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Calendar of AMS Meetings

THIS CALENDAR lists all meetings which have been approved by the Council 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 yet 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 headquarter's 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.

MEETING #	DATE	PLACE	ABSTRACT DEADLINE	ISSUE
831	January 21–24, 1987 (93rd Annual Meeting)	San Antonio, Texas	EXPIRED	January
832	March 26–28, 1987	Honolulu, Hawaii	February 2	February
833	April 3–4, 1987	Kent, Ohio	February 4	February
834	April 25–26, 1987	Newark, New Jersey	February 6	February
835	June 18–20, 1987	Tacoma, Washington	April 17	June
836	August 5–8, 1987*	Salt Lake City, Utah		
	January 6–9, 1988 (94th Annual Meeting)	Atlanta, Georgia		
	August 8–12, 1988 (AMS Centennial Celebration)	Providence, Rhode Island		
	January 11–14, 1989 (95th Annual Meeting)	Phoenix, Arizona		

* Preregistration/Housing deadline is June 1.

DEADLINES

Advertising	(*Feb.* 1987 *Issue*) *Feb.* 18, 1987	(*Apr.* 1987 *Issue*) *Mar.* 23, 1987	(*June* 1987 *Issue*) *Apr.* 29, 1987
News/SMIC	(*Feb.* 1987 *Issue*) *Feb.* 2, 1987	(*Apr.* 1987 *Issue*) *Mar.* 5, 1987	(*June* 1987 *Issue*) *Apr.* 13, 1987

Other Events Sponsored by the Society

January 20–22, 1987, AMS Short Course: The Moment Problem, San Antonio, Texas. Details: This issue.

February 18, 1987, Symposium on Some Mathematical Questions in Biology: Models in Population Biology, Chicago, Illinois. Details: This issue.

April 30–May 9, 1987, AMS-SIAM Summer Seminar on Computational Aspects of VLSI Design with an Emphasis on Semiconductor Device Simulation, University of Minnesota, Minneapolis. Details: This issue.

May 12–16, 1987, Symposium on the Mathematical Heritage of Hermann Weyl, Duke University, Durham, North Carolina. Details: This issue.

June 14–July 25, 1987, Joint Summer Research Conference in the Mathematical Sciences, University of Colorado, Boulder, Colorado. Details: This issue.

July 12–August 15, 1987, Joint Summer Research Conference in the Mathematical Sciences, Cornell University, Ithaca, New York. Details: This issue.

July 6–24, 1987, Summer Research Institute on Theta Functions, Bowdoin College, Brunswick, Maine. Details: This issue.

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Notices
of the American Mathematical Society

Volume 34, Number 1, January 1987

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Notices: highlights

Susan Landau, in her special article "Factoring Polynomials Quickly," gives a historical account of factoring polynomials into irreducibles over the rationals. Beginning with the historical events concerning the feasibility of factorization and the complexity of the algorithms, she brings the reader through the current literature to the fast algorithms and symbolic computation programs that now exist. Page 3.

Supercomputers are becoming indispensable as a tool in some areas of mathematics research. Recognizing their value, the NSF has put together a system of supercomputing centers and a network which connects these centers to many educational institutions across the country. This article describes some of the characteristics of these powerful machines and the ways the researcher can access the facilities. Page 9.

Richard S. Palais, in his column, introduces Part I of the Report by the Boston Computer Society on Technical Wordprocessors for the IBM PC and Compatibles: TWP and People Needs. This is not a review of individual software packages, but a complete, well-organized, and interesting account of the trends in technical word processing. Page 15.

Kenneth Hoffman, in his Washington Outlook column, examines the activities currently taking place across the country with respect to mathematics education. He describes the activities of the newly formed Mathematical Sciences Education Board and stresses the need for an involved mathematics community. Page 33.

NSF Budget for the Mathematical Sciences Division has been approved at the level originally requested. This translates into $59.8 million, or a 15.5% increase in their budget. Page 36.

San Antonio Meeting in January will have an outstanding scientific program, including the Gibbs Lecture by Thomas C. Spencer, the Colloquium Lecture by Peter D. Lax, and seven AMS Invited Addresses. In addition, there will be twelve Special Sessions in a broad range of mathematical areas. The topic for this year's Short Course is "Moments in Mathematics." Page 49.

Factoring Polynomials Quickly

Susan Landau

Computer science has a way of reaching back to the origins of mathematics: arithmetic and computations. Finding primes, factoring integers—the old problems recur. This is the story of another: factoring polynomials into irreducibles over the rationals. The question of computability was answered centuries ago, but an efficient solution was arrived at only recently.

The problem has a venerable history: Isaac Newton tried his hand at it, and saw a way to find linear and quadratic divisors. In 1793, Friedrich von Schubert, an astronomer, generalized Newton's technique and determined all factors.

Von Schubert's idea was to calculate $f(1)$, $f(2), \ldots, f(n)$, where n is the degree of $f(x)$, the polynomial in question. Then factor the $f(i)$. If $d(1), d(2), \ldots, d(n)$ is a particular sequence of divisors of $f(1), \ldots, f(n)$, then the $d(i)$ define a potential factor of $f(x)$, one which can easily be found by interpolation. The complete factorization of $f(x)$ can be determined in this way.

Von Schubert's technique would satisfy logicians—it shows that the question is decidable—but not someone who really wanted to factor. It's too slow. The algorithm requires at least 2^n steps to show that a polynomial of degree n is irreducible. It is infeasible for factoring polynomials of degree 20 or more. The issue is complexity: how long must a factoring algorithm take?

Computer scientists believe that polynomial time solutions—algorithms which take a polynomial number of steps in the size of the input—are the only feasible kind. Von Schubert's algorithm is exponential in the degree of the polynomial.

Actually there are two parts which contribute to a polynomial's size: its degree, and the number of bits needed to express its coefficients. Considering first the degree, there are two possible measures for univariate polynomials: the sparse notation, in which '$x^n - 1$' would be written as $(1, n; 0, -1)$, taking $O(\log\ n)$ bits, and the dense, in which the same polynomial would be $(1, 0, 0, \ldots, 0, -1)$, requiring $O(n)$ bits. Since a polynomial of degree n may have as many as n factors, the more natural dense notation has been accepted as the 'right' measure of a polynomial's size.

As for the coefficients, suppose $f(x) = f_n x^n + \cdots + f_1 x + f_0$. Then if $g(x)$ is a factor of $f(x)$ of degree m, the ith coefficient of $g(x)$ is less than $\binom{m}{i}(\sum_{i=0}^{n} f_i^2)^{1/2}$. (We will denote $(\sum_{i=0}^{n} f_i^2)^{1/2}$ by $|f(x)|$.) This means that $g(x)$ may be expressed in a number of bits that is polynomial in the size of $f(x)$, and since there are at most n factors of $f(x)$, a complete factorization can be written down in polynomial space. In theory, at least, a polynomial time solution to the polynomial factorization problem is possible.

Certain parts of the problem are easy. For example, it has long been known how to pull out multiple factors of a polynomial. Suppose $f(x)$ has an irreducible factor, $g(x)$, of multiplicity k. Then $g^{k-1}(x)$ divides the $\gcd(f(x), f'(x))$ (while $g^k(x)$ does not). The gcd is quickly computed by the subresultant version of the Euclidean Algorithm, which also avoids any coefficient blowup. Instead

This article is the sixteenth in the series of Special Articles published in *Notices*. The author, Susan Landau, is an assistant professor of computer science at Wesleyan University. She received her Ph.D. from M.I.T.; her thesis gave a polynomial time method for determining solvability by radicals. Her research interests include computational complexity and algebra.

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 *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.

of factoring $f(x)$, one factors

$$\frac{f(x)}{\gcd(f(x), f'(x))}$$

and $\gcd(f(x), f'(x))$. Iterating this procedure means that only squarefree polynomials need be factored.

If you can't factor polynomials over the rationals, why not try factoring over smaller fields? In 1967 Berlekamp discovered deterministic and probabilistic methods to factor squarefree polynomials mod p. Sometime later Rabin created an even simpler version of the probabilistic algorithm with expected running time of $O(n^3 \log p)$ steps for factoring a squarefree polynomial of degree n. Meanwhile Zassenhaus countered with Hensel's Lemma (which explains how to lift a squarefree factorization mod m to one mod m^2). Zassenhaus's idea was to factor a polynomial over the integers by first factoring over a suitable prime modulus (one which does not divide the discriminant of the polynomial, and thus keeps $f(x)$ squarefree mod p), then raising that to a factorization mod p^2, then mod p^4, and so on ... until the modulus was large enough—though still polynomial sized in terms of the original problem—to lift to a factorization over the integers. Consider

$$\begin{aligned} f(x) &= x^4 - 8x^3 + x^2 - 24x - 6 \\ &= (x^2 + 2x + 3)(x^2 + 3) \qquad (\text{mod } 5) \\ &= (x^2 - 8x - 2)(x^2 + 3) \qquad (\text{mod } 25) \\ &= (x^2 - 8x - 2)(x^2 + 3) \qquad (Z) \end{aligned}$$

It's a good idea, and it works well much of the time. Difficulties arise because polynomials may have a finer factorization in Z/pZ than they do in Z, and the ensuing problem of combining factors mod p to determine factors in Z may be costly. For certain polynomials, it's a disaster. Swinnerton-Dyer pointed out one such: the polynomial whose roots are $\pm\sqrt{2}\pm\sqrt{3}\pm\cdots\pm\sqrt{p_n}$, where p_n is the nth prime. This polynomial factors into either linear or quadratic polynomials mod m for any modulus m one might choose, yet it is a polynomial which is irreducible over the integers. To discover its irreducibility, one must look at all possible combinations of mod m factors, an exponential nightmare. The class of polynomials which raise difficulties like this is small—essentially those with 'nice' Galois groups—and so, despite its worst-case exponential running time, Berlekamp-Hensel became the factoring algorithm of choice during the 1970s.

Other classic problems fell into polynomial time, yet polynomial factorization remained stubbornly exponential. Pieces were chipped away: Weinberger showed that under the assumption of the Extended Riemann Hypothesis, one could test irreducibility in polynomial time, and Cantor showed that—ERH or no—irreducible polynomials have short proofs of that fact. Cantor and Zassenhaus gave a new, improved mod p factoring routine. The central question, however, of how to avoid the exponential increase which arose from looking at combinations of mod p factors remained.

Suppose p does not divide the discriminant of $f(x)$, and $h(x)$ is an irreducible factor of $f(x)$ in Z/pZ. One approach is to consider the unique factor of $f(x)$ in Z which $h(x)$ divides (which exists since $f(x)$ is squarefree in Z/pZ). Call it $h_0(x)$. The issue then, is to efficiently determine $h_0(x)$ from $h(x)$.

It was classical mathematics which provided the tool: Minkowski lattices. Lattices are simple generalizations of Z^n, but they are the key to important theorems, and now, to important algorithms. Hendrik Lenstra introduced them into computer science with an elegant polynomial time solution for integer linear programming with a bounded number of variables.

Let $b_1, b_2, \ldots, b_n$ be a set of linearly independent vectors in Z^n. Then the n-dimensional lattice $L \in Z^n$ with basis b_i is the set of integral linear combinations of the b_i. Several natural questions immediately arise: Given a basis of a lattice, how does one quickly determine an orthogonal one? How does one find short vectors? Is there a fast algorithm for determining the shortest vector in a lattice?

It was this last question which Lenstra answered for fixed dimension in 1981. Shortly afterwards Lovász found a polynomial time basis reduction algorithm which computes, among other things, a nonzero basis vector b such that $|b| \leq 2^{(n-1)/2}|x|$ for all nonzero vectors x in the lattice L. Arjen Lenstra, Hendrik Lenstra and Lovász (hence L^3) combined ideas to create a polynomial time polynomial factorization algorithm.

The L^3 algorithm builds an m-dimensional lattice L whose vectors are polynomials in x determined by $h(x)$, an irreducible factor of $f(x)$ mod p . (Recall that $h(x)$ determines $h_0(x)$, a unique irreducible factor of $f(x)$ in $Z[x]$.) If $h_0(x)$ is of degree m then it will be found by the Lovász basis reduction algorithm, since any vector in L which is linearly independent of $h_0(x)$ will be $2^{m/2}$ times longer than it. The proof of this fact is surprisingly simple, and we present it here. However we omit the proof that basis reduction can be done quickly, and instead refer the interested reader to the original paper. Note that the bounds we show are less than optimal, and are chosen for the sake of a simpler argument.

Let the polynomial to be factored be $f(x) \in Z[x]$, and suppose that it is primitive (which means that the gcd of its coefficients is 1), squarefree and of degree n. Factor $f(x)$ mod p, where p is chosen so that $p \nmid \text{disc}(f(x))$. (One can find such a p which will be polynomial size in n

and $|f(x)|$.) Pick an irreducible factor of $f(x)$ in Z/pZ, say $h(x)$ of degree l ($l < n$). Now raise the factorization to one mod p^k (where k is chosen so that $p^k \geq (2^{n/2}\binom{2n}{n}|f(x)|^2)^n$), using Hensel lifting, and let $\tilde{h}(x)$ be the image of $h(x)$. We will find $h_0(x)$, the unique irreducible factor of $f(x)$ in $Z[x]$ which $\tilde{h}(x)$ divides.

We assume $h_0(x)$ has degree m. Define a lattice with basis as follows: $b_i = p^k x^i$ for $0 \leq i < l$, and $b_i = \tilde{h}(x)x^{i-l}$ for $l \leq i \leq m$. Now if we think of the polynomials as vectors, with the coefficient of x^i as the the $(i+1)$st coordinate, then the b_i are linearly independent, since they form an upper diagonal matrix.

But since $h_0(x)$ is a factor of $f(x)$, we have that

$$|h_0(x)| \leq \binom{2m}{m}^{1/2}|f(x)| \leq \binom{2n}{n}^{1/2}|f(x)|.$$

Remember that k was chosen to satisfy $p^k > (2^{n/2}\binom{2n}{n}|f(x)|^2)^n$. It is clear that $h_0(x)$ is in the lattice, and we claim that any vector of L which is linearly independent of $h_0(x)$ is $2^{m/2}$ times longer than $h_0(x)$. Thus $h_0(x)$ can be determined by the basis reduction algorithm.

We prove the claim. Let $g(x)$ be any element of L which is linearly independent of $h_0(x)$. Then $\gcd(g(x), h_0(x)) = 1$ in $Z[x]$. Thus the polynomials $h_0(x)x^i$, $0 \leq i < \deg(g(x))$, and $g(x)x^j$, $0 \leq j < \deg(h_0(x))$, are linearly independent. Consider the resultant, R, of $h_0(x)$ and $g(x)$. By Hadamard's inequality and the fact that the degree of $g(x) \leq m$, we have

$$\det(R) \leq |h_0(x)|^m |g(x)|^m.$$

Now $\tilde{h}(x)$ divides both $h_0(x)$ and $g(x)$ modulo p^k, since both polynomials are elements of L. In particular, $\det(R)$ must be zero modulo p^k. But because $R \neq 0$, we know that $p^k \leq \det(R)$. Then $|g(x)| > 2^{n/2}\binom{2n}{n}^{1/2}|f(x)|$, thus proving the claim.

The polynomial $h_0(x)$ has degree between l and n, the degree of $f(x)$, so that the basis reduction algorithm to determine $h_0(x)$ from $h(x)$ is done at most n times. As mentioned earlier, one can pick bounds somewhat more carefully, in which case the L^3 algorithm takes $O(n^{9+\epsilon} + n^{7+\epsilon}|f(x)|)$ steps to factor $f(x)$ (for any $\epsilon > 0$).

Randomness is central to computer algorithms. It can mean an exponential speedup for an algorithm, as in the Solovay–Strassen primality test, which is an $O(n)$ deterministic algorithm, and an $O(\log n)$ probabilistic one. Many cryptographic schemes rely on random bits. In a certain sense, the roots of polynomials are not random. If an approximate root of an integer polynomial is given, along with a bound on the degree and coefficient size of its minimal polynomial, then in polynomial time, the minimal polynomial can be determined. Therein lies another factoring scheme.

In particular, if $f(x)$, a monic polynomial over Z is given, a root α of $f(x)$ can be approximated in polynomial time. The lattice algorithm can then be used to determine $g(x)$, the minimal polynomial of α. Of course, $g(x)$ is a factor of $f(x)$. This variant of the L^3 algorithm was discovered by Kannan, Arjen Lenstra, and Lovász, and independently by Schönhage. Its running time is identical to that of L^3.

Arjen Lenstra generalized the L^3 algorithm to a variety of situations: for algebraic number fields, for multivariate polynomials over finite fields, fields of characteristic p, and for Q. A number of others, including von zur Gathen, Kaltofen, Trager, Landau, Chistov, and Grigoriev, used different techniques to also find polynomial time solutions for diverse factoring problems.

Before L^3, Arjen Lenstra had seen a connection between lattices and factorization over algebraic number fields; after L^3 he gave a polynomial time method for factoring a monic polynomial $f(x)$ in $Q(\alpha)[x]$, where α satisfies a monic irreducible polynomial, $g(t)$, over Q. The technique is the same as for L^3: determine a factorization of $f(x)$ over a finite field (in this case, $Z[t]/(p, H(t))$, where $g(t)$ is squarefree in Z/pZ and $H(t)$ is one of its irreducible factors in that field), extend to a factorization over an appropriate ring ($Z[t]/(p^k, H(t))$ for a large enough k), and use basis reduction to factor. The details are messy, and we will not present them.

In some ways though, Kronecker had everyone beat by a century. In 1882, he proposed using norms for factoring polynomials over algebraic number fields. The idea is simple. Again let $f(x)$ be a squarefree polynomial of degree n in $Q(\alpha)[x]$, where α satisfies $g(t)$, an irreducible monic polynomial of degree m over Z. One can view the polynomial $f(x)$ as a polynomial in x and α or, equivalently, in x and t. We define the $\text{Norm}_{Q(\alpha)/Q}(f(x)) = \prod f(x, \alpha_i)$, where the product is over all conjugates, α_i, of α. We can compute it quickly since it is the $\text{Resultant}_t(g(t), f(x))$. Then if $F(x) = \text{Norm}_{Q(\alpha)/Q}(f(x))$, $F(x)$ is a polynomial in $Q[x]$ of degree mn. If it is squarefree and equal to $\prod_{i=1}^{r} f_i(x)$, where the $f_i(x)$ are irreducible in $Q[x]$, then $f(x) = \prod_{i=1}^{r} \gcd(f_i(x), f(x))$. As long as $f(x)$ is squarefree to begin with, one can always 'twiddle' the polynomial so as to ensure that $F(x)$ will be. Landau, building on work of Trager, showed that all these reductions can be performed in polynomial time. Thus one can factor over algebraic number fields in polynomial time using norms.

Multivariates present a multistranded story. Complicating the issue is size, for again there are several competing candidates. (For the moment we ignore the issue of the size of coefficents.) The 'dense' representation is the one

in which each coefficient of each monomial in $f(x_1, \ldots, x_n)$ of degree less than d is given; this takes $(d+1)^n$ terms. In practice, however, multivariate polynomials often omit a large number of terms. In that case it is more efficient to write $f(x_1, \ldots, x_n) = \sum_{d \in N^n} x_1^{d_1} \cdots x_n^{d_n}$ as $(f_d, d_1, \ldots, x_n)$, leaving out all zero coefficients f_d. This is the 'sparse' representation. Clearly $s_{\text{dense}}(f) \geq s_{\text{sparse}}(f)$; the gap may be exponential.

Early algorithms by Musser, and by Wang and Rothschild, proposed substituting integer values for all but one of the variables in $f(x_1, \ldots, x_n)$, then factoring and interpolating. Difficulties abound, the worst of which is that even if the original polynomial and its factors are sparse, the algorithm may suffer from exponential sized intermediate expressions. Zippel proposed a probabilistic algorithm for handling that. His idea was that each time a coefficient did not appear under a substitution, it was set to zero. Of course there are bad evaluation points, but Zippel's algorithm was set to make their probability small.

In 1981, Kaltofen showed that factoring a multivariate polynomial over Q with a bounded number of variables was polynomial time equivalent to factoring a bivariate polynomial, by transforming $f(x_1, \ldots, x_n)$ to

$$f(x, c_1 x^d, \ldots, c_{n-2} x^{d^{n-2}}, y),$$

where the c_i's and d are suitably large integers. In 1982, Kaltofen improved this to a polynomial time reduction to univariate factorization. At the same time, Arjen Lenstra showed that the L^3 algorithm could be used to factor multivariate polynomials with a fixed number of variables in a variety of settings in polynomial time. Chistov and Grigoriev independently discovered a number of similar polynomial time reductions.

What was needed was a way to handle polynomials with any number of variables, and a key was Hilbert's Irreducibility Theorem. The classic theorem states that over certain fields F, for any irreducible polynomial $f(x_1, \ldots, x_n)$ and for almost all (in the Lebesgue sense) $a_2, \ldots, a_n$ in F, the polynomial $f(x_1, a_2, \ldots, a_n)$ is also irreducible. The difficulty lies with the 'almost all'; a better bound is needed for an efficient algorithm. Different forms were found by Heintz and Sieveking, by von zur Gathen and by Kaltofen.

In 1983 von zur Gathen showed that the irreducibility of multivariate polynomials over an arbitrary (effectively computable) field can be determined in probabilistic polynomial time in s_{sparse}. Kaltofen and von zur Gathen found a fast—again probabilistic polynomial time—algorithm for the factorization of sparse multivariates with a bounded number of factors. In some sense, that was the best they could hope for, for sparse polynomials can have factors of more than polynomial length. Then von zur Gathen changed the rules of the game.

Von zur Gathen proposed straightline programs—code using only $+, -, \times$, and constants, and no loops or branch statements—as an appropriate measure for the multivariate factorization problem. The polynomial $x^5y^4 + 11y^8 + 17$ is described as:

```
a:=x*x;
a:=a*a;
a:=a*x;
b:=y*y;
b:=b*b;
a:=a*b;
b:=b*b;
b:=b*11;
a:=a+b;
answer:=a+17;
```

Kaltofen showed that, surprisingly, this straightline measure is robust under factorization. A sparse polynomial, input as a straightline program, can be factored in polynomial time. In some sense that settles the factorization question.

When you build a better mousetrap, it's important to remember the mouse. Almost all the algorithms described above have been implemented; how good are they?

Polynomial time factoring algorithms developed since L^3 have depended upon the lattice algorithm. The old Berlekamp-Hensel algorithm is exponential. Yet for many factoring problems, the practical algorithm is Berlekamp-Hensel. It's faster.

For univariates over Q, the L^3 algorithm requires at least $O(n^7 + n^4 \log |f(x)|)$ steps. Berlekamp-Hensel is almost always quicker on univariate polynomials. Berlekamp-Hensel runs into trouble only when the Galois group is 'nice', which is loosely defined as a permutation group on n elements which is small compared to S_n. Most—in a strong sense—irreducible polynomials do not have nice Galois groups. It is important to keep in mind, however, that the polynomials one might choose to factor are often not typical.

For multivariates, the direct lattice approach is generally to be avoided, although a recent variation by van der Hulst and Arjen Lenstra is good. They substitute a rational approximation of a transcendental number for one of the variables. This provides a faster algorithm for bivariate polynomial factorization than previously published methods.

Another situation in which lattices provide a good algorithm is for algebraic number fields. This is an early algorithm of Arjen Lenstra's which is practical (despite a worst-case exponential running time) because it avoids computations on algebraic numbers until it searches for the true factors.

And what happens in practice? MACSYMA, the workhorse of symbolic computation programs, uses Berlekamp-Hensel to factor univariate polynomials, and a variation of Wang's original al-

gorithm for multivariates. It's impressive; it factored

$$(x^{25} + x^{17} + 11x^5 + 12) \cdot (x^{26} + 47x^{18} + 19x^6 + 81)$$

in one minute on a VAX, and

$$(ax^3y^2 + bx^2y^3 + dfxy + 11) \cdot (a^3b^2e^4 + a^2b^3 + 3ab + 2) \cdot (abc^2y + abx + ac^2f^2 + 4) \cdot (abc^3d^2 + d^3xy^2 + dex^2y + 5)$$

—a polynomial with two hundred and fifty terms—in only fifteen seconds. What's theoretically slow can still be practically fast.

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Supercomputers and the NSF

Most scientific researchers have heard about the new supercomputers that can perform in minutes tasks that used to take weeks. Until recently, however, relatively few researchers have been able to use supercomputers, for they are costly, often difficult to access, and not easy to use. In 1984, the National Science Foundation (NSF) launched a supercomputer program designed to remove these obstacles and make supercomputers available to researchers in all scientific disciplines. In this article we will discuss what supercomputers are, who is using them, and how the NSF program works. While computers have not traditionally played a major role in mathematical research, the NSF's plan to create a unified, nationwide community of supercomputer users will provide an excellent forum for mathematicians to interact with researchers in all fields to exchange ideas, problems and solutions.

What are Supercomputers?

The term "supercomputer" can be nebulous because it refers to the fastest computer available at the time the term is used. Right now, however, the term is fairly specific, for it refers to computers that use two architectures not found in conventional computers. First, supercomputers use vector architecture or "pipelining," which can be understood as follows. Suppose a vector of data is given to a computer, and an instruction is to be performed on each component of the vector. A conventional "serial" computer would perform the entire instruction on each component in turn. But with pipelining, the instruction is broken into a sequence of shorter steps which can be performed simultaneously on different components of the vector, so that the instruction is executed more efficiently. In this way, pipelining is analogous to an assembly line. Pipelining is sometimes called SIMD (single instruction, multiple data) architecture, as opposed to the "serial" architecture of conventional computers, which is called SISD (single instruction, single data). Second, supercomputers utilize aspects of parallel or MIMD (multiple instruction, multiple data) architecture, which, when compared to a serial computer, is analogous to having several assembly lines that can build different objects. An array of processors accepts vectors of data with each processor performing different instructions. With these architectures, supercomputers are ideally suited to engineering and science applications, for they perform optimally on tasks requiring a few calculations on a large amount of data, or a complex series of calculations on a smaller set of preformatted numbers.

In 1978, Cray Research Incorporated introduced the first "vector" machine, the Cray 1, which performed roughly 10 times faster than the fastest machine before it. Control Data Corporation (CDC) introduced the Cyber 205 in 1981, and since then Cray and CDC have dominated the supercomputer market. In 1983, CDC created a new company, ETA Systems, to focus exclusively on supercomputers. ETA is now planning the ETA-10, a state-of-the-art, 8-processor vector-parallel machine which should appear sometime in 1987. While comparisons between supercomputers are often oversimplified and misleading—especially when one of them hasn't been built yet—the ETA-10 is predicted to be a substantial improvement over the Cyber 205. International Business Machines Corporation (IBM) entered the market more recently than CDC and Cray. One of IBM's ventures is a joint marketing agreement with Floating Point Systems (FPS) to sell the FPS-164 array processors attached to an IBM host computer for solving various simulation and modeling problems.

But the cost of a supercomputer, at \$5–20 million, has caused many to turn instead to concurrent or parallel processors, which are similar in concept to supercomputers. They consist of collections of powerful microprocessors that can work in concert on different parts of a single task. Concurrent processors are financially attractive because they are cheaper than supercomputers (\$200,000–1.5 million), and because additional microprocessors can be added to upgrade the system at a relatively low cost. They are generally slower than supercomputers, and there are many problems associated with them, such as coordinating the functions of the individual microprocessors and controlling the flow of data between them. But these are just the sorts of problems future supercomputers will pose—for most experts agree that parallel computing is the way of the future—so despite their slowness concurrent processors are often used for experimentation in parallel computing.

An outstanding problem with supercomputers (and with concurrent processors as well) is that software has not kept pace with hardware developments. Trying to use a supercomputer as if it were simply a more powerful serial computer

is likely to be a costly mistake, for programming a supercomputer usually requires a very different approach. To fully exploit the power of a supercomputer requires an understanding not only of how the problem at hand can be suitably broken into steps or "vectorized," but also of the machine's architecture and how well the particular algorithms and numerical techniques used suit that architecture. One must even understand how supercomputers made by different manufacturers vary in their suitability to a particular task. Supercomputer use requires a much greater involvement in all aspects of computing, and therefore demands an interdisciplinary approach.

Supercomputers in Research

Researchers in many fields are finding supercomputers indispensable to their work, particularly for "experimental theory" in which computers are used for simulation and experimentation. Particle physicists studying quantum chromodynamics have used supercomputers to illuminate the behavior of quarks, the components of protons and neutrons. Astrophysicists have created a new branch of their field called numerical relativity in which supercomputers model, for example, dust and gas spiraling into a black hole. In the field of plasma physics, supercomputers have led researchers to solutions of certain problems of fluid flow, though the problem of turbulence in plasmas still awaits more powerful computers. By modeling cold viruses, the propagation of cracks in metals, weather patterns, and even neurons in the brain, researchers have been able to visually examine and interpret these phenomena to confirm their intuition, recognize patterns, and gain new understanding.

The power of computers in science rests in their ability to bring the methods of mathematics to bear on scientific problems. Yet mathematics itself has not benefited as other sciences have from recent strides in computing capability. One reason is simply the nature of the field: as Jacob Schwartz of New York University's Courant Institute put it, "The mathematician is always interested in general principles and less in individual facts, which is why, of all the sciences, math has been the least influenced by computers." Another problem has been that, in the past, computers were not powerful enough for the purposes of many mathematicians.

However, with the dramatic increases in computing power over the last ten years, mathematicians have begun to explore the possible roles for computers in mathematics research. Some examples of recent computer-aided mathematics research are Louis de Branges's proof of the Bieberbach conjecture, Dennis Hejhal's work in number theory, Steven Orszag's work in turbulence and fluid dynamics, and Richard Ewing's work on mathematical models of reservoirs. Of course, a computer rarely provides a proof; it usually provide clues and confirms hunches that can guide the mathematician in the search for a proof or counterexample. They are often used for running preliminary checks to bolster confidence in a conjecture or to avoid wasting valuable time and energy. This psychological aspect should not be underestimated: as Stuart Geman of Brown University observed when discussing his use of computers, "It's far easier to prove a difficult theorem if you know it's true."

Mathematicians are also exploiting powerful new computer graphics to "see" and manipulate higher-dimensional geometric objects. Recent examples include the work of David Hoffman and William Meeks III on minimal surfaces, John Hubbard's work on Julia sets, and the work of Thomas Banchoff. Charles Peskin has recently used computer graphics to create a two-dimensional model of a human heart in order to improve the design of artificial heart valves. The model poses tough problems of fluid flow contained within elastic boundaries, and his three-dimensional simulations will require the power of a supercomputer. Again, while computer graphics cannot prove general theorems, they can greatly enhance the mathematical intuition leading to the formulation of conjectures, proofs, and counterexamples, and they can provide the heuristic hints needed to solve nonlinear problems. In these ways, computers can remove limiting mindsets, and their speed and versatility can make a mathematician more creative.

Supercomputers and the NSF

Oil and aerospace companies and government-sponsored national laboratories began using supercomputers in the late 1970s. The prices of the machines were beyond the budgets of most colleges and universities, so academic researchers wanting to use supercomputers had no recourse but to beg for time from the laboratories since few could pay the $1,000–$2,000 per hour user charges. Even after receiving permission to use the machines, they had to wait for security clearances usual in such laboratories, and then wait until the machines weren't busy with other tasks. This so-called "supercomputer famine" and the resulting dissatisfaction, together with the growing foreign threat to American dominance in the computer industry, prompted the NSF to reconsider its fifteen-year old decision to stop funding large computing facilities at universities. In 1984, the NSF launched a $200 million, five-year plan to make supercomputers available to academic researchers in all scientific disciplines. As part of the plan, the NSF has established five supercomputing facilities: the Center for Theory and Simulation in Science and Engineering (known as the Theory Center) at Cornell University; the San Diego Supercomputing Center (SDSC) at the University of California, San Diego; the

John von Neumann Center (JVNC) at Princeton University; the National Center for Supercomputing Applications (NCSA) at the University of Illinois at Urbana-Champaign; and the Pittsburgh Supercomputing Center (PSC), run jointly by the University of Pittsburgh, Carnegie-Mellon University, and Westinghouse Corporation.

To connect researchers to distant supercomputing facilities, the NSF is spending $6 million this year to develop a nationwide network called NSFnet. One of its main features is its "backbone," which will directly connect the five NSF supercomputing centers and the National Center for Atmospheric Research (NCAR). (NCAR is an NSF-sponsored laboratory that is a node on the NSF backbone because it brings much experience with supercomputers to the NSF project.) There are so many nationwide networks already operating, such as ARPAnet, BITnet, CSnet, and MFEnet, that the NSF decided not to build yet another network, but rather to integrate existing networks into a single interactive system, making NSFnet a "network of networks." Once completed, NSFnet will provide speedier access than is now available and will maintain a standard protocol to facilitate communications between computers. Using NSFnet, a researcher will be able to access a supercomputer, load programs, run batch and interactive jobs, receive output, transfer data files, and use electronic mail to communicate with colleagues across the nation, all from a desktop terminal. As Larry Smarr, director of the Illinois center, put it, "From a personal computer in the intellectual center, we will be able to play the supercomputer like an enormous pipe organ." (For more information on NSFnet and other existing networks, see "Computer Networking for Scientists," *Science*, 28 February 1986.)

Access to Supercomputers Facilities

There are several ways to gain access to the NSF supercomputers. The first and most basic way is the dial-up phone access to the NSF supercomputers, so that all you need is a modem and a terminal. Second, all the NSF centers will soon be accessible through ARPAnet, the Defense Advanced Research Projects Agency's nationwide computer network, and some are available through other nationwide networks. The NSF has entered into a memorandum of agreement with DARPA which provides for expansion of ARPAnet to up to forty new institutions. The third way is through the smaller networks that are affiliated with each node on the NSFnet backbone. All of the institutions in the JVNC and SDSC consortia have access to all five NSF supercomputers; the Pittsburgh Supercomputing Center is planning a similar consortium network. NCAR maintains a satellite network primarily for atmospheric researchers, and several institutions are directly connected to the Illinois supercomputing facility. The Theory Center at Cornell is in the process of establishing a "smart node" network, each node of which will be directly linked to the Cornell supercomputer and will serve as a funnel for neighboring institutions to the Cornell facility. The Theory Center is currently soliciting inquiries about joining the smart node network. (A list of the institutions in these consortia and networks follows this article.)

Finally, there are the five larger regional networks which the NSF has funded and which are presently under construction: MIDnet, which will connect eight midwestern universities; SESQUInet, which will connect six research institutions in Texas; New York State Education and Research network (NYSERnet), which will connect fifteen universities and industrial laboratories in New York state; the Bay Area Regional Research network (BARRnet), which will connect six California research institutions; and SURAnet, which the Southeastern Universities Research Association (SURA) is constructing to connect sixteen universities in the southeastern United States. (A list of the institutions to be on these regional networks follows this article.) These networks will provide access to the facilities at all five NSF supercomputing centers. The NSF's Division of Advanced Scientific Computing (DASC) is now encouraging proposals for joining these networks and for the construction of other regional networks.

Resources for Supercomputing

If you are considering using a supercomputer, one of the first questions that comes to mind is that of funding. The NSF will consider proposals either for research projects utilizing supercomputers, or just for supercomputing time. If you are already receiving an NSF grant, contact the director of the NSF program administering your grant; requests for 10–50 hours of supercomputing time are routinely approved at no cost to the program. For smaller projects, you can contact the centers directly. The NSF's Division of Advanced Scientific Computing can also provide supercomputing time and in any case is a good source of general and specific information. They can describe the focus of each center to help you to choose the center and machine best suited to your task.

The second question that probably comes to mind is that of learning to use a supercomputer. Each NSF supercomputer center offers short courses and training sessions about every three months, and in some cases NSF grants will cover the travel costs. While a visit to one of the centers is probably the best way to learn how to use the facilities, documentation (hard copy and on-line) and telephone consulting are available. If there are many users in a particular location, a center can send out a road team to train the users,

but the demand must be quite high. The consortium centers (JVNC at Princeton and SDSC at University of California, San Diego) comprise about forty institutions. Each institution has a local resource person who can provide help.

In addition, the NSF has held summer supercomputing institutes for the past two summers. As well as providing training in the basics of supercomputing, each institute had a particular focus. For example, the University of Minnesota's 1986 summer supercomputing institute emphasized astrophysical fluid flow, molecular dynamics, and algebraic manipulations, with the Institute for Mathematics and its Applications jointly conducting the final two weeks emphasizing computational algorithms and numerical techniques. These supercomputing institutes have reportedly been very successful and in high demand. As a result, their number rose from three to six from 1985 to 1986, and the number of participants rose from one hundred to two hundred. While established researchers will not be excluded, these institutes are primarily geared toward scientists beginning their research careers. Qualified participants can also receive a stipend and travel grant. The NSF should make plans by early 1987 for institutes in the summer of 1987.

Despite these efforts, help is sometimes hard to come by, for there is a serious shortage of qualified supercomputer experts, and many colleges and universities have called for more assistance on their own campuses. To compound the problem, many computer programs will need to be rewritten before they can take advantage of the power of a supercomputer. With all its difficulties, supercomputing is not for everyone, but its potential power is impossible to ignore. Yet this power can only be utilized in mathematics when mathematicians have envisioned a role for supercomputers in their research.

For general information regarding supercomputing and the NSF, contact: John W. D. Connolly, Division Director, Division of Advanced Scientific Computing, Room 533, National Science Foundation, 1800 G Street N.W., Washington, D.C. 20550. Telephone: (202)357-7558.

The following is a list of the NSF supercomputing centers, together with the type of machine at each center, people to contact for more information or to apply for time, and the institutions on the networks associated with each center. Included is a list of the institutions on the NCAR satellite network and on the regional networks.

Allyn Jackson

NSF Supercomputer Centers

Center for Theory and Simulation in Science and Engineering (Theory Center)
Cornell University
IBM 3090/4 with FPS array processors
Information:
Lawrence Lee (607)255-3985
Peter Seigel (607)256-4981
To apply for time:
Ann Redelff (607)255-8686
Pat Colasurdo (607)255-9405

Cornell Smart Node Network
Information:
Linda Morris (607)255-8686

Pittsburgh Supercomputing Center (PSC)
Cray X-MP/48
Information:
Vivian Benton (412)268-4960
To apply for time:
Bob Stock (412)268-4960

PSC Constituent institutions
Carnegie-Mellon University
University of Pittsburgh
Westinghouse Corporation

John von Neumann Center (JVNC)
Princeton University
Cyber 205 (with an upgrade planned to an ETA 10)
Information:
Joseph Traub (609)520-2000
To apply for time:
Ben Bryan (609)520-2000

JVNC Consortium Institutions
University of Arizona
Brown University
University of Colorado
Columbia University
Institute for Advanced Studies
Massachusetts Institute of Technology
New York University
Pennsylvania State University
Princeton University
University of Rochester
Rutgers University
Harvard University
University of Pennsylvania

San Diego Supercomputer Center (SDSC)
University of California, San Diego
Cray X-MP/48
Information:
C. Fox (619)534-5040
Wayne Pfeiffer (619)534-5120
To apply for time:
Dan Bender (619)534-5030

SDSC Consortium Institutions
Agouron Institute
University of California, Berkeley
University of California, Irvine
University of California, Riverside
University of California, Santa Barbara
California Institute of Technology
University of Maryland
University of Michigan
Salk Institute
University of California, San Diego
San Diego State University
University of California, San Francisco
Scripps Clinic and Research Foundation
Scripps Institute of Oceanography
Southwest Fisheries
Stanford University
University of California, Los Angeles
University of Utah
University of Washington
University of Wisconsin
National Optical Astronomical Observatories
University of Hawaii at Manoa

National Center for Supercomputing Applications (NCSA)
University of Illinois at Urbana-Champaign
Cray X-MP/24
Information:
Robert Wilhelmson (217)244-0072
To apply for time:
Robert Wilhelmson or Janus Wehmer (217)244-0072

Direct connections with NCSA
University of Chicago
Indiana University
Northwestern University
University of Illinois, Chicago

NCAR Satellite Network Nodes

Information:
Joseph Choy (303)497-1222
Colorado State University
University of Colorado
University of Illinois at Urbana-Champaign
University of Maryland
University of Miami
University of Michigan
Oregon State University
University of Washington
University of Wisconsin
Woods Hole Oceanographic Institution

Regional Networks

SURAnet Nodes
Information:
Glenn Ricart (301)454-4323
University of Delaware
University of Maryland
George Washington University
Virginia Polytechnic University
Triangle Universities Computing Center
(including *Duke, North Carolina State Universities*, and *University of North Carolina)*
Clemson University
University of Georgia
Georgia Institute of Technology
Florida State University
University of Alabama at Birmingham
Louisiana State University
University of Tennessee
University of Kentucky
West Virginia University

MIDnet nodes
Information:
Douglas Gale (402)472-5108
Iowa State University
University of Kansas
Kansas State University
University of Missouri at Columbia
University of Nebraska at Lincoln
University of Oklahoma
Oklahoma State University
Washington University

SESQUInet nodes
Information:
Guy Almes (713)527-4834
Baylor University
Houston Area Research Center
University of Houston
Rice University
Texas A&M University
Texas Southern University

Bay Area Regional Research Network (BARRnet) nodes
Information:
William Yundt (415)723-3909
University of California, Berkeley
University of California, Davis
University of California, San Francisco
University of California, Santa Cruz
NASA Ames Research Center
Stanford University

NYSERnet nodes
Information:
Bill Schrader (212)395-4480
State University of New York at Albany
State University of New York at Buffalo
City University of New York
Columbia University
New York University
Rensselaer Polytechnic Institute
Syracuse University
State University of New York at Binghamton
State University of New York at Stonybrook
Clarkson University

New Acquisition Editor

The Society is pleased to announce the appointment of Mr. Edwin F. Beschler as an acquisition editor with responsibility for seeking out new monographs and general books in mathematics for publication in various Society series. The position will supplement the activities of Professor Thomas F. Banchoff, previously appointed as an acquisition editor, and will provide, for mathematicians who wish to consider publishing with the American Mathematical Society, an additional professional contact as normally provided by commercial and university publishing houses. Mr. Beschler will report to the book editorial committees, which are charged by the AMS with publication decisions, and will be available for consultation on editorial, production, and marketing questions.

Mr. Beschler brings to this position twenty-five years of publishing experience with Academic Press, many of which were devoted to acquisitions in the mathematical sciences. He is currently Executive Vice President and Editorial Director of JAI Press in Greenwich, Connecticut. He can be contacted through the AMS office in Providence.

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One final point. On behalf of the mathematical community, the Society supports many vital functions which produce no income, or less income than they cost. It does this principally by using the revenue earned from its publications, which in another company might go to the stockholders. By publishing with the AMS you will be helping to support many activities beneficial to the entire mathematical community.

Mathematical Text Processing

Richard S. Palais

What follows is the promised article on technical word processing by members of the IBM PC Technical Special Interest Group of the Boston Computer Society. But in it you will *not* find the promised tables and reviews detailing features of the many different technical word processors for PC compatibles and comparing their performance on the BCS benchmarks. Fear not; you will get your fill of these in Part II of their article, which will appear in the next issue of *Notices*.

In fact, in Part I the discussion of TWP software is not even specific to the IBM PC family of machines. Rather it is a remarkably complete, well-organized, and interesting account of the entire burgeoning field of technical word processing. As such there is, of course, some overlap with my earlier articles. But while I have concentrated on questions most directly of interest to individual mathematicians, who want to use a word processor as an aid in doing and communicating their own mathematical research, the BCS group has taken a far wider perspective. They have looked not only to issues that affect individual users, but also into the important compatibility problems that arise when many different users in an organization will be employing the same documents or software, but in different ways and for differing purposes. Moreover they have kept the *developers* of software in mind as well as the users. And they consider everything from an informal memo to a complete technical book; a far wider variety of documents than the research paper that was always at the back of my mind. Finally, their article has the most balanced discussion I have yet seen of the prickly user interface question, and in particular of the relative merits of a markup language versus a WYSIWYG approach.

It is clear that the authors did this as a labor of love, but it is just as clear that the effort involved was enormous, and I would like to express thanks to them for an important public service well done.

Technical Wordprocessors for the IBM PC and Compatibles, Report by the Boston Computer Society Part I – TWP Capabilities and People Needs

Richard Goldstein, James Loomis, and Avram Tetewsky

The authors wish to thank Curtis Deno and Al Cameron for their comments and suggestions. However, this report does not necessarily reflect their opinions.

I. Introduction

The value of scientific or engineering work depends largely on the sharing of information within an organization or a broader technical community. Unfortunately, formal technical communication is poorly supported by standard word processing equipment. Although rapidly maturing, capability gaps need to be filled and user interfaces improved within the current crop of technical wordprocessors (TWPs). The purposes of this report are twofold. First, to assist users in understanding their needs and how to fill those needs. Second, to promote the establishment of high standards for TWP software on microcomputers through heightened user and vendor awareness.

Four major aspects are considered in selecting a technical wordprocessor. At the core, it must contain the ability to incorporate technical material (e.g., equations). Manuscript capabilities are needed to organize the document. Layout capabilities are needed to control the exact look of the document. The fourth aspect considered is the user interface: how does the user interact with the program to take advantage of its technical, manuscript, and layout capabilities. User preferences are a strong factor in selecting an interface.

Addressing these four aspects is a complex task for several reasons: each of these four major issues subsumes a large number of issues; many of these issues have no clear-cut answer—they

depend on specific user-preferences. Because the first three aspects (equations, manuscript issues, and layout capabilities) can be assessed independently of user preferences, this article goes into greatest depth in these areas. The fourth aspect, the user interface, is a highly subjective area depending upon individual user preferences. Therefore, this aspect, although extremely important, eludes quantification.

This report, assembled by the Boston Computer Society IBM PC Technical Special Interest Group (see Appendix in Part II), provides a methodology for picking systems within budget constraints and over a variety of document needs, from simple memos to full technical books. Part II will review what is available today.

User TWP capability requirements vary with specific TWP needs. FIGURE 1 shows TWP selection considerations. Different TWP users have a variety of documents they need to create, through the user interface and capabilities of a TWP. Underlying the process are constraints, mainly in the areas of time and money, but also in areas such as data interchange and revision control. Matching a TWP to a user and their document goals begins with an assessment of needed capabilities and an awareness of the major issues. The discussions in Part I of this report are in preparation for the product comparisons of Part II.

Different types of users are listed in the left column of FIGURE 1. On the far right of FIGURE 1 are the types of output documents that could be produced: from a simple interdepartmental memo with equations up to a technical book with equations, manuscript/organizational features such as index and table of contents, and sophisticated page layouts (such as multi-column). The job then reduces to finding the product that best allows a particular user to produce a specific type of TWP document.

As shown in FIGURE 1, the software is controlled through an interface that allows the user to access the software's capabilities. The implementation of a particular interface will suit some users better than others.

Finally, there are constraints, including budget for money and for time, and "political," e.g., the need to exchange data with existing computers. While last year's report[1] focused on equation capabilities that could satisfy technical disciplines such as chemistry, mathematics, physics, and engineering, this year's report covers issues related to the entire TWP problem. Part I of this report is organized into:

II. An overview section which discusses both TWP capability categories and people needs
III. A detailed discussion of TWP capabilities within the three major categories
IV. The user interface issue—WYSIWYG vs. markup languages
V. Customizability and additional TWP capabilities
VI. Technical wordprocessing costs
VII. Future trends—where is it all leading?

A glossary of commonly used terms is provided in Appendix A.

[1] *Technical wordprocessors for the IBM PC and compatibles*, Notices of the AMS **33** (January 1986), 8–37

Users	TWP Product: Interface	TWP Product: Capabilities	Document
* Clerical			* Memo/Informal
* Microcomputer Support Person	* WYSIWYG	* Equations	* Short Report
* Technical	* ML	* Manuscripts/ Organizations	* Journal Article
* Technical and Willing to Program	* Hybrid	* Layout	* Long Technical Proposal
* Manager of Technical	* Other	* Other	* Report/Book
* Committees			* Other

Constraints

* Hardware Costs	* Data Interchange
* Software Costs	* Revision Control
* Brainware Costs	* Others

FIGURE 1

Review Methodology
(Note: This figure is basically a set of vertical lists. Items appearing in the same row are not necessarily related.)

In Part II of this report (to be published in the next issue of *Notices*):

- TWP benchmarks will be described;
- Reviews of individual software packages will be presented;
- TWP capabilities and performances will be summarized in tabular form for easy comparison.

The summary tables and results will be organized so that users can compare products that are actually competitors, based on budget constraints, target applications, and interface.

II. Overview of TWP Capabilities and People Needs

Specific TWP needs depend not only on the documents being created by a person or a group of people, but also on the environment in which they work and their preferred method of working.

People needs within an example 1,000 employee research firm provide a practical vehicle for presenting key TWP definitions. Typical product capabilities and interfaces are also identified that could satisfy several types of user(s), e.g., the research engineer, the co-op professor, the secretarial/wordprocessing group, the systems engineer, the publication department, or users who already have a large investment in existing mainframe documents.

Regardless of the size of an organization, all problems start with the communication/documentation of ideas via the technical memo. Often handwritten material is given to a nontechnical typist. In this process, considerable time is spent by the author either writing in symbols and equations by hand or interacting with the typist to get proper symbols and symbol placement. If 30% of working time is spent, on the average, by technical professionals on writing[2], imagine how much time is wasted on these two activities. A more serious cost is imposed when the information is never written down either because it is too frustrating to go through the secretarial route, or because existing business wordprocessors are too painful to use as TWPs.

A. Equation Capabilities

Whether a researcher wants to think and/or revise technical material at the computer screen, or have a secretary type a technical memo, the capabilities of a technical wordprocessing package must extend beyond those of a traditional wordprocessor—it must handle equations and other technical constructs. Equations are made up of Greek, math, and other scientific symbols; at a minimum, a TWP must be able to handle many different symbol sets. A symbol set is a set of characters; the ASCII character set of A–Z, a-z, 0–9, and other commonly used English symbols is one example of a symbol set. The set of upper and lower case Greek is a commonly used TWP symbol set. However, having a large number of symbol sets is not enough. To make equations easily understandable, some graphical coordination is needed.

Equations require that certain characters be made larger, especially summation, integral, and product signs. In addition to a minimum number of character sizes, it is sometimes necessary to reuse the same character with a different style (e.g., italic). Finally, characters may need to be altered: super/subscripted, underlined, or modified with other attributes (attributes affect the look of certain small pieces, such as a letter or a word, of a document). Quantifying these capabilities, fonts are defined as a group of related symbols sharing a common size and style. Thus, there is both font size and font style (see Glossary for a more precise definition). When the basic font is underlined or super/subscripted, an attribute has been added (Section III discusses some of the overlap in these definitions). Thus, technical researchers, secretaries, and the publication department will all want a system with "good equation capabilities," i.e., a system that can coordinate a variety of symbol sets, font-sizes, font-styles, and attributes. However, the user interface preferences vary among TWP users.

B. User Interfaces

Technical people who produce memos are more interested in content than other issues, such as typesetting/page layout. For those users who want to replace the paper and pencil step with an all electronic system, the ability to think at the screen is very important. If the individual thinks graphically, then the WYSIWYG, "What You See Is What You Get," user interface is probably preferred.

The WYSIWYG interface typically consists of painting in an equation by using a variety of special key combinations to access the symbol sets, font-sizes, font-styles, and attributes. To make the painting easier, some systems provide special inputting options that automatically handle some of the painting—these systems automatically center fractions and adjust integrals and summations using an auto-paint option. Some WYSIWYG systems also provide editing capability so that insertions and deletions either move all super- and subscripted lines in tandem or move them separately based on the user's commands. On the other hand, people who do not think graphically may be very comfortable, or may even prefer, using a markup language (ML) interface.

Markup languages use English-like sentences to describe equations and other features. For example, `\alpha^2` would be the TEX markup command for a Greek alpha with a superscript 2.

[2] Richard S. Palais, *Mathematical Text Processing*, Notices of the AMS **33** (October 1986), 741–751.

Over the years a variety of markup languages have evolved: TROFF/NROFF with EQN for systems that run the UNIX operating system; and Script with EQN and GML options for IBM mainframes. As long as the user is comfortable with a non-graphic interface for specifying equations, the ML provides an acceptable interface, and it relieves the user of the burden of having to precisely paint in a equation. In fact, WYSIWYG interfaces can be extremely tedious to use when the user goes beyond the monospaced 25 line by 80 column screen because there is too much detail to worry about. In the organizational and layout areas, discussed later, the ML interface can usually beat a WYSIWYG interface. On the other hand, ML can be extremely frustrating when it comes to figuring out syntax errors.

If short technical memos are the only concern, there are a variety of low cost products that provide good equation capability using either the WYSIWYG, ML, or a hybrid. At a minimum, these systems will provide IBM Selectric symbol ball #10 output capability. Some of the hybrids will even attach themselves to popular business wordprocessors (e.g., Wordperfect, Microsoft Word, Wordstar, Volkswriter, MultiMate, and Wang). Hybrids that attach to existing products can use either the WYSIWYG or ML approach. Many ML hybrids offer options to split the screen to preview the equation—i.e., in the top of the screen, the user sees the input `\alpha^2` and in the bottom screen window, the user sees the actual output approximately as it would appear in print. All so-called WYSIWYG systems are approximate at best, since screens have much lower resolution than does even a good dot-matrix printer.

C. Layout Capabilities

Technical publication demands greatly exceed simple memo capabilities. Publication departments and researchers who want to publish their results will demand TWPs with additional page-layout capabilities above and beyond simple monospaced equations and single column formats. Layout capabilities include such features as multi-column formats and the ability to specify exactly how n-level super/subscripts are to be positioned as a function of level. Most publications are the result of numerous revisions. Therefore, the ability to brainstorm at the screen is not as important as the ability to precisely specify the page layout. If both equation and layout capabilities are required within a WYSIWYG, the options become a bit more expensive because of hardware.

D. Manuscript (Organizational) Capabilities

Layout and equation capabilities are not the only considerations in selecting a TWP. Manuscript capabilities become necessary for documents larger than simple memos. A publications department, a secretary, or an engineer may be satisfied with manually numbering references, figures, and table lists for small publications. However, those writing large documents such as books, MIL Spec/NASA requirement documents, equipment manuals, or lengthy technical reports will want automatic organizational features—for both efficiency and accuracy reasons.

Consider a NASA requirements document, or the specifications for an Air Traffic Controller program. At a minimum, all of the requirements clauses must be numbered and cross-referenced. A sophisticated table of contents with a listing of all figures, tables, and equations must also be assembled. Any time an insertion/deletion is made, all of the page numbers and references have to be updated. When major revisions are made, a document compare mode with all changes marked by a side-bar is required. The same organizational features that go into a requirements document would also go into a book or technical manual. In addition to numbering equations and figures, the automatic building of multi-level indexes, table of contents, and endnote/footnote lists is equally important. The ability to symbolically reference material in forward and backward directions is an often-used feature in preparing manuscripts. For example, in one part of a document, an author could include "see page xxx for more details," where xxx is determined when the document is printed.

Although manuscript features seem like an extra frill, consider the hidden costs of mistakes in a large requirements document, or the valuable time wasted by tying up a system engineer and a secretary organizing a large document by hand, or the down time due to a poorly written user manual without a good index.

In most cases, the user interface for accessing automatic organizational features is through a markup command. However, as CPU power increases, it may be possible to create WYSIWYG processors that can automatically cycle through a long document and display important organizational aids as they are updated. Of course, this will mean that the document will not be WYSIWYG for certain stages of its existence, and may also carry tradeoffs relating to the user interface.

E. Addressing TWP Needs Within an Organization

While the problem of finding a TWP that suits one's individual needs is important, the viability of an organization, or team effort, depends on how efficiently it works as a unit. Engineers, theoreticians, and managers are supported by the wordprocessing, publications, and MIS departments. Some communication is internal in the form of memos or reports, while other forms consist of larger documents needed for coordinating team efforts. Finally, external communication takes the form of technical reports and user's manuals.

A significant proportion of technical professionals work near a PC or computer terminal, so efficiency can be improved by typing their material directly into electronic form. Many professionals are looking for small packages that can be used on their PC at home. However, allowing individuals to create their own documents in electronic form leads to the issue of compatibility among workers, particularly if user preferences for different interfaces are to be accommodated.

Organizations have two basic approaches they can take to adopting TWP capability. The first is to standardize on a single product. The second is to allow for diverse products. Organizations choosing the first route should make sure the product they choose has sufficient power and flexibility to accommodate a spectrum of user needs and preferences. A large quantity of consulting and possibly a full-time support person may be needed.

The second approach, allowing diverse TWPs, requires either building software bridges between products to achieve automated integration or accepting some inefficiency when material created by one TWP has to be reentered into a second TWP. As long as each specific product documents its internal formats, or provides data interchange facilities, it may be practical to have several products that communicate with each other—especially if different TWPs work best on existing microcomputers or terminals.

In any case, an organization contemplating the acquisition of TWP capability should take the time to perform a comprehensive needs assessment before committing themselves to a package or combination of packages. Wrong decisions can be extremely costly, in terms of both direct and indirect costs. A major purpose of this report is to assist such evaluations.

III. Major TWP Capabilities

In the space of an article it is not possible to fully describe all capabilities of a technical wordprocessor. What we try to do instead is give the user a flavor of the possibilities, including some discussion of what may become common in the near future.

This section has several subsections, each dealing with a major issue. The three subsections included here deal with:

A. Symbols, Fonts, Attributes, and Equations
B. Manuscript Features
C. Layout Features

Each subsection is divided into two parts, one on BASIC capabilities, one on ADVANCED capabilities. BASIC capabilities are those needed for more than just informal memos. We believe that the combination of BASIC abilities defines a minimum level of acceptability. ADVANCED capabilities are those that provide extra power and flexibility for the user. That is, the user is offered the opportunity to redefine various aspects of the program. Individual sections provide examples of additional options offered by the vendor; flexibility is discussed separately in a later section. Everyone should have the BASIC capabilities, and they should not cost much in terms of either money or time. ADVANCED capabilities may be too expensive for some people. That is, some users might like to have the ADVANCED capabilities but are unwilling to pay the time or money costs.

There is, of course, some overlap between the BASIC and ADVANCED groups of capabilities as well as between the Manuscript and Layout capability categories.

A. Symbols, Fonts, Attributes, and Equations

The elements of this section have a common theme—what kinds of characters and constructs can the TWP produce? "Symbols" are special individual characters (such as the symbol for infinity) that may be of varying sizes. Fonts are full sets of characters that together make an alphabet with its normal accompanying individual characters (e.g., punctuation). Attributes are things like sub- and superscripts, or underlining.

1. Symbols. Virtually any writer of technical material will need to use the following:

a) complete upper/lower case Greek character set;
b) math symbol set, including inequality, set theory, infinity, proportionality, pieces to build large integral, product, and summation signs;
c) commonly used foreign characters, at a minimum, those included in the IBM graphics set; that is, characters with diacritics, such as the German umlaut;
d) symbols to construct box graphics;
e) 45-degree lines for building diagrams;
f) arrowheads for each of the eight major directions.

This is a BASIC list of symbols that any TWP should contain. For many users, some of these will be used only rarely, but other users may have frequent call for any or all of these symbols. With these basic symbols, a user can form, if not either elegantly or attractively, almost any of the symbols and/or constructs that are widely used by technical writers in any of the "western" countries. The user must have control over how these are to be used. The vendor or a third party may also provide supplementary symbols for specific technical areas, such as chemistry.

ADVANCED capabilities are additional options, and provide flexibility and power for the user. Here, we discuss the additional options only; flexibility is discussed in general in a later section. Two capabilities, added to the BASIC ones listed above, will give virtually any user the ability to create any symbol or symbol set desired:

a) wide-selection of primitive graphic characters to construct whatever the user wants;
b) option for user to create several symbol sets.

Although there are numerous ways to implement each of these, we consider just their presence in any implementation to be an ADVANCED capability. Two important implementation styles are described below under Fonts.

2. Fonts. As discussed, we include both font styles (serif vs. sans serif, traditional straight vs. italic, etc.) and font sizes (pica, elite, etc.) under the heading of fonts. Part of the issue is that when one changes the height of a particular style, various shape and/or width changes should also be made for aesthetic reasons. For example, if the height and the width of a given style is multiplied by 1.5 and if no changes are made to shape, then the characters will tend to look too narrow and too sharp (too angled).

BASIC capabilities include standard business fonts, plus italics and bold for emphasis. In standard business fonts, we recommend Courier, Prestige, and Gothic. While any given individual is likely to prefer one of these, the combination of all three will cover almost everyone's standard needs. Italic versions of each of these should also be available, and the user should be able to easily indicate that any given letter should be italicized. Many current programs that are otherwise excellent limit their font offerings to whatever the user's printer offers; so, users should be careful here.

It is quite clear that ADVANCED font capabilities span a wide range from just the inclusion of additional fonts (or allowing the user to import an arbitrary number of additional fonts), to the ability to create additional characters, to the ability to create entire additional fonts. Additional fonts might include such fonts as Times Roman or Helvetica, but should definitely include at least one serif font and at least one sans serif font. (Serifs are the little lines that stem at an angle, usually 90 degrees, from the tops and bottoms of individual letters.)

Remembering that we consider different font sizes to be different fonts, this last ability of creating entirely new fonts may refer either to changing the sizes of existing fonts, to creating new font styles in the same sizes as the existing fonts, or to creating new font styles in new sizes. Furthermore, the creation of new fonts, whether new sizes or new styles or both, can be done in at least two very different ways.

Fonts can be created either dot-by-dot (that is, by specifying the bit pattern for each character), or by using what is basically a programming language that designs characters with manipulable parameters. Most programs use the former, which forces the user to specify the bit pattern, which is printer specific. Fortunately, these programs tend to give the user plenty of guidance, either in the form of examples for various printers, or in the form of grids that are set up and can be edited in the sense that individual "bits" can be turned on or off. Neither form is particularly easy to use and, to our knowledge, each requires the user to design every new character.

The other technique exists, as far as we know, only in METAFONT, an option with the various systems of TEX. This is essentially a programming language that allows one to manipulate the elements of characters (symbols) in a prescribed way; one initially designs a set of characters (at least as hard as using the above-described procedures) using approximately 60 parameters (many more for some special symbol sets). Any of these parameters can then be changed to give a new font. An example of a parameter is stem height (or stem width). To go from Roman to Italic, one might change only about 6 of these parameters; this also applies to changing the point size of a font. For optimal legibility, one wants to change the width and possibly the "roundedness" of a font when changing the height.

3. Attributes. These are special ways of outputting the textual information. These include both ways of emphasizing certain text, for example, underline, and ways of making the textual output look good. A simple example of this last point is the use of small superscripted numbers for footnote markers. These small superscripted numbers (or other characters at the user's preference) can be printed without affecting the interline spacing of the text. For a TWP, a full set of characters should exist in the correct size for sub- and superscripts. The BASIC capabilities of a TWP include the above (underlining, boldfacing, subscripts, superscripts) and the ability to mix these (for example, boldface with superscript, or underline with subscripts).

ADVANCED capabilities here refer to a fuller mixing of the attributes as well as to multiple, or nested, uses of the attributes. Examples include:

a) n-level sub- or superscripts: $x^{\exp(y)^2}$;
b) both a sub- and a superscript on the same character, with correct vertical alignment;
c) an underlined superscript.

4. Equations. The benchmarks, especially the benchmarks from our first report in the January 1986 issue of *Notices of the AMS*, discuss equations in some detail. Here we should note that both in-line and set-off equations are very important, and any TWP should be able to handle either with no trouble. This includes lining up the equation(s) with textual material and other equations or other graphical material.

Summary. As individual capabilities, the above list is incomplete when discussing a TWP. One must be able to use all the above in a coordinated manner without causing the TWP to lose control of functions such as line splitting or page splitting. One should also be able to use any of the above, in any combination, with some technical construct

that is part of the document, in addition to using any of it within textual material. Technical constructs include tables, matrices, various kinds of flow or circuit diagrams, etc.

B. Manuscript Features

Manuscript features organize a document into a coherent, presentable piece of work. Most of these features should be found in any good wordprocessor, though some of them are particularly useful to technical writers.

Some Manuscript features are so BASIC that we do not bother listing them, for example, automatic pagination. These rudimentary items are necessary before a product may even be called a wordprocessor. We believe that the following items are BASIC in the sense that all TWPs should have each of these in addition to the more rudimentary features.

1. One-line header and footer with page number option. That is, on each page one should be able to have the TWP automatically place an arbitrary string of characters at either the top of the page (header) or the bottom (footer), or both; the string can be different for the header and footer. The user should have the choice of whether the automatically placed page number goes in the header or footer and where it goes (e.g., flush right, center of page, etc.).
2. Simple footnotes/endnotes. The program should be able to handle either same-page footnotes or endnotes and mark them automatically, without the user having to specify the number of lines to be left for the note. As a BASIC ability, the TWP is acceptable if only one of these is allowed per document (or per section/chapter) as long as the user has a choice of which to use at any given time. Simple notes are limited to paragraph style (no specially indented quotations) and are marked consecutively.
3. Hyphenation capability. The program should allow automatic hyphenation with built-in hyphenation rules for all textual material. BASIC includes only global control, that is, turning hyphenation on and off within a document.

Although the list of BASIC manuscript capabilities is fairly short, the list of ADVANCED abilities is not. In addition, the items included under ADVANCED capabilities are much more complex than are the BASIC capabilities.

1. User-specified hyphenation exceptions. When the user doesn't like the hyphenation result for a particular word, the user should be able to override the process for just that word. This includes both specifying what the breakpoints should be for that word and also turning off hyphenation completely for that word, either for the entire document or for just that appearance of the word.
2. User amend/add/delete hyphenation rules. If the user doesn't like the hyphenation result for an entire class of words, then the user should be able to change the rule, delete the rule, or even to add a new rule. Some rules are quite straightforward. What is the minimum number of characters on each side of the hyphen? While the TWP will have a default value for this, the user should be able to change this from, say, four to three. Some rules are much more complex. Maybe the user wants to ignore hyphenation possibilities entirely for certain prefixes or suffixes. Or, maybe the user doesn't want the last word of a paragraph to be hyphenated under any conditions. Can the user add or modify existing rules to get this result?
3. Footnotes distinct from endnotes. The user should be able to have both same-page footnotes and endnotes in the same document. Each should be automatically and separately marked, and the TWP should track them independently of each other. Further, for either set of notes, the user should be able to restart the marking sequence at any point (e.g., start with number 1 at the beginning of each chapter).
4. Automatic reference numbering. Many publication schemes request in-text references rather than reference-type footnotes or endnotes. These come in several styles: numbered; last name of author and year of publication; first 4 characters of last name and year; etc. The program should allow the user to choose which style he or she wants, including styles that the vendor may never have heard of, and to order the references in whatever order the user prefers (e.g., order of appearance, alphabetically, chronologically, etc.). Further, the user should be able to set up, or choose, the printing style for the references (e.g., last name set off to left, rest of material —in user-chosen order—printed as an indented block, etc.). We are all familiar with how this is done in our field, but what if we want to submit an article elsewhere, or we are submitting a technical report to the government; there are so many styles that flexibility on the part of the vendor is very important here.
5. Header and footer control. The program should allow the header and/or the footer to have several lines of arbitrary character strings and should at least allow the user to specify certain strings to be left- flush, others to be centered, and still others to be right-flushed. Further, the different parts of the header, for example, should not all have to be the same number of lines; for example, a 3-line left-flush header, with a centered

one-line header that changes depending on whether the page number is odd or even, and a right-flushed header should all be allowed at once. A convenient idea is to allow the file name and the system date and time to be printed, at the user's choice, in the header or footer without the user having to say what that file name is.

6. Automatic indexing. This should include more than one index. For example, one for authors and one for subjects, or one for commands, one for symbols, and one for subjects. For each index, at least 2 levels should be allowed. For example, there might be an entry for numbering, and then subentries under this for numbering equations, chapters, tables, footnotes, etc. In addition, one should be able to emphasize certain entries. Example: In writing documentation one often has multiple entries for a command, but it is only defined in one place. Even if the definition is not the first occurrence of the command (maybe for another command the user writes see "XXXXXX"), the index should allow the definition page to be listed first and to be highlighted in some way, such as boldfaced. If an index entry appears on several successive pages, then the TWP should automatically replace this set of numbers with a range. Example: Replace 3, 4, 5, 6 with 3-6.
7. Numbering Schemes. A TWP should be able to automatically number various constructs and to keep each numbering system separate. The numbering style may also differ for each; the user should be offered several choices of numbering schemes as well as the ability to design a new one. Each of the constructs in the list below should exist and be numbered separately at each of several levels. In some cases, this means restarting the numbering for each chapter. In other cases, this may mean a numbering system that includes the chapter number in it. TABLE 2.3 might mean the third table of the second chapter. The following types of constructs may each need their own numbering scheme:
   a) footnotes;
   b) endnotes;
   c) equations;
   d) tables;
   e) figures;
   f) references;
   g) chapters, sections, etc.;
   h) list items—What you are now reading is a list. The program should allow several levels of lists (nested lists) and should allow the user to choose a style of numbering. Should the first level be arabic numbers, the second lower-case letters, the third, lower-case roman numerals, or should the first be upper-case roman, the second upper-case alpha, the third arabic, etc. Bulleted lists should also be allowed.
8. Table of Contents, List of Tables, List of Figures, etc. All these should be available, and all should be capable of being formed automatically and with the correct page numbers inserted (as well as the correct table numbers, etc.). Further, the user should be able to force something into a list even if it does not meet the criteria for automatic inclusion. For example, the user may want to have a particular example included in the Table of Contents even though it is not a chapter or even a section. (This year's benchmark contains an example of this.)
9. Symbolic references, both forward and backward. These, too, should be available. When writing, say page 3, the user may want to refer the reader to an equation that will be appearing about 10 pages later. Even though the user doesn't know either the equation number or the page number, he or she should be able to insert a symbol for these into the input text and have the program automatically replace the symbol(s) with the correct numbers. At the least, any of the material listed above under numbering schemes (number 7 above) should be capable of being symbolically referenced.

C. Layout Features

In addition to getting the material onto the page and having some organizational help in putting the document together, there are also "layout" issues. How does the page look? It is often hard to draw a sharp line between manuscript issues and layout issues but we have found the distinction helpful. It may help to think of the following three issues.

1. The first issue is a content issue—what can we get onto the page using the TWP?
2. The second issue refers to organizational matters—can we do things that help the writer, the reader, or both, to find their way around the document?
3. The third issue is more one of aesthetics—can we design the document, including each page and each piece, in whatever way we like it to look?

Here again, the list of BASIC capabilities is fairly short:

1. The user specifies the size of a page, e.g., the page margins. This can be done either by separately specifying each of the four margins (top, bottom, left, and right), or by specifying just the top and left margins along with the page width and page length.
2. The user is able to specify both the line spacing and the number of lines per page.
3. If the product is not a typesetting-type TWP (e.g., TEX), then the user is able to specify

the character spacing to be used, and whether it is proportional. The user should be able to change the character spacing (cpi) at any point within the document.

4. The user should be able to leave a specified amount of space for a figure and prevent page breaks in the middle of the figure space. This may result in white space on certain pages.

The ADVANCED capabilities are again much wider ranging than are the BASIC capabilities.

