Cox is BMS Staff Director.

This year, the Board formed an Executive Committee to handle the increasing workload. Executive Committee members are Phillip Griffiths, Ronald Pyke, Shmuel Winograd of IBM Corporation, and Ronald Douglas of SUNY Stony Brook. This summer, the Board will expand from 12 to 15 members to incorporate expertise in operations research and mathematical sciences applications in the social and health sciences.

The BMS is involved in a wide variety of projects, some of which are described below.

MS2000. This project, cosponsored by the NRC's Mathematical Sciences Education Board (MSEB), will conduct a comprehensive assessment of all aspects of the collegiate mathematical sciences, from the undergraduate through professional levels. MS2000 will gather statistics, initiate discussion, and make recommendations for change. MS2000 held a Talent Review Workshop on April 11. (For more information on MS2000, see the article, "MS2000 Committee Selected," *Notices*, April 1988, page 535.)

Science Week Symposium. Each year during National Science and Technology Week, BMS sponsors a symposium at the National Academy of Sciences. This year's symposium, held on April 28, also celebrated National Mathematics Awareness Week. The symposium, entitled "The Impact of Mathematics: Nonlinear Mathematics, Chaos and Fractals in Science," focused on recent mathematical research in these areas and applications to research in the sciences and engineering. The expository talks were aimed at a general science and science policy audience and were complemented by striking visual displays.

CATS Activities. Two reports in statistical science are now available: "Statistical Models and Analysis in Auditing," and "Discriminant Analysis and Clustering." Initiated at the request of government agencies, these two state-of-the-art survey reports are of interest to the broad mathematical sciences community as well. CATS is also planning to publish the proceedings of last year's Science Week event, which focused on statistical science and intends to initiate projects in quality, productivity and standards for statistical software.

Research Trends Report. This state-of-the-art report presents an overview of research trends and important areas of current research activity in the mathematical sciences. Written for a general mathematical sciences audience, the report comprises 3 major sections on core mathematics, applied mathematics and the statistical sciences and 8 vignettes on research areas with recent interesting and promising developments. Prepared at the request of federal agencies, this report will be of interest to mathematical scientists, other scientists, university administrators, and policymakers interested in the state of mathematical sciences research in the mid-1980s. The report is expected to appear this summer.

Annual BMS Chairmen's Colloquium. Each fall, the BMS sponsors a meeting of chairmen of mathematical sciences departments in Washington, DC. The meeting is designed to promote discussion on issues of national importance, to inform the chairmen about developments in science policy, and to identify and seek solutions to common problems. The 1988 meeting, to be held October 14-15, will focus on two themes: the use of computers in the mathematical sciences, with emphasis on their use in research and training; and opportunities afforded by new modes of funding, such as centers and groups.

National Security Agency panel. This BMS panel provides peer review for the NSA's Mathematical Sciences program, which funds research in the areas of algebra, number theory, discrete mathematics, combinatorics, probability, and statistics. The panel, chaired by Andrew Gleason of Harvard University, met in January and made recommendations on the 86 proposals received by the program this year. Because of the volume of proposals, the panel's membership will be increased from 7 to 10.

Cross-disciplinary and Focused Report Series. This series of NRC reports will comprise reports of 2 types. The cross-disciplinary reports will describe the ways in which the mathematical sciences have contributed substantially to progress in other fields of science, as well as cases in which cross-disciplinary work stimulated new research in the mathematical sciences. The reports will be intended for a wide audience: colleagues in other disciplines, policy makers, funding agencies, as well as mathematical scientists. The focused reports will be written for mathematical scientists and will document important examples of collaboration across major areas of the mathematical sciences. The BMS will convene a group this summer to lay plans for the reports.

Follow-up to the David Report. The 1984 David Report documented underfunding and other alarming facts and trends affecting the infrastructure of the mathematical sciences. This report had considerable impact and resulted in, among other things, the creation of the BMS and a 90% increase in federal funding support for mathematical sciences research. Several groups have urged that a second report be written to document and assess improvements and progress and to look towards research opportunities which could benefit science as a whole. The BMS is considered the most suitable group to undertake this second report.

AFOSR panel. This panel recently completed a report evaluating the Mathematical and Information Sciences program at the Air Force Office of Scientific Research and recommending areas of increased emphasis. Reports like this represent one of the services BMS provides to the federal agencies. A similar report was written for the Office of Naval Research one year ago.

Television program on Ramanujan. With the MSEB, the BMS sponsored on March 14 a special preview showing at the National Academy of Sciences of the Nova Public Televsion program entitled, "The Man Who Loved Numbers," based on the life of the Indian mathematician Srinivasa Ramanujan. Several important dignitaries, including the Science Advisor to the President and the Ambassador of India, were present.

In addition to Staff Director Cox, the BMS staff includes Seymour Selig, Robert Smythe, William Rosen, and MS2000 project director Bernard Madison. New projects and the need for new staff in 1988 are anticipated. The BMS staff can be reached at: Board on Mathematical Sciences, National Academy of Sciences, Room NAS312, 2101 Constitution Avenue, Washington, DC 20418; telephone 202-334-2421.

Fulbright Teacher Exchange Program

The United States Information Agency has announced details for the 1989-1990 Fulbright Teacher Exchange Program. The Teacher Exchange Program will involve a one-to-one exchange of teachers at the elementary, secondary and postsecondary levels with suitable teachers overseas. The 1989-1990 overseas exchange programs will involve Argentina, Australia, Belgium/Luxembourg, Brazil, Canada, Colombia, Chile, Cyprus, Denmark, the Federal Republic of Germany, Finland, France, Hungary, Iceland, Mexico, The Netherlands, Norway, Panama, the Philippines, Senegal, South Africa, Switzerland, and the United Kingdom. The number of exchange positions available and the eligibility requirements vary by country. The program will also provide opportunities for teachers to participate in summer seminars, which will range from three to eight weeks in length. During the summer of 1989, seminars will be held in Italy and The Netherlands.

Applications will be available in the summer of 1988. (Programs are announced a year in advance and are subject to change.) Completed applications must be received by USIA postmarked by October 15, 1988. For further information, write to the Fulbright Teacher Exchange Program, E/ASX, United States Information Agency, 301 Fourth Street, S. W., Washington, D.C. 20547. Telephone: 202-485-2555.

– United States Information Agency News Release

Model Agreements for Cooperative Research

The Government-University-Industry Research Roundtable has published "Simplified and Standardized Model Agreements for University-Industry Cooperative Research." The purpose of this document is to streamline the negotiation process and decrease the time and effort required to reach an agreement between the two parties. The document provides two model agreements containing appropriate legal language concerning various aspects of such agreements—reports, costs, publicity, publications, insurance, etc. The Research Roundtable is sponsored by the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. Copies of this publication are available from: Government-University-Industry Research Roundtable, National Academy of Sciences, 2101 Constitution Avenue, N.W. (NAS342), Washington, DC 20418; telephone 202-334-3486.

Mathematics Symposium at the National Academy of Sciences

Mathematics and other branches of science are meeting at their frontiers as scientists find that increasingly sophisticated mathematics is necessary to solve complex and difficult scientific questions. This was the message of a symposium held April 25 during the 125th annual meeting of the National Academy of Sciences. The symposium, entitled "Mathematics in the Sciences," was part of "100 Years of American Mathematics," a year-long series of events that grew out of the AMS Centennial.

Moderator and organizer Felix Browder of Rutgers University said that, because the purpose of the symposium was to highlight the role of mathematics in other sciences, distinguished practitioners from other disciplines were invited to speak on the use of mathematics in their fields of research. The symposium was well-attended and drew an audience of several hundred, most of them registrants of the NAS meeting. The lectures were nontechnical and open to the public.

The focus of the talks was not simply on mathematics as a tool, but on the surprising effectiveness of mathematics and on the interplay between mathematics and other sciences. Using examples from various topics such as string theory and quantum electrodynamics, David Gross, Professor of Physics of Princeton University, spoke on "Physics and Mathematics at the Frontier." Gross decried the "increased abstraction and rigor" of the Bourbaki school, which he feels made mathematical papers inaccessible to those in other fields and was in part responsible for a separation between mathematics and physics. However, he said that in the last ten years, the two fields have begun to reconnect as recent results in string theory have pushed ahead to the frontiers of mathematical research. He remarked that "string theory may bring a fundamental generalization of geometry."

Leo P. Kadanoff, Professor of Physics at the University of Chicago, provided an illuminating and accessible description of the onset of chaos in his lecture, "Snatching Chaos from Order." Using a simple population model, he described how period doubling and chaos can come about. Going on to other examples, such as acoustic feedback and convection, he explained how these cases are similar to the insect model in certain respects and that those systems that become chaotic as a result of period doubling have in common certain "universal" features. While fully developed chaos and chaos in systems ruled by more complicated equations are not well understood, it is the universal properties that scientists are searching for.

Complementing Kadanoff's lecture was a witty and incisive talk by Robert M. May, Professor of Zoology at Princeton University. In his talk, entitled "Mathematics in Ecology and Evolutionary Biology: The Dynamics of Surprise," May described the effects of chaos on population growth and the spread of epidemics. He pointed out that in this area, one's perspective is crucial: his talk showed how a deterministic approach can give the appearance of unpredictability, but he could just as easily have given a talk on how, for example, unpredictable influences in evolution can produce the illusion of a smoothly varying deterministic system. These two lectures on chaos showed not only that mathematics is the crucial key to understanding such systems, but also that there are many profound questions that need to be answered and that the theory is far from complete.

The ability of mathematics to organize complex, changing systems was also exemplified by the talk entitled "Economic Equilibrium: What It Is and How to Compute It," presented by Herbert E. Scarf, Professor of Economics at Yale University. Scarf explained the various forces that come into play in the general equilibrium model of an economy and demonstrated how mathematical fixed point theorems can prove the existence of prices that satisfy the simultaneous equations and inequalities of the model.

Benoit Mandelbrot wrapped up the symposium with a lecture entitled, "Fractals: the Mathematics, the Physics, and the Art." Mandelbrot, an IBM Fellow and Adjunct Professor of Mathematical Sciences at Yale University, illustrated his talk with striking examples of fractal art and described how fractals have been an important force in physics. For example, fractals have allowed researchers to calculate how much space is needed in order to insure that the path traced by the Brownian motion of a particle in the plane should have no self-intersections. Also, he described how fractals have reduced certain problems in the understanding of percolation to their essential geometric characteristics.

The symposium showed mathematics as a powerful and dynamic tool that changes and grows in response to other sciences and to its own inner workings. Though, as May put it, "mathematics as an art is an acquired taste," it seemed that all the speakers had learned to appreciate both its beauty and its efficacy.

For Your Information

Congress and the NSF Budget

Allyn Jackson

The last meeting of the Advisory Committee for the Mathematical Sciences for the National Science Foundation (NSF) was held March 24-25. In addition to continuing discussions initiated at its November meeting, the committee was presented with an explanation by some key NSF officials of the Foundation's yearly budget process. The purpose was to inform the committee of this important but often mystifying process.

As the officials' interesting and cogent elucidation may be of interest to the general mathematical community, a summary of their remarks is reproduced here. The officials who spoke were: James Hays, Senior Science Adviser; Joseph L. Kull, Director of the Division of Budget; John H. Moore, Deputy Director of the Foundation; Richard S. Nicholson, Assistant Director for Mathematical and Physical Sciences; and Joel M. Widder, Legislative Specialist. The meeting took place March 24-25 at NSF headquarters in Washington, DC.

Long Range Planning

The process of building the NSF budget is based on the NSF's long-range plan, which sets priorities for the Foundation for the next five years. Each division in the NSF formulates its own long-range plan and submits it to the directorate in which it resides. The Division of Mathematical Sciences (DMS) is housed in the Mathematical and Physical Sciences (MPS) Directorate, which also includes physics, astronomy, materials research, and chemistry. The division directors work with the directorate head to develop a long-range plan for the directorate as a whole.

Nicholson pointed out that this planning process is really a balancing act: the needs of disciplines that are facility-intensive (such as astronomy and physics) must be balanced with those that are individual-intensive (such as mathematics); issues of infrastructure and support for graduate students and postdoctoral associates must be balanced with support of senior investigators; and modes of support—large centers, groups, and individuals—must also be balanced. Nicholson voiced his support for the Mathematical Sciences Research Groups, which the committee has enthusiastically endorsed and for which the DMS is slated to receive new funds in 1989. Nicholson said that the groups provide flexibility in mathematical sciences research grants, which he acknowledged to be "pitifully small."

While special plans—such as the Computational Science and Engineering initiative, which has its roots in the DMS—are useful in the long-range plan, Nicholson pointed out that if every NSF division has two or three initiatives, then NSF Director Erich Bloch "has a hundred things to explain to Congress." This is why the Foundation's long-range plan is organized around three basic themes that are important but also simple to explain: centers and groups, disciplinary research and facilities, and education and human resources.

Role of the National Science Board

Each June the National Science Board meets to develop a budget plan for the fiscal year 16 months away. (The Board serves in an advisory capacity to set policy for the NSF and includes representatives from all areas of science and engineering. The Board presently has no members in the mathematical sciences, but one of the members, William F. Miller, a computer scientist and President and Chief Executive Officer of SRI International, is an AMS member.) According to Hays, the emphasis at this meeting is on the plan—the Board sets the budget priorities by looking at themes and strategies rather than dollar amounts. At the meeting, there are various presentations by NSF officials and discussions about new directions the Foundation is considering.

Kull explained that, days after the Board's meeting, the NSF issues a "budget call," which provides technical and policy guidance based on the priorities set by the Board. With the assistance of its budget analyst, each directorate uses the budget call to prepare its own budget. By the end of July, the directorates' budgets are sent to the Board's Executive Committee, which discusses how the budgets relate to the priorities set at the June meeting. The budgets are also presented to various Board committees for review. Kull said that this process allows the budget to receive the attention of high-level officials over a considerable amount of time.

The Office of Management and Budget

By September 1, the NSF must submit its budget to the Office of Management and Budget (OMB). The OMB oversees nearly every aspect of every federal agency's activities in order to prevent duplication of effort and to insure that various programs do not run at cross purposes. In addition to formulating the spending blueprint that the Administration sends to Congress each year, the OMB writes legislative regulations, drafts legislation, collects information, and works with the agencies on their proposed budgets. With the growth of the Office's influence since Ronald Reagan took office in 1981, some have criticized the OMB, saying that it exercises excessive control over federal agencies in order to shape policy according to the Administration's priorities.

However, Kull says that, while some OMB officials may attend some of the NSF's advisory committee meetings or meetings of the National Science Board, the OMB "stays clear of our planning process" and that the NSF has "an excellent working relationship" with the OMB. After the OMB receives the NSF's proposed budget, it meets with the heads of each directorate. Kull called these meetings "fairly informal" and said they are mostly used to discuss any increases and new programs.

It is clear that the OMB believes the NSF is doing a good job: in 1987, the OMB supported the NSF's proposal to double its budget in five years, beginning with an increase of 16.5% for 1988. However, Congress did not follow that plan in its allocation to the NSF for fiscal 1988 and gave the Foundation only a disappointing 6.5% increase. Despite the setback, Kull and the other NSF officials remained steadfastly optimistic about the overall plan. Kull said that 12% average compounded yearly increases are "locked in" on the OMB computer until 1993. Although such assurances may seem ephemeral, he told the committee not to take them lightly, stating that no other federal agency has had this kind of support from the President and the OMB. Of course, with a new Administration in place at the beginning of 1989, it is unclear how these plans will fare in coming years. However, this support has already had positive effects: Moore said that the budget request for 1989 went smoothly in part because of OMB support.

Between September and January, the OMB assembles a package containing the President's request for spending for the entire federal government. This package is usually submitted to Congress in late January or early February. However, this year the submission for fiscal 1989 was delayed until late February because of Congress's arduous, 3-month delay in passing this year's spending bill.

The 1989 Budget

Widder described the budget approval process for the fiscal year 1989, a year which in some respects is anomolous. Last fall, when Congress and the Administration were unable to agree on the 1988 budget, they called a reconciliation meeting in November, a month after the fiscal year had begun. At the meeting, Congress and the White House not only agreed on a plan for fiscal 1988, but also formulated broad outlines for the 1989 budget. These outlines specify increases for various budget categories as well as the revenue to be assessed. When Congress passed this reconciliation plan into law, it avoided the Gramm-Rudman automatic spending cuts.

After Congress finally passed the fiscal 1988 spending bill in February, the Administration submitted its request for fiscal 1989. In the request, the NSF budget appears in the "nondefense discretionary programs" category. Widder explained that, because the outlines agreed upon last November have set a ceiling on each budget category, any increase for any program within a category siphons money off another program. Congress has generally been less enthusiastic about increased defense spending than the President and has often shifted funds in the President's request from defense to non-defense categories. However, the reconciliation bill will prevent such shifts in the fiscal 1989 budget.

The 1989 request calls for $3.3 billion increase in nondefense discretionary programs, and $3.1 billion of that increase is to go into science and space programs at such agencies as the National Aeronautics and Space Administration, the Department of Energy, and the NSF. Widder expressed some skepticism that Congress would allow such an overwhelming proportion of the increase to go to science and space programs, rather than to domestic programs, especially in an election year. Saying the Congress will look to the scientific community for priorities, Widder pointed out that the tight budget situation means that the NSF is competing against such large projects as the space station, mapping the human genome, and the superconducting supercollider. "The NSF is small science compared to those programs," he said. "What are the priorities of the scientific community?"

17 Categories and 13 Committees

Congress divides the budget request into 17 "functions," such as energy, defense, agriculture, health, justice, etc. (The NSF budget comes under Function 250, entitled General Science, Space, and Technology.) However, there are only 13 Congressional appropriations subcommittees to which the functions are distributed, so the mix of various components of the budget functions make for some strange bedfellows. For example, the NSF falls under the "Housing and Urban Development and Independent Agencies" subcommittees of the House and Senate Appropriations Committees. (In the House, the subcommittee is chaired by Edward P. Boland, Democrat from Massachusetts, and in the Senate, by William Proxmire, Democrat from Wisconsin.) As a result, the NSF each year competes for increases against quite unrelated agencies or programs under the purview of these two subcommittees: the Veterans Administration, Housing and Urban Development, the Environmental Protection Agency, and others.

While the subcommittees are cognizant of the importance of the NSF and the value of scientific research, the peculiar mixture of programs in these subcommittees often compels the members to attach higher priorities elsewhere. Indeed, it was noted that it is not these subcommittees that need to be informed of the value of the NSF, but rather the other members of Congress.

Widder said that, while NSF employees are specifically prohibited from lobbying Congress on behalf of their agency, it is entirely appropriate for them to furnish information about the NSF to those in the scientific community who wish to educate Congress about the role of the Foundation and the importance of scientific research to the nation.

A Mutual Education Process

The committee appeared to find the explanations thoughtful and informative and questioned the officials closely on several points. On behalf of the committee, Chairman Alan C. Newell thanked them for taking a bold approach in seeking a doubling of the NSF budget and thanked Nicholson in particular for sustaining strong support of mathematics this year, when the budget increase for the Foundation was far less than was hoped. All agreed that the mathematical community, and the scientific community more generally, would benefit from a greater understanding of the issues discussed.

The budget process may seem at times like a needlessly intricate and arbitrary system, but it provides for a measure of checks and balances that allow the government to compare the priorities of the disparate needs that compete for funds. One NSF official noted that increases in funding for mathematics and for science in general must be viewed in the context of all the other budgetary needs that the Administration, the OMB, and Congress must consider. The budget deliberation is a mutual education process: in order to make its expectations and justifications realistic, the mathematical community must be prepared not only to educate policymakers about the importance of supporting mathematics, but also to learn about the way the budget system works.

Mathematical Sciences in the FY89 Budget[1]

Frank Gilfeather

Overview and Trends

The trend, begun in the mid 1980s, of significantly increased federal support for the mathematical sciences seems to have continued into 1989. During this period, initially there were broad based increases in all agency programs, however in recent years significant increases have been most prominent at the National Science Foundation (NSF) and at the Defense Advanced Research Projects Agency (DARPA). The overall increase in constant dollars since 1982 is about 74 percent and is equally shared between NSF and the Department of Defense (DOD) agencies. The relative growth rate in program budgets is a matter of community interest and is somewhat uneven especially in the DOD agencies. In addition, there appears to be a shift in emphasis between programs, support levels, and support elements. The trend of primary importance in federal mathematics funding is the emergence of various center and large project support mechanisms.

The major impact on basic research budgets in the mathematical sciences continues to be the dynamics of the current effort to double the overall NSF budget. How this is done will significantly affect mathematics because of the dominance of NSF in federal mathematics funding (over 50 percent). Mathematics has

[1] This report was prepared for the Joint Policy Board for Mathematics and as part of the *AAAS Report XIII: Research and Development, FY 1989*, April 1988.

fared extremely well when compared to the other divisions in the Mathematics and Physical Sciences (MPS) Directorate at NSF, however the extent to which MPS will participate in general NSF enhancements is uncertain. In addition, the direct support level of any division at NSF, while important, does not fully reflect how a discipline participates in the new resources at NSF, since major portions of the new resources are designated for cross-directorate activities.

In addition to participating in the general increased support levels for basic research over the last few years, the significant enhancement of mathematics budgets in the 1980s attests to the impact of the 1984 National Research Council (NRC) report, *Renewing U.S. Mathematics: Critical Resources for the Future*. The National Science Board in 1984 passed a resolution "that a concerted effort should be made by all funding agencies to increase support for the mathematical sciences for several years until a proper level of sustaining support has been achieved." Subsequent acknowledgment of this report includes reports to the DOD University Forum and language in the 1986 University Research Initiative (URI) legislation urging redressing of the funding issue raised in the NRC report.

Key recommendations of this important report were for increases in graduate student and postdoctoral support levels and significant enhancement of computational support. Considerable increases in these areas are now seen in several agency programs. However another recommendation concerned the unusually low number of investigators supported and the relatively low support level of supported investigators. The report's conclusion that only about one third of active research mathematicians receive any federal support for their research remains unchanged. The report was concerned about the effect this low support level will have on the nation's scientific and technical strength and its manpower levels into the next century.

Distribution of Federal Support

Although the NSF is the only federal agency responsible for support across the entire spectrum of the mathematical sciences, other federal agencies play a significant role in support of basic research in the mathematical sciences. Research is also funded by the DOD, the Department of Energy (DOE) and the National Security Agency (NSA). Some agencies have no extramural programs of support for mathematical sciences. Details of support by these agencies are difficult to obtain and must be estimated.

The role of NSF in support of academic basic research for the mathematical sciences is unique and of critical importance. NSF continues to provide about 80 percent of the support in core mathematics and an overall total of over 50 percent. The mission agencies, e.g., DOD and DOE have focused their support primarily on applied mathematics, statistics, and computer science. The NSA has focused its support in certain areas of algebra, discrete mathematics and statistics.

The evolution of the mathematical sciences budgets by major organizations is given in the following table. It is important to note that in those agencies where mathematics and computer sciences are jointly funded, an estimate was made as to the split between university-based mathematics and computer science budgets.

Within agencies certain trends are observed. The 1989 figures show that several DOD agencies are just regaining their 1986 and 1987 budget levels. We note that factors such as URI and Strategic Defense Initiative (SDI) make accurate assessment of program levels almost impossible to determine. For example, some agencies used 1987 URI money to fund multi-year programs entirely while others funded one year increments of multi-year programs. Moreover, the nature of some newly supported projects are considerably different from existing core programs, thus resulting in the displacement of investigators and projects.

The portion of DOD's research and development funding for research efforts that most directly advance science or strengthen the technology base is divided into two categories: basic research (6.1 funding) and exploratory development (6.2 funding). DOD support research in the mathematical sciences is accomplished primarily through the following arms of the various departments:

- The Army Research Office (ARO)
- The Office of Naval Research (ONR)
- The Air Force Office of Scientific Research (AFOSR)
- The Defense Advanced Research Projects Agency (DARPA).

In addition, DOD supports a substantial amount of 6.1 and 6.2 research intramurally at various DOD laboratories. Some of these laboratories provide funding support for applied mathematics, statistics, and computer science. This work is highly mission oriented, with only a small percent of the funding going to university-based research. The first three agencies (ARO, ONR, AFOSR) are much alike in their basic method of operation. However, DARPA differs in that it is not attached to any one department and does little of its own contract administration.

Federal Agency Support in the Mathematical Sciences
(millions of dollars)

	FY1982	FY1983	FY1984	FY1985	FY1986	FY1987	Current[1] FY1988	Budget[2] FY1988
Dept. of Defense								
AFOSR	6.70	7.30	10.20	11.82	13.30	15.30	14.30	15.48
ARO	6.00	6.50	6.80	7.50	8.40	9.70	10.60	10.60
ONR	10.60	12.70	11.90	11.98	12.81	11.30	10.70	10.70
DARPA	–	–	–	1.00	5.50	9.20	12.00	15.00
Total DOD	23.30	26.50	28.90	32.30	40.01	45.50	47.60	51.78
Dept. of Energy	2.30	2.80	2.90	3.50	3.94	4.30	5.20	5.80
NSA[3]	–	–	–	–	–	1.40	2.10	2.50
Other Agencies (estimates)	2.00	2.00	2.00	2.00	2.00	1.00	1.00	1.00
Total non-NSF	27.60	31.30	33.80	37.80	45.95	52.20	55.90	61.08
NSF								
DMS	31.20	34.10	41.20	47.50	51.74	59.42	63.67	67.97
Other	3.00	3.00	4.00	5.00	5.50	5.00	5.00	5.00
Total NSF	34.20	37.10	45.20	52.50	57.24	64.42	68.67	72.97
Total	61.80	68.40	79.00	90.30	103.19	116.62	124.57	134.05

[1]These figures are subject to change and include amounts for URI and SDI.
[2]The DOD figures include estimates for URI and SDI budgets.
[3]Prior to 1987 the National Security Agency program was included with other agencies.

Agency Programs

Each agency provides support for a variety of programs including institutes, individual and group awards, equipment awards, and special programs. In addition, all agencies participate in a variety of special programs often administered at a cross discipline level, for example, equipment awards, special fellowship awards including women and minority fellowships, and small institution awards. Agency programs are also involved in cooperative funding arrangements with other disciplines and other agency programs. These include industrial, university, and laboratory cooperative programs.

The mathematical sciences agencies have experienced condiserable number of major personnel changes in the last few years. In addition to a new director at NSF's Division of Mathematical Sciences (DMS) in 1988, there was a new director in mathematics at ONR last year and a new director has just been chosen at AFOSR. Also, in addition to the usual rotator program positions, there are several key secondary and permanent program positions in transition.

A. National Science Foundation (NSF)

Within NSF's DMS, the FY 1989 budget request will permit the development of a new activity to be called Mathematical Sciences Research Groups. The groups are expected to provide a mechanism for continued emphasis on support for graduate students and postdoctoral researchers while providing new opportunities for researchers to develop projects requiring the concerted efforts of a group of individuals on a problem or related problems. Other activities of note include participation in a number of new interdisciplinary efforts, the emphasis being on interaction between mathematics and the biological sciences and on cosmology.

Continuing support at about current levels will be provided to the base of individual research awards, to the existing program of special projects (including postdoctoral research fellowships, equipment, conferences and workshops, and institutes), and to the activities related to undergraduate education. It should be noted that the overall program in DMS (current and new activities) should lead to some modest increases in the total number of researchers and students supported.

In 1987 a new program in computational mathematics was begun. It is proving popular and will continue to be an integral part of the NSF program in mathematical science. This program is slated to reach its steady-state level in 1989. The support for the two NSF mathematics institutes, Mathematical Sciences Research Institute at Berkeley and the Institute for Mathematics Applications at Minnesota will be essentially level. About 60 percent of the researchers supported at these institutes are postdoctoral and young researchers. There will be continued emphasis placed on the support for young investigators.

B. Air Force Office of Scientific Research (AFOSR)

The AFOSR mathematical sciences programs in 1988 emphasized nonlinear sciences (nonlinear dynamics, nonlinear wave propagation, etc.). In FY 89, roughly ten percent of the overall budget will once again be set aside for initiative topics. Those topics will include an increased emphasis on inverse scattering, parallel computing methods for optimization, and research in theoretical fluid dynamics and mathematical control theory to study issues in the active control of fluid flows and combustion processes. The bulk of the budget in mathematical sciences continues to support research in areas of traditional interest to the Air Force, including mathematical control theory (especially control of systems governed by partial differential equations), computational mathematics and numerical analysis, probability and statistics, applied analysis and mathematics of physical, chemical, and biological systems, optimization, and discrete mathematics.

C. Army Research Office (ARO)

The Army's mathematical sciences research program has the following program areas: applied analysis, physical mathematics, numerical analysis and scientific computing, probability and statistics, and system and control theory. The ARO budget comprises three funding divisions with 3/5 in core funds and 1/5 in each of SDI and URI center funds. The trends in this program are for growth in nonlinear analysis. The ARO center at Cornell University is involved in many of the above topics and including aspects of computational geometry and symbolic computation.

D. Office of Naval Research (ONR)

The Navy's mathematical sciences program continues to face uncertainty over eventual levels of funding. The Mathematical Sciences Division at ONR is currently organized into the following seven program areas: boundary value and inverse problems, calculus of variations, numerical analysis, probability and statistics, signal analysis, discrete mathematics, and operations research. In addition, ONR handles research and development work at the Naval Research Laboratory, Naval Air Systems Command, Naval Sea Systems Command and the Naval Electronic Systems Command. In the past, the order of magnitude of funds for each of these was about $1 million except for Naval Research Laboratory funds which have been somewhat larger.

E. Department of Energy (DOE)

The Applied Mathematical Sciences subprogram in the DOE Office of Energy Research has two distinct roles. Mathematical sciences research has as its objective fundamental knowledge in the mathematical and computing sciences aimed at understanding and manipulating mathematical models of the complex physical processes involved in DOE research and development programs. The Energy Science Advanced Computation activity is aimed at providing state of the art supercomputing resources to ER funded researchers.

The Mathematical Sciences research program funds basic research at national laboratories and universities in three major categories: analytical and numerical mathematics, computational statistics and information analysis techniques, and advanced computing concepts for parallel architectures and languages. Approximately one half the funding goes to Mathematics departments and the other half goes to Computer Sciences departments. By institution, approximately one half goes to the DOE national laboratories and one half to universities. It should be noted that most of the national laboratories are directed affiliated with nearby university departments: e. g., the Mathematics Departments at Lawrence Berkeley Laboratory and the University of California at Berkeley, the Applied Mathematics Division at Ames Laboratory and the Mathematics Department at Iowa State University. All the DOE national laboratories provide support for graduate students and postdoctoral fellows in mathematics and computer science.

Areas of mathematical research supported include applied analysis, computational mathematics, linear algebra, nonlinear dynamics, algebraic geometry in applied computer graphics and in supersymmetric string theory, systems of ordinary and partial differential equations pertaining to physical processes in energy production systems, computational statistics, and many areas of computer science, such as numerical analysis, functional languages, parallel architectures and algorithms, and evaluation of performance of parallel architecture computing systems.

F. Defense Advanced Research Project Agency (DARPA)

A new mathematics program emerged at DARPA in the mid 1980s and has now become the second largest DOD supporter of research in the mathematical sciences. The thrust of this new program is in the areas of dynamical systems, harmonic analysis, data compression, neural connections, and computational algorithms. This program contains several large URI programs and in addition it has emerged as a major funding source for several other large research projects. The impressive growth and the direction of this program are largely the responsibility of its dynamic director.

G. National Security Agency (NSA)

The NSA currently has a modest program ($1.4 million) for support in basic, unclassified external mathematical sciences research. Areas of interest in the NSA program include: algebra, number theory, discrete mathematics, statistics and probability. The NSA has announced plans to steadily enhance this effort in future years. Reflected in their support program and of considerable concern to NSA and others, is the continuing decline of U.S. Ph.D. graduates in mathematical sciences and the continuing high percentage of non-U.S. Ph.D. students at our lending institutions.

H. Other Agencies

Several collateral agencies such as the National Aeronautics and Space Administration and the National Institutes of Health have modest mathematics sciences programs. The National Bureau of Standards as well as the numerous national laboratories attached to other agencies provide considerable in-house mathematics, statistics, and computer research programs.

1988 AMS Elections

Council Nominations

Vice-Presidents and Members-at-Large

One vice-president and five members-at-large of the Council will be elected by the Society in a contested election in the fall of 1988.

The vice-president will serve for a term of two years effective January 1, 1989. The Council has nominated one candidate for the position, namely:

Sun-Yung Alice Chang

The Council plans to name a second candidate.

The five members-at-large will serve for a term of three years. The Council nominated seven candidates. They are:

Jonathan L. Alperin	George R. Sell
Fan R. K. Chung	William Yslas Velez
Lawrence J. Corwin	Robert J. Zimmer
Hugo Rossi	

The Council plans to name additional candidates for member-at-large to bring their number to at least ten.

The deadline for petitions proposing additional nominations is July 6. Such proposals will not reach the Council for action by mail ballot until after that date.

President's Candidates

Nominating Committee 1989 and 1990

Four members of the Nominating Committee are to be elected in the fall of 1988. Continuing members are:

Roger C. Alperin	Jane P. Gilman
Ronald A. DeVore	Leonard L. Scott

President G. D. Mostow has named six of the eight candidates for the other four places. They are:

John B. Garnett	Andy Roy Magid
Victor Klee	James D. Stasheff
Ray A. Kunze	Alan D. Weinstein

If nominations by petition have not appeared bringing the total number of candidates to at least eight, it will be brought up to eight by the President.

Everett Pitcher, Secretary
Bethlehem, Pennsylvania

Nominations by Petition

Vice-President or Member-at-Large

Nominations by petition for the positions of vice-president and member-at-large of the Council, in the manner described in the rules and procedures, are acceptable.