1. Widow/Orphan control. Widows and orphans are single lines of a paragraph on a page. For example, just the first line of a paragraph appears at the bottom of a page, or just the last line of a paragraph appears at the top of a page. Many people do not like the looks of widows/orphans, and a package should allow one to prevent their occurrence if so desired.
2. Multi-column formats. There are several varieties here: "snaking" columns, as one finds in newspapers or in IEEE publications; "parallel" columns, such as having questions on left and answers on the right or as used in scripts; "marginal notes," which are special columns that just have notes (such as working notes) in them. For each type, the user should be able to choose whether middle-of-the-page headings, as for a new section, should cross columns (whole page width headings), or be limited to just one column. For each type of column, the user should have a choice of more than 2 columns if so desired.
3. Fine control over all fonts, micro spacings, etc. The user should have at least some typesetting-type control over the output. This includes the ability to use multiple fonts, with frequent (within a line) switches, and control over both vertical and horizontal spacing. Horizontal spacing includes both interword and intraword (between letters). Vertical spacing refers to between lines as well as such layout issues as the amount of white space appearing before and after each level of heading. For example, 2 blank lines before each subsection heading and one blank line after the heading before the text. The user should have extensive control over these issues, some in "style sheets," others within the text file. That is, where appropriate, both global and local control should be available to the user.
4. Floating text and tables. Tables occur in virtually all technical writing. Thus, this point specifically discusses tables. However, this same point holds regarding many other constructs, and the TWP should not limit this capability, if it has it, to tables. When a table would normally print starting at a point on the page where there is, say, 2 inches remaining, and the table actually takes up 3.5 inches of vertical space, what happens? The worst situation is that the table is split—we hope that no program will do this. A BASIC capability is to insert a page break just before printing the table. The ADVANCED capability mentioned here is to "float" the material, e.g., move the table to the next page and move text from below the table to above it so that one is not left with 2 inches of white space preceding the table. Of course, if one does not want any of the text to appear before the table, then the TWP should allow one to have white space. If one is willing to have some text float, but not have the text immediately following the table float, then the program should be capable of floating, say, the second paragraph after the table but leaving the first paragraph. Of course, the TWP should automatically determine how much material to float for optimum looks without losing the sense. For example, if there are no restrictions on which text can float, then maybe a paragraph can be split around the table, but if the first paragraph following the table is not to be floated, but the second paragraph is, then the paragraph cannot be split around the combination of the table and the first paragraph, though it can be split around the table. Whether text is split in this way should be at the user's discretion. The benchmark, to be presented in Part II, will include a "floating table."
5. Separate control for special types of pages. The user should be able to separately design the layout for pages such as the Table of Contents, the Index, the List of Tables, etc. The user should have the option of specifying these layouts globally, as in style sheets, or locally.
6. Conditional overrides of global attributes. The user should be able to conditionally override global layout decisions, or to conditionally design the layout in a global sense. For example, the layouts for odd and even numbered pages may differ. This could be as simple as having different headers, as in our benchmark, or it could be different margins for odd and even pages to make the document look better when bound. As another example, given the different resolutions of screens and printers, one might want different layouts when previewing on the screen than when printing, and this should be easy to set up.
7. Import graphic material. In every technical area, graphics are an important component of documents. Some graphics are full-page, and thus easy to incorporate, though the TWP needs the ability to count its page and increase the page numbers correctly. However, other graphics are less than full-page and we would like to put them on a page with some text. A TWP should be

able to print a graphic from another program and integrate this with the remainder of the document, although one should expect to have to tell the TWP how much space is to be taken by this graphic. For example, this year's benchmark includes the printing of a "power function" curve that takes about 3 vertical inches. The TWP should print this correctly and fill the remainder of the page with normal text.

IV. TWP User Interfaces

The people needs problem boils down to creating a human–machine interface that lets the user comfortably work with his/her computer. Although people needs can be stated, they are not easily solved. Expanding upon FIGURE 1, the user interface aspect breaks into the human-to-software interface and the human-to-capability interface aspects, as shown in FIGURE 2.

This section is organized around various criteria that one might use in assessing user interfaces. Within each criterion, the tradeoffs among the two major interfaces are discussed. The next section discusses some of the costs associated with these interfaces.

First, a few definitions and explanations. Command-driven wordprocessing systems consist of one reserved key that takes the user out of the text window and brings the user to a command line. At the command line, the user can issue commands to do searches, replaces, change attributes or characters sets, and most other commands. Some examples of command-driven systems are: Lotus 1-2-3—the slash key followed by the first letter of each command; Wordstar—the control key followed by the first letter of each command; XyWrite-III—the F5 key followed by the command. All of these systems have an abort key to terminate the command and return the user to the text region. Toggle keys are also common. For example, if the user is already in insert mode, hitting the insert key takes the user from insert mode back into overstrike mode; hitting it again will take the user out of overstrike back to insert mode.

Because certain functions are used so frequently, many command-driven systems have dedicated special keys to perform the same function as a command. For example, insert mode can be set either by a command or by hitting the insert key. The same is true for cursor movements by character, word, sentence, paragraph, and page. Although customization is discussed later, it is important to note that many packages will let the user choose the assignment of special keys to commands that the user commonly uses.

On the other hand, command systems can be hard to learn. Thus, menu systems have evolved. However, the distinction between command and menu systems is not clear-cut. For example, the Lotus 1-2-3 command example applies to the menu system because the backslash command key also triggers a menu of all possible commands; Wordstar will also bring up menus if the menu help is turned on; XyWrite-III is not menu-driven, but a help file can be brought up. However, some menu systems are always on and once learned, the menus can be time consuming to use and difficult to automate—i.e., customizing the system so that one or two keys replace several menus.

The Apple Macintosh interface, pioneered at the Xerox Research Labs, uses a menu system and a mouse. The menu is displayed graphically and office analogies are used to label each processing option. For example, to delete a file, the user might move a picture of a file folder with the name of the file the user is working on into the trash can area using a mouse/trackball/joystick to perform the movements. Like menu systems, the Macintosh interface can be very easy to learn, but if customization options are nonexistent, it could be painful to use in the long run.

Users/Working Modes		Human-Machine Interface		Product-Document Interface	
Users	Working Mode	Human-to-Software	Human-to-Capability	TWP Capabilities	Document
Clerical	Brainstorming	Command-Driven	WYSIWYG	Equation	Memo/Informal
Publications Department	Inputting	Menu-Driven	ML	Manuscript	Short Report
Technical	Revising	Mouse-Driven	Hybrid	Layout	Journal Article
Technical & Program Manager	Team-Efforts	Hybrid		Others	Long Report/Book
	Final-Printing	Customizable			Other

FIGURE 2

A Detailed Look at People Needs

(Note: This figure is basically a set of vertical lists. Items appearing in the same row are not necessarily related.)

Customization is an important means for obtaining improved interfaces for user-specific tasks. String and command language macros are two major customization features. Lotus 1-2-3 and dBase-III provide two common examples of systems which have both string and command language macros. Style sheets offer an additional means of customization. Customization features will be discussed in detail in Section V.

Having discussed the categories of human–software interfaces as well as defining several commonly used terms, we now discuss the advantages and disadvantages of the major interfaces (WYSIWYG and markup languages). Since some of these advantages and disadvantages would be categorized differently by other writers, we discuss the "tradeoffs" between the two types of systems.

The quality of the user interface may be assessed with the following criteria: the amount of detail the user must learn; the amount of effort required to perform common functions; the average number of errors made by users, including those errors from which recovery is difficult; and the time waiting for the TWP to perform its functions. The criteria are not completely compatible with each other: "...it is impossible to achieve simultaneously all of the desirable properties of an interface for all classes of users."[3] Each user must weight the different elements and make his/her own choices between these issues. Please note that "hybrid" systems have some of the strong points of each of the other two (WYSIWYG and markup), as well as some of the weak points of each. Add-on products are markup type products, even if they are add-ons to WYSIWYG wordprocessors, and thus are not discussed separately in this section.

Note first that although one of these interfaces is called what-you-see-is-what-you-get, the resolution of even very high quality screens is much lower than the resolution of printers. For example, take a good dot-matrix printer that gives resolution of 180 dpi (dots per inch) vertically and horizontally. On a screen that is 9" wide but 7" high, the screen resolution would have to be 1260 by 1620 to match the printer. For a 300 dpi laser printer, this screen would need a resolution of 2100 by 2700. A standard page-sized (8-1/2" by 11") WYSIWYG screen requires proportionally greater resolution. This difference between screen and printer resolutions means, of course, that what you see is not quite what you get.

The more important issues here revolve around how one likes to work and how one weights various considerations. The following is a list of the major issues to be considered.

A. Ease of Learning
B. Ease of Use
C. Brainstorming
D. Frequency of User Errors
E. Response Time
F. TWP Capabilities
G. Quality of Output
H. Customizability, Flexibility, Expressiveness
I. Symbolic Evaluation

A. Ease of Learning

Some programs are very easy to learn to use—one can virtually ignore the manual and just start in and produce. Unfortunately, these programs tend to be rather limited with respect to capabilities, quality of output, etc. Usually, WYSIWYG systems are easier to learn than are markup languages.

B. Ease of Use

Even after one has been using the program for a while, one may either find oneself constantly returning to the manual or the on-line help, or one may be slowed down by the awkward menu system. The judgement here is strongly affected by individual tastes: some people find WYSIWYGs easier to use, while others find markups easier. To some extent the issue revolves around whether one likes to, or wants to, think about both content and looks when first drafting a document (or making major editing changes). Some people are positively distracted by either thinking about the looks of the document or having the screen constantly changing during the stage of creative writing; others like to have momentary breaks from writing by seeing how the document will look.

Of course, ease of use also refers to the ease of obtaining various special effects and constructs; that is, the ease of formatting as well as the ease of inputting and editing. Here, for other than small, simple constructs, the power of markup languages provides advantages over the speed and simplicity of WYSIWYGs. For example, suppose the user entered "a-sub-i" at several places in a document and later wanted to change all of them to "b" (no subscript); many WYSIWYGs would have trouble with this. For constructs that are larger than the screen, or that will not show on the screen anyway (because of insufficient flexibility or resolution), the advantage for markups is even greater.

C. Brainstorming

This is the process of sitting down, either jointly or severally, and starting to produce without an outline. Some people will want immediate visual feedback in this case, while others will want not to have immediate feedback. If two or more people are "brainstorming" together and have different desires, then no system will work for them.

[3] R. Furuta, J. Scofield, and A. Shaw, *Document Formatting Systems: Survey, Concepts, and Issues*, Computing Surveys **14** (September 1982), 465.

D. Frequency of User Errors or Particularly Hard-to-Recover-from Errors

Two types of error are of prime importance here: 1. incorrect input and 2. badly designed technical constructs. Markups are command-driven while WYSIWYGs may be either command- or menu-driven.

1. Menu-driven systems tend to have fewer and less serious errors of the first type; that is, when one types in something other than what one meant to type in, the effect is immediate and obvious and recovery is usually fairly easy.
2. In command-driven WYSIWYGs, the effect is also fairly obvious and immediate, but recovery may be much more difficult depending on where the command now is in the user's file, whether one can see the command to determine exactly what was entered, and how easy it is to edit that command. Recovery may be very difficult.
3. Markup languages are command-driven and the commands are visible in the input file, but there may still be serious problems since the effect is neither immediate nor obvious. It can take some time to determine exactly which of the many entered commands is the cause of the unacceptable output, though it is usually fairly easy to solve. Ease of recovery is entirely dependent on ease of determining which command is at fault since the input and output files are different files; that is, the unacceptable output has had no effect on the input file. The error message received, even if clear, may refer to the point at which the "compiler" noticed the problem rather than to the point at which the cause of the problem may be found. A markup language feature sends error messages to a disk file so that a multi-window editor can allow the user to fix errors while looking at the error listing.

Of course, any judgement on frequency and seriousness of errors must be weighed against the power and flexibility of what the user can do with the TWP. Menu-driven WYSIWYGs have the fewest serious errors and are easiest to repair. However, they have the least capabilities and the least power and flexibility.

E. Response Time

This has two aspects, one related to initial entry, the other to editing. The initial entry question is one of visual feedback, while the editing question is one of overhead.

1. Visual feedback. Does the user receive any visual feedback from the program as he or she enters the text and/or technical material? If the user does receive visual feedback, how quickly and thoroughly does he or she get it? WYSIWYGs have a large advantage over markups here.
2. Overhead. How much work does the program have to do, and how long does it take, to reformat after the user makes a small editing change? Thus, if one changes only one sentence in a 20 page document, how long does it take before one can see the result? Markup languages tend to have a lot of unnecessary overhead at this point: one must reformat the entire document, or at least all of it up to the point of change, even if previewing only the changed material and the surrounding material. Again, WYSIWYGs have an advantage here.

F. TWP capabilities

These have been discussed above in detail. Whether certain capabilities are needed or desired is up to each user. Please remember, however, that certain features are currently only available in markup TWPs, as will be seen in Part II of this report.

G. Quality of Output

How much control over the output does the user have? While response time is the area where WYSIWYGs shine, output quality is where markups win. WYSIWYGs attempt to have at least some reasonable relation between the screen and the printed output and this prevents "optimal" formatting. Even if screen resolutions were enormously higher, showing the optimal formatting on-screen would be very time consuming; so time consuming that the system would no longer be interactive. Of course, one could settle for lower print quality and retain the interactiveness, but most people would probably find this unacceptable. Output quality is one of the major strengths of the markup languages.

H. Customizability, Flexibility, Expressiveness

Can the user change the look and feel of the program; make the program do something in a different way; or write macros, style sheets, perform mathematical calculations, have conditional structures (e.g., use style "A" in this condition, style "B" in that condition)? Since this is discussed in more detail elsewhere in this article, it is sufficient here to point out that markups provide more of this to the user. There is a sense in which WYSIWYGs could provide more than they generally do, and some are improving in this direction, but they cannot match the markup languages without a reduction in their interactiveness.

I. Symbolic Evaluation

Can the user input temporary markers that the program will automatically replace at the appropriate time? Can the program do any symbolic evaluation? One example of symbolic evaluation

might allow one to output a list of numbers by using an index function: e.g., {i}10 might be turned into "1 2 3 4 5 6 7 8 9 10," while {i,2}10 would become "2 4 6 8 10." This could be very useful for easily setting up symbolic matrices: {i,3,4}a might give one a 3 by 4 matrix with each element being the letter "a" with row and column subscripts. A different type of symbolic evaluation is the MACSYMA type--provide the symbolic solution to a partial differential equation. Again, markups provide more than WYSIWYGs; and, again, WYSIWYGs could do more, and some do, but there are tradeoffs with interactiveness that one must consider.

Finally, what if one wants to import graphics into one's document from another program? All TWPs either have great difficulty or find it impossible to show these graphics on the screen in the context of the document. In addition, WYSIWYGs find it troublesome, and many find it impossible, to print these correctly inside a document. Markups, which tend to find it easier to include DOS commands or printer commands within a file, can usually include such a graphic in the printed document although they cannot show it to the user on the screen, in the context of the document at all. Some programs are sufficiently compatible with certain graphics programs that they can easily import graphics from these programs. Further, some TWP vendors have said that they will provide the developer of any graphics program the necessary information so that the graphics program can output files that can be more easily integrated into the TWP documents. However, if the user plans to import graphics, then the user must check the entire procedure out very carefully, including whatever graphics capabilities the TWP may have and whether these are bit-mapped or object descriptions. The ability of the TWP to edit any graphics should also be considered. Part of the benchmark, to be reported on in Part II of this report, includes a test of importing graphics.

V. TWP Customizability and Additional TWP Capabilities

For convenience and power, TWPs offer customizability and additional capabilities to augment the basic capabilities discussed in Section III. Without customizability and additional capabilities, TWP users are constrained even though essential TWP capabilities are present. Customizability is a key feature for reducing the time and aggravation costs for medium to heavy TWP work. First, customizability in the areas of macros, style sheets, new fonts/characters, and print commands will be discussed. Then additional capabilities in the areas of datafile interchange, revision control, include capabilities, and format checking will be discussed.

A. TWP Customizability

Customization increases TWP user productivity while often eliminating monotonous repetition. The two major vehicles for customization are macros and style sheets.

1. Macros. For TWPs, it is convenient to divide macros into two types, even though both are essentially the striking of a few keys instead of the striking of numerous keys. The first type can be called "string substitution." Here the TWP user presses one or two keys and has the effect of typing several other keys. The exact same effect is achieved in using keyboard enhancer products such as SuperKey or ProKey. String substitution macros are used to easily enter complicated strings, when the complicated string must be entered several times, or to bypass several command menus.

Simple customizations consist of letting the user pick his or her key combination choices, i.e., keyboard macros. However, keyboard macros can only do so much. Once the user has used a system for a few weeks, there is always a desire to automate some sequence of operations that requires a true command language with parameters. This next level of customization is a command language that lets the user string together several primitive operations into a specialized operation--much like FORTRAN or Pascal routines. For example, the user might want to have the TWP automatically take specific setup actions based on the extension of the file he or she is editing. Another example of customization is to create commands which automatically build and number tables. Command menus can be created as part of command macros for easy user access. Another type of macro, related to format checking (see below) might be called a "structural" macro, which defines a structure or construct such as a special equation form with replaceable parameters. To produce such a construct, the user just calls the macro with arguments that replace the parameters. For example, one might use this regarding a partial differential equation where the macro was the structure of the equation and the parameters were the particular variables in this instance of the equation. The number of variables may differ across instances of the equation. This would call for replacement by an arbitrary number of symbols.

One of the major points of this report is that it is not possible for a vendor to anticipate important user-specific needs. Thus, providing flexibility and power for users to extend the program is essential. The ability to build new program commands is one of the most important ways in which this flexibility and power can be given to users. Consider one fairly simple example. Many TWPs have the ability to structure "ordered nested lists," lists that are marked in a way that gives order to the list (numbers, letters, etc.) and that can be nested. How each level is marked should be at the user's choice. But, one sometimes

wants to set up an entire structure for a list with many levels. This could be done by building a new command that incorporates all the spacing and marking decisions for numerous levels. Then the levels are automatically marked as they are entered. For example, one could build three new commands each for a different type of list.

a) UL: an unordered list where the first level is marked by a filled-in bullet, the second by a hyphen, and the third by an open bullet.
b) OFL: a formal ordered list where the first level is marked by an uppercase roman numeral, the second level by an uppercase English letter, the third level by an arabic numeral, etc.
c) OSL: a simple ordered list where the first level is marked by an arabic numeral, the second level by a lowercase English letter, the third by a lowercase roman numeral, etc.

2. Style Sheets

User capabilities are greatly extended by customizable "style sheets." These reduce the level of user effort required to produce document types in standardized styles. Oftentimes, these are included with TWP software. For example, PC-TEX users can create nicely laid out letters within a short time using the letter style sheet included. Such aspects as type styles and margins are controlled by a style sheet. Although using a canned style sheet is easy, modifying a style sheet requires a much better understanding of the TWP. The ability to locally override the controls imposed by a style sheet is an important feature to look for.

Further customization features are as follows.

a) Adding print commands to include an ability of your printer not included by the built-in print attributes.
b) Adding new fonts/characters: either ones designed within the TWP software or ones made available in third party software (e.g., Fancy Fonts, or printer-specific fonts).
c) The capability to select automatic numbering, manual numbering, or both within a document or style of document.

Customizable TWPs should include default customizations, if only for educational value. Unfortunately, these are not always included, so the user then spends unnecessary time learning the customization features.

B. Additional TWP Capabilities

At the operating system level, additional TWP capabilities are in the areas of datafile interchange, revision control, include capabilities, and format checking. Across operating systems, one may want to be able to use the same TWP. Several TWPs to be reviewed in Part II exist on machines ranging from IBM mainframes through VAXes and workstations to Macintoshes and even CPM machines, as well as on MS-DOS machines. These will be noted in the Part II reviews. Even though these capabilities augment the basic capabilities discussed in Section III, they may be equally important for many applications. For example, revision control may be crucial for integrating the efforts for a team project.

1. Datafile Interchange. The datafile interchange issue involves input data and output data. Although some TWPs have greater capabilities for datafile interchange than others, foresight in the TWP planning process is necessary to minimize problems. Unfortunately, this type of issue sometimes becomes apparent only after a TWP product is purchased at a critical time when the product is being placed under heavy demands. For example, datafile interchange is an important issue for a collaborative study in which several individuals working with different TWPs need to integrate their work within a single document. Consider another situation where output datafile interchange can be a problem. A final copy needs the quality expected from a laser printer. However, the organization only has a laser printer which does not support full page graphics, as required by their TWP.

The first example was a situation where input datafile interchange problems were likely to occur. The input datafile consists of text and special commands specific to a single TWP. Input data interchange capability is the ability to import or export files from outside software. As a minimum, most TWPs include the capability to import/export standard DOS text files (7-bit ASCII). Further capabilities in this area would include the ability to handle graphic material as well as other TWP file formats. A very strong import/export capability would bridge a WYSIWYG program with a markup language. The basic issue limiting the usefulness of import/export capability of import/export features is the amount of information lost in the process. Special symbols and layout may become lost.

Output data interchange is the capability to capture TWP output in a file in order to transform it for a different output device (printer). For example, Adobe's PostScript language, used in the Apple Laserwriter and other printers creates device-independent files. With proper "device driver" software, device-independent files are transformed into input needed by a particular device.

2. Revision Control. Revision control allows a TWP user to see the changes made between one document and another. Changes are often shown by underlining, strikeout, and marginal "red-lining." Additional revision control features include the following.

a) Include revision history notes (e.g., date and time).
b) Track versions and then output any given version on demand.

c) Track different authors.
d) Track different sections for different audiences.
e) Compare versions and produce special "comparison" version.

3. Include Capabilities. Include capabilities are useful for being able to organize large volumes of material into several files, which are read when a document is printed, or for easy integration of the work of several authors. One central file usually contains the include commands for several other files. Command macros can also be stored in include files for reusability. These files, as style sheet files, should be automatically included without the user having to enter any special commands. Of course, since one may want to use a different set of macros, or a different style sheet for different documents, one should be able to specify which set to use with one argument when invoking the program. Secondary files can be brought into the final document by include commands within include files.

4. Format Checking. Format checking is one more TWP capability to be mentioned. Format checking assures that syntactic rules are followed. For example, rules governing the use of parentheses and quotation marks can be enforced by a format check. Custom format checks for a special construct may be performed through macros.

5. Recovery. If the system crashes while the user is working on a file, the TWP should have the capability to limit the amount of material lost. This can be done in several ways: periodic automatic backups or transaction logs or journals to keep track of changes made since start of session.

VI. TWP Costs

Selecting a technical wordprocessor has three aspects: understanding user TWP needs, understanding TWP capabilities, and assessing costs and constraints. Earlier portions of this report dealt with the first two aspects. This portion discusses costs. Costs include human effort required for installation, training, and use, as well as software/hardware costs. User-efficiency, and thus cost, also depends in large measure upon the fit between user needs and TWP capabilities.

Software costs easily come to mind when estimating the cost of a TWP system. However, the software purchase price is just part of a total cost which includes hardware requirements as well as time spent learning and using the package. For example, software has a narrower price range than hardware costs such as printers or monitors. The major purpose of this report is to improve the TWP software selection process, since TWP software is the key component of a TWP system. TWP software is more than an economical replacement for human labor. Good TWP software improves the content and appearance of technical communication. On the other hand, improper TWP software can be a terrible time/money sink.

Hardware requirements are important to consider when selecting a TWP. Hardware costs include storage, processing power, displays, and printers. The cost of meeting these requirements, either at a minimum or a recommended level, may easily exceed the cost of the software. Most packages require a well-equipped PC. Some are intolerably slow on a PC with slow disk access. The end result of technical wordprocessing is printed output. User output quality and speed requirements drive printer costs. Part of planning is to make certain the software and printer match to produce the results the user wants.

Storage requirements for TWPs are in two areas: RAM memory and disk memory. Requirements in both areas are often sizable. Many TWP packages require a PC equipped with 512K of memory. 640K may be needed to provide space for resident programs. At least one TWP directly uses Lotus-Intel-Microsoft extended memory. The second area of storage requirements is disk storage. A hard disk is usually required, although some TWPs work quite well on floppy based systems. The "high-end" systems have disk storage requirements measured in Megabytes. For example, TEX TWPs may use 5 MBytes of disk space to store detailed font information. Hard disk capabilities are measured in information access times as well as capacity. The importance of disk access time is seen in part of the speed advantage of standard IBM PC/ATs over standard IBM PC/XTs. This is particularly important when reformatting a WYSIWYG file, or previewing a markup file. RAM disks provide the fastest, although volatile, memory.

Processing power requirements are related to work efficiency and the limits of human patience. Many TWPs have high computation requirements, particularly WYSIWYG packages. Such packages are therefore better suited to higher performance PCs, i.e., greater than a standard 4.77 MHz 8088 PC. Improved performance is available in a machine with an 8086 processor running at 8MHz (e.g., Compaq DeskPro or an AT&T 6300) or a machine with an 80286 processor, such as the IBM PC/AT, or the newer 80386-based micro computers. Processing power is related to CPU, clock speed, and bus width. Memory speed is also important: "slow" RAM memory slows the processor down with "wait states."

Graphics cards and displays are the area of greatest hardware diversity for IBM PCs and compatibles. New graphics cards arrive at the marketplace each week. Monitors become available all the time with brand names never heard of before, and perhaps never again. Fortunately some standards have been established. Shortly after the introduction of the IBM PC, the IBM monochrome display adaptor (MDA), the Hercules monochrome graphics card (HCG), and

IBM's color graphics adaptor (CGA) were the major displays. Over the past two years, IBM's enhanced color graphics adaptor (EGA) has grown increasingly popular. Today a number of good MDA/HGC/CGA/EGA "all-in-one" adaptors exist. Hercules's new Hercules Plus card promises higher performance yet maintains compatability with the older HGC.

Display quality and prices vary widely. The process of finding a suitable display card/monitor combination begins by seeing what display cards are supported by the TWP software the user plans to buy. In the case of markup languages without preview, only text is displayed on the user's monitor; so, the choice is unrestricted, since all cards have text display capability. Graphic display capabilities are needed for WYSIWYGs and for preview of markup languages. Basic categories of graphical capability are resolution, color, and visual quality. One approach to selecting a display for graphics starts with deciding how much resolution the user needs. Then decide if color is needed. The third attribute, visual quality, is especially important for a system to be used for long periods of time and brings in the issue of selecting a monitor.

Visual quality is limited by the combination of display card and monitor. For example, even standard CGA looks vastly better on a high quality NEC MultiSync monitor than on a standard IBM color monitor. The multi-sync monitor is, of course, more expensive. Hercules graphics offer excellent monochrome graphic capabilities for a limited budget. The HGA+, which adds built-in multiple font capability to HGA, is starting to be supported by software at this time.

There are a wide variety of printers and printer types. A first step is deciding what quality of output is needed and what printing speed is needed. Nine-pin dot matrix printers are a well-established technology. However, 18- and 24-pin printers are also available. Although 9-pin printers offer good values for those with simple needs, the 24-pin printers make better resolution available for printing graphics. Furthermore, they are usually faster than their predecessors. However, they are more expensive. Most dot matrix printers offer at least a 150 dot-per-inch (dpi) resolution. Some printers claim 240 dpi resolution.

Daisy wheel printers offer the virtue of highly-readable fully formed characters. Unfortunately, they have limited versatility to handle special character graphics for technical communication. Sometimes, users with limited TWP needs can get by with special software and printwheels.

Laser printers offer high quality, speed, and quietness at a price. Essentially all laser printers being sold to PC users are based on 300 dpi resolution "engines." What distinguishes one laser printer from another is the amount of on-board memory and whether an on-board language, usually Post-Script, is built in. Lack of on-board features limits the capabilities of a laser printer for full page graphics capabilities, unless special PC hardware, such as a JLaser board is purchased.

Special input devices are sometimes used in TWPs. Most common among these is the mouse. Other devices include graphics tablets, joysticks, trackballs, lightpens, touchscreens, optical scanners, voice recognition, and so on. When graphic capabilities become strongly integrated within TWPs, these devices will also assume a greater role.

User effort is an added cost category consisting of the time and effort spent by users to get started using a system and the ongoing expenditure of time to perform their work with the system. These costs begin from when the user takes the software out of its shrink-wrap and hooks up the printer. Hopefully, the user has tried out the system first, either at a dealership or, better yet, with a friend or colleague. Some prior firsthand experience makes getting started with one's own system less frustrating. Usually the software is installed on a hard disk during a menu-driven process. During the setup process, the user specifies the display and printer he or she is using. This information is then saved in a file. Some install programs let users specify the specific printer control strings if they have an "oddball" printer.

After installing a TWP, learning begins. The efficiency of the learning process depends upon the quality of software and documentation. How much the user needs to learn depends in a large part upon the complexity of the software and the degree of customization needed. Some TWPs include an on-disk tutorial to assist the new user in getting started. Written introductory material is often given in a tutorial or "quick-start" section. Program reference cards, on-line help, and good documentation indexing provide ongoing assistance. Surprisingly, some user manuals are not indexed.

The hard part of using a TWP usually begins after the tutorial ends and the user wants it to perform work. The quality of documentation and built-in help become apparent as the answers to questions are sought. Customizability soon becomes an issue. For example there are many ways to number sections. Furthermore, efficient ways are sought to perform the more tedious, repetitive tasks. Sometimes customization is either within user capacities or built into the product (via style files). Other times it is not; so, expertise is sought from either the local "guru" or a hired consultant, but there may be trouble when the consultant leaves. In any case, customizability is an important TWP capability.

Customizability is an essential feature for users needing sophisticated capabilities and high efficiency. Customization comes in two flavors: preconfigured style files or user-created style files.

Preconfigured style files are templates making it possible for new users to quickly create documents (e.g., letters or reports) using highly sophisticated features. However, modifying these files is a more difficult matter and represents added cost. Customization beyond standard style files is nearly inevitable when technical documents must follow rigid standards of an organization (e.g., DOD). Changing standards and new applications may justify the hiring of a full-time TWP support person if a local guru is not already available within the organization. Fortunately, an entire organization can benefit from the efforts of such a person. Customization work should be documented for understanding later when further changes become necessary. User effort is also affected by the quality of the documentation. In some cases, third-party guides may be more helpful than the vendor's documentation.

The cost of ongoing user efforts to create documents depends upon the goodness-of-fit between TWP needs and capabilities of the package after any customization. It also depends upon user effectiveness which is reflected in user satisfaction. If the user is comfortable in using a package, it is likely that the package fits into their work style, so they can be producing results rather than fighting an incompatible interface. For example, if the user wants to be able to directly record technical information into the TWP as he or she is brainstorming, the interface quality takes on greater importance. A second example relates TWP capabilities to efficiency. Suppose a large technical document is being written by multiple authors. Strong manuscript features and revision control greatly aid the process, lowering cost while increasing quality.

VII. Future Trends

What is happening to TWPs? The technology clearly has not reached anything approaching the ultimate in technical wordprocessing. Can we expect to see major advances in the next few years? If so, what kinds of advances might we see? What kinds might we like to see? This final section of Part I of our report briefly discusses these questions. The basis for some parts of this discussion will be presented in Part II of this report which will appear in the next issue of *Notices*. The combination of last year's report, the earlier sections of Part I of this report, and Part II of this report will provide a detailed discussion of what one can find, and expect, on current IBM PC/XT/AT type machines. Some systems now being built on larger machines have additional capabilities. These are discussed here. Additionally, some desirable capabilities do not exist on any system that we know, but deserve discussion anyway.

A further mixing of the strengths of WYSIWYG and markup languages is needed and is coming. A group in the Division of Computer Science at the University of California at Berkeley is taking one large step on 32-bit machines. VorTEX, visually-oriented TEX, splits the screen of a Sun workstation. In one window the user enters normal TEX commands; the other immediately shows the result of these commands ("simultaneous preview"). One can then be in either window, edit the material in that window, and have the material in the other window be immediately updated. For example, one could edit the "preview" window and have the TEX input be changed to conform with what one wants the output to look like.

Related is the issue of symbolic references. One would clearly like to set aside a window in which what is being referenced is shown when the reference itself is in the main window. For example, if the main window is showing a reference to, one hopes, a particular equation, then the subsidiary window will allow one to check that by showing what is being referenced. The user can then immediately see whether the correct equation is being referenced. This will greatly ease the process of checking cross-references.

Although apparently never to be completed, a group at Yale started to devise a program called PEN. A specialized piece of this, called PENMATH, was designed both as a TWP and with numeric evaluation and symbolic evaluation capabilities. That is, for some mathematical problems one could obtain, within the TWP, the numeric, or symbolic, result of a construct. Although the initial design was rather limited in these capabilities, the design did call for facilities allowing "the user to define new scalar operators or to extend existing ones."[4] Some wordprocessors currently have numeric evaluation capabilities: some have full 4-function calculators; some have macro capabilities that include calculator functions; some just allow one to add or subtract internal variables, such as "date of next meeting = today plus 11" resulting in the correct date being printed. Others have no such ability at present.

As a final technical issue, we can look forward to enormous improvements in our ability to import graphics from other programs. Not only should all TWPs have this capability, but they should do it much more elegantly than now. For example, the usual procedure at present is to tell the TWP how much vertical (and horizontal) space to leave on the page. However, this requires knowing the size of the graphic; clearly, one would like the TWP to learn this for itself and automatically insert the right space. Some of the issues involved in doing this, especially if it is to be done to the

[4] T. Allen, R. Nix, and A. Perlis, *PEN: A Hierarchical Document Editor*, Proceedings ACM SIGPLAN, SIGOA Symposium on Text Manipulation, SIGPLAN Notices **16** (June 1981) 74–81.

screen as well as to the printer, are very complex, so this may not happen for a while.

Much progress remains in the maturing of TWPs as a market. What this represents for the users is the standardization of powerful features, many of which were in the advanced category of this report. For example, microjustification is likely to become a standard feature. Furthermore, the customization capabilities should increase and become more accessible to average TWP users who have neither the time nor inclination to learn programming.

Appendix A. Glossary of Terms

1. Character Attributes—These include underline and super- and subscript.
2. Floating Text—The ability to change the order of material from the input order to improve the looks of the document. (See the example above.)
3. Font—A font is a set of symbols defined by the following: metrics, which give the dimensions of the boxes into which they fit, and the actual geometric descriptions of the shapes of the symbols which go into these boxes. To describe a font, there is the font style and font size.
   a) Font Styles—Examples of font "styles" (shapes) include Roman, Courier, Roman Italic, and Prestige.
   b) Font Sizes—The height and width and other metrics. There are many technical details in specifying the height and width because portions of the characters stick out. (See Palais's *Mathematical Text Processing*, Notices of the AMS **33** (October 1986), 741–751.)
4. ML—Markup language (e.g., TEX, forMath, Script, Scribe, RUNOFF, TROFF, Wordstar "dot" commands, Microsoft Word commands, Wordperfect commands, etc.).
5. Symbol Sets—A set of characters. The English symbol set, the Greek symbol set, the math symbol set.
6. TWP—Technical wordprocessor.
7. Typesetting Terms: Kerning, lead control, and ligature.
   a) Kerning—technically, the piece of a letter that sticks out beyond the body of the letter is called "kern;" loosely used to refer to horizontal spacing between letters.
   b) Lead control—the amount of vertical spacing between characters of "text" in a document; also leading.
   c) Ligature—a character that consists of two or more characters joined together horizontally.

   Example. Suppose a vendor offers three-inch Roman, five-inch Roman, three-inch Italic Roman, and three-inch Greek. For the purposes of this review, this vendor will be said to offer: one additional symbol set (Greek); two font styles (Roman and Italic Roman); and two font sizes (for the Roman style) and one font size (for the Greek style). To minimize confusion, font sizes and font styles will be distinguished.
8. Widow/Orphan—When a paragraph is split across pages such that one page has only one line of the paragraph and the other page has the remaining lines.
9. WYSIWYG—"What you see is what you get" is a style of user interface in which the user sees what will be printed as it is entered (e.g., T3). Hybrids of ML and WYSIWYG are common (e.g., MS-Word).

Washington Outlook

Kenneth M. Hoffman

Education: National Leadership from Our Community

We are in the early phases of a period of sweeping change in mathematics education nationally, change more significant and more exciting than any we have seen in our lifetimes. Nearly all of us will be touched by it–most of us in rather dramatic ways.

In November of 1983, a diverse set of leaders from the mathematical sciences research and education communities met at Airlee House in Virginia. They met to describe the major issues in school mathematics and to devise ways for our community to reach and to stay on the crest of the wave of change then mounting across the country. A similar gathering was held at Madison a month later. The principal recommendation which flowed from these two conferences–sponsored by the National Science Foundation and the Department of Education–was that some sort of national steering committee was needed for mathematical sciences education.

The Conference Board of the Mathematical Sciences, representing thirteen mathematical sciences professional societies, took up the challenge. In 1985, based on the work of a committee chaired by Paul Sally, University of Chicago, the Conference Board recommended to the National Research Council that it establish the Mathematical Sciences Education Board (MSEB). The product of the first year's work of the MSEB is a master plan for leading states and localities through twenty years of planned stages of change to adapt school mathematics to the increased breadth of the mathematical sciences and to modern computer technology. The first stage, which might be called Ground Zero, will be based on recommended standards now being developed through a joint project with the National Council of Teachers of Mathematics. These standards are aimed at raising expectations and increasing consistency from state-to-state and locality-to-locality, utilizing the best that is out there now. From this base will be launched subsequent stages of change, calling for significant modification of the approaches to mathematics.

One major component of the MSEB program is a joint project with the National Research Council's Board on Mathematical Sciences, "Collegiate Mathematical Sciences in the Year 2000," which is an adaptation of the proposed major review of collegiate mathematics that Bernie Madison, University of Arkansas, has been shaping over the last couple of years. It will be as comprehensive and far-reaching as the MSEB review of K-12 mathematics.

At the heart of the school and college studies and the recommended plans for educational improvement in the future lies the concern with curriculum and instruction. It is in these arenas that bold changes are certain to be recommended. The changes will not come suddenly, nor will they come as pronouncements from Washington. Widespread discussion of new approaches will take place in our community and throughout the country over the next few years. Strong leadership from the professional societies, working with the two Research Council boards, will be required if we are to move through the coming period of change in a less than chaotic way. The ideas and energetic participation of the members of our community will be even more important.

Spectral Sequence Constructors in Algebra and Topology

Donald W. Barnes

(Memoirs of the AMS, Number 317)

Spectral sequence constructors are a special type of functor to filtered chain complexes. They provide a means of comparing the various constructions which have been given for certain spectral sequences, for example, the spectral sequence of a group extension. In this book, the theory of spectral sequence constructors is developed, the four main constructions of the spectral sequence of a Hopf algebra extension are discussed and compared, and a uniqueness theorem for the spectral sequence is proved. A similar study is made of the spectral sequence of a fibration, and its uniqueness is also established.

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Acknowledgment

The Editors wish to thank David Mumford of Harvard University for the excellent article on Oscar Zariski which appeared in the November issue of *Notices*. We regret that, in error, his name did not appear at the end of that article.

Prix Scientifique 1986

In 1985, the largest insurance company in France, Union des Assurances de Paris (UAP), established the Prix Scientifique UAP, to be awarded annually to a maximum of three scientists in recognition of major fundamental research in such fields as mathematics, computer science, theoretical physics, biological sciences, linguistics, and economics. The 1986 prizes, of about $10,000 each, were awarded on September 22, 1986, during the UAP's annual scientific conference, Journées Scientifiques UAP. Among the three recipients were theoretical computer scientist Phillipe Flajolet and mathematician Wilfried Schmid.

Phillipe Flajolet was born in 1948 in Lyons, France, and received his doctorate in mathematical and information sciences in 1979 from l'Université d'Orsay in Paris. He is currently the director of Recherche et Responsable Scientifique du Groupe "Algorithmes" at l'Institut National de Recherche en Informatique Automatique and professor of computer science at l'Ecole Polytechnique in Paris. Flajolet received the UAP Prize for his important contributions to theoretical computer science in the area of algorithms. His work is at once profound from the mathematical and theoretical points of view, and rich in the variety of its applications.

Wilfried Schmid, an AMS member, was born in Hamburg, Germany in 1943. He received his Ph.D. in mathematics from the University of California at Berkeley in 1967, and is now professor of mathematics at Harvard University. Schmid received the UAP Prize for his fundamental contributions to the theory of representations of semi-simple Lie groups. His results in this area have inspired work in physics, and Schmid has, in turn, used examples from physics to considerably advance his research.

Courant Institute Prize for Mathematical Talent

On the occasion of its 50th Anniversary, in 1985, the Courant Institute initiated a competition for undergraduate scientists. Students were invited to submit original solutions to mathematical problems of their own choosing.

The first place winner was Avrim Blum, a junior at M.I.T., for his entry, "Random walk on a circle." The second prize winner was Denise Freed, a senior at Cornell, whose entry was entitled, "A new expression for the denominator of Weyl's character formula." In addition to cash prizes of $1,000 and $750 respectively for the first and second place winners, the papers are being considered for publication in *Communications in Pure and Applied Mathematics*.

The deadline for this year's competition is **February 1, 1987**. Information and a complete set of rules can be obtained by writing to Talent Contest, NYU-CIMS, 251 Mercer Street, New York, NY 10012.

Marchuk Elected President of the Academy of Sciences of the U.S.S.R.

On October 16, 1986, the Politburo of the U.S.S.R. unanimously elected Gury I. Marchuk, a physicist and mathematician, to succeed Anatoly P. Alexandrov as President of the Academy of Sciences.

Marchuk was born June 8, 1925, in the village of Petro-Khersonets in the southern Urals. In 1942, he enrolled in Leningrad University where he received the Candidate's Degree in 1952 and the Doctoral Degree in 1956. Following positions in Obninsk (1953–1962) and Novosibirsk (1962–1980), he moved to Moscow in 1980 as Head of the Department of Computational Mathematics at the Academy of Sciences.

His mathematical work has been in modeling and numerical analysis in the areas of nuclear reactor theory, geophysics, and immunology.

News from the Mathematical Sciences Institute

Cornell University

The Mathematical Sciences Institute, sponsored by the U.S. Army, announces a Workshop on Stochastic Control to be held April 22–25, 1987. The objective of the workshop is to bring together engineers, probabilists, and statisticians working on control of deterministic and random processes, and to enable a cross-fertilization of concepts and techniques. Participants include K. P. Astrom, D. A. Berry, W. H. Fleming, B. Fristedt, R. Kertz, U. Krengel, H. J. Kushner, S. Shreve, W. D. Sudderth, J. Tsitsiklis, and P. Varaiya. The organizing committee consists of D. Heath (chairman), N. U. Prabhu, and J. Thorp.

Mathematical Sciences Research Institute
Berkeley

During 1986–1987, MSRI is featuring a large program in arithmetic algebraic geometry. It is early in the academic year as this is being written, but already there has been a notable advance due to Karl Rubin, a Sloan Fellow from Ohio State University who is at MSRI for the year. Attached to any elliptic curve E over a number field there is an abelian group Ш (the Tate-Shafarevich group) which, crudely put, measures the failure of the Hasse principle for curves of genus 1. It has been conjectured that Ш is always finite. Hitherto this was not known for a single E, but it has now been proved for infinitely many E defined over the rational numbers: those with complex multiplication and with an L-function not vanishing at 1. Examples include $y^2 = x^3 - x$ and $y^2 = x^3 + 17x$; the order of Ш is 1 and 4, respectively, in these examples. These are also the first examples of curves for which the Birch and Swinnerton-Dyer Conjecture is known to be true.

Here is a synopsis of the forthcoming events of 1986–1987; for more detail see the MSRI column in the October 1986 *Notices*. There will be number theory workshops with dates January 20–24 (Iwasawa Theory) and March 23–27 (Galois Groups over Q); Nonlinear Hyperbolic Waves (May 26–28); and finally a microprogram on Commutative Algebra (June 15–July 2). Some financial support is available for Galois Groups (deadline January 1), Commutative Algebra (deadline February 15), and Hyperbolic Waves (deadline March 15). To apply, write to the Mathematical Sciences Research Institute, 1000 Centennial Drive, Berkeley, CA 94720. It is suggested that some information be included, such as a vita and/or bibliography.

An additional microprogram has been set for the future. The topic is noncommutative rings and the dates are July 5–19, 1989. The organizing committee consists of Susan Montgomery, Lance Small, and Robert Warfield (chairman).

Theoretical and Applied Mathematics

The United States National Committee on Theoretical and Applied Mechanics (USNC/TAM) has announced preliminary plans for the 17th International Congress of Theoretical and Applied Mathematics to be held August 21–27, 1988, in Grenoble, France. The committee is calling for papers from United States authors, and the deadlines for submission are in early 1988.

The committee is also seeking proposals to host between twelve and twenty IUTAM (International Union of Theoretical and Applied Mechanics) symposia planned for the calendar years 1990-1991. The purpose of the symposia is to assemble a small group of active scientists in well-defined fields. Each symposium will invite approximately 60 participants solely on the basis of their scientific merit, and about 25 of them will present prepared lectures. USNC/TAM will competitively screen the symposium proposals, and forward their recommendations to the IUTAM where the proposals will compete with those from other countries. Final decisions will be made at the International Congress in 1988.

For more information on these events, see the display advertisement in the back of this issue.

Fee Increase at AMS Sectional Meetings

Registration fees for the AMS's sectional meetings have not increased since 1981, while the costs of planning and holding the meetings have risen. As a result, the Executive Committee and Board of Trustees of the Society found it necessary to increase the registration fees for sectional meetings. The fee for AMS members is now $30, up from $10; for nonmembers, the new fee is $45, up from $16; and for students and the unemployed, the new fee is $10, up from $5. There are four sections—Central, Eastern, Far Western, and Southeastern—and each section holds two meetings per year, in the spring and fall.

Errata

In the article, "The University Research Initiative," which appeared in the October 1986 issue of *Notices*, the faculty of the program funded by the Army Research Office was incorrectly listed. S. K. Mitter of the Massachusetts Institute of Technology (MIT) is the principal investigator of the consortium program involving MIT, Brown University, and Harvard University. R. W. Brockett and U. Grenander will lead the research efforts at Harvard and Brown, respectively. A full list of the faculty of the program follows.

MIT: B. Awerbuch, D. P. Bertsekas, R. G. Gallager, S. Goldwasser, P. Humblet, F. T. Leighton, B. C. Levy, S. Micali, S. K. Mitter, B. Musicus, R. Rivest, G. Strang, D. W. Stroock, J. Tsitsiklis, N. Trefethen, G. D. Verghese, and A. S. Willsky.

Brown University: W. H. Fleming, S. Geman, U. Grenander, H. J. Kushner, and D. McClure.

Harvard University: R. W. Brockett, Y. C. Ho, P. Huber, D. Mumford, and L. Valiant.

Reagan Announces National Science Board Nominees

President Reagan has nominated four new members and renominated another to serve on the National Science Board (NSB). The 24-member NSB is the policymaking body of the National Science Foundation.

New members are James L. Powell, President of Franklin and Marshall College; F. Albert Cotton, Professor of Chemistry and Director of the Laboratory for Molecular Structure and Bonding at Texas A&M University; James B. Holderman, President of the University of South Carolina; and John C. Hancock, Executive Vice President and Chief Technical Officer of United Telecommunications, Inc., of Kansas City, Missouri. Renamed to the Board is Mary L. Good, President of Engineered Materials Research, Allied-Signal Corporation of Des Plaines, Illinois. All will serve six-year terms on the NSB ending in May 1992. –NSF News Release

Electronic Information Exchange

The National Science Foundation has made two awards totalling $800,000 to two universities in a $6 million program designed to improve the generation and communication of mixed media documents among differing computing environments. Such documents include text, mathematical notation, graphics and images, and eventually could include or interact with voice, animation, sound and video media, and remote computational computers.

Awards of $400,000 each were made to Carnegie-Mellon University and the University of Michigan. The awards represent the start of the Foundation's Experimental Research in Electronic Submission (EXPRES) project, which ultimately will provide a basis for electronic information interchange and collaboration among the nation's geographically dispersed science and engineering community.

The universities will determine how new techniques of communicating mixed media documents can be applied to how research proposals to NSF are developed, submitted, reviewed, and processed. The NSF proposal process was chosen as the initial research testbed because it embodies all aspects of the problem, but permits a measure of control necessary for experimentation.

Both institutions will investigate the technological and sociological barriers to generating, transmitting, and processing compound documents in a multidisciplinary, multiuniversity, and multivendor environment. Each team will consist of scientists from the lead university and from other universities and industry. Many other universities will participate with Carnegie-Mellon and Michigan as test sites.

Each team will install a pilot system capable of creating compound (multimedia) documents, sending them over local and wide-area networks, and allowing storage and retrieval, display, and modification by authorized persons en route and at the destination. In the latter stages of the three-year EXPRES project, the teams are expected to demonstrate the ability to process documents created by the other system.

Substantial additional funding in equipment grants and technical support will be provided each team by cooperating industrial affiliates.

–NSF News Release

Computational Mathematics Program at the NSF

The Division of Mathematical Sciences (DMS) of the NSF has established a Computational Mathematics Program, which is intended to provide funding for equipment and personnel to support research internal to mathematics, as well as interdisciplinary research. The program received the full $3 million it requested for fiscal year 1986.

It is expected that research will be funded not only in the traditional computational areas of scientific computing, numerical analysis, and computational statistics, but also in geometry, algebra, and other core areas of mathematics where computation has begun to play an increasingly important role. In addition, the program will support research in more foundational aspects of computation in mathematics, such as questions of correctness and consistency in software systems.

The Division of Mathematical Sciences of the NSF announced its intention to establish such a program in a "Dear Colleague" letter which was sent to a broad cross section of the mathematical sciences community. (The letter appeared in the October 1986 issue of *Notices*.) The letter generated interest in the program, and the DMS began receiving proposals to be funded once the program was established. The DMS will now begin reviewing those proposals.

This program is part of the NSF's initiative in Computational Science and Engineering, which has fostered programs in other divisions of the NSF as well.

For more information, contact Melvyn Ciment, Program Director, at (202)357-9764.

NSFnet Adds Two Regional Networks

The NSF has made grants to establish two regional computer networks: MIDnet, which will consist of eight midwestern universities; and New York State Education and Research network (NYSERnet), which will comprise fifteen academic research institutions and industrial laboratories in New York state.

Both of these networks will connect the constituent institutions to each other and to the NSF's backbone network, NSFnet, which provides access to 5 supercomputer centers funded by the NSF. These centers are located at San Diego, Cornell University, the University of Illinois at Urbana-Champaign, Pittsburgh, and the John von Neumann Center in Princeton, New Jersey. The NSF provides time on supercomputers at these centers to scientists throughout the United States as a service to universities unable to afford the kinds of computers required for research and development.

The universities in MIDnet will be linked to each other and to NSFnet by means of dedicated medium speed telephone lines. The NSF grant will cover the cost of the leased lines for three years. Each institution in the consortium will provide the necessary hardware and software to install and maintain their link to the campus computer network. They will also provide their users with the support necessary to fully utilize the resources available on NSFnet.

NSF's grant for NYSERnet will provide for dedicated communication lines, communication routers, and network management and operations. NYSERnet Incorporated, a not-for-profit company, has been established to seek support from New York state industrial firms to enable them to interact with their research counterparts at university and government laboratories.

For more information, including a list of institutions on these two networks, see the article "Supercomputing and the NSF" in this issue.

Remote Access to Science Resources Studies Data

The Division of Science Resources Studies (SRS) announces the establishment of the SRS Remote Bulletin Board System (RBBS), a service of the NSF providing up-to-date information on financial and human resources for science and engineering activities. It contains comprehensive statistical tabulations, brief narrative reports on current studies, and announcements of available publications.

The SRS RBBS is available to anyone with a personal computer equipped with a modem. The "host" computer is a personal computer. The system answers the telephone at 300 baud, no parity, eight data bits (XMODEM), and one stop bit. We suggest using 1200 baud if you have that capability. The host computer will automatically adjust to the baud rate that you are using. The phone number is (202)634-1764.

The SRS RBBS is menu-driven and includes instructions regarding both the structure and use of the system. The textual BULLETINS can be viewed while on the system. The statistical tabulations or FILES must be downloaded to the users' computer for viewing. The FILES are available in ASCII or LOTUS 1-2-3 format. The SRS RBBS currently contains the following data:

- Federal Funds for Research and Development: Fiscal Years 1984, 1985, and 1986 (ASCII and LOTUS 1-2-3);
- Scientific and Engineering Expenditures at Universities and Colleges: FY 1984 (ASCII);
- Scientific and Engineering Personnel Employed at Universities and Colleges: January 1985 (ASCII);
- Graduate Enrollment and Support in Science/Engineering: Fall 1984 (ASCII);
- Federal Support to Individual Universities, Colleges, and Selected Nonprofit Institutions: FY 1984 (ASCII);
- Characteristics of Recent Science/Engineering Graduates: 1984 (ASCII);
- Scientists, Engineers, and Technicians in Manufacturing Industries: 1983 (ASCII);
- Employment and Demographic Characteristics: U.S. Scientists and Engineers: 1984 (ASCII);
- International Comparisons of Science and Technology Data (LOTUS 1-2-3);
- Trends in National Patterns of Science and Technology Resources Data (LOTUS 1-2-3).

Additional data will be provided through the SRS RBBS as it becomes available. Your comments and suggestions for improvements to the system are welcome. For assistance in accessing SRS RBBS, call (202)634-4636. –NSF *Bulletin*

Good News for DMS Budget

The Division of Mathematical Sciences (DMS) of the NSF received the full $59.8 million it requested for fiscal year 1987. This figure represents a 15.5% increase over last year's budget. The increase is proportionally higher than increases in many other divisions within the NSF, because, according to NSF Director Erich Bloch, the emphasis on mathematics is needed to compensate for inadequate funding and to attract new students to the field. About 5% of the DMS budget will go into a new program in computational mathematics. While the establishment of the new program means that the increase for existing programs is effectively about 10%, that increase is nonetheless significant because it is still proportionally higher than in other divisions and because Computational Mathematics will now support areas previously supported by other programs.

Journal of the American Mathematical Society

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The Journal of the American Mathematical Society will be published quarterly, beginning in January 1988. It will contain research articles of the highest quality in all areas of pure and applied mathematics. Authors are requested to include introductions which will be accessible to research mathematicians in all fields.

There are no page charges for this journal.

Manuscripts may be submitted to any of the editors. The journal will be set by the AMS, using the $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX macro package developed to simplify the use of TEX for mathematics. So if you prepared your manuscript using $\mathcal{A}\mathcal{M}\mathcal{S}$-TEX, your tapes or floppies can be used directly without need for further proofreading.

Letters to the Editor

Military Funding in Mathematics

This letter is a shortened version of a paper

Military funding in mathematics

Bill Thurston

originally submitted as an article to the *Notices*. I hope that the AMS will decide to start publishing opinion articles *per se*, as do the APS (American Physical Society) in *Physics Today* and the ACM (Association for Computing Machinery) in *CACM*.

The article was commissioned by a group of mathematicians concerned about increasing military funding in mathematics. The original group was Lipman Bers, Lucy Garnett, Linda Keen, Lee Mosher, Barbara Simons, Mike Shub, Jean Taylor and Bill Thurston; we are in touch with many more. This letter does not necessarily reflect the opinions of anyone but me.

We plan a mailing list, and possibly a telephone tree. For more information, write to Bill Thurston, Mathematics Department, Washington Road, Princeton, NJ 08544.

Resolutions on this subject will be introduced at the Council and the General Meeting in San Antonio in January. There will be two related panel discussions during the January meeting: one on military funding in mathematics, and one on Star Wars software reliability.

What is the right question?

In many discussions of funding of science and of mathematics, ethical considerations having to do with the wider society or the longer term are dismissed as extraneous, unprofessional, or political. Such an atmosphere does not do us justice. Human society works only because people regard the welfare of the wider society as an important goal, often above their own narrow interests. People vary widely in their conclusions, but I believe we are nearly unanimous in the starting point.

For the topic at hand, the question is not "how can we maximize the resources and influence of ourselves and mathematics?" but "how can we most benefit society, mathematics and ourselves?"

We mathematicians are the only people who are in a good position to evaluate our impact on society. It is our civic duty to do so *especially* when we disagree.

Although most people desire to act in the best interests of society, many do not think through clearly what this means.

When a moral comparison between alternatives is unclear, people follow the gentle or not-so-gentle pressure of the here and now, the pocketbook.

Relevance

The issue is timely and urgent. We all are aware of deserving mathematicians who are denied NSF support for their research because money is scarce. We know mathematicians who have recently turned to the military, and others who are resisting acceptance of military funding.

I have personally had to come to grips with the issues because I am seeking financing for computation at Princeton, so I can quit spending a large part of my time on computer systems administration, maintenance and programming. Repeatedly, people approach me with opportunities for military funding.

I have chosen not to take that route. More than one person has criticized me, on ethical grounds, for *not* accepting military funding.

The military and support of science

World War II was a high point for the US military. The country had a united spirit in fighting against an evil regime in Germany and an imperialist regime in Japan — almost everyone was involved. Aspects of the war are controversial in some circles, but the patriotic unity and spirit of our nation is not disputed.

After World War II, the ONR (Office of Naval Research), followed by the AFOSR (Air Force Office of Scientific Research) and the ARO (Army Research Office) began supporting basic research in mathematics and other sciences. Many mathematicians whom I respect praise the management

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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.

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of funding during this period. I was too young to be involved, and I accept what people tell me.

The NSF was founded in the early 50s and began to replace the military agencies as a funding source. The military agencies gradually shifted toward applied rather than basic research.

When Sputnik was launched in 1957, science became a high national priority. More resources became available. The Advanced Research Project Agency, or ARPA (to which Defense was later prepended making it DARPA) was founded in 1958. In theory, DARPA is an agency which funds initiatives in areas of strategic interest to the US, rather than providing sustained or broad support for science. They have played a crucial role in the development of Computer Science as a discipline.

During the long and bitter war in Vietnam, the military presence on campus was curtailed, after much controversy. Finally, the Mansfield amendment was passed in 1969, ordering the military only to fund projects directly related to their mission; other scientific funding was supposed to go through the NSF. The trend has persisted until the present.

During the years of the Carter and Reagan administrations, the military budget has grown tremendously. The military is not the same organization it was after World War II. Our large military establishment has no definite mission against which performance is tested. Projects such as the MX missile have some kind of bureaucratic logic, but are hard to justify by any external criterion.

The effect of this huge influx of military money on science and engineering is documented in the pamphlet *Basic research: the key to economic competitiveness* by NSF director Erich Bloch: federal money for research and development has shifted from about 50 percent civilian and 50 percent military in 1980, to 28 percent civilian and 72 percent military in 1985. When the comparison is limited to research (excluding development), the percentages for military funding are smaller but the increase is similar. The thrust of this change has been away from basic research, and toward applied research.

Within the last two or three years, a new program in mathematics has arisen through DARPA. Its budget is now $10,000,000, quite a large chunk of the total Federal mathematics support. This program has evoked controversy, partly because it touches areas of mathematics which have not previously had military funding and partly because of criticisms of its management and narrow stated goals. It is defended and supported by our mathematical leadership on the grounds that if we cooperate with the program, we will eventually be able to straighten out its problems.

The SDI (Strategic Defense Initiative or "Star Wars") is another major potential source of military funds for mathematics. There is currently about a million dollars of SDI money in mathematics, but next year there may be much more. The Board on Mathematical Sciences recently organized a meeting between mathematicians and representatives from ISTO (Innovative Science and Technology Office), the arm of SDI funding research in universities, to investigate how mathematicians could help with SDI.

I won't take space to explain the dangerous and fraudulent nature of SDI, for in my experience mathematicians and scientists largely agree on this. SDI might not be politically viable after the end of the Reagan administration. Some scientists argue that although they regard SDI as stupid, they need not work against it, since it is unimportant and will die of its own weight.

But SDI has already had a large influence on the arms race. The Reagan administration has rejected the concept of a mutual verifiable ban on nuclear testing on the grounds that it would interfere with SDI research. In Iceland it has rejected a near-agreement for major mutual disarmament on the same grounds. *Newsweek* reports that Richard Perle (an influential DoD hawk) uses SDI as a monkey wrench in the arms control process. Whatever the ultimate outcome of the arms-control talks, and whatever opinion we have on the desirability of arms-control or of SDI, we cannot dismiss SDI as insignificant.

Generations

Those of us who came of age during the Vietnam war experienced a culture very different from that of people just a few years older. The generation gap was strong; it was "us" against "them." "They" were living in the past, sending "us" to fight in an immoral war. Many of us were involved in student demonstrations and student strikes. We were sprayed with tear gas, whether or not we protested. We had friends who were killed, others who refused induction and were convicted as felons, and others who served in Vietnam and survived with psychological scars that still dominate their lives.

But it is important for us of the Vietnam generation not to live in the past. Mathematics is a multigenerational and international enterprise. We need to recognize that others have been shaped by very different and sometimes very terrible experiences.

Many mathematicians who came of age during or after World War II but before the Vietnam war decry the current nature of the military, the SDI program, and perhaps the current DARPA program, and would like to see a return to the seemingly benign relationship between science and the military, as it was after World War II.

This is no longer the post World War II era and it is no longer the Vietnam era. We should re-examine the issue of military funding in light of the present and of what we hope for the future.

MILITARY SOCIETY AND ACADEMIC SOCIETY

There is a basic contradiction between the principles which govern a military force and the principles of the academic environment. Military action is coercive. It is an extreme recourse, which should only be used under great duress. A military force is governed by authority, for it must act in concert.

In contrast, an academic institution is a place for reflective thought, diverse views, and considered discussions, not for the exercise of authority or coercion. It protects people from political fashions. It serves a society as a source of new ideas and a source of criticism for old beliefs.

For the health of society, military institutions and academic institutions should be *separated.* If, as many say, military institutions are not healthy enough to meet their internal research needs, let's cure the sickness rather than spread the disease.

For purposes of discussion, we can divide military funding of science into two loose categories: true military research, and general research.

True military research is by its very nature secretive. Information which is freely exchanged in the international academic community does not give a competitive military advantage to a particular nation. True military research certainly does not belong in a university. Nevertheless, it is present. For example, senior faculty in some of the best computer science departments are working on a big project to design "intelligent" military vehicles.

Much of the research funded by the military on university campuses is not truly military research, but general research. Scientists on military grants often maintain that they are doing the same basic research they would be doing if their grant was from NSF. On the collective level this is clearly false: military funding priorities are very special.

It is a dangerous reversal of the proper relationship between military and civilian life when control of civilian enterprises is funneled through the military. This reversal has taken place in fields not far from mathematics. It is difficult for students in many fields to *avoid* working on military projects. In places like MIT, graduate students in physics routinely shuttle between summer jobs doing true military research at the affiliated military laboratories, and general research funded by the military on the campus. The reversed relationship has funneled too much of our scientific and engineering effort into military matters.

In computer science, the major departments are now the ones which have a good relation with DARPA. According to an ACM report *Imbalance between growth and funding in academic computing science* by Gries, Miller, Ritchie and Young, a survey showed that in the top four departments the NSF support per faculty member in 1985 averaged $31,000, while that from the Department of Defense averaged $279,000. Such a department is in effect owned by the military. During quiet periods, the military is usually wise enough not to pull as much as they might on the strings, but the strings are well in place, to be pulled at need and at will. The military funding has emphasized applied research at the expense of theoretical research. In important areas of research such as VLSI (very large scale integration, the technology used for today's most important computer chips), the influence is so strong that information exchange is primarily at military conferences, not in journals. The information is available only to insiders.

The setting of research priorities should be a civilian process. The reversal of roles in which the military took responsibility for scientific research may have been appropriate during and shortly after World War II, but it is inappropriate, inefficient and dangerous today.

MATHEMATICS DEPARTMENTS

Mathematicians are reluctant to concern themselves with grants of their colleagues.

Such an attitude makes sense only as long as grants are small in scale, and do not impinge on others. With the new funding, this is no longer the case. There are community issues within mathematics departments of immediate concern to mathematicians.

The typical military grant is large in comparison to other sources of funding within most departments, especially in this time of funding scarcity. The money has an impact on graduate students. A department has two choices: student support is either distributed among students in a wide pool, or it goes to students of the participants in the grant.

With the first approach, students are essentially forced to take military money in order to remain in the department. Students are in a position of disadvantage in presenting their case, and it is not right to trample over their scruples.

The second approach leads to inequity: students of those who accept military grants likely receive better funding than those who do not accept military grants.

An additional difficulty is that foreign students are not eligible for support on many military grants.

There is a similar problem regarding computer equipment, which is increasingly important to mathematicians. If equipment is pooled within a department, members of the department are forced to accept military money to use the equipment. If equipment is not pooled, mini-empires are created within departments, a commonplace and divisive phenomenon in some disciplines.

Should people who have scruples against military grants or who do not have research

interests in fields favored by military agencies be handicapped in attracting graduate students, in this time of a shortage of students? *Do we want this process to determine the direction of mathematics?*

MANAGEMENT

Military funding is frequently not managed for the good health of science. There are two reasons for this.

First, although the decision process varies among military agencies, it often involves much less expert and disinterested outside input than the process in the NSF. Thus, decisions are much more dependent on the integrity and quality of the program directors — which is variable. Personal relationships, rather than quality of research, may determine research grants. Researchers are tempted to say what the program administrator wants to hear. It is easy to invent proposals which are persuasive to people who don't quite know what is going on.

Second, the research funded by the military must be justified by military needs, not just scientific interest. At the 1986 mathematics chairman's day, Arthur Wouk of the ARO (Army Research Office), described the mission of the ARO program in mathematics: shock, blast, and penetration. His frankness is to be commended; it is not the ARO that sets these goals, but the army research labs and the generals. Some mathematical methods useful for understanding shock, blast, and penetration are of general interest, but this is a byproduct. Similar public statements can be found for the other military agencies.

The narrowing of goals stemming from mission-directed research saps the health of mathematics. The strength of mathematics comes from its diversity and its unity. Mathematicians study a tremendous range of interesting phenomena. As we go from one mathematical theory to another, we find connections which give us glimpses of one magnificent edifice which encompasses them all. Mission-directed research prevents us wandering where our interests lead. If one compares the tremendous intellectual breadth of research supported by the NSF mathematics division to that supported, with a comparable total budget, by the military agencies, it is clear that the ratio of ideas per dollar is far larger for the NSF.

WE LIVE IN A DEMOCRATIC COUNTRY

One rationalization for military research starts from the fact that we live in a democratic country. The train of thought continues: Democracy means individuals following the will of the majority. Since the general public and elected officials seek increased military power, it is our duty to go along; moreover we must explain our own research in military terms so they will listen to us.

In fact, the few bits of preference we communicate on election day are but a small part of democracy. The real workings of democracy are the discussions and actions of many people; elections are the guarantee and catalyst for this process.

For instance, military contractors often say their work is chosen through a democratic process for the good of the country. But the defense contractors all have strong lobbying efforts in Washington. Military projects are in fact born and nurtured in a coalition of lobbyists from industry, lobbyists from the Pentagon, and politicians. The military contractors have a large input to and a large responsibility for the choice of their work.

The combined mathematical societies, through the Joint Policy Board on Mathematics (JPBM) and its representative Ken Hoffman, have been sponsoring a strong effort in the Pentagon and in Congress to persuade them to increase Federal support, and in particular, military support, for research in mathematics. Their effort has been effective. The JPBM has solicited grants from DARPA for funding of mathematics awareness week. Ken Hoffman has defended DARPA against criticisms within the mathematical community. The JPBM and the Board on Mathematical Sciences selects and solicits mathematicians to testify before Congress and speak to the press: they explain that we need to present a simple message, spoken with one voice.

It is disingenuous to say our actions are merely in obedience to a democratic decision; these actions *are* the democratic process. Let us use this process to express our actual knowledge and our real beliefs.

THEOREMS AND BOMBS: THE EFFECTS OF MILITARY FUNDING

Many say that the act of accepting military funding is irrelevant to society at large: its only practical effect is to channel money away from bombs into better uses.

Money is one aspect of the research which is rather negligible to the military. The entire Federal mathematics research budget is about 1/5000 the size of the military budget, comparable in cost to a single fighter plane.

What difference, then, does military funding make? Strong effects are clearly visible: effects in technology, in politics, in the international order, and in culture. I will discuss these in turn.

Technology. In dismissing the relevance of their work to the real world, pure mathematicians forget that the development of mathematical knowledge is an informal process not measured merely by theorems. Progress in mathematics is mainly the clarification and compression of thinking and the sharpening of concepts and analytical tools. The accompanying logical lattice of

formally stated and established theorems is significant, but as new and sharper concepts replace old, mathematicians can often quickly reconstruct proofs for theorems which were once difficult.

Mathematics is a universal subject precisely *because* it is abstract. The fields of mathematics are intellectually closely related. Although human limitations lead individuals to specialize, still, mathematicians have in common a powerful and general-purpose way of thinking.

Recently, through circumstance, I have spent time with computer scientists. I find myself talking and thinking about computer science problems, and analyzing them with modes of thought sometimes foreign to the culture of computer science. I enjoy this. My experience would be similar if I were to spend time with physicists, biologists, economists, chemists, engineers ... — or with weapons makers. My theorems are not the commodity which I have to offer them, but rather expertise in mathematical modes of thinking.

When the military funds academic research, the most important *technological* commodity they buy is access to the intellect and intellectual environment of the researchers.

Politics. Military funding of scientific research by respected scientists and in respected academic institutions has a political effect, independent of its technological effect.

First, the funding undercuts potentially strong opposition by scientists to military projects. Some people argue that mathematicians should oppose the DARPA program in mathematics on an institutional level, but not on an individual level; people should take grants from them, but register their opposition to the program as a whole. How many of the mathematicians currently receiving DARPA support are likely to publicly register such opposition? At the 1986 DARPA mathematics meeting at Boston University, the director of the DARPA mathematics program, Dr. Helena Wisniewski stressed the need for people with grants in the program to go out and support the program. This is natural; people with grants from the NSF go out and defend their program. It puts those who accept support in an awkward position if they believe the program itself is dubious.

Donald Hicks, recently resigned as undersecretary of defense for research and engineering, made an infamous public statement in which he said that he would like to see funds cut off from scientists receiving support from the DoD who speak out and "bite the hand that feeds them."

A second political effect of military funding arises from the high prestige of university research in the eyes of the public and Congress. This acts as a political lever. Ionson, the director of SDI's Office for Innovative Science and Technology, said, "It's probably something that's never been done, but this office is trying to sell something to Congress. If we can say that this fellow at MIT will get money to do such and such research, it's really something to sell." Scientists will never receive a large proportion of the defense budget, but they can make a large impression in the minds of Congress. Their research greases the way for far bigger expenditures on far more noxious projects. On a smaller scale, program directors in the military agencies cite distinguished participants, who are given freedom to ignore the program mission, in order to justify their entire programs.

Military funding of mathematics is like a portion of the military advertising budget. It is small in proportion to the total budget, but highly visible. Computer-generated pictures by mathematicians appear on their glossy brochures and postcards. Many people who would not even consider accepting direct payments to advertise in favor of higher military funding or SDI accept "advertising" money indirectly for their research. When you accept support, you should consider whether the product you advertise is a product you wish to promote.

The international order. Mathematics is a particularly international field. The military encroachment on US mathematics will drain this international spirit. Many foreign mathematicians already are inhibited from discussing international relations with Americans because of different understandings of the world; this effect will grow.

In every country, people like Edward Teller warn about the enemy's ominous military research. All military-funded research adds to the atmosphere of threat, because politicians can't tell true military research from military-funded general research. The atmosphere of threat is more important than military capability. France has enough military warheads to destroy the United States, yet this does not disturb us, because our relations are generally good.

Culture. There are marked cultural differences between academic disciplines. The cultural differences play a large part in the careers and political outlooks of members of the disciplines. I don't think I need to give examples since we have all seen them. Militarily-funded general research paves the way to a culture which accepts true military research, classified research, and weapons research.

People model behavior on the behavior and expectations of those with whom they associate. This is a very powerful force.

NEEDS

The needs of mathematics and of mathematicians for more resources are clear and not in dispute. We are facing a shortage of mathematicians in the very near future — we need better support for students and for postdocs. Also, we have large needs for wider summer support, along with new

needs for computer equipment and technical staff to support and maintain the equipment.

Being poor does not mean we should sell out.

WE ARE NOT POWERLESS

Some people say it is a political fact that people in our country are much more ready to vote for something if it is justified in military terms. It is much easier to get what we want if we pose it thus. We are not the ones to decide how money will be spent; we have to take what comes along, or be left behind. Ken Hoffman compares the situation to Dunkirk: the boats may look rather leaky, but if we are going to sit on the beach and wait for a troop carrier we will be left behind.

We are not under attack from a hostile force. We are also not powerless. We have a strong case, and an important product: we do not have to sell it for potential military applications. Mathematicians have traditionally been detached from politics and lobbying, but that does not mean we never can or will take action.

There is great power in truth and sincerity. The mathematics community has tremendous reserves of human potential energy. If we are lean and hungry, we are likely to use our energy. If we are honest, it is likely to be effective, for whether justified or not, the public and Congress hold scientists (including mathematicians) in a certain awe. Let us tell the NSF, tell Congress, and tell the public what mathematics is really about.

CONCLUSIONS

1. There has been opposition within the AMS to discussion of the wider issues associated with military funding, with the explanation that they are political issues. Democracy is political; the issues are professionally and ethically of great moment, and we need to have a general discussion in which all responsible points of view are considered.

2. Funding of basic research is an important societal need, and it should be met through civilian agencies. Academia should be separated from the military. Military funding of research in universities, and of mathematics in particular, is bad for our society, bad for the universities, and bad for mathematics.

The military pattern of funding has a large negative impact, since it attaches strong strings from the military to academia. Even in normal times, this channels the short supply of mathematicians into an intellectually limited range of topics, and distorts the debates on societal issues. In troubled times, the strings can be exercised to disastrous effect.

Individual funding by military grants has a negative impact on the rest of the community — an impact on dangerous technology, on politics and public relations, on international relations, and on the culture of mathematics itself.

3. We should resist the increasing role of the military in academia and in mathematics, and work to replace military funding by civilian funding.

3a. Those of us who believe military funding is wrong should reconcile our actions to our beliefs.