Petitions are presented to the Council, which, according to Section 2 of Article VII of the bylaws, makes the nominations. The Council of 23 January 1979 stated the intent of the Council of nominating all persons on whose behalf there were valid petitions. The Council of 20 January 1987 established a policy that, beginning with the interval 1987–1996, the Council intends to approve no more than two nominations by petition of the same individual in any ten year period.

Prior to presentation to the Council, petitions in aid of a candidate for the position of vice-president or of member-at-large of the Council must have at least 50 valid signatures and must conform to several rules and operational considerations, which are described below.

The Nominating Committee for 1989

Four new members will be elected in a preferential ballot. The name of a candidate for member of the Nominating Committee may be placed on the ballot by petition. The candidate's assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and operational considerations, described below, should be followed.

Rules and Procedures

Use separate copies of the form for each candidate for vice-president, member-at-large, or member of the Nominating Committee.

1. To be considered, petitions must be addressed to Everett Pitcher, Secretary, P.O. Box 6248, Providence, Rhode Island 02940, and must arrive by July 6, 1988.
2. The name of the candidate must be given as it appears in the *Combined Membership List*. If the name does not appear in the list, as in the case of a new member or by error, it must be as it appears in the mailing lists, for example on the mailing label of the *Notices*. If the name does not identify the candidate uniquely, append the member code, which may be obtained from the candidate's mailing label or the Providence office.
3. The petition for a single candidate may consist of several sheets each bearing the statement of the petition, including the name of the position, and signatures. The name of the candidate must be exactly the same on all sheets.
4. On the next page is a sample form for petitions. Copies may be obtained from the Secretary; however, petitioners may make and use photocopies or reasonable facsimiles.
5. A signature is valid when it is clearly that of the member whose name and address is given in the left-hand column.
6. The signature may be in the style chosen by the signer. However, the printed name and address will be checked against the *Combined Membership List* and the mailing lists. No attempt will be made to match variants of names with the form of name in the CML. A name neither in the CML nor on the mailing lists is not that of a member. (Example: The name Everett Pitcher is that of a member. The name E. Pitcher appears not to be. Note that the mailing label of the *Notices* can be peeled off and affixed to the petition as a convenient way of presenting the printed name correctly.)
7. When a petition meeting these various requirements appears, the Secretary will ask the candidate whether he is willing to have his name on the ballot. Petitioners can facilitate the procedure by accompanying the petitions with a signed statement from the candidate giving his consent.

NOMINATION PETITION FOR 1988 ELECTION

The undersigned members of the American Mathematical Society propose the name of

____

as a candidate for the position of (check one):

- ☐ **Vice-President**
- ☐ **Member-at-Large of the Council**
- ☐ **Member of the Nominating Committee**

of the American Mathematical Society for a term beginning January 1, 1989.

Name and Address (printed or typed, or *Notices* mailing label)	
	____________ Signature
	____________ Signature
	____________ Signature
	____________ Signature
	____________ Signature
	____________ Signature

Meetings and Conferences of the AMS

FUTURE MEETINGS

Let's Meet at the Centennial!

Beginning with the Atlanta banquet which launched the year-long "100 Years of American Mathematics" celebration (and at which the Master of Ceremonies welcomed "300,000 pounds of mathematicians"), and closing in October with the National Research Council's Report to the Nation on the current state of mathematical education in this country, a series of ten events has been scheduled to commemorate the first Centennial of the American Mathematical Society. Of these ten events, the crowning jewel will be the AMS Centennial Celebration, August 8 – 12, in Providence, Rhode Island. While we encourage participation in all the "100 Years" events, we emphasize in particular the Celebration in Providence. **So, let's meet at the Centennial!**

The AMS Centennial harks back to the founding of the Society in November, 1888, after Thomas Scott Fiske, together with two other classmates, circulated an invitation to all interested parties to an organizational meeting at Columbia College. The three persons responding to the invitation included J. H. Van Amringe, Fiske's dissertation mentor. A constitution was adopted in December of that year. Van Amringe was elected President and Fiske, Secretary. Later, Fiske became the Society's seventh President.

Since Fiske was on the faculty at Columbia, it was natural that all Society functions emanated from this address, including publication of the *Bulletin* and the *Transactions.* The first issue of the *Bulletin* appeared in October 1891, and historical accounts through the years attest to its immense influence on the dissemination of mathematical ideas.

Originally organized under the name of the New York Mathematical Society, the organization had, by 1894, attained a national character, and its name was changed in that year to reflect this status. However, ties to Columbia were so strong that it was not until 1951 that the Society moved to Providence. The main reason for moving was that four individuals who were influential in Society affairs were at Brown University: Jacob D. Tamarkin and Otto E. Neugebauer, editors of *Mathematical Reviews*, an increasingly important Society publication; R. G. D. Richardson, secretary of the Society; and Raymond Claire Archibald, AMS librarian. The membership, which had started with six in 1888, grew to 210 in 1894 through Fiske's personal campaign, to 2,127 at the end of 1937, and to 22,337 in 1988.

Since the average life span of *homo sapiens* is such that not many attain one hundred years in longevity, a century is plainly a long time. Yet, in terms of the persons and events that exert a great influence on our lives, reflection may convince us that the one hundred years is well within our experiential appreciation. To bring this into sharper focus, we may note that many of us of a certain vintage cut our teeth on *Integral and Differential Calculus* by Osgood (AMS President 1905 – 1906), *Introduction to Higher Algebra* by Bôcher (1909 – 1910), *A Treatise on the Differential Geometry of Curves and Surfaces* by Eisenhart (1931 – 1932), as well as books on the theory of equations and Galois fields by Dickson (1917 – 1918), on projective coordinates by Morley (1919 – 1920), on the calculus of variations by Bliss (1921 – 1922), on tensors and spinors by Veblen (1923 – 1924), and on topology by Lefschetz (1935 – 1936) and by R. L. Moore (1937 – 1938). All of these works exemplify the profound influence exerted in relatively recent times on students and mathematicians by some of the people who served the Society as President during its first fifty years.

Today, as one of the world's largest and most prestigious mathematical organizations, the AMS has an important responsiblity to bring together all segments of the larger mathematical community. For example, while the majority of AMS members are American, the Society's large number of foreign members reflects the fact that mathematicians form a worldwide community. Reciprocity agreements with foreign mathematical societies have strengthened these international ties. The AMS is also concerned with increasing the number of women and minorities in mathematics. Together with other mathematical organizations, the AMS has assembled joint committees on women in the mathematical sciences, and on opportunities in mathematics for disadvantaged groups. Several women have held leadership positions in the Society. At the turn of the century, Charlotte Angas Scott of Bryn Mawr College was on the first AMS Council in 1894 and served as AMS Vice President in 1905. More recent was the Presidency of Julia Robinson in 1983 – 1984. In addition, Mary Ellen Rudin of University of Wisconsin at Madison, Cathleen Morawetz of the Courant Institute of Mathematical Sciences, Mary Gray of American University, and Karen Uhlenbeck of the University of Texas at Austin have served as Vice Presidents, Council members, Trustees, or have given major papers at national meetings.

The Centennial Celebration will feature a special symposium titled "Mathematics Into the Twenty-First Century." This program will cover the principal areas of active mathematical research and will feature a number of stellar young researchers who will be in the vanguard of mathematical leadership in the next quarter century. In addition, the AMS-MAA Joint Invited Addresses will be presented by three renowned mathematicians whose work has profoundly influenced research in the United States and the world.

The Centennial program will begin with keynote speaker Edward E. David, Jr., Chairman of the committee that produced the influential David Report, who will speak on where mathematicians stand as a scientific community.

Lest the program look like all serious business, we mention the gala Opening Reception at the State House on the evening of August 8 and the traditional New England clambake. The Society will hold open house at its offices Tuesday – Thursday, 1:00 p.m. – 3:00 p.m. Tours of Providence and Newport will be available, and special exhibits will be displayed at Brown University. All in all, it bears repeating: **Let's meet at the Centennial!** The magic numbers are 8.8.88.

Centennial Public Information Committee: John W. Addison, Jr., Yousef Alavi (Chair), William G. Chinn, Ronald R. Coiffman, Ronald Graham, Peter J. Hilton, Don R. Lick, Jean J. Pedersen, and Clifford Taubes.

Centennial Celebration, Providence, RI, August 8 – 12, 1988

Supplement to Announcement in April Notices

Please refer to the Preliminary Announcement for this meeting which appears on pages 559 – 599 of the April 1988 issue of *Notices*. The Table of Contents and Important Deadlines for the preliminary announcement are reproduced below for convenience.

Symposium on Mathematics into the Twenty-First Century

PERSI DIACONIS will be introduced by Gian Carlo Rota.

AMS Short Course

Lecture #5 was inadvertantly omitted from the Timetable. Lecture #5 is *The Mandelbrot set*, BODIL BRANNER, from 11:15 a.m. to 12:30 p.m. on Sunday, August 7.

Activities of Other Organizations

Panelists for the Association for Women in Mathematics panel discussion on *Centennial reflections on women in American mathematics* at 8:00 p.m. on Tuesday, August 9, include MABEL S. BARNES, Professor Emeritus, Occidental College; JUDY GREEN, Rutgers University, Camden; JEANNE LADUKE, DePaul University; VIVIENNE MALONE-MAYES, Baylor University; and OLGA TAUSSKY-TODD, California Institute of Technology.

Message Center

The telephone number for the Message Center is 401-331-9358.

IMPORTANT DEADLINES

AMS Abstracts	
Of contributed papers	**Expired**
Centennial Preregistration and Housing	**June 1**
MAA Minicourse Preregistration	**June 1**
Motions for AMS Business Meeting	**July 12**
Clambake cancellations (50% refund)	**until July 25**
MAA and ΠME Banquets (50% refund)	**until July 25**
Preregistration cancellations (50% refund)	**until August 4**
Airport transfer cancellations (50% refund)	**after August 4**
Changes to residence hall packages	**after August 4**
Housing cancellations (90% refund)	**until August 4**
Housing cancellation penalty (10% plus one night)	**after August 4**
Tours (50% refund)	**until August 4**

Child Care

The following are additional child care facilities in the area.

Child Care Center Inc., 345 Blackstone Boulevard, Providence, 401-272-3959. Ages: 2 months to 6 years.

YMCA Parent/Child Center, 438 Hope Street, Providence, 401-521-0155. Ages: 3 to 12 years.

JCC of RI Preschool, 401 Elmgrove Avenue, Providence, 401-861-8800. Ages: 3 months to 6 years.

Providence Central YMCA, 160 Broad Street, Providence, 401-456-0100. Ages: 1-1/2 to 6 years, approximately $60 per week

Federal Hill House Day Care Center, 9 Courtland Street, Providence, 401-421-4722. Ages: 3 to 12, sliding scale fees.

Smith Hill Day Care, 25 Danforth Street, Providence, 401-831-1720. Ages 2 to 6 years, approximately $2 per hour.

Tours

Participants interested in attending the Tour of Historic Providence or Living History Tour of Newport should be sure to indicate their preferred day and/or time in the margin of the Preregistration/Housing Form next to items #16 – #19 or on a separate sheet of paper.

Invited Speakers and Special Sessions

Invited Speakers at AMS Meetings

The individuals listed below have accepted invitations to address the Society at the times and places indicated. For some meetings, the list of speakers is incomplete.

AMS Centennial Celebration
Providence, August 1988

Michael Aschbacher	Victor G. Kac
Raoul H. Bott (AMS-MAA)	Peter D. Lax (AMS-MAA)
Luis A. Caffarelli	Saunders Mac Lane (AMS-MAA)
Persi Diaconis	Andrew Majda
Charles L. Fefferman	Charles S. Peskin
Michael H. Freedman	Dennis P. Sullivan
Harvey M. Friedman	Robert E. Tarjan
Benedict H. Gross	William P. Thurston
Joseph Harris	Karen K. Uhlenbeck
Roger E. Howe	Edward Witten
Vaughan F. R. Jones	

Lawrence, October 1988

Bjørn Dahlberg	Peter Scott
Steven E. Herder	Sidney M. Webster

Claremont, November 1988

William Jacob	Francis Bonahon
Robert Brooks	

Phoenix, January 1989

John B. Conway	Peter Landweber
Percy Alec Deift	Steve Smale (AMS-MAA)
David Fried	Luc Tartar
R. L. Graham (AMS-MAA)	

Organizers and Topics of Special Sessions

The list below contains all the information about Special Sessions at meetings of the Society available at the time this issue of *Notices* went to the printer. The section below entitled **Information for Organizers** describes the timetable for announcing the existence of Special Sessions.

August 1988 AMS Centennial Celebration in Providence
There will be no Special Sessions.

October 1988 Meeting in Lawrence
Central Section
Associate Secretary: Andy Roy Magid
Deadline for organizers: Expired
Deadline for consideration: August 2, 1988

Andrew Acker, *Partial differential equations–Geometric equations*
John K. Beem and Phillip E. Parker, *Geometry and mathematical physics*
Ralph Byers, *Numerical linear algebra*
Bruce Crauder and Sheldon Katz, *Algebraic geometry*
Tyrone Duncan, *Control theory*
William Fleissner, *Applications of set theory*
James Foran, *Real analysis*
Steven E. Hurder and Noberto Salinas, *Operatory theory and applications to geometry*
Daniel Katz and Jeffery Lang, *Commutative algebra*
Jill Pipher and Gregory Vechota, *Potential theory and partial differential equations in nonsmooth domains*
Peter Scott, *3-manifolds*

November 1988 Meeting in Claremont
Far Western Section
Associate Secretary: Lance W. Small
Deadline for organizers: Expired
Deadline for consideration: August 2, 1988

Francis Bonahon and David Gabai, *Low dimensional geometry*
Robert Brooks and S. -Y. Cheng, *The spectrum of the Laplacian*
William Jacob and Adrian Wadsworth, *Division algebras*

January 1989 Meeting in Phoenix
Associate Secretary: Lance W. Small
Deadline for organizers: Expired
Deadline for consideration: September 21, 1988

Melvyn S. Berger, *Mathematics of nonlinear science*
John B. Conway, Harry Gonshor, and Martin Kruskal, *Surreal numbers*
Percy Deift, *Integrable systems*
David Eisenbud and Craig Huneke, *Commutative algebra and algebraic geometry*
Larry C. Grove, *Computational group theory*
William A. Harris, *Singular perturbation theory*
Victor C. Katz and Florence Fasanelli, *History of Mathematics*
Albert Mardin and Burton Rodin, *Computational aspects of complex analysis*
Sidney Port, *Stochastic processes*
Marc A. Rieffell, *Operator algebras and geometry*
Hal L. Smith, *Mathematics in population biology*

April 1989 Meeting in Worcester
Eastern Section
Associate Secretary: W. Wistar Comfort
Deadline for organizers: July 15, 1989
Deadline for consideration: February 8, 1989

May 1989 Meeting in Chicago
Central Section
Associate Secretary: Andy Roy Magid
Deadline for organizers: August 15, 1989
Deadline for consideration: February 8, 1989

Jeffery Bergen, *Noncommutative ring theory*
Jonathan Cohen, *Numerical methods in harmonic analysis*

October 1989 Meeting in Hoboken
Eastern Section
Associate Secretary: W. Wistar Comfort
Deadline for organizers: January 15, 1989
Deadline for consideration: August 9, 1989

October 1989 Meeting in Muncie
Central Section
Associate Secretary: Andy Roy Magid
Deadline for organizers: January 15, 1989
Deadline for consideration: August 9, 1989

Information for Organizers

Special Sessions at Annual and Summer Meetings are held under the supervision of the Program Committee for National Meetings. They are administered by the Associate Secretary in charge of that meeting with staff assistance from the Meetings and Editorial Departments in the Society office in Providence.

According to the "Rules for Special Sessions" of the Society, Special Sessions are selected by the Program Committee from a list of proposed Special Sessions in essentially the same manner as Invited Speakers are selected. The number of Special Sessions at a Summer or Annual Meeting is limited. The algorithm that determines the number of Special Sessions allowed at a given meeting, while simple, is not repeated here, but may be found in "Rules for Special Sessions" which can be found on page 614 in the April 1988 issue of *Notices*.

Each Invited Speaker is invited to generate a Special Session, either by personally organizing one or by having a Special Session organized by others. Proposals to organize a Special Session are sometimes requested either by the Program Committee or by the Associate Secretary. Other proposals to organize a Special Session may be submitted to the Associate Secretary in charge of that meeting (who is an *ex-officio* member of the committee and whose address may be found below). These proposals must be in the hands of the Program Committee well in advance of the meeting and, in any case, at least nine (9) months prior to the meeting at which the Special Session is to be held in order that the committee may consider all the proposals for Special Sessions simultaneously. Proposals that are sent to the Providence office of the Society, to the *Notices*, or directed to anyone other than the Associate Secretary will have to be forwarded and may not be received in time to be considered for acceptance.

It should be noticed that Special Sessions must be announced in the *Notices* in such a timely fashion that any member of the Society who so wishes may submit an abstract for consideration for presentation in the Special Session before the deadline for such consideration. This deadline is usually three (3) weeks before the Deadline for Abstracts for the meeting in question.

Special Sessions are very effective at Sectional Meetings and can usually be accommodated. They are selected by the Committee to Select Hour Speakers for the Section. The processing of proposals for Special Sessions for Sectional Meetings is handled by the Associate Secretary for the Section, who then forwards the proposals to the Committee to Select which makes the final selection of the proposals. Each Invited Speaker at a Sectional Meeting is invited to organize a Special Session. Just as for national meetings, no Special Session at a Sectional Meeting may be approved so late that its announcement appears past the deadline after which members can no longer send abstracts for consideration for presentation in that Special Session.

The Society reserves the right of first refusal for the publication of proceedings of any Special Session. These proceedings appear in the book series *Contemporary Mathematics*.

More precise details concerning proposals for and organizing of Special Sessions may be found in the "Rules for Special Sessions" or may be obtained from any Associate Secretary.

Send Proposals for Special Sessions to the Associate Secretaries

The programs of sectional meetings are arranged by the Associate Secretary for the section in question:

Far Western Section (Pacific and Mountain)

Lance W. Small, Associate Secretary
Department of Mathematics
University of California, San Diego
La Jolla, CA 92093
(Telephone 619-534-3590)

Central Section

Andy Roy Magid, Associate Secretary
Department of Mathematics
University of Oklahoma
601 Elm PHSC 423
Norman, OK 73019
(Telephone 405-325-2052)

Eastern Section

W. Wistar Comfort, Associate Secretary
Department of Mathematics
Wesleyan University
Middletown, CT 06457
(Telephone 203-347-9411)

Southeastern Section

Frank T. Birtel, Associate Secretary
Department of Mathematics
Tulane University
New Orleans, LA 70118
(Telephone 504-865-5646)

As a general rule, members who anticipate organizing Special Sessions at AMS meetings are advised to seek approval at least nine months prior to the scheduled date of the meeting. No Special Sessions can be approved too late to provide adequate advance notice to members who wish to participate.

Information for Speakers

A great many of the papers presented in Special Sessions at meetings of the Society are invited papers, but any member of the Society who wishes to do so may submit an abstract for consideration for presentation in a Special Session, provided it is received in Providence prior to the special early deadline announced above and in the announcements of the meeting at which the Special Session has been scheduled. Contributors should know that there is a limitation in size of a single special session, so that it is sometimes true that all places are filled by invitation. Papers not accepted for a Special Session are considered as ten-minute contributed papers.

Abstracts of papers submitted for consideration for presentation at a Special Session must be received by the Providence office (Editorial Department, American Mathematical Society, P. O. Box 6248, Providence, RI 02940) by the special deadline for Special Sessions, which is usually three weeks earlier than the deadline for contributed papers for the same meeting. The Council has decreed that no paper, whether invited or contributed, may be listed in the program of a meeting of the Society unless an abstract of the paper has been received in Providence prior to the deadline.

Mathematical Sciences Meetings and Conferences

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 or symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. (Information on meetings of the Society, and on meetings sponsored by the Society, will be found inside the front cover.)

AN ANNOUNCEMENT will be published in *Notices* if it contains a call for papers, and specifies the place, date, subject (when applicable), and the speakers; a second full announcement will be published only if there are changes or necessary additional information. Once an announcement has appeared, the event will be briefly noted in each issue until it has been held and a reference will be given in parentheses to the 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 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 *Notices*, care of the American Mathematical Society in Providence.

DEADLINES for entries in this section are listed on the inside front cover of each issue. 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 *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.

1987–1988. **Academic Year Devoted to Differential Geometry**, University of North Carolina, Chapel Hill, North Carolina. (November 1987, p. 1137)

1987–1988. **Academic Year Devoted to Several Complex Variables**, Mittag-Leffler Institute, Djursholm, Sweden. (January 1987, p. 131)

1988-1989. **Academic Year Devoted to Operator Algebras**, Mittag-Leffler Institute, Djursholm, Sweden. (February 1988, p. 307)

September 14, 1987–June 25, 1988. **Program on Applied Combinatorics**, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, Minnesota. (April 1987, p. 548)

January–July 1988. **Symposium on Representation Theory and Group Theory**, Manchester, England. (April 1987, p. 548)

March 6–December 24, 1988. **Mathematisches Forschungsinstitut Oberwolfach** (Weekly Conferences), Federal Republic of Germany. (March 1988, pp. 457-458)

April 17–December 24, 1988. **Mathematisches Forschungsinstitut Oberwolfach** (Weekly Conferences), Federal Republic of Germany. (October 1987, p. 995)

*October 1988–August 1989. **Symposium on Singularity Theory and Its Applications**, University of Warwick, Coventry, United Kingdom.

ORGANIZERS: D. Mond, J. Montaldi, M. Roberts, I. Stewart.

CONFERENCE TOPICS: Real Singularity Theory; Multiple Points of Mappings; Nonisolated Singularities; Bifurcation Theory; Hamiltonian Systems; Local Differential Geometry.

INFORMATION: E. Shiels, Mathematics Institute, University of Warwick, Coventry CV47AL, United Kingdom.

January 1–December 23, 1989. **Mathematisches Forschungsinstitut Oberwolfach** (Weekly Conferences), Federal Republic of Germany. (April 1988, p. 629)

May 1988

30–June 3. **Canadian Applied Mathematics Society Conference on Continuum Mechanics and its Applications**, Simon Fraser University, British Columbia, Canada. (Note changes from October 1987, p. 998)

30–June 3. **International Conference on Numerical Mathematics**, Kent Ridge, Republic of Singapore. (April 1987, p. 553)

30–June 3. **Sixth International Conference on the Theory and Applications of Graphs**, Western Michigan University, Kalamazoo, Michigan. (June 1987, p. 685)

30–June 3. **Theorie des Nombres**, Marseille, France. (January 1988, p. 158)

30–June 4. **Conference on Hyperplane Sections and Related Topics**, L'Aquila, Italy. (January 1988, p. 158)

31–June 2. **Thirteenth Annual Summer Institute of Applied Statistics**, Provo, Utah. (April 1988, p. 632)

31–June 3. **Conference on Reaction-Diffusion Equations**, Heriot-Watt University, Edinburgh, United Kingdom. (February 1988, p. 309)

31–June 3. **National Computer Exposition/National Computer Conference**, Los Angeles, California. (April 1988, p. 632)

June 1988

1–3. **Quality and Productivity Research Conference**, Xerox Training Center, Leesburg, Virginia. (April 1988, p. 632)

1–4. **Algebraic Logic and Universal Algebra in Computer Science**, Iowa State University, Ames, Iowa. (February 1988, p. 309)

1–4. **Kingston Research Conference: Thirty Years of Modern Optimal Control**, University of Rhode Island, Kingston, Rhode Island. (March 1988, p. 460)

4–August 11. **Joint Summer Research Conferences in the Mathematical Sciences**, Bowdoin College, Brunswick, Maine. (January 1988, p. 158)

INFORMATION: C. Kohanski, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

5–7. **Canadian Mathematical Society Summer Meeting**, Regina, Saskatchewan. (April 1988, p. 632)

5–8. **Statistical Society of Canada's Annual Meeting**, University of Victoria, Victoria, British Columbia, Canada. (November 1987, p. 1139)

5–9. **IEEE Computer Society Conference on Computer Vision and Pattern Recognition**, University of Michigan Campus, Ann Arbor, Michigan. (March 1988, p. 461)

5–11. **Applications of Operator Algebras to Knot Theory and Mathematical Physics**, United States Naval Academy, Annapolis, Maryland. (April 1988, p. 633)

5–12. **Third International Symposium on Differential Geometry**, Peñiscola, Spain. (October 1987, p. 998)

6–8. **Fourth Annual ACM Symposium on Computational Geometry**, University of Illinois, Urbana-Champaign, Illinois. (February 1988, p. 310)

6–10. **The Second International Conference on Vector and Parallel Computing Issues in Applied Research and Development**, Tromsø, Norway. (January 1988, p. 158)

6–10. **Fractals and the Microcomputer**, Salisbury State College, Salisbury, Maryland. (February 1988, p. 310)

6–10. **Algorithmique**, Marseille, France. (March 1988, p. 461)

6–10. **NSF-CBMS Regional Research Conference in the Mathematical Sciences: Arrangements of Hyperplanes**, Flagstaff, Arizona. (March 1988, p. 461)

6–10. **Conference in Honor of Jacques-Louis Lions**, Paris, France. (March 1988, p. 461)

6–10. **NSF-CBMS Conference on Applications of Operator Algebras to Knot Theory and Mathematical Physics**, United States Naval Academy, Annapolis, Maryland. (April 1988, p. 633)

6–10. **Twelfth Nordic Conference on Mathematical Statistics**, Turku, Finland. (April 1988, p. 633)

6–16. **Twelfth International Conference on Operator Theory**, Bucharest, Romania. (February 1988, p. 310)

6–24. **SMS-NATO ASI: Methods in Field and Superstring Theories**, Université de Montréal, Montréal, Canada. (January 1988, p. 158)

7–10. **Twenty-Sixth Annual Meeting of the Association for Computational Linguistics**, Buffalo, New York. (March 1988, p. 461)

8–10. **Eighth International Conference On Analysis and Optimization of Systems**, Antibes, France. (March 1988, p. 461)

11–14. **International Conference on Almost Everywhere Convergence in Probability and Ergodic Theory**, Columbus, Ohio. (October 1987, p. 998)

12–15. **Symposium on Chaotic Dynamical Systems**, Conference Center "Woudschoten" (near Utrecht), The Netherlands. (March 1988, p. 461)

12–18. **Workshop on Coding Theory and Applications**, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, Minnesota. (August 1987, p. 814)

13–14. **Third International Workshop of the Bellman Continuum**, Sophia Antipolis, France. (April 1988, p. 633)

13–16. **Fourth SIAM Conference on Discrete Mathematics**, Cathedral Hill Hotel, San Francisco, California. (April 1988, p. 633)

13–17. **Nonlinear Hyperbolic Problems Conference**, Talence, France. (October 1987, p. 999)

13–17. **Program Design and Data Abstraction**, Salisbury State College, Salisbury, Maryland. (February 1988, p. 310)

13–17. **Gordon Conference on Theoretical Biology and Biomathematics**, Tilton Academy, Tilton, New Hampshire. (February 1988, p. 310)

13–17. **Empirical Processes, Theory and Applications**, University of Iowa, Iowa City, Iowa. (April 1988, p. 633)

*13–17. **Mathematical Modeling Workshop**, University of Maine, Orono, Maine.

SPONSORS: The Conferences and Institutes Division, University of Maine, and The Northeast Section of the Mathematical Association of America.

INFORMATION: C. W. Dodge, Mathematics Department, University of Maine, Orono, Maine 04469, 207-581-3908.

13–18. **Meeting on Functional Analysis**, El Escorial, Spain. (April 1988, p. 633)

*13–24. **Summer School on Computers**, Bréau-sans-Nappe, France.

CONFERENCE THEMES: Task Level Robot Planning; Control of Rigid Robots; Visual Perception and Robotics.

PROGRAM: The summer classes, to be held in Bréau-san-Nappe, are designed for researchers and engineers. Approximately 30 participants will comment on the advances in particular fields and compare their experiences. Instruction is available in English and French and includes small group workshops.

INVITED SPEAKERS: T. Lozano-Pérez, MIT; B. Espiau, IRISA; O. Faugeras, INRIA.

INFORMATION: Secrétariat des Ecoles d'Eté, EDF 1 , Avenue du Général de Gaulle, 92140 Clamart, France. Telephone: (1) 47 65 43 06.

13–August 26, 1988. **Gordon Research Conferences: The Frontiers of Science (Weekly Conferences)**, New Hampshire and Rhode Island. (April 1988, p. 633)

14–17. **Structure in Complexity Theory, Third Annual Conference**, Georgetown University, Washington, District of Columbia. (March 1988, p. 461)

15–17. **The Seventh Pacific Coast Resource Modeling Conference**, Ensenada, Mexico. (January 1988, p. 159)

15–17. **National Educational Computing Conference (NECC '88)**, Dallas, Texas. (March 1988, p. 461)

15–17. **Western Regional Meeting of the Biometric Society (WNAR) and the Institute of Mathematical Statistics**, Honolulu, Hawaii. (April 1988, p. 633)

*16–18. **Northeast Conference on General Topology and Applications**, Wesleyan University, Middletown, Connecticut.

PROGRAM: The conference honors Melvin Henriksen and marks his sixtieth birthday. There will be sessions for 25-minute contributed papers. The deadline for consideration is June 1, 1988.

INVITED HOUR SPEAKERS: A. Dow, J. Isbell, R. D. Mauldin, J. V. Mill, W. Pfeffer, A. Stone.

INFORMATION: R. M. Shortt, Department of Mathematics, Wesleyan University, Middletown, Connecticut 06457.

* 16–18. **Fifth Annual Western Workshop in Geometric Topology**, Colorado College, Colorado Springs, Colorado.

PROGRAM: J. Hempel will be the principal speaker with other participants giving presentations.

INFORMATION: J. Henderson, Department of Mathematics, Colorado College, Colorado Springs, Colorado 80903.

16–21. **Geometry of Solutions to PDE**, Cortona, Italy. (March 1988, p. 462)

16–22. **Mathematical Methods in Computer-Aided Design**, Oslo, Norway. (February 1988, p. 310)

16–23. **Annual Seminar Canadian Mathematical Society–Banach Spaces and Geometry of Convex Bodies**, Banff, Alberta, Canada. (January 1988, p. 159)

18–24. **AMS-IMS-SIAM Summer Research Conference on Spatial Statistics and Imaging**, Brunswick, Maine. (April 1988, p. 634)

19–24. **SRCOS-ASA Summer Research Conference**, Holiday Island, Arkansas. (April 1988, p. 634)

19–24. **1988 IEEE International Symposium on Information Theory**, Kobe, Japan. (October 1987, p. 999)

19–25. **Workshop on Design Theory and Applications**, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, Minnesota. (August 1987, p. 814)

* 19–July 2. **Summer School and Workshop on Paths, Flows and VLSI-Layout**, Rheinische Friedrich-Wilhelms-Universität Bonn, West Germany.

ORGANIZERS: B. Korte, L. Lovász, A. Schrijver.

INFORMATION: Applications should be sent to H. J. Promel, Research Institute of Discrete Mathematics, University of Bonn, Nassestrasse 2, D-5300 Bonn 1, West Germany.

20. **Stability and Chaos in Neural Network Learning**, Oregon State University, Corvallis, Oregon. (March 1988, p. 462)

20. **Regional Conference on Empirical Processes: Theory and Applications**, Iowa City, Iowa. (April 1988, p. 634)

20–24. **Fifth International Conference on Boundary and Interior Layers: Computational and Asymptotic Methods**, Shanghai, China. (June 1987, p. 685)

20–24. **International Algebra Conference**, Lisbon, Portugal. (February 1987, p. 364)

20–24. **Conference on Matrix Spectral Inequalities**, The Johns Hopkins University, Baltimore, Maryland. (February 1988, p. 310)

20–24. **The Numerical Solution of IVPs for ODEs**, Toronto, Canada. (April 1988, p. 634)

* 20–24. **SIGPLAN '88: Conference on Programming Language Design and Implementation**, Colony Square Hotel, Atlanta, Georgia.

INFORMATION: D. Wise, Conference Chair, Indiana University, 101 Lindley Hall, Bloomington, Indiana 47405, 812-335-9770.

20–25. **Geoffrey J. Butler Memorial Conference on Differential Equations and Population Biology**, University of Alberta, Edmonton, Alberta, Canada. (January 1988, p. 159)

20–July 8. **Summer School: Data Processing Operating and Management**, Nice, France. (March 1988, p. 462)

25–30. **International Conference on Biomathematics**, Xian, China. (October 1987, p. 999)

26–July 1. **Weak Convergence Methods for Nonlinear Partial Differential Equations**, Loyola University, Chicago, Illinois. (April 1988, p. 634)

27–30. **Conference on Stochastic Processes and Their Use on PC**, Debrecen, Hungary. (March 1988, p. 462)

27–July 1. **Geometrie Algebrique, Informatique and Complexite**, Marseille, France. (March 1988, p. 462)

27–July 1. **Seventeenth Conference on Stochastic Processes and Their Applications**, Rome, Italy. (April 1988, p. 634)

27–July 2. **Seventeenth International Colloquium on Group Theoretical Methods in Physics**, Ste-Adele, Quebec, Canada. (February 1988, p. 310)

* 27–July 8. **Summer School on Numerical Analysis**, Bréau-sans-Nappe, France.

CONFERENCE THEMES: Finite Element Methods Applied to Electromagnetic Field Problems; Mathematical Models of Hysteresis; Variational Models and Mixed Methods in Electromagnetism.