We should also discuss the issues, without rancor, with people who believe military funding is right, and with those who believe military funding is wrong but that acceptance of military funding is right. Many sincere and well-intentioned mathematicians have military grants; some of them work in fields or subcultures where they have little choice but to accept them. During the era of the Vietnam war, there was much name-calling concerning the question of the military on campus. We need to recognize the honesty and good will of those who accept military grants, while opposing their actions. It is up to the conscience of the individual what grants to accept.

3b. The AMS should take a position in the JPBM and instruct its agents not to promote military funding, and it should make a policy decision not to participate in military grants.

3c. The Board on Mathematical Sciences, an arm of the NRC and NAS, should stop acting as a marketing agent for military funding programs.

3d. When a consensus can be reached, the AMS should take the further step of advocating decreased military funding, taking particular care to find appropriate alternate funding for fields which have traditionally depended on military support.

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The Goal of Communicating

When trying to glean from papers the authors' motivations for doing the work, we often get an impression that the authors might be saying "so and so worked on this problem and I can generalize those results," in other words, the goal is one-upmanship. There is very little discussion of goals in the literature. Graduate students form their views of research in large part from the literature so this lack of guidance encourages the beginner to do motivationless research.

I would like to propose to those who might feel a lack of direction that they try to adopt as their primary research goal the discovery and communication of ideas that people need to know. Ideas that surprise. Ideas that are useful. Ideas that need to be communicated. Why they need to be communicated and to whom is up to the researcher to decide. This type of research requires a different approach. At least half the effort should be put into finding the right problem. Technical power in the proofs may turn out to be useful, but it is a secondary by-product, no more important than the results. There are

many very skilled technicians working on the available problems so there may be little loss if you aim at reexamining what needs to be solved. Assume that dozens of workers in the field are missing important directions and find them. How are people going to get field medals for solving famous problems unless you find good problems for them?

Instead of the one-upmanship goal which results in piling complexity upon complexity, let us recall that most of the tools we use over and over are relatively simple and the mathematics community gets much greater mileage out of elegant, simple ideas. Indeed, in many great "expository" efforts, such as in the Bourbaki series, the attempt to describe fundamental ideas turned out to require many new, basic, simple ideas. One medical journal classifies papers without new data as expository. Perhaps we should adopt the view that all our papers are "expository" in the sense that we are giving an exposition of ideas, or perhaps we should advocate the regular use of the term "distinguished exposition" to describe what our journals should ask for.

One hundred years ago there was an intellectual community of which mathematics was a part. Then came the mathematics community as technical difficulties increased and exposition decreased. Exposition was still a goal. Several nontechnical books for the layman were dedicated to the extremely difficult ideas of Gödel. Now fields become less and less accessible. People remark how wonderfully mathematics is interconnected when those ever rarer instances of interconnection appear. Does anyone see a trend?

Our standards of exposition are making it more difficult to interconnect mathematics: Research papers simply CANNOT contain results and definitions that EVERYBODY knows. "Everybody" means only people who have spent several years doing research in the field in question. As a mathematician who has many contacts with physicists, I sometimes encounter physicists who want to understand various theorems. The results are necessary for their research. They are respected scientists, though of course they have not taken even the basic mathematics graduate courses that everybody takes. They find they cannot read papers in math journals. Of course, mathematicians sometimes cannot read math papers, but it seems the physicists find they NEVER can. If abstract mathematics is supposed to be occasionally useful in surprising ways in areas outside of mathematics, who is supposed to find the specific applications? Well at least mathematicians read mathematics papers sometimes, but a study of the 1,000 most cited scientists [1] turned up ZERO mathematicians. On the average, compared with the sciences, mathematics papers cite few papers (especially when you exclude people's references to their own work). To me this indicates that while some research is widely celebrated, very little of it is very useful to mathematicians. Mathematics is becoming ever more disjointed and this process could be slowed by having the literature more accessible.

[1] E. Garfield, the 200 "Pure" Mathematicians Most Cited in 1978 and 1979..., Current Contents September 6, 1982.

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The American Mathematical Society is beginning a Chinese translation program, under the direction of an Editorial Committee presently consisting of:

Professor Sun-Yung Alice Chang, University of California, Los Angeles

Professor Tsit-Yuen Lam, University of California, Berkeley (Chairman)

Professor Tai-Ping Liu, University of Maryland

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Outstanding research monographs in Chinese will be translated, as well as lecture notes or other surveys that are of exceptional merit. No journals will be translated from cover to cover, at present, but selected articles will be translated and published in collections, as books.

Maintaining this program will require the services of a number of translators, to cover the various branches of mathematics with the necessary expertise. If you would or might be interested in engaging in such an endeavor, please write or phone Ms. Mary C. Lane, Director of Publications, at the AMS headquarters (800-556-7774), and further details will be sent to you. The Society pays for this work, and you may establish various conditions such as an upper bound on the number of pages per month or per item that you wish to receive, and you may of course return any item not lying within your own area of interest.

The mathematical community will be indebted to everyone who assists in this undertaking.

Applications Sought for Senior and Postdoctoral Research Associateships

The National Research Council announces the 1987 Resident, Cooperative, and Postdoctoral Research Associateship Programs for research in the sciences and engineering to be conducted in behalf of 26 federal agencies or research institutions, whose laboratories are located throughout the United States. The programs provide Ph.D. scientists and engineers of unusual promise and ability with opportunities to perform research on problems largely of their own choosing yet compatible with the research interests of the supporting laboratory. Initiated in 1954, the Associateship Programs have contributed to the career development of over 4,000 scientists ranging from recent Ph.D. recipients to distinguished senior scientists.

Approximately 450 new full-time Associateships will be awarded on a competitive basis in 1987 for research in mathematics, as well as in the following areas: chemistry; earth and atmospheric sciences; engineering and applied sciences; biological, health, behavioral sciences and biotechnology; space and planetary sciences; and physics. Most of the programs are open to both U.S. and non-U.S. nationals, and to both recent Ph.D. degree recipients and senior investigators.

Awards are made for one or two years; senior applicants who have held the doctorate at least five years may request shorter tenure. Stipends for the 1987 program year will begin at $26,350 a year for recent Ph.D.'s and be appropriately higher for Senior Associates. A stipend supplement of approximately $5,000 may be available to regular (not senior) awardees holding recognized doctoral degrees in those disciplines wherein the number of degrees conferred by U.S. graduate schools is significantly below the current demand. In the 1986 program year, these areas have been engineering, computer science, and space-related biomedical science.

Reimbursement is provided for allowable relocation costs and for limited professional travel during tenure. The host laboratory provides the Associate with programmatic assistance including facilities, support services, necessary equipment, and travel necessary for the conduct of the approved research program.

Applications to the National Research Council must be postmarked no later than **January 15, 1987**, **April 15, 1987**, and **August 15, 1987**. Initial awards will be announced in March and April (July and November for the two later competitions) followed by awards to alternates later.

Information on specific research opportunities and federal laboratories, as well as application materials, may be obtained from the Associateship Programs, Office of Scientific and Engineering Personnel, JH 608-D3, National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. Telephone: (202)334-2760.

NAS Scientific Exchange Program with the U.S.S.R. and Eastern Europe

The National Academy of Sciences (NAS) invites applications from American scientists who wish to make visits beginning during the period September 1, 1987, through December 31, 1988, to the U.S.S.R., Bulgaria, Czechoslovakia, the German Democratic Republic, Hungary, Poland, Romania, and Yugoslavia. Long-term research visits of 3 to 12 months duration are encouraged, particularly if contact with colleagues in the other country has already been established. The minimum length of visits is 1 month in one country.

Applicants must be U.S. citizens and have a doctoral degree or its equivalent by June 1987 in physics; chemistry; mathematics and computer sciences; engineering; and a number of other physical, biological, and sociological sciences. Necessary expenses will be met by the NAS and the foreign academy, including reimbursement for long-term visitors for salary lost up to a predetermined maximum and expenses for accompanying family members for visits exceeding 5 months.

Requests for applications should reach the National Academy of Sciences not later than **February 13, 1987**. Applications must be postmarked by **February 28, 1987**. Address application requests to National Academy of Sciences, Office of International Affairs, Soviet and East European Affairs (JH-218), 2101 Constitution Avenue, N.W., Washington, D.C. 20418. Telephone: (202)334-2644.

Queries

Edited by Hans Samelson and Stuart Antman

QUESTIONS ARE WELCOMED from AMS members regarding mathematical matters such as details of, or references to, vaguely remembered theorems, sources of exposition of folk theorems, or the state of current knowledge concerning published or unpublished conjectures. This is not intended as a problem corner, except for occasional lists of problems collected at mathematical meetings.

REPLIES from readers will, when appropriate, be edited into a composite answer and published in a subsequent column. All answers received will be forwarded to the questioner.

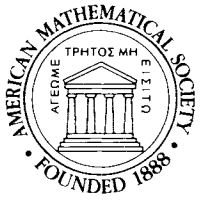
QUERIES and RESPONSES should be typewritten if at all possible and sent to Queries Column, American Mathematical Society, P. O. Box 6248, Providence, Rhode Island 02940.

Queries

370. Dr. Maurice Machover (St. John's University, Mathematics Department, Jamaica, New York 11439). Is there an analogue to the formula

$$Z = \frac{1}{2\pi i} \oint_C \frac{f'(z)}{f(z)}\, dz,$$

for the total number of zeroes (counting multiplicities) of the analytic function f inside the simple closed contour C, which gives only the number of zeroes of *order higher than one*? (Maybe an appropriate modification of the integrand will work.)



Axiomatic Set Theory

James E. Baumgartner, Donald A. Martin and Saharon Shelah, Editors

Mathematicians interested in understanding the directions of current research in set theory will not want to overlook this book, which contains the proceedings of the AMS Summer Research Conference on Axiomatic Set Theory, held in Boulder, Colorado, June 19–25, 1983. This was the first large meeting devoted exclusively to set theory since the legendary 1967 UCLA meeting, and a large majority of the most active research mathematicians in the field participated. All areas of set theory, including constructibility, forcing, combinatorics and descriptive set theory, were represented; many of the papers in the proceedings explore connections between areas. Readers should have a background of graduate-level set theory.

There is a paper by **S. Shelah** applying proper forcing to obtain consistency results on combinatorial cardinal "invariants" below the continuum, and papers by **R. David** and **S. Freidman** on properties of $0^{\#}$. Papers by **A. Blass**, **H.-D. Donder**, **T. Jech** and **W. Mitchell** involve inner models with measurable cardinals and various combinatorial properties. **T. Carlson** largely solves the pin-up problem, and **D. Velleman** presents a novel construction of a Souslin tree from a morass. **S. Todorcevic** obtains the strong failure of the $\square$ principle from the Proper Forcing Axiom and **A. Miller** discusses properties of a new species of perfect-set forcing. **H. Becker** and **A. Kechris** attack the third Victoria Delfino problem while **W. Zwicker** looks at combinatorics on $P_\kappa(\lambda)$ and **J. Henle** studies infinite-exponent partition relations. **A. Blass** shows that if every vector space has a basis then AC holds. **I. Anellis** treats the history of set theory, and **W. Fleissner** presents set-theoretical axioms of use in general topology.

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American Mathematical Society

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San Antonio Meetings, January 21 – 24, 1987

Program

The January 1987 Joint Mathematics Meetings, including the 93rd Annual Meeting of the AMS, the 70th Annual Meeting of the Mathematical Association of America, and the 1987 annual meetings of the Association for Symbolic Logic, Association for Women in Mathematics, and the National Association for Mathematicians, will be held January 21 – 24 (Wednesday – Saturday), 1987, in San Antonio, Texas. MAA will cosponsor a session on Wednesday, January 21, with the National Council for Teachers of Mathematics (NCTM). Sessions will take place in the San Antonio Convention Center and the San Antonio Marriott Hotel.

The members of the Local Arrangements Committee are Donald F. Bailey, Robert M. Fossum (ex-officio), William J. LeVeque (ex-officio), Kenneth A. Ross (ex-officio), Gregory P. Wene (chairman), Lawrence R. Williams, and Bennir A. Zinn.

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IMPORTANT DEADLINES

AMS Abstracts	
For consideration for special sessions	**Expired**
Of contributed papers	**Expired**
MAA Abstracts	
Of contributed papers	**Expired**
Employment Register (Applicants & Employers)	**Expired**
EARLY Preregistration and Housing	**Expired**
Preregistration and Housing	**Expired**
MAA Minicourse Preregistration	**Expired**
Motions for AMS Business Meeting	**December 22**
Preregistration cancellations (50% refund)	**January 16**

93rd Annual Meeting of the AMS January 21 – 24, 1987

Sixtieth Josiah Willard Gibbs Lecture

The 1987 Gibbs lecture will be presented at 8:30 p.m. on Wednesday, January 21, by THOMAS C. SPENCER of the Courant Institute of Mathematical Sciences, New York University. The title of his lecture is *Schrödinger operators and dynamical systems.*

Colloquium Lectures

There will be a series of four Colloquium Lectures presented by PETER D. LAX of the Courant Institute of Mathematical Sciences, New York University. The title of this lecture series is *Uses of the non-Euclidean wave equation.* The lectures will be given at 1:00 p.m. daily, Wednesday through Saturday, January 21 – 24.

Prizes

The 1986 Leroy P. Steele Prizes and the 1987 Frank Nelson Cole Prize in Number Theory will be awarded at 4:25 p.m. on Thursday, January 22.

Invited Addresses

By invitation of the Program Committee, there will be seven fifty-minute invited addresses. The names of the speakers, their affiliations, the dates and times of their talks, and titles follow:

MARC CULLER, University of Illinois at Chicago, *Free groups, trees and their automorphisms*, 11:10 a.m. Saturday;

RONALD J. DIPERNA, University of California, Berkeley, *Nonlinear partial differential equations and vortex theory*, 10:05 a.m. Wednesday;

RICHARD T. DURRETT, Cornell University, *Crabgrass, measles, and gypsy moths: An introduction to modern probability*, 10:05 a.m. Friday;

ROBERT M. HARDT, University of Minnesota, Minneapolis, *Regularity and singularity for energy minimizing maps*, 3:20 p.m. Thursday;

ROBERT J. MCELIECE, California Institute of Technology, *The capacity of neural networks*, 9:00 a.m. Wednesday;

DAVID J. SALTMAN, University of Texas, Austin, *Noether's problem, Galois theory and the Brauer group*, 9:00 a.m. Friday;

LESLEY M. SIBNER, University of Pennsylvania, *Analytic aspects of gauge field theory*, 2:15 p.m. Thursday.

Special Sessions

By invitation of the same committee, there will be twelve special sessions of selected twenty-minute papers. The topics of these special sessions, the names and affiliations of the mathematicians arranging them, the dates and times they will meet, and final lists of speakers, are as follows:

Geometric methods in group theory, ROGER ALPERIN, University of Oklahoma, Friday 1:00 p.m., Saturday 8:00 a.m. and 1:30 p.m. Hyman Bass, Stephen G. Brick, Kenneth S. Brown, J. W. Cannon, Daryl Cooper, Mark Feighn, Benjamin Fine, William J. Floyd, Ross Geoghegan, S. M. Gersten, Henri Gillet, Richard Goldstein, John Hempel, Horace Y. Mochizuki, Walter D. Neumann, Walter Parry, Steven Plotnick, John G. Ratcliffe, Frank Rimlinger, Peter B. Shalen, John R. Stallings, Marvin Tretkoff, and Karen Vogtmann.

Nonlinear partial differential equations, RONALD J. DIPERNA, University of California, Berkeley, Wednesday 2:15 p.m., Thursday 9:00 a.m., and Friday 1:00 p.m. Russell Caflisch, Peter Constantin, Craig Evans, Greg Forest, Kenneth Golden, Robert Kohn, Andrew Majda, David McLaughlin, Graeme Milton, John Neu, George Papanicolaou, Gilbert Strang, and Michael Weinstein.

Classical real analysis, MICHAEL J. EVANS, North Carolina State University, Raleigh, and PAUL D. HUMKE, St. Olaf College, Thursday 8:00 a.m., Friday 1:00 p.m., and Saturday 8:00 a.m. and 1:00 p.m. Steven Agronsky, Aliasghar Alikhani-Koopaei, J. M. Ash, Jack Brown, Zoltan Buczolich, Peter Bullen, George Cross, Geraldo Soares de Souza, James Foran, K. M. Garg, Jerry Gibson, Paul D. Humke, Alexander S. Kechris, Miklos Laczkovich, Lee Larson, Cheng-Ming Lee, B. A. Mair, Daniel Mauldin, Sandra Meinershagen, Ibrahim Mustafa, Richard O'Malley, Krzysztof Ostaszewski, Washek F. Pfeffer, H. W. Pu, Dan Rinne, A. Szymanski, Kevin Taylor, S. J. Taylor, Brian Thomson, Daniel Waterman, Clifford Weil, and Wladyslaw Wilczynski.

Brauer groups and Galois theory, BURTON FEIN, Oregon State University, DAVID J. SALTMAN, University of Texas at Austin, and MURRAY SCHACHER, University of California, Los Angeles, Thursday 9:00 a.m., Friday 1:00 p.m., and Saturday 9:00 a.m. Lindsay Childs, Frank Demeyer, Burton Fein, Walter Feit, Timothy Ford, Gary Greenfield, Darrell Haile, Raymond Hoobler, Bill Jacob, Nathan Jacobson, David Leep, Patrick Morandi, and Leonid Stern.

Geometric inequalities, MICHAEL GAGE, University of Rochester, and ERWIN LUTWAK, Polytechnic Institute of New York, Wednesday 2:15 p.m., Thursday 8:00 a.m., and Friday 1:00 p.m. Fred Almgren, Ilya J. Bakelman, Isaac Chavel, Boris V. Dekster, Charles L. Epstein, Michael Gage, Eric L. Grinberg, Paul Goodey, H. Groemer, James Hebda, Ralph Howard, David J. Johnson, Erwin Lutwak, Robert Osserman, Clinton M. Petty, Richard E. Pfiefer, Igor Riven, J. R. Sangwine-Yager, Richard P. Stanley, Jean E. Taylor, Andrejs E. Treibergs, Richard A. Vitale, and Lawrence J. Wallen.

Stochastic processes and analysis, JOSEPH GLOVER, University of Florida, and A. O. PITTENGER, University of Maryland, Thursday 8:00 a.m., Friday 1:00 p.m., and Saturday 8:00 a.m. R. Banuelos, M. Bramson, A. Carverhill, J. T. Cox, R.W.R. Darling, B. Davis, Joseph Glover, L. Gray, F. Knight, T. Liggett, P. March, T. McConnell, M. Nagasawa, M. Pinsky, L. Pitt, A. O. Pittenger, M. Rao, and R. Schonmann.

Combinatorics and group representations, PHILIP J. HANLON, University of Michigan, Wednesday 2:30 p.m., Thursday 8:30 a.m., and Friday 1:00 p.m. Lynn Butler, A. R. Calderbank, Ira Gessel, Curtis Greene, Philip J. Hanlon, David Jackson, Joe Kung, Robert Proctor, Jeffrey Remmel, Bruce Sagan, Richard Stanley, Dennis Stanton, John Stembridge, Sheila Sundaram, and Dennis White.

Theoretical optimization, LYNN MCLINDEN, University of Illinois, Urbana-Champaign, and JAY S. TREIMAN, West Michigan University, Thursday 8:00 a.m., Friday 1:00 p.m., and Saturday 8:00 a.m. G. A. Beer, J. M. Borwein, R. W. Chaney, F. H. Clarke, J. Gauvin, K. Georg, A. A. Goldstein, M. S. Gowda, S.-P. Han, L. McLinden, J.-S. Pang, N. S. Papageorgiou, A. B. Poore, H. M. Strojwas, S. Simons, R. A. Tapia, J. S. Treiman, D. E. Ward, and H. Wolkowicz.

Orthogonal polynomials and the moment problem, PAUL G. NEVAI, Ohio State University, Friday 1:00 p.m. and Saturday 8:30 a.m. R. Askey, E. Bannai, T. Chihara, G. Chudnovsky, J. Dombrowski, W. Gautschi, M. Ismail, A. Mate, J. Nuttall, M. Rahman, and E. Saff.

Recent results in gauge field theory and Riemannian geometry, LESLEY M. SIBNER, University of Pennsylvania, Wednesday 2:15 p.m., Thursday 8:00 a.m., and Friday 1:00 p.m. Patricio Aviles, Abbas Bahri, Robert Bryant, Wenziong Chen, Amy Cohen, Dennis DeTurck, Jose F. Escobar, Samuel I. Goldberg, Robert E. Gompf, David Groisser, H. H. W. Hofer, Jerry Kazdan, Guojun Liao, Thomas H. Otway, Thomas Parker, Robert Sibner, Lorenzo Sadun, Gabor Toth, and D. Yang.

Mathematical physics, GREGORY P. WENE, University of Texas, San Antonio, Saturday 8:30 a.m. and 1:00 p.m. M. S. Berger, A. Bohm, L. C. Biedenharn, Thomas P. Branson, K. L. Duggal, John R. Klauder, Robert H. Oehmke, N. A. Salingaros, James Stasheff, and R. O. Wells, Jr.

Geometric variational problems, BRIAN WHITE, Stanford University, Thursday 8:00 a.m., Friday 1:00 p.m., and Saturday 8:00 a.m. William K. Allard, Frederick Almgren, Patricio Aviles, Robert L. Bryant, Sheldon Chang, Jaigyoung

American Mathematical Society Short Course Series

Introductory Survey Lectures on
Moments in Mathematics

San Antonio, Texas, January 20–22, 1987

The American Mathematical Society, in conjunction with its ninety-third Annual Meeting, will present a Short Course titled *Moments in Mathematics* on Tuesday, Wednesday, and Thursday, January 20, 21, and 22, at the San Antonio Convention Center. The program is under the direction of Henry Landau of AT&T Bell Laboratories. Six lectures are planned, and it is anticipated that proceedings will be published in the series *Proceedings of Symposia in Applied Mathematics.*

Function theory, spectral decomposition of operators, probability, approximation, electrical and mechanical inverse problems, prediction of stochastic processes, and the design of algorithms for signal-processing VLSI chips are among a host of important theoretical and applied topics illuminated by the classical problem of moments, a problem fascinating in its own right because of its elegance and simplicity. The aim of this course is to survey some of these ramifications and the current research which derives from them.

The course will consist of six lectures. The titles, speakers, and schedule for the talks are as follows:

January 20, afternoon:

"The Classical Background," Henry J. Landau, AT&T Bell Laboratories.

"Geometry of the Moment Problem," J.H.B. Kemperman, Rutgers University.

January 21, afternoon:

"Moment Problems and Operators in Hilbert Space," Donald Sarason, University of California, Berkeley.

"Signal Processing Applications of Some Moment Problems," Thomas Kailath, Stanford University.

January 22, morning:

"The Multidimensional Moment Problem and Semigroups," Christian Berg, University of Copenhagen, Denmark.

"Moment Problems in Probability and Statistics," Persi Diaconis, Stanford University.

While no specialized background is required of participants, a familiarity with the basic notions of real and complex analysis will generally be assumed. Synopses of the lectures and accompanying reading lists appeared in the October issue of *Notices.* Complete lecture notes will be mailed to those who preregistered for the course and will be available at the Short Course registration desk for those registering for the course on site.

All who wish to participate in the Short Course may do so upon payment of a $35 advance registration fee ($45 on site). There are reduced fees for students and unemployed individuals. Please refer to the sections titled **Registration at the Meetings** for details.

Those who plan to also register for the Joint Annual Meeting should take note of a special session entitled "Orthogonal polynomials and the moment problem," organized by Paul G. Nevai of Ohio State University. For more information, see the **Special Session** section of the San Antonio meeting announcement in this issue of *Notices.*

The Short Course was recommended by the Society's Committee on Employment and Educational Policy (CEEP), whose members are Stefan A. Burr, Edward A. Connors, Philip C. Curtis, Jr., Gerald J. Janusz, Donald C. Rung (chairman), and Audrey A. Terras. The Short Course series is under the direction of the CEEP Short Course Subcommittee, whose members are Stefan A. Burr (chairman), Lisl Novak Gaal, Gerald J. Janusz, Robert P. Kurshan, and Barbara L. Osofsky.

Choe, John Hutchinson, Rob Kusner, Frank Morgan, Dana Nance, Jon T. Pitts, Jayakumar Ramanathan, J. H. Rubinstein, Leon Simon, Nat Smale, Jean E. Taylor, and Jon Wolfson.

Contributed Papers

There will be sessions for contributed papers Wednesday afternoon, Thursday morning, Friday afternoon, and Saturday morning.

Late papers will not be accepted.

Other AMS Sessions

Mathematics and Government Speaker

The AMS Committee on Science Policy will sponsor a Special Invited Address. A high ranking official of the U.S. Government will speak on Wednesday, January 21 from 7:15 p.m. to 8:15 p.m.

Panel Discussion on the Effect of Department of Defense Funding on Mathematics

A panel discussion on *The effect of Department of Defense funding on mathematics* is being organized by WILLIAM BROWDER of Princeton University and RONALD G. DOUGLAS of SUNY at Stony Brook. This panel will take place at 7:30 p.m. on Thursday, January 22. Panelists include HYMAN BASS, Columbia University; ETTORE INFANTE, University of Minnesota, Minneapolis; WILLIAM THURSTON, Princeton University; and STEVEN WEINTRAUB, Louisiana State University.

Committee on the Agenda for Business Meetings

The Society has a Committee on the Agenda for Business Meetings. The purpose is to make Business Meetings orderly and effective. The committee does not have legal or administrative power. It is intended that the committee consider what may be called "quasi-political" motions. The committee has several possible courses of action on a proposed motion, including but not restricted to

(a) doing nothing;

(b) conferring with supporters and opponents to arrive at a mutually accepted amended version to be circulated in advance of the meeting;

(c) recommending and planning a format for debate to suggest to a Business Meeting;

(d) recommending referral to a committee;

(e) recommending debate followed by referral to a committee.

There is no mechanism that requires automatic submission of a motion to the committee. However, if a motion has not been submitted through the committee, it may be thought reasonable by a Business Meeting to refer it rather than to act on it without benefit of the advice of the committee.

The committee consists of M. Salah Baouendi, Everett Pitcher (chairman), and Carol L. Walker.

In order that a motion for the Business Meeting of January 22, 1987 receive the service offered by the committee in the most effective manner, it should have been in the hands of the secretary by December 22, 1986.

Everett Pitcher, Secretary

Panel Discussion on Social Importance of Mathematics

The AMS Committee on Science Policy is sponsoring a panel discussion on *The problem of Star Wars software reliability*, organized by DAVID EISENBUD of Brandeis University at 7:00 p.m. on Friday, January 23. Speakers will include DAVID PARNAS, Queens University.

Council Meeting

The Council of the Society will meet at 5:00 p.m. on Tuesday, January 20.

Business Meeting

The Business Meeting of the Society will take place immediately following the award of the Steele and Cole Prizes at 4:25 p.m. on Thursday, January 22. The secretary notes the following resolution of the Council: Each person who attends a Business Meeting of the Society shall be willing and able to identify himself as a member of the Society. In further explanation, it is noted that *each person who is to vote at a meeting is thereby identifying himself as and claiming to be a member of the American Mathematical Society.* For additional information on the Business Meeting, please refer to the box titled Committee on the Agenda for Business Meetings.

70th Annual Meeting of the MAA January 21–24, 1987

Invited Addresses

There will be seven invited fifty-minute addresses. The names of the speakers, their affiliations, the dates and times of their talks, and the titles follow:

STEVEN J. BRAMS, New York University, *Game theory, nuclear deterrence, and Star Wars*, 2:15 p.m. Friday;

ANDREA A. DISESSA, University of California, Berkeley, *Artificial worlds and real mathematics*, 3:20 p.m. Wednesday;

DANIEL H. GOTTLIEB, Purdue University, *Algebraic topology and robots*, 2:15 p.m. Wednesday;

RICHARD K. GUY, University of Calgary, *The strong law of small numbers*, 10:05 a.m. Saturday;

PETER D. LAX, Courant Institute of Mathematical Sciences, New York University, *Euclidean/non-Euclidean wave equation*, 9:00 a.m. Saturday;

FRANK T. LEIGHTON, Massachusetts Institute of Technology, *Networks, parallel computation, and VLSI*, 9:00 a.m. Thursday;

JOHN W. MILNOR, Institute for Advanced Study, *Self-similarity and hairiness in the Mandelbrot set*, 10:05 a.m. Thursday.

Minicourses

Fourteen Minicourses are being offered by the MAA. The names and affiliations of the organizers, the topics, the dates and times of their meetings, and the enrollment limitations of each are as follows:

Minicourse #1: *A microcomputer linear algebra course using LIN-KIT* is being organized by HOWARD ANTON. Part A is scheduled from 9:00 a.m. to 10:55 a.m. on Wednesday, January 21, and Part B from 2:15 p.m. to 4:15 p.m. on Thursday, January 22. Enrollment is limited to 30.

LIN-KIT is a powerful microcomputer package which can do linear algebra operations in either exact rational arithmetic (without the distraction of round-off error) or floating point arithmetic (facilitating study of computational aspects). Its data storage and retrieval capabilities lend themselves to self-paced courses.

The Minicourse will consist of (1) a "hands-on" session on the use of LIN-KIT, (2) a problem-solving session, making application of LIN-KIT, (3) a session on design of courses to meet various needs, and (4) a summary session devoted to discussion and perhaps design of a new computer-based linear algebra course. Microcomputers will be used extensively by participants, but prior experience is **not** required.

Minicourse #2: *Introduction to computer graphics* is being organized by JOAN P. WYZKOSKI, Fairfield University. Part A is scheduled from 9:00 a.m. to 10:55 a.m. on Wednesday, January 21, and Part B from 2:15 p.m. to 4:15 p.m. on Thursday, January 22. Enrollment is limited to 30.

Graphs and illustrations of geometrical objects are useful tools in the teaching of mathematics. Computer graphics simplifies the production of these teaching aids. This Minicourse will present some of the mathematical techniques used to produce realistic pictures on graphics display devices. Some of the topics to be discussed are curve and surface sketching, 2D and 3D transformations, perspective drawing, and hidden line removal. Suggestions will be given for the use of these techniques to complement mathematics instruction. Since personal computers will be available for demonstrations and in-class implementations, programming experience is necessary.

Minicourse #3: *The teaching of applied mathematics* is being organized by W. GILBERT STRANG, Massachusetts Institute of Technology. Part A is scheduled from 9:00 a.m. to 10:55 a.m. on Wednesday, January 21, and Part B from 2:15 p.m. to 4:15 p.m. on Thursday, January 22. Enrollment is limited to 80.

The organizer will discuss one possible framework for an introduction to modern applied mathematics. After basic courses in calculus and linear algebra, there is an important need that is not met by the traditional advanced calculus. The course should include both discrete and continuous problems, and numerical and combinatorial algorithms, bringing out their analogies and developing the mathematical ideas that are shared by different applications. The organizer is convinced that this syllabus is also the right way to organize the mathematics needed by engineers and computer scientists; that subject does not have to be old-fashioned and boring. Topics from several areas will be presented exemplifying this unifying approach. Participants will be invited to discuss effective ways to teach applied mathematics.

Minicourse #4: *Interesting applications of elementary mathematics* is being organized by JOANNE S. GROWNEY, Bloomsburg University. Part A is scheduled from 9:00 a.m. to 10:55 a.m. on Friday, January 23, and Part B from 7:00 p.m. to 9:00 p.m. on Friday, January 23. Enrollment is limited to 40.

Students with modest mathematical backgrounds often are unaware of the ways that the arithmetic and logic that they already know can be used in many ways: to organize and understand information, to make decisions, and to solve problems. This Minicourse will introduce to participants a variety of interesting and significant applications that can be used in "general education" courses designed to develop mathematics appreciation and quantitative reasoning skills in students in the humanities and other non-quantitative fields.

Mathematical topics will be presented in the context of solving particular problems. Problem types to be considered include: organizing information, scheduling time, individual decision making, group decision making, achieving a goal, analysis of a fad, and simulation.

Treatment of topics will include strategies for development of student skills in divergent thinking and evaluation as well as convergent thinking (problem solving). Lists of references for further reading will be supplied.

Minicourse #5: *Discrete mathematics using difference equations* is being organized by JAMES T. SANDEFUR, JR., Georgetown University. Part A is scheduled from 4:30 p.m. to 6:30 p.m. on Wednesday, January 21, and Part B from 7:00 p.m. to 9:00 p.m. on Thursday, January 22. Enrollment is limited to 30.

Difference equations provide a non-standard structure to discrete mathematics, permitting standard topics such as linear algebra and probability to be interspersed with interesting models including Markov processes and predator-prey relationships. The Minicourse will introduce both linear and nonlinear difference equations and provide illustrative applications of each. Microcomputers will be used to calculate solutions for mathematical models and generate graphical output. Prior programming experience is **not** required.

Minicourse #6: *Using microcomputer software in teaching calculus* is being organized by DAVID P. KRAINES, Duke University and DAVID A. SMITH, Benedict College. Part A is scheduled from 4:30 p.m. to 6:30 p.m. on Wednesday, January 21, and Part B from 7:00 p.m. to 9:00 p.m. on Thursday, January 22. Enrollment is limited to 30.

Selected IBM-compatible commercial softward packages will be demonstrated, and ways to use them in teaching and supplementing traditional calculus courses will be presented. Participants will have "hands-on" use of the selected materials. Handouts will provide information about other calculus materials available for IBM, Apple II series, and Macintosh computers.

There is no Minicourse #7.

Minicourse #8: *Computer simulation of discrete systems* is being organized by ZAVEN A. KARIAN, Denison University. Part A is scheduled from 9:00 a.m. to 10:55 a.m. on Friday, January 23, and Part B from 1:00 p.m. to 3:00 p.m. on Saturday, January 24. Enrollment is limited to 30.

Computer simulations are particularly useful in situations where: (a) complete mathematical formulation of a problem is not possible or available; (b) available analytic methods require simplifying assumptions which distort the true nature of the problem; (c) available methods are so complex that they become impractical; (d) it is too complex or too expensive to conduct real-world experiments; (e) it is necessary to change the time scale to study the dynamics of a system.

The objective of this course is to provide an understanding of the design, implementation, and analysis of discrete-event computer simulations. The emphasis will be on the computational issues associated with the implementation of simulations through GPSS and/or SIMSCRIPT II.5, the two most widely used discrete-event simulation programming languages. In the second session, there will be an opportunity to work with some models on IBM-PC compatible systems using these languages.

Minicourse #9: *Recurrence relations* is being organized by MARGARET BARRY COZZENS, Northeastern University. Part A is scheduled from 9:00 a.m. to 10:55 a.m. on Friday, January 23, and Part B from 1:00 p.m. to 3:00 p.m. on Saturday, January 24. Enrollment is limited to 30.

Problems where the behavior of a system can be expressed in terms of the behavior of a system at a previous stage or time can often be solved using a recurrence relation. In addition, recurrence relations are used to model population growth, heating and cooling, radioactive decay, the spread of information and disease, and the time to run computer algorithms. This Minicourse will show how recurrence relations can be included in the curriculum of a wide variety of courses, from advanced high school courses, to finite math courses, to calculus, and to discrete structures courses. It will show how models based on recurrence relations lead in a natural way to models based on differential equations, and therefore can and should be integrated in calculus courses.

Microcomputers will be available to enhance the understanding of recurrence relations and the problems studied.

Minicourse #10: *Integrating history into undergraduate mathematics courses* is being organized by JUDITH V. GRABINER, Pitzer College. Part A is scheduled from 9:00 a.m. to 10:55 a.m. on Friday, January 23, and Part B from 1:00 p.m. to 3:00 p.m. on Saturday, January 24. Enrollment is limited to 50.

The history of mathematics can help us teach students to understand mathematical ideas better by understanding how those ideas actually came to be. This Minicourse will take an in-depth look at two examples from the calculus: the calculus as algorithm, and the foundations of the calculus. It will include careful study of selections from the work of men like Fermat, Leibniz, Newton, and Cauchy. Brief accounts (and supporting materials) for other examples, from probability and statistics and from computer science, will be touched on as well. Finally, guidance will be given on how to learn more, what materials are most helpful, and how to develop other examples on one's own.

Minicourse #11: *Teaching mathematical modeling* is being organized by FRANK R. GIORDANO, U.S. Military Academy and MAURICE D. WEIR, Naval Postgraduate School. Part A is scheduled from 9:00 a.m. to 10:55 a.m. on Friday, January 23, and Part B from 1:00 p.m. to 3:00 p.m. on Saturday, January 24. An optional third session, Part C, will use the microcomputer facility and is scheduled from 3:30 p.m. to 5:30 p.m. on Saturday, January 24. Enrollment is limited to 40.

The MAA Committee on the Undergraduate Program in Mathematics recommended in 1981 that "Students should have an opportunity to undertake 'real world' mathematical modeling projects..." as part of the common core curriculum for all mathematical science majors. This because many applications of problems in science, industry, and government are best approached using mathematical modeling techniques.

This Minicourse provides an introduction to the modeling process, to several topics underlying the construction of mathematical models and addresses issues related to the design of an undergraduate course in modeling.

The optional third session will consist of demonstrations and "hands-on" running of models on microcomputers.

Minicourse #12: *True BASIC in freshman calculus* is being organized by JAMES F. HUR-

LEY, University of Connecticut. Part A is scheduled from 7:00 p.m. to 9:00 p.m. on Friday, January 23, and Part B from 3:30 p.m. to 5:30 p.m. on Saturday, January 24. Enrollment is limited to 30. Prerequisite: none, although some familiarity with BASIC would be helpful.

Microcomputers can significantly enrich introductory calculus in a number of ways. This Minicourse will illustrate one such way, which uses a powerful, fully structured version of BASIC developed at Dartmouth by the inventors of BASIC, John Kemeny and Thomas Kurtz. Writing programs in this language can both teach precise, logical thinking akin to that needed to construct proofs and also provide impressive concrete illustrations of basic mathematical concepts. Participants will experience the ease of use and power of True BASIC by entering and running several simple programs designed for student creation, and will also use programs that numerically illustrate limits, differentiation, implicit differentiation, optimization, root approximation, integration, sequences, series, Taylor polynomials, and numerical solution of differential equations. Considerable attention will be devoted to True BASIC's machine-independent graphics, which afford easy plotting of functions, parametric equations, and polar coordinate equations.

Minicourse #13: *For all practical purposes* is being organized by SOLOMON A. GARFUNKEL, COMAP, Inc. Part A is scheduled from 7:00 p.m. to 9:00 p.m. on Friday, January 23, and Part B from 3:30 p.m. to 5:30 p.m. on Saturday, January 24. Enrollment is limited to 40.

This course deals with introducing contemporary applications throughout the undergraduate curriculum. Materials presented will include tapes from the soon-to-be-released PBS telecourse *For all practical purposes* as well as print modules from the UMAP series. Applications will cover a wide variety of fields with special emphasis on discrete mathematics and applications to management science and decision making.

Minicourse #14: *Applications of discrete mathematics* is being organized by FRED STEPHEN ROBERTS, Rutgers University. Part A is scheduled from 7:00 p.m. to 9:00 p.m. on Friday, January 23, and Part B from 3:30 p.m. to 5:30 p.m. on Saturday, January 24. Enrollment is limited to 60.

One of the reasons that discrete mathematics has become so important is the enormous variety of applications of the subject. This Minicourse will explore these applications. The emphasis will be on several simple and traditional discrete techniques: basic counting rules of combinatorics, the principle of inclusion and exclusion, the notion of graph coloring, and the concept of eulerian path. These techniques will be quickly reviewed (though prior knowledge of combinatorics or graph theory will not be necessary). Applications will include switching functions in computer science, DNA chains in genetics, power in simple games in economics and political science, scheduling and operations research, engineering problems involving telecommunications and mobile radio transmission, urban sciences, computer graph plotting of electrical networks, and keypunching errors in computing.

Minicourse #15: *Constructing placement examinations* is being organized by JOHN W. KENELLY, Clemson University. Part A is scheduled from 7:00 p.m. to 9:00 p.m. on Friday, January 23, and Part B from 3:30 p.m. to 5:30 p.m. on Saturday, January 24. Enrollment is limited to 40.

Lectures and workshops will take participants, step-by-step, through the entire process of constructing and implementing placement exams, including: preliminary planning, writing test items, designing a test for establishing cut-off scores, and evaluating the test. Placement testing problems of participants' own institutions will be discussed during question and answer periods.

Participants interested in attending any of the Minicourses should have completed the Minicourse Preregistration Form **and sent it directly to the MAA Office at the address given on the form so as to arrive prior to the November 15 deadline**.

The Minicourses are open only to persons who have registered for the Joint Mathematics Meetings and paid the Joint Meetings registration fee.

If the only reason for registering for the Joint Meetings is to gain admission to a Minicourse, this should have been indicated by checking the appropriate box on the Minicourse Preregistration Form. Then, if the Minicourse is fully subscribed, full refund can be made of the Joint Mathematics Meetings preregistration fee. Otherwise, the Joint Meetings preregistration will be processed, and then be subject to the 50 percent refund rule. PREREGISTRATION FORMS FOR THE JOINT MEETINGS SHOULD HAVE BEEN MAILED TO PROVIDENCE PRIOR TO THE DEADLINE OF NOVEMBER 15.

The registration fee for Minicourses #1, #2, #5, #6, #8, #9, and #12 is $35 each. The registration fee for the other Minicourses is $25 each.

Contributed Papers

Contributed papers were accepted on five topics in collegiate mathematics. The topics, organizers, their affiliations, and days they will meet are:

- *Remedial mathematics: Issues and innovations*, GEOFFREY R. AKST, Borough Manhattan Community College CUNY, Friday morning and Saturday afternoon.
- *The history of mathematics*, DUANE BLUMBERG, University of Southwestern Louisiana, Thursday afternoon.

- *New methods of teaching calculus*, WADE ELLIS, JR., West Valley College, San Jose, Wednesday morning.
- *Experiences with computer support for service courses*, CAROL JONES, University of Houston-Downtown, Wednesday morning.
- *Retaining and recruiting undergraduate women in mathematics courses: Aspirations and experiences*, PATRICIA C. KENSCHAFT, Montclair State College, Saturday afternoon.

The deadline for submitting papers for these sessions was **September 30. Late papers will not be accepted.**

Other MAA Sessions

MAA-NCTM Panel Discussion

A panel discussion on *Reform in mathematics education* is being jointly sponsored by the MAA and the National Council of Teachers of Mathematics (NCTM); it is scheduled from 9:00 a.m. to 10:55 a.m. on Wednesday, January 21. The moderator is JOHN DOSSEY, president of NCTM, and the panel members are DONALD L. CHAMBERS, Department of Public Instruction (Madison, WI); F. JOE CROSSWHITE, past-president of NCTM; PAUL FOERSTER, Alamo Heights High School (San Antonio); CAROL GREENES, Boston University; SHIRLEY A. HILL, Mathematical Sciences Education Board; and JACK PRICE, Palos Verdes Peninsula School District (Rolling Hills, CA).

Software Session

A session on *The leading edge of software* has been organized by WARREN PAGE, New York City Technical College (CUNY). The session is scheduled from 7:30 p.m. to 9:30 p.m. on Thursday, January 22. Speakers include THOMAS BANCHOFF, Brown University, *The educational differential geometry environment (EDGE)*; HARRY LEWIS, Harvard University, *Computer graphics for teaching and learning multivariable calculus*; and JUDAH L. SCHWARTZ, Massachusetts Institute of Technology and Harvard University, *Fostering conjectures and exploration in Euclidean geometry.*

Two-Year College Reception

The Committee on Two-Year Colleges is sponsoring an informal reception for two-year college faculty from 4:30 p.m. to 6:00 p.m. on Wednesday, January 21.

The Mathematical Competition in Modeling

BERNARD A. FUSARO, Salisbury State College, has organized a presentation on *The mathematical competition in modeling (MCM)* from 2:15 p.m. to 4:15 p.m. on Thursday, January 22. Introductory remarks by the organizer will be followed by three winning solution papers from the contest, which will be presented by the winning student teams.

ICME-6 Panel Discussion

A panel discussion titled *Post-secondary mathematics at ICME-6: What are the major issues?* is scheduled from 2:15 p.m. to 3:45 p.m. on Thursday, January 22. The organizers are JOHN M. MACK, University of Sydney, and LYNN A. STEEN, St. Olaf College. The purpose of this session is to obtain "an American perspective," identifying the issues most needing debate in 1988 on mathematics education in colleges and universities.

MAA-ACM-IEEE Panel Discussion

The Joint MAA-ACM-IEEE Task Force on Teaching Computer Science in Mathematics Departments is sponsoring a panel discusion in order to exchange views with members of MAA. This panel is organized by ZAVEN A. KARIAN, Denison University, and is scheduled from 2:15 p.m. to 4:00 p.m. on Thursday, January 22. Three members of the Task Force will make brief statements and the remaining time will be devoted to an open discussion.

Mathematics as a Humanistic Discipline

ALVIN WHITE, Harvey Mudd College, is organizing a session on *Mathematics as a humanistic discipline* which is scheduled from 8:00 a.m. to 10:55 a.m. on Friday, January 23. Participants will include the organizer; DONALD W. BUSHAW, Washington State University; UBIRATAN D'AMBROSIO, Univ Estadual de Campinas (Brazil); PHILIP J. DAVIS, Brown University; A. GARDINER, University of Birmingham (England); SHIRLEY A. HILL, Mathematical Sciences Education Board; ANNELI LAX, Courant Institute of Mathematical Sciences, New York University; DAVID B. MEREDITH, San Francisco State University; ROBERT OSSERMAN, Stanford University; FRANCES A. ROSAMOND, Ithaca; and SHERMAN K. STEIN, University of California, Davis.

CCIME Panel Discussion

The Committee on Computers in Mathematics Education (CCIME) is sponsoring a panel discussion on *The use of computers in teaching differential equations.* The panel will be chaired by HOWARD LEWIS PENN, U.S. Naval Academy, and is scheduled from 9:00 a.m. to 10:30 a.m. on Friday, January 23. Speakers include J. M. A. DANBY, North Carolina State University, *Applications, a new look*; DONALD LEWIS, Cornell University, *Use of symbolic manipulator languages in the teaching of differential equations*; and HOWARD LEWIS PENN, *Use of computer graphics in the teaching of differential equations.*

Project 2061 Mathematics Panel

The *Mathematics panel report of AAAS Project 2061* is scheduled from 2:15 p.m. to 4:15 p.m. on Saturday, January 24. "What are the important ideas of mathematics that people should know and

TIMETABLE

(Central Standard Time)

The final version of the Timetable and Program, including room assignments, will be distributed at the meeting.

	AMERICAN MATHEMATICAL SOCIETY SHORT COURSE SERIES
TUESDAY, January 20	MOMENTS IN MATHEMATICS
10:00 a.m. - 3:00 p.m.	REGISTRATION (Short Course Only) Outside Room 102
3:00 p.m. - 4:15 p.m.	The classical background Henry J. Landau
4:45 p.m. - 6:00 p.m.	Geometry of the moment problem J. H. B. Kemperman
WEDNESDAY, January 21	
2:15 p.m. - 3:30 p.m.	Moment problems and operators in Hilbert space Donald Sarason
4:00 p.m. - 5:15 p.m.	Signal-processing applications of some moment problems Thomas Kailath
THURSDAY, January 22	
8:30 a.m. - 9:45 a.m.	The multidimensional moment problem and semigroups Christian Berg
9:45 a.m. - 11:00 a.m.	Moment problems in probability and statistics Persi Diaconis

	JOINT MATHEMATICS MEETINGS	
TUESDAY, January 20	American Mathematical Society	Mathematical Association of America
9:00 a.m. - 4:00 p.m.		BOARD OF GOVERNORS' MEETING
4:00 p.m. - 8:00 p.m.	REGISTRATION North Banquet Hall	
5:00 p.m. - 10:00 p.m.	COUNCIL MEETING	
7:00 p.m. - 9:00 p.m.		SECTION OFFICERS' MEETING
WEDNESDAY, January 21	AMS	Mathematical Association of America and Other Organizations
8:00 a.m. - 10:30 a.m.		MAA - CONTRIBUTED PAPER SESSION Experiences with computer support for service courses Carol Jones
8:00 a.m. - 10:50 a.m.		MAA - CONTRIBUTED PAPER SESSION New methods of teaching calculus Wade Ellis, Jr.
8:00 a.m. - 5:00 p.m.	REGISTRATION North Banquet Hall	
9:00 a.m. - 9:30 a.m.	EMPLOYMENT REGISTER ORIENTATION SESSION	
9:00 a.m. - 9:50 a.m.	INVITED ADDRESS The capacity of neural networks Robert J. McEliece	
9:00 a.m. - 10:55 a.m.		MAA/NCTM - PANEL DISCUSSION Reform in mathematics education Donald L. Chambers F. Joe Crosswhite John Dossey (moderator) Paul Foerster Carol Greenes Shirley A. Hill Jack Price

understand by the age of 18?" The program will begin with a 30-minute presentation on the sbustance of the panel's recommendations by LEON HENKIN, University of California, Berkeley. Independent responses will be given by C. HERBERT CLEMENS, University of Utah; KATHERINE P. LAYTON, Beverly Hills High School; and a third person yet to be specified.

Panel Discussion on Approval Voting

There will be a panel on *Approval voting* on Saturday, January 24, from 2:15 p.m. to 3:30 p.m. The moderator is PHILIP D. STRAFFIN, JR., Beloit College. Speakers are STEVEN J. BRAMS, New York University, and SAMUEL MERRILL, III, Wilkes College and Yale University.

Statistics Presentation

There will be a presentation titled *Working with statistics: Statistical process control (SPC) techniques* from 2:15 p.m. to 4:15 p.m. on Saturday, January 24. Speakers will include BARBARA ASHLEY and ANALISA L. FRANCE, Jefferson Community College (Louisville, KY). The presentation will give an overview of the ways in which elementary statistics are being used to improve quality in business and industry.

Prize Session and Business Meeting

The MAA Prize Session is scheduled from 3:20 p.m. to 4:30 p.m. on Friday, January 23. The Chauvenet Prize, the Award for Distinguished Service to Mathematics, and six Certificates of Meritorious Service will be presented. The 1986 Carl B. Allendoerfer, Lester R. Ford, and George Pólya Awards for expository writing will also be presented.

The Business Meeting of the MAA will take place at 4:40 p.m. following the Prize Session. Some bylaw changes will be submitted for membership approval. This meeting is open to all members of the Association.

Board of Governors

The MAA Board of Governors will meet at 9:00 a.m. on Tuesday, January 20. This meeting is open to all members of the Association.

Section Officers

There will be a Section Officers' meeting at 7:00 p.m. on Tuesday, January 20.

Films

The MAA Film Program will take place on Friday, January 23, at 7:30 p.m. The program is as follows:

7:30 p.m. – *Fly Lorenz*

7:50 p.m. – *Planar double pendulum*

8:25 p.m. – *On size and shape: Overview*

9:00 p.m. – *The impossible dream: Election theory*

Joint AMS–MAA Sessions

AMS-MAA Invited Addresses

By invitation of the AMS-MAA Joint Program Committee (Judith V. Grabiner, chairman, Paul R. Halmos, F. Reese Harvey, and W. Gilbert Strang), three speakers will address the joint meeting of the AMS and MAA on the history and development of mathematics. The names of the speakers, their affiliations, the titles, dates, and times of their talks follow:

EDWARD N. LORENZ, Massachusetts Institute of Technology, *Strange attractors: Are they still strange?*, 11:10 a.m. Friday.

UTA C. MERZBACH, National Museum of American History, *Algebraic traditions on two continents*, 11:10 a.m. Thursday.

HUGH L. MONTGOMERY, University of Michigan, Ann Arbor, *The role of analytic number theory in the development of analysis*, 11:10 a.m. Wednesday.

AMS-MAA Symposium

The AMS and MAA are cosponsoring a symposium on *The role of mathematicians in pre-college education* at 7:30 p.m. on Thursday, January 22. This symposium has been organized by PHILIP WAGREICH of the University of Illinois at Chicago. Speakers include C. HERBERT CLEMENS, University of Utah; LARRY HATFIELD, University of Georgia; LEON HENKIN, University of California, Berkeley; HARVEY KEYNES, University of Minnesota, Minneapolis; PAUL J. SALLY, JR., University of Chicago; and PHILIP WAGREICH. This symposium will deal with various questions related to the involvement of mathematicians in pre-college education. Does it benefit education? How does it affect mathematicians? How to get financial support? Is there moral and financial support from mathematics departments? Is it possible to be involved in pre-college education and continue to do research in mathematics? Members of the panel will give brief presentations describing projects with which they are involved. Open discussion will follow.

AMS-MAA-MSEB Forum on the K-12 Curriculum

Over the next two decades, the nation's schools must make a dramatic transition in their mathematics programs, with emphasis shifting from drill in paper-and-pencil computations to experience in using the conceptual, analytical, and problem-solving techniques of mathematics. This transition will involve fundamental changes in content, modes of instruction, teacher education, and methods of assessing student progress. The impact on collegiate mathematics will be substantial. In this forum, members of the Mathematical Sciences Education Board of the National Research Council will present their current thinking about how to bring about the transition, and will seek reactions and advice from the forum's

TIMETABLE

WEDNESDAY, January 21	American Mathematical Society	Mathematical Association of America and Other Organizations
9:00 a.m. - 10:55 a.m.		MAA - MINICOURSE #1 (Part A) A microcomputer linear algebra course using LIN-KIT Howard Anton
9:00 a.m. - 10:55 a.m.		MAA - MINICOURSE #2 (Part A) Introduction to computer graphics Joan P. Wyzkoski
9:00 a.m. - 10:55 a.m.		MAA - MINICOURSE #3 (Part A) The teaching of applied mathematics W. Gilbert Strang
9:00 a.m. - 5:00 p.m.	EXHIBITS	
9:00 a.m. - 5:00 p.m.	AMS EXHIBIT AND BOOK SALE	MAA BOOK SALE
9:30 a.m. - 4:00 p.m.	EMPLOYMENT REGISTER REGISTRATION	
10:05 a.m. - 10:55 a.m.	INVITED ADDRESS Nonlinear partial differential equations and vortex theory Ronald J. DiPerna	
11:10 a.m. - noon	AMS-MAA INVITED ADDRESS The role of analytic number theory in the development of analysis Hugh L. Montgomery	
1:00 p.m. - 2:00 p.m.	COLLOQUIUM LECTURES Lecture I: Uses of the non-Euclidean wave equation Peter D. Lax	
2:15 p.m. - 3:05 p.m.		MAA - INVITED ADDRESS Robots and topology Daniel H. Gottlieb
	SPECIAL SESSIONS	
2:15 p.m. - 5:40 p.m.	Nonlinear partial differential equations I	
2:15 p.m. - 6:10 p.m.	Geometric inequalities I	
2:15 p.m. - 5:20 p.m.	Recent results in gauge field theory and Riemannian geometry I	
2:15 p.m. - 4:15 p.m.	Combinatorics and group representations I	
	SESSIONS FOR CONTRIBUTED PAPERS	
2:15 p.m. - 4:55 p.m.	Associative and nonassociative rings	
2:15 p.m. - 5:40 p.m.	Group theory I	
2:15 p.m. - 5:55 p.m.	Topological groups, real functions and integral equations	
2:15 p.m. - 5:40 p.m.	Special functions, generating functions and difference equations	
2:15 p.m. - 4:55 p.m.	Partial differential equations I	
2:15 p.m. - 6:10 p.m.	Functional analysis I	
2:15 p.m. - 4:40 p.m.	Operator theory	
2:15 p.m. - 4:25 p.m.	Calculus of variations and optimal control	
2:15 p.m. - 4:55 p.m.	Probability I	
2:15 p.m. - 5:40 p.m.	Statistics and numerical analysis	
2:15 p.m. - 5:40 p.m.	Applied mathematics	

participants. Individuals intending to participate in the forum may wish to review materials on the K-12 curriculum prepared by MSEB. To obtain these materials in advance of the forum, contact: MSEB, National Research Council, 2101 Constitution Avenue, NW, Washington, DC 20418; 202-334-3294. Copies will also be available at the forum, which will take place at 9:30 a.m. on Friday, January 23.

AMS-MAA Workshop

The AMS and MAA are cosponsoring a workshop at 4:30 p.m. on Wednesday, January 21. This workshop is being organized by JOEL SCHNEIDER, Director of Content of the new series *Square One TV*, produced by the Children's Television Workshop. This exciting new series will premiere on public television on January 26 and is targeted to children ages eight to fourteen. Highlights include "Mathnet" (a take-off on Dragnet), which uses a detective metaphor to teach problem-solving, and a musical approach to infinity. Children from the local San Antonio school system will be invited to view this program along with mathematicians and press. A question and answer session will follow the showing of the program.

AMS-MAA Panel Discussion

The AMS and MAA are cosponsoring a panel discussion at 7:00 p.m. on Thursday, January 22 on *What makes news in mathematics?* Speakers will include media representatives from the west coast, east coast, and the San Antonio area, and two mathematicians currently involved in public information in mathematics. A question and answer session will follow.

Activities of Other Organizations

The **Association for Symbolic Logic** (ASL) Council will meet on Thursday and Friday, January 22–23, from 8:00 p.m. to 11:00 p.m. In addition to the contributed papers on Friday and Saturday, January 23–24, there will be six invited talks. The speakers are STEFFEN LEMPP, SAMUEL BUSS, MARCIA GROSZEK, EHUD HRUSHOVSKI, STEVE JACKSON, and ROMAN KOSSAK. There will be an ASL reception on Friday, January 23, from 5:30 p.m. to 7:00 p.m.

The **Association for Women in Mathematics** (AWM) will sponsor a panel discussion on *Responses to the David Report: Initiatives for women and minorities* on Wednesday, January 21 at 3:20 p.m.

The AWM Business Meeting will be held at 4:20 p.m. on Wednesday, January 21.

A reception is being planned by AWM at 9:30 p.m. on Wednesday, January 21.

The AWM will also sponsor the seventh annual Emmy Noether Lecture at 9:00 a.m. on Thursday, January 22, by JOAN BIRMAN. The title of her talk is *Studying links via braids.*

The **Interagency Commission for Extramural Mathematics Programs** (ICEMAP) will present a session at 4:25 p.m. on Wednesday, January 21. The program will focus on current topics in federal mathematical support. Presentations will be made by the National Science Foundation, Department of Energy, and the Department of Defense agencies discussing a variety of new and continuing programs and opportunities for federal funding.

The **Joint Policy Board for Mathematics** (JPBM) Committee for Mathematics Department Heads has organized a National Meeting of Department Heads at 7:00 p.m. on Thursday, January 22. This session will feature a program conducted by DAVID P. ROSELLE, Provost at Virginia Polytechnic Institute and State University, on *Accreditation for mathematics departments.* This will be followed by Birds-of-a-Feather sessions on *The evaluation of instruction for large schools* by DONALD W. BUSHAW; *The evaluation of instruction for small schools* by DAVID W. BALLEW; *Master's degrees in the mathematical sciences for large schools* by RICHARD HABERMAN; and *Master's degrees in the mathematical sciences for small schools* by BERNARD A. FUSARO.

The Committee for Department Chairs of the JPBM will also cosponsor a workshop for department chairs with the American Council on Education (ACE) on Tuesday, January 20 from 9:00 a.m. to 5:00 p.m. Participants who are interested in this workshop should see **News and Announcements** in the October issue of *Notices.*

The **National Association of Mathematicians** (NAM) will receive the William W. S. Claytor Session of Invited Presentations at 9:00 a.m. on Saturday, January 24. The session chair is ROOSEVELT GENTRY, Jackson State University. Presenters include CURTIS CLARK, Georgia State University, *Ultimately economical graphs*; BESSIE L. TUCKER, Jackson State University, *On some properties of a sub-class of close-to-convex functions*; and DONALD COLE, General Dynamics-Operations Research, *Some existence results for partial differential equations.*

NAM will also sponsor a panel discussion on *Re-thinking the teaching of calculus* on Saturday, January 24 at 10:00 a.m. The moderator is MERDIS J. MCCARTER, Winston-Salem State University. Panelists include GLORIA HEWITT, University of Montana; RONALD G. DOUGLAS, SUNY at Stony Brook; RAYMOND RICHARDSON, Tennessee State University; and HARLEY FLANDERS, University of Michigan.

The NAM Business Meeting will take place at 1:00 p.m. on Saturday, January 24. ROGERS NEWMAN will preside.

The **National Science Foundation** (NSF) will sponsor a session on *Federal support for mathematics education* at 5:30 p.m. on Wednesday, January 21, organized by JOHN A. THORPE,

TIMETABLE

WEDNESDAY, January 21	American Mathematical Society	Mathematical Association of America and Other Organizations
3:20 p.m. - 4:10 p.m.		MAA - INVITED ADDRESS Artificial worlds and real mathematics Andrea A. diSessa
3:20 p.m. - 4:20 p.m.		Association for Women in Mathematics PANEL DISCUSSION: Responses to the David Report: Initiatives for women and minorities
4:20 p.m. - 4:50 p.m.		AWM - BUSINESS MEETING
4:25 p.m. - 5:30 p.m.	Interagency Commission for Extramural Mathematics Programs (ICEMAP)	
4:30 p.m. - 5:30 p.m.	AMS-MAA WORKSHOP Square One TV Joel Schneider	
4:30 p.m. - 6:00 p.m.		MAA - Committee on Two-Year Colleges CASH BAR SOCIAL HOUR AND DISCUSSION
4:30 p.m. - 6:30 p.m.		MAA - MINICOURSE #5 (Part A) Discrete mathematics using difference equations James T. Sandefur, Jr.
4:30 p.m. - 6:30 p.m.		MAA - MINICOURSE #6 (Part A) Using microcomputer software in teaching calculus David P. Kraines David A. Smith
5:30 p.m. - 6:30 p.m.	NATIONAL SCIENCE FOUNDATION SESSION: Federal support for mathematics education Susan Forman Louise Raphael John A. Thorpe (organizer)	
7:15 p.m. - 8:15 p.m.	Committee on Science Policy SPECIAL INVITED ADDRESS Speaker and title to be announced	
8:30 p.m. - 9:30 p.m.	JOSIAH WILLARD GIBBS LECTURE Schrödinger operators and dynamical systems Thomas C. Spencer	
9:30 p.m. - 11:00 p.m.		AWM - RECEPTION

THURSDAY, January 22	AMS	Mathematical Association of America and Other Organizations
8:00 a.m. - 4:00 p.m.	REGISTRATION North Banquet Hall	
	SPECIAL SESSIONS	
8:00 a.m. - 10:50 a.m.	Classical real analysis I	
8:00 a.m. - 10:50 a.m.	Geometric inequalities II	
8:00 a.m. - 10:50 a.m.	Stochastic processes and analysis I	
8:00 a.m. - 10:50 a.m.	Recent results in gauge field theory and Riemannian geometry II	
8:00 a.m. - 10:50 a.m.	Theoretical optimization I	
8:00 a.m. - 10:50 a.m.	Geometric variational problems I	
	SESSIONS FOR CONTRIBUTED PAPERS	
8:00 a.m. - 10:55 a.m.	General topology I	
8:00 a.m. - 10:55 a.m.	Group theory II	

Deputy Division Director, Division of Materials Development, Research and Informal Science Education, National Science Foundation. Speakers include SUSAN FORMAN, Bronx Community College and formerly with the Department of Education; LOUISE RAPHAEL, Howard University; and JOHN A. THORPE.

The NSF will also be represented at a booth in the exhibit area. NSF staff members will be available to provide counsel and information on NSF programs of interest to mathematicians. The booth will be open the same days and hours as the exhibits.

The **Rocky Mountain Mathematics Consortium** (RMMC) Board of Directors will meet on Thursday, January 22 from 2:15 p.m. to 4:15 p.m.

Other Events of Interest

Book Sales

Books published by the AMS and MAA will be sold at discounted prices somewhat below the cost for the same books purchased by mail. **These discounts will be available only to registered participants wearing the official meeting badge.** VISA and MASTERCARD credit cards will be accepted for book sale purchases at the meeting. The book sales will be open the same days and hours as the exhibits and are located in the North Banquet Hall.

Exhibits

The book and educational media exhibits will be located in the North Banquet Hall and will be open Wednesday through Friday, January 21–23 from 9:00 a.m. to 5:00 p.m. All participants are encouraged to visit the exhibits during the meeting. **Participants visiting the exhibits will be asked to display their meeting badge or acknowledgment of preregistration from the Mathematics Meetings Housing Bureau in order to enter the exhibit area.**

Mathematical Sciences Employment Register

Those wishing to participate in the Employment Register at the San Antonio meetings should read carefully the important article about the Register which follows this meeting announcement.

Accommodations

Hotels

The rates listed below are subject to an 11 percent hotel/motel tax. The number in parentheses after the name of the hotel is the number it carries on the map. The estimated walking distance from the hotel to the San Antonio Convention Center is given in parentheses following the telephone number.

Participants should be aware that, when major conventions occur in any large city, additional safety problems are created, especially at night.

Petition Table

At the request of the AMS Committee on Human Rights of Mathematicians, a table will be made available in the meeting registration area at which petitions on behalf of named individual mathematicians suffering from human rights violations may be displayed and signed by meeting participants acting in their individual capacities.

Signs of moderate size may be displayed at the table, but must not represent that the case of the individual in question is backed by the Committee on Human Rights unless it has, in fact, so voted. Volunteers may be present at the table to provide information on individual cases, but notice must be sent at least seven (7) days in advance of the meeting to the Meetings Department in Providence (telephone 401-272-9500). Since space is limited, it may also be necessary to limit the number of volunteers present at the table at any one time. The Committee on Human Rights may delegate a person to be present at the table at any or all times, taking precedence over other volunteers.

Any material which is not a petition (e.g., advertisements, résumés) will be removed by the staff. **When registration closes, any material on the table will be discarded, so individuals placing petitions on the table should be sure to remove them prior to the close of registration.**

Those who are attending the meetings alone, or who are concerned about walking to and from the meetings after dark, are encouraged to choose a hotel in close proximity to the San Antonio Convention Center. Participants are also urged to read the "Words to the Wise" in the local information insert in the program they receive at the meetings.

Reservations at these hotels cannot be made by calling the hotel directly until after January 12. Also, after that date, the rates below may not apply.

In all cases "single" refers to one person in one bed; "double" refers to two persons in one bed; "twin" refers to two persons in two twin beds; and "twin double" refers to two persons in two double beds. A rollaway cot for an extra person can be added to a room; however, not all hotels are able to do so.

Participants should be aware that it is general hotel practice in most cities to hold a nonguaranteed reservation until 6:00 p.m. only. When one guarantees a reservation by paying a deposit or submitting a credit card number as guarantee in advance, however, the hotel usually will honor this reservation up until checkout time the following day. If the individual holding the reservation has not checked in by that time, the room is then released for sale, and the hotel retains the deposit or applies one night's room charge to the credit card number submitted.

If you hold a guaranteed reservation at a hotel, but are informed upon arrival that there is

TIMETABLE

THURSDAY, January 22	American Mathematical Society	Mathematical Association of America and Other Organizations
8:00 a.m. - 10:25 a.m.	SESSION FOR CONTRIBUTED PAPERS Functions of one complex variable	
8:30 a.m. - 10:50 a.m.	SPECIAL SESSION Combinatorics and group representations II	
8:30 a.m. - 10:55 a.m.	SESSION FOR CONTRIBUTED PAPERS Commutative algebra and algebraic geometry	
9:00 a.m. - 9:50 a.m.		MAA - INVITED ADDRESS Networks, parallel computation, and VLSI Frank T. Leighton
9:00 a.m. - 10:00 a.m.		AWM - EMMY NOETHER LECTURE Studying links via braids Joan Birman
9:00 a.m. - 10:50 a.m.	SPECIAL SESSIONS Nonlinear partial differential equations II	
9:00 a.m. - 10:50 a.m.	Brauer groups and Galois theory I	
9:00 a.m. - 10:25 a.m.	SESSIONS FOR CONTRIBUTED PAPERS Partial differential equations II	
9:00 a.m. - 10:40 a.m.	Harmonic analysis	
9:00 a.m. - 10:55 a.m.	Functional analysis II	
9:00 a.m. - 10:55 a.m.	Probability II	
9:00 a.m. - 10:10 a.m.	Computational mathematics	
9:00 a.m. - 5:00 p.m.	EXHIBITS	
9:00 a.m. - 5:00 p.m.	AMS EXHIBIT AND BOOK SALE	MAA BOOK SALE
9:00 a.m.	EMPLOYMENT REGISTER DISTRIBUTION OF SCHEDULES	
9:30 a.m. - 5:30 p.m.	EMPLOYMENT REGISTER INTERVIEWS	
10:05 a.m. - 10:55 a.m.		MAA - INVITED ADDRESS Self-similarity and hairiness in the Mandelbrot set John W. Milnor
11:10 a.m. - noon	AMS-MAA INVITED ADDRESS Algebraic traditions on two continents Uta C. Merzbach	
1:00 p.m. - 2:00 p.m.	COLLOQUIUM LECTURES Lecture II: Uses of the non-Euclidean wave equation Peter D. Lax	
2:15 p.m. - 3:05 p.m.	INVITED ADDRESS Analytic aspects of gauge field theory Lesley M. Sibner	
2:15 p.m. - 3:45 p.m.		MAA - PANEL DISCUSSION: Post-secondary mathematics at ICME-6: What are the major issues ? John M. Mack Lynn A. Steen
2:15 p.m. - 4:00 p.m.		MAA-ACM-IEEE Task Forde on Teaching Computer Science in Mathematics Departments PANEL DISCUSSION Zaven A. Karian
2:15 p.m. - 4:15 p.m.		MAA - PRESENTATION: The mathematical competition in modeling (MCM) Bernard A. Fusaro

no room for you, there are certain things you can request the hotel do. First, they should provide for a room at another hotel in town for that evening, at no charge. (You have already paid for the first night when you made your deposit.) They should pay for taxi fares to the other hotel that evening, and back to the meetings the following morning. They should also pay for one telephone toll call so that you can let people know you are not at the hotel you expected. They should make every effort to find a room for you in their hotel the following day, and, if successful, pay your taxi fares to and from the second hotel so that you can pick up your baggage and bring it to the first hotel. Not all hotels in all cities follow this practice, so your request for these services may bring mixed results, or none at all.

Please make all changes to or cancellations of hotel reservations with the Mathematics Meetings Housing Bureau in Providence **before January 12, 1987**. The telephone number in Providence is 401-272-9500 (extension 239). After that date, changes should be made directly with the hotel. **Cancellations must be made directly with the hotel 48 hours prior to date of arrival in order to receive refunds of deposits.**

The following hotels/motels accept American Express, MASTERCARD, VISA, Carte Blanche, Diners Club credit cards, personal checks with identification, and travelers' checks in payment for room charges.

Please note that public transportation is limited on Saturdays in San Antonio. Participants who have been assigned to the Holiday Inn Downtown - Market Square and the La Quinta Market Square Motor Inn should be prepared to use taxicabs to and from the San Antonio Convention Center on that day.

San Antonio Marriott (1)
Headquarters Hotel
711 E. Riverwalk
San Antonio, Texas 78205
Telephone: 512-224-4555 (1 block)

Singles	$60
Doubles	$60
Triples	$66
Triples	$66 (with cot)
Quads	$70
Quads	$70 (with cot)
Suites	$125 - $300

There is no charge for children 12 years of age and under. The San Antonio Marriott is a full-service hotel.

The Crockett Hotel (2)
320 Bonham
San Antonio, Texas 78205-2083
Telephone: 512-225-6500 (3 blocks)

Singles	$54
Doubles	$54
Triples	$59
Quads	$59
Suites	$150

There is no charge for children 18 years of age and under. The Crockett Hotel is a full-service hotel.

Hilton Palacio del Rio (3)
200 South Alamo
San Antonio, Texas 78205
Telephone: 512-222-1400 (1 block)

Singles	$60
Doubles	$60
Triples	$66
Triples	$66 (with cot)
Quads	$70

There is no charge for children. The Hilton is a full-service hotel.

Holiday Inn Downtown at Market Square (4)
318 West Durango
San Antonio, Texas 78204
Telephone: 512-225-3211 (10 blocks)

Singles	$47
Doubles	$47
Triples	$47
Triples	$47 (with cot)
Quads	$47
Quads	$47 (with cot)

There is no charge for children 17 years of age and under. The Holiday Inn is a full-service hotel.

Hyatt Regency San Antonio (5)
123 Losoya Street
San Antonio, Texas 78205
Telephone: 512-222-1234 (3 blocks)

Singles	$62
Doubles	$68
Triples	$75
Triples	$90 (with cot)
Quads	$75
Quads	$90 (with cot)
Suites	$150 - $411

There is no charge for children 18 years of age and under. The Hyatt Regency is a full-service hotel.