PROGRAM: The summer classes, to be held in Bréau-sans-Nappe, are designed for researchers and engineers. Approximately 30 participants will comment on the advances in particular fields and compare their experiences. Instruction is available in English and French and includes small group workshops.

INVITED SPEAKERS: C. Emson, Rutherford Appleton Laboratory; I. D. Mayergoyz, University of Maryland; A. Bossavit, EDF.

INFORMATION: Secrétariat des Ecoles d'Eté: EDF 1, Avenue du Général de Gaulle, 92140 Clamart, France. Telephone: (1) 47 65 43 06.

27–July 15. **Microprogram on the Structure of Banach Spaces**, Mathematical Sciences Research Institute, Berkeley, California. (June 1987, p. 685)

27–July 29. **Summer Seminars for School Teachers: The Great Theorems of Mathematics**, Ohio State University, Columbus, Ohio. (April 1988, p. 634)

27–August 5. **Summer Program on Signal Processing**, Institute for Mathematics and Its Applications, University of Minneapolis, Minnesota. (April 1988, p. 634)

* 29–July 2. **Third Analysis Conference in Cork on Operator Theory and Operator Algebras**, University College, Cork, Ireland.

PRINCIPAL SPEAKERS: I. D. Berg, L. Brown, J. Cuntz, and Z. Slodkowski.

INFORMATION: R. E. Harte and G. J. Murphy, Department of Mathematics, University College, Cork, Ireland.

July 1988

3–23. **Summer Research Institute on Operator Theory/Operator Algebras and Applications**, University of New Hampshire, Durham, New Hampshire. (January 1988, p. 159)

INFORMATION: J. Balletto, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

4–8. **Infinite Dimensional Lie Algebras and Groups**, Marseille, France. (November 1987, p. 1139)

*4–8. **Third International Workshop on Statistical Modeling**, Vienna, Austria.

INFORMATION: R. Hatzinger, Biostatistik, Psychiatrische Univ., Wahringer Gurtel 18-20, A-1090 Vienna, Austria.

5–8. **Tenth Dundee Conference on the Theory of Ordinary and Partial Differential Equations**, Dundee, Scotland. (October 1987, p. 999)

5–8. **Third Annual Symposium on Logic in Computer Science**, University of Edinburgh, Edinburgh, Scotland. (March 1988, p. 462)

5–8. **IMA Conference on Applications of Matrix Theory**, Bradford, England. (April 1988, p. 635)

*6–8. **Workshop on the Role of Mathematicians in Education Reform**, Chicago, Illinois. (April 1988, p. 635)

INFORMATION: K. Poyner Brown, Department of Mathematics, MC 249, University of Illinois at Chicago, Box 4348, Chicago, Illinois 60680, 312-996-2439.

6–16. **Automorphic Forms, Shimura Varieties and L-Functions**, University of Michigan, Ann Arbor, Michigan. (March 1988, p. 462)

10–16. **Representation Theory and Group Theory**, Manchester, England. (February 1987, p. 364)

11–13. **IMA Conference on Inverse Problems and Imaging Associated with Pattern Recognition**, Strathclyde, Scotland. (April 1988, p. 635)

11–15. **Theorie de L'Homotopie**, Marseille, France. (March 1988, p. 462)

11–15. **SIAM Annual Meeting**, Hyatt Regency Hotel, Minneapolis, Minnesota. (April 1988, p. 635)

11–16. **Twenty-third International Conference of Actuaries**, Helsinki, Finland. (April 1988, p. 635)

13–15. **Ohio Section Short Course: Using Computer Algebra Systems to Teach Calculus**, Denison University, Granville, Ohio. (April 1988, p. 635)

13–15. **IMA Conference on Mathematical Structures for Software Engineering**, Manchester, England. (April 1988, p. 635)

13–20. **Edinburgh Mathematical Society's 1988 Saint Andrews Colloquium**, St. Andrews, Fife, Scotland. (February 1987, p. 364)

17–27. **Ninth Congress of the International Association of Mathematical Physics**, Swansea, Wales. (February 1987, p. 364)

18–22. **Twelfth IMACS World Congress on Scientific Computation**, Paris, France. (February 1987, p. 364)

18–23. **International Biometric Conference**, Namur, Belgium. (April 1988, p. 635)

18–29. **Second Workshop on Stochastic Analysis**, Silivri (Istanbul), Turkey. (April 1988, p. 635)

18–29. **AMS-SIAM Summer Seminar on Computational Solution of Nonlinear Systems Equations**, Colorado State University, Fort Collins, Colorado. (January 1988, p. 159)

INFORMATION: B. Verducci, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

20–31. **Ninth Latin American School of Mathematics**, Santiago, Chile. (November 1987, p. 1140)

22–28. **Twelfth IMACS World Congress on Scientific Computation**, Paris, France. (April 1988, p. 635)

*24–30. **International Conference on Radicals – Theory and Applications**, Sendai, Japan. (Note change, October 1987, p. 999)

*24–August 5. **Constructive Methods in Computing Science**, Marktoberdorf, Germany.

INFORMATION: F. Bauer, Institut für Informatik, Technische Universität PF 20 2420, 8000 München 2, Germany.

25–28. **First International Conference on Optimal Design and Analysis of Experiments**, Neuchatel, Switzerland. (February 1988, p. 311)

*25–28. **Third KIT Mathematics Workshop**, Taejon, Korea.

PROGRAM: The program will consist of a series of lectures by the invited speakers, and some one-hour talks in algebra and topology. The number of participants is limited to 100.
INVITED SPEAKERS: M. Nagata, Kyoto University; G. Lachaud, CIRM France; R. Stern, University of Utah; J. Levine, Brandeis University.
CALL FOR PAPERS: Papers are solicited in all areas of algebra and topology. A small amount of financial support will be available to the limited number of talkers. The deadline for submission of papers is May 31, 1988.
INFORMATION: Y. Y. Oh, Director, Mathematics Research Center, Korea Institute of Technology, Kusongdong, Taejon, 302-338, Korea.

25–29. **Third International Conference on Fibonacci Numbers and Their Applications**, Pisa, Italy. (April 1988, p. 635)

25–30. **Third International Congress on Computational and Applied Mathematics**, University of Leuven, Belgium. (August 1987, p. 814)

25–30. **International Symposium on Engineering Mathematics**, Beijing, China. (April 1988, p. 635)

27–August 3. **Sixth International Congress on Mathematical Education**, Budapest, Hungary. (March 1988, p. 463)

31–August 6. **Nonstandard Analysis**, University of Massachusetts, Amherst, Massachusetts, and Smith College, Northampton, Massachusetts. (January 1988, p. 159)

August 1988

1–5. **Fifteenth Annual Conference and Exhibition on Computer Graphics and Interactive Techniques (SIGGRAPH '88)**, Georgia World Congress Center, Atlanta, Georgia. (October 1987, p. 999)

1–5. **Thirty-eighth Gordon Research Conference on Statistics in Chemistry and Chemical Engineering**, New Hampton, New Hampshire. (April 1988, p. 636)

*1–6. **Group Actions and Invariant Theory**, McGill University, Montreal, Quebec, Canada.

SPEAKERS: A. Bialynicki-Birula, D. Luna, H. Kraft, J. Carrel, M. Putcha, G. Schwarz, T. Petrie, I. Dolgachev, L. Renner.
INFORMATION: Group Actions, P. Russell, McGill University, Department of Mathematics and Statistics, 805 Sherbrooke West, Montreal, Quebec, Canada H3A 2K6. Telephone: 514-398-3835.

1–7. **International Symposium on Number Theory and Analysis**, Tsing Hua University, Beijing, People's Republic of China. (February 1988, p. 311)

1–9. **Eighteenth International Congress of the History of Science**, Hamburg (August 1–5) and Munich (August 6–9), Federal Republic of Germany. (March 1988, p. 463)

*1–12. **Conference on Computational Tools of Numerical Approximation and Control**, Montana State University, Bozeman, Montana.

CONFERENCE THEME: This conference is designed to bring together control theorists and numerical analysts to explore the rapidly expanding numerical needs of the problems arising in control.
SPEAKERS: C. Byrnes, Arizona State University; W. Gautschi, Purdue University; C. Martin, Texas Tech University; F. Stenger, University of Utah.
INFORMATION: K. Bowers or J. Lund, Department of Mathematical Sciences, Montana State University, Bozeman, Montana 59717.

4–11. **Algebraic Logic Conference**, Budapest, Hungary. (October 1987, p. 999)

5–8. **Second Boston Workshop for Mathematics Faculty**, Wellesley College, Wellesley, Massachusetts. (January 1988, p. 159)

6–7. **AMS Short Course on Chaos and Fractals: The Mathematics Behind the Computer Graphics**, Providence, Rhode Island.

INFORMATION: M. Foulkes, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940. (April 1988, p. 597)

8–12. **AMS Centennial Celebration**, Providence, Rhode Island. (April 1987, p. 553)

INFORMATION: For further details, see the Meetings section of the April 1988 *Notices*.

8–12. **Fifth Marcel Grossman Meeting**, Perth, Western Australia. (April 1988, p. 636)

8–13. **Spaces of Self-Homotopy Equivalences**, Centre de recherches mathematiques, Université de Montréal, Montréal, Québec. (February 1988, p. 311)

*8–14. **Conference on Algebraic Logic**, Budapest, Hungary.

ORGANIZERS: The Janos Bolyai Mathematical Society and the Association for Symbolic Logic.
PROGRAM: Cylindric-, polyadic-, relation algebras; Boolean algebras with operators; modal algebras; theories of relations and their computer science aspects, and anything related to the new *Tarski-Givant* book. Calculi of relations, other algebraizations of logic and universal algebraic (e.g., via discriminator varieties) or categorical approaches to algebraic logic.
INVITED SPEAKERS: W. J. Blok, W. Craig, S. Givant, L. Henkin, G. McNulty, J. D. Monk, D. Pigozzi.
INFORMATION: I. Nemeti, Department of Mathematics, Iowa State University, 400 Carver Hall, Ames, Iowa 50011, 515-294-8134, 294-8184 (offices); 515-292-0726 (home). (Note changes from February 1988, p. 311)

9–12. **International Symposium in Real Analysis**, University of Ulster, Coleraine, Northern Ireland. (February 1987, p. 364)

9–12. **Henstock Real Analysis Symposium**, University of Ulster, Coleraine, Northern Ireland. (March 1988, p. 463)

9–13. **First International Symposium on Algebraic Structures and Number Theory**, Hong Kong. (November 1987, p. 1140)

12–14. **International Conference on Mathematical Modelling in Sciences and Technology**, Madras, India. (Note date change, October 1987, p. 999)

13–17. **Kaehler Geometry and Several Complex Variables**, Eastern University, Charleston, Illinois. (April 1988, p. 636)

*13–17. **NSF-CBMS Regional Conference: Rigidity in Several Complex Variables**, Eastern Illinois University, Charleston, Illinois.

INVITED SPEAKER: Y-T. Siu, Harvard University.
INFORMATION: P. Coulton, Department of Mathematics, Eastern Illinois University, Charleston, Illinois 61920.

14–18. **Institute of Mathematical Statistics Annual Meeting**, Fort Collins, Colorado. (October 1987, p. 999)

14–27. **Harmonic Analysis on Reductive Groups**, Bowdoin College, Brunswick, Maine. (This conference has been postponed. For further details, see the announcement for July 30–August 12, 1989, in this section of Mathematical Sciences Meetings and Conferences)

15–19. **New Directions in Dynamical Systems**, Brown University, Providence, Rhode Island. (October 1987, p. 999)

15–19. **International Symposium on Approximation, Optimization and Computing**, University of Regina, Saskatchewan, Canada. (February 1988, p. 312)

*15–19. **Advances in the Theory of Frechet Spaces**, Istanbul, Turkey.

INFORMATION: T. Terzioglu, Mathematics Department, Middle East Technical University, Ankara, Turkey.

15–20. **Universal Algebra**, Karlovy Vary, Czechoslovakia. (March 1988, p. 463)

16–19. **Institute of Mathematical Statistics Symposium on Probability and its Applications**, Colorado State University, Fort Collins, Colorado. (October 1987, p. 999)

16–September 9. **Summer School on Dynamical Systems**, International Centre for Theoretical Physics, Trieste (Italy). (April 1988, p. 636)

17–24. **Functional Analysis/Optimisation**, Australian National University, Canberra. (April 1988, p. 636)

19–24. **Georgia Topology Conference**, University of Georgia, Athens, Georgia. (February 1988, p. 312)

20–26. **Groups**, Pusan, Republic of Korea. (June 1987, p. 686)

21–25. **Crypto 88 Conference**, Santa Barbara, California. February 1988, p. 312)

21–27. **Seventeenth International Congress of Theoretical and Applied Mechanics**, Grenoble, France. (January 1987, p. 135)

21–27. **International Conference on General Algebra**, Krems/Donau, Austria. (November 1987, p. 1140)

21–September 7. **Eighteenth Ecole d'ete de Calcul des Probabilities**, Saint-Flour, Cantal. (March 1988, p. 463)

22–25. **1988 Joint Statistical Meetings**, New Orleans, Louisiana. (June 1987, p. 686)

22–25. **Fifth International Conference on the New Quality Philosophy in Statistical Research and Statistical Education (Satellite Conference)**, New Orleans, Louisiana. (March 1988, p. 464)

22–26. **Conference on Categorical Topology and its Relations to Algebra, Analysis** and **Combinatorics**, Prague, Czechoslovakia. (October 1987, p. 1000)

22–26. **International Conference on Operator Theory: Advances and Applications**, University of Calgary, Alberta, Canada. (November 1987, p. 1140)

22–26. **20th Nordic Congress of Mathematicians**, Trondheim, Norway. (November 1987, p. 1140)

22–26. **Conference in Differential Geometry In Honor of M. Perdigão Do Carmo**, Rio de Janeiro, Brazil. (March 1988, p. 464)

22–27. **Conference on Numerical Methods and Applications**, Sofia, Bulgaria. (March 1988, p. 464)

22–September 16. **Summer School: Jordan Algebras and Jordan Triples: Geometry and Analysis**, Poitiers, France. (March 1988, p. 464)

23–30. **1988 Association for Symbolic Logic European Summer Meeting**, Padova, Italy. (January 1988, p. 160)

27–31. **First Islamic Countries Conference on Statistical Sciences**, Lahore, Pakistan. (March 1988, p. 464)

28–31. **European Conference for Mathematics in Industry**, Glasgow, Scotland. (March 1988, p. 464)

29–September 1. **Fourteenth International Conference on Very Large Databases**, Hyatt Regency Hotel, Long Beach, California. (March 1988, p. 464)

29–September 2. **ICO Topical Meeting on Optical Computing**, Orsay, France. (October 1987, p. 1000)

29–September 2. **Orbit Method in Representation Theory**, Copenhagen, Denmark. (October 1987, p. 1000)

29–September 2. **Workshop on Symplectic Topology**, Mathematical Sciences Research Institute, Berkeley, California. (February 1988, p. 321)

29–September 2. **COMPSTAT '88 Eighth Symposium on Computational Statistics**, Copenhagen, Denmark. (March 1988, p. 464)

29–September 2. **Harmonic Analysis in Lie Groups**, Copenhagen, Denmark. (April 1988, p. 637)

29–September 2. **International Conference on Mathematical Statistics**, Olsztyn, Poland. (April 1988, p. 637)

29–September 2. **Thirteenth International Symposium on Mathematical Programming**, Tokyo, Japan. (April 1988, p. 637)

30–September 2. **Ninth Annual Meeting of the International Society of Clinical Biostatistics**, Innsbruck, Austria. (April 1988, p. 637)

September 1988

6–10. **International Neural Network Society 1988 Annual Meeting**, Boston, Massachusetts. (February 1988, p. 312)

12–16. **Theorie des Nombres**, Marseille, France. (March 1988, p. 464)

12–16. **Eurographics '88: Research, Practice and Experience**, Nice, France. (March 1988, p. 464)

13–16. **Workshop on Arboreal Group Theory**, Mathematical Sciences Research Institute, Berkeley, California. (January 1988, p. 160)

13–23. **Heyting Summer School and Conference on Mathematical Logic**, Chaika near Varna, Bulgaria. (February 1988, p. 312)

14–16. **Fifth IMA International Conference on Control Theory**, Strathclyde, Scotland. (April 1988, p. 637)

14–17. **Meeting of Topology**, Centro Congressi Cocumella, Sorrento (Naples), Italy. (March 1988, p. 464)

18–24. **DMV-Jahrestagung 1988**, Regensburg, Federal Republic of Germany. (March 1988, p. 464)

19–23. **Sixth International Colloquium on Differential Geometry**, Universidad de Santiago de Compostela, Santiago de Compostela, Spain. (February 1988, p. 312)

19–23. **Histoire de la Relativite Generale**, Marseille, France. (March 1988, p. 464)

* 23–25. **Fall Foliage Combinatorial Group Theory Conference**, Shaker Village, New Hampshire.