La Mansion del Rio Hotel (6)
112 College Street
San Antonio, Texas 78205
Telephone: 512-225-2581 (4 blocks)

Singles	$60
Doubles	$70
Triples	$80
Triples	$80 (with cot)
Quads	$80
Quads	$80 (with cot)
Suites	$275 - $425

There is no charge for children 18 years of age and under. The La Mansion is a full-service hotel.

La Quinta Convention Center Motor Inn (7)
1001 E. Commerce Street
San Antonio, Texas 78205
Telephone: 512-222-9181 (2 blocks)

TIMETABLE

THURSDAY, January 22	American Mathematical Society	Mathematical Association of America and Other Organizations
2:15 p.m. - 4:10 p.m.		MAA - CONTRIBUTED PAPER SESSION The history of mathematics Duane Blumberg
2:15 p.m. - 4:15 p.m.		MAA - MINICOURSE #1 (Part B) A microcomputer linear algebra course using LIN-KIT Howard Anton
2:15 p.m. - 4:15 p.m.		MAA - MINICOURSE #2 (Part B) Introduction to computer graphics Joan P. Wyzkoski
2:15 p.m. - 4:15 p.m.		MAA - MINICOURSE #3 (Part B) The teaching of applied mathematics W. Gilbert Strang
2:15 p.m. - 4:15 p.m.		Rocky Mountain Mathematics Consortium BOARD OF DIRECTORS' MEETING
3:20 p.m. - 4:10 p.m.	INVITED ADDRESS Regularity and singularity for energy minimizing maps Robert M. Hardt	
4:25 p.m. - 6:00 p.m.	STEELE & COLE PRIZE SESSION AND BUSINESS MEETING	
7:00 p.m. - 9:00 p.m.	NATIONAL MEETING OF DEPARTMENT HEADS	
7:00 p.m.	PANEL DISCUSSION: Accreditation for mathematics departments David P. Roselle	
8:00 p.m.	SESSION: Birds-of-a-Feather The evaluation of instruction for large schools Donald W. Bushaw	
8:00 p.m.	The evaluation of instruction for small schools David W. Ballew	
8:00 p.m.	Master's degrees in the mathematical sciences for large schools Richard Haberman	
8:00 p.m.	Master's degrees in the mathematical sciences for small schools Bernard A. Fusaro	
7:00 p.m. - 9:00 p.m.		MAA - MINICOURSE #5 (Part B) Discrete mathematics using difference equations James T. Sandefur, Jr.
7:00 p.m. - 9:00 p.m.		MAA - MINICOURSE #6 (Part B) Using microcomputer software in teaching calculus David P. Kraines David A. Smith
7:00 p.m. - 9:30 p.m.	AMS-MAA PANEL DISCUSSION What makes news in mathematics?	
7:30 p.m. - 9:30 p.m.	Committee on Science Policy - PANEL DISCUSSION: The effect of Department of Defense funding on mathematics Hyman Bass William Browder (organizer) Ronald G. Douglas (organizer) Ettore Infante William Thurston Steve Weintraub	
7:30 p.m. - 9:30 p.m.		MAA - SESSION The leading edge of software Thomas Banchoff Harry Lewis Warren Page (organizer) Judah L. Schwartz

Singles	$46
Doubles	$56
Triples	$61
Triples	$61 (with cot)
Quads	$66
Quads	$66 (with cot)

There is no charge for children 18 years of age and under. The La Quinta Convention Center Motor Inn is a full-service Inn.

La Quinta Market Square Motor Inn (8)
900 Dolorosa Street
San Antonio, Texas 78207
Telephone: 512-271-0001 (10 blocks)

Singles	$37
Doubles	$45
Triples	$49
Quads	$49

There is no charge for children 17 years of age and under. There are no food services available in this Inn.

TraveLodge on the River (9)
100 Villita Street
San Antonio, Texas 78205
Telephone: 512-226-2271 (4 blocks)

Singles	$43
Doubles	$46
Triples	$49
Triples	$49 (with cot)
Quads	$52
Quads	$52 (with cot)
Suites	$90

There is no charge for children 17 years of age and under. The TraveLodge is a full-service hotel, and provides free transportation to and from the airport baggage claim areas.

The AMS-MAA Joint Meetings Committee always endeavors to obtain the lowest possible sleeping room rates for participants at annual meetings. The Committee is also responsible for maintaining a sound fiscal position for these meetings, and, until recently, has been able to keep the deficits at a reasonable level, while still providing the very best meeting facilities available to the participants.

As the meetings have grown in scope and complexity over the years, however, it has been necessary to find larger facilities with more and more session rooms. Unfortunately, the cost of these facilities is higher than can be covered by the registration fees, and the Committee has arranged for all of the hotels in San Antonio to collect an extra $2 per room per night from participants, which will be used to offset the rental cost of the San Antonio Convention Center. (The rates above include this extra charge.) The Committee hopes that these extra funds will not be necessary at future annual meetings, and therefore chose this method over an increase in the registration fees.

Registration at the Meetings

Meeting preregistration and registration fees only partially cover expenses of holding meetings. All mathematicians who wish to attend sessions are expected to register, and should be prepared to show their meeting badge, if so requested. **Badges are required to enter the exhibit area, to obtain discounts at the AMS and MAA Book Sales, to cash a check with the meeting cashier, and to attend all sessions scheduled in the Theatre in the San Antonio Convention Center. (If a preregistrant should arrive too late in the day to pick up his/her badge, he/she may show the acknowledgment of preregistration received from the Mathematics Meetings Housing Bureau as proof of registration.)** The fees for Joint Meetings registration at the meeting listed below are 30 percent more than the preregistration fees.

Participants wishing to attend sessions for one day only may take advantage of the one-day fees listed below. These special fees are effective daily January 21 through 24, and are available at the meeting to members and nonmembers only. These one-day fees are not applicable to student, unemployed, or emeritus participants, whose fees for registration at the meetings are listed below.

Joint Mathematics Meetings

Member of AMS, ASL, MAA or NCTM	$ 77
Emeritus Member of AMS, MAA	$ 21
Nonmember	$117
Student/Unemployed	$ 21

One Day Fee

Member of AMS, ASL, MAA or NCTM	$ 40
Nonmember	$ 61

Employment Register

Employer	$100
Applicant	$ 20
Employer Posting fee	$ 15

AMS Short Course

Student/Unemployed	$ 15
All Other Participants	$ 45

MAA Minicourses
(if openings available)

Minicourses # 1, 2, 5, 6, 8, 9, or 12	$ 35
Minicourses # 3, 4, 10, 11, 13, 14, or 15	$ 25

Registration fees may be paid at the meetings in cash, by personal or travelers' check, or by VISA or MASTERCARD credit card. Canadian checks must be marked for payment in U.S. funds.

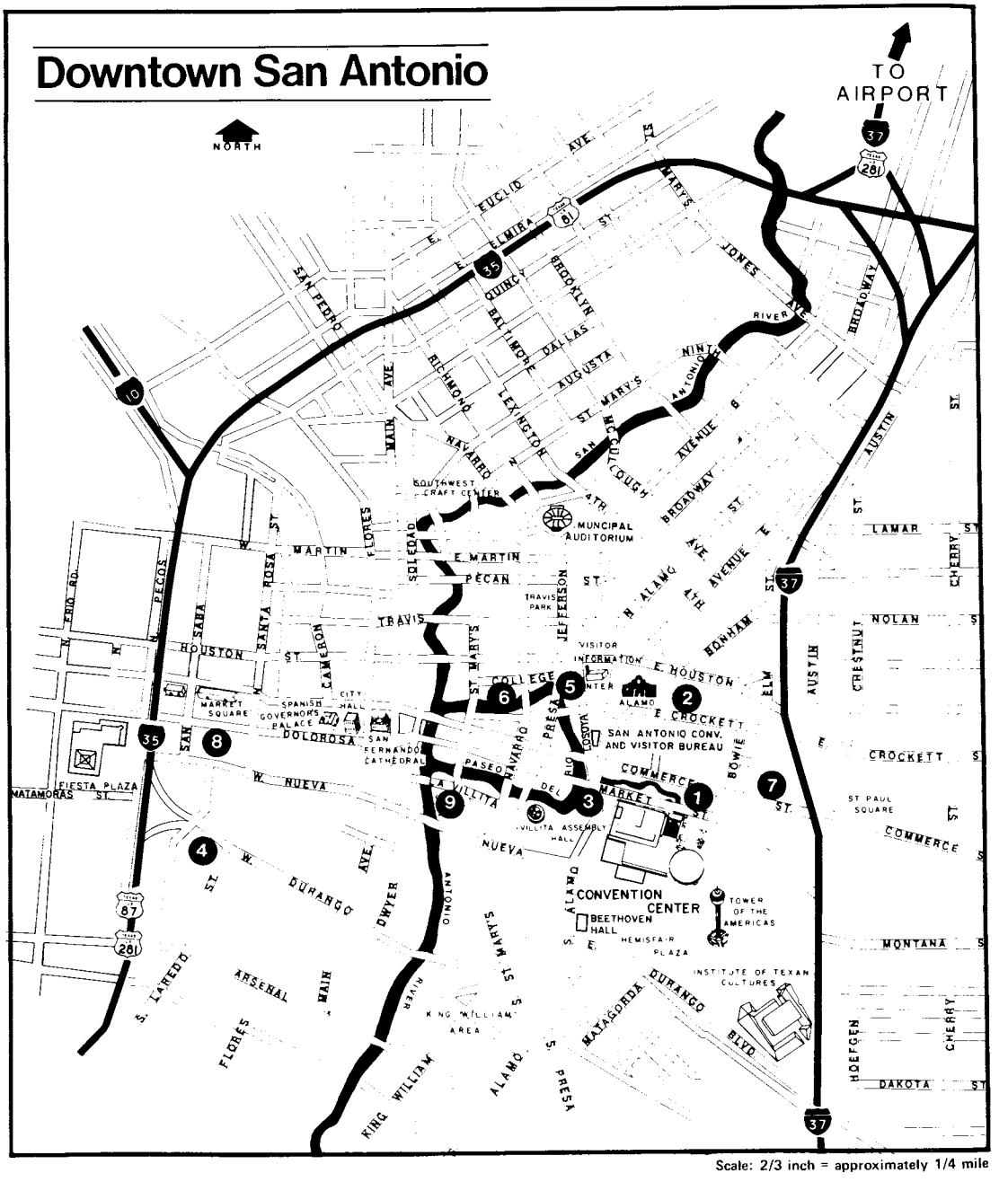
There is no extra charge for members of the families of registered participants, except that all professional mathematicians who wish to attend sessions must register independently.

All **full-time** students currently working toward a degree or diploma qualify for the student registration fees, regardless of income.

TIMETABLE

THURSDAY, January 22	American Mathematical Society	Mathematical Association of America and Other Organizations
7:30 p.m. - 10:00 p.m.	AMS-MAA SYMPOSIUM The role of mathematicians in pre-college education C. Herbert Clemens Larry Hatfield Leon Henkin Harvey Keynes Paul J. Sally, Jr. Philip Wagreich (organizer)	
8:00 p.m. - 10:00 p.m.	NO-HOST COCKTAIL PARTY	
8:00 p.m. - 11:00 p.m.		Association for Symbolic Logic COUNCIL MEETING

FRIDAY, January 23	AMS	MAA and Other Organizations
morning		ASL - CONTRIBUTED PAPER SESSIONS
8:00 a.m. - 4:00 p.m.	REGISTRATION North Banquet Hall	
8:00 a.m. - 10:55 a.m.		MAA - SESSION: Mathematics as a humanistic discipline Donald W. Bushaw Ubiratan D'Ambrosio Philip J. Davis A. Gardiner Shirley A. Hill Anneli Lax David B. Meredith Robert Osserman Frances A. Rosamond Sherman K. Stein Alvin White (organizer)
8:30 a.m. - 10:55 a.m.		MAA - CONTRIBUTED PAPER SESSION Remedial mathematics: Issues and innovations (Part I) Geoffrey R. Akst
9:00 a.m. - 9:50 a.m.	INVITED ADDRESS Noether's problem, Galois theory, and the Brauer group David J. Saltman	
9:00 a.m. - 10:30 a.m.		MAA - Committee on Computers in Mathematics Education - PANEL DISCUSSION: The use of computers in teaching differential equations J. M. A. Danby Donald Lewis Howard Lewis Penn (chair)
9:00 a.m. - 10:55 a.m.		MAA - MINICOURSE #4 (Part A) Interesting applications of elementary mathematics JoAnne S. Growney
9:00 a.m. - 10:55 a.m.		MAA - MINICOURSE #8 (Part A) Computer simulation of discrete systems Zaven A. Karian
9:00 a.m. - 10:55 a.m.		MAA - MINICOURSE #9 (Part A) Recurrence relations Margaret Barry Cozzens
9:00 a.m. - 10:55 a.m.		MAA - MINICOURSE #10 (Part A) Integrating history into undergraduate mathematics courses Judith V. Grabiner
9:00 a.m. - 10:55 a.m.		MAA - MINICOURSE #11 (Part A) Teaching mathematical modeling Frank R. Giordano Maurice D. Weir



Scale: 2/3 inch = approximately 1/4 mile

HOTEL

1. San Antonio Marriott — Headquarters Hotel
2. The Crockett Hotel
3. Hilton Palacio del Rio Hotel
4. Holiday Inn — Downtown at Market Square
5. Hyatt Regency San Antonio Hotel
6. La Mansion del Rio Hotel
7. La Quinta Convention Center Motor Inn
8. La Quinta Market Square Motor Inn
9. Travelodge on the River

TIMETABLE

FRIDAY, January 23	American Mathematical Society	Mathematical Association of America and Other Organizations
9:00 a.m. - 5:00 p.m.	EXHIBITS	
9:00 a.m. - 5:00 p.m.	AMS EXHIBIT AND BOOK SALE	MAA BOOK SALE
9:00 a.m.	EMPLOYMENT REGISTER DISTRIBUTION OF SCHEDULES	
9:30 a.m. - 5:30 p.m.	EMPLOYMENT REGISTER INTERVIEWS	
9:30 a.m. - 10:55 a.m.	AMS-MAA Mathematical Sciences Education Board Forum on the K-12 curriculum	
10:05 a.m. - 10:55 a.m.	INVITED ADDRESS Crabgrass, measles, and gypsy moths: An introduction to modern probability Richard T. Durrett	
11:10 a.m. - noon	AMS-MAA INVITED ADDRESS Strange attractors: Are they still strange? Edward N. Lorenz	
1:00 p.m. - 2:00 p.m.	COLLOQUIUM LECTURES Lecture III: Uses of the non-Euclidean wave equation Peter D. Lax	
1:00 p.m. - 2:00 p.m.		ASL - INVITED ADDRESS The structure of the d. r. e. degrees Steffen Lempp
	SPECIAL SESSIONS	
1:00 p.m. - 4:00 p.m.	Geometric methods in group theory I	
1:00 p.m. - 4:20 p.m.	Nonlinear partial differential equations III	
1:00 p.m. - 4:15 p.m.	Classical real analysis II	
1:00 p.m. - 3:20 p.m.	Brauer groups and Galois theory II	
1:00 p.m. - 4:10 p.m.	Geometric inequalities III	
1:00 p.m. - 3:50 p.m.	Stochastic processes and analysis II	
1:00 p.m. - 3:20 p.m.	Combinatorics and group representations III	
1:00 p.m. - 3:50 p.m.	Orthogonal polynomials and the moment problem I	
1:00 p.m. - 4:15 p.m.	Recent results in gauge field theory and Riemannian geometry III	
1:00 p.m. - 4:10 p.m.	Theoretical optimization II	
1:00 p.m. - 3:50 p.m.	Geometric variational problems II	
	SESSIONS FOR CONTRIBUTED PAPERS	
1:00 p.m. - 4:10 p.m.	Combinatorics and graph theory I	
1:00 p.m. - 4:10 p.m.	Number theory I	
1:00 p.m. - 3:40 p.m.	Ordinary differential equations I	
1:00 p.m. - 3:40 p.m.	Geometry and algebraic topology	
1:00 p.m. - 3:55 p.m.	Differential geometry	
1:00 p.m. - 3:40 p.m.	General topology II	
2:00 p.m. - 4:10 p.m.	Applied mathematics and mathematical physics	
2:10 p.m. - 3:10 p.m.		ASL - INVITED ADDRESS Recursively saturated ω_1-like models of arithmetic Roman Kossak
2:15 p.m. - 3:05 p.m.		MAA - INVITED ADDRESS Game theory, nuclear deterrence, and Star Wars Steven J. Brams

The unemployed status refers to any person currently unemployed, actively seeking employment, and who is not a student. It is not intended to include any person who has voluntarily resigned or retired from his or her latest position.

Persons who qualify for emeritus membership in either the Society or the Association may register at the emeritus member rate. The emeritus status refers to any person who has been a member of the AMS or MAA for twenty years or more, and is retired on account of age from his or her latest position.

Nonmembers who preregister or register at the meeting and pay the nonmember fee will receive mailings from AMS and MAA, after the meeting is over, containing information about a special membership offer.

Registration Dates, Times, and Locations

AMS Short Course

Outside Room 102, San Antonio Convention Center

Tuesday, January 20 10:00 a.m. to 3:00 p.m.

Joint Mathematics Meetings

[and MAA Minicourses (until filled)]

North Banquet Hall, San Antonio Convention Center

Tuesday, January 20	4:00 p.m. to 8:00 p.m.
Wednesday, January 21	8:00 a.m. to 5:00 p.m.
Thursday, January 22 through Saturday, January 24	8:00 a.m. to 4:00 p.m.

Registration Desk Services

Assistance, Comments, and Complaints

A log for registering participants' comments or complaints about the meeting is kept at the Transparencies section of the registration desk. All participants are encouraged to use this method of helping to improve future meetings. Comments on all phases of the meeting are welcome. If a written reply is desired, participants should furnish their name and address.

Participants with problems of an immediate nature requiring action at the meeting should see the Director of Meetings, who will try to assist them.

Audio-Visual Assistance

A member of the AMS/MAA staff will be available to advise or consult with speakers on audio-visual usage. Speakers having unusual audio-visual requirements such as slide or film projectors should make their requests **prior to the beginning of the meeting.**

Rooms where special sessions and contributed paper sessions will be held are equipped with an overhead projector and screen. **Blackboards will not be available.**

Baggage and Coat Check

Inquire at the meetings registration desk.

Information Table

The information table at Joint Meetings of the AMS and MAA is set up in the registration area for the dissemination of information of a nonmathematical nature of possible interest to the members. The administration of the information table is in the hands of the AMS-MAA Joint Meetings Committee, as are all arrangements for such joint meetings. The following rules and procedures apply.

1. Announcements submitted by participants should ordinarily be limited to a single sheet no more than $8\frac{1}{2}'' \times 14''$.

2. A copy of any announcement proposed for the table is to be sent to: H. Hope Daly, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940 to arrive at least one week before the first day of the scientific sessions.

3. The judgment on the suitability of an announcement for display rests with the Joint Meetings Committee. It will make its judgments on a case by case basis to establish precedents.

4. Announcements of events competing in time or place with the scheduled scientific program will not be accepted.

5. Copies of an accepted announcement for the table are to be provided by the proponent. Announcements are not to be distributed in any other way at the meeting (for example, not by posting or personal distribution of handbills).

6. It may be necessary to limit the number of events or the quantity of announcements distributed at a meeting.

7. At the close of registration, the table will be swept clean. A proponent who wishes the return of extra copies should remove them.

Check Cashing

The meeting cashier will cash personal or travelers' checks up to $50, upon presentation of the official meeting registration badge, provided there is enough cash on hand. Canadian checks must be marked for payment in U.S. funds. It is advisable that participants bring travelers' checks with them. When funds are low the meetings cashier will not be able to cash checks and travelers' checks can be easily cashed at local banks, restaurants, or hotels.

Local Information

This section of the desk will be staffed by members of the Local Arrangements Committee and other volunteers from the San Antonio mathematical community.

Lost and Found

See the Joint Meetings cashier.

TIMETABLE

FRIDAY, January 23	American Mathematical Society	Mathematical Association of America and Other Organizations
	SESSION FOR CONTRIBUTED PAPERS	
2:15 p.m. - 4:10 p.m.	Linear algebra	
3:20 p.m. - 5:40 p.m.		MAA - PRIZE SESSION AND BUSINESS MEETING
3:20 p.m. - 4:20 p.m.		ASL - INVITED ADDRESS Title to be announced Marcia Groszek
5:30 p.m. - 7:00 p.m.		ASL - RECEPTION
7:00 p.m. - 9:30 p.m.	Committee on Science Policy PANEL DISCUSSION: The problem of Star Wars software reliability David Eisenbud (organizer) David Parnas	
7:00 p.m. - 9:00 p.m.		MAA - MINICOURSE #4 (Part B) Interesting applications of elementary mathematics JoAnne S. Growney
7:00 p.m. - 9:00 p.m.		MAA - MINICOURSE #12 (Part A) True BASIC in freshman calculus James F. Hurley
7:00 p.m. - 9:00 p.m.		MAA - MINICOURSE #13 (Part A) For all practical purposes Solomon A. Garfunkel
7:00 p.m. - 9:00 p.m.		MAA - MINICOURSE #14 (Part A) Applications of discrete mathematics Fred Stephen Roberts
7:00 p.m. - 9:00 p.m.		MAA - MINICOURSE #15 (Part A) Constructing placement examinations John W. Kenelly
7:30 p.m. - 10:00 p.m.		MAA - FILM PROGRAM
7:30 p.m.		Fly Lorenz
7:50 p.m.		Planar double pendulum
8:25 p.m.		On size and shape: Overview
9:00 p.m.		The impossible dream: Election theory
8:00 p.m. - 11:00 p.m.		ASL - COUNCIL MEETING

SATURDAY, January 24	AMS	MAA and Other Organizations
8:00 a.m. - 4:00 p.m.	REGISTRATION North Banquet Hall	
	SPECIAL SESSIONS	
8:00 a.m. - 10:50 a.m.	Geometric methods in group theory II	
8:00 a.m. - 11:40 a.m.	Classical real analysis III	
8:00 a.m. - 11:20 a.m.	Stochastic processes and analysis III	
8:00 a.m. - 10:50 a.m.	Theoretical optimization III	
8:00 a.m. - 10:50 a.m.	Geometric variational problems III	
	SESSION FOR CONTRIBUTED PAPERS	
8:00 a.m. - 12:10 p.m.	Combinatorics and graph theory II	
	SPECIAL SESSIONS	
8:30 a.m. - 10:50 a.m.	Orthogonal polynomials and the moment problem II	
8:30 a.m. - 10:50 a.m.	Mathematical physics I	

Mail

All mail and telegrams for persons attending the meetings should be addressed as follows: Name of Participant, c/o Joint Mathematics Meetings, P. O. Box 2277, San Antonio, TX 78298. Mail and telegrams so addressed may be picked up at the mailbox in the registration area during the hours the registration desk is open. U.S. mail not picked up will be forwarded after the meeting to the mailing address given on the participant's registration record.

Personal Messages

Participants wishing to exchange messages during the meeting should use the mailbox mentioned above. Message pads and pencils are provided. It is regretted that such messages left in the box cannot be forwarded to participants after the meeting is over.

Telephone Messages

A telephone message center is located in the registration area to receive incoming calls for participants. The center is open from January 20 through 24, during the hours that the Joint Mathematics Meetings registration desk is open. Messages will be taken and the name of any individual for whom a message has been received will be posted until the message has been picked up at the message center. The telephone number of the message center is 512-270-2950.

Transparencies

Speakers wishing to prepare transparencies in advance of their talk will find the necessary materials and copying machines at this section of the registration desk. A member of the staff will assist and advise speakers on the best procedures and methods for preparation of their material. There is a modest charge for these materials.

Visual Index

An alphabetical list of registered participants, including local addresses and arrival and departure dates, is maintained in the registration area.

Miscellaneous Information

Child Care

The Marriott Hotel has babysitting services available which can be arranged through the Concierge desk or by calling North Side Sitters at 341-9313. The current rates are $4 per hour for one family and $5.50 per hour for more than one family in the same room. There is a four-hour minimum and an additional $7 transportation and parking fee for the babysitter. A list of local babysitters is available at the Local Information section of the registration desk.

Local Information

The Paseo del Rio, an arm of the San Antonio River, extends for about two-and-one-half miles through the center of the city. Located on the river are several of the major hotels, as well as restaurants, shops, craftsmen, and art galleries. Small river taxis ply the river, and one may go from one end of the river to the other for a nominal fee. The banks of the river are beautifully landscaped, and a walkway known as the "River Walk" extends the length of the river with frequent egresses to hotels and shops away from the river. The Convention Center is at one end of the Paseo del Rio.

Among the many places of interest in San Antonio are the Alamo (including the Alamo Museum); Brackenridge Park, which has a Chinese Sunken Garden, a one-fifth scale model of a diesel train, and the San Antonio Zoo, ranked as one of the finest in the world; the Hertzberg Circus Collection; La Villita and the Arneson River Theater, a small historic Mexican village and an open air theater; the five Missions of San Antonio, founded between 1720 and 1731; and the Spanish Governor's Palace.

Parking

Parking is available at all hotels as follows:

San Antonio Marriott – Valet parking is $5 per night; self-parking in adjacent lot is approximately $2.25.

The Crockett Hotel – Valet parking is $6 per night.

Hilton Palacio del Rio – Valet parking is $7.50 per night.

Holiday Inn Downtown at Market Square – There is no charge for parking.

Hyatt Regency San Antonio – Valet parking is $7 per night.

La Mansion del Rio Hotel – Valet parking is $6 per night.

La Quinta Convention Center Motor Inn – There is no charge for parking.

La Quinta Market Square Motor Inn – There is no charge for parking.

TraveLodge on the River – There is no charge for parking.

Although most hotels offer valet parking, there are also self-parking lots located immediately adjacent to the convention center. There is a parking lot at Market and Bowie Streets next to the Marriott Hotel. Other parking lots can be found on Commerce Street, East Nueva Street, Navarro Street, and South Presa Street. There is also limited parking at the Towers of the Americas parking lot.

Smoking

Please note that smoking is not allowed in any of the session rooms in the San Antonio Convention Center or the San Antonio Marriott Hotel.

TIMETABLE

SATURDAY, January 24	American Mathematical Society	Mathematical Association of America and Other Organizations
	SESSION FOR CONTRIBUTED PAPERS	
8:30 a.m. - 11:40 a.m.	History, logic and foundations	
9:00 a.m. - 9:50 a.m.		MAA - INVITED ADDRESS Wave propagation and characteristics Peter D. Lax
9:00 a.m. - 10:00 a.m.		National Association of Mathematicians WILLIAM W. S. CLAYTOR SESSION OF INVITED PRESENTATIONS Curtis Clark Donald Cole Roosevelt Gentry (chair) Bessie L. Tucker
	SPECIAL SESSION	
9:00 a.m. - 10:50 a.m.	Brauer groups and Galois theory III	
	SESSIONS FOR CONTRIBUTED PAPERS	
9:00 a.m. - 11:25 a.m.	Number theory II	
9:00 a.m. - 10:55 a.m.	Ordinary differential equations II	
9:30 a.m. - 10:30 a.m.		ASL - INVITED ADDRESS Intuitionistic bounded arithmetic and polynomial-time computation Samuel Buss
10:00 a.m. - 11:30 a.m.		NAM - PANEL DISCUSSION Re-thinking the teaching of calculus Ronald G. Douglas Harley Flanders Gloria Hewitt Merdis J. McCarter (moderator) Raymond Richardson
10:05 a.m. - 10:55 a.m.		MAA - INVITED ADDRESS The strong law of small numbers Richard K. Guy
11:10 a.m. - noon	INVITED ADDRESS Free groups, trees, and their automorphisms Marc Culler	
11:00 a.m. - noon		ASL - INVITED ADDRESS Title to be announced Ehud Hrushovski
afternoon		ASL - CONTRIBUTED PAPER SESSIONS
1:00 p.m. - 2:00 p.m.	COLLOQUIUM LECTURES Lecture IV: Uses of the non-Euclidean wave equation Peter D. Lax	
	SPECIAL SESSIONS	
1:00 p.m. - 3:20 p.m.	Mathematical physics II	
1:00 p.m. - 4:15 p.m.	Classical real analysis IV	
1:00 p.m. - 1:55 p.m.		NAM - BUSINESS MEETING
1:00 p.m. - 3:00 p.m.		MAA - MINICOURSE #8 (Part B) Computer simulation of discrete systems Zaven A. Karian
1:00 p.m. - 3:00 p.m.		MAA - MINICOURSE #9 (Part B) Recurrence relations Margaret Barry Cozzens
1:00 p.m. - 3:00 p.m.		MAA - MINICOURSE #10 (Part B) Integrating history into undergraduate mathematics courses Judith V. Grabiner

Social Event

There will be a no-host cocktail party in the Arcade in the San Antonio Convention Center at 8:00 p.m. on Thursday, January 22.

Travel

In January, San Antonio is on Central Standard Time. There is regular airline service to the San Antonio International Airport by several major airline carriers. The airport is a little over eight miles from the city center, which takes about ten minutes to reach by taxi ($10) or by airport limousine ($5). Most major car rental agencies maintain desks at the airport. Amtrak has thrice-weekly service from New Orleans to the east, and from Los Angeles to the west, and from St. Louis to the northeast.

Weather

The location of San Antonio on the edge of the Gulf Coastal Plains results in a modified subtropical climate, predominantly continental during the winter months. The average daily high temperature for January is 62 degrees F, and the daily low 42 degrees F.

Factorizations of $b^n \pm 1$, b = 2, 3, 5, 6, 7, 10, 11, 12 up to High Powers

John Brillhart, D. H. Lehmer, J. L. Selfridge, Bryant Tuckerman, and S. S. Wagstaff, Jr.

"One characteristic that differentiates human beings from other animals is the ability to react with ebullience to an intellectual stimulus. Accordingly, the arrival of this book provided a welcome opportunity to reaffirm that I belong to the human race. Friends who share with me an interest in and curiosity about topics like the subject of this book have recounted how they, too, were 'turned on' when they turned its pages.

"We had good reason to feel the way we did. During the first quarter of this century, Allan Cunningham undertook the factoring of various numbers which captured his fancy. In particular, he and his associates published factorizations of $b^n \pm 1$ for the bases $b = 2, 3, 5, 6, 7, 10, 11,$ and 12, with n going into several high values. Since then, sporadic additional factorizations within and beyond the original ranges have appeared. Much of the effort to supplement all this work with within the past two decades, with larger factors than Cunningham was able to compute, has been referred to as 'the Cunningham project'. Some of this work was funded, some was done privately on personal time, and some was done with the expressed or implied consent of the organization or institution for which the researcher worked. Much was done on 'free' machine time.

"Many different computational devices and computers were used. Indeed, the computational effort was both an effect and a cause of more research, improvements, and advancements in number theoretical theorems and techniques. Accounts of this effort, as well as descriptions and explanations of the research, along with references, are given in the textual parts of this book.

"The long-awaited initial product of 'the Cunningham project' is *Factorizations of* $b^n \pm 1$."

— *Samuel Yates*

Contemporary Mathematics, Volume 22, September 1983, 248 pages (softcover)
Individual member $14, List price $24, Institutional member $19. To order, please specify CONM/22NA

Shipping/Handling: 1st book $2, each add'l $1, max. $25; by air, 1st book $5, each add'l $3, max. $100
Prepayment is required. Order from American Mathematical Society, P.O. Box 1571, Annex Station, Providence, RI 02901-9930, or call toll free 800-556-7774 to charge with Visa or MasterCard.

TIMETABLE

SATURDAY, January 24	American Mathematical Society	Mathematical Association of America and Other Organizations
1:00 p.m. - 3:00 p.m.		MAA - MINICOURSE #11 (Part B) Teaching mathematical modeling Frank R. Giordano Maurice D. Weir
1:30 p.m. - 5:50 p.m.	SPECIAL SESSION Geometric methods in group theory III	
1:30 p.m. - 3:55 p.m.		MAA - CONTRIBUTED PAPER SESSION Remedial mathematics: Issues and innovations (Part II) Geoffrey R. Akst
2:00 p.m. - 5:00 p.m.		MAA - CONTRIBUTED PAPER SESSION Retaining and recruiting undergraduate women in mathematics courses: Aspirations and experiences Patricia C. Kenschaft
2:00 p.m. - 3:00 p.m.		ASL - INVITED ADDRESS Title to be announced Steve Jackson
2:15 p.m. - 3:30 p.m.		MAA - PANEL DISCUSSION: Approval voting Steven J. Brams Samuel Merrill III Philip D. Straffin, Jr. (moderator)
2:15 p.m. - 4:15 p.m.		MAA - PANEL DISCUSSION: Mathematics panel report of AAAS Project 2061 C. Herbert Clemens Leon Henkin Katherine P. Layton
2:15 p.m. - 4:15 p.m.		MAA - PRESENTATION Working with statistics: Statistical process control (SPC) techniques Barbara Ashley Analisa L. France
3:30 p.m. - 5:30 p.m.		MAA - MINICOURSE #11 (Part C - optional) Teaching mathematical modeling Frank R. Giordano Maurice D. Weir
3:30 p.m. - 5:30 p.m.		MAA - MINICOURSE #12 (Part B) True BASIC in freshman calculus James F. Hurley
3:30 p.m. - 5:30 p.m.		MAA - MINICOURSE #13 (Part B) For all practical purposes Solomon A. Garfunkel
3:30 p.m. - 5:30 p.m.		MAA - MINICOURSE #14 (Part B) Applications of discrete mathematics Fred Stephen Roberts
3:30 p.m. - 5:30 p.m.		MAA - MINICOURSE #15 (Part B) Constructing placement examinations John W. Kenelly

Motions at the Business Meeting

A group consisting of William P. Thurston, Michael Shub, Irwin Kra, Lipman Bers, Lee D. Mosher, Lucy J. Garnett, Linda Keen, and Jean E. Taylor has stated its intention of introducing the following two motions at the Business Meeting.

Motion 1. Many scientists consider SDI (commonly referred to as Star Wars) incapable of achieving its stated goals and dangerously destabilizing. Participation by universities and professional organizations lends a spurious scientific legitimacy to it. Therefore the AMS will lend no support to the Star Wars program. In particular, no one acting as a representative of the AMS shall participate in efforts to obtain funding for Star Wars research or to mediate between agencies granting Star Wars research and those seeking to apply for it.

Motion 2. The AMS is concerned about the increasing militarization of support for mathematics research. There is a tendency to distribute this support through narrowly focussed (mission oriented) programs which circumvent normal peer review procedures. This tendency, unless checked, may skew and ultimately injure mathematics in the United States. Therefore those representing the AMS are requested to direct their efforts towards increasing the fraction of non-military funding for mathematics research, as well as towards increasing total research support.

The handling of motions at a Business Meeting is described in Article X, Section 1 of the bylaws, here quoted in entirety.

Section 1. The annual meeting of the Society shall be held between the fifteenth of December and the tenth of February next following. Notice of the time and place of this meeting shall be mailed by the secretary or an associate secretary to the last known post office address of each member of the Society. The times and places of the annual and other meetings of the Society shall be designated by the Council. There shall be a business meeting of the Society at the annual meeting and at the summer meeting. A business meeting of the Society shall take final action only on business accepted by unanimous consent, or business notified to the full membership of the Society in the call for the meeting, except that the business meetings held at either the annual meeting or the summer meeting may take final action on business which has been recommended for consideration by the Council and has been accepted by the vote of four-fifths of the Society present and voting at such a meeting. Such notification shall be made only when so directed by a previous business meeting of the Society or by the Council.

It is the interpretation of the Secretary that each motion, if passed, would constitute "final action," so that the Business Meeting may not vote on the substance. The Business Meeting has at least the following options. It may amend the motions, refer them to a committee with or without instructions, vote not to consider the motions further, or vote to put them on the agenda of a future Business Meeting for definitive action. The next two Business Meetings are in Salt Lake City in August 1987 and in Atlanta in January 1988.

The Committee on the Agenda will consider these motions in the manner described in the box on page 52 and may have a recommendation. Other information and advice may also be available.

Everett Pitcher
Secretary

Mathematical Sciences Employment Register

January 1987 Meeting in San Antonio

The Mathematical Sciences Employment Register (MSER), held annually at the Joint Mathematics Meetings in January, provides opportunities for mathematical scientists seeking professional employment to meet employers who have positions to be filled. Job listings (or descriptions) and résumés prepared by employers and applicants are displayed at the meeting for the participants so that members of each group may determine which members of the other group they would like to have an opportunity to interview. A computer program assigns the appointments, matching requests to the extent possible, using an algorithm which maximizes the number of interviews which can be scheduled subject to constraints determined by the number of time periods available, the numbers of applicants and employers, and the pattern of requests. The report below outlines the operation of the register, indicating some of the procedures involved for the benefit of those not familiar with its operation.

The Mathematical Sciences Employment Register is apparently unique among employment services offered by professional organizations in the sciences, engineering and the humanities. The computer programs used are constructed around a matching program, devised by Donald R. Morrison, and based on an algorithm described in his paper "Matching Algorithms" in *Journal of Combinatorial Theory*, volume **6** (1969), pages 20 to 32; see also "Matching Algorithms" (abstract) *Notices*, August 1967, page 630. The number of interviews arranged by the program is significantly greater than the number possible at the employment registers of other organizations, in many cases greater by an order of magnitude.

1987 Employment Register in San Antonio

The Employment Register will take place in the South Banquet Hall, San Antonio Convention Center on Wednesday, Thursday, and Friday, January 21, 22, and 23, 1987. A short (optional) orientation session will be conducted by the AMS-MAA-SIAM Committee on Employment Opportunities at 9:00 a.m. on Wednesday, January 21. The purpose of the orientation session is to familiarize participants with the operation of the Register and with the various forms involved. Following orientation, participants should pick up their material for participating in the Employment Register. Computer-scheduled interviews will be held on Thursday and Friday, January 22 and 23. **No interviews will be held on Wednesday.**

Fifteen-minute intervals are allowed for interviews, including two or three minutes between successive interviews. The interviews are scheduled in half-day sessions: Thursday morning and afternoon, and Friday morning and afternoon, amounting to four half-day sessions for interviews. There are ten time periods (9:30 – 11:45 a.m.) in which interviews can be scheduled in the morning and fourteen time periods (1:15 – 5:00 p.m.) in the afternoon. It is possible that an applicant or employer may be scheduled for the maximum number of interviews in a session. Requests for interviews will be accommodated depending on the availability of participants. The scheduling program does not have a provision allowing participants to specify particular times for interviews beyond the choice of session (day, and morning or afternoon). Such requests cannot be accommodated.

Requests for interviews taking place during the two sessions on Thursday MUST BE SUBMITTED on Wednesday between 9:30 a.m. and 4:00 p.m. Requests for interviews to take place during the Friday sessions must be submitted on Thursday before 4:00 p.m. Those who fail to do so cannot be included in the pool of available participants when the matching program which schedules the interviews is run on the computer that night. This applies to all employers and applicants both preregistered and on-site registrants. Forms submitted with preregistration achieve registration for the Employment Register only. These forms do not automatically include the participant in the interviewing process. The interview request forms handed out at the Employment Register must be turned in before the 4:00 p.m. deadline in order to receive a computer printed schedule the next day.

On Thursday and Friday mornings at 9 a.m. all schedules for applicants and employers for the day (both morning and afternoon sessions) will be available for distribution in the South Banquet Hall.

The Friday afternoon session is the annual "employers' choice" session. For this session interviews will be scheduled on the basis of requests made by employers. Applicants do not submit specific interview requests for this session; but, in order to participate they must indicate their availability for the session by returning the Interview Request Form for Friday, indicating that they will attend the afternoon session that day.

Applicants should be aware of the fact that interviews arranged by the Employment Register represent only an initial contact with employers, and that hiring decisions are not ordinarily made during or immediately following such interviews. **Applicants are advised to bring a number of copies of their vitae or résumés so that they may leave them with prospective employers.**

The Mathematical Sciences Employment Register is sponsored by the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics;

Background of Applicants

Statistics from previous Employment Registers have shown employers sought to fill approximately 180 positions, 10 of which were nonacademic jobs. For 98% of the positions, holders of doctoral degrees were preferred, for 65% of the positions only applicants with doctorates were acceptable, for 30% of the positions, holders of masters degrees were considered eligible. Few of the nonacademic employers indicated an interest in holders of bachelors degrees in mathematics.

it is operated by members of the AMS staff under the general supervision of the joint AMS-MAA-SIAM Committee on Employment Opportunities.

Anyone with questions about the Employment Register should contact Carole Kohanski at the American Mathematical Society at 401-272-9500, extension 286. The telephone number to be used after the Register begins is 512-270-2930. Participants should note that this number will be for those who will be participating in the Employment Register and is not for contacting participants or taking messages. Those who wish to leave messages should call the message center telephone number found in the San Antonio meeting announcement.

Preregistered Employers/Applicants

Employers and applicants who have preregistered for the Employment Register may pick up their MSER material after 9:30 a.m. on Wednesday, January 21, in the South Banquet Hall. **(This material includes the interview request forms which are handed out at the meeting only.)** These are not the forms that are submitted with preregistration.

Employers' job listings and applicants' résumés will be posted at the meeting, so that applicants and employers may review them.

Nonpreregistered Applicants and Employers

Employers and applicants who wish to participate in the Register who have neither preregistered nor paid the Employment Register fee must first go to the Joint Mathematics Meetings registration desk in the North Banquet Hall, San Antonio Convention Center in order to complete their registration. **No provision will be made to handle cash transactions at the site of the Employment Register.** Registration for the Joint Meetings is required for participation in the Employment Register. It is also required that all participating employer interviewers register for the Joint Mathematics Meetings.

Onsite registration for the Employment Register is $100 for employers and $20 for applicants. This registration fee for employers covers the cost of a copy of the December Issue of *Employment Information in the Mathematical Sciences* (EIMS). This publication contains printed copies of the résumés of applicants who preregistered prior to the deadline and a copy of the Winter List of Applicants.

After registration has been completed, applicants and employers should come to the South Banquet Hall to fill out the forms necessary to participate in the Employment Register.

Nonparticipating Employers

Employers who attend the Joint Mathematics Meetings, but do not want to interview, can post job descriptions, subject to approval, at the Employment Register. Postings will not be allowed in the Joint Meetings registration area. A fee of $15 will be charged payable to the cashier at the Joint Mathematics Meetings registration desk. Participants should be sure to inform the cashier that they would like to post a job description but are not planning to interview and obtain the proper receipt in order to receive the form necessary for posting at the Employment Register desk.

Winter Lists of Applicants and Employers

The Winter List of Applicants, which is a summary of the résumés of preregistered applicants, will be available for sale at the AMS Exhibits and Book Sale at the meeting. The price at the meeting is $4 each. Any copies remaining after the meeting will be available from the Providence office of the Society for $6 each.

The Winter List of Employers consists of summaries of the position listings submitted by the employers who preregistered for the meeting; it will be distributed to the applicants participating in the Register. Others may purchase the Winter List of Employers at the AMS Exhibits and Book Sale at the meeting or from the Providence office after the meeting. The prices are the same as stated in the previous paragraph.

Please note that these lists will not be updated with onsite employers or applicants after the Employment Register has concluded.

December Issue of Employment Information in the Mathematical Sciences

For several years the periodical *Employment Information in the Mathematical Sciences* (EIMS) has published six issues per year listing open positions in academic, governmental and industrial organizations, primarily in North America, along with a few listings from countries in other parts of the world. EIMS is a joint project of the American Mathematical Society (publisher), the Mathematical Association of America, and the Society for Industrial and Applied Mathematics.

The December issue of EIMS contains résumés of persons seeking professional positions in the mathematical sciences. Résumés of applicants taking part in the Employment Register and those not attending will be included in the December 1986 issue provided they were received before the November 15 deadline.

Copies of the December issue of EIMS will be distributed in San Antonio to the employers who participate in the Employment Register.

Please note that the December issue of EIMS contains the Winter List of Applicants, but does not contain the Winter List of Employers.

Additional copies of the December Issue of EIMS will be available for sale at the AMS Exhibits and Book Sale at the meeting. Prices at the meeting are $7 each for the December issue. Any copies remaining after the meeting will be available from the Providence office of the Society for $12.

Program of the AMS and MAA Sessions

The time limit for each contributed paper in the AMS general sessions is ten minutes. In AMS special sessions, the time limit varies from session to session and within sessions. To maintain the schedule, time limits will be strictly enforced.

Abstracts of papers presented in AMS sessions at this meeting will be found in the January issue of *Abstracts of papers presented to the American Mathematical Society*, ordered according to the numbers in parentheses following the listings below.

Abstracts of papers presented in MAA sessions at this meeting will be found in a colored insert in the program given to registrants.

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

Wednesday, January 21, 1987, 8:00 a.m.

MAA Session on Experiences with Computer Support for Service Courses

8:00 - 8:20 (1) *Computer use in precalculus courses.* RONALD H. WENGER, University of Delaware

8:25 - 8:35 (2) *Lotus spreadsheets in calculus courses.* BARBARA C. NEVILS, Bentley College

8:40 - 8:50 (3) *Using Cactusplot in applied calculus.* TONI CARROLL, Siena Heights College

8:55 - 9:05 (4) *Computer programming for calculus.* JOHN FERLING, Claremont McKenna College

9:10 - 9:20 (5) *Using computer applications to enhance the traditional finite mathematics courses.* DEBORAH WOODS, University of Cincinnati

9:25 - 9:35 (6) *The use of computers in American Assembly of Collegiate Schools of Business (AACSB) mathematics courses.* RONALD BARNES, University of Houston, Downtown

9:40 - 9:55 (7) *Mathematics and statistics IBM-PC programs for engineering majors.* CLARK KIMBERLING, University of Evansville

10:00 - 10:10 (8) *Functions and statistics with computers—the University of Chicago School Mathematics Project.* JAMES E. SCHULTZ, Ohio State University

10:15 - 10:30 (9) *Teleteaching: Using telephones and personal computers to teach at a distance.* DANIEL GAROFF*, DAVID ELLEN and DEBORAH HUGHES HALLETT, Harvard University and the Cambridge Teleteaching Group

Wednesday, January 21, 1987, 8:00 a.m.

MAA Session on New Methods of Teaching Calculus

8:00 - 8:10 (10) *Restructuring calculus: A proposal for the second semester.* DEBORAH HUGHES HALLETT, Harvard University

8:10 - 8:20 (11) *A discrete approach to the calculus.* SHELDON P. GORDON, Suffolk County Community College

8:20 - 8:30 (12) *Teaching beginning calculus with a numerical emphasis.* G. EDGAR PARKER, James Madison University

8:30 - 8:40 (13) *Using history in teaching calculus.* VICTOR J. KATZ, University of the District of Columbia

8:40 - 8:50 (14) *Calculus with numerical, symbolic, and graphic computing.* PAUL ZORN, St. Olaf College

9:00 - 9:10 (15) *Calculus and a computational laboratory.* ERNEST J. MANFRED* and GEORGE REZENDES, United States Coast Guard Academy

9:10 - 9:30 (16) *Integration of videotapes into the teaching of calculus.* ELENA ANNE MARCHISOTTO, California State University, Northridge

9:35 - 9:45 (17) *Some feasible entry points for computer support in single-variable calculus.* JOHN F. LUCAS, University of Wisconsin, Oshkosh

9:45 - 9:55 (18) *Calculus microcomputer laboratory at USC.* WLODEK PROSKUROWSKI, University of Southern California

10:05 - 10:15 (19) *Two simple techniques that can make the second semester of calculus a success.* MARTIN E. FLASHMAN, Humboldt State University

10:15 - 10:25 (20) *The modern infinitesimal and the teaching of calculus.* GREGORY D. FOLEY, Ohio State University

10:30 - 10:40 (21) *Using a computer algebra system to reduce time spent in teaching integral calculus.* JEANETTE R. PALMITER, Ohio State University

10:40 - 10:50 (22) *Teaching introductory calculus using story-shell curriculum units and a small-group cooperative methods.* FREDRIC W. TUFTE, University of Wisconsin, Platteville

Wednesday, January 21, 1987, 9:00 a.m.

AMS Invited Address

9:00 – 9:50 (23) *The capacity of neural networks.* ROBERT J. MCELIECE, California Institute of Technology (831-92-585)

Wednesday, January 21, 1987, 9:00 a.m.

MAA Minicourse #1: Part A

9:00 – 10:55 *A microcomputer linear algebra course using LIN-KIT.* HOWARD ANTON

Wednesday, January 21, 1987, 9:00 a.m.

MAA Minicourse #2: Part A

9:00 – 10:55 *Introduction to computer graphics.* JOAN P. WYZKOSKI, Fairfield University

Wednesday, January 21, 1987, 9:00 a.m.

MAA Minicourse #3: Part A

9:00 – 10:55 *The teaching of applied mathematics.* W. GILBERT STRANG, Massachusetts Institute of Technology

Wednesday, January 21, 1987, 10:05 a.m.

AMS Invited Address

10:05 – 10:55 (24) *Nonlinear P. D. E. and vortex theory.* RONALD J. DIPERNA, University of California, Berkeley (831-35-376)

Wednesday, January 21, 1987, 11:10 a.m.

AMS-MAA Invited Address

11:10 – 12:00 (25) *The role of analytic number theory in the development of analysis.* Preliminary report. HUGH L. MONTGOMERY, University of Michigan, Ann Arbor

Wednesday, January 21, 1987, 1:00 p.m.

AMS Colloquium Lectures: Lecture I

1:00 – 2:00 (26) *Uses of the non-Euclidean wave equation,* I. PETER D. LAX, Courant Institute of Mathematical Sciences

Wednesday, January 21, 1987, 2:15 p.m.

AMS Special Session on Nonlinear Partial Differential Equations, I

2:15 – 3:00 (27) *Long time existence for a slightly perturbed Vortex sheet.* RUSSEL E. CAFLISCH* and OSCAR F. ORELLANA, Courant Institute of Mathematical Sciences, New York University (831-35-151)

3:10 – 3:40 (28) *Explicit examples of oscillations and concentrations.* ANDREW J. MAJDA, Princeton University (831-76-176)

3:50 – 4:10 (29) *Semiclassical limit of a nonlinear Schrödinger equation.* DAVID W. MCLAUGHLIN, University of Arizona (831-35-205) (Sponsored by R. DiPerna)

4:30 – 5:00 (30) *A new field equation recursion method for bounding effective tensors of composites.* GRAEME W. MILTON, Courant Institute of Mathematical Sciences, New York University (831-35-223) (Sponsored by R. Diperna)

5:10 – 5:40 (31) *The role of vortices in the dynamics of complex scalar fields.* JOHN NEU, University of California, Berkeley (831-76-568) (Sponsored by Ronald J. DiPerna)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Special Session on Geometric Inequalities, I

2:15 - 2:35 (32) *A strong form of isoperimetric inequality in* $\mathbf{R}^n$. ROBERT OSSERMAN, Stanford University (831-52-76)

2:40 - 3:00 (33) *Heat diffusion in insulated convex domains.* ISAAC CHAVEL, City College, City University of New York (831-52-49)

3:05 - 3:25 (34) *The support function, Wirtinger's inequality and a Bonnesen inequality for locally convex immersed curves.* Preliminary report. CHARLES EPSTEIN, University of Pennsylvania, and MICHAEL GAGE*, University of Rochester (831-52-75)

3:30 - 3:50 (35) *Stability results for certain projection bodies.* Preliminary report. PAUL GOODEY, National Science Foundation, Washington, D.C. (831-52-207)

3:55 - 4:15 (36) *Isoperimetric inequalities for k-dimensional cross sections of convex sets.* Preliminary report. ERIC L. GRINBERG, University of Michigan, Ann Arbor (831-52-443)

4:20 - 4:40 (37) *Some stability problems concerning geometric inequalities.* Preliminary report. H. GROEMER, University of Arizona (831-52-59)

4:50 - 5:10 (38) *On a problem of Busemann and Petty.* ERWIN LUTWAK, Polytechnic University (831-52-442)

5:20 - 5:40 (39) *Shape of random convex bodies: Distribution of the isoperimetric deficit.* Preliminary report. RICHARD A. VITALE, Claremont Graduate School (831-60-41)

5:50 - 6:10 (40) *Infinitesimal aspects of a problem of Busemann and Petty.* Preliminary report. ERIC L. GRINBERG, University of Michigan, Ann Arbor, and IGOR RIVIN*, Symbolics Inc., Cambridge, Massachusetts (831-52-516) (Sponsored by Erwin Lutwak)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Special Session on Recent Results in Gauge Field Theory and Riemannian Geometry, I

2:15 - 2:35 (41) *The Weyl problem in differential geometry.* Preliminary report. JERRY L. KAZDAN, University of Pennsylvania (831-35-392)

2:40 - 3:00 (42) *Scalar curvatures on* S^2. WENXIONG CHEN*, Academia Sinica, People's Republic of China, and University of Pennsylvania, and WEIYUE DING, Academia Sinica, People's Republic of China (831-35-209)

3:05 - 3:25 (43) *Nonuniqueness for solutions of the Korteweg-deVries equation.* AMY COHEN*, Rutgers University, New Brunswick, and THOMAS KAPPELER, University of Pennsylvania (831-35-445)

3:30 - 3:50 (44) *On the Yamabe problem on complete Riemannian manifold.* PATRICIO AVILES*, University of Illinois, Urbana-Champaign, and ROBERT MCOWEN, Northeastern University (831-53-444)

4:00 - 4:20 (45) *Solvability of some degenerate PDE arising in the geometry of 3-manifolds.* Preliminary report. ROBERT L. BRYANT, Rice University (831-35-518)

4:30 - 4:50 (46) *Topological methods in non-linear analysis and differential geometry.* Preliminary report. ABBAS BAHRI, Courant Institute of Mathematical Sciences, New York University (831-35-567) (Sponsored by Lesley M. Sibner)

5:00 - 5:20 (47) *Removable singularities of Riemannian metrics.* P. D. SMITH, Lehigh University, and D. YANG*, Rice University (831-53-582)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Special Session on Combinatorics and Group Representations, I

2:15 - 2:35 (48) *The p-analogues of finite chain products.* LYNNE M. BUTLER, Princeton University (831-05-553)

2:40 - 3:00 (49) *Geometric invariants for quasi-symmetric designs.* A. R. CALDERBANK, AT&T Bell Laboratories, Murray Hill (831-05-24)

3:05 - 3:25 (50) *Jack symmetric functions.* RICHARD P. STANLEY, Massachusetts Institute of Technology (831-05-15)

3:30 - 3:50 (51) *Invariance theorems for balanced shifted tableaux.* CURTIS GREENE, Haverford College (831-05-459)

3:55 - 4:15 (52) *On a correspondence of Zeilberger and Franzblau.* Preliminary report. PHIL HANLON, University of Michigan, Ann Arbor (831-05-403)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Session on Associative and Non-associative Rings

2:15 - 2:25 (53) *On the global dimension of fibre products.* ELLEN KIRKMAN* and JAMES KUZMANOVICH, Wake Forest University (831-16-165)

2:30 - 2:40 (54) *On the global dimension of a ring modulo its nilpotent radical.* ELLEN KIRKMAN and JAMES KUZMANOVICH*, Wake Forest University (831-16-166)

2:45 - 2:55 (55) *Local endomorphism near-rings.* Preliminary report. CARTER G. LYONS and GARY L. PETERSON*, James Madison University (831-16-167)

3:00 - 3:10 (56) *The group of units in a compact ring.* JO-ANN COHEN and KWANGIL KOH*, North Carolina State University (831-16-184)

3:15 - 3:25 (57) *Exact embedding functors and left coherent rings.* GEORGE HUTCHINSON, National Institutes of Health, Bethesda, Maryland (831-16-268)

3:30 - 3:40 (58) *Homomorphic images of strongly right bounded rings.* GARY BIRKENMEIER, University of Southwestern Louisiana, and RALPH TUCCI*, Loyola University (831-16-438)

3:45 - 3:55 (59) *Finite dimensional Hopf algebras are free over grouplike subalgebras.* WARREN D. NICHOLS*, Florida State University, and M. BETTINA ZOELLER, Western Kentucky University (831-16-493)

4:00 - 4:10 (60) *Zero-divisors in Cayley-Dickson algebras.* Preliminary report. THEODORE S. ERICKSON*, Wheeling College, and FRED COHEN, PAUL EAKINS and AVI SATHAYE, University of Kentucky (831-17-316) (Sponsored by Onkar Nath Pandit)

4:15 - 4:25 (61) *Endomorphisms and null subalgebras of finite dimensional algebras.* DAVID FINSTON, Virginia Commonwealth University (831-17-487)

4:30 - 4:40 (62) *An example of a Lie coalgebra $M \neq 0$ for which* $\mathrm{Loc}(M) = 0$. WALTER J. MICHAELIS, University of New Orleans (831-17-417)

4:45 - 4:55 (63) *A commutativity theorem for rings.* HISAO TOMINAGA, Okayama University, Japan, and ADIL YAQUB*, University of California, Santa Barbara (831-16-164)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Session on Group Theory, I

2:15 - 2:25 (64) *Mixed p-local S-modules and co-valuated groups.* MARK T. LANE, Massachusetts Institute of Technology, Lincoln Laboratory, Lexington (830-20-369)

2:30 - 2:40 (65) *Splitting fields.* Preliminary report. C. VINSONHALER and W. WICKLESS*, University of Connecticut, Storrs (831-20-277)

2:45 - 2:55 (66) *Pure subgroups of torsion-free groups.* PAUL HILL*, Baylor University, and CHARLES MEGIBBEN, Vanderbilt University (831-20-219)

3:00 - 3:10 (67) *Presentations of inverse monoids.* Preliminary report. JOSEPH B. STEPHEN, University of Nebraska, Lincoln (831-20-329)

3:15 - 3:25 (68) *Subgroups of graph groups.* CARL DROMS, James Madison University (831-20-29)

3:30 - 3:40 (69) *Partial orders and the semigroup of triangular relations.* Preliminary report. ROBERT BRANDON, Eastern Oregon State College (831-20-425)

3:45 - 3:55 (70) *On left absolutely flat bands.* SYDNEY BULMAN-FLEMING and KENNETH MCDOWELL*, Wilfrid Laurier University (831-20-198)

4:00 - 4:10 (71) *A note on perfect semigroups.* SYDNEY BULMAN-FLEMING* and KENNETH MCDOWELL, Wilfrid Laurier University (831-20-199)

4:15 - 4:25 (72) *Rewriting products of group elements.* RUSSELL BLYTH, University of Illinois, Urbana-Champaign (831-20-134)

4:30 - 4:40 (73) *A-solvable abelian groups.* ULRICH ALBRECHT, Auburn University, Auburn (831-20-466) (Sponsored by Thomas H. Pate)

4:45 - 4:55 (74) *Infinite rank Butler abelian groups.* MANFRED DUGAS and K. M. RANGASWAMY*, University of Colorado, Colorado Springs (831-20-465)

5:00 - 5:10 (75) *Hyper-t groups.* Preliminary report. H. PAT GOETERS, Auburn University, Auburn (831-20-428)

5:15 - 5:25 (76) *Covering classes for the alternating group.* KAREN FAWCETT* and GARY L. WALLS, University of Southern Mississippi (831-20-245)

5:30 - 5:40 (77) *On the projective characters of the finite Chevalley groups.* RANDALL R. HOLMES, University of Illinois, Urbana-Champaign (831-20-250)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Session on Topological Groups, Real Functions and Integral Equations

2:15 – 2:25 (78) *Constructing continuous topologies on a group.* Preliminary report. BRADD CLARK* and VICTOR SCHNEIDER, University of Southwestern Louisiana (831-22-310)

2:30 – 2:40 (79) *Duality and Kostant's partition function.* ROBERT W. DECKHART, Northern Arizona University (831-22-460)

2:45 – 2:55 (80) *Symmetric functions whose set of points of discontinuity is uncountable.* TAN CAO TRAN, Loras College (831-26-586)

3:00 – 3:10 (81) *Extensions of uniformly continuous functions.* Preliminary report. GERD H. FRICKE, Wright State University, Dayton (831-26-558)

3:15 – 3:25 (82) *A strengthening of Hölder's inequality.* Preliminary report. WILLIAM MCMILLEN, University of South Alabama (831-26-44)

3:30 – 3:40 (83) *On a simple proof of limit* $\sin\theta = 0$ *and limit* $\cos\theta = 1$ *as* $\theta \to 0$ *via trigonometric identities.* Preliminary report. S. VERMA, University of Nevada, Las Vegas (831-26-415) (Sponsored by L. J. Simonoff)

3:45 – 3:55 (84) *On m-recurrent nonsingular endomorphisms.* C. E. SILVA, Williams College (831-28-421)

4:00 – 4:10 (85) *Almost everywhere continuous functions with values in a metric space.* Preliminary report. K. G. JOHNSON, Columbus College (831-28-401)

4:15 – 4:25 (86) *Measurable spaces with c.c.c.* Preliminary report. R. M. SHORTT, Wesleyan University (831-28-153)

4:30 – 4:40 (87) *A simple approach to the Daniell integral.* Preliminary report. PIOTR MIKUSINSKI, University of Central Florida (831-28-135)

4:45 – 4:55 (88) *Uniqueness in* $[0, L]$ *moment problems and tomography.* WALTER CARRINGTON, University of Massachusetts Medical Center (831-44-517)

5:00 – 5:10 (89) *Closed-form solution of a system of nonlinear singular integral equations.* Preliminary report. JOHN R. HATCHER, Southwest Missouri State University (831-45-318)

5:15 – 5:25 (90) *Weak solutions for a stochastic equation of the Volterra-Skorohod type.* Preliminary report. MARICA LEWIN, University of Texas, Arlington (831-45-326) (Sponsored by Constantin Corduneanu)

5:30 – 5:40 (91) *Regularization approach to abstract Volterra equations.* CONSTANTIN CORDUNEANU, University of Texas, Arlington (831-45-343)

5:45 – 5:55 (92) *The minimal ideal of closed subsemigroups of* βS. Preliminary report. DENNIS E. DAVENPORT, Howard University (831-22-163) (Sponsored by Neil Hindman)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Session on Special Functions, Generating Functions and Difference Equations

2:15 – 2:25 (93) *A q-analog of a Whipple's transformation for hypergeometric series in* $U(n)$. STEPHEN C. MILNE, University of Kentucky (831-33-195)

2:30 – 2:40 (94) *Bounds on the Legendre functions.* ALLAN FRYANT, Utica College of Syracuse University (831-33-350) (Sponsored by Aaron Naftalevich)

2:45 – 2:55 (95) *Combinatorial stochastic matrices.* DANIEL S. MOAK, Michigan Technological University (831-33-353)

3:00 – 3:10 (96) *Generalized generating functions for photoemissive detectors.* JEAN MIRRA, FRANK MCNOLTY* and WILLIAM SHERWOOD, Lockheed Missiles & Space Company, Sunnyvale, California (831-33-02)

3:15 – 3:25 (97) *Some reproducing identities for families of mean values.* J. L. BRENNER, Palo Alto, California, and MICHAEL E. MAYS*, West Virginia University (831-39-484)

3:30 – 3:40 (98) *Generating functions for Fibonacci and generalized Fibonacci sequences.* S. PETHE, University of Malaya, Malaysia (831-40-275)

3:45 – 3:55 (99) *Subsequence and semiregular acceleration of convergence.* T. A. KEAGY, University of Texas, Tyler (831-40-287)

4:00 – 4:10 (100) *A comparison theorem for difference equations.* PAUL W. ELOE, University of Dayton (831-39-103)

4:15 – 4:25 (101) *Summability methods associated with ideals of bounded sequences.* JEFF CONNOR, Loyola University (831-40-535)

4:30 – 4:40 (102) *Korovkin type inequalities for convex probability measures.* Preliminary report. GEORGE A. ANASTASSIOU, Memphis State University (831-41-276)

4:45 – 4:55 (103) *Rate of convergence and the saturation class of lacunary trigonometric interpolation operators.* C. R. SELVARAJ, Kent State University (831-41-355)

5:00 – 5:10 (104) *A note on Borel summability.* Preliminary report. K. SONI and R. P. SONI*, University of Tennessee, Knoxville (831-40-501)

5:15 - 5:25 (105) *Quasi-interpolation and interpolation by multivariate splines.* CHARLES CHUI, Texas A&M University, College Station, HARVEY DIAMOND*, West Virginia University, and LOUISE RAPHAEL, Howard University (831-41-426)

5:30 - 5:40 (106) *The Remez algorithm for monosplines.* MICHAEL PETERS, Kent State University (831-41-356)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Session on Partial Differential Equations, I

2:15 - 2:25 (107) *Singularities of harmonic functions on $SU(2)$: A function theoretic setting.* Preliminary report. PETER A. MCCOY, United States Naval Academy, Annapolis, Maryland (831-35-306)

2:30 - 2:40 (108) *Gradient inequalities which imply convergence of steepest descent.* JOHN W. NEUBERGER, North Texas State University (831-35-93)

2:45 - 2:55 (109) *A well-posed mixed-type boundary value problem.* Preliminary report. JOHN M. RASSIAS, The American College of Greece, Attiki (831-35-192)

3:00 - 3:10 (110) *Remainder estimates for the asymptotics of elliptic eigenvalue problems with indefinite weights.* JACQUELINE FLECKINGER, Université Paul Sabatier, France, and MICHEL L. LAPIDUS*, University of Georgia (831-35-10)

3:15 - 3:25 (111) *The convergence of cell discretization approximations to the solution of elliptic partial differential equations in R^n.* HOWARD SWANN, San Jose State University (831-35-348)

3:30 - 3:40 (112) *Schauder estimates and existence theory for entire solutions of linear parabolic equations.* CHRISTOPHER MAWATA, University of Hawaii, Honolulu (831-35-278)

3:45 - 3:55 (113) *Epidemiological models with age-structure and proportionate mixing.* Preliminary report. CARLOS CASTILLO-CHAVEZ*, Cornell University, HERBERT W. HETHCOTE, University of Iowa, and VIGGO ANDREASEN, SIMON A. LEVIN and WEI-MIN LIU, Cornell University (831-35-437)

4:00 - 4:10 (114) *Transport equations with second order differential collision operators.* SUZANNE M. LENHART, University of Tennessee, Knoxville (831-35-262)

4:15 - 4:25 (115) *Regularity of solutions of two-dimensional Monge-Ampère equations.* FRIEDMAR SCHULZ, University of Iowa (831-35-525)

4:30 - 4:40 (116) *The existence and behavior of viscous structure for plane detonation waves.* DAVID H. WAGNER, University of Houston, University Park (831-35-548)

4:45 - 4:55 (117) *Asymptotic solutions to compressible fluid flow.* MARIA E. SCHONBEK, University of California, Santa Cruz (831-35-560)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Session on Functional Analysis, I

2:15 - 2:25 (118) *Polynomial approximation in the mean with respect to harmonic measure on crescents.* JOHN AKEROYD, University of Arkansas, Fayetteville (831-46-361)

2:30 - 2:40 (119) *The approximation numbers $\gamma_n(T)$ and Q-precompactness.* ASUMAN AKSOY*, Oakland University, and MASATOSHI NAKAMURA, Kobe University, Japan (831-46-311)

2:45 - 2:55 (120) *On weak analytic subsets in ℓ^∞.* Preliminary report. ELIZABETH M. BATOR*, North Texas State University, and ROBERT E. HUFF, Pennsylvania State University, University Park (831-46-312)

3:00 - 3:10 (121) *Linear spaces of sequences.* GEORGE BRAUER, University of Minnesota, Minneapolis (831-46-317)

3:15 - 3:25 (122) *Abstract cones with truncation.* P. C. DELIYANNIS, Illinois Institute of Technology (831-46-43) (Sponsored by M. J. Frank)

3:30 - 3:40 (123) *Enveloping C^*-algebras for semilattices with a topology.* Preliminary report. JOHN DUNCAN*, University of Arkansas, Fayetteville, and ALAN PATERSON, University of Aberdeen, Scotland (831-46-365)

3:45 - 3:55 (124) *Kernel operators on Banach lattices.* Preliminary report. WILLIAM FELDMAN, University of Arkansas, Fayetteville (831-46-362)

4:00 - 4:10 (125) *Ergodic properties of a class of nonlinear operators.* Preliminary report. M. P. HEBLE, University of Toronto, and K. SUNDARESAN*, Cleveland State University (831-46-347)

4:15 - 4:25 (126) *Some results in extrapolation spaces.* Preliminary report. ROHAN HEMASINHA*, University of West Florida, and MARIO MILMAN, Florida Atlantic University (831-46-468)

4:30 - 4:40 (127) *Uniformly non-$\ell^1(n)$ Orlicz-Bochner spaces.* ANNA KAMINSKA, A. Mickiewicz University, Poland, and BARRY TURETT*, Oakland University (831-46-257)

4:45 - 4:55 (128) *Isometries of some smooth normed spaces of analytic functions.* CLINTON J. KOLASKI, University of Minnesota, Duluth (831-46-282)

5:00 - 5:10 (129) *Uniform convergence of operators and Grothendieck spaces with the Dunford-Pettis property.* DENNY LEUNG, Catholic University of America (831-46-160)

5:15– 5:25 (130) *Uniform differentiability in the first coordinate.* Preliminary report. RUSSELL G. BILYEU and PAUL W. LEWIS*, North Texas State University (831-46-334)

5:30– 5:40 (131) *A characterization of a class of composition operators.* RAYMOND E. LEWKOWICZ, Wright State University (831-46-303)

5:45– 5:55 (132) *On a geometrical convergence in Banach spaces.* TECK-CHEONG LIM, George Mason University (831-46-129) (Sponsored by Stanley Zoltek)

6:00– 6:10 (133) *Jauch-Piron states on W^*-algebras.* Preliminary report. LASZLO ZSIDO, University of Cincinnati (831-99-588)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Session on Operator Theory

2:15– 2:25 (134) *A remark to joint Browder spectra of D-commuting systems.* RAM VERMA, Mount Olive College (831-47-18)

2:30– 2:40 (135) *Relative domains of integral operators.* IWO LABUDA, University of Mississippi, and PAWEL SZEPTYCKI*, University of Kansas (831-47-38)

2:45– 2:55 (136) *Volterra-Stieltjes integral equations with unbounded kernels on inner product spaces.* Preliminary report. THERESE SHELTON, Clemson University (831-47-423)

3:00– 3:10 (137) *A triangular form for operators with totally disconnected spectrum.* Preliminary report. ROBERT R. ROGERS, State University of New York, Buffalo (831-47-300)

3:15– 3:25 (138) *On axiomatic bifurcation theory.* DAN PASCALI, Forest Hills, New York (831-47-561)

3:30– 3:40 (139) *Solvability of systems of nonlinear wave equations.* P. S. MILOJEVIĆ, New Jersey Institute of Technology (831-47-504)

3:45– 3:55 (140) *Tikhonov's regularization of an arbitrary closed linear operator.* SUNG J. LEE, University of South Florida (831-47-156)

4:00– 4:10 (141) *A new class of strongly decomposable operators.* RIDGLEY LANGE*, Central Michigan University, and SHENGWANG WANG, University of Pittsburgh (831-47-418)

4:15– 4:25 (142) *Generalized Hahn-Banach theorem.* Preliminary report. PRZEMO KRANZ, University of Mississippi (831-47-434) (Sponsored by James F. Porter)

4:30– 4:40 (143) *Perturbations of the unilateral shift and transitive operator algebras.* MOHAMAD A. ANSARI, Pennsylvania State University, Reading (831-47-431)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Session on Calculus of Variations and Optimal Control

2:15– 2:25 (144) *Non-existence and discontinuities in theoretical optimization of elastic systems.* VADIM KOMKOV, Winthrop College (831-49-23)

2:30– 2:40 (145) *Controllability of a general nonlinear system constrained by a differential-difference inclusion.* G. G. WATKINS, Western Washington University (831-49-58) (Sponsored by Robin W. Chaney)

2:45– 2:55 (146) *The nonlinear proximal point algorithm.* JAVIER LUQUE, University of North Florida (831-49-67)

3:00– 3:10 (147) *Application of the method of contractor directions to optimization and optimal control.* URSZULA LEDZEWICZ-KOWALEWSKA, Louisiana State University, Baton Rouge (831-49-155) (Sponsored by Mieczyslaw Altman)

3:15– 3:25 (148) *Diffusing control systems.* Preliminary report. EMILIO O. ROXIN, University of Rhode Island (831-49-197)

3:30– 3:40 (149) *Numerical solutions of extremal problems.* JOHN GREGORY, Southern Illinois University, Carbondale (831-49-253) (Sponsored by John Greene)

3:45– 3:55 (150) *A maximal element principle for constraint sets.* MIECZYSLAW ALTMAN, Louisiana State University, Baton Rouge (831-49-265)

4:00– 4:10 (151) *Numerical methods for abnormal quadratic cost control problems.* Preliminary report. ROHAN J. DALPATADU, University of Nevada, Las Vegas (831-49-283) (Sponsored by Peter J. S. Shiue)

4:15– 4:25 (152) *Area-minimizing integral currents with boundaries invariant under polar actions.* JULIAN C. LANDER, Massachusetts Institute of Technology, Lincoln Laboratory, Lexington (831-49-368)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Session on Probability, I

2:15– 2:25 (153) *An $M/M/1$ queue with endogenous priority.* SUDHIR KUMAR TRIVEDI, University of Agra, India (831-60-573) (Sponsored by Krishna M. Saksena)

2:30– 2:40 (154) *Random sets, measurable selections, and nonstandard analysis.* DAVID ROSS, University of Hull, England (831-99-590)

2:45– 2:55 (155) *A generalized Ito's formula for multidimensional Brownian motions.* H.-H. KUO, Louisiana State University, Baton Rouge, and N. R. SHIEH*, Louisiana State University, Baton Rouge, and Taiwan University, Republic of China (831-60-162)

3:00– 3:10 (156) *Continuity of Gaussian processes.* GENNADY SAMORODNITSKY, Technion Israel Institute of Technology and University of North Carolina, Chapel Hill (831-60-416) (Sponsored by Robert M. Fossum)

3:15– 3:25 (157) *Stability of stochastic large scale difference system.* Preliminary report. G. S. LADDE, University of Texas, Arlington, and M. SAMBANDHAM*, Atlantic University, Morehouse College (831-60-332)

3:30– 3:40 (158) *Regular extensions of measures.* HERMAN RUBIN, Purdue University, West Lafayette (831-60-284)

3:45– 3:55 (159) *Last exit time and harmonic measure for Brownian motion in R^d.* Z. R. POP-STOJANOVIC, University of Florida (831-60-322)

4:00 4:10 (160) *A note on Paley-Wiener-Zygmund stochastic integrals.* CHULL PARK*, Miami University, Oxford, and D. L. SKOUG, University of Nebraska, Lincoln (831-60-145)

4:15– 4:25 (161) *Limit theorems arising from sequences of multinomial random vectors.* ROSANA L. PANGANIBAN, University of California, Irvine (831-60-304)

4:30– 4:40 (162) *Stable sample paths.* JOHN P. NOLAN, University of North Florida (831-60-266)

4:45– 4:55 (163) *Prophet inequalities for parallel processes.* Preliminary report. THEODORE P. HILL*, Georgia Institute of Technology, and DOUGLAS P. KENNEDY, University of Cambridge, England (831-60-433)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Session on Statistics and Numerical Analysis

2:15– 2:25 (164) *A class of tests of independence between two sets of variates.* JACK TOMSKY, Lockheed Missiles & Space Company, Palo Alto, California (831-62-01)

2:30 2:40 (165) *A lower bound for number of treatments in main effects plus one plan for 2^6 factorials.* B. C. GUPTA, University of Southern Maine (831-62-17)

2:45 2:55 (166) *Inner confidence intervals for quantile intervals of finite populations.* Preliminary report. JOHN S. MEYER, Albion College (831-62-30) (Sponsored by Mark Meerschaert)

3:00– 3:10 (167) *An exact pairwise multiple comparison procedure for the AOV model with unbalanced data.* Preliminary report. TZE-SAN LEE, Western Illinois University (831-62-74) (Sponsored by Sudhir Gokhale)

3:15– 3:25 (168) *Statistical properties of certain doubly stochastic measures.* Preliminary report. ROGER B. NELSEN, Lewis and Clark College (831-62-240) (Sponsored by Gregory A. Fredricks)

3:30– 3:40 (169) *Nonlinear regression.* B. B. BHATTACHARYYA, North Carolina State University, and G. D. RICHARDSON*, University of Central Florida (831-62-499)

3:45– 3:55 (170) *Geometric interpolation.* WYMAN FAIR*, University of North Carolina, Asheville, and WILLIAM ETHERIDGE, University of North Carolina, Wilmington (831-65-131)

4:00– 4:10 (171) *A new algorithm for unstable three terms recurrence relations.* S. SIVASUNDARAM*, University of Texas, Arlington, and D. TRIGIANTE, University of Bari, Italy (831-65-243)

4:15– 4:25 (172) *Stability of numerical methods for Volterra integro-differential equations of convolution type.* V. L. BAKKE* and Z. JACKIEWICZ, University of Arkansas, Fayetteville (831-65-360)

4:30– 4:40 (173) *Numerical solution to Chandrasekhar X and Y equations with perturbations.* Preliminary report. BARUCH CAHLON, Oakland University (831-65-502)

4:45– 4:55 (174) *A discrete maximum principle for collocation methods.* Preliminary report. ELIZABETH G. YANIK, Virginia Commonwealth University (831-65-503) (Sponsored by Joe Yanik)

5:00– 5:10 (175) *On the convergence of particle methods for multidimensional Vlasov-Poisson systems.* Preliminary report. H. D. VICTORY, JR.* and KESHAB GANGULY, Texas Tech University (831-65-510)

5:15– 5:25 (176) *A second order accurate positive scheme for singularly perturbed boundary value problems.* VINCENT J. ERVIN, Georgia Institute of Technology (831-65-538) (Sponsored by Theodore P. Hill)

5:30– 5:40 (177) *Collocation methods for boundary integral equations on polygons.* Preliminary report. ERNST P. STEPHAN*, Georgia Institute of Technology, and MARTIN COSTABEL, Technical University Darmstadt, Federal Republic of Germany (831-65-556) (Sponsored by T. P. Hill)

Wednesday, January 21, 1987, 2:15 p.m.