Invited Speakers: B. Bogley, Tufts; D. Collins, Queen Mary College-University of London; M. Dyer, University of Oregon; W. Metzler, University of Frankfurt.
Information: M. P. Latiolais, Department of Mathematics and Computer Science, Dartmouth College, Hanover, New Hampshire 03755. (This conference is being held in conjunction with the Fall Foliage Topology Seminar.)

* 24–25. **Last Fall Foliage Topology Seminar**, Shaker Village, New Hampshire.

Invited Speakers: C. Frohman, SUNY-Albany; P. Groerss, Wellesley; S. Szczepanski, Rutgers; T. Tucker, Hamilton.
Information: M. P. Latiolais, Department of Mathematics and Computer Science, Dartmouth College, Hanover, New Hampshire 03755.

25–30. **International Symposium in Honor of René Thom**, Paris, France. (February 1988, p. 312)

26–30. **Computational Intelligence '88**, University of Milano, Milano, Italy. (March 1988, p. 465)

26–October 1. **Fifth International Conference on Complex Analysis**, Halle, German Democratic Republic. (October 1987, p. 1000)

30–October 1. **Sixteenth Annual Mathematics and Statistics Conference**, Miami University, Oxford, Ohio. (April 1988, p. 637)

October 1988

* 3–5. **Knowledge-Based Robot Control**, Bonas, France.

Information: G. Saridis, Rensselaer Polytechnic Institute, Troy, New York 12181.

4–6. **Colloque Ergoia 88 Ergonomie et Intelligence Artificelle**, Biarritz, France. (April 1988, p. 637)

9–13. **International Conference on Computer Languages**, Castle Premier, Miami Beach, Florida. (March 1988, p. 465)

10–12. **IEEE Workshop on Visual Languages**, University of Pennsylvania, Pittsburgh, Pennsylvania. (March 1988, p. 465)

* 10–14. **Workshop on Mathematical Programming**, Catholic University of Rio De Janeiro, Brazil.

Organizers: Catholic University of Rio De Janeiro, Brazil, and the Mathematical Programming Society.
Information: C. C. Ribeiro, Catholic University of Rio De Janeiro, Department of Electrical Engineering, Gavea-Caixa Postal 38063, Rio De Janeiro 22452, Brazil. Telephone: (55) (21) 529-9334/529-9336/529-9246/-529-9397.

* 12–14. **Sensor-Based Robots: Algorithms and Architectures**, Bonas, France.

INFORMATION: C. Lee, School of Electrical Engineering, Purdue University, West Lafayette, Indiana 47907.

*21–22. **Tenth Midwest Probability Colloquium**, Northwestern University, Evanston, Illinois.

INVITED SPEAKERS: D. Burkholder, University of Illinois; L. Gray, University of Minnesota; S. Lalley, Purdue University.
INFORMATION: M. Pinsky, Department of Mathematics, Northwestern University, Evanston, Illinois 60208, 312-491-5519.

*28–29. **Seventeenth Midwest Differential Equations Conference**, Iowa State University, Ames, Iowa.

PROGRAM: The focus will be on Systems, Control, and Differential Equations. Six sessions of contributed talks are planned.
INVITED SPEAKERS: T. Banks, Brown University; J. Burns, VPI; C. Byrnes, Arizona State; S. Gibbons, UCLA; H. Hermes, University of Colorado, Boulder; M. Pinsky, Northwestern.
INFORMATION: G. Seifert, R. K. Miller, J. Murdock, W. Kliemann, Iowa State University, Department of Mathematics, 400 Carver Hall, Ames, Iowa 50011, 515-294-1752.

28–30. **Central Sectional Meeting**, Lawrence, Kansas.

INFORMATION: J. Balletto, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

31–November 18. **Workshop in Mathematical Ecology**, Trieste, Italy. (March 1988, p. 465)

November 1988

4–5. **Southeast Differential Equations Conference**, Athens, Georgia. (March 1988, p. 465)

12–13. **846th Meeting of the AMS**, Claremont, California.

INFORMATION: J. Balletto, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

13–17. **French-Israeli Conference on Combinatorics and Algorithms**, Israel. (February 1988, p. 313)

18–19. **Quantitative Approaches to Diabetes**, Sydney, Australia. (April 1988, p. 638)

20–25. **Eighth Annual Conference: Towards a Whole Decade for Scientific and Technological Cooperation for International Development**, Jamaica, West Indies. (March 1988, p. 465)

21–December 16. **College on Global Geometric and Topological Methods in Analysis**, Trieste, Italy. (March 1988, p. 465)

December 1988

6–8. **First International Conference on Matter Elements Analysis**, Guangzhou, Guangdong, People's Republic of China. (October 1987, p. 1000)

*12–15. **International Conference on Computer Vision**, Tarpon Springs, Florida. (Note date change, March 1988, p. 465)

*12–17. **International Course on Computational Geometry**, Dipartimento di Matematica, Università, Catania, Italy.

PURPOSE: This course is designed to give a survey on the current state of research in computational techniques and complexity results in real algebraic and analytic geometry, and to demonstrate relevant applications of these topics. It will consist of short cycles of lectures (approximately 30 hours) and a panel discussion.
INVITED SPEAKERS: M. F. Coste-Roy, Rennes; J. Davenport, Bath; J. Heintz, Buenos Aires; F. Preparata, Urbana; T. Recio, Santander; M. Sharir, New York.
ORGANIZERS: A. Conte, A. Ferro, T. Mora.
INFORMATION: T. Mora, Dipartimento di Matematica, Università Via L. B. Alberti, 4 16132 Genova, Italy. Telephone: (010) 515141.

13–15. **IMA/SIAM International Conference on Mathematics of Signal Processing**, Warwick, England. (April 1988, p. 638)

*27–31. **Holiday Symposium on Fermat's Last Theorem**, New Mexico State University, Las Cruces, New Mexico.

PROGRAM: This symposium will focus on Fermat's Last Theorem and will consist of ten lectures, two each day. by J. Tate, of Harvard University. There will be additional sessions organized by J. Selfridge of Northern Illinois University, as well as sessions for contributed papers, research ideas, and discussion. Some support may be available for a limited number of participants.
INFORMATION: R. J. Wisner, Department of Mathematical Sciences, New Mexico State University, Box 30001, Las Cruces, New Mexico 88003-0001, 505-646-3901.

January 1989

*2–5. **International Colloquium in Ring Theory**, Bar-Ilan University, Ramat-Gan, Israel.

CONFERENCE TOPICS: Division Rings; PI-rings; Group Rings; Noetherian Rings; Rings of Differential Operators.
INVITED SPEAKERS: M. Artin; P. M. Cohn; E. Formanek; A. F. Goldie; N. Jacobson; D. Passman; L. Small; D. Saltman; T. Stafford.
INFORMATION: Conference Secretary, Research Institute for Mathematical Sciences, Bar-Ilan University, 52100 Ramat-Gan, Israel.

4–6. **American Statistical Association Winter Conference: Statistics in Society**, San Diego, California. (March 1988, p. 465)

6–12. **Nonlinear Wave Equations**, George Mason University, Fairfax, Virginia. (April 1988, p. 638)

*8–10. **Symposium in Honor of the Seventieth Birthday of Ted Harris**, Los Angeles, California.

INVITED SPEAKERS: P. Baxendale; R. Durrett; D. Griffeath; R. Holley; H. Kesten; H. Kunita; Y. le Jan; T. Liggett; C. Newman; P. Ney; F. Spitzer; S. Varadhan.
INFORMATION: J. Watkins, Department of Mathematics, University of Southern California, 1042 West 36th Place, DRB 306, Los Angeles, California 90089-1113.

8–11. **First Caribbean Conference on Fluid Dynamics**, Saint Augustine, Trinidad, West Indies. (June 1987, p. 686)

9–13. **Sixth Texas International Symposium on Approximation Theory**, College Station, Texas. (April 1988, p. 638)

9–14. **K-Theory and Dynamics**, University of Florida, Gainesville, Florida. (April 1988, p. 638)

11–14. **Joint Mathematics Meetings**, Phoenix, Arizona. (April 1987, p. 553)

INFORMATION: H. Daly, American Mathematical Society, Meetings Department, Post Office Box 6248, Providence, Rhode Island 02940.

*15–20. **American Association for the Advancement of Science Annual Meeting**, San Francisco, California.

INFORMATION: AAAS, 1333 H Street, Northwest, Washington, District of Columbia 20005, 202-326-6640.

23–27. **Workshop on Algorithms, Word Problems, and Classification in Combinatorial Group Theory**, Mathematical Sciences Research Institute, Berkeley, California. (February 1988, p. 313)

February 1989

*21–23. **Seventeenth Annual Computer Science Conference**, Commonwealth Convention Center, Louisville, Kentucky.

CALL FOR PAPERS: Submissions relating to the conference focus, Emerging Computer Trends of the 1990s, should be mailed by September 1, 1988 to J. D. McGregor, Department of Computer Studies, Murray State University, Murray, Kentucky 42071. INFORMATION: Conference Department A, Association for Computing Machinery, 11 West 42nd Street, New York, New York 10036.

March 1989

19–22. **ENAR Spring Meeting**, Lexington, Kentucky. (March 1988, p. 465)

April 1989

3–6. **IEEE International Conference on Control and Applications**, Jerusalem, Israel. (April 1988, p. 638)

10–13. **IEEE Artificial Neural Networks Conference**, Sheraton International Conference Center, Reston, Virginia. (Note date change, March 1988, p. 465)

*15–16. **Eastern Section Meeting**, College of the Holy Cross, Worcester, Massachusetts.

INFORMATION: J. Balletto, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

May 1989

8–10. **Forty-Third Annual Quality Congress**, Toronto, Canada. (March 1988, p. 465)

8–12. **Workshop on Arithmetic Groups and Buildings**, Mathematical Sciences Research Institute, Berkeley, California. (March 1988, p. 465)

*15–17. **1989 New Zealand Mathematics Colloquium**, Palmerston North, New Zealand.

INFORMATION: Colloquium Secretary, Department of Mathematics and Statistics, Massey University, Palmerston North, New Zealand.

19–20. **Central Section Meeting**, Loyola University, Chicago, Illinois.

INFORMATION: J. Balletto, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

23–27. **International Conference on Computing and Information**, Toronto, Ontario, Canada. (April 1988, p. 638)

*28–June 10. **AMS-SIAM Summer Seminar on the Mathematics of Random Media**, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

CHAIRMEN: W. Kohler, Virginia Polytechnic Institute and State University and B. White, Exxon Research and Engineering Company.
INFORMATION: B. Verducci, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

*29–June 1. **Third International Conference in Mathematics: Fractional Calculus and Its Applications**, Nihon University, Tokyo, Japan.

INFORMATION: K. Nishimoto, Mathematics Department, College of Engineering, Nihon University, Tamuracho, Koriyama, Japan 963.

June 1989

5–16. **Workshop on the Geometry of Hamiltonian Systems**, Mathematical Sciences Research Institute, Berkeley, California. (April 1988, p. 638)

July 1989

3–7. **Computational Ordinary Differential Equations**, London, England. (April 1988, p. 638)

10–12. **International Conference on Computational Techniques and Applications**, Griffith University, Brisbane. (April 1988, p. 639)

*10–21. **Microprogram on Noncommutative Rings**, Mathematical Sciences Research Institute, Berkeley, California. (Note date change, June 1987, p. 686)

30–August 4. **Sixteenth Annual Conference and Exhibition on Computer Graphics and Interactive Techniques (SIGGRAPH '89)**, Hynes Auditorium, Boston, Massachusetts. (March 1988, p. 466)

30–August 12. **Harmonic Analysis on Reductive Groups**, Bowdoin College, Brunswick, Maine. (January 1988, p. 160)

August 1989

1–9. **Eighteenth International Congress of the History of Science**, Hamburg, 1–5; Munich, 6–9, Federal Republic of Germany. (April 1988, p. 639)

6–10. **1989 Joint Statistical Meetings**, Washington, District of Columbia. (March 1988, p. 466)

*13–19. **Fourth Conference on Differential Equations and Applications**, Rousse, Bulgaria.

PROGRAM: The program will include plenary lectures (45 minutes) by leading scientists, and scientific reports (20-30 minutes). The reports of the participants in the conference will be published in the Proceedings of the conference.
INFORMATION: For further information concerning expenses, hotel accommodation, and the list of invited speakers, write to the Organizing Committee CDE-IV, Technical University, Komsomolska Street N8, 7017 Rousse, Bulgaria.

20–September 6. **Nineteenth Ecole d'ete de Calcul des Probabilities**, Saint-Flour, Cantal. (March 1988, p. 466)

28–September 1. **IFIP 89: Eleventh World Computer Conference**, San Francisco, California. (April 1988, p. 639)

29–September 6. **Forty-seventh Session of the International Statistical Institute**, Paris, France. (April 1988, p. 639)

September 1989

16–October 20. **Sixth World Congress on Medical Information**, Beijing, China. (April 1988, p. 639)

* 25–29. **Third International Conference on the Theory of Groups and Related Topics**, Australian National University, Canberra. (Note date change, April 1988, p. 639)

October 1989

* 21–22. **Eastern Section Meeting**, Stevens Institute of Technology, Hoboken, New Jersey.

  INFORMATION: J. Balletto, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

* 27–28. **Central Section Meeting**, Ball State University, Muncie, Indiana.

  INFORMATION: J. Balletto, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

January 1990

17–20. **Joint Mathematics Meetings**, Louisville, Kentucky. (April 1987, p. 553)

INFORMATION: H. Daly, American Mathematical Society, Meetings Department, Post Office Box 6248, Providence, Rhode Island 02940.

May 1990

25–31. **Tenth International Conference on Pattern Recognition**, Resorts Hotel, Atlantic City, New Jersey. (March 1988, p. 466)

August 1990

6–9. **1990 Joint Statistical Meetings**, Anaheim, California. (March 1988, p. 466)

January 1991

16–19. **97th Annual Meeting**, San Francisco, California.

INFORMATION: H. Daly, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

August 1991

* 17–21. **American Sociological Association Annual Meeting**, Cleveland, Ohio.

  INFORMATION: American Sociological Association, 1722 N Street, Northwest, Washington, District of Columbia 20036, 202-833-3410.

19–22. **1991 Joint Statistical Meetings**, Atlanta, Georgia. (March 1988, p. 466)

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REVIEWS IN PARTIAL DIFFERENTIAL EQUATIONS, 1980–86

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These five volumes contain the more than 19,200 reviews that appeared in *Mathematical Reviews* from 1980 through 1986 and have primary or a secondary classification in Partial Differential Equations (classification number 35). Relevant cross-references are provided with each review. The fifth volume of this set contains author and key indexes which make it very easy to locate items written by a specific author or to get information about collections or conference proceedings dealing with partial differential equations.

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FIXED POINT THEORY AND ITS APPLICATIONS
R. F. Brown, Editor
(Contemporary Mathematics, Volume 72)

Fixed point theory touches on many areas of mathematics, such as general topology, algebraic topology, nonlinear functional analysis, and ordinary and partial differential equations and serves as a useful tool in applied mathematics. This book represents the proceedings of an informal three-day seminar held during the International Congress of Mathematicians in Berkeley in 1986. Bringing together topologists and analysts concerned with the study of fixed points of continuous functions, the seminar provided a forum for presentation of recent developments in several different areas.

The topics covered include both topological fixed point theory from both the algebraic and geometric viewpoints, the fixed point theory of nonlinear operators on normed linear spaces and its applications, and the study of solutions of ordinary and partial differential equations by fixed point theory methods. Because the papers range from broad expositions to specialized research papers, the book provides readers with a good overview of the subject as well as a more detailed look at some specialized recent advances.

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MATHEMATICS AND GENERAL RELATIVITY
James A. Isenberg, Editor

(Contemporary Mathematics, Volume 71)

This volume contains the proceedings of the AMS-IMS-SIAM Joint Summer Research Conference in General Relativity, held in June 1986 at the University of California, Santa Cruz.

General relativity is one of the most successful alliances of mathematics and physics. It provides us with a theory of gravity which agrees with all experimentation and observation to date. In addition, there is a great deal of physical evidence for a number of interesting effects predicted by the theory of gravity—black holes, cosmological expansion, gravitational waves, and gravitational lenses. The enabling tool is the language of differential geometry. Throughout its 70-year history, general relativity has significantly stimulated pseudo-Riemannian as well as Riemannian geometry and has also motivated important work in complex geometry, topology, and the study of both elliptic and hyperbolic systems of partial differential equations.

This collection explores some of the directions in which mathematical general relativity has proceeded in recent years. Among the topics discussed are:

- The possibility of finding a quasi-local expression for energy
- Aspects of the global structure of solutions to Einstein's equations
- The stability of globally complete asymptotically flat spacetime solutions of Einstein's equations
- The relation between stability and the well-posedness of theories involving relativistic fluids
- The utility of Ashtekar's "New Variables" formulation of quantum as well as classical Einstein theory
- The quantum factor ordering problem
- The nature of the diffeomorphism group on Lorentz manifolds
- The global properties of Ricci flow on surfaces

The main feature characterizing most of the contributions is a concentration on questions with serious mathematical content.