AMS Session on Applied Mathematics

2:15– 2:25 (178) *Liquid-vapor modeling of merged components for social science systems.* Preliminary report. DENNIS G. COLLINS, University of Puerto Rico, Mayaguez (831-90-331)

2:30– 2:40 (179) *The multicoalitional bargaining set M_0 versus the classical bargaining set M.* IRINEL DRAGAN, University of Texas, Arlington (831-90-254)

2:45 - 2:55 (180) *A convergence rate for a Kelley cutting plane algorithm.* ROBERT R. MERKOVSKY, Miami University, Oxford (831-90-258) (Sponsored by Douglas E. Ward)

3:00 - 3:10 (181) *On an analogue to the theory of abstract integration.* MIGUEL PAREDES, Pan American University (831-90-285)

3:15 - 3:25 (182) *Special cases of the traveling salesman problem.* RICHARD H. WARREN, General Electric Co., King of Prussia, Pennsylvania (831-90-237)

3:30 - 3:40 (183) *Relationship between Boolean logic models and ODE systems with regard to excitation-inhibition patterns.* Preliminary report. JEROME EISENFELD, University of Texas, Arlington (831-92-327) (Sponsored by Pierre Vuillermot)

3:45 - 3:55 (184) *Bifurcations in epidemiological models.* WEI-MIN LIU*, Cornell University, HERBERT W. HETHCOTE, University of Iowa, SIMON A. LEVIN, Cornell University, and YOH IWASA, Kyushu University, Japan (831-92-128)

4:00 - 4:10 (185) *Numerical bifurcation analysis of a periodically driven competition model.* ALFREDO SOMOLINOS, Mercy College (831-92-472)

4:15 - 4:25 (186) *Determination of electrical potential in a nerve of no inductance, capacitance, leakance, and resistance.* KRISHNANAND VERMA, University of Nevada, Las Vegas (831-92-144) (Sponsored by Looy Simonoff)

4:30 - 4:40 (187) *Normal forms for certain non-linear control problems in the plane.* Preliminary report. ROBERT B. GARDNER, University of North Carolina, Chapel Hill (831-93-97)

4:45 - 4:55 (188) *Equivalence of four-state systems with two controls under feedback.* Preliminary report. CHARLES GRISSOM, JR., University of North Carolina, Chapel Hill (831-93-212)

5:00 - 5:10 (189) *A set of axioms for a value for partition function games.* EDWARD BOLGER, Miami University, Oxford (831-90-95) (Sponsored by Dennis K. Burke)

5:15 - 5:25 (190) *Feedback equivalence of control systems with 3 state variables and 2 control variables.* Preliminary report. GEORGE WILKENS, University of North Carolina, Chapel Hill (831-93-213)

5:30 - 5:40 (191) *A generalized handshaking problem.* DIANE M. SPRESSER, James Madison University (831-98-03)

Wednesday, January 21, 1987, 2:15 p.m.

MAA Invited Address

2:15 - 3:05 (192) *Robots and topology.* DANIEL H. GOTTLIEB, Purdue University

Wednesday, January 21, 1987, 3:20 p.m.

MAA Invited Address

3:20 - 4:10 (193) *Artificial worlds and real mathematics.* ANDREA A. DISESSA, University of California, Berkeley

Wednesday, January 21, 1987, 4:25 p.m.

Interagency Commission for Extramural Mathematics Programs (ICEMAP)

Wednesday, January 21, 1987, 4:30 p.m.

AMS/MAA Workshop: Square One TV

Wednesday, January 21, 1987, 4:30 p.m.

MAA Minicourse #5: Part A

4:30 - 6:30 *Discrete mathematics using difference equations.* JAMES T. SANDEFUR, JR., Georgetown University

Wednesday, January 21, 1987, 4:30 p.m.

MAA Minicourse #6: Part A

4:30 - 6:30 *Using microcomputer software in teaching calculus.* DAVID P. KRAINES, Duke University and DAVID A. SMITH, Benedict College

Wednesday, January 21, 1987, 5:30 p.m.

National Science Foundation Session: Federal Support for Mathematics Education

Wednesday, January 21, 1987, 7:15 p.m.

AMS Committee on Science Policy Special Invited Address

Wednesday, January 21, 1987, 8:30 p.m.

AMS Josiah Willard Gibbs Lecture

8:30– 9:30 (194) *Schrödinger operators and dynamical systems.* THOMAS C. SPENCER, Courant Institute of Mathematical Sciences

Thursday, January 22, 1987, 8:00 a.m.

AMS Special Session on Classical Real Analysis, I

8:00– 8:20 (195) *The space of Henstock integrable functions.* KRZYSZTOF OSTASZEWSKI, University of Louisville (831-28-47)

8:25– 8:45 (196) *Small spaces.* W. F. PFEFFER*, University of California, Davis, and K. PRIKRY, University of Minnesota, Minneapolis (831-26-92)

8:50– 9:10 (197) *Insertion theorems.* IBRAHIM MUSTAFA, University of California, Santa Barbara (831-26-152)

9:15– 9:35 (198) *Generalized integrals.* GEORGE CROSS, University of Waterloo (831-26-31) (Sponsored by Michael Jon Evans)

9:40–10:00 (199) *A Riemann view of the Lebesgue integral.* P. S. BULLEN*, University of British Columbia, and D. N. SARKHEL, University of Kalyani, India (831-26-35)

10:05–10:25 (200) *Some characterizations of VBG_* functions.* BRIAN S. THOMSON, Simon Fraser University (831-26-175)

10:30–10:50 (201) *Variations on Lusin's and Blumberg's theorems.* JACK B. BROWN, Auburn University, Auburn (831-26-108)

Thursday, January 22, 1987, 8:00 a.m.

AMS Special Session on Geometric Inequalities, II

8:00– 8:20 (202) *On almost regular simplexes.* BORIS V. DEKSTER*, Mount Allison University, and JOHN B. WILKER, University of Toronto (831-52-34)

8:25– 8:45 (203) *Horospheres in hyperbolic geometry.* Preliminary report. CHARLES L. EPSTEIN, University of Pennsylvania (831-53-515)

8:50– 9:10 (204) *The size of a complete submanifold of hyperbolic space in terms of the size of its asymptotic boundary.* RALPH HOWARD, University of South Carolina (831-53-405)

9:15– 9:35 (205) *Projections of convex polytopes.* Preliminary report. CLINTON M. PETTY, University of Missouri, Columbia (831-52-62)

9:40–10:00 (206) *On the number of faces of centrally-symmetric simplicial polytopes.* RICHARD P. STANLEY, Massachusetts Institute of Technology (831-52-14)

10:05–10:25 (207) *Counting crystal corners in locally F-minimizing surfaces.* JEAN E. TAYLOR, Rutgers University, New Brunswick (831-51-80)

10:30–10:50 (208) *Hypersphere bounds from integrals of curvature.* Preliminary report. ANDREJS E. TREIBERGS, University of Utah (831-52-141)

Thursday, January 22, 1987, 8:00 a.m.

AMS Special Session on Stochastic Processes and Analysis, I

8:00– 8:20 (209) *Skorokhod's problem revisited.* Preliminary report. A. O. PITTENGER, University of Maryland, Baltimore County (831-60-413)

8:30– 8:50 (210) *Invertibility of time change.* FRANK KNIGHT, University of Illinois, Urbana-Champaign (831-60-69)

9:00– 9:20 (211) *Positive solutions of semilinear elliptic equations.* JOSEPH GLOVER, University of Florida (831-60-120)

9:30– 9:50 (212) *Capacitary estimates.* Preliminary report. S. E. GRAVERSEN, Aarhus University, Denmark, and MURALI RAO*, University of Florida (831-60-182)

10:00–10:20 (213) *Connecting Brownian paths.* BURGESS DAVIS*, Purdue University, West Lafayette, and THOMAS S. SALISBURY, York University (831-60-118)

10:30–10:50 (214) *Stochastic properties of functions in $\Lambda*$ and $\lambda*$.* Preliminary report. LOREN D. PITT*, University of Virginia, and J. M. ANDERSON, University College, England (831-60-84)

Thursday, January 22, 1987, 8:00 a.m.

AMS Special Session on Recent Results in Gauge Field Theory and Riemannian Geometry, II

8:00 - 8:20 (215) *On classification of harmonic eigenmaps into spheres.* GABOR TOTH, Rutgers University, Camden (831-58-391) (Sponsored by Lesley M. Sibner)

8:30 - 8:50 (216) *Convex Hamiltonian energy surfaces and their periodic Hamiltonian trajectories.* IVAR EKELAND, Université Paris Dauphine, France, and HELMUT H. W. HOFER*, Rutgers University, New Brunswick (831-58-524) (Sponsored by Lesley M. Sibner)

9:00 - 9:20 (217) *Regularity of harmonic maps.* GUOJUN LIAO, University of Utah (831-53-389)

9:30 - 9:50 (218) *Positive solutions for some semilinear elliptic equations with critical Sobolev exponents.* JOSE F. ESCOBAR, Courant Institute of Mathematical Sciences, New York University (831-58-541)

10:00 - 10:20 (219) *Metrics for constant-rank Ricci tensors.* Preliminary report. DENNIS DETURCK, University of Pennsylvania (831-53-446)

10:30 - 10:50 (220) *Deformation of contact metric structures on three manifolds.* SAMUEL L. GOLDBERG, University of Illinois, Urbana-Champaign (831-53-551)

Thursday, January 22, 1987, 8:00 a.m.

AMS Special Session on Theoretical Optimization, I

8:00 - 8:20 (221) *Too many convex tangent cones.* Preliminary report. JAY S. TREIMAN, Western Michigan University (831-49-147)

8:30 - 8:50 (222) *Which subgradients have sum formulas?* DOUG WARD, Miami University, Oxford (831-49-26)

9:00 - 9:20 (223) *A smooth variational principle with applications to subdifferentiability and to differentiability of convex functions.* JONATHAN M. BORWEIN, Dalhousie University (831-46-148) (Sponsored by Jay S. Treiman)

9:30 - 9:50 (224) *Normal cone formulas in Banach spaces with smooth renorms.* HALINA M. STROJWAS, Carnegie-Mellon University (831-49-562)

10:00 - 10:20 (225) *The value function in control and optimization.* FRANK H. CLARKE, Université de Montréal (831-49-149)

10:30 - 10:50 (226) *Second-order optimality conditions for constrained semismooth minimization.* ROBIN W. CHANEY, Western Washington University (831-90-13)

Thursday, January 22, 1987, 8:00 a.m.

AMS Special Session on Geometric Variational Problems, I

8:00 - 8:20 (227) *On a problem of Poincaré.* WILLIAM K. ALLARD, Duke University (831-49-454)

8:30 - 8:50 (228) *On the existence and regularity of fundamental domains with least boundary area.* JAIGYOUNG CHOE, University of California at San Diego, La Jolla (831-53-380) (Sponsored by Rob Kusner)

9:00 - 9:20 (229) *The area minimizing integral currents are classical minimal surfaces.* SHELDON CHANG, Harvard University (831-58-470)

9:30 - 9:50 (230) *A bridge principle for minimal submanifolds and constant mean curvature hypersurfaces.* NAT SMALE, University of California at San Diego, La Jolla (831-53-409) (Sponsored by Rob Kusner)

10:00 - 10:20 (231) *Minimal surfaces obtained by equivariant variational methods in the large.* Preliminary report. JON T. PITTS*, Texas A&M University, College Station, and J. H. RUBINSTEIN, University of Melbourne, Australia (831-49-382)

10:30 - 10:50 (232) *Applications of minimax to periodic minimal surfaces and to 3-manifold theory.* Preliminary report. J. H. RUBINSTEIN*, University of Melbourne, Australia, and JON T. PITTS, Texas A&M University, College Station (831-49-456)

Thursday, January 22, 1987, 8:00 a.m.

AMS Session on General Topology, I

8:00 - 8:10 (233) *On product of a perfect paracompact space and a countable product of scattered paracompact spaces.* KAZIMIERZ ALSTER, Miami University, Oxford (831-54-161) (Sponsored by David Lutzer)

8:15 - 8:25 (234) *Characterizing minimally free rings of continuous functions.* PAUL BANKSTON, Marquette University (831-54-288)

8:30 - 8:40 (235) *Local compactness of hyperspaces.* Preliminary report. BRUCE S. BURDICK, Bates College (831-54-508)

8:45 - 8:55 (236) *Concerning free topological groups.* W. W. COMFORT*, Wesleyan University, and JAN VAN MILL, Vrije Universiteit, Netherlands (831-54-507)

9:00 - 9:10 (237) *A covering property related to the strict p-space problem.* Preliminary report. S. W. DAVIS, Miami University, Oxford (831-54-241)

9:15 - 9:25 (238) *Pre-open sets and feeble separation axioms.* CHARLES DORSETT, Louisiana Tech University (831-54-154)

9:30 - 9:40 (239) *Rigid stone spaces within ZFC.* Preliminary report. ALAN DOW, York University, ANANDA V. GUBBI*, Youngstown State University, and ANDRZEJ SZYMANSKI, Slippery Rock University (831-54-328)

9:45 - 9:55 (240) *Countable dense homogeneity and the Baire property.* BEN FITZPATRICK, JR.*, Auburn University, Auburn, and HAO-XUAN ZHOU, Sichuan University, People's Republic of China (831-54-06)

10:00 - 10:10 (241) *Compact sets in the patch topology.* Preliminary report. M. HENRIKSEN, Harvey Mudd College and Wesleyan University, and R. D. KOPPERMAN*, City College, City University of New York (831-54-305)

10:15 - 10:25 (242) *Conditional paracompactness in* $\square^{\omega}$ *(rationals).* L. BRIAN LAWRENCE, Howard University (831-54-301)

10:30 - 10:40 (243) *The locally finite topology on* 2^X. S. A. NAIMPALLY*, Lakehead University, and P. L. SHARMA, Butler University (831-54-08)

10:45 - 10:55 (244) *Pixley-Roy spaces over intervals.* JEFFREY NORDEN, State University of New York, Binghamton (831-54-509)

Thursday, January 22, 1987, 8:00 a.m.

AMS Session on Group Theory, II

8:00 - 8:10 (245) *Rational representations of finite p-groups.* CHARLES FORD, Saint Louis University (831-20-500)

8:15 - 8:25 (246) *Maximal abelian subgroups of p-groups.* IAN D. MACDONALD, Lafayette College (831-20-314)

8:30 - 8:40 (247) *On a characteristic subgroup of a finite group containing the Frattini subgroup and some solvability conditions.* PRABIR BHATTACHARYA*, University of Nebraska, Lincoln, and N. P. MUKHERJEE, Jawaharlal Nehru University, India (831-20-185)

8:45 - 8:55 (248) *On the lower near Frattini subgroups of generalized free products.* Preliminary report. MOHAMMAD K. AZARIAN, University of Evansville (831-20-102)

9:00 - 9:10 (249) *End invariants of finitely presented groups.* MICHAEL L. MIHALIK, Vanderbilt University (831-20-402)

9:15 - 9:25 (250) *Locally constructed formations.* Preliminary report. MARK HOFMANN, Skidmore College (831-20-274)

9:30 - 9:40 (251) *The locally free cancellation property of the group ring ZG.* HSIN-FONG CHEN, Pennsylvania State University, Mont Alto Campus (831-20-464)

9:45 - 9:55 (252) *Pseudo-monomial characters and pseudo-M-groups.* Preliminary report. ELSA L. GUNTER, University of Wisconsin, Madison (831-20-255) (Sponsored by Thomas Forster)

10:00 - 10:10 (253) *Rings of integers, Swan modules and elliptic functions.* ANUPAM SRIVASTAV, University of Illinois, Urbana-Champaign (831-20-100)

10:15 - 10:25 (254) *Groups which are products of finite simple groups.* GARY L. WALLS, University of Southern Mississippi (831-20-101)

10:30 - 10:40 (255) *A new type of group automorphism: Centralizing automorphisms.* Preliminary report. J. J. MALONE* and B. C. MCQUARRIE, Worcester Polytechnic Institute (831-20-427)

10:45 - 10:55 (256) *Conjugacy of Hall subgroups.* Preliminary report. PHILIP COBB, University of Illinois, Urbana-Champaign (831-20-302)

Thursday, January 22, 1987, 8:00 a.m.

AMS Session on Functions of One Complex Variable

8:00 - 8:10 (257) *Rational maps and symmetry.* Preliminary report. TIMO ERKAMA, University of Joensuu, Finland (831-30-90)

8:15 - 8:25 (258) *Some results on the radius of starlikeness for certain classes of analytic functions.* Preliminary report. E. J. MOULIS, JR., United States Naval Academy (831-30-570)

8:30 - 8:40 (259) *Entire functions and Fourier transforms.* Preliminary report. BADIH GHUSAYNI, Auburn University, Auburn (831-30-270)

8:45 - 8:55 (260) *Truncations of derivative type support point of S.* AYŞENUR ÜNAL, University of Michigan, Flint (831-30-281) (Sponsored by Peter L. Duren)

9:00 - 9:10 (261) *An inequality of Littlewood and Paley.* DANIEL H. LUECKING, University of Arkansas, Fayetteville (831-30-354)

9:15 - 9:25 (262) *The commutativity of analytic functions near a common fixed point.* LAWRENCE J. CRONE*, American University, and ARTHUR C. NEUENDORFFER, NOAA/NESDIS, Washington, D.C. (831-30-367)

9:30 - 9:40 (263) *Proof of a conjecture of Komatu.* HERB SILVERMAN, College of Charleston (831-30-486)

9:45 - 9:55 (264) *Schwarzians of univalent functions.* Preliminary report. MARIUS OVERHOLT, University of Michigan, Ann Arbor (831-30-279)

10:00 - 10:10 (265) *Boundary behaviour of invariant Green's potentials on the unit ball in C^n.* K. T. HAHN, Pennsylvania State University, University Park, and DAVID SINGMAN*, Pennsylvania State University, Delaware County Campus (831-31-218)

10:15 - 10:25 (266) *On the residue type formulas for holomorphic maps on complex spaces.* Preliminary report. CHIA-CHI TUNG, Mankato State University (831-32-344)

Thursday, January 22, 1987, 8:30 a.m.

AMS Special Session on Combinatorics and Group Representations, II

8:30 - 8:50 (267) *Some enumerative uses of the group algebra of S_N.* D. M. JACKSON, University of Waterloo (831-20-342)

9:00 - 9:20 (268) *The automorphism group of the strong order of the symmetric group.* JOSEPH P. S. KUNG*, North Texas State University, and DAVID C. SUTHERLAND, Middle Tennessee State University (831-05-111)

9:30 - 9:50 (269) *A common generalization of the Schensted and Berele algorithms.* ROBERT A. PROCTOR, University of California, Los Angeles (831-05-406)

10:00 - 10:20 (270) *On the Kronecker products of Schur functions of Hook shape.* JEFFREY B. REMMEL, University of California at San Diego, La Jolla (831-20-110)

10:30 - 10:50 (271) *Inductive and injective proofs of log concavity results.* BRUCE SAGAN, Michigan State University (831-05-407)

Thursday, January 22, 1987, 8:30 a.m.

AMS Session on Commutative Algebra and Algebraic Geometry

8:30 - 8:40 (272) *Dimension of the Hessenberg variety associated with a unipotent matrix.* Preliminary report. JAMES S. WOLPER, Mount Holyoke College (831-14-294)

8:45 - 8:55 (273) *Strong projective algebras and invertible algebras.* JOE YANIK, Virginia Commonwealth University (831-13-506)

9:00 - 9:10 (274) *Rings that are FGC relative to filters of ideals.* EROL BARBUT and WILLY BRANDAL*, University of Idaho (831-13-82)

9:15 - 9:25 (275) *Contracted primes of the complete ring of quotients.* Preliminary report. FREDERICK W. CALL, University of Wisconsin, Milwaukee (831-13-81)

9:30 - 9:40 (276) *The strong two generator property in some polynomial subrings.* Preliminary report. SCOTT T. CHAPMAN, North Texas State University (831-13-269)

9:45 - 9:55 (277) *Factorial Zariski rings.* JEFFREY LANG, University of San Francisco (831-13-169)

10:00 - 10:10 (278) *Strongly 2-generated ideals.* Preliminary report. DAVID C. LANTZ* and MARY B. MARTIN, Colgate University (831-13-528)

10:15 - 10:25 (279) *More on rings with a certain divisibility property.* Preliminary report. ALAN LOPER*, Hope College, and D. L. MCQUILLAN, University College, Ireland (831-13-485)

10:30 - 10:40 (280) *Quasi valuations and quasi valuation rings.* Preliminary report. NICK VAUGHAN, North Texas State University (831-13-320)

10:45 - 10:55 (281) *Nilpotent elements in Grothendieck rings.* ROGER WIEGAND, University of Nebraska, Lincoln (831-13-583)

Thursday, January 22, 1987, 9:00 a.m.

MAA Invited Address

9:00 - 9:50 (282) *Networks, parallel computation and VLSI.* FRANK T. LEIGHTON, Massachusetts Institute of Technology

Thursday, January 22, 1987, 9:00 a.m.

AMS Special Session on Nonlinear Partial Differential Equations, II

9:00 - 9:30 (283) *Relaxation of a variational method for impedance computed tomography.* ROBERT V. KOHN*, Courant Institute of Mathematical Sciences, New York University, and MICHAEL VOGELIUS, University of Maryland, College Park (831-49-226)

9:40 - 10:10 (284) *The point interaction approximation for boundary value problems in region with many small inclusions.* GEORGE PAPANICOLAOU, Courant Institute of Mathematical Sciences, New York University (831-35-394)

10:20 - 10:50 (285) *The constrained least gradient problem.* ROBERT KOHN, Courant Institute of Mathematical Sciences, New York University, and GILBERT STRANG*, Massachusetts Institute of Technology (831-49-229)

Thursday, January 22, 1987, 9:00 a.m.

AMS Special Session on Brauer Groups and Galois Theory, I

9:00 - 9:20 (286) *Brauer groups of fields of genus zero.* BURTON FEIN*, Oregon State University, MURRAY SCHACHER, University of California, Los Angeles, and JACK SONN, Technion-Israel Institute of Technology, Israel (831-12-88)

9:30 - 9:50 (287) *Valuations on division algebras.* BILL JACOB, Mathematical Sciences Research Institute, Berkeley (831-16-122)

10:00 - 10:20 (288) *A new look at constructing quaternion extensions with quadratic form theory.* Preliminary report. DAVID LEEP, University of Kentucky (831-12-408)

10:30 - 10:50 (289) *$\tilde{A}_5$ and $\tilde{A}_7$ are Galois groups over number fields.* WALTER FEIT, Yale University (831-12-140)

Thursday, January 22, 1987, 9:00 a.m.

AMS Session on Partial Differential Equations, II

9:00 - 9:10 (290) *Uniqueness for the characteristic Cauchy problem for a nonlinear equation.* Preliminary report. ALAN V. LAIR, Air Force Institute of Technology (831-35-358)

9:15 - 9:25 (291) *Reaction-diffusion systems: decay with asymptotic phase to spatial homogeneity.* MORRIS HIRSCH, University of California, Berkeley (831-35-27)

9:30 - 9:40 (292) *Nonuniqueness for a hyperbolic system: Cavitation in elastodynamics.* Preliminary report. KATHLEEN A. PERICAK-SPECTOR and SCOTT J. SPECTOR*, Southern Illinois University, Carbondale (831-35-53)

9:45 - 9:55 (293) *Moser estimates for higher order derivatives.* Preliminary report. DAVID R. ADAMS, University of Kentucky (831-35-57)

10:00 - 10:10 (294) *Scattering of multidimensional solitary waves.* HENRY A. WARCHALL, North Texas State University (831-35-72)

10:15 - 10:25 (295) *Essential spectra of a class of elliptic operators.* HOUSHANG H. SOHRAB, Towson State University (831-35-78)

Thursday, January 22, 1987, 9:00 a.m.

AMS Session on Harmonic Analysis

9:00 - 9:10 (296) *Translation invariance of cocycles of an irrational rotation.* Preliminary report. KATHY D. MERRILL, Colorado College (831-43-555)

9:15 - 9:25 (297) *Highly oscillatory singular integrals along curves.* MICHAEL ZIELINSKI, St. Olaf College (831-42-142)

9:30 - 9:40 (298) *Generalizations of the Sidon-Telyakovskii theorem.* ČASLAV V. STANOJEVIĆ, University of Missouri, Rolla, and VERA B. STANOJEVIĆ*, Southwest Missouri State University (831-42-280) (Sponsored by Simon Bernau)

9:45 - 9:55 (299) *Generalization of a result of Flett on approximation of a function by Fourier series.* R. N. MOHAPATRA*, University of Central Florida, and PREM CHANDRA, Vikram University, India (831-42-498)

10:00 - 10:10 (300) *Uniqueness and multiplicity conditions in bounded synthesis.* Preliminary report. DAVID COLELLA, St. Lawrence University (831-43-216)

10:15 - 10:25 (301) *On Riesz product measures; mutual absolute continuity and singularity.* SHELBY J. KILMER*, Southwest Missouri State University, and SADAHIRO SAEKI, Kansas State University (831-43-187) (Sponsored by Simon J. Bernau)

10:30 - 10:40 (302) *Polynomials orthogonal on several intervals.* JEFFREY S. GERONIMO* and WALTER VAN ASSCHE, Georgia Institute of Technology (831-42-554)

Thursday, January 22, 1987, 9:00 a.m.

AMS Session on Functional Analysis, II

9:00 - 9:10 (303) *Geometric properties characteristic of normed linear space.* GRATTAN MURPHY*, University of Maine, Orono, RAYMOND FREESE, Saint Louis University, and EDWARD ANDALAFTE, University of Missouri, St. Louis (831-46-193)

9:15 - 9:25 (304) *The ideal structure of certain nonselfadjoint operator algebras.* JUSTIN R. PETERS, Iowa State University (831-46-351)

9:30 - 9:40 (305) *Approximations for positive operators on Banach lattices.* CALVIN PISTON, John Brown University (831-46-295)

9:45 - 9:55 (306) *On biduals of C^*-tensor products.* JOHN C. QUIGG, Arizona State University (831-46-346)

10:00 - 10:10 (307) *Closed ideals of finite codimension in self-adjoint regular Banach algebras.* N. V. RAO, University of Toledo (831-46-242)

10:15 - 10:25 (308) *Injective Banach bundles, II.* D. A. ROBBINS, Trinity College (831-46-65)

10:30 - 10:40 (309) *Compactification of a semigroup.* Preliminary report. EBRAHIM SALEHI, University of Nevada, Las Vegas (831-46-159)

10:45 - 10:55 (310) *Variants of the Stone-Banach theorem.* EDWARD BECKENSTEIN, St. John's University, Staten Island, LAWRENCE NARICI, St. John's University, Jamaica, and AARON R. TODD*, Bernard M. Baruch College, City University of New York (831-46-264)

Thursday, January 22, 1987, 9:00 a.m.

AMS Session on Probability, II

9:00 - 9:10 (311) *Self-reciprocal density functions.* G. G. HAMEDANI*, Marquette University, and G G. WALTER, University of Wisconsin, Milwaukee (831-60-307)

9:15 - 9:25 (312) *Optional and predictable projections of abstract stochastic processes.* Preliminary report. JAMES K. BROOKS and NICOLAE DINCULEANU*, University of Florida (831-60-42)

9:30 - 9:40 (313) *Propagation of singularities for some two parameter processes.* ROBERT DECKER, University of Hartford (831-60-412)

9:45 - 9:55 (314) *A mathematical model of belief and prejudice.* Preliminary report. ANDREW G. BORDEN, JR.* and CHARLES W. HANSEN, The BDM Corporation, McLean, Virginia (831-60-28)

10:00 - 10:10 (315) *Law of large numbers for linear chemical reactions.* Preliminary report. DOUG BLOUNT, University of Wisconsin, Madison (831-60-511)

10:15 - 10:25 (316) *The supremum of a process with stationary independent and symmetric increments.* SIMEON M. BERMAN, Courant Institute of Mathematical Sciences, New York University (831-60-136)

10:30 - 10:40 (317) *A coherent view of comparative probability.* THOMAS E. ARMSTRONG, University of Maryland, Baltimore County (831-60-315)

10:45 - 10:55 (318) *An extension of a theorem due to Echeverria with applications to stochastic control.* Preliminary report. RICHARD H. STOCKBRIDGE, University of Wisconsin, Madison (831-60-359)

Thursday, January 22, 1987, 9:00 a.m.

AMS Session on Computational Mathematics

9:00 - 9:10 (319) *Minimal solutions to systems of equations over a free semigroup.* Preliminary report. QUAN QUOC NGUYEN, North Carolina State University (831-68-51)

9:15 - 9:25 (320) *BINEX: A knowledge-based expert system, application to binomial algebraic numbers.* KUODUO J. HUANG, California State University, Los Angeles (831-68-291)

9:30 - 9:40 (321) *Banyan models for the parallel implementation of the fast Fourier transform algorithm.* Preliminary report. WILLIAM H. JULIAN, New Mexico State University, Las Cruces (831-68-366)

9:45 - 9:55 (322) *On fault-tolerant consensus in message-order-synchronous networks.* RONALD J. WATRO, Mitre Corp., Bedford, Massachusetts (831-68-430)

10:00 - 10:10 (323) *Normal forms for relational data bases from an information-theoretic perspective.* LINDA RESH, AT&T Bell Laboratories, Naperville, Illinois, and ZALCSTEIN YECHEZKEL*, Memphis State University (831-68-432) (Sponsored by Edward T. Ordman)

Thursday, January 22, 1987, 10:05 a.m.

MAA Invited Address

10:05 - 10:55 (324) *Self-similarity and hairiness in the Mandelbrot set.* JOHN W. MILNOR, Institute for Advanced Study

Thursday, January 22, 1987, 11:10 a.m.

AMS-MAA Invited Address

11:10 - 12:00 (325) *Algebraic traditions on two continents.* UTA C. MERZBACH, Smithsonian Institution, Washington, D.C.

Thursday, January 22, 1987, 1:00 p.m.

AMS Colloquium Lectures: Lecture II

1:00 - 2:00 (326) *Uses of the non-Euclidean wave equation,* II. PETER D. LAX, Courant Institute of Mathematical Sciences

Thursday, January 22, 1987, 2:15 p.m.

AMS Invited Address

2:15 - 3:05 (327) *Analytic aspects of gauge field theory.* LESLEY M. SIBNER, University of Pennsylvania (831-35-249)

Thursday, January 22, 1987, 2:15 p.m.

MAA Session on the History of Mathematics

2:15 – 2:20 Introductory remarks. DUANE BLUMBERG, University of Southwestern Louisiana

2:20 – 2:30 (328) *The role of history in the undergraduate mathematics curriculum.* DAVID E. KULLMAN, Miami University

2:35 – 2:50 (329) *The Bernoulli family and their mathematical contributions.* GARY BRITTON, University of Wisconsin, Washington County

2:55 – 3:10 (330) *Historical notes for the calculus classroom.* V. FREDERICK RICKEY, Bowling Green State University

3:15 – 3:25 (331) *The transcendental functions in the first calculus texts.* VICTOR J. KATZ, University of the District of Columbia

3:30 – 3:40 (332) *Combinatorics by the measure.* ANGELA B. SHIFLET, Lander College

3:45 – 3:55 (333) *Lazzerini's lucky approximation of pi.* LEE BADGER, Weber State College

4:00 – 4:10 (334) *The Archives of American Mathematics and archival documentation in science and mathematics.* FREDERIC F. BURCHSTED, University of Texas

Thursday, January 22, 1987, 2:15 p.m.

MAA Minicourse #1: Part B

2:15 – 4:15 *A microcomputer linear algebra course using LIN-KIT.* HOWARD ANTON.

Thursday, January 22, 1987, 2:15 p.m.

MAA Minicourse #2: Part B

2:15 – 4:15 *Introduction to computer graphics.* JOAN P. WYZKOSKI, Fairfield University

Thursday, January 22, 1987, 2:15 p.m.

MAA Minicourse #3: Part B

2:15 – 4:15 *The teaching of applied mathematics.* W. GILBERT STRANG, Massachusetts Institute of Technology

Thursday, January 22, 1987, 3:20 p.m.

AMS Invited Address

3:20 – 4:10 (335) *Regularity and singularity for energy minimizing maps.* ROBERT M. HARDT, University of Minnesota, Minneapolis (831-58-248)

Thursday, January 22, 1987, 4:25 p.m.

AMS 1986 Leroy P. Steele Prizes and the 1987 Frank Nelson Cole Prize in Number Theory and Business Meeting

Thursday, January 22, 1987, 7:00 p.m.

Joint Policy Board for Mathematics: National Meeting of Department Heads

Thursday, January 22, 1987, 7:00 p.m.

MAA Minicourse #5: Part B

7:00 – 9:00 *Discrete mathematics using difference equations.* JAMES T. SANDEFUR, JR., Georgetown University

Thursday, January 22, 1987, 7:00 p.m.

MAA Minicourse #6: Part B

7:00 – 9:00 *Using microcomputer software in teaching calculus.* DAVID P. KRAINES, Duke University and DAVID A. SMITH, Benedict College

Thursday, January 22, 1987, 7:00 p.m.

AMS-MAA Panel Discussion

7:00 – 9:30 *What makes news in mathematics?*

Thursday, January 22, 1987, 7:30 p.m.

AMS Committee on Science Policy Panel Discussion

7:30 - 9:30 *The effect of Department of Defense funding on mathematics.*

Thursday, January 22, 1987, 7:30 p.m.

AMS-MAA Symposium

7:30 - 10:00 *The role of mathematicians in pre-college education.*

Friday, January 23, 1987, 8:30 a.m.

MAA Session on Remedial Mathematics: Issues and Innovations, Part I

8:30 - 8:40 Introductory remarks. GEOFFREY R. AKST, Borough Manhattan Community College

8:40 - 8:55 (336) *Math instruction as a component of exemplary remedial education programs: Results of a national survey.* ANITA MCDONALD, University of Missouri, St. Louis

9:00 - 9:15 (337) *Computerized adaptive testing: A model.* LUCKY ABERNATHY, College Board

9:20 - 9:35 (338) *Students, instructors and computers in remedial mathematics.* JOHN C. MILLER, City College, City University of New York

9:40 - 9:55 (339) *Calculators in the standardized assessment of mathematics: New College Board and MAA developments.* JOHN W. KENELLY, Clemson University

10:00 - 10:15 (340) *The impact of competency tests on remedial programs.* ELENA ANNE MARCHISOTTO, California State University, Northridge

10:20 - 10:35 (341) *Arizona State University's computer assisted mathematics fitness project.* GARY G. BITTER* and ALLAN CAMERON, Arizona State University

10:40 - 10:55 Discussion period

Friday, January 23, 1987, 9:00 a.m.

AMS Invited Address

9:00 - 9:50 (342) *Noether's problem, Galois theory and the Brauer group.* DAVID J. SALTMAN, Mathematical Sciences Research Institute (831-12-251)

Friday, January 23, 1987, 9:00 a.m.

MAA Minicourse #4: Part A

9:00 - 10:55 *Interesting applications of elementary mathematics.* JOANNE S. GROWNEY, Bloomsburg University

Friday, January 23, 1987, 9:00 a.m.

MAA Minicourse #8: Part A

9:00 - 10:55 *Computer simulation of discrete systems.* ZAVEN A. KARIAN, Denison University

Friday, January 23, 1987, 9:00 a.m.

MAA Minicourse #9: Part A

9:00 - 10:55 *Recurrence relations.* MARGARET BARRY COZZENS, Northeastern University

Friday, January 23, 1987, 9:00 a.m.

MAA Minicourse #10: Part A

9:00 - 10:55 *Integrating history into undergraduate mathematics courses,* JUDITH V. GRABINER, Pitzer College

Friday, January 23, 1987, 9:00 a.m.

MAA Minicourse #11: Part A

9:00 - 10:55 *Teaching mathematical modeling.* FRANK R. GIORDANO, U.S. Military Academy and MAURICE D. WEIR, Naval Postgraduate School

Friday, January 23, 1987, 9:30 a.m.

AMS-MAA Mathematical Sciences Education Board Forum on the K-12 Curriculum

Friday, January 23, 1987, 10:05 a.m.

AMS Invited Address

10:05 - 10:55 (343) *Crab grass, measles, and gypsy moths: An introduction to modern probability.* RICHARD DURRETT, Cornell University (831-60-127)

Friday, January 23, 1987, 11:10 a.m.

AMS-MAA Invited Address

11:10 - 12:00 (344) *Strange attractors: Are they still strange?* EDWARD N. LORENZ, Massachusetts Institute Technology

Friday, January 23, 1987, 1:00 p.m.

AMS Colloquium Lectures: Lecture III

1:00 - 2:00 (345) *Uses of the non-Euclidean wave equation,* III. PETER D. LAX, Courant Institute of Mathematical Sciences

Friday, January 23, 1987, 1:00 p.m.

AMS Special Session on Geometric Methods in Group Theory, I

1:00 - 1:20 (346) *Valuations on groups.* KENNETH S. BROWN, Cornell University (831-20-191)

1:25 - 1:45 (347) *Pseudo-length functions on groups.* Preliminary report. WALTER PARRY, Eastern Michigan University (831-20-379)

1:50 - 2:10 (348) *Adian groups, pregroups, and trees.* JOHN R. STALLINGS, University of California, Berkeley (831-20-173)

2:15 - 2:35 (349) *($\mathbf{Q} + \tau\mathbf{Q}$)-trees, Part I.* Preliminary report. PETER B. SHALEN, University of Illinois, Chicago (831-20-232) (Sponsored by Howard Mazur)

2:40 - 3:00 (350) *$Q + \tau Q$ trees, part* 2. Preliminary report. HENRI GILLET, University of Illinois, Chicago (831-20-371) (Sponsored by John W. Wood)

3:05 - 3:25 (351) *Spinning out free actions of surface groups on* **R**-*trees.* FRANK RIMLINGER, Columbia University (831-20-124)

3:40 - 4:00 (352) *Approximations of actions on* **R**-*trees.* MARK FEIGHN, University of Oklahoma and University of Texas, Austin (831-20-543) (Sponsored by Roger Alperin)

Friday, January 23, 1987, 1:00 p.m.

AMS Special Session on Nonlinear Partial Differential Equations, III

1:00 - 1:30 (353) *Local regularizing effects in dispersive linear and nonlinear partial differential equations.* PETRE CONSTANTIN*, University of Chicago, and JEAN-CLAUDE SAUT, Université de Paris-Sud, France (831-35-224) (Sponsored by Ronald J. DiPerna)

1:40 - 2:10 (354) *Geometric optics for certain reaction-diffusion equations.* LAWRENCE C. EVANS*, University of Maryland, College Park, and P. E. SOUGANIDIS, Brown University (831-35-393)

2:20 - 2:50 (355) *Finite-dimensional modal equations of a nearly integrable P.D.E.* Preliminary report. GREG FOREST, Ohio State University, Columbus (831-76-228)

3:00 - 3:30 (356) *Diffusions in nonuniform media.* KENNETH GOLDEN, Rutgers University, New Brunswick (831-82-222)

3:50 - 4:20 (357) *Solitary waves of nonlinear dispersive equations governing long wave propagation.* MICHAEL WEINSTEIN, Princeton University (831-35-227)

Friday, January 23, 1987, 1:00 p.m.

AMS Special Session on Classical Real Analysis, II

1:00 - 1:20 (358) *On infinite nth Peano derivatives: The Saga continues.* JAN MARIK and CLIFFORD WEIL*, Michigan State University (831-26-105)

1:25 - 1:45 (359) *Fractals related to the Wierstrass functions.* S. JAMES TAYLOR, University of Virginia (831-26-178)

1:50 - 2:10 (360) *On the Hausdorff dimension of the graphs of continuous functions.* R. DANIEL MAULDIN, North Texas State University (831-26-398)

2:15 - 2:35 (361) *Convergence of two dimensional conjugate trigonometric series.* Preliminary report. J. MARSHALL ASH, DePaul University (831-42-189)

2:40 - 3:00 (362) *On some sufficient conditions for a distribution to be a constant.* Preliminary report. CHENG-MING LEE, University of Wisconsin, Milwaukee (831-26-174)

3:05 - 3:25 (363) *Continuity and generalized difference quotients.* LEE LARSON, University of Louisville (831-26-400)

3:30- 3:50 (364) *On the maximum of Darboux functions.* HWANG-WEN PU, Texas A & M University, College Station (831-26-70)

3:55- 4:15 (365) *Monotonicity and convexity theorems for generalized Riemann derivatives.* PAUL D. HUMKE*, St. Olaf College, and MIKLOS LACZKOVICH, Eotvos Lorand University, Budapest (831-26-106)

Friday, January 23, 1987, 1:00 p.m.

AMS Special Session on Brauer Groups and Galois Theory, II

1:00- 1:20 (366) *Brauer groups of principal homogeneous spaces.* Preliminary report. RAYMOND HOOBLER, City College, City University of New York (831-14-471)

1:30- 1:50 (367) *Azumaya algebras and Sweedler crossed products.* LINDSAY N. CHILDS, State University of New York, Albany (831-16-55)

2:00- 2:20 (368) *Uniform distribution in the Brauer group.* GARY R. GREENFIELD, University of Richmond (831-16-39)

2:30- 2:50 (369) *Calculating the Brauer-Long group of $Z/2$-dimodule algebras.* Preliminary report. TIMOTHY J. FORD*, Florida Atlantic University, and FRANK R. DEMEYER, Colorado State University (831-13-09)

3:00- 3:20 (370) *Homomorphisms of projective modules over group rings.* Preliminary report. FRANK DEMEYER* and SUDHIR NATH, Colorado State University, and TIM FORD, Florida Atlantic University (831-16-68)

Friday, January 23, 1987, 1:00 p.m.

AMS Special Session on Geometric Inequalities, III

1:00- 1:20 (371) *Geometric inequalities and estimates of solutions for quasilinear equations.* Preliminary report. ILYA J. BAKELMAN, Texas A & M University, College Station (831-35-40)

1:25- 1:45 (372) *Gromov's norm and Riemannian foliations of negative curvature.* Preliminary report. JAMES HEBDA, Saint Louis University (831-53-64)

1:50- 2:10 (373) *Volumes of flows.* DAVID L. JOHNSON, Lehigh University (831-58-388)

2:20- 2:40 (374) *Surface area inequalities for ellipsoids using Minkowski sums.* RICHARD E. PFIEFER, San Jose State University (831-52-25) (Sponsored by G. D. Chakerian)

2:50- 3:10 (375) *The Blaschke diagram.* Preliminary report. J. R. SANGWINE-YAGER, Saint Mary's College (831-52-61)

3:20- 3:40 (376) *Lorentz spaces and metric properties of ovals.* LAWRENCE J. WALLEN, University of Hawaii, Honolulu (831-52-387)

3:50- 4:10 (377) *Optimal isoperimetric inequalities.* FRED ALMGREN, Princeton University (831-49-79)

Friday, January 23, 1987, 1:00 p.m.

AMS Special Session on Stochastic Processes and Analysis, II

1:00- 1:20 (378) *Shocks in the asymmetric exclusion process.* ENRIQUE D. ANDJEL, IMPA, Brasil, MAURY D. BRAMSON, University of Minnesota, Minneapolis, and THOMAS M. LIGGETT*, University of California, Los Angeles (831-60-183)

1:30- 1:50 (379) *Large deviations for the invariant measures of some interacting particle systems.* ROBERTO H. SCHONMANN, Cornell University (831-60-119) (Sponsored by Joseph Glover)

2:00- 2:20 (380) *A shape theorem for an epidemic model.* Preliminary report. TED COX*, Syracuse University, and RICHARD DURRETT, Cornell University (831-60-234)

2:30- 2:50 (381) *An invariance principle for processes with statistical mechanical properties.* LAWRENCE GRAY, University of Minnesota, Minneapolis (831-60-410)

3:00- 3:50 (382) *Rescaling the contact process.* Preliminary report. MAURY BRAMSON*, University of Minnesota, Minneapolis, and RICHARD DURRETT and GLENN SWINDLE, Cornell University (831-60-414)

Friday, January 23, 1987, 1:00 p.m.

AMS Special Session on Combinatorics and Group Representations, III

1:00- 1:20 (383) *Unimodality and classical association schemes.* Preliminary report. DENNIS STANTON, University of Minnesota, Minneapolis (831-05-478)

1:30- 1:50 (384) *Principal specializations of internal products.* Preliminary report. JOHN R. STEMBRIDGE, University of California, Los Angeles (831-05-404)

2:00- 2:20 (385) *Representations of $Sp(2n, C)$.* SHEILA SUNDARAM, University of Michigan, Ann Arbor (831-05-138)

2:30- 2:50 (386) *Matching in the boolean algebra under group actions.* Preliminary report. DENNIS WHITE, University of Minnesota, Minneapolis (831-05-546)

3:00 - 3:20 (387) *MacMahon's symmetric functions of several systems of quantities.* Preliminary report. IRA GESSEL, Brandeis University (831-05-52)

Friday, January 23, 1987, 1:00 p.m.

AMS Special Session on Orthogonal Polynomials and the Moment Problem, I

1:00 - 1:20 (388) *Some specific indeterminate moment problems related to classical orthogonal polynomials.* RICHARD ASKEY, University of Wisconsin, Madison (831-33-171)

1:30 - 1:50 (389) *On the zeros and the Christoffel numbers of certain orthogonal polynomials.* Preliminary report. EIICHI BANNAI*, Ohio State University, Columbus, and TASURO ITO, Ohio State University, Columbus, and Joetsu University of Education, Japan (831-05-181)

2:00 - 2:20 (390) *Hamburger moment problems for orthogonal polynomials.* Preliminary report. T. S. CHIHARA, Purdue University, Calumet Campus (831-42-375)

2:30 - 2:50 (391) *Spectral measures, orthogonal polynomials and absolute continuity.* JOANNE DOMBROWSKI, Wright State University (831-47-85)

3:00 - 3:20 (392) *Moment-preserving approximation by spline functions.* WALTER GAUTSCHI*, Purdue University, West Lafayette, and G. V. MILOVANOVIĆ, University of Niš, Yugoslavia (831-41-60)

3:30 - 3:50 (393) *Computations with continued fraction expansions and their applications.* DAVID CHUDNOVSKY* and GREGORY CHUDNOVSKY, Columbia University (831-99-591)

Friday, January 23, 1987, 1:00 p.m.

AMS Special Session on Recent Results in Gauge Field Theory and Riemannian Geometry, III

1:00 - 1:20 (394) *The geometry of the Yang-Mills moduli space: Semiclassical approximations.* Preliminary report. THOMAS PARKER, Brandeis University (831-58-542)

1:30 - 1:50 (395) *Geometry of moduli spaces of self dual Yang-Mills fields.* DAVID GROISSER, State University of New York, Stony Brook (831-81-563)

2:00 - 2:20 (396) *Continuum regularization of quantum Yang-Mills theory.* Preliminary report. LORENZO A. SADUN, University of California, Berkeley, and Harvard University (831-81-483)

2:30 - 2:50 (397) *Gauge theory and exotic* $\mathbf{R}^4$*'s.* ROBERT E. GOMPF, University of Texas, Austin (831-57-390)

3:00 - 3:50 (398) *Point singularities of coupled gauge fields with low energy.* THOMAS H. OTWAY* and LESLEY M. SIBNER, University of Pennsylvania (831-35-117)

3:55 - 4:15 (399) *Apparent higher dimensional singularities of the Yang-Mills equations.* Preliminary report. R. J. SIBNER*, Brooklyn College, City University of New York University and University of Pennsylvania, and L. M. SIBNER, Polytechnic Institute of New York and University of Pennsylvania (831-35-231)

Friday, January 23, 1987, 1:00 p.m.

AMS Special Session on Theoretical Optimization, II

1:00 - 1:20 (400) *On the* Arg min *multifunction for lower semicontinuous functions.* GERALD A. BEER*, California State University, Los Angeles, and PETAR S. KENDEROV, Bulgarian Academy of Sciences (831-49-86)

1:30 - 1:50 (401) *Existence results involving acyclic multifunctions.* LYNN MCLINDEN, University of Illinois, Urbana-Champaign (831-49-395)

2:00 - 2:20 (402) *Measurable multifunctions and their applications to convex integral functionals.* Preliminary report. NIKOLAOS S. PAPAGEORGIOU, University of California, Davis (831-28-139)

2:30 - 2:50 (403) *Are minimax theorems and variational inequalities of Hahn-Banach or Brouwer type?* STEPHEN SIMONS, University of California, Santa Barbara (831-49-172)

3:00 - 3:20 (404) *Generalized linear complementarity problems.* M. SEETHARAMA GOWDA* and T. I. SEIDMAN, University of Maryland, Baltimore County (831-90-150)

3:25 - 3:45 (405) *A decomposition method and its application to convex programming.* SHIH-PING HAN, University of Illinois, Urbana-Champaign (831-49-477) (Sponsored by Lynn McLinden)

3:50 - 4:10 (406) *Directional sensitivity for the optimal solutions in nonlinear mathematical programming.* JACQUES GAUVIN*, Ecole Polytechnique, Montréal, and ROBERT JANIN, Université des Antilles-Guyane, French West Indies (831-49-121) (Sponsored by Lynn McLinden)

Friday, January 23, 1987, 1:00 p.m.

AMS Special Session on Geometric Variational Problems, II

1:00– 1:20 (407) *Some geometric variational problems associated to framings of 3-manifolds.* Preliminary report. ROBERT L. BRYANT, Rice University (831-53-519)

1:30– 1:50 (408) *Regularity of minimal surfaces at corners.* Preliminary report. LEON SIMON, Stanford University (831-53-544) (Sponsored by Robert Hardt)

2:00– 2:20 (409) *A P.D.E. proof of Gromov's compactness of pseudo-holomorphic curves.* JON WOLFSON, Tulane University (831-53-480)

2:30– 2:50 (410) *Rigidity of minimal surfaces in the three sphere.* Preliminary report. JAYAKUMAR RAMANATHAN, University of Michigan, Ann Arbor (831-53-458) (Sponsored by Dan Burns)

3:00– 3:20 (411) *When is the union of two n-planes area-minimizing?* DANA NANCE, Duke University (831-49-457)

3:30– 3:50 (412) *Area-minimizing surfaces in Grassmannians.* HERMAN GLUCK and WOLFGANG ZILLER, University of Pennsylvania, and FRANK MORGAN*, Massachusetts Institute of Technology and Stanford University (831-53-230)

Friday, January 23, 1987, 1:00 p.m.

AMS Session on Combinatorics and Graph Theory, I

1:00– 1:10 (413) *Some necessary conditions for a $(0,1)$-matrix to be triangulizable.* N. TOOBAEI, Academy of Niavaran, Iran (831-05-188) (Sponsored by Robert M. Fossum)

1:15– 1:25 (414) *Generalized binomial coefficients from generalized factorial sequences.* DONALD R. SNOW, Brigham Young University (831-05-527)

1:30– 1:40 (415) *Some full and fully deterministic generalized Petersen graphs.* GERALD SCHRAG* and LARRY CAMMACK, Central Missouri State University (831-05-56)

1:45– 1:55 (416) *The determinant of the distance matrix of a graph with complete blocks.* ALLEN J. SCHWENK, Western Michigan University (831-05-308)

2:00– 2:10 (417) *Graceful labelings of cycles and prisms with pendant points.* DANIEL ROPP, Washington University (831-05-530) (Sponsored by Joseph A. Gallian)

2:15– 2:25 (418) *Topological graph theory and the Ménage problem.* ROBERT RIEPER, Western Michigan University (831-05-467)

2:30– 2:40 (419) *Multicolored Simon Newcomb problems.* Preliminary report. DON RAWLINGS, California Polytechnic State University (831-05-496)

2:45– 2:55 (420) *Cyclic colorations of 3-polytopes.* M. D. PLUMMER*, Vanderbilt University, and BJARNE TOFT, University of Odense, Denmark (831-05-321)

3:00– 3:10 (421) *The separation vector of a graph.* Preliminary report. RAYMOND E. PIPPERT* and LOWELL W. BEINEKE, Indiana University-Purdue University, Ft. Wayne, and LINDA LESNIAK, Drew University (831-05-260)

3:15– 3:25 (422) *Sidon graphs of groups.* Preliminary report. MANLEY PERKEL, Wright State University (831-05-54)

3:30– 3:40 (423) *Graph connectivity questions on the hypercube.* Preliminary report. EDWARD ORDMAN, Memphis State University (831-05-325)

3:45– 3:55 (424) *An algorithm for the Ramsey numbers $R(3,6)$ and $R(3,7)$.* Preliminary report. R. K. OLIVER, Indiana State University (831-05-357)

4:00– 4:10 (425) *Association schemes and derived PBIB designs of prime power order.* Preliminary report. ROBERT A. HULTQUIST and GARY L. MULLEN*, Pennsylvania State University, University Park, and HARALD NIEDERREITER, Austrian Academy of Sciences (831-05-364)

Friday, January 23, 1987, 1:00 p.m.

AMS Session on Number Theory, I

1:00– 1:10 (426) *A generalization of the conjectures of Erdos-Straus and Sierpinski.* Preliminary report. MOHAMMAD H. AHMADI, University of Wisconsin, Whitewater (831-99-587) (Sponsored by Richard Schauer)

1:15– 1:25 (427) *Partitions with "$d(a)$ copies of a."* ASHOK K. AGARWAL*, Pennsylvania State University, Mont Alto Campus, and GARY L. MULLEN, Pennsylvania State University, University Park (831-11-330)

1:30– 1:40 (428) *The tabulation of Kaprekar transformation of four-digit numbers.* Preliminary report. GEORGE BALDWIN, Texas Tech University, and SEOK SAGONG*, Hardin-Simmons University (831-11-363)

1:45– 1:55 (429) *Perfect polynomials over $GF(p)$ revisited.* JACOB T. B. BEARD, JR., Tennessee Technological University (831-12-494)

2:00 - 2:10 (430) *On irreducible polynomials over a field.* JOEL V. BRAWLEY, Clemson University (831-12-557)

2:15 - 2:25 (431) *Jordan decomposable derivations.* LUNG O. CHUNG, North Carolina State University (831-12-575)

2:30 - 2:40 (432) *On the distribution function for the average binary digit of n.* CURTIS N. COOPER* and ROBERT E. KENNEDY, Central Missouri State University (831-11-290)

2:45 - 2:55 (433) *Retractions of fields.* Preliminary report. JAMES DEVENEY* and JOE YANIK, Virginia Commonwealth University (831-12-263)

3:00 - 3:10 (434) *On density functions.* Preliminary report. MICHAEL J. DOLAN* and SHAN MANICKAM, Western Carolina University (831-11-529)

3:15 - 3:25 (435) *All infinite groups are Galois groups over any field.* MANFRED DUGAS*, University of Colorado, Colorado Springs, and R. GÖBEL, Essen University, West Germany (831-12-247)

3:30 - 3:40 (436) *A relation between two formulas of Hasse and Davenport.* JOHN GREENE, Southern Illinois University, Carbondale (831-11-324)

3:45 - 3:55 (437) *On digital sums of powers of integers.* ROBERT E. KENNEDY* and CURTIS N. COOPER, Central Missouri State University (831-11-298)

4:00 - 4:10 (438) *Length of the n-number game.* ANNE LUDINGTON, Loyola College (831-11-194)

Friday, January 23, 1987, 1:00 p.m.

AMS Session on Ordinary Differential Equations, I

1:00 - 1:10 (439) *Mathematical analysis of a class of nonlinear diffusion problems.* Preliminary report. J. B. GARNER* and J. L. SOLOMON, Mississippi State University (831-34-440)

1:15 - 1:25 (440) *Optimal L^p criteria for nonoscillation and disconjugacy.* Preliminary report. MARK S. ASHBAUGH, University of Missouri, Columbia (831-34-495)

1:30 - 1:40 (441) *Near-optimum regulators for stochastic singularly perturbed systems.* G. S. LADDE, University of Texas, Arlington, and O. SIRISAENGTAKSIN*, University of Houston, Downtown (831-34-217)

1:45 - 1:55 (442) *Monotone iterative technique for periodic boundary value problem for functional differential equations.* A. S. VATSALA, University of Southwestern Louisiana (831-34-533)

2:00 - 2:10 (443) *Diagonalization and stability of large-scale singularly perturbed linear system.* G. S. LADDE and M. KATHIRKAMANAYAGAN*, University of Texas, Arlington (831-34-157) (Sponsored by G. S. Ladde)

2:15 - 2:25 (444) *Existence of periodic solutions of second order differential equations with delay.* GERHARD METZEN, Memphis State University (831-34-422)

2:30 - 2:40 (445) *Study of nonlinear systems with singular perturbations.* Preliminary report. G. S. LADDE, University of Texas, Arlington, and S. G. RAJALAKSHMI*, Southwest Missouri State University (831-34-559)

2:45 - 2:55 (446) *Periodic solutions for $\dot{x}(t) = \lambda f(x(t), x(t-1))$.* RACHID BENKHALTI, University of Mississippi (831-34-436) (Sponsored by James F. Porter)

3:00 - 3:10 (447) *Boundary value problems for nth order Lipschitz equations.* JOHNNY HENDERSON, Auburn University, Auburn (831-34-12)

3:15 - 3:25 (448) *Ricati equations with unbounded quadratic term arising in transport theory.* Preliminary report. JONQ JUANG, Texas Tech University (831-34-21) (Sponsored by Paul Nelson, Jr.)

3:30 - 3:40 (449) *Efficient application of the Schauder-Tychonoff theorem to systems of functional equations.* Preliminary report. WILLIAM F. TRENCH, Trinity University (831-34-137)

Friday, January 23, 1987, 1:00 p.m.

AMS Session on Geometry and Algebraic Topology

1:00 - 1:10 (450) *Squaring the circle in a cylindrical glass of water.* ANDREAS ZACHARIOU* and ELENI ZACHARIOU, Athens, Greece (831-51-571) (Sponsored by P. Tsangaris)

1:15 - 1:25 (451) *An analysis of the Karajordanoff angle trisection approximation method.* JOHN F. LAMB, JR., East Texas State University (831-51-244) (Sponsored by Stuart Anderson)

1:30 - 1:40 (452) *The complete classification of vertex-transitive and edge-transitive polyhedra.* Preliminary report. STEVEN L. FARRIS, Ball State University (831-51-349)

1:45 - 1:55 (453) *Some inequalities for lattice polygons.* STANLEY RABINOWITZ, Alliant Computer Systems Corporation, Littleton, Massachusetts (831-52-469)

2:00 - 2:10 (454) *Smith operations and the transfer.* Preliminary report. RICHARD P. KUBELKA, San Jose State University (831-55-461)

2:15 - 2:25 (455) *Isomorphisms and peripheral structure of knot groups.* CHICHEN M. TSAU, St. Louis University (831-57-04)

2:30 - 2:40 (456) *Thin cell-like decompositions of $\mathbf{R}^n, n \geq 5$.* DENNIS J. GARITY, Oregon State University (831-57-505)

2:45– 2:55 (457) *Strongly acyclic maps and homology 3-manifolds with 0-dimensional singular set.* T. L. THICKSTUN, Southwest Texas State University (831-57-536)

3:00– 3:10 (458) *Dual homotopy invariants of Riemannian foliations.* Preliminary report. PETER Y. PANG, University of Illinois, Urbana-Champaign (831-57-537)

3:15– 3:25 (459) *Some remarks concerning index for C^0-homeomorpisms.* Preliminary report. MORTON BROWN, University of Michigan, Ann Arbor (831-58-323)

3:30– 3:40 (460) *Periodic orbits for two dimensional Hamiltonian systems.* Preliminary report. MICHAEL R. COLVIN, California Polytechnic State University (831-58-550)

Friday, January 23, 1987, 1:00 p.m.

AMS Session on Differential Geometry

1:00– 1:10 (461) *On the non compact Nash spaces.* Preliminary report. PETRU PAPADOPOL, Grand Canyon College (831-53-513)

1:15– 1:25 (462) *Special conformal collineations in a locally symmetric space.* Preliminary report. R. SHARMA* and K. L. DUGGAL, University of Windsor (831-53-104)

1:30– 1:40 (463) *Semi-symmetric hypersurfaces of anti-De Sitter spacetime that are S^1-invariant.* MICHAEL H. VERNON, Lewis Clark State College (831-53-214)

1:45– 1:55 (464) *Invariants of first order Lagrangian particle theories.* Preliminary report. MICHAEL SUTTON, University of North Carolina, Chapel Hill (831-53-215)

2:00– 2:10 (465) *Stability of constant mean curvature surface in $\mathbf{R}^3$.* Preliminary report. DONG PYO CHI* and SUNG EUN KOH, Seoul National University, Korea (831-53-221)

2:15– 2:25 (466) *Higher order flatness of projective spaces.* Preliminary report. GREGORY A. FREDRICKS*, Lewis and Clark College, and PHILLIP E. PARKER, Wichita State University (831-53-238)

2:30– 2:40 (467) *An analogue of the holonomy bundle for a foliated manifold.* ROBERT A. BLUMENTHAL* and JAMES J. HEBDA, Saint Louis University (831-53-252)

2:45– 2:55 (468) *Geodesics of Π-conjugate connections on a principal fibre bundle.* ANDRZEJ BUCKI, Lycoming College (831-53-574)

3:00– 3:10 (469) *Geodesic connectability.* Preliminary report. JOHN K. BEEM*, University of Missouri, Columbia, and PHILLIP E. PARKER, Wichita State University (831-53-239)

3:15– 3:25 (470) *Complete constant mean curvature surfaces in Euclidean three space.* Preliminary report. NICOLAOS KAPOULEAS, University of California at San Diego, La Jolla (831-53-267)

3:30– 3:40 (471) *The angle criterion.* Preliminary report. GARY LAWLOR, Stanford University (831-53-462)

3:45– 3:55 (472) *Area-minimizing cones over unitary groups.* Preliminary report. BENNY N. CHENG, Massachusetts Institute of Technology (831-53-463)

Friday, January 23, 1987, 1:00 p.m.

AMS Session on General Topology, II

1:00– 1:10 (473) *Plans to classify surfaces.* Preliminary report. MARGARET M. LASALLE, University of Southwestern Louisiana (831-54-130)

1:15– 1:25 (474) *Various smoothings of the long line and their tangent bundles,* I. PETER J. NYIKOS, University of South Carolina, Columbia (831-54-549) (Sponsored by R. M. Stephenson, Jr.)

1:30– 1:40 (475) *Continuously ray extendable continua.* Preliminary report. C. WAYNE PROCTOR, Stephen F. Austin State University (831-54-296)

1:45– 1:55 (476) *Maximal ideals in subalgebras of $C(X)$.* LOTHAR REDLIN*, Pennsylvania State University, Ogontz Campus, and SALEEM WATSON, California State University, Long Beach (831-54-569)

2:00– 2:10 (477) *General topology algebraically.* Preliminary report. ROGER RENNE, New College (831-54-271)

2:15– 2:25 (478) *Finite-point order compactifications.* THOMAS A. RICHMOND, Western Kentucky University (831-54-158)

2:30– 2:40 (479) *Hereditarily indecomposable Case-Chamberlin type continua.* PAMELA D. ROBERSON, Stephen F. Austin State University (831-54-297)

2:45– 2:55 (480) *Connected versus compact subjects of linearly ordered spaces.* Preliminary report. DAVID A. ROSE, Francis Marion College (831-54-439)

3:00– 3:10 (481) **P**-*extensions.* MOHAN TIKOO, Southeast Missouri State University (831-54-211)

3:15– 3:25 (482) *Topological techniques in general relativity.* U. D. VYAS*, Winston-Salem State University, and P. S. JOSHI, Tata Institute of Fundamental Research, India (831-54-66)

3:30– 3:40 (483) *Paracompactness, subparacompactness, and p-spaces.* HOWARD H. WICKE*, Ohio University, and JOHN M. WORRELL, JR., Big Spring, Texas (831-54-319)

Friday, January 23, 1987, 2:00 p.m.

AMS Session on Applied Mathematics and Mathematical Physics

2:00– 2:10 (484) *Regge-pole model.* STEPHEN L. WEINBERG, Berkeley Academy of Artscience, Berkeley, California (831-81-05)

2:15– 2:25 (485) *A problem with moments in elasticity theory.* CHRISTIAN CONSTANDA, University of Tulsa (831-73-292) (Sponsored by Richard A. Redner)

2:30– 2:40 (486) *Viscoelastic fluid flow through a porous annulus.* R. K. BHATNAGAR* and H. W. VAYO, University of Toledo (831-76-512)

2:45– 2:55 (487) *A uniqueness theorem for viscoelastic fluids.* C. V. EASWARAN* and S. R. MAJUMDAR, University of Calgary, and H. RAMKISSOON, University of West Indies (831-76-335)

3:00– 3:10 (488) *Hydromagnetic convection at a continuous moving surface.* K. VAJRAVELU, University of Central Florida (831-76-259)

3:15– 3:25 (489) *A variational principle for nonlinear water waves.* LOKENATH DEBNATH, University of Central Florida (831-76-45)

3:30– 3:40 (490) *Spin polarization in Thomas-Feimi theory.* Preliminary report. JEROME A. GOLDSTEIN, Tulane University, and GISELE RUIZ RIEDER*, Louisiana State University, Baton Rouge (831-81-441)

3:45– 3:55 (491) *A quantum mechanical moment problem and generalized uncertainty relations.* Preliminary report. F. J. NARCOWICH, Texas A&M University, College Station (831-81-236)

4:00– 4:10 (492) *Tensor products and probability weights.* M. KLÄY, University of Bern, Switzerland, and C. RANDALL and D. FOULIS*, University of Massachusetts, Amherst (831-81-133)

Friday, January 23, 1987, 2:15 p.m.

AMS Session on Linear Algebra

2:15– 2:25 (493) *Some results on growth in Gaussian elimination with complete pivoting.* JANE DAY* and BRIAN PETERSON, San Jose State University (831-15-186)

2:30– 2:40 (494) *Structure properties of a class of semimonotone matrices.* MELVYN W. JETER, Illinois Wesleyan University, and WALLACE C. PYE*, University of Southern Mississippi (831-15-532)

2:45– 2:55 (495) *Equivalence and similarity of multiparameter matrices and applications.* JOHN JONES, JR., Air Force Institute of Technology (831-15-123)

3:00– 3:10 (496) *The Moore-Penrose inverse of substochastic (s,t)-potent matrices.* Preliminary report. CECIL E. ROBINSON, JR., Millsaps College (831-15-337)

3:15– 3:25 (497) *Generalized eigenspaces of a nonnegative matrix.* NICHOLAS J. ROSE, North Carolina State University (831-15-299)

3:30– 3:40 (498) *Inverses of generalized Vandermonde matrices.* LUIS VERDE-STAR, Universidad Autónoma Metropolitana, México (831-15-492)

3:45– 3:55 (499) *Diagonalization over commutative rings.* R. BRUCE RICHTER and WILLIAM P. WARDLAW*, United States Naval Academy (831-15-488)

4:00– 4:10 (500) *Linear dependence and the Wronskian.* Preliminary report. KENNETH WOLSSON, Fairleigh Dickinson University, Teaneck (831-15-514)

Friday, January 23, 1987, 2:15 p.m.

MAA Invited Address

2:15– 3:05 (501) *Game theory, nuclear deterrence, and Star Wars.* STEVEN J. BRAMS, New York University

Friday, January 23, 1987, 3:20 p.m.

MAA Prize Session and Business Meeting

Friday, January 23, 1987, 7:00 p.m.

AMS Committee on Science Policy Panel Discussion

7:00– 9:30 *The problem of Star Wars software reliability.*

Friday, January 23, 1987, 7:00 p.m.