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Roger Penrose, *Aspects of quasi-local angular momentum*
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INDEX THEORY OF ELLIPTIC OPERATORS, FOLIATIONS, AND OPERATOR ALGEBRAS
Jerome Kaminker, Kenneth C. Millett, and Claude Schochet, Editors

(Contemporary Mathematics, Volume 70)

Combining analysis, geometry, and topology, this volume provides an introduction to current ideas involving the application of K-theory of operator algebras to index theory and geometry. In particular, the articles follow two main themes: the use of operator algebras to reflect properties of geometric objects and the application of index theory in settings where the relevant elliptic operators are invertible modulo a C^*-algebra other than that of the compact operators.

The papers in this collection are the proceedings of the special sessions held at two AMS meetings: the Annual meeting in New Orleans in January 1986, and the Central Section meeting in April 1986. Jonathan Rosenberg's exposition supplies the best available introduction to Kasparov's KK-theory and its applications to representation theory and geometry. A striking application of these ideas are found in Thierry Fack's paper, which provides a complete and detailed proof of the Novikov Conjecture for fundamental groups of manifolds of non-positive curvature. Some of the papers involve Connes' foliation algebra and its K-theory, while others examine C^*-algebras associated to groups and group actions on spaces.

Contents

1980 *Mathematics Subject Classifications*: 46, 53, 58; 57, 55
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John Brillhart, D. H. Lehmer, J. L. Selfridge, Bryant Tuckerman, and S. S. Wagstaff, Jr.

(Contemporary Mathematics, Volume 22, Second Edition)

This book is a revised and updated edition of a work that originally appeared in 1983. It gives a historical account of the various methods and machines that have been used to factor, and prove prime, the numbers $b^n \pm 1$. It is a revised version of an extension of a rare 1925 work by Cunningham and brings together results going back to the seventeenth century. The factorizations and the very large primes of special form are useful in group theory, number theory, discrete Fourier transforms, random number generators, and cryptography.

The present edition contains more than 2000 large primes which have never been published before.

The book contains complete factorizations of $b^n \pm 1$ for the given values of b and for all $n \leq 100$, and for many $n > 100$. Included is an extensive and valuable introduction which describes the developments in computing technology and in methods of factoring and primality testing which have occurred since 1925. An update to the introduction is included in this edition and discusses the major advances that have been made in the five years since the first edition appeared. The introduction also discusses the multiplicative structure of $b^n \pm 1$ and explains the relation between the two kinds of algebraic factorizations of these numbers.

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ZEROS OF BERNOULLI, GENERALIZED BERNOULLI, AND EULER POLYNOMIALS
Karl Dilcher
(Memoirs of the AMS, Number 386)

The three classes of polynomials studied in this book have important applications in the theory of finite differences, number theory, and classical analysis. The most significant contribution of this book is a proof that the Bernoulli and Euler polynomials and the generalized Bernoulli polynomial associated with certain quadratic characters have no zeros inside a parabolic region if the degree is sufficiently large. The author also finds zero-free regions for individual polynomials and for the partial sums for the sine and the cosine. The proofs are based on results on the maximum modulus of the zeros of polynomials related to those under investigation. Finally, the author studies the distribution of real zeros of generalized Bernoulli and Euler polynomials. The results are similar to known results about the classical Bernoulli polynomials. The book assumes a background at the level of an undergraduate education in mathematics and, in particular, requires knowledge of basic complex analysis.

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Nigel J. Kalton
(Memoirs of the AMS, Number 385)

This book is directed at research mathematicians and graduate students in the areas of functional analysis, Banach spaces, interpolation theory, and Hardy spaces. Recently Jawerth, Rochberg, and Weiss have studied certain nonlinear maps which arise from interpolation theory and satisfy commutator relationships with interpolated linear operators. The study of these nonlinear maps is a quite new idea which seems capable of further development. In this work, the author studies the behavior of such maps on rearrangement-invariant Banach function spaces and proves a very general commutator result. He shows that, when applied to the Hilbert transform, this theorem yields the Ceretelli-Davis theorem on the distribution of functions in the Hardy Space H_1.

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(American Mathematical Society Translations, Series 2, Volume 139)

This volume contains papers selected by leading specialists in algebraic semigroups in the U.S., the United Kingdom, and Australia. Many of the papers strongly influenced the development of algebraic semigroups, but most were virtually unavailable outside the U.S.S.R. Written by some of the most prominent Soviet researchers in the field, the papers have a particular emphasis on semigroups of transformations. Boris Schein of the University of Arkansas is the translator.

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I. V. Arak and A. Yu. Zaitsev, Editors

(Proceedings of the Steklov Institute, Volume 174)

Among the diverse constructions studied in modern probability theory, the scheme for summation of independent random variables occupies a special place. In the study of even this comparatively simple scheme it is possible to become familiar with the fundamental regularities characterizing the cumulative influence of a large number of random factors. Further, this abstract model is useful in many important practical situations.

This book is devoted to the study of distributions of sums of independent random variables with minimal restrictions imposed on their distributions. The authors assume either that the distributions of the terms are concentrated on some finite interval to within a small mass, or that all the terms have the same, but arbitrary, distribution (or other conditions not connected with moment restrictions are introduced). Surprisingly, very substantive results are possible even under such a general statement of the problems.

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AMS Reports and Communications

Recent Appointments

Committee members' terms of office on standing committees expire on December 31 of the year given in parentheses following their names, unless otherwise specified.

President G. D. Mostow has appointed Alice T. Schafer (1990) to the *Committee on Human Rights of Mathematicians* and as chairman. Continuing members of the committee are Michael I. Brin (1990), Bettye Anne Case (1989), Patrick X. Gallagher (1989), Herman R. Gluck (1989), Leon A. Henkin (1988), Neil I. Koblitz (1988), and Joel L. Lebowitz (1990).

Linda Keen (1989) has been appointed chairman of the *Committee on Professional Ethics* by President G. D. Mostow. Continuing members of the commmittee are C. Edmund Burgess (1990), Frank L. Gilfeather (1990), Paul R. Halmos (1988), and Anneli Lax (1988).

Paul J. Cohen has been appointed to the *Committee to Select the Winner of the Bôcher Prize for 1989* by President G. D. Mostow. Continuing members of the committee are Richard B. Melrose, chairman, and Louis Nirenberg.

Report of Past Meetings

Special Symposium on American Mathematics Entering its Second Century

A *Special Symposium on American Mathematics Entering its Second Century* was held on Saturday February 13, and Sunday February 14, 1988 in the John B. Hynes Convention Center as part of the annual meeting of the American Association for the Advancement of Science. The symposium was sponsored by the American Mathematical Society as part of the celebration of its Centennial year.

The members of the Organizing Committee were Hyman Bass, Columbia University (Chairman); Raoul Bott, Harvard Universtity; Ronald L. Graham, AT&T Bell Laboratories; Robion C. Kirby, University of California, Berkeley; George Daniel Mostow, Yale University; Lynn Arthr Steen, St. Olaf College; and Dennis P. Sullivan, City University of New York.

145 persons registered for the symposium of which 82 were members of AMS.

The symposium featured four areas of important mathematical research and activity. The sessions and their speakers were:

Mathematical Modeling, George Carrier, Harvard University, Presider. Speakers included David Mumford, Harvard University; Charles Peskin, Courant Institute of Mathematical Sciences; and George Carrier.

Groups, Symmetry and Randomness, George Daniel Mostow, Yale University, Presider. Speakers were Persi Diaconis, Harvard University; and George Daniel Mostow.

Spaces of Dimensions Two, Three and Four: Finding Them and Telling Them Apart, John Morgan, Harvard University and Columbia University, Presider. The speakers included David Allen Hoffman, University of Massachusetts at Amherst; William P. Thurston, Princeton University; Robion C. Kirby; and John Morgan.

Mathematics and the Physical Sciences, James G. Glimm, Courant Institute of Mathematical Sciences, Presider. Speakers featured Daniel G. Quillen, Oxford University; James A. Yorke, University of Maryland; and James Glimm.

In addition to the symposium, mathematics was featured on the AAAS program through a plenary address by Raoul H. Bott, Harvard University. Professor Bott spoke on *Mathematics and Physics: An uneasy but preordained collaboration* on Sunday, February 14, 1988.

A reception in celebration of the AMS Centennial was hosted on Saturday, February 13, by the symposium co-chairmen Hyman Bass and George Daniel Mostow. Approximately 150 mathematicians, AAAS members, and representatives of the scientific press attended.

Miscellaneous

Personal Items

Phyllis Lefton has been appointed Professor of Mathematics and Computer Science at Manhattanville College, Purchase, New York.

Qiao Li has been appointed Professor of Mathematics at the University of Science and Technology of China.

Qaiser Mustaq, Assistant Professor at the Quaid-i-Azam University, Islamabad, Pakistan, has recently been decorated with a gold Medal of Honour from the American Institute of Biographies for his work in Group Theory and LA-Semigroup Theory.

Harold J. Raveché, Dean of Science and Professor of Chemistry at Rensselaer Polytechnic Institute, has been elected the sixth president of the Stevens Institute of Technology.

Deaths

Lynn M. Bateman, of the University of Colorado at Denver, died on February 17, 1988, at the age of 37. She was a member of the Society for one year.

John D. Baum, Professor Emeritus of Oberlin College, died on November 17, 1987, at the age of 68. He was a member of the Society for 37 years.

Orrin Frink, of Pennsylvania State University, died on March 4, 1988, at the age of 86. He was a member of the Society for 64 years. (See the **News and Announcements** section of this issue of *Notices*.)

Edwin Harold Hadlock, Professor Emeritus of Mathematics at the University of Florida, died on January 28, 1988, at the age of 86. He was a member of the Society for 60 years.

Voris V. Latshaw, of Lehigh University, died on April 2, 1988, at the age of 84. He was a member of the Society for 57 years.

Bert Mendelson, Professor of Computer Science at Smith College, died on January 2, 1988, at the age of 61. He was a member of the Society for 34 years.

William H. Pell, retired head of the Mathematical Sciences section at the National Science Foundation, died on March 14, 1988, at the age of 73. He was a member of the Society for 50 years. (See the **News and Announcements** section of this issue of *Notices*.)

Visiting Mathematicians

The list of visiting mathematicians includes both foreign mathematicians visiting in the United States and Canada, and Americans visiting abroad. Note that there are two separate lists.

American Mathematicians Visiting Abroad

Name and Home Country	Host Institution	Field of Special Interest	Period of Visit
Brockwell, Peter J. (U.S.A.)	University of Melbourne, Australia	Stochastic Processes and Time Series Analysis	1/88 - 1/89
Hano, Jun-ich (U.S.A.)	Kyushu University, Japan	Differential Geometry	1/88 - 5/89
Leonard, Henry S., Jr. (U.S.A.)	UMIST, England	Finite Group Theory	8/87 - 8/88
Levi, Mark (U.S.A.)	E.T.H., Switzerland	Differential Equations, Dynamical Systems	8/88 - 8/89
Rota, Gian-Carlo (U.S.A.)	University of Cagliari, Italy	Combinatorics, Probability, Logic	3/89
Shult, Ernest (U.S.A.)	Albert-Ludwigs-Universität, West Germany	Geometry and Groups	8/88 - 8/89
Smith, Eric P. (U.S.A.)	University of Kent, United Kingdom	Statistics	3/89 - 8/89

Visiting Foreign Mathematicians

Ang, Dang Dinh (Korea)	Univesity of Utah	Inverse Problems and Applied Functional Analysis	9/88 - 12/88
Assem, Magdy (Egypt)	Purdue University	Harmonic Analysis on p-adic Groups	8/88 - 5/90
Baas, Nils A. (Norway)	Massachusetts Institute of Technology	Lie Groups, Differential Geometry, Harmonic Analysis	8/88 - 6/89
Balasko, Yves (Switzerland)	Cornell University	Mathematical Economics	9/88 - 12/88
Bourguignon, Jean-Pierre (France)	Ohio State University	Differential Geometry	4/89 - 7/89
Bouzar, Nadjib (Algeria)	University of Toronto	Ergodic Theory	9/88 - 8/89
Bridges, Douglas S. (England)	New Mexico State University	Computability Theory, Complexity Theory	7/88 - 12/88
Bruning, Jochen (West Germany)	Massachusetts Institute of Technology	Differential Geometry	8/88 - 6/89
Burn, Robert P. (United Kingdom)	Carleton University	Geometry	1/89 - 3/89
Chen, Yao-song (China)	Kansas State University	Computational Fluid Dynamics	6/88 - 8/88
Cho, Yeol Je (Korea)	St. Louis University	Linear 2-normed Spaces	12/87 - 12/88
Choi, Q-Heung (Korea)	University of Connecticut	Differential Equations	1/88 - 1/89
Choi, Tacksun Jung (Korea)	University of Connecticut	Differential Equations	1/88 - 1/89
Christophersen, Jan (Norway)	Massachusetts Institute of Technology	Algebraic Geometry, Commutative Algebra	9/88 - 8/89
Daccach, Janey (Brazil)	Purdue University	Algebraic Topology	9/88 - 11/89
Daniel, Klaus (Switzerland)	Virginia Polytechnic Institute and State University	Statistics	5/88 - 7/88

Name and Home Country	Host Institution	Field of Special Interest	Period of Visit
Deng, Dayi (China)	University of Colorado	Celestial Mechanics	1/88 - 1/89
Ferenczi, Miklos (Hungary)	Carleton University	Probability/Algebra	9/88 - 11/88
Főldes, Antonia (Hungary)	Indiana University	Statistics	8/88 - 5/89
Forti, C. B. (Italy)	University of Waterloo	Functional Equations	9/88 - 10/88
Forti, G. L. (Italy)	University of Waterloo	Functional Equations	9/88 - 10/88
Furstenberg, Hillel (Israel)	Yale University	Number Theory, Ergodic Theory	9/88 - 12/88
Gronau, Detlef (Austria)	University of Waterloo	Partial Differential Equations	10/88
He, Sheng-Wu (People's Republic of China)	Purdue University	Probability	9/88 - 2/89
Hibi, Takayuki (Japan)	Massachusetts Institute of Technology	Combinatorics, Algebra	9/88 - 7/89
Hoidn, Nicolai (Switzerland)	University of Toronto	Ergodic Theory	9/88 - 8/89
Horst, Camilla (West Germany)	Indiana University	Algebraic Geometry	8/88 - 5/89
Horst, Ernst (West Germany)	Indiana University	Partial Differential Equations	8/88 - 5/89
Hou, Zixin (People's Republic of China)	Massachusetts Institute of Technology	Lie Groups, Differential Geometry, Harmonic Analysis	9/88 - 8/89
Janssen, Peter A.E.M. (The Netherlands)	California Institute of Technology	Nonlinear Water Waves, Ocean Dynamics	5/88 - 7/88
Jureckova, Jana (Czechoslovakia)	Carleton University	Statistics	7/88 - 8/88
Kan, Charh-Huen (Republic of Singapore)	University of Toronto	Ergodic Theory	1/89 - 5/89
Kérchy, László (Hungary)	Indiana University	Functional Analysis	8/88 - 5/89
Landstad, Magnus (Norway)	University of Trondheim	Operator Algebras	6/88 - 7/88
Ling, Hsiao (China)	Indiana University	Partial Differential Equations	8/88 - 5/89
Lubotzky, Alexander (Israel)	Yale University	Number Theory, Group Representation, Computer Science	9/88 - 5/89
Michaux, Bertrand (France)	Indiana University	Numerical Analysis	8/88 - 5/89
Min, K. C. (Korea)	Carleton University	Categorical Topology	1/88 - 2/89
Mori, Shigefumi (Japan)	University of Utah	Algebraic Geometry	9/88 - 12/88
Nigam, A. K. (India)	Carleton University	Statistics	4/88 - 7/88
Preston, Gordon (Australia)	Northern Illinois University	Semigroups	2/88 - 7/88
Rakotoson, Jean Michel (France)	Indiana University	Applied Mathematics	8/88 - 5/89
Saint-Raymond, Xavier (France)	Purdue University	Partial Differential Equations	8/88 - 5/90
Shen, Jie (France)	Indiana University	Applied Mathematics	8/88 - 5/89
Sherry, T. N. (Ireland)	University of Western Ontario	Theoretical Physics	7/88 - 8/88
Strømme, Stein Arild (Norway)	Brigham Young University	Algebraic Geometry	9/88 - 12/88
Szpiro, Lucien (France)	Columbia University	Commutative Algebra, Algebraic Geometry	9/88 - 12/88
Tomei, Carlos (Brazil)	Yale University	Differential Equations, Scattering	1/89 - 5/89
van Lint, J. H. (The Netherlands)	California Institute of Technology	Combinatorics	9/88 - 5/89
Waldstätter, Roland (West Germany)	Cornell University	Mathematical Biology	9/88 - 6/89
Wefelmeyer, W. (West Germany)	Johns Hopkins University	Asymptotic Theory in Statistical Inference	10/87 - 9/88

Name and Home Country	Host Institution	Field of Special Interest	Period of Visit
You, Cheng-Ye (People's Republic of China)	Carleton University	Topology	7/88 - 9/88
You, Yuncheng (People's Republic of China)	Purdue University	Control Theory	8/88 - 12/89
Zhang, Shangyou (People's Republic of China)	Purdue University	Numerical Analysis	8/88 - 12/89

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Department of Mathematics

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Dr. David Boyd, Head
Department of Mathematics
The University of British Columbia
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before **August 30, 1988**

In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents.