MAA Minicourse #4: Part B

7:00– 9:00 *Interesting applications of elementary mathematics.* JOANNE S. GROWNEY, Bloomsburg University

Friday, January 23, 1987, 7:00 p.m.

MAA Minicourse #12: Part A

7:00 - 9:00 *True BASIC in freshman calculus.* JAMES F. HURLEY, University of Connecticut

Friday, January 23, 1987, 7:00 p.m.

MAA Minicourse #13: Part A

7:00 - 9:00 *For all practical purposes.* SOLOMON A. GARFUNKEL, COMAP, Inc.

Friday, January 23, 1987, 7:00 p.m.

MAA Minicourse #14: Part A

7:00 - 9:00 *Applications of discrete mathematics.* FRED STEPHEN ROBERTS, Rutgers University

Friday, January 23, 1987, 7:00 p.m.

MAA Minicourse #15: Part A

7:00 - 9:00 *Constructing placement examinations.* JOHN W. KENELLY, Clemson University

Saturday, January 24, 1987, 8:00 a.m.

AMS Special Session on Geometric Methods in Group Theory, II

8:00 - 8:20 (502) *Base change and applications for Λ-tree actions.* HYMAN BASS, Columbia University (831-20-520)

8:25 - 8:45 (503) *On the Bieri-Renz invariant.* Preliminary report. WALTER D. NEUMANN, University of Maryland, College Park, and Ohio State University, Columbus (831-20-564)

8:50 - 9:10 (504) *Automorphism groups of two generator metabelian groups.* HORACE Y. MOCHIZUKI, University of California, Santa Barbara (831-20-109)

9:15 - 9:35 (505) *Remarks on Bass's strong conjecture.* ROSS GEOGHEGAN, State University of New York, Binghamton (830-20-372)

9:40 - 10:00 (506) *Amalgamations and the Kervaire problem.* S. M. GERSTEN, University of Utah (831-20-448)

10:05 - 10:25 (507) *Equalizers of homomorphisms.* RICHARD GOLDSTEIN* and EDWARD TURNER, State University of New York, Albany (831-20-146)

10:30 - 10:50 (508) *Cutting and pasting in the Bass-Serre theory, part* II. Preliminary report. MARVIN TRETKOFF, Cornell University (831-20-378)

Saturday, January 24, 1987, 8:00 a.m.

AMS Special Session on Classical Real Analysis, III

8:00 - 8:20 (509) *Intermediate value theorems and monotonicity for path derivatives.* KEVIN B. TAYLOR, Saint Mary's College (831-26-179)

8:25 - 8:45 (510) *The set of ω-limit points.* Preliminary report. R. J. O'MALLEY, University of Wisconsin, Milwaukee (831-26-479) (Sponsored by Michael J. Evans)

8:50 - 9:10 (511) *Density topologies.* Preliminary report. WŁADYSŁAW WILCZYŃSKI, University of Łódź, Poland (831-26-73) (Sponsored by Michael J. Evans)

9:15 - 9:35 (512) *A summability method for Fourier series.* Preliminary report. DANIEL WATERMAN*, Syracuse University, and LAWRENCE D'ANTONIO, State University of New York, College at Purchase (831-26-46)

9:40 - 10:00 (513) *Attractor sets for typical continuous functions.* S. J. AGRONSKY*, California Polytechnic State University, A. M. BRUCKNER, University of California, Santa Barbara, and M. LACZKOVICH, Eötvös Loránd University, Hungary (831-26-190)

10:05 - 10:25 (514) *A characterization of extendable connectivity functions.* RICHARD G. GIBSON*, Columbus College, and FRED ROUSH, Alabama State University (831-26-107)

10:30 - 10:50 (515) *A fundamental theorem of calculus for the Lebesgue-Stieltjes integral.* K. M. GARG, University of Alberta (831-26-545)

10:55 - 11:15 (516) *A partitioning property for the symmetric differentiation basis.* JAMES FORAN, University of Missouri, Kansas City (831-26-89)

11:20 - 11:40 (517) *Approximate symmetric derivatives and level sets.* Preliminary report. DAN RINNE, California State University, San Bernardino (831-26-235) (Sponsored by Michael J. Evans)

Saturday, January 24, 1987, 8:00 a.m.

AMS Special Session on Stochastic Processes and Analysis, III

8:00 - 8:20 (518) *Propagation of chaos for colored diffusion processes.* MASAO NAGASAWA, University of California at San Diego, La Jolla, and University of Zürich (831-60-126) (Sponsored by Joseph Glover)

8:30 - 8:50 (519) *The maximal functions of harmonic analysis and their probabilistic counterparts.* TERRY R. MCCONNELL, Syracuse University (831-60-87)

9:00 - 9:20 (520) *Exponential square good-λ inequalities.* Preliminary report. RODRIGO BANUELOS*, University of Illinois, Urbana-Champaign, and CHARLES N. MOORE, Washington University (831-60-233)

9:30 - 9:50 (521) *Weak limits of periodic oblique reflecting Brownian motions.* Preliminary report. P. MARCH*, McGill University, and J. RUBINSTEIN, Stanford University (831-60-451) (Sponsored by J. C. Taylor)

10:00 - 10:20 (522) *Hitting time and hitting place of Riemannian Brownian motion.* Preliminary report. MARK A. PINSKY, Northwestern University (831-60-481)

10:30 - 10:50 (523) *Stochastic flows on a countable set-a stochastic semigroup approach.* Preliminary report. R. W. R. DARLING* and ARUNAVA MUKHERJEA, University of South Florida (831-60-411)

11:00 - 11:20 (524) *A conditional version of the Stroock Varadhan support theorem.* ANDREW CARVERHILL, University of North Carolina, Chapel Hill (831-60-482)

Saturday, January 24, 1987, 8:00 a.m.

AMS Special Session on Theoretical Optimization, III

8:00 - 8:20 (525) *Constrained optimization problems.* Preliminary report. AUBREY B. POORE, Colorado State University (831-49-125) (Sponsored by Lynn McLinden)

8:30 - 8:50 (526) *On the numerical stability of update formulas.* Preliminary report. KURT GEORG*, Colorado State University, and RAINER HETTICH, University of Trier, West Germany (831-65-91) (Sponsored by Lynn McLinden)

9:00 - 9:20 (527) *A volume and constraint reducing algorithm for linear programming.* HENRY WOLKOWICZ*, University of Waterloo, and ADI BEN-ISRAEL, University of Delaware (831-90-206) (Sponsored by Lynn McLindon)

9:30 - 9:50 (528) *How good are global Newton methods?* A. A. GOLDSTEIN, University of Washington (831-65-256) (Sponsored by Jay Treiman)

10:00 - 10:20 (529) *Polynomial-time quadratic programming based on Karmarkar's linear programming approach.* J. E. DENNIS, Rice University, A. M. MORSHEDI, Shell Development, Houston, Texas, and R. A. TAPIA*, Rice University (831-49-397) (Sponsored by Lynn McLinden)

10:30 - 10:50 (530) *Inexact Newton methods for the nonlinar complementarity program.* JONG-SHI PANG, University of Texas, Dallas (831-90-396) (Sponsored by Lynn McLinden)

Saturday, January 24, 1987, 8:00 a.m.

AMS Special Session on Geometric Variational Problems III

8:00 - 8:20 (531) *On stratification of functions of bounded variations and related questions.* PATRICIO AVILES*, University of Illinois, Urbana-Champaign, and YOSHI GIGA, Hokkaido University, Japan and Courant Institute of Mathematical Sciences, New York University (831-49-453)

8:30 - 8:50 (532) *Conformal geometry and complete minimal surfaces.* ROB KUSNER, University of California, Berkeley (831-53-589)

9:00 - 9:20 (533) *Minimal rearrangements of Sobolev functions.* JOHN E. BROTHERS* and WILLIAM P. ZIEMER, Indiana University, Bloomington (831-99-592)

9:30 - 9:50 (534) *Explicit solutions to some surface-energy-minimization problems: Crystals in corners, orientational aspects of crystals on a substrate, and cusps.* JEAN E. TAYLOR, Rutgers University, New Brunswick (831-49-383)

10:00 - 10:20 (535) *Regularity for curvature varifolds.* JOHN HUTCHINSON, Australian National University (831-53-381)

10:30 - 10:50 (536) *Area minimizing integral currents and n-energy minimizing mappings to spheres.* Preliminary report. FREDERICK ALMGREN*, WILLIAM BROWDER and ELLIOTT LIEB, Princeton University (831-49-455)

Saturday, January 24, 1987, 8:00 a.m.

AMS Session on Combinatorics and Graph Theory, II

8:00 - 8:10 (537) *First distribution invariants and E-K-R theorems.* NACHIMUTHU MANICKAM*, DePauw University, and N. M. SINGHI, Ohio State University, Columbus (831-05-210)

8:15 - 8:25 (538) *Values and bounds for Ramsey numbers associated with polynomial iteration.* BRUCE M. LANDMAN* and RAYMOND N. GREENWELL, Hofstra University (831-05-293)

8:30 - 8:40 (539) *Problems arising in the theory of quasigroup characters.* Preliminary report. KENNETH W. JOHNSON, Pennsylvania State University, Ogontz Campus (831-05-200)

8:45 - 8:55 (540) *A monoid structure on graphs with α-valuations.* Preliminary report. HO KUEN NG, San Jose State University (831-05-201)

9:00 - 9:10 (541) *On creating sets with large lower density.* NEIL HINDMAN, Howard University (831-05-98)

9:15 - 9:25 (542) *Clean triangulations.* NORA A. HARTSFIELD* and GERHARD RINGEL, University of California, Santa Cruz (831-05-547)

9:30 - 9:40 (543) *Genus distributions for bouquets of circles.* JONATHAN L. GROSS*, Columbia University, DAVID P. ROBBINS, Institute for Defense Analysis, Princeton, New Jersey, and THOMAS W. TUCKER, Colgate University (831-05-208)

9:45 - 9:55 (544) *Hook and shifted hook numbers.* Preliminary report. R. M. GRASSL* and A. P. MULLHAUPT, University of New Mexico (831-05-204) (Sponsored by Robert M. Fossum)

10:00 - 10:10 (545) *A Galois theory of graph theory and combinatorial problems.* Preliminary report. MAX GARZON, Memphis State University (831-05-424)

10:15 - 10:25 (546) *Labeling Möbius ladders.* JOSEPH A. GALLIAN, University of Minnesota, Duluth (831-05-203)

10:30 - 10:40 (547) *Infinite Hamiltonian paths in Cayley digraphs of hyperbolic symmetry groups.* DOUGLAS DUNHAM, University of Minnesota, Duluth, DOUGLAS JUNGREIS*, Harvard University, and DAVID WITTE, Massachusetts Institute of Technology (831-05-202) (Sponsored by Joseph A. Gallian)

10:45 - 10:55 (548) *On contractible edges.* Preliminary report. NATHANIEL DEAN* and ROBERT L. HEMMINGER, Vanderbilt University, and BJARNI TOFT, Odense Universitet, Denmark (831-05-345)

11:00 - 11:10 (549) *Folding of letter sequences.* JUDITH E. DAYHOFF*, Judith Dayhoff & Associates, Inc., Mountain View, California, and ROBERT ATHERTON, In-Motion Technology, Los Altos, California (831-05-540)

11:15 - 11:25 (550) *On $3-(p^r, 4, \lambda)$ designs admitting the affine group as automorphisms.* Preliminary report. SOMPORN SUTINUNTOPAS and NEAL BRAND*, North Texas State University (831-05-336)

11:30 - 11:40 (551) *On vertex transitive graphs of toughness exactly one.* KUNWARJIT S. BAGGA* and MARC J. LIPMAN, Indiana University-Purdue University, Ft. Wayne (831-05-490) (Sponsored by Raymond E. Pippert)

11:45 - 11:55 (552) *Latin squares, a Kneeser graph, and an Erdos coloring problem.* Preliminary report. JOBY M. ANTHONY, University of Central Florida (831-05-132) (Sponsored by Howard Sherwood)

12:00 - 12:10 (553) *All non-abelian groups of order $n, 10 \leq n \leq 32$ are sequenceable.* BRUCE A. ANDERSON, Arizona State University (831-05-96)

Saturday, January 24, 1987, 8:30 a.m.

AMS Special Session on Orthogonal Polynomials and the Moment Problem, II

8:30 - 8:50 (554) *Methods of solving moment problems.* MOURAD E. H. ISMAIL, Arizona State University (831-33-112)

9:00 - 9:20 (555) *Asymptotics for solutions of smooth recurrence equations.* WILLIAM C. BAULDRY, Purdue University, Calumet Campus, ATTILA MATE*, Brooklyn College, City University of New York, and PAUL NEVAI, Ohio State University, Columbus (831-42-36)

9:30 - 9:50 (556) *Orthogonal polynomial asymptotics from a singular integral equation.* J. NUTTALL, University of Western Ontario (831-45-113) (Sponsored by Paul Nevai)

10:00 - 10:20 (557) *A product formula for the continuous q-Jacobi polynomials.* MIZAN RAHMAN, Carleton University (831-33-170)

10:30 - 10:50 (558) *Distribution of zeros of extremal polynomials.* Preliminary report. EDWARD B. SAFF, University of South Florida (831-41-572)

Saturday, January 24, 1987, 8:30 a.m.

AMS Special Session on Mathematical Physics, I

8:30 - 8:50 (559) *Groups and supergroups in physics.* ARNO BOHM, University of Texas, Austin (831-81-114)

9:00 - 9:20 (560) *Special functions and identities defined by the algebra of $SU3$ tensor operators.* L. C. BIEDENHARN, Duke University (831-33-452)

9:30– 9:50 (561) *Wiener measures and continuous-time regularization of quantum-mechanical path integrals.* JOHN R. KLAUDER, AT&T Bell Laboratories, Murray Hill (831-81-115) (Sponsored by Gregory F. Wene)

10:00–10:20 (562) *On algebras associated with connections.* ROBERT H. OEHMKE, University of Iowa (831-17-385)

10:30–10:50 (563) *Current results concerning supermanifolds.* R. O. WELLS, JR., Rice University (831-17-576)

Saturday, January 24, 1987, 8:30 a.m.

AMS Session on History, Logic and Foundations

8:30– 8:40 (564) *Existentially closed double Stone algebras.* DAVID M. CLARK, State University of New York, College at New Paltz (831-06-497)

8:45– 8:55 (565) *Invertible π-relations.* LESLIE COHN and STEPHEN D. COMER*, The Citadel (831-06-338)

9:00– 9:10 (566) *Charles S. Peirce and the computer.* CAROLYN EISELE, New York, New York (831-01-473)

9:15– 9:25 (567) *Successor groups and ordered fields.* Preliminary report. SHERYL ETTLICH, Gonzaga University (831-06-339)

9:30– 9:40 (568) *Ultrafilters of character ω_1.* KLAAS PIETER HART, Miami University, Oxford (831-03-489)

9:45– 9:55 (569) *When the Boolean order on a commutative ring is a lattice.* M. HENRIKSEN, Harvey Mudd College (831-06-196)

10:00–10:10 (570) *Alternating walks and chain decompositions in partially ordered sets.* DAVID MAGAGNOSC* and KENNETH BOGART, Dartmouth College (831-06-491)

10:15–10:25 (571) *An extension of the closed unbounded filter.* ROBERT MIGNONE, College of Charleston (831-04-429)

10:30–10:40 (572) *Finite orthomodular lattices: A computer program and some results.* Preliminary report. WILLIAM DAVID MILLER, Kansas State University (831-06-220)

10:45–10:55 (573) *A_{null} is full.* JOHN SIMMS, Marquette University (831-03-289)

11:00–11:10 (574) *A representation theorem for a class of Heyting algebras.* Preliminary report. ALEXANDRU SOLIAN, University of North Carolina, Charlotte, and T. M. VISWANATHAN*, Unicamp, Brazil, and University of North Carolina, Charlotte (831-06-272)

11:15–11:25 (575) *Internal set theory with external classes.* NADER VAKIL, University of Washington (831-04-20)

11:30–11:40 (576) *Two notes useful in the teaching of linear algebra and of numerical analysis.* OSVALDO MARRERO, Villanova University (831-98-83)

Saturday, January 24, 1987, 9:00 a.m.

AMS Special Session on Brauer Groups and Galois Theory, III

9:00– 9:20 (577) *On Azumaya algebras arising from Clifford algebras.* Preliminary report. DARRELL HAILE*, Indiana University, Bloomington, and STEVEN TESSER, University of Cincinnati (831-16-177)

9:30– 9:50 (578) *Ostrowski's theorem for valued division algebras.* Preliminary report. PAT MORANDI, University of California at San Diego, La Jolla (831-16-19)

10:00–10:20 (579) *On the norm groups of algebraic number fields.* Preliminary report. LEONID STERN, Towson State University (831-11-116) (Sponsored by Burton Fein)

10:30–10:50 (580) *Jordan norms and simple associative algebras.* NATHAN JACOBSON, Yale University (831-17-37)

Saturday, January 24, 1987, 9:00 a.m.

AMS Session on Number Theory, II

9:00– 9:10 (581) *Sieving the positive integers by large primes.* D. A. GOLDSTON, San Jose State University, and KEVIN S. MCCURLEY*, University of Southern California (831-11-261)

9:15– 9:25 (582) *Class numbers of real quadratic fields.* R. A. MOLLIN, University of Calgary (831-11-50)

9:30– 9:40 (583) *Bernouilli numbers of general index.* C. MUSÈS, Mathematics and Morphology Research Centre, Miramonte, California (831-11-16) (Sponsored by K. Demys)

9:45– 9:55 (584) *Asymptotic behavior of linear recurrences.* Preliminary report. KENJI NAGASAKA, Shinshu University, Japan, and JAU-SHYONG SHIUE*, University of Nevada, Las Vegas (831-11-71)

10:00–10:10 (585) *Some automorphic forms arising in differential geometry.* Preliminary report. PHILLIP E. PARKER, Wichita State University (831-11-565)

10:15–10:25 (586) *The trace formula for Hecke operators for $\Gamma_0(N)$.* Preliminary report. SHEPLEY L. ROSS, II, Bates College (831-11-420) (Sponsored by Richard Sampson)

10:30–10:40 (587) *Splitting groups of prime order.* SHERMAN STEIN, University of California, Davis (831-11-168)

10:45 - 10:55 (588) *A reciprocity law for prime geodesics.* JEFFREY STOPPLE, Mathematical Sciences Research Institute, Berkeley (831-11-531)

11:00 - 11:10 (589) *Theta series attached to lattices of arbitrary rank.* Preliminary report. LYNNE WALLING, Dartmouth College (831-11-435)

11:15 - 11:25 (590) *Analytic continuation of Eisenstein series.* Preliminary report. SHEK-TUNG WONG, University of Illinois, Urbana-Champaign (831-11-286)

Saturday, January 24, 1987, 9:00 a.m.

AMS Session on Ordinary Differential Equations, II

9:00 - 9:10 (591) *Non-negative solutions for a class non-positone problems.* ALFONSO CASTRO, North Texas State University, and R. SHIVAJI*, Mississippi State University (831-34-225)

9:15 - 9:25 (592) *Existence and uniqueness of solutions to a non-linear boundary value problem at resonance.* LEW LEFTON, University of Illinois, Urbana-Champaign (831-34-309)

9:30 - 9:40 (593) *A generalized upper and lower solutions method and multiplicity results for periodic solutions of nonlinear first order ordinary differential equations.* M. N. NKASHAMA, Memphis State University (831-34-534) (Sponsored by J. R. Haddock)

9:45 - 9:55 (594) *An unusual boundary value problem on* $[0, \infty)$. JOHN V. BAXLEY, Wake Forest University (831-34-313)

10:00 - 10:10 (595) *Asymptotic behavior of the solutions of a certain nth order differential equation in the neighborhood of a regular singular point.* T. K. PUTTASWAMY, Ball State University (831-34-340)

10:15 - 10:25 (596) *Oscillatory and periodic solutions of two first order linear differential equations with piecewise constant delays.* Preliminary report. REZA AFTABIZADEH*, Ohio University, Athens, and JOSEPH WIENER, Pan American University (831-34-539)

10:30 - 10:40 (597) *Extremal solutions of the difference equation* $L_n y + p(t)y = 0$. Preliminary report. ALLAN PETERSON, University of Nebraska at Lincoln (831-34-352)

10:45 - 10:55 (598) *Classification of solutions of the difference equation* $Ly(t) + p(t)\ y(t) = 0$. Preliminary report. DARREL HANKERSON, University of Nebraska at Lincoln (830-34-370)

Saturday, January 24, 1987, 9:00 a.m.

MAA Invited Address

9:00 - 9:50 (599) *Wave propagation and characteristics.* PETER D. LAX, Courant Institute of Mathematical Sciences, New York University

Saturday, January 24, 1987, 10:05 a.m.

MAA Invited Address

10:05 - 10:55 (600) *The strong law of small numbers.* RICHARD K. GUY, University of Calgary

Saturday, January 24, 1987, 11:10 a.m.

AMS Invited Address

11:10 - 12:00 (601) *Free groups, trees, and their automorphisms.* MARC CULLER, University of Illinois, Chicago (831-20-521)

Saturday, January 24, 1987, 1:00 p.m.

AMS Colloquium Lectures: Lecture IV

1:00 - 2:00 (602) *Uses of the non-Euclidean wave equation,* IV. PETER D. LAX, Courant Institute of Mathematical Sciences

Saturday, January 24, 1987, 1:00 p.m.

AMS Special Session on Mathematical Physics, II

1:00 - 1:20 (603) *Constrained Hamiltonians, BRS and homological algebra.* JIM STASHEFF, University of North Carolina, Chapel Hill (831-81-386)

1:30 - 1:50 (604) *The singular linearization phenomenon.* MEL S. BERGER, University of Massachusetts, Amherst (831-35-22)

2:00 - 2:20 (605) *Energy of static magnetic field configurations.* NIKOS A. SALINGAROS, University of Texas, San Antonio (831-78-33)

2:30 - 2:50 (606) *Conformal deformation and the heat operator.* THOMAS P. BRANSON*, University of Iowa, and BENT ØRSTED, Massachusetts Institute of Technology (831-53-450)

3:00 - 3:20 (607) *Relativistic hydrodynamics and conformal collineations.* Preliminary report. K. L. DUGGAL, University of Windsor (831-83-07)

Saturday, January 24, 1987, 1:00 p.m.

AMS Special Session on Classical Real Analysis, IV

1:00 - 1:20 (608) *The weighted special atom spaces and its analytic characterization.* GERALDO SOARES DE SOUZA*, Auburn University, Auburn, and STEVEN BLOOM, Siena College (831-42-32)

1:25 - 1:45 (609) *Extreme path derivatives of a function with respect to a nonporous system of paths.* ALIASGHAR ALIKHANI-KOOPAEI, University of Wisconsin, Milwaukee (831-26-180)

1:50 - 2:10 (610) *Infinite Peano derivatives.* MIKLÓS LACZKOVICH, Eötvös Loránd University, Hungary (831-26-474) (Sponsored by Michael J. Evans)

2:15 - 2:35 (611) *Sets of convexity of continuous functions.* Z. BUCZOLICH, Eötvös Loránd University, Hungary (831-26-475) (Sponsored by Paul D. Humke)

2:40 - 3:00 (612) *The Lebesgue Stieltjes integral and the D#-derivation basis.* SANDRA MEINERSHAGEN, Northwest Missouri State University (831-28-99) (Sponsored by James Foran)

3:05 - 3:25 (613) *Category bases.* Preliminary report. Z. PIOTROWSKI, Youngstown State University, and A. SZYMAŃSKI*, Slippery Rock State University (831-26-399)

3:30 - 3:50 (614) *Generalized local Fatou theorem.* B. A. MAIR*, Texas Tech University, S. PHILIPP, University of California, Santa Cruz, and D. SINGMAN, Pennsylvania State University, Delaware County Campus (831-31-11)

3:55 - 4:15 (615) *Descriptive set theory and sets of uniqueness for trigonometric series.* ALEXANDER S. KECHRIS, California Institute of Technology (831-42-143)

Saturday, January 24, 1987, 1:00 p.m.

MAA Minicourse #8: Part B

1:00 - 3:00 *Computer simulation of discrete systems.* ZAVEN A. KARIAN, Denison University

Saturday, January 24, 1987, 1:00 p.m.

MAA Minicourse #9: Part B

1:00 - 3:00 *Recurrence relations.* MARGARET BARRY COZZENS, Northeastern University

Saturday, January 24, 1987, 1:00 p.m.

MAA Minicourse #10: Part B

1:00 - 3:00 *Integrating history into undergraduate mathematics courses.* JUDITH V. GRABINER, Pitzer College

Saturday, January 24, 1987, 1:00 p.m.

MAA Minicourse #11: Part B

1:00 - 3:00 *Teaching mathematical modeling.* FRANK R. GIORDANO, U.S. Military Academy and MAURICE D. WEIR, Naval Postgraduate School

Saturday, January 24, 1987, 1:30 p.m.

AMS Special Session on Geometric Methods in Group Theory, III

1:30 - 1:50 (616) *On infinite cyclic extensions of finitely generated free groups.* JOHN G. RATCLIFFE, Vanderbilt University (831-20-377)

2:00 - 2:20 (617) *Equations over groups and two-complexes.* STEPHEN G. BRICK, University of California, Riverside (831-20-552)

2:30 - 2:50 (618) *Branched covers and permutation groups.* Preliminary report. JOHN HEMPEL, Rice University (831-57-449)

3:00 - 3:20 (619) *Negatively curved groups.* Preliminary report. DARYL COOPER, University of Minnesota, Minneapolis (831-20-374)

3:30 - 3:50 (620) *Combinatorial group theory in the eight 3-dimensional geometries.* J. W. CANNON, Brigham Young University (831-20-373)

4:00 - 4:20 (621) *The kernel of the map from* $\mathrm{Out}(F_n)$ *to* $GL(n, \mathbf{Z})$. Preliminary report. MARC CULLER, Institute for Advanced Study, and KAREN VOGTMANN*, Cornell University (831-20-522)

4:30 - 4:50 (622) *The Tits alternative for one-relator products.* BENJAMIN FINE*, Fairfield University, FRANK LEVIN, Universitat Bochum, Federal Republic of Germany, and GERHARD ROSENBERGER, Universitat Dortmund, Federal Republic of Germany (831-20-476)

5:00 - 5:20 (623) *Growth functions of planar groups-reciprocity.* STEVEN PLOTNICK*, Columbia University, and WILLIAM FLOYD, Virginia Polytechnic Institute and State University (831-20-447) (Sponsored by R. Alperin)

5:30 - 5:50 (624) *Growth functions on planar groups—Euler characteristic.* WILLIAM J. FLOYD*, Virginia Polytechnic Institute and State University, and STEVEN P. PLOTNICK, Columbia University (831-20-523)

Saturday, January 24, 1987, 1:30 p.m.

MAA Session on Remedial Mathematics: Issues and Innovations, Part II

1:30– 1:40 Introductory remarks. GEOFFREY R. AKST, Borough Manhattan Community College

1:40– 1:55 (625) *Classifying remedial students and techniques for addressing their diverse educational needs.* ELIZABETH D. HUGHES, Housatonic Community College

2:00– 2:15 (626) *General studies and service mathematics courses: What background is necessary?* CHARLES E. MITCHELL, Western Carolina University

2:20– 2:35 (627) *Problems from mathematics of finance provide motivation in mathematics for general education.* JAMES R. SMART, San Jose State University

2:40– 2:55 (628) *Successful mathematics remediation and peer-tutors.* GABRIELLA WEPNER, Ramapo College of New Jersey

3:00– 3:15 (629) *Social science applications.* DEBORAH HUGHES HALLETT, Harvard University

3:20– 3:35 (630) *Calculator-based curricular modules for two-year college remedial mathematics courses.* MYRIAM STEINBACK, Macalester College

3:40– 3:55 Discussion period

Saturday, January 24, 1987, 2:00 p.m.

MAA Session on Retaining and Recruiting Undergraduate Women in Mathematics Courses: Aspirations and Experiences

2:00– 2:10 (631) *An anecdote from the 1939 William Lowell Putnam competition.* DONALD M. HILL, Florida A&M University

2:15– 2:30 (632) *Recruiting and retaining math majors in a women's college.* MIRIAM P. COONEY, Saint Mary's College

2:35– 2:50 (633) *Attracting and retaining undergraduate women math majors: A career night approach.* JACQUELINE M. DEWAR, Loyola Marymount University

3:00– 3:10 (634) *Support groups and study groups of college math students.* AMY COHEN and BRENDA LATKA*, Rutgers University, New Brunswick

3:15– 3:30 (635) *How hemispheric lateralization can be used to predict and promote success in college mathematics courses.* CYNTHIA MILLER, Spelman College

3:35– 3:50 (636) *Non-traditional students at a women's college: Preparing older women for mathematics.* VIVIAN KRAINES, Meredith College

4:00– 4:15 (637) *The math lab experience—academic support in an urban community college.* ELISE CARTER HARTMAN, University of Oklahoma

4:20– 4:35 (638) *Preparation, support, and challenge: The keys to recruitment and retention of undergraduate women in mathematics courses.* BARBARA LI SANTI, Mills College

4:35– 5:00 Discussion period

Saturday, January 24, 1987, 3:30 p.m.

MAA Minicourse #11: Part C–Optional

3:30– 5:30 *Teaching mathematical modeling.* FRANK R. GIORDANO, U.S. Military Academy and MAURICE D. WEIR, Naval Postgraduate School

Saturday, January 24, 1987, 3:30 p.m.

MAA Minicourse #12: Part B

3:30– 5:30 *True BASIC in freshman calculus.* JAMES F. HURLEY, University of Connecticut

Saturday, January 24, 1987, 3:30 p.m.

MAA Minicourse #13: Part B

3:30– 5:30 *For all practical purposes.* SOLOMON A. GARFUNKEL, COMAP, Inc.

Saturday, January 24, 1987, 3:30 p.m.

MAA Minicourse #14: Part B

3:30– 5:30 *Applications of discrete mathematics.* FRED STEPHEN ROBERTS, Rutgers University

Saturday, January 24, 1987, 3:30 p.m.

MAA Minicourse #15: Part B

3:30 – 5:30 *Constructing placement examinations.* JOHN W. KENELLY, Clemson University

Urbana, Illinois

Robert M. Fossum
AMS Associate Secretary

Eugene, Oregon

Kenneth A. Ross
MAA Secretary

Presenters of Papers

Numbers following the names indicate the speakers' positions on the program.
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Distributions of Values of Holomorphic Mappings

(Translations of Mathematical Monographs, Volume 61)

B. V. Shabat

A vast literature has grown up around the value distribution theory of meromorphic functions, synthesized by Rolf Nevanlinna in the 1920s and singled out by Hermann Weyl as one of the greatest mathematical achievements of this century. The multidimensional aspect, involving the distribution of inverse images of analytic sets under holomorphic mappings of complex manifolds, has been much less fully treated in the literature. This volume thus provides a valuable introduction to multivariate value distribution theory and a survey of some of its results, rich in relations to both algebraic and differential geometry and surely one of the most important branches of the modern geometric theory of functions of a complex variable.

Shabat presumes only the reader's familiarity with the elements of multidimensional complex analysis. A knowledge of the classical theory of value distribution is not required, since the book begins with preparatory material from the contemporary geometric theory of functions. After proving the two main theorems of value distribution theory, the author goes on to investigate further the theory of holomorphic curves and to provide generalizations and applications of the main theorems, focusing chiefly on the work of Soviet mathematicians.

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MATHEMATICAL REVIEWS

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The *Mathematical Reviews* Editorial Committee invites applications and recommendations for two-year appointments as Associate Editor of **MR**, to commence as soon as possible, but no later than the summer of 1987. Applications will be welcomed from persons taking leave from other positions, and in particular from tenured faculty members who could take leave to come to **MR** for two years.

The **MR** office is located in Ann Arbor, Michigan, adjacent to the campus of the University of Michigan, and the editors enjoy many faculty privileges at the university. At present, **MR** employs eleven editors, about a dozen consultants, and over fifty noneditorial personnel. It produces *Mathematical Reviews* and *Current Mathematical Publications* and various indexes, as well as the online service *Math\Sci*. The responsibilities of Associate Editors fall primarily in the day-to-day operations of classifying articles and books, assigning these items to reviewers, and editing the reviews when they are returned. Other responsibilities evolve in accordance with the individual's experience and capabilities. At this time, no particular area of mathematical specialization is sought, although strength in applied areas is desirable. Considerable breadth in mathematics, rather than special skill, is sought. A reading knowledge of two main foreign languages is important, but not essential. (Russian and Chinese are especially desirable.)

Those interested in combining a sabbatical or other leave with a part-time or full-time appointment as an Associate Editor should write for further details. The twelve-month salary is negotiable, and will be commensurate with the experience applicants bring to the position. Retirement, insurance plans, and other fringe benefits are similar to those in universities. Of special importance is a policy providing a study leave after at least two years. This amounts to three months of full pay for each two years spent as Editor.

Applications (including curriculum vitae, bibliography, data on experience, and names and addresses of three references) and recommendations should be sent to Dr. R. G. Bartle, Executive Editor, *Mathematical Reviews*, P. O. Box 8604, Ann Arbor, MI 48107. Telephone 313-996-5250. Those interested in applying for this position are urged to inquire immediately.

Mathematical Reviews is an equal opportunity employer.

Honolulu, March 26–28, 1987, University of Hawaii at Manoa

Second Announcement of the 832nd Meeting

The eight hundred and thirty-second meeting of the American Mathematical Society will be held at the University of Hawaii in Honolulu, Hawaii, on Thursday, Friday, and Saturday, March 26–28, 1987. This meeting will be held in conjunction with the Northern California section of the Mathematical Association of America.

The sessions will be held in Keller Hall, 3rd and 4th floors. The invited addresses will be delivered in the auditorium of the Physical Science Building which is connected to Keller Hall by overpasses. Keller Hall is across The Mall from the Hamilton Library.

Invited Addresses

By invitation of the Committee to Select Hour Speakers for Far Western Sectional Meetings, there will be two invited one-hour addresses. The speakers are:

EDWARD A. BERTRAM, University of Hawaii at Manoa.

MARTIN SCHARLEMANN, University of California, Santa Barbara.

The titles of their talks are not yet available.

Special Sessions

By invitation of the same committee, there will be seven special sessions of selected twenty-minute papers. The topics of these special sessions, the names and affiliations of the organizers, and partial lists of speakers are as follows:

Algebraic topology, CHRISTOPHER J. ALLDAY and HEINER DOVERMANN, University of Hawaii at Manoa. The tentative speakers include B. Cenkl, E. C. Cho, R. Cohen, J. Davis, W. Y. Hsiang, S. Kwasik, R. Lee, M. Masuda, J. Oprea, T. Petrie, M. Rothenberg, and S. Waner.

Low-dimensional topology, STEVEN BLEILER, University of British Columbia. The tentative list of speakers includes Mladen Bestvina, Charles Frohman, Cameron Gordon, M. Hilden, Jim Hoste, A. Kanwuchi, Darren Long, Yoav Moriah, Y. Nakanichi, Josef Przxytycki, Dale Rolfson, and Jonathan Simon.

Complex function theory, GEORGE CSORDAS, WAYNE SMITH, and DAVID STEGENGA, University of Hawaii at Manoa. The tentative speakers are Patrick Ahern, Sheldon Axler, David Drasin, Albert Edrei, Jose Fernandez, Frederick Gehring, Simon Hellerstein, Aimo Hinkannen, Keiji Izuchi, Boris Korenblum, Frank D. Lesley, Donald E. Marshall, Joseph Miles, John Rossi, Donald Sarason, Walter Schneider, Joel Shapiro, Daniel Shea, Kenneth Stephenson, and Richard S. Varga.

Rings and modules, KENT R. FULLER, University of Iowa. The tentative list of speakers includes G. Azumaya, D. Burkholder, J. Dauns, V. Dlab, J. Fisher, K. Goodearl, R. Gordon, E. Green, Y. Iwanaga, T. Lenagan, K. Masaike, B. Muller, W. K. Nicholson, J. Osterburg, M. Teply, and B. Zimmerman.

Combinatorics, JERROLD GRIGGS, University of South Carolina, Columbia. The tentative speakers include Brian Olspach, Fan Chung, Ronald L. Graham, Kathy Heinrich, and William T. Trotter.

Set theory and its applications, THOMAS JECH, Pennsylvania State University. The tentative list of speakers includes J. E. Baumgartner, Andreas R. Blass, Qi Feng, Matthew Foreman, Marcia J. Groszek, Yuzuru Kakuda, Aki Kanamori, Alexander S. Kechris, Richard Laver, Menachem Magidor, Donald A. Martin, William J. Mitchell, Masanao Ozawa, Karel Prikry, Robert Solovay, John Steel, and W. Hugh Woodin.

Differential geometry, PETER LI, University of Utah, RICHARD M. SCHOEN, University of California, Berkeley, and S.-T. YAU, University of California, San Diego. The tentative speakers are Robert Bryant, Shiu-Yuen Cheng, Doris Fischer-Colbrie, Richard Hamilton, Mario Micallef, Leslie Saper, Bruce Solomon, Brian White, Paul Yang, and Steven Yau.

Most of the papers to be presented at these special sessions will be by invitation. However, anyone submitting an abstract for the meeting who feels that his or her paper would be particularly appropriate for one of these special sessions should indicate this clearly on the abstract form and submit it by **January 12, 1987**, three weeks before the deadline for contributed papers, in order that it may be considered for inclusion. Participants are reminded that a charge of $16 is imposed for retyping abstracts that are not in camera-ready form.

Contributed Papers

There will also be sessions for contributed ten-minute papers. Abstracts should be prepared on the standard AMS form available from the AMS office in Providence or in Departments of Mathematics. Abstracts should be sent to the Editorial Department, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940, so as to arrive before the **February 2, 1987**, abstract deadline. Participants are reminded that a charge of $16 is imposed for retyping abstracts that are not in camera-ready form. Late papers will not be accommodated.

MAA Program

The MAA program will take place mostly on Saturday and will include the following invited

speakers. VICTOR L. KLEE, JR., University of Washington, will deliver a lecture titled *The even cycle mystery and its relatives.* At a noon luncheon IVAN NIVEN of the University of Oregon will deliver an address titled *The way things were.* HENRY O. POLLAK, Bell Communications Research (retired) will speak on *The loop-switching addressing problem, or how to embed an arbitrary graph in a squashed cube.* All three of the speakers are past presidents of the MAA.

Registration

The meeting registration desk will be located on the fourth floor of Keller Hall and will be open from 9:00 a.m. to 11:00 a.m. and 1:00 p.m. to 3:00 p.m. on Thursday and Friday, and from 9:00 a.m. to 11:00 a.m. on Saturday. The registration fees are $10 for members of the AMS or MAA, $16 for nonmembers, and $5 for students or unemployed mathematicians.

Petition Table

A petition table will be set up in the registration area. Additional information can be found in a box on page 812 in the San Antonio meeting announcement in the October issue of *Notices.*

Accommodations

A block of rooms is being held for meeting participants in the Hale Manoa and Hale Kuahine residence halls at the East-West Center on the campus. Participants should make reservations by writing to Dr. Adolph Mader, Department of Mathematics, 2565 The Mall, University of Hawaii at Manoa, Honolulu, Hawaii 96822. The rates are $14 for single occupancy, $17 for single occupant in a double room, and $19 per person for double occupancy. A deposit is not required, but the one-night rate for a room reserved will be charged if the reservation is not cancelled at least 72 hours prior to anticipated check-in.

Lincoln Hall, also at the East-West Center, has hotel-like rooms with rates ranging from $22 to $37 per night; however it is uncertain whether these rooms will be available since priority is given to visitors at the East-West Center.

NOTE: Childen cannot be accommodated in sleeping rooms at the East-West Center residence halls.

A block of rooms is also being held at the following hotel at Waikiki. Participants should make their reservations as early as possible, and be sure to mention participation in the AMS-MAA meeting at the University of Hawaii. Rates are subject to change by 1987, and do not include the 4.17 percent state sales tax and 5.25 percent hotel room tax. A credit card number or check as a deposit to cover the room rate for one night must be provided when making reservations. The deposit will be refunded if necessary, provided that cancellation is received a minimum of 72 hours prior to anticipated check-in.

Waikiki Plaza Hotel
2045 Kalakaua Avenue, Honolulu 96815
Telephone: 800-367-8047, extension 101, or 808-955-6363
Single $44 Double $44
Triple $54 Quadruple $64

Although rooms have **not** been blocked at the following locations, they are included here for information purposes. Again, rates do not include applicable taxes and are subject to change. Unless indicated otherwise, the rate indicated for single occupancy is generally the same when room is occupied by two persons.

Ala Wai Terrace Hotel
1547 Ala Wai Boulevard, Honolulu 96815
Telephone: 800-367-5170 (U.S.), 800-826-6786 (Canada), or 808-926-0679
Single $28 to $47
The Ala Wai Terrace also has special weekly and 30-day rates, and all rooms have kitchen facilities equipped with pots, pans, and linens.

Hilton Hawaiian Village
2005 Kalia Road, Honolulu 96815
Telephone: 800-HILTONS or 808-949-4321
Single $80 to $140

Holiday Inn-Waikiki Beach
2570 Kalakaua Avenue, Honolulu 96815
Telephone: 800-HOLIDAY or 808-922-2511
Single $68 to $78, $85, $98

Hyatt Regency Waikiki
2424 Kalakaua Avenue, Honolulu 96815
Telephone: 800-228-9000 or 808-922-9292
Single $90 to $190

Island Colony Hotel
445 Seaside Avenue, Honolulu 96815
Telephone: 800-367-5124 or 808-923-2345
Single $55 to $85 (Studios)

New Otani Kaimana Beach Hotel
2863 Kalakaua Avenue, Honolulu 96815
Telephone: 800-421-8795 or 808-923-1555
Single $56 to $125 Double $62 to $125
The New Otani is at the outer end of Waikiki and on the beach.

Quality Inn Waikiki
175 Paoakalani Avenue, Honolulu 96815
Telephone: 800-367-2317
Single $39 to $52 Double $42, $55

Reef Hotel
2169 Kalia Road, Honolulu 96815
Telephone: 800-367-5170 or 808-923-3111
Single $45 to $85

Food Service

The Campus Center Cafeteria is scheduled to be open Monday through Friday from 7:00 a.m. to 1:30 p.m. during the meeting. In addition, a variety of restaurants are located on University Avenue, Beretania, and King Streets, within easy walking distance (10 to 15 minutes). A list of restaurants with street map attached will be available at the meeting registration desk. In

addition to the usual fast food places, there are a variety of Chinese, Hawaiian, Korean, Mexican, and Japanese restaurants.

Travel

Honolulu is located on the island of Oahu, two time zones west of the Pacific Time Zone states. It is served by most major airlines, and there are many flights daily. Flying time from the west coast of the U.S. mainland to Honolulu is approximately four and one-half hours. Because this is a vacation resort area and March is still the high season, participants are advised to make hotel, airline, and car rental reservations as early as possible.

The University of Hawaii at Manoa is situated east of Honolulu, near Waikiki Beach. The bus system in Honolulu is quite good. To go from Waikiki to the University, take bus #4 Nuuanu-Dowsett and for the reverse trip take bus #4 University-Waikiki; the bus stops are located on University Avenue. The buses run every 15 minutes and require 60 cents in exact change each way.

Participants driving to the campus from Waikiki are advised to proceed northwest on Ala Wai Boulevard and take the first right onto McCully Street; take the first right turn off McCully onto Kapiolani Boulevard, then turn left onto University Avenue (the first street which **crosses** Kapiolani). Proceed north to Dole Street and turn right; continue on Dole Street to East-West Road and turn left. Visitor parking is at the lot between the Kennedy Theater of the East-West Center and the Keller Hall/Physical Sciences Building. The parking fee is 50 cents per hour.

Persons driving to the campus via the Lunalilo Freeway should take the University Avenue exit, proceed north on University Avenue, and then follow the instructions in the preceding paragraph.

Weather

The weather at this time of the year should be warm and sunny, with occasional showers in the morning and near the mountains. The average high for March is 81.5° F, and the average low is 67.5° F; the record high is 88° F and record low is 55° F. Only light, informal clothing is required.

Hugo Rossi
Salt Lake City, Utah — Associate Secretary

Some Mathematical Questions in Biology: Neurobiology

Robert M. Miura, Editor

This volume contains lectures presented at the 15th annual meeting on mathematical biology, organized by a joint AMS-SIAM committee, as part of the mathematical activities at the annual AAAS meeting, held January 7, 1982, in Washington, D.C. The meeting was devoted to neurobiology, and was very ably organized by Robert M. Miura. Neurobiology is a very large field, and there are many applications of mathematics that could have been selected. Miura and the committee wisely chose to concentrate on one or two topics concerned mainly with the properties of individual neurons and their processes.

In summary, this is an excellent collection of articles on some of the more interesting and timely problems of cellular neurobiology. The articles, especially those by Plant, Rinzel, and Nicholson and Phillips, are all excellent expositions of important problems. I recommend this volume to anyone interested in mathematical neurobiology.

– *Jack Cowan*
University of Chicago

Charles F. Stevens, *Quantitative specification of neuron form*
John Rinzel, *Neuronal plasticity (learning)*
Richard E. Plant, *The analysis of models for excitable membranes: An introduction*
Alwyn C. Scott, *Nerve pulse interactions*
John A. Connor and **Georgia Nikolakopoulou**, *Calcium diffusion and buffering in nerve cytoplasm*
Charles Nicholson and **Joseph M. Phillips**, *Diffusion in the brain cell microenvironment*

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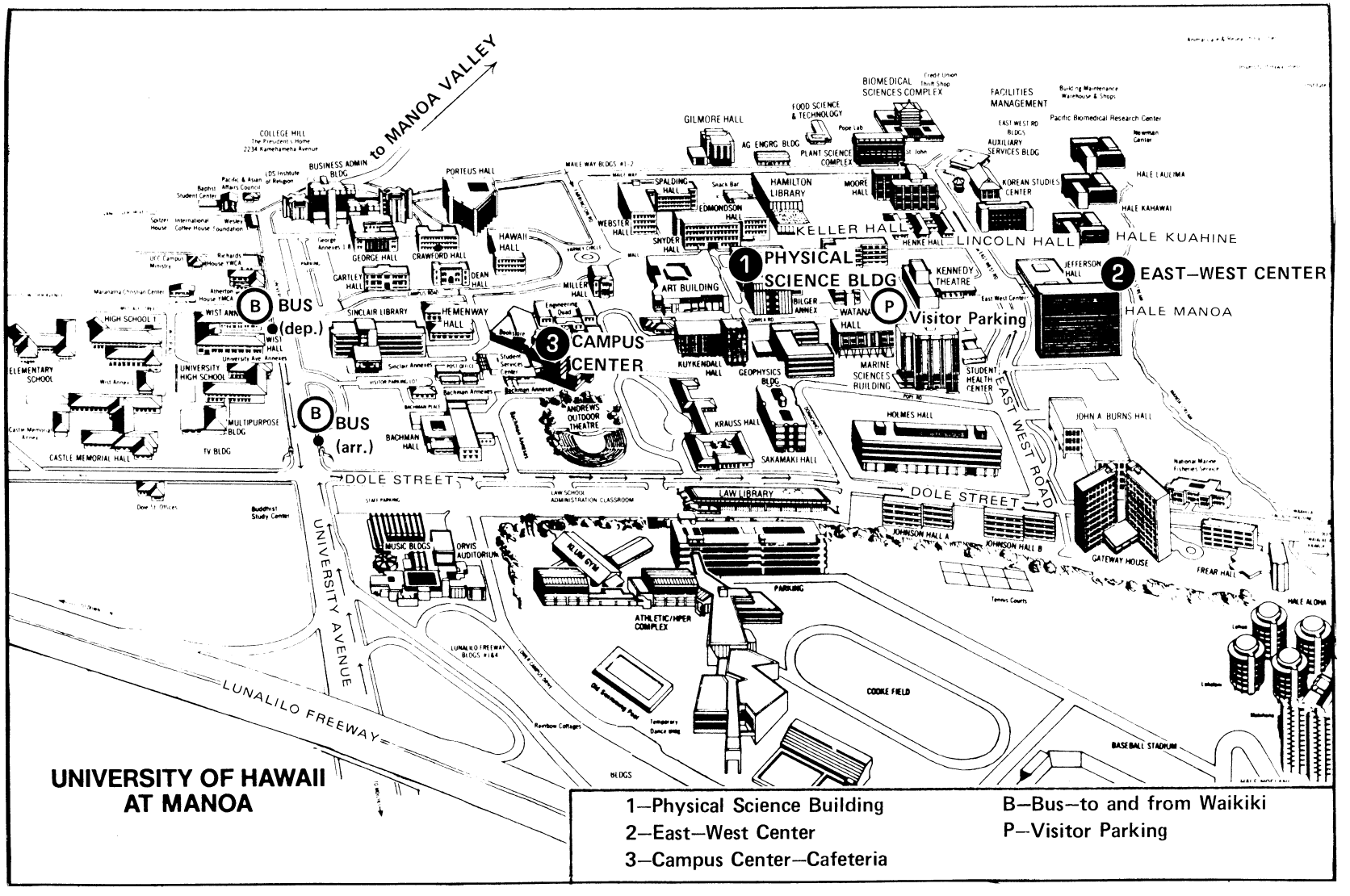
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2–East–West Center
3–Campus Center–Cafeteria
B–Bus–to and from Waikiki
P–Visitor Parking

Kent, April 3–4, Kent State University

Second Announcement of the 833rd Meeting

The eight hundred and thirty-third meeting of the American Mathematical Society will be held at Kent State University in Kent, Ohio, on Friday and Saturday, April 3–4, 1987.

Invited Addresses

By invitation of the Committee to Select Hour Speakers for Central Sectional Meetings, there will be four invited one-hour addresses. The speakers are as follows:

WILLIAM G. DWYER, University of Notre Dame, *Solving classification problems in algebraic topology.*

PETER LOEB, University of Illinois, Urbana-Champaign, *Standard Brownian motion is non-standard coin tossing.*

RIDGWAY SCOTT, University of Michigan, Ann Arbor, title to be announced.

LUCIEN SZPIRO, École Normale Supérieure and Mathematical Sciences Research Institute, Berkeley, title to be announced.

Special Sessions

By invitation of the same committee, there will be ten special sessions of selected twenty-minute papers. The topics of the sessions, the names and affiliations of the organizers, and partial lists of speakers are as follows:

Algebraic combinatorics: Association schemes and related topics, EIICHI BANNAI, Ohio State University and PAUL TERWILLIGER, University of Wisconsin, Madison. The tentative speakers are Richard A. Askey, Eiichi Bannai, Laura M. Chihara, Jonathan Hall, Tatsuro Ito, Robert Mena, Navin M. Singhi, Neal J. A. Sloane, Jonathan D. H. Smith, Stephen D. Smith, Sung-Yell Song, Dennis W. Stanton, Paul M. Terwilliger, and Richard M. Weiss.

Summability theory, JOHN A. FRIDY, Kent State University. The tentative speakers are G. Bennett, D. Borwein, P. Cass, J. Connor, J. DeFranza, D. Flemming, G. Fricke, T. Keagy, M. Parameswaran, D. Russell, and A. Snyder.

Characters of finite groups, STEPHEN M. GAGOLA, JR., Kent State University, and DAVID C. BUCHTAL, University of Akron. The tentative speakers include Pamela Ferguson, Marty Isaacs, Eliot Jacobson, Olaf Manz, Alan Parks, Alexandra Turull, Wolfgang Willems, and Tom Wolf.

Noncommutative ring theory, TIMOTHY J. HODGES and JAMES OSTERBURG, University of Cincinnati. The tentative list of speakers includes J. Bergen, V. Camillo, E. Green, L. Levy, A. Lichtman, L. Makar-Limanov, I. Musson, D. Passman, and D. Quinn.

Boundaries in potential theory, PETER A. LOEB, University of Illinois, Urbana-Champaign. The tentative speakers are A. Ancona, O. Blasco, J. Bleidtner, P. A. Loeb, and J. C. Taylor.

Cyclic homology and applications, HARRY MOSCOVICI, Ohio State University, and DAN BURGHELEA, IHES, France. The list of tentative speakers includes Paul Baum, J.-L. Brylinski, Gunnar Carlsson, Ralph Cohen, Ronald Douglas, Z. Fiedorowicz, David Fried, Ezra Getzler, P. Hanlon, Wu-Chung Hsiang, Steven Hurder, J. Kaminker, Ib Madsen, Andres Nicas, C. Ogle, C. Schochet, Ross Staffeldt, Robert Thomason, Dan Voiculescu, A. Wasserman, and C. Weibel.

Symbolic and algebraic manipulation, MICHAEL ROTHSTEIN, Kent State University. The tentative speakers include Bob Caviness, Guy Cherry, Richard Jenks, Michael Rothstein, David Stoutemeyer, and Paul Wand.

Scientific computation, RIDGWAY SCOTT, University of Minnesota, Minneapolis, and Univeristy of Michigan, Ann Arbor.

Geometry of Banach spaces and harmonic analysis, ANDREW M. TONGE and JOE DIESTEL, Kent State University. The tentative list of speakers includes Dale Alspach, R. Coifman, S. Drury, G. Edgar, P. Enflo, R. Gundy, P. Jones, N. Kalton, A. Pelczynski, H. Rosenthal, A. Shields, G. Weiss, W. Woyczynski, and R. Young.

Unstable homotopy theory, CLARENCE WILKERSON, Wayne State University.

Most of the papers to be presented at these special sessions will be by invitation. However, anyone submitting an abstract for the meeting who feels that his or her paper would be particularly appropriate for one of these special sessions should indicate this clearly on the abstract form and submit it by **January 14, 1987**, three weeks before the deadline for contributed papers, in order that it may be considered for inclusion. Participants are reminded that a charge of $16 is imposed for retyping abstracts that are not in camera-ready form.

Contributed Papers

There will also be sessions for contributed ten-minute papers. Abstracts should be prepared on the standard AMS form available from the AMS office in Providence or in Departments of Mathematics. Abstracts should be sent to the Editorial Department, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940, so as to arrive before the **February 4, 1987**, abstract deadline. Participants are reminded that a charge of $16 is imposed for retyping abstracts that are not in camera-ready form. It appears unlikely that late papers can be accommodated.

Registration

The meeting registration desk will be located in the third floor lounge of the KSU Student Center. The desk will be open from 8:30 a.m. to 4:30 p.m. on Friday, and from 8:30 a.m. to noon on Saturday. The registration fees are $30 for members of the AMS, $45 for nonmembers, and $10 for students or unemployed mathematicians.

Petition Table

A petition table will be set up in the registration area. Additional information can be found in a box on page 812 in the San Antonio meeting announcement in the October issue of *Notices*.

Accommodations

Blocks of rooms are being held at the following locations, all of which are within 4.5 miles from the campus. Participants should make their own arrangements directly with the hotel of their choice and be sure to mention the AMS meeting at Kent State University in order to obtain the special rates indicated. Note that rates do not include applicable taxes, and that the deadline for reservations is **March 7, 1987**.

University Inn (.5 mile)
540 South Water Street, Kent 44240
Telephone: 216-678-0123
Single $26 Double $30

Kent Motor Inn (.5 mile)
303 E. Main Street, Kent 44240
Telephone: 216-673-3411
$32 (1 to 4 persons)

Friendship Inn Eastwood (2 miles)
2296 State Road #59, Kent 44240
Telephone: 216-678-1111
Single $26 Double $28

Holiday Inn Akron - Kent (4.5 miles)
4363 State Route #43, Kent 44240
Telephone: 216-678-0101
Single $40 Double $40

Food Service

The cafeteria in the Student Center will be open from 7:00 a.m. to 6:30 p.m. on Friday, and from 7:00 a.m. to 1:30 p.m. on Saturday. More formal dining is available at the Schwebel Garden Room on the third floor of the Student Center. In addition, many fast food restaurants are located within a block of the campus.

Travel

Most major airlines serve Cleveland's Hopkins International Airport, from which Airport Limousine Service transports passengers directly to Kent. The fare is $11 per person, and departures are scheduled at 9:00 a.m., noon, and 5:30 p.m. daily. A special AMS limousine will be provided on Thursday night only, departing the airport terminal at 7:30 and 9:30 p.m. The limo desk is located inside the terminal near exit 6 and the baggage claim area.

Kent is located along Ohio Route 59, approximately 10 miles east of Akron, 35 miles southeast of Cleveland, and 100 miles northwest of Pittsburgh, Pennsylvania. By car it can be reached via the Ohio Turnpike to the north or from I-76 to the south. Drivers approaching from the Ohio turnpike should take exit 13 to Routes 14 and 43 south, and those from I-76 should take Route 43 north.

Parking

An all-day fee of $2 will be charged for parking on Friday in the lot adjacent to the Student Center. Stickers can be obtained at the meeting registration desk. There is no charge for parking on Saturday.

Robert M. Fossum
Urbana, Illinois Associate Secretary

CBMS REGIONAL CONFERENCE SERIES, NUMBER 49

Homology and Dynamical Systems

John M. Franks

This book is an exposition of a number of results dealing with the connections between algebraic topology and dynamical systems. For the most part proofs are included; where they are omitted a reference is given. The topics covered include: Morse gradients, symbolic dynamics and subshifts of finite type, Smale and Morse-Smale diffeomorphisms and flows, and the zeta function and homology zeta function of a diffeomorphism.

The book is intended for graduate students or researchers interested in the relationship between topology and dynamical systems. It is especially appropriate for persons with a background in topology who want to learn about dynamical systems. This book would be appropriate for a graduate level course. Except for an assumed background in algebraic topology the material is largely self-contained.

There are numerous books on algebraic topology and many on dynamical systems. This is the only book devoted to the inter-relationships of these two fields.

1980 *Mathematics Subject Classifications*: 58; 57
ISBN 0-8218-1700-0, LC 82-8897
127 pages (softcover), 1982
All individuals $10, List price $16
To order, please specify CBMS/49NA

Shipping/Handling: 1st book $2, each add'l $1, max. $25; by air, 1st book $5, each add'l $3, max. $100
Prepayment is required. Order from American Mathematical Society, P.O. Box 1571, Annex Station, Providence, RI 02901-9930, or call toll free 800-556-7774 to charge with Visa or MasterCard.

Newark, April 25 – 26, New Jersey Institute of Technology

Second Announcement of the 834th Meeting

The eight hundred and thirty-fourth meeting of the American Mathematical Society will be held at New Jersey Institute of Technology in Newark, New Jersey, on Saturday and Sunday, April 25 – 26, 1987.

Invited Addresses

By invitation of the Committee to Select Hour Speakers for Eastern Sectional Meetings, there will be four invited one-hour addresses. The speakers, the titles of their talks, and the scheduled times of presentation are:

ROBERT V. KOHN, New York University, Courant Institute of Mathematical Sciences, *Determining conductivity by boundary measurements*, 1:30 p.m. Sunday.

RODOLFO R. ROSALES, Massachusetts Institute of Technology, title to be announced, 11:15 a.m. Saturday.

BIRGIT SPEH, Cornell University. *Representation theory and the cohomology of locally symmetric spaces*, 1:30 p.m. Saturday.

LARS B. WAHLBIN, Cornell University, *Local behavior in finite element methods: An overview*, 11:00 a.m. Sunday.

These four invited lectures will be presented in the Theater on the NJIT campus.

Special Sessions

By invitation of the same committee, there will be nine special sessions of selected twenty-minute papers. The topics of these sessions, the names and affiliations of the organizers, and partial lists of speakers are as follows:

Inverse problems, DALJIT SINGH AHLUWALIA, New Jersey Institute of Technology, and ROBERT V. KOHN. The tentative speakers include Richard W. Beals, Robert Burridge, Margaret Cheney, Percy Deift, Peter Doyle, David Isaacson, Bruce Lowe, David Stickler, John Sylvester, William Symes, and Alejandro Uribe.

Computational mathematics and applications, ROMAN ANDRUSHKIW and ROY PLASTOCK, New Jersey Institute of Technology. The tentative list of speakers includes E. Allgower, R. S. Falk, M. Harir, B. Horn, R. Jenks, K. Perlin, T. Poggio, L. B. Rall, W. C. Rheinboldt, J. T. Schwartz, G. W. Strang, R. Vichnevetsky, and L. B. Wahlbin.

Nonlinear dynamics and chaos, DENIS BLACKMORE, New Jersey Institute of Technology. The tentative speakers include Melvyn S. Berger, Denis Blackmore, Paul Blanchard, Fern Hunt, Robert M. May, John Mallet-Paret, Jane Cronin Scanlon, Hugh Bruce Stewart, Son Tu, and James A. Yorke.

Cellular automata and symbolic dynamics, ROBERT H. GILMAN, Stevens Institute of Technology. The tentative speakers include Roy Adler, Mike Boyle, Bruce Kitchens, Douglas Lind, and John Smillie.

Differential geometry, VLADISLAV V. GOLDBERG, New Jersey Institute of Technology. The tentative list of speakers includes Thomas F. Banchoff, Robert L. Bryant, Robert B. Gardner, Hillel Gauchman, Herman Gluck, Shmuel I. Goldberg, Vladislav V. Goldberg, Alfred Gray, Theodore Shifrin, Gabor Toth, Jaak Vilms, and Wolfgang Ziller.

Harmonic analysis on reductive p-adic Lie groups, C. DAVID KEYS, Rutgers University, Newark.

Unitary representations, cohomology and G/Γ, ANTHONY W. KNAPP, SUNY at Stony Brook and Cornell University.

Nonlinear functional analysis, PETRONIJE MILOJEVIĆ, New Jersey Institute of Technology. The tentative list of speakers includes Patrick M. Fitzpatrick, Helmut Hofer, Patrick J. McKenna, Raymond Michalek, P. S. Milojevic, Roger D. Nussbaum, and W. V. Petryshyn.

Group actions on manifolds, JOHN D. RANDALL and MARK STEINBERGER, Rutgers University, Newark. The tentative speakers include William Browder, Sylvain Cappell, Mike Davis, Ian Hamilton, Peter Kahn, Ronnie Lee, Frank S. Quinn, Jr., John D. Randall, Mel Rothenberg, Reinhard Schultz, Mark Steinberger, Shmuel Weinberger, and James West.

Most of the papers to be presented at these special sessions will be by invitation. However, anyone submitting an abstract for the meeting who feels that his or her paper would be particularly appropriate for one of these special sessions should indicate this clearly on the abstract form and submit it by **January 16, 1987**, three weeks before the deadline for contributed papers, in order that it may be considered for inclusion. Participants are reminded that a charge of $16 is imposed for retyping abstracts that are not in camera-ready form.

Contributed Papers

There will also be sessions for contributed ten-minute papers. Abstracts should be prepared on the standard AMS form available from the AMS office in Providence or in Departments of Mathematics. Abstracts should be sent to the Editorial Department, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940, so as to arrive before the **February 2, 1987**, abstract deadline. Participants are reminded that a charge of $16 is imposed for

retyping abstracts that are not in camera-ready form. It is unlikely that late papers can be accommodated.

Computer Mathematics Exhibit

By invitation of the Center for Nonlinear Science and Mathematical Computation of NJIT, several leading computer vendors will display their latest mathematics (graphics) hardware and software in the Ballroom of The Center at NJIT during and after the Saturday dinner (see below). Mathematicians interested in participating as exhibitors should contact Denis Blackmore at the NJIT Department of Mathematics; the telephone number is 201-596-3492.

Registration

The meeting registration desk will be located in the Lobby of The Center. The desk will be open from 8:15 a.m. to 3:00 p.m. on Saturday, and from 8:15 a.m. to 11:00 a.m. on Sunday. The registration fees are $30 for members of the AMS, $45 for nonmembers, and $10 for students or unemployed mathematicians.

Social Event

A buffet dinner featuring Spanish and Portugese cuisine will take place from 5:30 p.m. to 7:00 p.m. on Saturday, April 25, in the Ballroom at The Center. The price for the dinner, including wine, is $15 and must be paid at the meeting registration desk prior to 3:00 p.m. on Saturday; tickets will **not** be available after that time. Reservations are necessary and may be obtained by calling or writing to Denis Blackmore at the Department of Mathematics; the telephone number is 201-596-3492.

Petition Table

A petition table will be set up in the registration area. Additional information can be found in a box on page 812 in the San Antonio meeting announcement in the October issue of *Notices*.

Accommodations

Rooms have been blocked at the Hilton Gateway Hotel in downtown Newark, which is about 3/5 mile from campus. Participants should make their own reservations directly with the hotel, identifying themselves as attending the American Mathematical Society's meeting at NJIT. The cutoff date for reservations is April 10, 1987.

Hilton Gateway Hotel
Gateway Center
Raymond Boulevard
Newark, NJ 07102
Telephone: 201-622-5000
Single $62 Double $62

A number of additional motels which are located three to five miles from the campus will be listed in the next announcement.

Food Service

The Center cafeteria will be open from 8:30 a.m. to 4:30 p.m. on Saturday, and from 11:00 a.m. to 5:00 p.m. on Sunday.

Several fine Spanish and Portuguese restaurants are located in the Ironbound district of Newark, within easy walking distance of the Hilton Gateway Hotel. A list of restaurants will be available at the meeting registration desk.

Travel

Newark International Airport, which is about five miles from the NJIT campus, is served by most major airlines. Several car rental agencies have counters at the airport terminal. The taxi fare from the airport to downtown Newark is approximately $10 to $12. An inexpensive ($2.50) minibus, Newark Airlink, provides service on the half hour to Newark's Pennsylvania Station which is across the street from the Hilton Gateway Hotel. Most hotels and motels provide complimentary limousine service to their guests, which can be summoned by using the courtesy phones at the airport terminal.

Regularly scheduled limousine service between the airport and downtown Newark is available through Newark Airport Limousine and Car Service. The current one-way fare is a flat rate of $15 for one to four persons per car. Reservations should be made a day in advance by calling 201-242-5012.

Newark is also served by AMTRAK trains and Greyhound Bus Lines, with both arriving at and departing from Newark's Pennsylvania Station.

Participants staying at the Hilton Gateway Hotel who do not wish to walk to the NJIT campus can cross the street to Pennsylvania Station and take the subway train to the Warren Street station, which is adjacent to the campus. The current one-way fare is 30 cents.

Persons arriving by car may reach New Jersey Institute of Technology via the Garden State Parkway and the New Jersey Turnpike from north and south; via Interstate Route 280 from east and west; and via Route 21 north from Newark International Airport.

From the Garden State Parkway: Take Exit 145 to Route 280 East, staying in the right lane, and follow signs marked "High Street-Harrison." Take High Street Exit 14A and turn right at the traffic light; proceed through three traffic lights and the NJIT campus is one block further on the right.

From the New Jersey Turnpike: Take Exit 15W to Route 280 West and proceed to the State Street Exit, Newark. Turn left at the foot of the ramp and go one short block to stop sign. Turn left onto Dr. Martin Luther King, Jr. Boulevard and proceed through four traffic lights. The NJIT campus is one block further on the right.

From Routes 1, 9 or 22: Northbound traffic departs at exit marked "Newark," which leads to McCarter Highway (Route 21) through Newark. At the major business district, turn left onto Raymond Boulevard; the NJIT campus is several blocks west of the business district, at the end of Raymond Boulevard.

From New York Thruway: Exit 14A connects directly to the Garden State Parkway, then follow the Parkway directions above.

From George Washington Bridge: Follow New Jersey Turnpike south to Exit 15W onto Route 280 West; then follow westbound directions above.

From Lincoln Tunnel: Proceed west on Route 3 to New Jersey Turnpike, south to Exit 15W to Route 280 West, and follow westbound directions above.

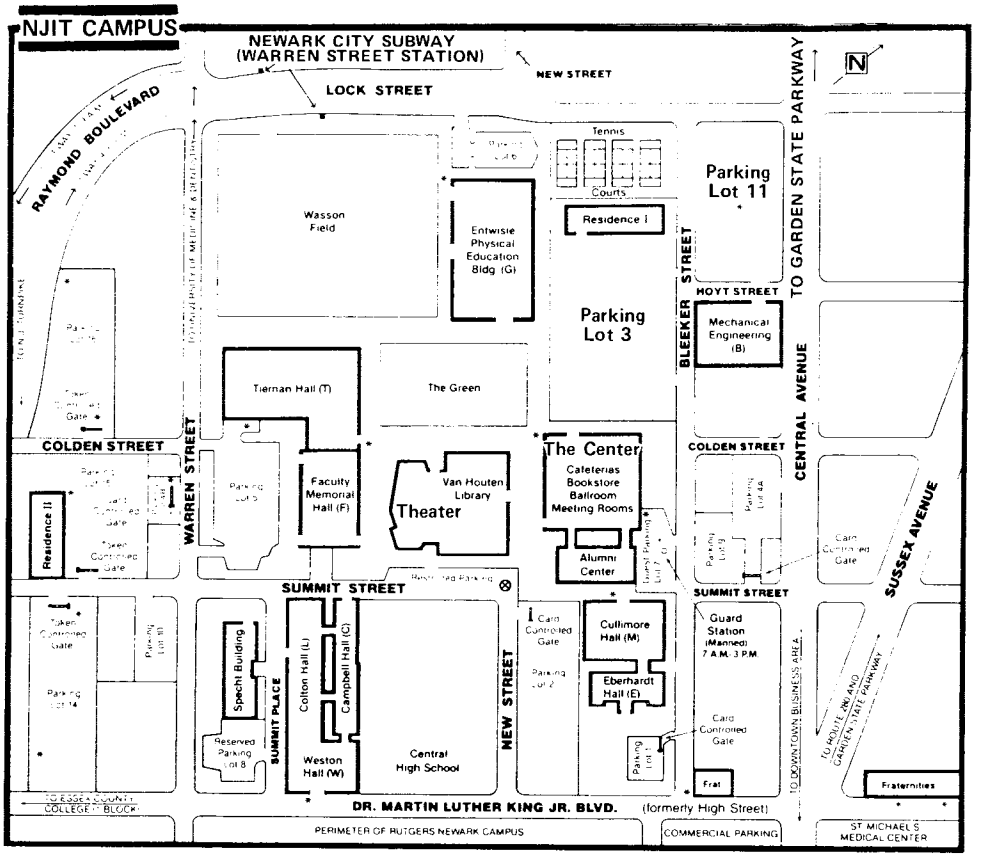
From Holland Tunnel: Follow signs to New Jersey Turnpike; take the Turnpike north to Exit 15W to Route 280 West, and follow westbound directions above.

Parking

Ample free parking for meeting participants will be available in Lots #3 and #11 on the NJIT campus.

W. Wistar Comfort
Associate Secretary

Middletown, Connecticut



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.

Honolulu, March 1987

Edward A. Bertram
Martin Scharlemann

Kent, April 1987

William G. Dwyer
Peter Loeb
Ridgway Scott
Lucien Szpiro

Newark, April 1987

Robert V. Kohn
Rodolfo R. Rosales
Birgit Speh
Lars B. Wahlbin

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.

March 1987 Meeting in Honolulu

Far Western Section
Deadline for organizers: Expired
Deadline for consideration: January 12, 1987

Christopher J. Allday and Heiner Dovermann, *Algebraic topology*
Steven Bleiler, *Low dimensional topology*
George Csordas, Wayne Smith, and David Stegenga, *Complex function theory*
Kent R. Fuller, *Rings and modules*
Jerrold Griggs, *Combinatorics*
Thomas Jech, *Set theory and its applications*
Peter Li, Richard Schoen, and S.-T. Yau, *Differential geometry*

April 1987 Meeting in Kent

Central Section
Deadline for organizers: Expired
Deadline for consideration: January 14, 1987

Eiichi Bannai and Paul Terwilliger, *Algebraic combinatorics: Association schemes and related topics*
John A. Fridy, *Summability theory*
Stephen M. Gagola, Jr. and David C. Buchtal, *Characters of finite groups*
Timothy J. Hodges and James Osterburg, *Noncommutative ring theory*
Peter A. Loeb, *Boundaries in potential theory*
Harry Moscovici and Dan Burghelea, *Cyclic homology and applications*
Michael Rothstein, *Symbolic and algebraic manipulation*
Ridgway Scott, *Scientific computation*
Andrew M. Tonge and Joe Diestel, *Geometry of Banach spaces and harmonic analysis*
Clarence Wilkerson, *Unstable homotopy theory*

April 1987 Meeting in Newark

Eastern Section
Deadline for organizers: Expired
Deadline for consideration: January 16, 1987

Daljit Singh Ahluwalia and Robert V. Kohn, *Inverse problems*
Roman Andrushkiw and Roy Plastock, *Computational mathematics and applications*
Denis Blackmore, *Nonlinear dynamics and chaos*
Robert H. Gilman, *Cellular automata and symbolic dynamics*
Vladislav V. Goldberg, *Differential geometry*
C. David Keys, *Harmonic analysis on reductive p-adic Lie groups*
Anthony W. Knapp, *Unitary representations, cohomology and G/Γ*
Petronije Milojević, *Nonlinear functional analysis*
John D. Randall and Mark Steinberger, *Group actions on manifolds*

Spring 1987 Meeting

Southeastern Section
No meeting will be held

Information for Organizers

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

Some Special Sessions arise from an invitation to a proposed organizer issued through the Associate Secretary. Others are spontaneously proposed by interested organizers or participants. Such proposals are welcomed by the Associate Secretaries.

The number of Special Sessions at a Summer or Annual Meeting is limited to twelve. Proposals, invited or offered, that are received at least nine months prior to the meeting are screened for suitability of the topic and of the proposed list of speakers, and for possible overlap or conflict with other proposals. (Specific deadlines for requesting approval for Special Sessions at national meetings are given above.) If necessary, the numerical limitation is enforced.

Proposals for Special Sessions should be submitted directly to the Associate Secretary in charge of the meeting (at the address given in the accompanying

box). If such proposals are sent to the Providence office, addressed to *Notices*, or directed to anyone other than the Associate Secretary, they will have to be forwarded and may not be received before the quota is filled.

In accordance with an action of the Executive Committee of the Council, no Special Session may be arranged so late that it may not be announced in *Notices* early enough to allow any member of the Society who wishes to do so to submit an abstract for consideration for presentation in the Special Session before the deadline for such consideration.

Special Sessions are effective at Sectional Meetings and can usually be accommodated. They are arranged by the Associate Secretary under the supervision of the Committee to Select Hour Speakers for the section. The limitation on the number of sessions depends on the space and time available. The same restriction as for national meetings applies to the deadline for announcing Special Sessions at sectional meetings: no Special Session may be approved too late for its announcement to appear in time to allow a reasonable interval for members to prepare and submit their abstracts prior to the special early deadline set for consideration of papers for Special Sessions.

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*.

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, Post Office 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.

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)

Hugo Rossi, Associate Secretary
Department of Mathematics
University of Utah
Salt Lake City, UT 84112
(Telephone 801-581-8159)

Central Section

Robert M. Fossum, Associate Secretary
Department of Mathematics
University of Illinois
1409 West Green Street
Urbana, IL 61801
(Telephone 217-333-3975)

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.

Symposium on Some Mathematical Questions in Biology
Models in Population Biology

Chicago, Illinois, February 18, 1987

The twenty-first annual Symposium on Some Mathematical Questions in Biology will be held on Wednesday, February 18, 1987, in the Acapulco Room of the Hyatt Regency Chicago in conjunction with the annual meeting of the American Association for the Advancement of Science. The symposium is sponsored by the American Mathematical Society, the Society for Industrial and Applied Mathematics, and Section A (Mathematics) of the American Association for the Advancement of Science.

Details regarding registration, local arrangements, and program information for the AAAS meeting appeared in the November 21 issue of *Science*.

The AMS-SIAM Committee on Mathematics in the Life Sciences serves as the Organizing Committee for the symposium. The committee consists of Gail A. Carpenter (Northeastern University); Kenneth L. Lange (Massachusetts Institute of Technology); Hans G. Othmer (University of Utah); Alan S. Perelson (Los Alamos National Laboratory); Richard E. Plant, chairman (University of California, Davis); and John Rinzel (National Institutes of Health).

The theme of the symposium is Models in Population Biology. There will be two half-day sessions, each including three one-hour lectures.

PROGRAM

Chairman: Alan M. Hastings

9:00 a.m. **Some Mathematical Questions in Biology—Models in Population Biology**
Presiding: ROBERT BOYD, University of California, Los Angeles

Evolutionary models of social learning. ROBERT BOYD, University of California, Los Angeles

Diffusion model for migration and selection. THOMAS NAGYLAKI, University of Chicago

Multilocus population genetics models. ALAN M. HASTINGS, University of California, Davis

2:30 p.m. **Some Mathematical Questions in Biology—Models in Population Biology**
Presiding: ALAN M. HASTINGS, University of California, Davis

The maintenance of plasmids and transposons in bacterial populations. BRUCE R. LEVIN, University of Massachusetts, Amherst

Interactions between environment and competition: Community structure in a variable environment. PETER L. CHESSON, Ohio State University

Detecting order in the chaos of nature: Nonlinear ecology and epidemiology. WILLIAM M. SCHAFFER, University of Arizona

1987 Summer Seminar In Applied Mathematics, April 30 – May 9

Computational Aspects of VLSI Design with an Emphasis on Semiconductor Device Simulation

The eighteenth AMS-SIAM Summer Seminar in Applied Mathematics will be held April 30 – May 9, 1987, at the Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, Minnesota. The seminar will be sponsored jointly by the American Mathematical Society, the Society for Industrial and Applied Mathematics, and the Institute for Mathematics and its Applications. It is anticipated that it will be supported by grants from federal agencies. The topic, *Computational aspects of VLSI design with an emphasis on semiconductor device simulation*, was selected by an AMS-SIAM Committee on Applied Mathematics whose members at the time were C. K. Chu, Constantine M. Dafermos, James M. Hyman, Alan G. Konheim, George C. Papanicolaou (chairman), and Robert F. Warming. The proceedings of the seminar will be published by the Society in the *Lectures in Applied Mathematics* series.

The seminar will form a part of the 1986 – 1987 Institute for Mathematics and its Applications program on Scientific Computation. The design of very large scale integrated (VLSI) semiconductor devices is an important problem in a variety of technological applications. The goal of simulation is to remove the need of actually fabricating prototype chips in order to study their behavior and optimize their design. Even the simplest system of partial differential equations which can be used to model semiconductor devices poses severe computational challenges. This is true partly because of the strong nonlinearity of the system and partly because of the large and rapid variations in the solution.

The first three days of the seminar will feature a series of three lectures each on process modeling by R. W. DUTTON of Stanford University, on device modeling by W. FICHTNER of the ETH, Zurich, and on circuit modeling by A. SANGIOVANNI-VINCENTELLI of the University of California, Berkeley. These lectures will be expository in nature and will introduce the subject to the participants. The following week will feature lectures of a more technical nature by a set of speakers including R. BANK of University of California, San Diego; J. BLUE of National Bureau of Standards; F. BREZZI of the Universita di Pavia; W. COUGHRAN of AT&T Bell Labs; P. DEGOND of Ecole Polytechnique; J. JEROME of Northwestern University; T. KERKHOVEN of Yale University; P. MARKOWICH of Technical University of Vienna; H. MITTLEMAN of Arizona State University; L. PETZOLD of Lawrence Livermore National Laboratories; C. RAFFERTY of Stanford University; C. RINGHOFER of Arizona State University; and D. ROSE of Duke University. These speakers have been invited by the Organizing Committee which consists of Randolph Bank (chairman), William Coughran, Eric Grosse, R. Kent Smith, and Mitchell Luskin. In order to allow ample time for informal discussion among participants, only three lectures per day will be presented.

A brochure will be available from the AMS office which includes a description of the scientific program, information on accommodations, and local information. Each participant will pay a $20 social fee to cover the cost of refreshments served at breaks and for social events. There will also be a seminar registration fee.

Those interested in attending the seminar should send the following information to Betty A. Verducci, Conference Coordinator, American Mathematical Society, P. O. Box 6248, Providence, RI 02940 **by February 13, 1987**.

Please type or print the following:

1. Full name;
2. Mailing address;
3. Telephone number and area code for office and home;
4. Anticipated arrival and departure dates;
5. Your scientific background relevant to the topic of the seminar;
6. Financial assistance requested (please estimate cost of travel);
7. Indicate if support is not required, and if interested in attending even if support is not offered.

Participants who wish to apply for a grant-in-aid should so indicate; however, funds available for the seminar are very limited and individuals who can obtain support from other sources should do so.

Graduate students who have completed at least one year of graduate school are encouraged to participate.

Symposium

The Mathematical Heritage of Hermann Weyl

With the anticipated support of the National Science Foundation, a symposium on *The Mathematical Heritage of Hermann Weyl* will take place Tuesday through Saturday, May 12–16, 1987, at Duke University in Durham, North Carolina. This topic was selected by the 1985 Committee on Summer Institutes and Special Symposia, whose members at the time were Albert Baernstein II, Eric Friedlander, Hui-Hsiung Kuo (chairman), H. Blaine Lawson, Jr., Judith D. Sally, and John Wermer.

The Organizing Committee for the symposium includes Michael F. Atiyah, Lipman Bers, Felix E. Browder, S. S. Chern, George D. Mostow, R. O. Wells, Jr. (chairman), and C. N. Yang.

The symposium is to honor Hermann Weyl for his great accomplishments in mathematics. In addition, it is intended to provide a stimulus to the younger generation of mathematicians by indicating the cohesive nature of modern mathematical ideas as looked at from the vantage point of Weyl's ideas. Although Weyl did not cover all of mathematics, the breadth of his contributions is nevertheless astonishing and formed the basis for some of the best of modern mathematics.

Lectures will be presented by the following speakers: JAMES G. ARTHUR (University of Toronto), MICHAEL F. ATIYAH (University of Oxford, England), FELIX E. BROWDER (University of Chicago), ROBERT L. BRYANT (Rice University), SIMON K. DONALDSON (University of Oxford, England), RONALD G. DOUGLAS, (SUNY, Center at Stony Brook), HARRY FURSTENBERG (Hebrew University, Jerusalem), PHILLIP A. GRIFFITHS (Duke University), VICTOR W. GUILLEMIN (Massachusetts Institute of Technology), ROGER E. HOWE (Yale University), ROBERT LANGLANDS (Institute for Advanced Study), H. BLAINE LAWSON, JR. (SUNY, Center at Stony Brook), JAMES I. LEPOWSKY (Rutgers University), LOUIS NIRENBERG (NYU, Courant Institute of Mathematical Sciences), ROGER PENROSE (University of Oxford, England), I. M. SINGER (Massachusetts Institute of Technology), CLIFFORD TAUBES (Harvard University), DAVID A. VOGAN, JR. (Massachusetts Institute of Technology), EDWARD WITTEN (Princeton University), C. N. YANG (SUNY, Center at Stony Brook), and S.-T. YAU (University of California, San Diego). The titles of these lectures are not yet available and will be announced later.

Accommodations

Blocks of rooms are being held for participants at the following hotels which are within walking distance of the campus. Individuals should make their own reservations directly with the hotel of their choice and be sure to identify themselves as participants in the American Mathematical Society's symposium at Duke University, in order to obtain these special rates. The deadline for reservations is **April 10, 1987**, after which reservations will be accepted on a space available basis. Please note that rates do not include the applicable 4 percent state sales tax.

Brownestone Inn (.6 mile) (formerly Hilton Inn)
Reservations Manager
2424 Erwin Road, Durham 27705
Telephone: 919-286-7761
Outside North Carolina: 1-800-367-0293
Inside North Carolina: 1-800-872-9009
Single or Double $52
Rate includes continental breakfast.

Sheraton University Inn (1.4 miles)
2800 Middleton Avenue at Morreene Road
(Rte. 15-501), Durham 27705
Telephone: 919-383-8575
Single or Double $52 and $67*
*VIP floor rate includes continental breakfast.

Information concerning registration, food service, etc., will appear in the February issue of *Notices*.

Joint Summer Research Conferences in the Mathematical Sciences

University of Colorado, Boulder, June 14 to July 25
and Cornell University, July 12 to August 15, 1987

The 1987 Joint Summer Research Conferences in the Mathematical Sciences will be held at the University of Colorado, Boulder, from June 14 to July 25, and at Cornell University, from July 12 to August 15. It is anticipated that the series of conferences will be supported by grants from the National Science Foundation and other agencies.

There will be five conferences in five different areas of mathematics to be held at each institution. The topics and organizers for the conferences were selected by the AMS-IMS-SIAM Committee on Joint Summer Research Conferences in the Mathematical Sciences from proposals submitted by individuals and topics suggested by committee members. The committee considered it important that the conferences represent diverse areas of mathematical activity, with emphasis on areas currently especially active, and paid careful attention to subjects in which there is important interdisciplinary activity at present.

The conferences are similiar in scientific structure to those held throughout the year at Oberwolfach. They are intended to complement the Society's program of annual Summer Institutes and Summer Seminars, which have a larger attendance and are substantially broader in scope. The conferences are research conferences, and are not intended to provide an entree to a field in which a participant has not already worked.

It is expected that support will be available for a limited number of participants in each conference. Others, in addition to those funded, will be welcome, within the limitations of the facilities of the campus. In the spring a brochure will be mailed to all who are invited to attend the conferences. The brochure will include information on room and board rates, the residence and dining hall facilities, travel and local information and a Residence Housing Form to use for on-campus housing accommodations. Information on off-campus housing will also be included in the brochure. Participants are required to make their own housing and travel arrangements. Each participant will be required to pay a fee of $25 to cover the cost of social events and refreshments served at breaks, in addition to a $15 registration fee.

Those interested in attending one of the conferences should send the following information to Carole Kohanski, Summer Research Conference Coordinator, American Mathematical Society, P.O. Box 6248, Providence, RI 02940.

Please type or print the following:

1. Title and dates of conference desired
2. Full name
3. Mailing address
4. Telephone number & area code for office and home
5. Your scientific background relevant to the topic of the conference
6. Financial assistance requested. Please estimate cost of travel.
7. Indicate if support is not required, and if interested in attending even if support is not offered.

The deadline for receipt of applications is March 2, 1987. After that date the Organizing Committee for each conference will consider the requests (selection of the participants and the allocation of support is made by the Organizing Committee.) You will be notified by the AMS of the committee's decision no later than May 1, 1987. Funds available for these conferences are limited and individuals who can obtain support from other sources should do so. Women and members of minority groups are encouraged to apply and participate in these conferences.

Any questions concerning the scientific portion of the conference should be directed to the chairman or any member of the Organizing Committee.

The Joint Summer Research Conferences in the Mathematical Sciences are under the direction of the AMS-IMS-SIAM Committee on Joint Summer Research Conferences in the Mathematical Sciences. The following Committee members chose the topics for the 1987 conferences: William B. Arveson, Ronald L. Graham, Benedict H. Gross, Malcolm R. Leadbetter, Angus J. Macintyre, Jerrold E. Marsden (Chairman), John R. Martin, James McKenna, Tilla Klotz Milnor, Evelyn Nelson, Katusumi Nomizu.

Descriptions of the subject matter of each of the 1987 Conferences appeared in the October *Notices*, pages 836 to 839; they were accompanied by lists of members of the respective organizing committees.

University of Colorado, Boulder

June 14 to June 20

Categories in computer science and logic

JOHN W. GRAY (University of Illinois at Urbana-Champaign), Chairman

June 21 to June 27

Hamiltonian dynamical systems

KENNETH MEYER (University of Cincinnati), Co-Chairman

DON SAARI (Northwestern University), Co-Chairman

June 28 to July 4

Graphs and algorithms

JOE BUHLER (Reed College), Co-Chairman

PHYLLIS CHINN (Humboldt State University), Co-Chairman

July 5 to July 11

Geometry of group representations

WILLIAM GOLDMAN (University of Maryland), Co-Chairman

ANDY MAGID (University of Oklahoma), Co-Chairman

July 19 to July 25

The connection between infinite dimensional and finite dimensional dynamical systems

BASIL NICOLAENKO (Los Alamos National Laboratories), Chairman

Cornell University

July 12 to July 18

Mathematical developments arising from linear programming

JEFFREY C. LAGARIAS (AT&T Bell Laboratories), Co-Chairman

MICHAEL TODD (Cornell University), Co-Chairman

July 19 to July 25

Geometry of random motion

RICHARD DURRETT (Cornell University), Co-Chairman

MARK PINSKY (Northwestern University), Co-Chairman

July 26 to August 1

Crystal growth and pattern formation in phase transitions

STUART P. HASTINGS (SUNY at Buffalo), Co-Chairman

NICHOLAS D. KAZARINOFF (SUNY at Buffalo), Co-Chairman

August 2 to August 8

Complex analytic dynamics

JOHN H. HUBBARD (Cornell University), Chairman

August 9 to August 15

Statistical inference from stochastic processes

NARAHARI U. PRABHU (Cornell University), Chairman

Complex Representations of GL(2, K) for Finite Fields K

Ilya Piatetski-Shapiro

These notes give a beautiful exposition of the theory of representations of the group GL(2, K), where K is a finite field. In 71 well-organized pages, the author manages to cover a remarkable amount of material clearly, concisely, and with many details. The table of contents goes like this: Preliminaries (induced representations of finite groups and the conjugacy classes of GL(2, K), etc.); The representations of GL(2, K) (inducing representations from the upper triangular subgroup, construction of the cuspidal representations of GL(2) via characters of the quadratic extension of K, the small Weil group and the small reciprocity law); Γ-functions and Bessel functions (Whittaker models, computation of Γ-factors, and computation of the character table for GL(2, K)).

The reviewer heartily recommends these notes for anyone interested in either entering this research area or teaching a self-contained introduction to the theory of group representations. Although many of the proofs given exploit the fact that K is finite, in presenting the material the author definitely has in mind the current research being done in the theory of (infinite-dimensional) representations of GL(2) (and more general groups) over a local (as opposed to a finite) field K.

– *Stephen Gelbart (Rehovot)*
Mathematical Reviews, 84m:20046

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1987 Summer Research Institute, July 6 – 24

Theta Functions

The thirty-fifth Summer Research Institute sponsored by the American Mathematical Society will be devoted to *Theta functions* and will take place at Bowdoin College in Brunswick, Maine, from July 6 to 24, 1987. Members of the Organizing Committee include Enrico Arbarello, New York University; David Chudnovsky, Columbia University; Gregory Chudnovsky, Columbia University; Leon Ehrenpreis, Yeshiva University (co-chairman); Robert Gunning, Princeton University (co-chairman); Takahiro Kawai, Kyoto University; and Henry McKean, New York University. It is anticipated that the institute will be partially supported by a grant from the National Science Foundation. Funds for financial assistance will be limited and, therefore, it will be necessary for many participants to obtain their own funds. Proceedings of the institute will be published in the AMS series *Proceedings of Symposia in Pure Mathematics*.

This topic was selected by the 1985 Committee on Summer Institutes, whose members at that time were Albert Baernstein II, Eric Friedlander, Hui-Hsiung Kuo (chairman), H. Blaine Lawson, Judith D. Sally, and John Wermer.

Theta functions have a long and distinguished mathematical history, and interest in these functions has been renewed and deepened by the wide variety of areas of mathematical research in which they have currently come to play a major and exciting role, both in extension of their traditional areas of application and in new areas altogether. Recent results on the well-known Riemann-Schottky problem in algebraic geometry have been striking indeed, with great strides in geometric forms of solutions and in the solution of the Novikov conjecture characterizing Jacobi varieties by means of partial differential equations. Considerable progress has been made in extending the classical role of theta functions in the solution of integrable Hamiltonian systems to the study of such nonlinear equations as the KDV, KP, and so on, as part of an intensive recent study of the KP hierarchy and various generalizations. This progress and the work on theta functions in partition theory have come to be of interest in mathematical physics, both in statistical mechanics and in string theory. Theta functions have been a crucial tool in the study of diophantine equations, as well as in the recent solution of Mordell's Conjecture.

The three weeks of the Summer Research Institute are planned to cover various aspects of the theory of theta functions with roughly the following schedule:

Week I: scattering and KP equations, strings, integrable systems, Kac-Moody algebras;

Week II: algebraic geometry, the Schottky problem, Prym varieties;

Week III: number theory, modular forms, combinatorics

It is intended that the morning sessions will be systematic expository lectures covering the topics set for that week, while the afternoon sessions will be topical seminars on current research developments as well as working and problem seminars. The hope is to provide an opportunity to learn the wide variety of different roles now played by theta functions, to broaden the perspectives of the participants and provoke further interactions, and to follow recent developments of interest to those engaged in research in the various areas of mathematics covered.

Housing accommodations will be available in the campus residence halls for participants and their families, and cafeteria-style meals will be served daily in the adjacent dining hall. Residence and dining facilities, as well as rooms used for the scientific sessions at Bowdoin College, are accessible to the handicapped.

A brochure of information will be sent to all who are invited to attend the institute. It will include information about the scientific program, the residence and dining facilities, room and board rates, travel and local information, and a reservation form for on-campus housing accommodations. Each participant will pay a social fee of $25 to cover the cost of social events and refreshments served at breaks. There will also be a meeting registration fee.

Anyone who wishes to receive an invitation to participate in the institute and/or be considered for financial assistance should write to Conference Coordinator, 1987 Summer Institute, American Mathematical Society, P. O. Box 6248, Providence, Rhode Island 02940 prior to **April 3, 1987**. After that date the Organizing Committee will consider the requests, and applicants who are granted support will subsequently be notified that funds are available.

Special Meetings

THIS SECTION contains announcements of meetings 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.) All meetings listed here, to the best of our knowledge, are open meetings and the public is invited to attend.

AN ANNOUNCEMENT will be published in *Notices* if it contains 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.

IN GENERAL, announcements of meetings 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 special meetings 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.

1986–1987. **Academic Year Devoted to Algebraic Geometry**, Mittag-Leffler Institute, Djursholm, Sweden. (January 1986, p. 130)

1986–1987. **Special Year in Modern Analysis**, University of Illinois at Urbana-Champaign, Urbana, Illinois. (October 1986, p. 840)

1986–1987. **Workshop for Academic Year**, University of Arizona, Tucson, Arizona.

Program: February 5–9, Tutorial workshop in solitons, dynamical systems, geometry and mathematical physics for potential graduate students; February 19–21, Random Schrödinger equations; and March 29–April 4, Nonlinear optics.

Information: L. Grove or A. Newell, Department of Mathematics, Building Number 89, University of Arizona, Tucson, Arizona 85721, 602-621-6885 or 602-621-2868.

1987–1988. **Academic Year Devoted to Several Complex Variables**, Mittag-Leffler Institute, Djursholm, Sweden.

Program: Emphasis will be placed on topics like holomorphic mappings, the $\overline{\partial}$ operator, residue theory, integral formulas, complex capacities, the Monge-Ampère operator, CR structures, H^∞, and also complex differential geometry and stochastic methods in complex analysis.

Information: J. Fornaess, Princeton University, Department of Mathematics, Fine Hall, Princeton, New Jersey 08544 or C. Kiselman, Uppsala University, Department of Mathematics, Thunbergsvägen 3, S-752 38 Uppsala, Sweden.

October 12, 1986–December 13, 1987. **Mathematisches Forschungsinstitut Oberwolfach** (Weekly Conferences), Federal Republic of Germany. (October 1986, p. 840)

Information: Institute Director, Albertstrasse 24, D-7800 Freiburg, Federal Republic of Germany.

January 12, 1987–June 20, 1987. **Research Program on Different Aspects of the Mathematical Theory of Evolution Equations**, University and the Scuola Normale Superiore, Pisa, Italy.

Program: During the 1987 spring semester, there will be workshops, extended and short visits of leading mathematicians, intensive courses of lectures, as well as informal activities.

Information: K. Nicotra, Evolution Equations Program, Scuola Normale Superiore, I-56100 Pisa, Italy.

January

12–February 8. Control Theory, *Scientific Committee*: R. Conti, E. De Giorgi, S. Mitter.

February

9–March 7. Parabolic Equations and Semigroups, *Scientific Committee*: S. Campanato, G. Da Prato, A. Marino.

March

9–April 4. Hyperbolic Equations, *Scientific Committee*: L. Cattabriga, F. Colombini, M. Murthy, S. Spagnolo.

April

27–May 23. Fluid Dynamics, *Scientific Committee*: H. Beirao Da Veiga, G. Prodi, G. Prouse.

May

25–June 20. Mathematical Models in Chemistry and Biology, *Scientific Committee*: M. Iannelli, W. Jaeger, L. Modica.

DECEMBER 1986

1. **Focus on Fusion**, Quaid-I-Azam University, Islamabad, Pakistan. (November 1986, p. 960)

1–5. **Minisymposium on Numerical Simulation in Oil Recovery**, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, Minnesota. (August 1986, p. 653)

2–5. **Second International Conference on Artificial Intelligence**, Marseilles, France. (August 1986, p. 653)

3–5. **Forty Second Annual Conference on Applied Statistics**, Atlantic City, New Jersey. (March 1986, p. 370)

3–6. **Theory of Robots Symposium**, Vienna, Austria. (January 1986, p. 134)

6–8. **Annual Winter Meeting of the Canadian Mathematical Society**, University of Ottawa, Ottawa, Canada. (November 1986, p. 960)

11–12. **International Conference on the Numerical Modeling of Semiconductors**, Los Angeles, California. (October 1986, p. 842)

15–17. **Cryptography and Coding**, Cirencester, Glos., England. (June 1986, p. 560)

15–19. **International Workshop on Multivariate Approximation**, Santiago, Chile. (October 1986, p. 842)

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JANUARY 1987

January–May. **Nonlinear PDE's**, Brigham Young University, Provo, Utah. (June 1986, p. 560)

5–7. **First International Symposium on Domain Decomposition Methods for Partial Differential Equations**, Rocquencourt, France. (October 1986, p. 842)

7–9. **American Statistical Association Winter Conference: Statistics in the Information Age**, Orlando, Florida. (October 1986, p. 842)

12–14. **Conference on Industry-University Collaborations in the Mathematical Sciences**, Claremont, California. (August 1986, p. 653)

12–16. **Seminar on Approximation and Optimization**, Havana, Cuba. (August 1986, p. 653)

19–23. **Structures for Documents**, Aussois, France. (August 1986, p. 653)

19–30. **Twenty-seventh Summer Research Institute of the Australian Mathematical Society**, University of New England, Armidale, N.S.W., Australia. (August 1986, p. 653)

20–24. **Workshop on Iwasawa Theory and Special Values of L-functions**, Mathematical Sciences Research Institute, Berkeley, California. (August 1986, p. 653)

29–31. **Utah State University Department of Mathematics Second Conference on Matrix Theory**, Utah State University, Logan, Utah. (August 1986, p. 653)

FEBRUARY 1987

February. **Séminaire International Grands Calculateurs Scientifiques**, Paris, France. (August 1986, p. 653)

2–27. **Workshop on Mathematics in Industry**, International Centre for Theoretical Physics, Trieste, Italy.
Information: J. Eells, International Centre for Theoretical Physics, 34100 Trieste, Italy. Telephone: 2240-1.

8–12. **Applied Mathematics Conference**, Wairakei, New Zealand. (October 1986, p. 842)

13–18. **Annual Meeting, American Association for the Advancement of Science**, Chicago, Illinois. (March 1986, p. 370)

16–20. **Workshop on Materials with Nonlinear Constitutive Laws**, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, Minnesota. (August 1986, p. 653)

17–19. **Association for Computing Machinery Computing Science Conference**, St. Louis, Missouri. (October 1986, p. 842)

MARCH 1987

7. **Third Southeastern Logic Symposium**, Charleston, South Carolina. (November 1986, p. 961)

8–11. **Computer Science and Statistics: 19th Symposium on the Interface**, Temple University, Philadelphia, Pennsylvania. (October 1986, p. 842)

16–20. **Seminaire de Probabilités XXII**, Laboratoire d'Automatique et d'Analyse des Systemes, Toulouse, France. (August 1986, p. 653)

20–21. **Southeastern Analysis Meeting**, University of Alabama, Tuscaloosa, Alabama.
Organizers: A. Hopenwasser, R. Moore, T. Trent.
Information: R. Moore, Department of Mathematics, University of Alabama,Tuscaloosa, Alabama 35487-1416.

22–25. **Institute of Mathematical Statistics Central Regional Meeting**, Dallas, Texas. (March 1986, p. 370)

22–26. **Computer Graphics '87**, Philadelphia Civic Center, Philadelphia, Pennsylvania.
Purpose: The Computer Graphics '87 conference gathers the industry's most widely known users, vendors, and academicians to review the past, explain the present and predict the future of computer graphics.
Information: Computer Graphics '87, National Computer Graphics Association, 2722 Merrilee Drive, Suite 200, Fairfax, Virginia 22031, 800-225-6242.

22–29. **Fifth International Conference on Geometry**, University of Haifa, Haifa, Israel. (October 1986, p. 842)

23–27. **Workshop on Galois Groups over Q and Related Topics**, Mathematical Sciences Research Institute, Berkeley, California. (October 1986, p. 842)

23–27. **Workshop on Scientific Software**, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, Minnesota. (August 1986, p. 654)

23–30. **NSF-CBMS Conference on Mathematical Statistics**, Ohio State University. (June 1986, p. 560)

25–27. **Conference on Information Sciences and Systems**, Johns Hopkins University, Baltimore, Maryland. (October 1986, p. 843)

27–28. **Eleventh Annual Southeastern Section–Society for Industrial and Applied Mathematics Conference**, University of Georgia, Athens, Georgia. (November 1986, p. 961)

28–31. **Eighteenth Iranian Mathematical Conference**, Birjand University, Iran. (November 1986, p. 961)

30–15 April. **Workshop and Conference on Number Theory and Dynamical Systems**, University of York, York, United Kingdom. (October 1986, p. 843)

APRIL 1987

2–3. **Conference on Applications of Functional Analysis to Differential and Integral Equations**, Idaho State University, Pocatello, Idaho.
Invited Speakers: P. M. Anselone, J. Locker.
Call for Papers: Abstracts of 20-minute contributed papers are to be submitted by February 28, 1987, to the address below.
Information: P. Lang, Mathematics Department, Idaho State University, Pocatello, Idaho 83209, 208-236-3819.

6–8. **Conference on Combinatorial Optimization**, University of Southampton, United Kingdom. (October 1986, p. 843)

8–10. **Charter Centenary Conference of the Royal Statistical Society**, Cambridge, United Kingdom. (November 1986, p. 961)

8–10. **Third Workshop on the Mathematical Foundations of Programming Semantics**, Tulane University, New Orleans, Louisiana. (October 1986, p. 843)

9–11. **Eleventh Annual Lecture Series in the Mathematical Sciences**, Fayetteville, Arkansas.
Call for Papers: Contributed papers should be submitted by February 15, 1987, to the address below.
Speakers: R. Bañuelos, A. Bennett, D. Burkholder, B. Davis, D. DeBlassie, S. Dilworth, G. Edgar, and T. McConnell.
Information: I. Monroe, Department of Mathematical Sciences, Science-Engineering 301, University of Arkansas, Fayetteville, Fayetteville, Arkansas 72701.

10–11. **Twentieth Small College Computing Symposium**, Macalester College, Saint Paul, Minnesota.
Purpose: The conference addresses issues related to the teaching of computer science and the use of computer technology in a small college environment.
Information: G. Schneider, Department of Computer Science, Macalester College, 1600 Grand Avenue, Saint Paul, Minnesota 55105.

11–12. **Twenty-first Meeting of the Midwest Partial Differential Equations Seminar**, University of Illinois, Chicago, Illinois.
Information: D. Tartakoff, Department of Mathematics, University of Illinois at Chicago, Post Office Box 4348, Chicago, Illinois 60680.

21–25. **Conference on Nonlinear Numerical Methods Based on the Use of Rational Functions**, University of Antwerp, Belgium. (August 1986, p. 654)

23–24. **The Eighteenth Annual Modeling and Simulation Conference**, Pittsburgh, Pennsylvania. (October 1986, p. 843)

27–30. **Workshop on Mathematical Modeling in Combustion and Related Topics**, École Centrale de Lyon, France. (August 1986, p. 654)

28–May 1. **The Mathematics of Finite Elements and Applications 1987**, Uxbridge, United Kingdom. (October 1986, p. 843)

29–May 8. **AMS-SIAM Summer Seminar on Computational Aspects of VLSI Design with an Emphasis on Semiconductor Device Simulation**, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, Minnesota. (August 1986, p. 654)

MAY 1987

11–15. **Thirty-first Annual Meeting of the Australian Mathematical Society**, Deakin University, Geelong, Victoria, Australia. (August 1986, p. 654)

18–21. **Eighth Symposium on Computer Arithmetic**, Como, Italy. (October 1986, p. 843)

20–23. **Combinatorial Matrix Analysis Conference**, University of Victoria, Victoria, British Columbia, Canada. (October 1986, p. 843)

21–23. **Second Conference in Geometry and Topology**, Lehigh University, Bethlehem, Pennsylvania.
Program: There will be five invited hour lectures and sessions for 40-minute contributed papers.
Call for Papers: Papers are solicited in differential and algebraic geometry and algebraic and geometric topology. Send an abstract before April 15, 1987, to the address below.
Information: D. Davis, C. Hsiung, or D. Johnson, Department of Mathematics, Christmas-Saucon Hall 14, Lehigh University, Bethlehem, Pennsylvania 18015.

25–26. **Foundations and Philosophy of Probability and Statistics, A Symposium in Honor of I. J. Good**, Virginia Polytechnic Institute and State University, Blacksburg, Virginia. (November 1986, p. 962)

25–29. **The Ninth International Symposium on Noise in Physical Systems**, Université de Montréal, Québec, Canada. (March 1986, p. 370)

26–28. **Multiple-valued Logic**, University of Massachusetts, Boston, Massachusetts.
Information: D. Simovici, Department of Mathematics and Computer Science, University of Massachusetts at Boston, Boston, Massachusetts 02125, 617-929-7966.

26–28. **Workshop on Nonlinear Hyperbolic Waves**, Mathematical Sciences Research Institute, Berkeley, California. (August 1986, p. 654)

27–30. **Fifth Biennial Conference of the Association for Christians in the Mathematical Sciences**, Calvin College, Grand Rapids, Michigan.
Invited Speakers: D. Knuth, M. Detlefson, and C. Jongsma.
Information: P. Zwier, Department of Mathematics and Computer Science, Calvin College, Grand Rapids, Michigan 49506.

28–1 June. **Fourth Southeast Asian Conference on Mathematical Education**, Singapore. (August 1986, p. 654)

31–June 3. **1987 Annual Meeting, Statistical Society of Canada**, Quebec City, Canada. (November 1986, p. 962)

JUNE 1987

1–4. **Second International Tampere Conference in Statistics**, Tampere, Finland. (November 1986, p. 962)

1–10. **Second Annual Meeting of the International Workshop in Analysis and Its Applications**, Dubrovnik-Kupari, Yugoslavia. (October 1986, p. 843)

4–6. **Computer Experimentation in Nonlinear Analysis**, University of Missouri, Columbia, Missouri.
Speakers: J. Yorke, University of Maryland, A. Newell, University of Arizona, M. Barnsley, Georgia Institute of Technology, C. Grebogi, University of Maryland, and R. Devaney, Boston University.
Information: C. Chicone, Department of Mathematics, University of Missouri, Columbia, Missouri 65202, 314-882-6331 or 314-882-6221.

4–6. **Congress on Educational Computing in Mathematics**, Università di Roma I, Roma, Italia. (*Note change from August 1986, p. 654)

8–19. **Singapore Group Conference Theory**, National University of Singapore, Republic of Singapore. (March 1986, p. 370)

9–12. **Workshop on Nonlinear Hyperbolic Equations for Applied Sciences**, Torino, Italy.
Program: The workshop will concentrate on interdisciplinary exchange, with the aim of presenting the most recent results on the mathematical theory of nonlinear hyberbolic problems and some relevant applications in natural sciences and engineering.
Invited Speakers: T. Liu, C. Bardos, Y. Choquet-Bruhat, C. Cercignani, S. Rionero, H. Beirao da Veiga, R. DiPerna, R. Kaflisch, S. Spagnolo, F. Strocchi.
Information: Institute for Scientific Interchange, Villa Gualino, viale S. Severo 65, I-10133 Torino, Italy.

11–13. **Sixth Pacific Coast Resource Modeling Conference**, University of British Columbia, Vancouver, Canada.
Program: The conference is devoted to the mathematical modeling of natural resource systems; their biological and physical processes and the economic and operational basis of their management.
Call for Papers: The deadline for submission of abstracts is May 1, 1987.
Information: C. Clark or R. Lamberson, Institute of Applied Mathematics, University of British Columbia, Vancouver, British Columbia, Canada.

14–21. **Number Theory, Trace Formulas and Discrete Groups**, Oslo, Norway.
Program: This symposium in honor of Atle Selberg will have survey talks on Selberg's work and its development.
Speakers: J. Arthur, E. Bombieri, D. Bump, H. Jacquet, R. Langlands, H. Montgomery, D. Mostow.
Information: K. Aubert, Department of Mathematics, University of Oslo, Post Office Box 1053, Blindern, 0316 Oslo, Norway.

15–16. **NASECODE V SHORT COURSE: The Interfaces and Integration of Process, Device and Circuit Models—An Introduction**, Trinity College, Dublin, Ireland. (October 1986, p. 843)

15–19. **Conference on Combinatorics and Complexity**, University of Ilinois at Chicago, Chicago, Illinois.
Information: W. Maass, U. Peled, or V. Pless, Department of Mathematics, Statistics, and Computer Science, University of Illinois at Chicago, Box 4348, Chicago, Illinois 60680, 312-996-3041.

15–19. **Mathematical Association of America's North Central Section Summer Seminar on Graph Theory and Linear Algebra**, University of Minnesota, Duluth, Minnesota.
Program: Eight lectures by A. Schwenk on the relationship between graph theory and linear algebra; talks by invited speakers and contributed papers (talks) by participants.
Information: J. Gallian, Department of Mathematics and Statistics, University of Minnesota, Duluth, Minnesota 55812.

15–26. **Workshop and Short Course on Stochastic Networks**, University of Wisconsin, Madison, Wisconsin.
Program: Stochastic networks, tools for their analysis, and applications to computer systems, communication networks, neural networks, and other complex systems will be covered.
Speakers: Y. Abu-Mostafa, P. Gacs, B. Hajek, F. Kelly, E. Posner, and W. Whitt.
Information: T. Kurtz, Department of Mathematics, University of Wisconsin-Madison, 480 Lincoln Drive, Madison, WI 53706.

15–July 3. **Microprogram on Commutative Algebra**, Mathematical Sciences Research Institute, Berkeley, California. (October 1985, p. 679)

16–19. **Second Annual Conference on Structure in Complexity Theory**, Cornell University, Ithaca, New York. (November 1986, p. 962)

17–19. **NASECODE V Conference: The Fifth International Conference on the Numerical Analysis of Semiconductor Devices and Integrated Circuits**, Trinity College, Dublin, Ireland. (October 1986, p. 843)

22–25. **Second Annual Symposium on Logic in Computer Science**, Cornell University, Ithaca, New York. (November 1986, p. 962)

23–26. **Sixth IMACS International Symposium on Computer Methods for PDE's**, Lehigh University, Bethlehem, Pennsylvania. (January 1986, p. 134)

23–27. **International Conference on Generalized Functions, Convergence Structures and Their Applications**, Dubrovnik, Yugoslavia. (June 1986, p. 560)

29–July 3. **Première Conférence Internationale sur les Mathématiques Appliquées et Industrielles**, Paris, France. (August 1986, p. 654)

30–July 4. **Third International Seminar on Random Graphs and Probabilistic Methods in Combinatorics**, Poznań, Poland. (October 1986, p. 844)

JULY 1987

July–August. **Low Dimensional Topology Symposium**, University of Sussex, Brighton, Great Britain. (August 1986, p. 654)

6–10. **Third Gregynog Symposium on Differential Equations**, University of Wales, United Kingdom. (October 1986, p. 844)

6–16. **A Research Symposium in Complex Analysis**, Imperial College, South Kensington, London, England. (October 1986, p. 844)

10–11. **Logic and Linguistics Conference**, Stanford University, Stanford, California.
Information: Association for Symbolic Logic/Linguistic Society of America 87, R. Thomason, Linguistics Department, University of Pittsburgh, Pittsburgh, Pennsylvania 15260.

13–17. **Automata, Languages, and Programming**, Karlsruhe, Federal Republic of Germany. (August 1986, p. 654)

13–17. **Eleventh British Combinatorial Conference**, London, United Kingdom. (November 1986, p. 962)

13–17. **Inequalities: Fifty Years on From Hardy, Littlewood and Polya**, University of Birmingham, Birmingham, England. (October 1986, p. 844)

19–24. **Conference on Potential Theory**, Charles University, Prague, Czechoslovakia. (June 1986, p. 560)

27–29. **SLU-GTE Conference on Commutative Harmonic Analysis**, Saint Lawrence University, Canton, New York.
Program: Invited speakers and contributed talks. Deadline for abstracts is May 1, 1987.
Speakers: Y. Domar, S. Drury, C. Graham, T. Korner, and O. McGehee.
Information: D. Colella, Department of Mathematics, Saint Lawrence University, Canton, New York 13617, 315-379-5471.

27–31. **International Symposium on Information and Coding Theory**, State University of Campinas, Campinas, Brazil.
Call for Papers: Persons intending to contribute papers should send two copies each of an extensive summary not later than April 30, 1987. A full length paper may be sent not later than July 31, 1987. Send to below address.
Information: P. Rathie, Universidade Estadual de Campinas, 13083 Campinas, S. P., Brazil. Telephone: PABX (0192) 39-1301.

31–August 3. **Boston Workshop for Mathematics Faculty**, Wellesley College, Wellesley, Massachusetts.
Purpose: To strengthen the teaching of calculus, linear algebra, differential equations, and applied mathematics.
Information: G. Strang, Room 2-240, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139.

AUGUST 1987

1–6. **Fifth Conference on Graph Theory of China**, People's Republic of China. (August 1986, p. 654)

3–7. **Georgia Topology Conference**, University of Georgia, Athens, Georgia.
Information: C. McCrory, Department of Mathematics, University of Georgia, Athens, Georgia 30602.

3–21. **Mathematical and Statistical Developments of Evolutionary Theory**, Université de Montréal, Montréal, Canada.
Speakers: E. Akin, F. Christiansen, W. Ewens, W. Hines, A. Jacquard, S. Karlin, S. Lessard, S. Levin, C. Matessi, T. Ohta, and D. Sankoff.
Deadline for Application: Before March 20, 1987.
Information: G. David, Département de Mathématiques et de Statistique, Université de Montréal, Carte Postale 6128, Montréal H3C 3J7, Canada.

4–7. **Sixth International Conference on Mathematical Modelling: An Interdisciplinary Integrative Forum for Researchers and Educators in Engineering, Economics, Biological, Medical, Environmental, Social and other Sciences**, Washington University, St. Louis, Missouri. (*Note change from October 1986, p. 844)

9–15. **International Conference on Abelian Groups**, Perth, Western Australia. (June 1986, p. 560)

9–22. **Harmonic Analysis on Real and p-adic Groups**, Bowdoin College, Brunswick, Maine. (October 1986, p. 844)

10–21. **Set Theory and its Applications–Conference at York**, York University, Toronto, Canada.
Call for Papers: Write to below address for details.
Purpose: The purpose of the conference is to encourage various mathematicians to apply set theoretic techniques in their own discipline.
Information: A. Dow, D. Pelletier, J. Steprans, or S. Watson, Department of Mathematics (STACY), N520 Ross Building, York University, North York, Ontario, Canada M3J 1P3, 416-736-5250.

16–21. **Sixteenth Conference on Stochastic Processes and their Applications**, Stanford University, Stanford, California. (August 1986, p. 654)

17–20. **International Conference on Rings, Modules, and Radicals**, Hobart, Tasmania. (June 1986, p. 560)

17–22. **Eighth International Congress of Logic, Methodology and Philosophy of Science**, Moscow, Union of Soviet Socialist Republics.
Call for Papers: Abstracts of contributed talks should be mailed to the address below before March 1, 1987. The abstract should be not more than four single-spaced pages in length and should be written in one of the official Congress languages (English, French, German, Russian, Spanish), but preferably in English.
Information: I. Frolov, Volkhonka 14, Moscow 119842, Union of Soviet Socialist Republics.

18–21. **Third Conference on Numerical Methods and Approximation Theory**, University of Niš, Niš, Yugoslavia.
Information: G. Milovanović, Faculty of Electronic Engineering, Department of Mathematics, Post Office Box 73, 18000 Niš, Yugoslavia.

24–28. **Conference on Differential Equations "Equadiff '87"**, Democritus University of Thrace, Greece. (January 1986, p. 134)

24–28. **International Conference on Web Geometry and Related Fields**, Szeged University, Szeged, Hungary. (June 1986, p. 560)

24–28. **Second International Conference on Combinatorial Mathematics and Computing**, Canberra, Australia. (March 1986, p. 370)

24–28. **Sixth National Conference on Artificial Intelligence**, Seattle, Washington. (March 1986, p. 370)

24–29. **Meeting on Geometry of Banach Spaces**, Mons, Belgium. (August 1986, p. 655)

31–September 4. **First International Conference on Statistical Data Analysis Based on the L_1-Norm and Related Methods**, University of Neuchâtel, Neuchâtel, Switzerland.
Program: The conference will include invited talks and contributed papers.
Call for Papers: Abstracts limited to one typed page written in English are to be submitted to the address below by December 31, 1986.
Information: Y. Dodge, Conference Organizer, Université de Neuchâtel, Groupe d'Informatique et de Statistique, Pierre-à-Mazel 7, CH-2000 Neuchâtel, Switzerland. Telephone: (038) 25 72 05.

SEPTEMBER 1987

7–9. **Summer Conference on Category Theory and Computer Science**, University of Edinburgh, Edinburgh, Scotland.
Call for Papers: Deadline for submissions is March 1, 1987. Authors should send 5 copies of draft paper to below address.
Topics: Topics will include, but are not limited to, semantics of programming languages, program specification, categorical logic, and type theory.
Information: D. Pitt, Department of Mathematics, University of Surrey, Guildford, Surrey GU2 5XH, United Kingdom.

8–11. **Third International Conference on the Teaching of Mathematical Modelling and Applications**, University of Kassel, Kassel, Federal Republic of Germany.
Purpose: The aims of the conference are to present appropriate research and developmental studies and to provide an international forum for the discussion and exchange of experiences with applications and modelling, especially considering the immense social and technological change in the area of maths teaching.
Information: W. Blum, Gesamthochschule Kassel Universität, Fachbereich Mathematik, Heinrich-Plett-Strasse 40, D-3500 Kassel, Federal Republic of Germany. Telephone: (0561) 804-4623 or (4631).

9–12. **Internationale Konferenz über Anwendungen und Modellbildung im Mathematikunterricht**, Kassel, Federal Republic of Germany. (June 1986, p. 560)

13–19. **Journées Arithmétiques 1987**, Ulm, Federal Republic of Germany. (June 1986, p. 560)

20–26. **DMV-Jahrestagung 1987**, Berlin, Federal Republic of Germany. (June 1986, p. 560)

OCTOBER 1987

October. **87 ICAR-International Conference on Advanced Robotics**, Paris or Nice, France. (August 1986, p. 655)

October. **Journées Méthodes Numériques en Méchanique des Fluides**, Sophia-Antipolis, France. (August 1986, p. 655)

26–31. **Mathematical Methods in Operations Research**, Sofia, Bulgaria.
Call for papers: One camera ready page should be sent to the address below by May 1, 1987.
Topics: Topics at the conference will be Nonsmooth analysis and optimization, Optimal control and dynamic systems, Discrete optimization and combinatorics, Numerical methods, Interactive optimization software, and Applications.
Information: International Conference, Mathematical Methods in Operations Research, Institute of Mathematics with Computer Centre, Bulgarian Academy of Sciences, 1113 Sofia, 8 Acad. G. Bonchev, Bulgaria.

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APRIL 1988

17–30. **The First Canadian Number Theory Society Conference**, Banff, Alberta, Canada.
Information: R. Mollin, University of Calgary, Department of Statistics, 2500 University Drive N.W., Calgary, Alberta, Canada T2N 1N4.

AUGUST 1988

21–27. **Seventeenth International Congress of Theoretical and Applied Mechanics**, Grenoble, France.
Call for Papers: Submit an extended summary of about 500 words and an abstract of 100–150 words. The abstract must be typed double space on a single page. The author is also invited to prepare a copy of the presentation slides or an outline of the poster. Also, the author should prepare a statement of preference for lecture session or poster session. By January 8, 1988, submit 2 copies of the abstract, 2 copies of the summary, and 1 copy each of the statement of preference and the slides or poster to: R. Christensen, Chairman, United States Papers Committee, Lawrence Livermore Laboratory, Post Office Box 808 L-338, Livermore, California 94550. Also, by February 8, 1988, submit 6 copies of the abstract, 6 copies of the summary, and 1 copy each of the statement of preference and slides or poster to: D. Caillerie, Secretary of the International Congress of Theoretical and Applied Mechanics 1988, Institut de Mecanique de Grenoble, Domain Universitaire, Boîte Postale 68, 38402 Saint Martin D'Heres Cedex, France.
Information: Further information may be obtained from the Congress Secretary at the above Grenoble address.

NEW AMS PUBLICATIONS

NONSTRICTLY HYPERBOLIC CONSERVATION LAWS

Barbara Lee Keyfitz and Herbert C. Kranzer, Editors
(Contemporary Mathematics, Volume 60)

The area of nonstrictly hyperbolic conservation laws is emerging as an important field, not only because it developed from applications of current interest, such as reservoir simulation, visco-elasticity, and multiphase flow, but also because the subject raises interesting mathematical questions of well-posedness, the structure of solutions, and admissibility criteria for weak solutions. The papers in this collection are based on talks presented at an AMS Special Session, *Nonstrictly hyperbolic conservation laws*, held in Anaheim, California, in January 1985.

Requiring some background in conservation laws, this collection will be of interest to research mathematicians working in the field of nonstrictly hyperbolic partial differential equations, as well as students who are learning the area and are looking for new applications and challenging problems in this field. The collection provides an overview of the field, examples of applications, descriptions of available techniques, and a bibliography of the literature.

Contents

S. S. Antman and R. Malek-Madani, *Waves in nonlinearly viscoelastic media*
M. Ben-Artzi, *The generalized Riemann problem in compressible duct flow*
M. Brio and C. C. Wu, *Characteristic fields for the equations of magnetohydrodynamics*
D. G. Ebin and R. A. Saxton, *The equations of incompressible elasticity*
J. Glimm and D. H. Sharp, *Elementary waves for hyperbolic equations in higher space dimensions: An example from petroleum reservoir modeling*
E. Harabetian, *Cauchy-Kovalesky theorems for hyperbolic systems of conservation laws with piecewise analytic initial data*
H. Hattori, *The entropy rate admissibility criterion and the double phase boundary problem*
B. L. Keyfitz, *Some elementary connections among nonstrictly hyperbolic conservation laws*
W. B. Lindquist, *The scalar Riemann problem in two spatial dimensions: Piecewise smoothness of solutions*
D. Marchesin, H. B. Medeiros and P. J. Paes-Leme, *A model for two phase flow with hysteresis*
C. S. Morawetz, *On the transonic flow past an airfoil*
M. Shearer, *Phase jumps near the Maxwell line*
M. Slemrod and V. Roytburd, *Measure-valued solutions to a problem in dynamic phase transitions*
B. Temple, *Degenerate systems of conservation laws*

1980 *Mathematics Subject Classifications*: 35B65, 35C99, 35L65, 35L67, 65M10, 73, 76N99, 76W05
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RESIDUES AND TRACES OF DIFFERENTIAL FORMS VIA HOCHSCHILD HOMOLOGY

Joseph Lipman, Editor
(Contemporary Mathematics, Volume 61)

Requiring some understanding of homological algebra and commutative ring theory, this book will give those who have encountered Grothendieck residues in geometry or complex analysis a better understanding of residues, as well as an appreciation of Hochschild homology. While numerous papers have treated the topic of residues from a variety of viewpoints, no books have addressed this topic. The author fills this gap by using Hochschild homology to provide a natural, general, and easily accessible approach to residues, and by identifying connections with other treatments of residues. Developing a theory of the Grothendieck symbol by means of elementary homological and commutative algebra, the author derives residues from a simple pairing between Hochschild homology and cohomology groups, and defines all concepts along the way. The author also establishes some functorial properties and

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introduces certain trace and cotrace maps with potential use in other contexts.

Contents

The residue homomorphism

Functorial properties

Quasi-regular sequences

Appendix A: Residues on algebraic varieties

Appendix B: Exterior differentiation

Trace and cotrace

1980 *Mathematics Subject Classifications*: 14-XX, 14F10, 32A27, 13D99, 16A61
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OPERATOR ALGEBRAS AND MATHEMATICAL PHYSICS

Palle E. T. Jorgensen and Paul S. Muhly, Editors

(Contemporary Mathematics, Volume 62)

This volume contains papers presented at the University of Iowa 1985 Summer Conference in honor of H.-J. Borchers, N. M. Hugenholtz, R. V. Kadison, and D. Kastler and gives a systematic, up-to-date treatment of the fruitful interaction that the last two decades have brought between operator algebras and mathematical physics. Special attention is paid to an overview of the algebraic approach to quantum field theory, and, in particular, to quantum statistical mechanics. More than half the papers culminate with a presentation of new results which have not appeared previously in journals, and, with a few exceptions, these new results are presented with complete proofs.

This book is addressed to graduate students and researchers working in a broad spectrum of areas in mathematics and mathematical physics. Functional analysis, operator algebras, operator theory, differential geometry, cyclic cohomology, K-theory, and index theory are applied to questions in the quantum theory of fields and statistical mechanics. The individual papers are self-contained, but the reader should have some familiarity with the basic concepts of functional analysis and operator theory, although no physics background is assumed.

Contents

I. Biographical Sketches
Klaus Fredenhagen, *A biographical sketch of Hans-Jurgen Borchers*
Marinus Winnink, *A biographical sketch of Nico M. Hugenholtz*
Erling Stormer, *A biographical sketch of Richard V. Kadison*
Rudolf Haag, *A biographical sketch of Daniel Kastler*

II. The algebraic approach to quantum theory of fields and statistical mechanics
Huzihiro Araki, *Bogoliubov automorphisms and Fock representations of the canonical anticommutation relations*
H. J. Borchers, *On the interplay between the spectral condition and locality in quantum field theory*
Klaus Fredenhagen, *The structure of local algebras of observables*
N. M. Hugenholtz, *How the C^*-algebraic formulation of statistical mechanics helps understanding the approach to equilibrium*
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Shoichiro Sakai, *Perturbations and KMS-states in C^*-dynamical systems (A generalization of the absence-theorems for phase transitions in continuous quantum systems)*

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Daniel Kastler, *$\mathbf{Z}/2$-graded cyclic cohomology within the differential envelope*
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Marc A. Rieffel, *Non-stable K-theory and non-commutative tori*

IV. Positivity in operator algebras
William Arveson, *Non-linear states on C^*-algebras*
Erling Stormer, *Cones of positive maps*
Jun Tomiyama, *On the geometry of positive maps in matrix-algebras*

V. Dynamical systems and derivations
Derek W. Robinson, *Differential operators on C^*-algebras*
Ola Bratteli, *Derivations and free group actions*
Ola Bratteli and Akitaka Kishimoto, *Automatic continuity of derivations on eigen-spaces*
Shoichiro Sakai, *Dynamics in continuous quantum systems*

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Joachim Cuntz and Nigel Higson, *Kuiper's theorem for Hilbert modules*

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Gerald W. Johnson and Michel L. Lapidus, *Feynman's operational calculus, generalized Dyson series and the Feynman integral*
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Edward G. Effros, *On multilinear completely bounded module maps*
Berndt Brenken, Joachim Cuntz, George A. Elliott and Ryszard Nest, *On the classification of non-commutative tori. III.*

VIII. Von Neumann algebras
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Richard H. Herman and Vaughn F. R. Jones, *Central sequences in crossed products*

1980 *Mathematics Subject Classifications*: 46LXX, 46L05, 46L60, 46L55; 46L10, 81E05, 82A15
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INTEGRAL GEOMETRY

Robert L. Bryant, Victor Guillemin, Sigurdur Helgason, and R. O. Wells, Jr., Editors
(Contemporary Mathematics, Volume 63)

The topic of integral geometry is not as well known as its counterpart, differential geometry. However, research in integral geometry has indicated that this field may yield as equally deep insights as differential geometry has into the global and local nature of manifolds and the functions on them. In 1984, an AMS-IMS-SIAM joint summer research conference on integral geometry was held at Bowdoin College. This volume consists of papers presented there.

The papers range from purely expository to quite technical and represent a good survey of contemporary work in integral geometry. Three major areas are covered: the classical problems of computing geometric invariants by statistical averaging procedures; the circle of ideas concerning the Radon transform, going back to the seminal work of Funck and Radon around 1916–1917; and integral-geometric transforms which are now being used in the study of field equations in mathematical physics. Some of these areas also involve group-representation theoretic problems.

Contents

Carlos A. Berenstein, *Spectral synthesis on symmetric spaces*
Ethan D. Bolker, *The finite random transform*
Edward G. Dunne, *Hyperfunctions in representation theory and mathematical physics*
David V. Finch and Alexander Hertle, *The exponential Radon transform*
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Richard S. Ward, *Non-linear integral transforms*
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THE LEGACY OF SONYA KOVALEVSKAYA

Linda Keen, Editor
(Contemporary Mathematics, Volume 64)

Sonya Kovalevskaya was a distinguished mathematician and considered by her contemporaries to be among the best of her generation. Her work, ideas and approach to mathematics are still relevant today, while her accomplishments continue to inspire women mathematicians.

The academic year 1985–86 marked the 50th anniversary of the Association for Women in Mathematics and the 25th anniversary of the Mary Ingraham Bunting Institute of Radcliffe College, Harvard University–both organizations that have enhanced women's role in mathematics. These two occasions provided a framework for a Kovalevskaya celebration, which included a symposium at Radcliffe College, and special sessions at the the AMS meeting in Amherst, Massachusetts, both in October 1985. The papers in this collection were drawn from those two events.

The first group of papers contains background material about Kovalevskaya's life and work, including a discussion of how she has been perceived by the mathematical community over the last century. The rest of the papers contain new mathematics and cover a wide variety of subjects in geometry, analysis, dynamical systems and applied mathematics. They all involve in one form or another Kovalevskaya's main areas of interest, differential equations and mathematical questions arising from physical phenomena.

Contents

Ann Hibner Koblitz, *Sofia Kovalevskaia: her life and work*
Roger Cooke, *Sonya Kovalevskaya's place in nineteenth century mathematics*
Ann Hibner Koblitz, *Changing views of Sofia Kovalevskaia*
Dennis M. Deturck and Carolyn S. Gordon, *Isospectral metrics and finite Riemannian coverings*
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Tilla Klotz Milnor, *A conformal analog of Bernstein's theorem for timelike surfaces in Minkowski 3-space*
Richard S. Palais and Chuu-lian Terng, *Geometry of canonical forms*
Jean Taylor, *Geometric analysis in crystalline media*
Chuu-lian Terng, *Some geometric developments related to Kowaleski's work*
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John W. Cahn and Jean E. Taylor, *An introduction to quasicrystals*
Enrico Bombieri and Jean E. Taylor, *Quasicrystals, tilings, and algebraic number theory: some preliminary connections*

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JORDAN ALGEBRAS IN ANALYSIS, OPERATOR THEORY, AND QUANTUM MECHANICS

Harald Upmeier
(CBMS Regional Conference Series, Number 67
Supported by the National Science Foundation)

This book is based on the CBMS Regional Conference held at the University of California, Irvine, on July 15–19, 1985. In recent years Jordan algebras have found interesting applications in seemingly unrelated areas of mathematics such as operator theory, the foundations of quantum mechanics, complex analysis in finite and infinite dimensions, and harmonic analysis on homogeneous spaces. The author describes some relevant results and puts them in a general framework, based on the concepts of JB-algebra and JB^*-triple.

Contents

JB-algebras and JB^*-triples
Bounded symmetric domains and JB^*-triples
Siegel domains and Cayley transformations
Geometry of Jordan structures and quantum mechanics
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Index theory for multivariable Toeplitz operators
Quantization of curved phase spaces

1980 *Mathematics Subject Classifications*:
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SOME MATHEMATICAL QUESTIONS IN BIOLOGY—PLANT BIOLOGY

Louis J. Gross and Robert M. Miura, Editors
(Lectures on Mathematics in the Life Sciences, Volume 18)

Distinguishing itself among other books on mathematics in plant biology, this book is unique because it presents a broad overview of how plant biologists are currently utilizing mathematics in their research, and is the only one to particularly emphasize plant ecology. Each article is unified by an attempt to tie models at one level of organization to an understanding at other levels. This approach strengthens the connections between theoretical development and observable biology, facilitating the testing of new predictions.

Intended for mathematicians, plant biologists and ecologists alike, this book requires only a basic knowledge of differential equations, linear algebra and mathematical modeling; a knowledge of plant biology is helpful. Readers will gain a perspective on what types of biological systems can benefit from mathematical treatment and an appreciation of the current important problems in plant biology.

Contents

Karl J. Niklas, *Computer simulations of branching-patterns and their implications on the evolution of plants*
Richard H. Rand and J. L. Ellenson, *Dynamics of stomate fields in leaves*
John H. M. Thornley and I. R. Johnson, *Modelling plant processes and crop growth*
Louis J. Gross, *Photosynthetic dynamics and plant adaptation to environmental variability*
Hal Caswell, *Matrix population models in the analysis of complex plant life cycles*
Jonathan Roughgarden, *The theoretical ecology of plants*

1980 *Mathematics Subject Classification*:
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CIRCADIAN RHYTHMS

Gail A. Carpenter, Editor
(Lectures on Mathematics in the Life Sciences, Volume 19)

The articles in this collection are based on lectures given at the 20th Annual Symposium on Some Mathematical Questions in Biology, held in May 1986, and sponsored jointly by the AMS, the Society for Industrial and Applied Mathematics and Section A of the American Association for the Advancement of Science. For the past thirty years, due particularly to the fundamental work of Pittendrigh, Aschoff, and Wever, theoretical analysis of circadian rhythms and sleep have gone hand in hand with experimental and clinical studies. Circadian rhythms have been investigated at levels ranging from cell fragments to humans, from biochemistry to behavior. This experimental diversity is reflected in a diversity of modeling approaches, several of which are represented in this collection. One class of models focuses on the circadian sleep and activity cycles of humans, for which some investigators postulate pacemaker systems with two coupled oscillators, while others propose single oscillator models. Other analyses focus upon the activity patterns of small vertebrates or upon anatomical data and physiological recordings. The mathematical formulations and analyses utilize nonlinear dynamical systems, stochastic models, and computer simulations. The articles in this volume discuss, analyze, and compare these various experimental, theoretical, and mathematical approaches.

Contents

Steven H. Strogatz, *A comparative analysis of models of the human sleep-wake cycle*
Domien G. M. Beersma, Serge Daan, and Derk Jan Dijk, *Sleep intensity and timing: A model for their circadian control*
Richard E. Kronauer, *Temporal subdivision of the circadian cycle*
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Gail A. Carpenter and Stephen Grossberg, *Mammalian circadian rhythms: A neural network model*
Rütger A. Wever, *Mathematical models of circadian one- and multi-oscillator systems*

1980 *Mathematics Subject Classifications*:
92A18, 65C20, 65H10
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YANG-MILLS FIELDS AND EXTENSION THEORY

Robert Pool
(Memoirs of the AMS, Number 358)

Efforts have been made toward transferring the theory of Yang-Mills fields on Minkowski space to geometric statements on ambitwistor space. This memoir describes several of the correspondences between analytic objects on Minkowski space and geometric ones on ambitwistor space. The author describes the curvature and current of Yang-Mills fields on Minkowski space as elements of cohomology groups over ambitwistor space, and shows that the Yang-Mills current corresponds to the third-order obstruction to extending the corresponding vector bundle.

Contents

Preliminaries
The basic fibrations
Minkowski space
Sheaves on $\mathbb{M}$
Further notation
Local coordinates

Basic ambitwistor results
Data on $\mathbb{M}$
Vector bundles on $\mathbb{A}$
The topology of the mapping σ
The relative deRham sequence on $\mathbb{G}$
Direct image sheaves
Direct image sheaves for vector bundles

The Penrose transform and the Ward correspondence
The ambitwistor transform
The generalized Ward correspondence

Extensions of bundles over $\mathbb{A}$
Preliminaries
Extensions of bundles over $\mathbb{A}$
Proof of lemma V.1

Curvature and current of a Yang-Mills field

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THE SELBERG TRACE FORMULA FOR $PSL_2(R)^N$

Isaac Y. Efrat
(Memoirs of the AMS, Number 359)

The Selberg trace formula relates the geometry of a symmetric Riemannian manifold, obtained as a quotient space, to the spectrum of its invariant differential operators. For certain applications one needs the formula evaluated explicitly, but to do so has proven quite involved and until recently has only been tractable for spaces of rank one. In this memoir the author addresses this need by providing an explicit trace formula suitable for such applications as Weyl laws and geodesic asymptotics. He evaluates the Selberg trace formula for all discrete, irreducible, cofinite subgroups of $PSL_2(\mathbf{R})^n$ by studying the spectral theory of the fundamental domain and analyzing the appropriate Eisenstein series. The Hilbert modular groups play a special role because they are related to the general case by a rigidity theorem, and also because of their inherent number theoretic interest. Aimed at those interested in automorphic forms, number theory, and spectral theory, this book requires only a basic knowledge of trace formulas on general symmetric spaces and discrete subgroups of $PSL_2(\mathbf{R})^n$.

Contents

The compact contribution to the trace
Discrete subgroups acting on H^n
A pre-trace formula
Contribution of the identity
Contribution of the elliptic elements
Centralizers of mixed elements
Contribution of the mixed elements
Equivalence classes of quadratic forms

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PATH FUNCTIONS AND GENERALIZED BASIC HYPERGEOMETRIC FUNCTIONS

Kevin W. J. Kadell
(Memoirs of the AMS, Number 360)

In this memoir the author obtains path functions and their basic properties by extending the constructive theory of partition generating functions developed by Sylvester, Durfee, Andrews, and others. Giving infinite families of generalizations of some basic hypergeometric summation formulas, he provides an interesting trade-off between complexity and rate of convergence. He adds one free parameter to the q-analog of the limiting form of Jackson's theorem to generalize that result.

Contents

Path functions
The constructive approach
Results for $(xq)_\infty$
The infinite products Π_N, $N \geq 0$
Separations
Expansions of Π_n, $N \geq 0$

1980 *Mathematics Subject Classifications*: 33A30, 05A15; 05A17, 11, 39B40, 41A25
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PREGROUPS AND BASS-SERRE THEORY

Frank S. Rimlinger
(Memoirs of the AMS, Number 361)

Pregroups carry the minimum amount of algebraic information needed to characterize equivalence of reduced words by interleaving. Thus free products with amalgamation and HNN extensions have natural pregroup structures, but little is known in general about the internal structure of arbitrary pregroups. This memoir reveals a direct connection between the universal group of a pregroup and the fundamental group of a graph of groups. The author shows that a group is free by finite if and only if it is the universal group of a finite pregroup, and that a finite pregroup with no nontrivial perfect square has free universal group. He also gives many examples exhibiting peculiarities in the internal structure of finite pregroups. This book is directed to those interested in combinatorial methods in groups theory, and will give those interested in groups acting on trees a new perspective. The exposition is at an introductory level and requires only a general knowledge of Bass-Serre theory.

Contents

The definition of a pregroup
The pregroups of finite height
The subpregroup of units
Pregroup actions and generating sets
A presentation for the universal group of a pregroup of finite height
A graph of groups structure for pregroups of finite height
A pregroup structure for graphs of groups of finite diameter

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STRUCTURE OF THE LEVEL ONE STANDARD MODULES FOR THE AFFINE LIE ALGEBRAS $B_\ell^{(1)}$, $F_4^{(1)}$ AND $G_2^{(1)}$

Marly Mandia

(Memoirs of the AMS, Number 362)

One of the most important problems in the representation theory of affine Kac-Moody algebras is the construction of their "standard" modules. This work gives a realization of all the level one standard modules for the affine Kac-Moody algebras $B_\ell^{(1)}$, $F_4^{(1)}$ and $G_2^{(1)}$ in the "principal picture" by constructing explicit bases of the vacuum spaces for the corresponding Heisenberg subalgebras. Viewing each such standard module V as a subspace of a basic module for an affine Lie algebra of type D or E, the author obtains generalized anticommutation relations for the Z_v-algebra. For the level one standard $F_4^{(1)}$ and $G_2^{(1)}$-modules, the author also uses the generalized commutation relations for the Z_v-algebras obtained by J. Lepowsky and R. L. Wilson, as well as the principal character of the vacuum spaces and the classical Rogers-Ramanujan identity.

Contents

Preliminaries
Structure of the standard $\tilde{B}_\ell$-modules of level one
Structure of the standard $\tilde{G}_2$-modules of level one
Structure of the standard $\tilde{F}_4$-modules of level one

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ALGEBRA, MATHEMATICAL LOGIC, NUMBER THEORY, TOPOLOGY

I. M. Vinogradov et al.

(Proceedings of the Steklov Institute, Volume 168)

This volume is the first in a series of collected survey articles to celebrate the Fiftieth Anniversary of the Steklov Mathematical Institute. The important trends and problems in mathematics that were pursued at the institute, in the areas of number theory, algebra, logic, and topology are highlighted in this publication. Subsequent volumes will survey other mathematical areas.

Contents

I. M. Vinogradov and A. A. Karatsuba, *The method of trigonometric sums in number theory*
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D. K. Faddeev, *Galois theory (in the Steklov Mathematical Institute of the Academy of Sciences)*
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Personal Items

Paul S. Fan has been appointed to assistant professor at the University of Arizona.

Kathryn E. Hare has been appointed to assistant professor at the University of Alberta.

William G. McCallum has been appointed to assistant professor at the University of Arizona.

James S. Muldowney of the University of Alberta has been awarded a 1986 Rutherford Prize for excellence in teaching by the University of Alberta.

Katherine Pedersen, associate professor of mathematics at Southern Illinois University at Carbondale, has been awarded that institution's Great Teacher Award at its annual Alumni Recognition Luncheon.

Arturo J. Pianzola has been appointed to assistant professor at the University of Alberta.

Gordon E. Swaters has been appointed to assistant professor at the University of Alberta.

Joseph F. Traub, professor and chairman of computer science at Columbia University, has been appointed president of Consortium for Scientific Computing and professor of computer science at Princeton University.

Lai-Sang Young has been appointed to associate professor at the University of Arizona.

M. Michael Yovanovich of the University of Waterloo, Waterloo, Ontario, has been named a Fellow of the American Society of Mechanical Engineers.

Deaths

Paul Belgodère, former president of the Société Mathématique de France, died on September 27, 1986, at the age of 65. He was a member of the Society for 37 years.

Omar Catunda of Salvador, Brazil, died on August 12, 1986, at the age of 79. He was a member of the Society for 39 years.

Howard L. Jackson of McMaster University, Hamilton, Canada, died on January 26, 1986, at the age of 52. He was a member of the Society for 25 years.

Carey M. Jensen, former professor of mathematics at Mankato State University, Minnesota, and Augustana College, Illinois, died on October 6, 1986, at the age of 91. He was a member of the Society for 61 years.

Irving Reiner of the University of Illinois died on October 28, 1986, at the age of 62. He was a member of the Society for 41 years.

Visiting Mathematicians

(Supplementary List)

Mathematicians visiting other institutions during the 1986-1987 academic year have been listed in recent issues of *Notices*: June 1986, pages 569–571; August 1986, pages 672-673; October 1986, pages 851-852; and November 1986, page 975. The listing below gives the name and home country, the host institution, period of visit, and field of special interest of additional visiting mathematicians.

David Assaf (Israel), University of Arizona, August 1986 to June 1987, statistics, stochastic models.

Andrew Bernoff (England), University of Arizona, August 1986 to June 1987, computational science.

Jean-Guy Caputo (France), University of Arizona, August 1986 to June 1987, fluid mechanics and dynamical systems.

Roger Eggleton (England), University of Arizona, January 1987, number theory.

Jean Pierre Françoise (France), University of Arizona, August 1986 to June 1987, algebraic geometry.

Ulrich Hornung (West Germany), University of Arizona, January 1987 to February 1987, numerical analysis.

Arieh Iserles (England), University of Arizona, August 1986 to June 1987, numerical analysis.

Closed Geodesics on Riemannian Manifolds

Wilhelm Klingenberg

This book contains expository lectures from the CBMS Regional Conference held at the University of Florida, August 2–6, 1982.

Contents

1. The Hilbert manifold of H^1-curves
2. The loop space and the space of closed curves
3. The second order neighborhood of a critical point

Appendix. The S^1- and the Z_2-action on ΛM

4. Closed geodesics on spheres
5. On the existence of infinitely many closed geodesics

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New Members

Beginning with this issue, *Notices* will, on a regular basis, list the newly elected members of the American Mathematical Society. This list will include ordinary members, nominees of institutional members, and reciprocity members, as well as new institutional and corporate members. The following individuals have been elected to membership.