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Samuel Gitler, Chairman
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Northern is primarily an undergraduate institution and a commitment to teaching is an essential requirement for the positions. Scholarship and professional activity are both encouraged and supported.

Persons interested in a temporary position are also encouraged to apply. Applicants should send a resume, transcripts, and three letters of recommendation to Dr. Terrance Seethoff, Head; Mathematics and Computer Science Department; Northern Michigan University; Marquette, MI 49855-5340. Applications will be accepted until the position is filled.

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DEPARTMENT OF MATHEMATICS

Permanent positions at the following levels and areas will be filled within 1988: At the Professor (1st) level: one position in Algebra or Geometry and one in Partial Differential Equations. At the Assistant Professor (3d) level: one position in Analysis and one in Applied Mathematics or Statistics. At the instructor (4th level): one position in Algebra or Geometry. (Foundations and Topology are included in either Analysis or Algebra-Geometry). Greek citizenship is required by law for permanent positions. Visiting positions are also usually available every semester at all levels and areas of mathematics. For more information write to Prof. Susanna Papadopoulou, Chairperson, Mathematics Department, University of Crete, Iraklion, Greece, enclosing vita and representative research work.

University of Wisconsin-Superior, Mathematical Sciences, Superior, WI 54880

Two positions, one or possibly both tenure track, in Mathematics beginning September 1988. A tenure track position requires a Ph.D. in a Mathematical Science. A Masters degree will be considered for one position, but Ph.D. preferred. Excellence in teaching and continuing scholarly activity is expected. All areas considered but preference given to areas of analysis, operations research or applied statistics. A Computer Science Option is offered within the department. Computer experience is desirable. Rank and salary are negotiable/competitive. Send resume, transcripts, and 3 letters of recommendation to: Dr. Ronald Roubal, Division of Sciences and Mathematics, University of Wisconsin-Superior, Superior, WI 54880. Applications will be considered until the positions are filled. AA/EO Employer.

VICTORIA UNIVERSITY OF WELLINGTON
LECTURESHIP IN MATHEMATICS

Applications are invited for a lectureship in the Department of Mathematics available from 1 October 1988.

Expertise in combinatronics or algebra is particularly sought, but applications in all areas of pure mathematics will be treated on merit. The appointee will be expected to engage in research, and teach at all levels.

Enquiries to Professor R. Goldblatt, Chairperson, Department of Mathematics, tel. (04)721-000.

The salary scale for lecturers is $NZ32,000-$NZ38,500 per annum.

Conditions of appointment and method of application available from the Administrative Assistant (Appointments), Victoria University of Wellington, PO Box 600, Wellington, New Zealand, with whom applications close on 31 July 1988.

POSITIONS AVAILABLE

Department of Mathematics
University of Alberta

Applications are invited for the position of Research Associate or Postdoctoral Fellow for one year. The appointment may be extended if funding is available. The successful candidate will be expected to participate in the Applied Mathematics Institute. Requirements are a Ph.D. in Applied Mathematics or Computer Science. Candidates with active research interest in scientific computing and fluid dynamics are particularly encouraged to apply. Salary will be commensurate with qualifications and experience, and will be within the range of $30,000–$35,000 per annum.

Send vitae and arrange for three letters of reference to be sent to: Professor L. Erbe, Chairman, Department of Mathematics, University of Alberta, Edmonton, Canada, T6G 2G1. The University of Alberta is committed to the principle of equity in employment, but in accordance with Canadian Immigration requirements, priority will be given to Canadian citizens and permanent residents. Closing date for applications is August 1, 1988 or when position is filled. Please refer to File AMD2C when responding to this advertisement.

The Department of Mathematics is actively seeking applications in the area of computational mathematics and numerical analysis. We anticipate making several tenure-track appointments at the assistant professor level or above beginning in the fall of 1989. A Ph.D. is required. Applications will be reviewed as they are received and will be accepted until the positions are filled. A formal letter of application expressing interest, a resume, and the names, addresses, and telephone numbers of three references should be sent to Chairman, Numerical Analysis Search Committee, Department of Mathematics, Virginia Tech, Blacksburg, VA 24061-0123. Virginia Tech is an Equal Opportunity/Affirmative Action Employer.

Applications and nominations are invited for the position of Head of the Department of Mathematics and Astronomy at the University of Manitoba. The Department consists of 27 mathematicians and two astronomers and offers undergraduate programs in both mathematics and astronomy, and graduate programs in mathematics. The term of a Head in the Faculty of Science is normally five years.

The academic appointment will be at a rank and with a salary consistent with qualifications and experience.

The successful candidate will be able to provide effective leadership to a department that is strong in both teaching and research.

Applications should be received by September 15, 1988, and the appointment will take effect July 1, 1989.

Responses from both women and men are encouraged. In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents.

C. C. Bigelow, Dean
Faculty of Science
250 Machray Hall
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KNOX COLLEGE
DEPARTMENT OF MATHEMATICS
AND COMPUTER SCIENCE
GALESBURG, IL 61401

Tenure track position at the assistant professor level beginning Sept. 88. Candidates must have a Ph.D. in Mathematics and a commitment to excellence in teaching and continued scholarly development. Ability to teach computer science at the introductory level is desirable. Preferred fields are analysis, topology, or geometry. Salary is competitive. Teaching load is two courses per term for each of three terms. Send letter of application, resume, graduate transcript, and three letters of recommendation to Dennis M. Schneider, Chair.

Knox is an EO/AA employer and encourages applications from women and minority candidates.

Texas Christian University
Department of Mathematics

Lecturer in mathematics: one-year appointment for Academic Year 1988-89. Duties: to teach 3 introductory-level mathematics courses per semester. Ph.D. in mathematics required; previous college-level teaching experience desirable. Send letter of application, resume, and names of 3 references to: Victor A. Belfi, Chairman, Department of Mathematics, P.O. Box 32903, Ft. Worth, TX 76129. Deadline for applications is June 15, 1988. TCU is an AA/EOE.

University of Wisconsin-Parkside

Visiting assistant professor of mathematics for Fall 1988. One-year appointment with the possibility of renewal. Ph.D. in mathematics and evidence of good teaching and research ability required. Affirmative consideration will be given to women and minority candidates. Send vita and three letters of reference to N. Wielenberg, Chairman Mathematics Recruitment, University of Wisconsin-Parkside, Box No. 2000, Kenosha, Wisconsin 53141. Applications accepted until position is filled.

AMERICAN UNIVERSITY

A tenure track position is available at the rank of Assistant Professor beginning in Fall, 1988 in the Department of Mathematics and Statistics.

Qualifications: A Ph.D in Mathematics Education; evidence of teaching, scholarship and University service.

Responsibilities: Graduate teaching, advising, curriculum development, scholarship and University service.

Salary competitive, commensurate with qualifications and experience. Send curriculum vitae and three letters of recommendation to Austin Barron, Chair, Department of Mathematics and Statistics, The American University, Washington, DC, 20016. An EEO/AA University; minority and women candidates are encouraged to apply.

POSITIONS AVAILABLE

University of Puerto Rico
HUMACAO UNIVERSITY COLLEGE
DEPARTMENT OF MATHEMATICS
Humacao, Puerto Rico 00661

The Department of Mathematics of the Humacao University College has two tenure track positions available at the Assistant Professor level. One of the positions requires a Ph.D. in Mathematics with a strong background in statistics or applied Mathematics. A Ph.D. in Mathematics with significant experience teaching Computer Science courses or a Ph.D. in Computer Science is required for the other position. EOE/AA.

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UNIVERSITY OF WAIKATO

Hamilton, New Zealand

CHAIR OF MATHEMATICS

The University of Waikato invites applications from suitably qualified persons for the established Chair in the Department of Mathematics, which becomes available following the resignation of Professor R. J. Hosking. Applicants should have expertise in one or more fields of Pure Mathematics, Applied Mathematics, or Statistics.

The Department of Mathematics has the equivalent of 14 full-time academic staff members, with research interests covering a wide range of disciplines. It is one of the two main Departments in the new School of Computing and Mathematical Sciences, which offers a four-year, professions-oriented first degree. The Department has approximately 2,000 course enrolments at undergraduate and graduate levels, its work encompassing both service and mainstream components in the various degrees of all the Schools in the University.

The appointee will be expected to provide academic and professional leadership, exert a strong influence on the development of teaching programmes, stimulate research activity in the Department, and strengthen links between the University and the community. The appointee may be required to serve as Chairperson of Department or Dean from time to time.

Essential requirements are advanced academic qualifications with a strong research record, and extensive teaching experience.

The range of salaries for professors in New Zealand Universities is NZ$68,000—NZ$85,000 per annum.

Information on the conditions of appointment and details of the method of application are available from the Secretary General, Association of Commonwealth Universities (Appts), 36 Gordon Square, London WC1H OPF, or from the Registrar, University of Waikato, Private Bag, Hamilton, New Zealand. The Reference is A88/5. Applications close on **30 June 1988**.

Equality of employment opportunity is University policy.

The Joy of TeX

A Gourmet Guide to Typesetting with the AMS-TeX macro package

M. D. SPIVAK

The Joy of TeX is the user-friendly user's guide for AMS-TeX, an extension of TeX, Donald Knuth's revolutionary program for typesetting technical material. AMS-TeX was designed to simplify the input of mathematical material in particular, and to format the output according to any of various preset style specifications.

There are two primary features of the TeX system: it is a computer system for typesetting technical text, especially text containing a great deal of mathematics; and it is a system for producing beautiful text, comparable to the work of the finest printers.

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This book is designed as a user's guide to the AMS-TeX macro package and details many features of this extremely useful text processing package. Parts 1 and 2, entitled "Starters" and "Main Courses," teach the reader how to typeset most normally encountered text and mathematics. "Sauces and Pickles," the third section, treats more exotic problems and includes a 60-page dictionary of special TeXniques.

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40 Sequences, series, summability
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83 Relativity
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*Minimum dues for **contributing members** are $132.*

*For either **students** or **unemployed individuals,** dues are $22, and annual verification is required.*

*The annual dues for **reciprocity members** who reside outside the U.S. and Canada are $44. 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 ($66 or $88).*

*The annual dues for **external members**, those who reside in developing countries which do not have any mathematical society, are $47.*

*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 either unemployed or student members.*

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(N.B.: A separate form appears in this issue for preregistration for MAA Minicourses)

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(date)

☐ PLEASE CHECK HERE IF YOU WILL **NOT** REQUIRE A ROOM

☐ PLEASE CHECK HERE IF YOU WILL BE STAYING AT A HOTEL/MOTEL NOT LISTED ON THE REVERSE

Please complete the appropriate sections on the reverse for housing and travel.

HOUSING SECTION:

PLEASE COMPLETE "HOTELS" OR "UNIVERSITY HOUSING" AND TRAVEL SECTIONS BELOW:

HOTELS

Please rank hotels in order of preference by writing 1 or 2 in the spaces at the left on form, and by circling the requested room type and rate. If the rate requested is no longer available, you will be assigned a room in the next hotel. Rates listed below are subject to 10% local tax.

GUARANTEE REQUIREMENTS: $50 by check **OR** a credit card guarantee with VISA, MasterCard, or American Express (for housing only). No other credit cards will be accepted. PLEASE SUPPLY THIS INFORMATION ON THE REVERSE, together with mailing address for confirmation of room reservation.

Order of choice		Single	Double	Twin double	Triple 2 beds	Triple 2 beds w/cot	Quad 2 beds	Quad 2 beds w/cot	Suite
		$	$	$	$	$	$	$	$
	Omni Biltmore (Headquarters Hotel)	70	80	80	80	95	80	95	150
	Holiday Inn	65	65	65	65	71	65	71	135

I will arrive on (date) ________ at ________ a.m./p.m., and depart on (date) ________ at ________ a.m./p.m.

Please list other room occupants; indicating ages of children.

FULL NAME ARRIVAL DATE DEPARTURE DATE

____

____

UNIVERSITY HOUSING

NOTE: Full prepayment for room and board is required. Please make checks payable to AMS. Canadian checks must be marked "In U.S. Funds". VISA and MasterCard credit cards will also be accepted. Confirmation of residence hall reservations will be sent to address indicated on reverse.

Please circle applicable rates (per person) listed below for each day and enter totals in column at far right:

	Adults	Children* under 7 years in bed	Child 7 years and older in sleeping bag	Child under 7 years in sleeping bag	**Enter your total rate per day**
8/5	$22.20 single $17.70 double	$22.20 single $17.70 double	No charge	No charge	
8/6	$22.20 single $17.70 double	$22.20 single $17.70 double	No charge	No charge	
8/7	$27.00 single $22.50 double	$24.60 single $20.10 double	$4.80 single $4.80 double	$2.40 single $2.40 double	
8/8	$27.00 single $22.50 double	$24.60 single $20.10 double	$4.80 single $4.80 double	$2.40 single $2.40 double	
8/9	$27.00 single $22.50 double	$24.60 single $20.10 double	$4.80 single $4.80 double	$2.40 single $2.40 double	
8/10	$27.00 single $22.50 double	$24.60 single $20.10 double	$4.80 single $4.80 double	$2.40 single $2.40 double	
8/11	$27.00 single $22.50 double	$24.60 single $20.10 double	$4.80 single $4.80 double	$2.40 single $2.40 double	
8/12	$22.20 single $17.70 double	$22.20 single $17.70 double	No charge	No charge	
*There is no charge for infants in arms. **Total for Residence Hall Package =**					

Please list other room occupants; indicating ages of children.

FULL NAME ARRIVAL DATE DEPARTURE DATE

____

____

TRAVEL SECTION: Flight information is mandatory for those purchasing airport transfers.

I plan to arrive by plane on ________ (airline/flight#) scheduled to arrive at ________ Airport on ________ (date) at ________ a.m./p.m.

I plan to depart by plane on ________ (airline/flight#) scheduled to leave at ________ Airport on ________ (date) at ________ a.m./p.m. ☐ I plan to drive to the meeting ☐ I will need a parking sticker for the Brown University campus

For office use only:

Codes:	Options:	Hotel:	Room type:	Dormitory:	Room #:
Dates:	Hotel Deposit	Dormitory Payment	Total Amt. Paid:		
Special Remarks:					

MAA Minicourse Preregistration Form, Providence, Rhode Island

August 8–12, 1988

NOTE: This is not an AMS Short Course Form. Please use the AMS Centennial Celebration Pregistration/Housing Form to preregister for the AMS Short Course.

To register for MAA Minicourse(s), please complete THIS form and return it with your payment to:

Susan Wilderson
Mathematical Association of America
1529 Eighteenth Street, N.W.
Washington, DC 20036
Telephone: 202-387-5200

____ Telephone: ________________

(Please print) Surname First Middle

____

Street address City State Zip

- Deadline for MAA Minicourse preregistration: June 1, 1988
- Deadline for cancellation in order to receive a 50% refund: August 4, 1988
- Each participant must fill out a separate Minicourse form.
- Enrollment is limited to two Minicourses, subject to availability.
- Please complete the following and send both form and payment to Susan Wilderson at the above address:

  I would like to attend ☐ 1 Minicourse ☐ 2 Minicourses

  Please enroll me in MAA Minicourse(s): #__________ and #__________

  In order of preference, my alternatives are: #__________ and #__________
- PAYMENT

  Check enclosed: $ __________

  Credit card type: ☐ MasterCard ☐ Visa

  Credit card # ____________________________ Expiration date: ________________

  ____________________________ ____________________________

  Your Employing Institution Signature (as it appears on credit card)

Minicourse Number and Name	Organized by	Fee
1. **EXP**. **EXP**Test, and the creation of testbanks	Peter Frisk	$50
2. Contributions of algebraic coding theory to finite geometry	E. F. Assmus, Jr. & J. D. Key	$30
3. A survey of educational software	David P. & Vivian Kraines	$50
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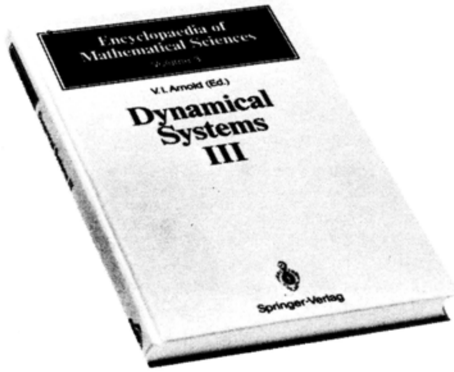
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