Ordinary

Josefina Alvarez
Florida Atlantic University
Boca Raton, Florida

Russell I Barnard
Analog Devices
Norwood, Massachusetts

Wayne D Blizard
4227 Cedarglen Road
Victoria V8N 4N7
British Columbia, Canada

M V Bodnarescu
Baumbluete 4
D4300 Essen (1)
Federal Republic of Germany

Daryl Cooper
University of Minnesota
Minneapolis, Minnesota

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CSCI
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Theodore H Einwohner
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Kasetsart University
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Utah State University
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Erie, Pennsylvania

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Australian Mathematical Society
David Elliott

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Deutsche Mathematiker-Vereinigung E. V.
Werner Haussmann
Egon Schulte

Indian Mathematical Society
Udit N Singh

Islenzka Staerdfraedafelagid
Jon I Magnusson
Ragnat Sigurdsson

London Mathematical Society
Alan L T Paterson
Anthony J Scholl

Mathematical Society of Japan
Masatoshi Enomoto
Osamu Hatori
Ryuichi Ito
Shyuichi Izumiya
Yasuo Matsushita
Nobukazu Otsuki

Osterreichische Mathematische Gesellschaft
Friedrich Haslinger

Real Sociedad Matematica Espanola
Antonio Martinon

Sociedad de Matematica de Chile
Hernan R Henriquez
Peter D Miletta

Societat Catalana de Ciencies Fisiques Quimiques i Matematiques
Francisco Guillen
Pere Pascual-Gainza

Southeast Asian Mathematical Society
Kar-Ping Shum

Unione Matematica Italiana
Giovanni Gallavotti

Wiskundig Genootschap
Jan De Lange
Ruud Pelliuaan

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.

William A. Veech has been appointed to the ad hoc *Committee on Institutional Membership* by then Chairman of the Board, Frederick W. Gehring.

Kyu Park was appointed by Ex-President Irving Kaplansky to be a Teller for the election of 1986.

Donald G. Aronson (1988) and Jerry Kaminker (1988) have been appointed by Ex-President Irving Kaplansky to the *Committee to Select Hour Speakers for Central Sectional Meetings.* Nancy K. Stanton (1987) has been appointed chairman. Continuing members of the committee are Robert M. Fossum (ex officio) and Jeffrey D. Vaaler (1987).

Richard H. Herman (1988), Lesley M. Sibner (1988), and Thomas Crawford Spencer (1988) have been appointed by Ex-President Irving Kaplansky to the *Committee to Select Hour Speakers for Eastern Sectional Meetings.* Roger Keith Dennis (1987) has been appointed chairman. Continuing members of the committee are Joel M. Cohen (1987) and W. Wistar Comfort (ex officio).

Ex-President Irving Kaplansky appointed Heinz-Otto Kreiss (1988) to the *Committee to Select Hour Speakers for Far Western Sectional Meetings.* Continuing members of the committee are Hugo Rossi (ex officio), Murray M. Schacher (1988), Gary M. Seitz (1987), and Ronald J. Stern (1987), chairman.

Jon F. Carlson (1988) and Frank S. Quinn III (1988) were appointed by Ex-President Irving Kaplansky to the *Committee to Select Hour Speakers for Southeastern Sectional Meetings.* John J. Walsh (1987) was appointed chairman. Continuing members of the committee are J. Thomas Beale (1987) and Frank T. Birtel (ex officio).

Jerome A. Goldstein (1989) and Gail S. Young (1989) were appointed and Robert R. Phelps (1989) was reappointed by Ex-President Irving Kaplansky to the *Committee on Academic Freedom, Tenure, and Employment Security.* Continuing members are Shoshichi Kobayashi (1987), Vera S. Pless (1987), and Halsey L. Royden (1988), chairman.

Ex-President Irving Kaplansky reappointed Stefan A. Burr (1989) and appointed David J. Lutzer (1989) to the *Committee on Employment and Educational Policy.* Other members of the committee are Edward A. Connors (1988), Philip C. Curtis, Jr., (1987), Donald C. Rung (1987), chairman, and Audrey A. Terras (1988).

Bettye Ann Case (1989), Patrick X. Gallagher (1989), and Herman R. Gluck (1989) were appointed by Ex-President Irving Kaplansky to the *Committee on Human Rights of Mathematicians.* Charles Herbert Clemens (1987) was appointed chairman. Continuing members of the committee are Leon A. Henkin (1988), Neil I. Koblitz (1988), and Seymour Schuster (1987).

Ex-President Irving Kaplansky appointed Linda Keen (1989) to the *Committee on Professional Ethics.* C. Edmund Burgess (1987) was appointed chairman. Other members of the committee are Judith V. Grabiner (1987), Paul R. Halmos (1988), and Anneli Lax (1988).

Jeanne W. Kerr (AMS, 1989), Suzanne Marie Lenhart (AMS, 1989), and Bhama Srinivasan (AMS, 1989) were appointed by Ex-President Irving Kaplansky to the joint AMS-ASA-IMS-MAA-NCTM-SIAM *Committee on Women in the Mathematical Sciences.* Continuing members of the committee are Nancy Angle (NCTM, 1987), Susan J. Devlin (ASA), Marjorie Enneking (NCTM, 1989), Susan Geller (AMS, 1987), Marjorie G. Hahn (IMS), Carole B. LaCampagne (AMS, MAA, 1987), Jeanne LaDuke (MAA, 1989), Betty K. Lichtenberg (NCTM, 1988), Joyce R. McLaughlin (SIAM, 1987), Ingram Olkin (IMS), Linda Petzold (SIAM, 1986), Alice T. Schafer (MAA, 1988), Elizabeth L. Scott (IMS). NCTM members terms expire on April 30.

Courtney S. Coleman (AMS, 1989), L. G. Makar-Limanov (AMS, 1989), and Paul G. Nevai (AMS, 1989) were appointed by Ex-President Irving Kaplansky to the joint AMS-ASL-IMS *Committee on Translations from Russian and Other Slavic Languages.* Continuing members of the AMS subcommittee are Michael I. Brin (1987), Charles V. Coffman (1988), Allen Devinatz (1988), Igor Dolgachev (1987), Richard Ericson (1987), Vladislav V. Goldberg (1988), John R. Isbell (1988), Dmitry Khavinson (1987), Boris M. Schein (1987), chairman. The ASL subcommittee members are Vladimir Lifschitz (1987), Elliott Mendelson, chairman, Gregory Minc (1987) and B. F. Wells. The IMS subcommittee members are Eugene Dynkin, chairman, B. Pittel, A. Rukhin, and W. J. Studden.

Ex-President Irving Kaplansky (AMS), President Ronald Pyke (IMS), and President Gene H. Golub (SIAM) appointed James W. Daniel (SIAM, 1988), Martin Golubitsky (SIAM, 1988), and James I. Lepowsky (AMS, 1988) to the joint AMS-IMS-SIAM *Committee on Joint Summer Research Conferences in the Mathematical*

Sciences. Continuing members of the committee are William B. Arveson (AMS, 1987), chairman, Ronald L. Graham (AMS, 1987), John R. Martin (AMS, 1987), Tilla Klotz Milnor (1987), Evelyn Nelson (AMS, 1987), and Ingram Olkin (IMS, 1988).

Wendell H. Fleming, Gilbert Strang, and Hans F. Weinberger have been appointed to the joint AMS-SIAM *Committee to Select the Winner of the Birkhoff Prize for 1988* by Ex-President Irving Kaplansky (AMS) and President Gene Golub (SIAM). Professor Weinberger will serve as chairman.

Reports of Past Meetings

The October Meeting in Logan

The eight hundred and twenty-eighth meeting of the American Mathematical Society was held at Utah State University in Logan, Utah on Friday and Saturday, October 10–11, 1986. There were 122 registrants, including 106 members of the Society.

Invited Addresses. By invitation of the Committee to Select Hour Speakers for Far Western Sectional Meetings, there were two invited addresses as follows. PETER LI of the University of Utah spoke on *Harmonic functions on complete manifolds.* He was introduced by Michael Anderson. KENNETH C. MILLET of the University of California, Santa Barbara spoke on *New combinatorial methods in three dimensional topology.* He was introduced by Steven Bleiler.

Special Sessions. By invitation of the same committee, there were five special sessions of selected papers. The topics of these sessions, the names and affiliations of the organizers, and a list of the speakers is as follows:

Analysis on Manifolds, S. Y. CHENG, University of California, Los Angeles. The speakers were: Michael Anderson, Hui-Dona Cao, C. K. Han, Douglas Moore, V. Oliker, Luen-Fai Tam, Andrejs Treibergs, Johan Tysk, and S. W. Wei.

Applications and Computational Aspects of Numerical Continuation Methods, EUGENE ALLGOWER, Colorado State University. The speakers were: Eusebius Doedel, Kurt Georg, Baker Kearfott, T.-Y. Li, Hans Mittelmann, Alexander Morgan, Roy Plastock, Aubrey Poore, Jon Tavantzis, Chris Tiahrt, and Layne Watson.

Geometric Topology, DAVID WRIGHT and JIM CANNON, Brigham Young University. The speakers were: Colin Adams, Ric Ancel, Mladen Bestvina, P. L. Boweres, John Bryant, Ed Burgess, Jim Cannon, Bill Eaton, David Gabai, Dennis Garity, Matt Grayson, C. F. Ho, Jim Hoste, Stephen Humphries, Chris Lacher, Duane Loveland, Jerry Levine, V. T. Liem, John Luecke, Gordana Matic, Yoav Moriah, Josef Przytycki, Dale Rolfson, T. Benny Rushing, Martin Scharlemann, Jon Simon, Mike Starbird, Keith Wolcott, and David Wright.

Random Fields, Random Measures and Applications, ED WAYMIRE, Utah State University. The speakers were: Kenneth S. Alexander, Florin Avram, Rabi N. Bhattyacharya, D. Brennan, Robert M. Burton, Colleen Cutler, Richard Darling, S. N. Ethier, Marie M. Franzoso, Evarist Gine, Charles M. Newman, Mina Ossiander, Richard F. Serfozo, Winfried Stute, Ed Waymire, and Stanley C. Williams.

Representations of Reductive Groups, DAVID COLLINGWOOD, University of Oregon. The speakers were: Brian Boe, J. Chang, Devra Garfinkle, Henryk Hecht, R. Irving, J. Johnson, Dragan Miličič, Ivan Mirkovic, Thomas Przbinda, Hugo Rossi, R. Scaramuzzi, Brad Shelton, Peter Trombi, and Joseph Wolf.

Contributed Papers. There were also two sessions for contributed ten-minute papers, of one and three papers respectively.

Hugo Rossi
Salt Lake City, Utah — Associate Secretary

LIE ALGEBRAS AND RELATED TOPICS

D. J. Britten, F. W. Lemire, and R. V. Moody, Editors

As the Proceedings of the 1984 Canadian Mathematical Society's Summer Seminar, these papers focus on some recent advances in the theory of semisimple Lie algebras and some direct outgrowths of that theory. Of particular interest are notes for several courses presented at the meeting: an important survey article by R. Block and R. Wilson on restricted simple Lie algebras, a survey of universal enveloping algebras of semisimple Lie algebras by W. Bohro, a course on Kac-Moody Lie algebras by I. G. Macdonald, and a course on formal groups by M. Hazewinkel.

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The Department of Mathematics at Boston University anticipates an opening for an Assistant Professor in Fall 1987. Preference given to applicants in Applied Mathematics, Dynamical Systems, Statistics and related fields. Women and minorities are encouraged to apply. Send vita and three letters of reference to: Search Committee, Department of Mathematics, Boston University, 111 Cummington Street, Boston, MA 02215.

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Senior level appointment in Mathematical Statistics anticipated for Fall 1987. Record of distinguished achievements in research, commitment to excellence in teaching required. Women, minorities esp. encouraged to apply. Send nominations and applications to: Search Committee, Department of Mathematics, 111 Cummington Street, Boston University, Boston, MA 02215.

Associate or Assistant Professor position in Probability is anticipated for Fall 1987. Demonstrated excellence in research and a strong commitment to teaching at the graduate and undergraduate level required. Candidates with established research records as well as new Ph.Ds are encouraged to apply. Women and minorities are especially encouraged to apply. Send vita and three letters of reference to: Professor Murad Taqqu, Probability Position, Department of Mathematics, 111 Cummington Street, Boston University, Boston, MA 02215.

Northern Kentucky University

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Northern Kentucky University, founded in 1968, has a student body of 9000, and is located just 7 miles from downtown Cincinnati, Ohio. Greater Cincinnati, with its rich cultural heritage, is an excellent place to live.

Candidates must have an earned doctorate in one of the mathematical sciences or computer science, a strong undergraduate teaching record and demonstrated academic leadership.

Applicants should submit a curriculum vitae and three letters of recommendation to:

Daniel Curtin, Chair
Search Committee
Department of Mathematical Sciences
Northern Kentucky University
Highland Heights, KY 41076

Review of applications will begin February 1, 1987 and continue until the position is filled. The anticipated appointment date is July 1, 1987.

Northern Kentucky University is an Affirmative Action/Equal Opportunity Employer and actively seeks the candidacy of minorities and women.

POSITIONS AVAILABLE

DARTMOUTH COLLEGE
Assistant Professor of Mathematics

The Department of Mathematics and Computer Science expects to have a three-year tenure-track assistant professorship available for fall of 1987. New PhD's must show exceptional promise in teaching and research. More advanced candidates should also have a strong research program and a reputation for excellent work. Tenure would normally be considered in the sixth year of the appointment, but it may be possible to arrange somewhat earlier tenure consideration for candidates with an exceptional postdoctoral record. Research in algebra (including algebraic geometry and algebraic number theory) is of most interest, followed by combinatorics, probability and topology; applications are welcome in all fields. Assistant professors teach four ten-week courses spread over two or three quarters and may supervise graduate students. Send letter of application, statement of research accomplishments and plans, graduate transcript, résumé and four letters of recommendation to Recruiting Committee Chair, Department of Math and CS, Bradley Hall, Hanover, NH 03755. Applications received by Jan. 31 receive first consideration. Dartmouth College is committed to affirmative action and strongly encourages women and minorities to apply.

DEPARTMENT OF MATHEMATICS & COMPUTER SCIENCE
RUTGERS UNIVERSITY AT NEWARK

The Department of Mathematics and Computer Science anticipates several tenure track assistant and associate professorships, as well as one one-year visiting research lecturer at the rank of associate or full professor to begin September 1987. Candidates should exhibit strong research accomplishments or potential. Salary and teaching load are negotiable.

Applicants from all fields are invited. Areas of research interest in the department include number theory, representation theory and automorphic forms, combinatorics and logic, topology, and low dimensional topology and Teichmüller theory.

Candidates should send a resume and have three references write to:

Jane Gilman, Chair
Department of Mathematics & Computer Science
Rutgers – The State University
Newark, New Jersey 07102

The closing date for applications is January 15, 1987. However, late applications will be accepted until the position is filled. Rutgers University is an equal opportunity, affirmative action employer.

Applications are invited for a tenure-track position in Mathematics at Bard College for the Fall of 1987. Bard is a Liberal Arts College with a young and expanding Mathematics Department. We are seeking someone with a strong interest in building an innovative mathematics program in a liberal arts context. Candidates must have a Ph.D. by the Fall of 1987 and a commitment to teaching and continued mathematical activity. To apply, submit a resume, a statement of teaching and research interests, and 3 letters of recommendation (at least one concerning teaching) to Prof. Ethan Bloch, Mathematics Search Committee, Box 91, Bard College, Annandale-on-Hudson, NY 12504. Deadline for applications is January 15, 1987; late applications will be considered until the position is filled. Bard College is an AA/EOE.

DEPARTMENT OF MATHEMATICS & COMPUTER SCIENCE
RUTGERS UNIVERSITY AT NEWARK
PROFESSOR OF MATHEMATICS

The Department of Mathematics and Computer Science anticipates an opening at the Rank of Professor beginning Fall 1987. Candidates should exhibit strong research accomplishments. Salary and teaching load are negotiable.

Applicants from all fields are invited. Areas of research interest in the department include number theory, representation theory and automorphic forms, combinatorics and logic, topology, and low dimensional topology and Teichmüller theory.

Candidates should send a resume and the names of three references to:

Jane Gilman, Chair
Department of Mathematics & Computer Science
Rutgers – The State University
Newark, New Jersey 07102

The closing date for applications is January 15, 1987. However, late applications will be accepted until the position is filled. Rutgers University is an equal opportunity, affirmative action employer.

ALLEGHENY COLLEGE
DEPARTMENT OF MATHEMATICS
MEADVILLE, PA 16335

Tenure-track positions in an expanding department are available beginning in September 1987. Applicants should have a PhD in mathematics and strong commitments to the teaching of undergraduate students and to continued professional development. Rank and salary are competitive and commensurate with qualifications and experience. Fringe benefits include TIAA-CREF, health and life insurance, full tuition benefits for family, and IBM PC's in faculty offices. There may also be a sabbatic replacement position open to persons with at least a Master's degree and teaching experience.

Screening of applicants will begin December 1, and continue until all positions are filled. Send application, graduate transcripts, and three letters of recommendation to Ronald E. Harrell, Search Committee Chairperson. Early applicants should also indicate whether they plan to attend the Joint Mathematics Meetings in San Antonio. Allegheny College is an Equal Opportunity Employer.

The Ohio State University
CHAIR IN NUMERICAL ANALYSIS AND SCIENTIFIC COMPUTATION

The Department of Mathematics has been awarded a Chair in Numerical Analysis and Scientific Computation. Applications are invited from individuals with outstanding credentials in any area of applied mathematics whose research activities make significant use of large scale computing. The appointee will hold the academic rank of Professor of Mathematics and will be expected to provide the academic leadership in the developing field of scientific computation at Ohio State.

Individuals interested in this position should contact

Joseph Ferrar, Chairman
Department of Mathematics
The Ohio State University
231 W. 18th Avenue
Columbus, Ohio 43210
Telephone: 614/422-7173

The Ohio State University is an Equal Opportunity/Affirmative Action Employer.

POSITIONS AVAILABLE

THE GEORGE WASHINGTON UNIVERSITY DEPARTMENT OF MATHEMATICS

Applications are invited for one or more tenure track positions at the Assistant Professor level beginning September 1987. Candidates must have a Ph.D. in Mathematics, a serious commitment to excellence in teaching, and must give evidence of strong research potential in the areas of Logic, Combinatorics, or Applied Mathematics. Applicants should send vita, statement of current research activities, and three letters of recommendation to: H. D. Junghenn, Chairman, Department of Mathematics, George Washington University, Washington, D.C. 20052. Applications will be accepted until February 15, 1987. The George Washington University is an Equal Opportunity Educational Institution/Affirmative Action Employer.

U. S. NAVAL ACADEMY Department of Mathematics

Applications are invited for several tenure-track appointments at the rank of Assistant or Associate Professor commencing in January or August of 1987. The initial salary will be competitive and commensurate with experience and qualifications. Research opportunities exist for augmenting salary during the summer intersessional period. Specialization in applied mathematics or operations research is of particular interest. Applicants must possess an earned Ph.D. by the date of appointment, have a commitment to excellence in teaching, and be capable of pursuing an independent program of research. Inquiries and applications should be sent to Prof. J. M. D'Archangelo, Mathematics Department, U. S. Naval Academy, Annapolis, Maryland 21402-5002. Required of all applicants are a resume, transcripts of academic records, and at least three letters of recommendation from persons familiar with the applicant's teaching and research. Interviews will be conducted at the annual AMS/MAA meeting in San Antonio in January. The Naval Academy is an EO/AA employer

NORTH CAROLINA STATE UNIVERSITY DEPARTMENT OF MATHEMATICS

Beginning July 1, 1987, junior level tenure track positions are available in applied analysis (PDE, dynamical systems, optimal control).

Applicants must have a Ph.D. in Mathematics and have a strong record or potential in both research and instruction. Send a resumé, relevant reprints, thesis abstract, and three letters of reference to Professor R. H. Martin, Search Committee Chairman, Department of Mathematics, Box 8205, North Carolina State University, Raleigh, North Carolina 27695-8205.

North Carolina State University is an Affirmative Action and Equal Opportunity Employer.

NORTH CAROLINA STATE UNIVERSITY DEPARTMENT OF MATHEMATICS

Beginning July 1, 1987, junior level tenure track positions are available in algebra and geometry. Candidates should have a Ph.D. in Mathematics and have a strong record or potential in both research and instruction. Send resumé, relevant reprints, thesis abstract and three letters of reference to Professor M. F. Singer, Search Committee Chairman, Department of Mathematics, Box 8205, North Carolina State University, Raleigh, North Carolina 27695-8205.

North Carolina State University is an Affirmative Action and Equal Opportunity Employer.

COLLEGE OF CHARLESTON DEPARTMENT OF MATHEMATICS

Applications are invited for at least 3 tenure-track positions at the Assistant Professor level beginning August 1987, at least one of which is in an applied area. Candidates must have a Ph.D. in one of the mathematical sciences, a commitment to undergraduate teaching, and potential for continuing research. The normal teaching load is 9 hrs/wk for those engaged in research. The salary is competitive. Internal grants for release time or financial support for research projects are available as is travel support. Applicants should send a vita and have three letters of recommendation sent to William L. Golightly, Chairman, Department of Mathematics, College of Charleston, Charleston, SC 29424. The process of evaluating applications will begin on January 15, 1987, but applications will be considered until the positions are filled. The College of Charleston is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF SOUTH FLORIDA Department of Mathematics

Tenure-track teaching and research positions are available beginning August 1987. Applicants must possess a Ph.D. degree. Applicants specializing in Approximation Theory, Computer Science, Control Theory, Differential Equations, Logic, Numerical Analysis, Probability, or Statistics are preferred. Rank and salary will depend on credentials. To apply send curriculum vitae and have three letters of recommendation sent to Kenneth L. Pothoven, Chairman, Tampa, FL 33620-5700. Application Deadline: Feb 10, 1987. The University of South Florida is an equal opportunity employer.

NEW COLLEGE OF USF

Tenure-earning position at assistant professor level anticipated for Fall, 1987. Ph.D. in Mathematics or Applied Mathematics, commitment to excellence in teaching and scholarship required. New College is a small, highly selective liberal arts college with a faculty/student ratio of 1:8, recently ranked eighth in U. S. in proportion of graduates successfully completing Ph.D. (Chron. Higher Educ., 8/7/85). The program stresses student independent study and research, and close student-faculty interaction. Send application with résumé, three letters of reference, and statement on teaching philosophy and research interests to Prof. Soo Bong Chae, Division of Natural Sciences, New College of USF, Sarasota, FL 34243-2197. Deadline for applications is 2/1/87. EO/AA employer.

THE UNIVERSITY OF ALABAMA MATH FACULTY POSITIONS

The Mathematics Department expects approximately three vacancies beginning August 16, 1987, contingent upon funding. Will probably hire at the rank of assistant professor, but applicants with qualifications for higher rank will be considered. Applicants should have or reasonably expect to have by August 16, a Ph.D. or the equivalent. Excellence in both teaching and research required. Will consider applicants in all areas, particularly applied math and topology. Applications invited both for tenure track and visiting positions. (Each position may be filled either way.) Women and minorities particularly encouraged to apply. A curriculum vita, reprints and/or preprints, and at least three letters of recommendation should be sent to: Search Committee, Box 1416, Tuscaloosa, AL 35487-1416. THE UNIVERSITY IS AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER.

POSITIONS AVAILABLE

AUBURN UNIVERSITY
Department of Algebra, Combinatorics and Analysis

The department expects to make one or more tenure track appointments beginning September 1987 in each of the following areas: algebra (abelian groups, ring theory, module theory, with emphasis on non-Artinian) combinatorics (candidates with extensive knowledge of computer science); probability; ordinary differential equations or partial differential equations; numerical analysis. Rank open, salary negotiable. Additional visiting positions expected in these and other areas.

Send resume and arrange for three letters of reference to be sent to James R. Wall, Division of Mathematics, Auburn University, AL 36849.

AUBURN UNIVERSITY IS AN EQUAL OPPORTUNITY AFFIRMATIVE ACTION EMPLOYER.

UNIVERSITY OF SOUTHERN MISSISSIPPI DEPARTMENT OF MATHEMATICS

Applications are invited for three tenure-track positions, one of which may be at a senior rank. Candidates must have the Ph.D. in mathematics, serious research interests, and a dedication to teaching. Preference will be given to those candidates whose research interests complement those of the current faculty. These interests include algebra, combinatorics, differential geometry, graph theory, linear algebra, and mathematical physics. We are also interested in developing a research base in numerical analysis and differential equations. Success in attracting external funding to support basic and/or applied research, though not required, will enhance the application.

The normal teaching load is 6-9 credit hours per semester (15-16 per academic year), including both undergraduate and graduate courses. The successful applicant will be expected to establish an active mathematical research program and to participate in the usual faculty service activities (e.g., advisement, curriculum development, committee assignments).

The salary is negotiable and competitive, dependent upon qualifications. The starting date will be Fall, 1987-88. While the application deadline is open, selection may begin as early as 2/1/87. Interviews will be conducted at the 93rd Annual Meeting of the AMS, January 21–24, 1987, in San Antonio, TX. Candidates should contact the Department prior to January 16 to schedule interviews of duration longer than those available through the MSER.

The University of Southern Mississippi is one of the State's three designated comprehensive universities, with an on-campus enrollment of 10,000+. The Department has 25 full-time faculty members and offers the B.S., B.A., and M.S. degrees in mathematics. We also offer the course work to support the Ph.D. in secondary education with mathematics as a specialization area. Hattiesburg is a city of about 45,000 people in the pine-forested, rolling hills just 70 miles north of the beautiful and bustling Mississippi Gulf Coast. Outdoor recreational opportunities are abundant. The white sands and emerald water of the Florida Gulf Coast are just a few hours away, while New Orleans is within an easy two-hour drive. The climate is subtropical, with mild winters. The average daily high in January is 65°F. Early spring produces an astounding display of color from the indigenous azalea, dogwood and magnolia.

Send résumé and three letters of recommendation to: Chair, Search Committee, Department of Mathematics, University of Southern Mississippi, Hattiesburg, MS, 39406-5045. The University of Southern Mississippi is an affirmative action, equal opportunity employer. Applications from women and minority group members are encouraged.

CENTRE COLLEGE MATHEMATICS POSITION

Applications are invited for a tenure-track position at the rank of instructor or assistant professor, beginning September, 1987. A Ph.D (or the early anticipation of one) is required. The position requires the teaching of a wide range of undergraduate courses and a strong commitment to liberal arts education. The ability to teach mathematical statistics or computer programming is desirable. Letters of application, résumés, transcripts and three letters of reference should be sent to Dean Leonard DiLillo, Centre College, Danville, KY 40422. Centre College is an AA/EOE

The Ohio State University Department of Mathematics

The Department of Mathematics of The Ohio State University hopes to fill several positions, both visiting and permanent, effective Autumn Quarter 1987. Candidates in all areas of applied and pure mathematics are invited to apply. Significant research accomplishments or exceptional research promise, and evidence of good teaching ability, will be expected of successful applicants.

Please send credentials and have letters of recommendation sent to Professor Joseph Ferrar, Department of Mathematics, The Ohio State University, 231 W. 18th Avenue, Columbus, Ohio 43210. Reviews of resumes will begin immediately.

The Ohio State University is an Equal Opportunity/Affirmative Action Employer.

The Ohio State University Department of Mathematics

Research Instructorships in Mathematics

Applications are invited for the position of research instructor in mathematics for the academic year 1987-88. Candidates should hold a Ph.D. (or equivalent) in mathematics and show strong research promise.

Please send credentials and have letters of recommendation sent to Professor Joseph Ferrar, Department of Mathematics, The Ohio State University, 231 W. 18th Avenue, Columbus, Ohio 43210. The Ohio State University is an Equal Opportunity/Affirmative Action Employer.

FACULTY APPOINTMENTS

The Department of Mathematical Sciences at The Johns Hopkins University invites applications for junior (tenure-track) and senior (tenured) appointments, effective Fall 1987, in the area of operations research, broadly defined. Specializations of particular interest include (but are not limited to) decision science, mathematical programming, network flows, combinatorial optimization, algorithms, numerical methods, discrete mathematics, and large-scale systems. Candidates should be active researchers having outstanding accomplishments or demonstrated potential in research, teaching and/or innovative applications. Interested persons are asked to send their vitas to

Professor Robert J. Serfling, Chairman
Department of Mathematical Sciences
The Johns Hopkins University
Baltimore, Maryland 21218

Junior applicants are asked also to write describing their professional interests and aspirations, and to have three letters of reference sent; recent or new Ph.D.'s are asked also to furnish official university transcripts.

The Johns Hopkins University is an Equal Opportunity/Affirmative Action Employer. Employment is offered without discrimination on the basis of race, color, religion, sex or national origin.

POSITIONS AVAILABLE

The Ohio State University
CHAIR IN NUMERICAL ANALYSIS AND SCIENTIFIC COMPUTATION

The Department of Mathematics has been awarded a Chair in Numerical Analysis and Scientific Computation. Applications are invited from individuals with outstanding credentials in any area of applied mathematics whose research activities make significant use of large scale computing. The appointee will hold the academic rank of Professor of Mathematics and will be expected to provide the academic leadership in the developing field of scientific computation at Ohio State.

Individuals interested in this position should contact

Joseph Ferrar, Chairman
Department of Mathematics
The Ohio State University
231 W. 18th Avenue
Columbus, Ohio 43210
Telephone: 614/422-7173

The Ohio State University is an Equal Opportunity/Affirmative Action Employer.

Tenure-track, possibly senior, positions anticipated to begin August 15, 1987. Outstanding research record and/or proven research potential and teaching excellence required. Preferred areas: statistics and numerical methods, but candidates in areas of global analysis, dynamical systems, control theory, probability and functional analysis will also be considered for junior positions. Women and minority groups candidates are especially encouraged to apply. Visiting positions most likely in the area of applications of probability and graph theory to chemistry. Send vita plus three letters of recommendations to professor W. A. Woyczynski, Chairman, Department of Mathematics and Statistics, Case Western Reserve University, Cleveland, OH 44106.

An affirmative action, equal opportunity employer.

OTTO SZASZ VISITING PROFESSORSHIP

The Department of Mathematical Sciences of the University of Cincinnati has established a visiting professorship named in honor of the late Otto Szasz. The professorship will be tenable for a period of one year. Applicants with strong research accomplishments in an area compatible with one of the existing research groups of the Department may address inquiries to C. W. Groetsch, Head, Department of Mathematical Sciences, Mail Location 25, University of Cincinnati, Cincinnati, Ohio 45221.

The University of Cincinnati is an AA/EOE.

UNIVERSITY OF CINCINNATI, DEPT. OF MATH. SCIENCES MAIL LOCATION #25, CINCINNATI, OH 45221

The Department of Mathematical Sciences expects to make several tenure-track appointments at the assistant professor level. There is also the possibility of visiting positions. Preference for two of these tenure-track positions will be given to numerical analysis and applied statistics or closely related fields. Candidates in other fields with outstanding potential for research, scholarship and teaching and the ability to strengthen existing research areas in the Department are also encouraged to apply. Send vitae and 3 letters of reference to C. W. Groetsch, Head, Department of Mathematical Sciences, Mail #25, University of Cincinnati, Cincinnati, OH 45221. U.C. is an AA/EOE.

COMPUTATIONAL AND APPLIED MATHEMATICS
Northern Illinois University
Fall 1987

Several anticipated tenure track positions at the Assistant/Associate Professor levels. All areas of computational and applied mathematics considered, with Numerical Optimization being a top priority. There are active groups in Numerical and Applied Linear Algebra, Control Theory, Nonlinear PDE and Numerical PDE. Candidates must have a Ph.D. and a strong commitment to research and teaching.

Research faculty have a two course load. The department has strong undergraduate and graduate programs (Master's and Ph.D).

Send vita and three letters of reference to Professor B. N. Datta (for Numerical Computational Mathematics and Optimization) or to Professor Fred Bloom (for Theoretical Partial Differential Equations), Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115. Closing: January 15, 1987 or until positions filled.

Northern Illinois University is an Equal Opportunity/Affirmative Action Employer.

Van Vleck Assistant Professorships

The Department of Mathematics at the University of Wisconsin-Madison solicits applications for the position of Van Vleck Assistant Professor to begin fall 1987. Positions are for a specified term of three academic years at a salary of at least $28,000. Candidates must receive their doctorate prior to September 1987.

Candidates should have a strong commitment to good teaching and exhibit outstanding potential for mathematical research. Preference will be given to candidates who are likely to interact well with other members of the Department.

The usual teaching load is two courses per semester. There is a high probability of additional income through research or teaching during summers between consecutive years of appointment.

Application forms are available from the Hiring Committee, Department of Mathematics, 223 Van Vleck Hall, 480 Lincoln Drive, Madison, WI, 53706. Supporting materials should include a vita, a one to three page abstract of the candidate's dissertation, and three or four letters of recommendation at least one of which discusses the candidate's experience and capabilities as a teacher in detail.

Applications will be accepted until all positions are filled; however, in order to ensure full consideration, the application and all supporting materials must be received by December 31, 1986. AA/EOE

UCLA DEPARTMENT OF MATHEMATICS REGULAR POSITIONS IN MATHEMATICAL COMPUTER SCIENCE

One or two positions in mathematical computer science. Preference will be given to candidates in analysis of algorithms, coding theory, computational complexity, and the theory of programming languages. Very strong research and teaching background required. Positions initially budgeted at the assistant professor level. Sufficiently outstanding candidates at higher levels and/or in other fields will also be considered. Teaching load: Five quarter courses per year.

To apply, write to Yiannis N. Moschovakis, Chair, Department of Mathematics, University of California, Los Angeles, CA 90024.

UCLA is an equal opportunity/affirmative action employer.

POSITIONS AVAILABLE

UNIVERSITY OF WISCONSIN-MADISON
Department of Mathematics

The Department of Mathematics at the University of Wisconsin-Madison solicits applications for tenure-track or possible tenure positions to begin fall 1987. Appointments will be made at the assistant professor level unless qualifications and experience require appointment at higher rank. We are interested in candidates of established excellence as researchers as well as recent recipients of the PhD who exhibit outstanding potential. All candidates should have a strong commitment to good teaching. Consideration of established candidates will begin November 24, 1986. Consideration of recent PhD recipients will begin December 31. Applications will continue to be accepted until all positions are filled; however, only applications received by these dates along with all supporting materials are assured full consideration.

Application forms are available from the Tenure Track Screening Committee, Department of Mathematics, 223 Van Vleck Hall, 480 Lincoln Drive, Madison, WI 53706.

The University of Wisconsin-Madison is an AA/EOE.

LOYOLA UNIVERSITY
DEPARTMENT OF MATHEMATICAL SCIENCES

The Department of Mathematical Sciences anticipates several tenure-track positions beginning in August, 1987. Requirements are the Ph.D., an active research program, and a commitment to quality teaching. All areas will be considered, but for at least one of the positions preference will be given to individuals interested in participating in our computer science and/or statistics programs. Interviews will begin in January and continue until all positions are filled. To apply send detailed C.V. and three letters of recommendation to:

Professor R. J. Lucas
Department of Mathematical Sciences
Loyola University of Chicago
6525 N. Sheridan Road
Chicago, IL 60626

Loyola University of Chicago is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF ILLINOIS AT CHICAGO
DEPARTMENT OF MATHEMATICS, STATISTICS, AND COMPUTER SCIENCE

Applications are invited for tenure-track/tenure positions from excellent researchers in algorithms, complexity theory, numerical analysis, combinatorial and probabilistic analysis, and other areas of theoretical or mathematical computer science.

The Department has an active research group in computer science, with current focus on algorithms, complexity, combinatorics, coding theory, and language design. It offers the stimulating research environment of a highly rated mathematics department, with strong research groups in many areas related to computer science, including group theory, symbolic algebra, logic, queuing theory, and matrix theory. The Department has very successful B.S. and M.S. programs in Computer Science, and a growing Ph.D. program in Theoretical Computer Science. Applications in other areas of the mathematical sciences may be considered if positions become available. Send vita and direct 3 letters of reference to Chairman, Search Committee, Dept. of Math., Stat., and Comp. Sci., Univ. of Illinois at Chicago, Box 4348, Chicago, Il 60680. UIC is an affirmative action/equal opportunity employer.

OKLAHOMA STATE UNIVERSITY
DEPARTMENT OF MATHEMATICS

Several tenured, tenure-track and visiting positions at all professorial ranks for Fall, 1987. All areas are currently under consideration, but we especially encourage applications in Algebraic Geometry, Complex/Harmonic Analysis, Differential Geometry, Lie Groups and Representation Theory, and Partial Differential Equations.

Minimum qualifications are a Ph.D. in Mathematics, evidence of research achievement or potential, and a commitment to teaching. Post-doctoral experience is desirable. Normal duties include research and at most six hours teaching per semester. For full consideration, send a resume and arrange to have three letters of reference sent by January 15, 1987 to William Jaco, Head, Department of Mathematics, Oklahoma State University, Stillwater, OK 74078-0613. OSU is an equal opportunity/affirmative action employer. Women and minorities are especially encouraged to apply.

Rice University
Department of Mathematics

Applications are invited for one or more research/teaching positions in the fields of algebra, analysis, geometry, or topology at the rank of Assistant Professor or higher.

Applications should be received by February 15, 1987.

Applications are also invited for two Griffith Conrad Evans Instructorship postdoctoral appointments for two to three years for a promising research mathematician with research interests in common with the active research areas at Rice.

Applications should be received by February 15, 1987.

Please mail inquiries to:

Appointments Committee
Department of Mathematics
Rice University
P. O. Box 1892
Houston, TX 77251

Rice University is an Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF WYOMING
Department of Mathematics

Invites applications for the following positions:

1. A senior-level position in the area of computational mathematics. Candidates should have an outstanding record of accomplishment in an area of applied mathematics that makes significant use of high speed computers. The appointee will be expected to interact with our newly established Center for Computational Mathematics and Mechanics and to provide leadership in the developing field of scientific computation.

2. One or more tenure-track positions at the assistant professor level. The Department plans to build on existing strengths, which include applied mathematics and combinatorics, but may make appointments in other areas as well.

3. One or more visiting positions at levels appropriate for the applicant.

Send resume and direct three letters of recommendation to:

Professor Ben Roth
Chairman, Recruiting Committee
Mathematics Department
University of Wyoming
Laramie, WY 82071

Applications completed by January 31, 1987 will be given first consideration. The University of Wyoming is an Equal Opportunity Employer.

POSITIONS AVAILABLE

UNIVERSITY OF ILLINOIS AT CHICAGO MATHEMATICS AND COMPUTER EDUCATION

The Department of Mathematics, Statistics, and Computer Science invites applications for tenure-track, tenured or visiting positions in Mathematics and Computer Science Education.

The Department offers the stimulating environment of a highly rated Mathematics Department along with a strong commitment to the improvement of pre-college education. It currently has a number of successful programs in the area of pre-college mathematics and computer education. These include undergraduate programs for the certification of elementary and secondary teachers; an M.S.T. degree program; a Doctor of Arts program; courses for gifted pre-college students; and extensive teacher in-service and continuing education programs.

The department has received funding to expand and improve these programs and to set up a center for further development of the following activities: research in the teaching and learning of mathematics; study of the impact and applications of new technology such as microcomputers; curriculum improvement in pre-college mathematics and computer instruction; inservice programs for the enhancement of primary and secondary teachers.

Applicants must have a Ph.D. or a D.A. in Mathematics, Mathematics Education, Computer Science, or related field, an outstanding research and publication record, experience in undergraduate and graduate teaching and previous involvement with teacher education programs. Applications are also invited for visiting positions of 1 or more quarters. Send vita and direct 3 letters of reference to Chairman, Search Committee, Dept. of Mathematics, Statistics, and Computer Science, Univ. of Illinois at Chicago, Box 4348, Chicago, IL 60680.

UIC is an affirmative action/equal opportunity employer.

Mathematics Department Chairperson Department of Mathematics Illinois State University

The Department of Mathematics at Illinois State University invites applications for the position of Chairperson. The appointment will be made at the rank of Professor. The salary is competitive. Duties will begin on or about July 1, 1987.

Qualifications–Applicants must have a Ph.D. in Mathematics or Mathematics Education and a solid record of achievement in research, teaching, and leadership. They must have demonstrated effective administrative skills and a strong commitment to mathematics, applied mathematics, statistics, and mathematics education. Experience with graduate programs is desirable.

The Department–The ISU Department of Mathematics has 42 full-time faculty positions and offers undergraduate, masters, and Doctor of Arts programs, with opportunities in both mathematics and mathematics education. A Ph.D. in Mathematics Education is currently being developed. Current faculty research interests include analysis, combinatorics, graph theory, number theory, statistics, and various areas of mathematics education. The department serves over 4000 students each semester.

Application Procedures–To ensure consideration applicants should send, before February 15, 1987, a letter of application, a complete vita, a transcript, and names and addresses of at least 3 references to: Mathematics Chair Search Committee; c/o Professor Larry Alferink, Department of Psychology; Illinois State University; Normal, Illinois; 61761.

Illinois State University is an Equal Opportunity/ Affirmative Action, Employer.

UNIVERSITY OF MISSOURI-COLUMBIA, Dept. of Math., Columbia, MO 65211 Aug. 1987

Applications at all faculty levels are invited for up to three tenure track positions. The positions require a Ph.D. degree and a commitment to a distinguished research career. The department hopes to hire one person in harmonic or probabilistic analysis at the rank of Associate Professor or above. Selection for all positions will be based primarily on demonstrated research achievement. Quality teaching is expected of all candidates. Send vita and three letters of recommendation to Keith Schrader at address above. Deadline for applications is Jan 15, 1987, or until positions are filled. Equal opportunity/affirmative action employer.

Department of Mathematics University of Kansas

Anticipate some instructorships beginning fall semester 1987, which are normally renewable for second and third year. Salary to be determined. Research interests should be in areas closely related to those of current staff. Ph.D. or dissertation accepted with only formalities to be completed. Send detailed resume and dissertation abstract; arrange for three letters of reference to be sent directly to C. J. Himmelberg, Chairman, Department of Mathematics, University of Kansas, Lawrence, KS 66045-2142. Deadline date: December 1, 1986, then monthly until August 1, 1987.

The University of Kansas is an Affirmative Action/ Equal Opportunity Employer.

UCLA DEPARTMENT OF MATHEMATICS REGULAR POSITIONS IN APPLIED/COMPUTATIONAL MATHEMATICS

Three or four regular positions in applied and computational mathematics. Preference will be given to candidates in numerical analysis, mathematical modeling, and scientific/engineering computing. Very strong research and teaching background required. Positions initially budgeted at the assistant professor level. Sufficiently outstanding candidates at higher levels and/or in other fields will also be considered. Teaching load: Five quarter courses per year.

To apply, write to Yiannis N. Moschovakis, Chair, Department of Mathematics, University of California, Los Angeles, CA 90024.

UCLA is an equal opportunity/affirmative action employer.

OCCIDENTAL COLLEGE

The Department of Mathematics invites applications for a Regular Assistant Professorship beginning September 1987. A Ph.D. in Computer Science or Ph.D. in Mathematics with expertise in Computer Science is required. Candidates are expected to demonstrate excellence in teaching and have active research interests. Occidental is a liberal arts college offering a degree in Mathematics with an optional emphasis in Computer Science. The teaching load is two courses per term (8–9 hours). The salary range $26,500–$30,000. Occidental actively supports affirmative action; applications from ethnic minorities and women are strongly encouraged. Interviews will be held at AMS meeting in San Antonio, January 1987. Send vita and three letters of reference (one about teaching) to Nalsey Tinberg, Department of Mathematics, Occidental College, 1600 Campus Road, Los Angeles, California 90041, by February 10, 1987. Applications received after that date will still be considered as long as the position remains open.

POSITIONS AVAILABLE

Department of Mathematics
University of Kansas

Applications are invited for tenure-track and temporary positions at all levels, commencing August 16, 1987 or as negotiated. Field is unrestricted but preference will be given to algebra and numerical analysis, and to areas meshing well with the department's needs. Require Ph.D or Ph.D. dissertation accepted with only formalities to be completed.

Application, detailed resume with description of research, and three recommendation letters shoud be sent to C. J. Himmelberg, Chairman, Department of Mathematics, University of Kansas, Lawrence, KS 66045-2142.

Deadlines: December 1, 1986 for first consideration, then monthly until August 1, 1987.

The University of Kansas is an AA/EOE.

DEPARTMENT OF MATHEMATICS
The University of Texas at Austin
Austin, Texas 78712

A number of appointments are expected for Fall 1987 at the Instructor level (customarily new Ph.D.'s) and the Assistant Professor level (customarily at least two years experience beyond the Ph.D.). Candidates should have strong research credentials. Salaries will be competitive. Applicants should send vita, detailed summary of research interests, and at least three letters of recommendation to the Recruiting Committee Chairman at the above address as soon as possible and in any event no later than January 15, 1987. The University of Texas is an equal opportunity employer.

UCLA DEPARTMENT OF MATHEMATICS
REGULAR POSITIONS IN PURE MATHEMATICS

Four or five regular positions in pure mathematics. Specific fields of interest include algebra/number theory, analysis, differential equations, geometry/topology, logic, probability, and statistics. Very strong research and teaching background required. Positions initially budgeted at the assistant professor level. Sufficiently outstanding candidates at higher levels and/or in other fields will also be considered. Teaching load: Five quarter courses per year.

To apply, write to Yiannis N. Moschovakis, Chair, Department of Mathematics, University of California, Los Angeles, CA 90024.

UCLA is an equal opportunity/affirmative action employer.

University of California, Riverside

Applications are invited for a tenure-track or tenure position in Computer Science beginning Fall 1987. Candidates must have demonstrated excellence in research and teaching. Research specialties in all areas of Computer Science will be considered but we are particularly interested in research areas in Computer Systems or Computer Methodology and Applications. The position is open as to the level of appointment.

Applicants should send a curriculum vitae and see that at least three letters of recommendation are sent to:

Professor Theodore J. Barth, Chair
Computer Science Search Committee
Department of Mathematics and Computer Science
University of California
Riverside, CA 92521

University of California, Riverside, is an Affirmative Action/Equal Opportunity Employer.

OREGON STATE UNIVERSITY

Visiting appointments in mathematics for 1987-88. Ph.D. or equivalent training and experience. All ranks considered. Preference to applicants who augment research areas in the department, or who meet instructional needs. Full or part-time appointments. Renewals may be possible.

No closing date.

Write to:

Professor P. M. Anselone, Chairman
Department of Mathematics
Oregon State University
Corvallis, OR 97331-4605
Attn: Staff Selection Committee

Oregon State University is an Affirmative Action/Equal Opportunity Employer and complies with Section 504 of the Rehabilitation Act of 1973.

The University of Wyoming
Head—Department of Mathematics

The Department of Mathematics at the University of Wyoming invites applications for the position of Department Head. The University is the sole four-year institution of higher education in the state of Wyoming with an enrollment of 10,000 students. The mathematics program offers degrees in mathematics, applied mathematics, and several joint-degree options at the bachelor, master and doctoral levels. The department has a growing major research component in applied mathematics including a petroleum research institute with funding from major industrial supporters. Other active research areas in the department include numerical analysis, partial differential equations, functional analysis, optimization theory, dynamical systems, rigidity theory, and combinatorics.

Candidates should have a strong research record compatible with department interests and a commitment to excellence in instruction. Applicants should submit a current curriculum vita and the names of at least three suitable references to

Myron B. Allen, Chair
Search Committee
Mathematics Department
University of Wyoming
Laramie, WY 82070

Applications will be considered through January 31, 1987. The University of Wyoming is an equal opportunity employer.

UNIVERSITY OF CALIFORNIA, IRVINE
DEPARTMENT OF MATHEMATICS

Applications for the following two openings in 1987 are invited:

a) Assistant Professor in Probability/Statistics

b) Assistant Professor either in areas where Analysis and Geometry overlap, or in Algebra.

This revises an advertisement that appeared in November 1986 by including Algebra as an area for recruitment. Applications submitted prior to this revision remain valid.

Candidates for these positions must have a Ph.D. and a research record. Duties include research, undergraduate and graduate teaching. Send applications, curriculum vitae, work in print or in preparation, and three letters of recommendation to Professor Abel Klein, Chairman of the Recruitment Committee, Department of Mathematics, University of California, Irvine, CA 92717. Appointments begin on July 1, 1987. U.C. Irvine is an Affirmative Action Equal Opportunity Employer.

POSITIONS AVAILABLE

UNIVERSITY OF CALIFORNIA, IRVINE
DEPARTMENT OF MATHEMATICS

Applications for a tenured position in Differential Geometry opening in 1987 are invited:

Candidates for this position must have a Ph.D. and a research record. Duties include research, undergraduate and graduate teaching. Send applications, curriculum vitae, work in print or in preparation, and three names of references to Professor Abel Klein, Chairman of the Recruitment Committee, Department of Mathematics, University of California, Irvine, CA 92717.

Appointment begins on July 1, 1987. U.C. Irvine is an Affirmative Action Equal Opportunity Employer.

University of California, Santa Barbara
Department of Mathematics

Applications are invited for two tenure track appointments at the assistant professor level, effective July 1, 1987. Candidates in the area of applied discrete mathematics are especially sought, but junior candidates in all areas of the mathematical sciences will be given serious consideration. Outstanding research and teaching accomplishments and potential will be the primary criteria for selection. Ph.D. required by the time of appointment. Applicants should send vitae and publication list, and arrange to have three letters of recommendation sent to: Alex Rosenberg, Chairman, Department of Mathematics, South Hall 6607, University of California, Santa Barbara, CA 93106 by January 10, 1987.

UCSB is an equal opportunity/affirmative action employer.

OREGON STATE UNIVERSITY

Applications are invited for an Associate Professor position that may become available in applied mathematics or numerical analysis. Salary negotiable, depending on qualifications. Start September 1987. Closing date January 15, 1987. Write to:

Professor P. M. Anselone, Chairman
Department of Mathematics
Oregon State University
Corvallis, OR 97331-4605
Attn: Staff Selection Committee

Oregon State University is an Affirmative Action/Equal Opportunity Employer and complies with Section 504 of the Rehabilitation Act of 1973.

OREGON STATE UNIVERSITY

Applications are invited for an Assistant Professor position that may become available in applied mathematics. numerical analysis, geometry, or probability. Salary negotiable, depending on qualifications. Start September 1987. Closing date January 15, 1987. Write to:

Professor P. M. Anselone, Chairman
Department of Mathematics
Oregon State University
Corvallis, OR 97331-4605
Attn: Staff Selection Committee

Oregon State University is an Affirmative Action/Equal Opportunity Employer and complies with Section 504 of the Rehabilitation Act of 1973.

PIKEVILLE COLLEGE
PIKEVILLE, KENTUCKY 41501

Two positions beginning January or August, 1987. Applicants should have the ability and willingness to teach undergraduates mathematics. Ph.D. required, experience desired. Salary and fringe benefits competitive. Send resume, transcripts, and three letters of reference to Robert Mayfield, Dean. Pikeville is an AA/EO Employer.

TEACH IN ASIA OR EUROPE

The University of Maryland University College seeks excellent teachers for openings on U.S. military bases overseas. Appointments begin August, 1987. Requirements include M.A. or Ph.D., recent college teaching experience, and U.S. citizenship. Competence to teach in another discipline desirable. Benefits include transportation and military base privileges (PX, commissary, etc.). Frequent travel and the cost of schooling make these positions difficult for those with children. Send resume to Dr. Lois A. Mohr, Assistant to the Chancellor, Overseas Programs, The University of Maryland University College, College Park, MD 20742-1642. AA/EEO.

Southern Illinois University at Edwardsville
Mathematics and Statistics
Edwardsville, Illinois 62026-1653

SIUE, a state university 20 miles from downtown St. Louis, Mo, invites applications for positions in three areas – 3 assist. prof. in Math., one each assistant/associate prof. in Stat and in Math. Ed.–beginning Sept. 1987. Only applicants who have a doctorate or equivalent experience, or will complete Ph.D. requirements by Sept 1, 1987, will be considered. We seek applicants with excellent research accomplishments/potential and a strong commitment to teaching. For the Math. Ed. position, preference will be given to applicants with experience in the common schools who could work effectively with area schools on mathematics education at the elementary and middle school levels and work with relevant local, state, and federal agencies. Salary is competitive ($24,000–$32,000), based on qualifications and experience. Direct inquiries to Mathematics Search, Math. Ed. Search, or Statistics Search Committee, as appropriate. SIUE is an AA/EEO Employer.

THE JOHNS HOPKINS UNIVERSITY
Department of Mathematics

Applications and nominations are invited for a senior level (professor or associate professor) position in analysis. Partial differential equations and mathematical physics are of particular interest. Send résumé to:

Jean-Pierre Meyer, Chairman
Department of Mathematics
The Johns Hopkins University
Baltimore, Maryland 21218

An assistant professorship and several visiting positions will also be available for the academic year 1987–1988. Areas of interest (in addition to the above) are differential geometry, several complex variables, algebraic topology, group representations, algebraic number theory and algebraic geometry. Applications should be sent to Chairman, Appointments Committee, at the above address.

The Johns Hopkins University is an Equal Opportunity/Affirmative Action employer.

POSITIONS AVAILABLE

UNIVERSITY OF MISSOURI-KANSAS CITY, MATH DEPARTMENT, 5100 ROCKHILL ROAD, KANSAS CITY, MO 64110

A tenure track Assistant Professorship will be available for Fall 1987. Applicants should have completed the Ph.D. by the time of employment, be able to teach effectively at the undergraduate and graduate level, and show promise of developing a research career which will contribute to the department's doctoral program. Applicants from all areas will be considered; preference given to combinatorics, statistics, and complex analysis. A letter of application, vita, and three letters of recommendation should be sent to Professor Phillip Barker, Chair.

The University of Missouri is an EO/AA employer.

RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY, Department of Mathematics, New Brunswick, NJ, anticipates the following open positions beginning Sept. 1987:

(1) TENURE-TRACK AND TENURE POSITIONS. The Department anticipates several appointments to tenure-track assistant professorships. Depending on the qualifications of the applicants, some may be at the tenure (associate or full professor) level. Candidates must have Ph.D., outstanding research ability in pure or applied mathematics, and concern for teaching. Normal course load approx. 6 hours. Preference given to applicants working in differential geometry, Lie theory, logic, numerical analysis, topology, Mathematical physics, and ring theory (ideally interacting with algebraic geometry). However, exceptionally strong candidates in all fields are encouraged to apply and will be given careful consideration.

(2) HILL ASSISTANT PROFESSORSHIPS. These are three-year non-renewable positions. Candidates should have recently received the Ph.D., show outstanding promise in research ability in pure or applied mathematics, and have concern for teaching. Normal course load approx. 6 hours.

(3) LECTURESHIPS (Assistant Professor level). Normal course load approx. 6 hours. Candidates must have Ph.D., show outstanding promise in research ability in pure or applied mathematics, and have concern for teaching. These are one or two year non-tenure-track positions.

(4) LECTURESHIPS (Instructor level). Primary responsibility for teaching. Normal course load 9–10 hours. Candidates must have Ph.D., teaching experience at the college level, and some interest in research. These are one or two year non-tenure-track positions.

(5) INSTRUCTORSHIPS. Responsibility for teaching mainly at the level of precalculus and below. Normal course load 12 hours. Candidates must have masters degree or equivalent related experience and provide evidence of teaching ability. These are one or two year non-tenure-track positions.

(6) VISITING POSITIONS. Normal course load approx. 7 hours. These positions are intended to permit individuals with regular appointments elsewhere to visit Rutgers for the purpose of engaging in joint research with members of the faculty. Candidates must have Ph.D., proven record of outstanding research accomplishments in pure or applied mathematics, and concern for teaching. These are one or two year non-renewable positions.

SEARCH COMMITTEE, Dept of Math, Rutgers University, New Brunswick, NJ 08903 by January 15, 1987. Indicate position desired and give # of your area of specialty according to AMS Mathematical Subject Classification. RUTGERS UNIVERSITY IS AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER.

NEW MEXICO STATE UNIVERSITY DEPT MATH SCI, LAS CRUCES, NM 88003

Visiting positions and possible tenure-track, assistant professor positions in pure and applied mathematics, numerical analysis, statistics, computer vision. Start August 24, 1987. Salary competitive. Ph.D. (or equivalent) and strong commitment to teaching and research essential. Applications are kept on file through hiring period and positions filled as openings occur. Send vita and arrange for three reference letters to be sent to Carol L. Walker, Head, Department of Mathematical Sciences, New Mexico State University, Las Cruces, NM 88003. An Equal Opportunity/Affirmative Action Employer.

UNIVERSITY OF CALIFORNIA, LOS ANGELES, PROGRAM IN COMPUTING, LOS ANGELES, CA 90024.
R. J. Miech, Director

The Program in Computing at UCLA offers lower division courses in computing to the general student population. We are seeking an individual capable of teaching elementary computing courses.

The basic requirements are:

1) A masters degree in one of the sciences plus two additional years of education and/or experience.

2) The ability to teach introductory and intermediate courses in Pascal.

The lecturership is a temporary position. The initial appointment is for one year, with the possibility of renewal for a second. The teaching load is five quarter courses a year. The salary will be approximately $30,000 for nine months. There are excellent opportunities for Summer School employment. Send resume to:

R. J. Miech, Director
Program in Computing
Department of Mathematics
University of California
Los Angeles, CA 90024

The University of California, Los Angeles, is an AA/EEO.

KENYON COLLEGE MATHEMATICS DEPARTMENT GAMBIER, OH 43022

Tenure-track position starting 87–88. Entry level AsstProf, but candidates with some experience can be considered. Must have PhD by 8/87. Must have broad background in math. Preference for candidates in prob/stats or applications. Good background in CS or combinatorics or modeling is an asset. Strong commitment to undergrad teaching and scholarship is required. Teach 3 courses per sem. Send vitae, transcripts, and three letters of reference (at least one regarding teaching) to Stephen Slack at above address. Call (614)427–2244 Ext2267 for info. Send info by Jan 1 to help make an interview at AMS meeting in Jan more useful. Deadline is Feb 8, 1987. Kenyon is an EOE.

STETSON UNIVERSITY DELAND, FLORIDA 32720

Tenure track Assistant Professorship in mathematics available beginning Fall 1987. Ph.D. in mathematics required. Normal teaching load: 12 hours per semester. Applicants should have a commitment to excellence in teaching while at the same time pursuing scholarly activities. Send resume and three letters of recommendation to Professor Dennis Kletzing, Department of Mathematics/Computer Science, Stetson University, DeLand, Florida 32720.

Stetson University is an equal opportunity employer.

POSITIONS AVAILABLE

KENYON COLLEGE
MATHEMATICS DEPARTMENT
GAMBIER, OH 43022

Tenure-track position starting 87–88. Senior AsstProf or beginning AssocProf level. Must have PhD. Must have broad background in math. Preference for math applications. Background in CS or combinatorics or modeling or prob/stats is an asset. Strong commitment to undergrad teaching and scholarship is required. Teach 3 courses/sem. Send vitae, transcripts, and three letters of reference (at least one regarding teaching) to Stephen Slack at above address. Call (614)427–2244 Ext2267 for info. Send info by Jan 1 to help make an interview at AMS meeting in Jan more useful. Deadline is Feb 8, 1987. Kenyon is an EOE.

CALVIN COLLEGE
DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE

The Calvin College Department of Mathematics and Computer Science will have tenure track openings and possibly temporary openings for the 1987–88 academic year. Applicants in Mathematics, Computer Science, and Mathematical Statistics will be considered. The Department currently has 18 full-time faculty and nearly 100 majors at the junior-senior level. Calvin College is a Christian liberal arts college, and each faculty member is expected to demonstrate a Reformed and Christian perspective in her or his teaching and other professional activities. To apply, contact Professor T. Jager, Chairman, Dept. of Mathematics and Computer Science, Calvin College, Grand Rapids, MI 49506. Calvin College is an equal opportunity, affirmative action employer.

LAMAR UNIVERSITY, DEPARTMENT OF MATHEMATICS
BOX 10047, BEAUMONT, TX 77710

The Department of Mathematics of Lamar University invites nominations and applicants for a Department Head, starting August 25, 1987. Minimal qualifications include a Ph.D. in Mathematics or Mathematical Sciences and a record of professional accomplishments. Administrative experience is desirable. Salary commensurate with experience. Send a detailed resume and 3 letters of recommendation to: Dr. J. R. Hopper, Chairman of Search Committee. Deadline for applications: February 15, 1987. (Subsequent deadlines at 30 day intervals thereafter until position is filled.) An Affirmative Action/Equal Opportunity Employer.

MACALESTER COLLEGE

The Department of Mathematics and Computer Science is inviting applications for a tenure track position beginning in Fall, 1987. Applicants should have or be very near completion of a Ph.D in either Mathematics or Computer Science and will be expected to participate in the development and teaching of upper level courses in computer science.

Macalester is a four-year, residential liberal arts college of approximately 1700 students. The department offers majors in both mathematics and computer science. Applicants should be committed to excellence in undergraduate teaching and scholarship. Salaries and benefits are competitive. Macalester is an equal opportunity employer.

Applications should be directed to John Schue, Chairman; Department of Mathematics and Computer Science, Macalester College, St. Paul, MN 55105; providing a resume and three references. Applications will be accepted until the position is filled.

VALDOSTA STATE COLLEGE

Four tenure-track positions beginning Fall, 1987; (3) in mathematics at the Asst./Assoc. Prof. level and one in C.S. at the rank of Asst. Prof. Ph.D. required for math positions with special consideration given to applicants in algebra, probability or statistics, operations research, numerical methods, and applied math. Candidates for C.S. position should have a Ph.D. in C.S. Preferred areas: operating systems, data communications, software engineering, data base management, data structures, artificial intelligence. Applicants for either position should have a commitment to excellence in teaching and continued scholarly activity. Send vita to: John W. Schleusner, Head, Department of Mathematics and Computer Science, VSC, Valdosta, Georgia 31698. Application deadline is March 20, 1987. VSC is an AA/EOE.

QUEEN'S UNIVERSITY AT KINGSTON, Department of Mathematics and Statistics. The department has two positions available from July 1, 1987. One is a three-year renewable (tenure-track) position and the other is a three-year Queen's National Scholarship which might become tenure track. Candidates should have demonstrated potential in research and teaching. Outstanding candidates in any field will be considered, but the department is particularly interested in applicants who work in analysis, probability or statistics. Salary will depend on experience and qualifications. Applicants should send a vita to: Professor L. L. Campbell, Head, Department of Mathematics and Statistics, Queen's University, Kingston, Ontario K7L 3N6. Applicants should arrange for three letters of recommendation to be sent to the above address. At least one letter should comment on the candidate's teaching ability. Applications should be sent as soon as possible. The closing date for applications is January 31, 1987. In accordance with Canadian immigration requirements, this advertisement is directed to Canadian citizens and permanent residents. Candidates of either sex are equally encouraged to apply.

Anticipating Assistant or Associate Professor level position, August 1987, in Applied Mathematics (Probability, Statistics included) Qualifications: Ph.D. in Applied Mathematics, Candidates must have excellent research potential, commitment to teaching, be able to work with M.S. and Ph.D. students. Specializations in Numerical Analysis, Control Theory, Stochastic Processes, Probability, Partial Differential Equations, Fluid Mechanics given special consideration. EO/AAE

Send application letter, detailed resume, three letters of reference directly to:

Dharam V. Chopra, Chairman
Department of Mathematics/Statistics
The Wichita State University
Wichita, KS 67208

Deadline: February 1, then monthly until May 1, 1987.

ILLINOIS WESLEYAN UNIVERSITY, DEPARTMENT OF MATHEMATICS, BLOOMINGTON, IL 61702.

Applications are invited for a tenure track position starting fall semester 1987. Candidates must possess a Ph.D. in mathematics, a dedication to quality teaching in an independent, liberal arts university, and active research interests. Rank and salary will be competitive. Candidates from all areas of mathematics are encouraged to apply. Preference may be given to individuals who have active professional interests in applied mathematics. Candidates should submit a vita and three letters of recommendation by January 15, 1987 to Melvyn W. Jeter, Head, Department of Mathematics, Illinois Wesleyan University, Bloomington, IL 61702. Equal Opportunity Employer.

POSITIONS AVAILABLE

DEPARTMENT OF MATHEMATICS
UNIVERSITY OF ROCHESTER

Applications are invited for positions at the tenure-track assistant professor level or higher, beginning September 1987. Significant research accomplishments or exceptional research promise, as well as evidence of good teaching ability, are required. Initial tenure-track appointment is for four years. There is no restriction as to field. In addition to a curriculum vitae, candidates should send a summary of research plans, available preprints or reprints, and have at least three reference letters sent to:

Chairman, Mathematics Department
University of Rochester
Rochester, NY 14627

An equal opportunity/affirmative action employer.

UNIVERSITY OF SOUTH CAROLINA
Department of Mathematics

Applications are invited for tenure-track faculty positions at all levels. Applications in all areas of mathematics will be considered; the Department particularly wishes to strengthen its programs in applied and computational mathematics. The Ph.D. degree or its equivalent is required, and all appointments will be consistent with the Department's commitment to excellence in research and teaching at both the undergraduate and graduate levels. Faculty research is strongly supported through funding for visitors and travel, and excellent library and computing facilities. The Department operates its own computation center (VAX 8300 and 11/750); terminals installed in each faculty office provide access to the VAX complex and to the University's IBM 3081 mainframes and FPS 264 array processor. A detailed résumé, containing a summary of research accomplishments and goals, and four letters of recommendation should be sent to:

Dr. Colin Bennett, Chairman
Department of Mathematics
University of South Carolina
Columbia, South Carolina 29208

The University of South Carolina is an Affirmative Action/Equal Opportunity employer.

MISSISSIPPI STATE UNIVERSITY

The Department of Mathematics and Statistics at Mississippi State University anticipates two or more tenure track positions at the assistant professor level for the 1987–88 academic year. A Ph.D. is required. Responsibilities include teaching and research. Candidates should submit a vita and three letters of recommendation to John R. Gilbert, Chairman Screening Committee, Department of Mathematics and Statistics, Mississippi State, MS 39762. Screening will begin December 15, 1986 and continue until positions are filled. Mississippi State University is an equal opportunity/affirmative action employer.

University of Mississippi
Department of Mathematics
University, MS 38677

One or two tenure track positions and one visiting position at the Assistant or Associate Professor level beginning Fall, 1987. Ph.D. required. Special preference may be given to the areas of functional analysis, differential equations, or graph theory and combinatorics. To ensure consideration, send resume, transcript and three letters of recommendation to Dr. James F. Porter postmarked by February 1, 1987. The University of Mississippi is an Equal Opportunity/Affirmative Action Employer.

FLORIDA INTERNATIONAL UNIVERSITY
DEPARTMENT OF MATHEMATICAL SCIENCES
Miami, FL 33199

The Department of Mathematical Sciences announces tenure-track positions at the assistant professor level beginning August, 1987. Candidates must have a Ph.D. in Mathematics, research potential and a serious interest in teaching. Teaching load is 15 semester hours per academic year; summer teaching normally available. Preferred areas of specialization include harmonic analysis, algebra, and mathematical logic; qualified candidates in other areas considered. Send resumes and 3 letters of reference to Recruitment Committee, Department of Mathematical Sciences, Florida International University, Miami, FL 33199. FIU is a member of the State University of Florida and an equal opportunity/affirmative action employer.

Stanford University
Computer Science Department

The department has several openings for tenure track positions in theoretical computer science. The term theoretical computer science is to be broadly construed to include work of a theoretical nature in areas such as programming languages, robotics, graphics and computer-aided design, artificial intelligence, etc., in addition to the more classical areas of algorithms and complexity. Applicants must have a record of strong research and an interest and competence in teaching.

Candidates should send curriculum vitae with suggested references to Prof. Leonidas J. Guibas, c/o Phyllis Winkler, Computer Science Department, Stanford University, Stanford, CA 94305. A deadline of January 31, 1987 is suggested for fullest consideration.

Stanford is an Equal Opportunity/Affirmative Action employer and welcomes applications from women and minorities.

COLUMBIA UNIVERSITY
Department of Computer Science
Lectureships

Positions as Lecturer or Senior Lecturer will be offered to excellent teachers with superior research and academic backgrounds. Faculty of all ranks in other mathematical disciplines, as well as computer science, are encouraged to apply for these non-tenured term appointments, whose duration will typically be three to six years. Pay is comparable to professorial levels.

These lectureships provide an opportunity for teacher/scholars with some substantial prior computing experience to make a transition to computer science. Columbia University has an outstanding young research faculty and facilities, now working in a five-million dollar office and research-laboratory building. All of our "lecturer alumni" are presently in good positions at leading universities and colleges.

Lecturers will teach two undergraduate courses each semester. They must be able to make highly effective presentations to large classes. The University has several DEC 2060 computer systems dedicated to instructional use. Many terminals or students are in dormitories and other convenient locations. Knowledge of innovative uses of technology for teaching is desirable.

Send resume and names of three references by February 15, 1987, if possible, to Professor Jonathan Gross, Vice-Chairman, Department of Computer Science, Columbia University, New York, New York 10027. Please write "Re Lectureship" on the envelope of your letter of inquiry or application.

Columbia University is an Equal Opportunity/Affirmative Action Employer. We are interested in receiving applications from qualified women and minorities.

POSITIONS AVAILABLE

DEPARTMENT OF MATHEMATICS
KANSAS STATE UNIVERSITY

Subject to budgetary approval, applications are invited for several tenure-track and visiting positions at the assistant professorship level commencing August 18, 1987. All fields will be considered, but at least one position will be in computational mathematics. Candidates must have strong research credentials and a commitment to excellence in teaching. A Ph.D. in mathematics or a Ph.D. dissertation accepted with only formalities to be completed is required. Application, detailed resume with description of research and three letters of recommendation should be sent to: Louis Pigno, Head, Department of Mathematics, Cardwell Hall, Kansas State University, Manhattan, KS 66506. Deadlines: February 1, 1987 for first consideration, then monthly until August 1, 1987. AA/EOE.

The UNIVERSITY OF PITTSBURGH

Applications invited for three (3) tenure-track positions, AY 1987. **Preferred areas**: analysis, applied mathematics, computational mathematics, PDE's. **Level**: assistant professor, higher rank for strong candidate in PDE's. **Present teaching load**: two classes/term, 2-term, 8-month AY. Ph.D., publications and active research program, effective teaching ability required. C. V., four letters of recommendation, reprints, preprints should be sent to W. E. Deskins, Ch., Department of Mathematics and Statistics, University of Pittsburgh, Pittsburgh, PA 15260. An Equal Opportunity/Affirmative Action Employer.

SACRED HEART UNIVERSITY
Fairfield, CT

Applications are invited for a fall 1987 tenure-track position at the Assistant Professor level. Ph.D. in Mathematics and evidence of excellence in teaching are required. Send a letter of application, resume, transcripts, and three letters of recommendation before February 15, 1987 to: Dr. David L. Wilson, Chairperson, Department of Mathematics, Sacred Heart University, P. O. Box 6460, Bridgeport, CT 06606-0460. AA/EOE.

Department of Mathematics
Southern Methodist University

Applications are invited for a Professor and a tenure-track Assistant Professor beginning September 1987. Candidates for the senior position should be distinguished scholars providing leadership in one or more areas of research in applied mathematics. A successful grant record and the supervision of doctoral dissertations are desirable. Candidates for the junior position should have an outstanding research record or superior potential. A commitment to excellence in teaching is expected of all candidates.

The department has ten active applied mathematicians doing research in areas such as mathematical modeling, nonlinear wave phenomena, numerical analysis (differential equations and optimization), and scientific computation. Recently Lawrence Shampine has been appointed the first holder of the Betty Clements Chair in Applied Mathematics.

Applicants should send a vita and three letters of reference (for the senior position, names only) to Richard Haberman, Chairman, Department of Mathematics, Southern Methodist University, Dallas, Texas 75275, or call (214) 692-2506.

The university is an Equal Opportunity/Affirmative Action/Title IX employer.

CLEMSON UNIVERSITY
Department of Mathematical Sciences

The Department of Mathematical Sciences invites applications for two anticipated tenure-track faculty positions beginning Fall Semester, 1987. One anticipated position would be filled at the ASSISTANT PROFESSOR level, and the other at the ASSISTANT or the ASSOCIATE PROFESSOR level. Current research in the Department includes the areas of algebra and analysis, computational mathematics, discrete mathematics, operations research, and statistics. Active BA, BS, MS, and two PhD programs emphasize an interest in applications and the computational aspects of mathematical sciences. The Department jointly administers a PhD program in Management Science with the University Management Department.

Candidates should possess the PhD degree in a relevant field and exhibit the potential for high quality sustained research in an area of interest to the Department. Individuals whose primary research lies in Stochastic Processes or Statistics are especially encouraged to apply.

Academic year salaries will be competitive and commensurate with credentials. The recent award of a long term ONR University Research Initiative contract and Departmental resources open the possibility of summer research support for outstanding new faculty. A sixteen node hypercube FPS parallel processor and conventional facilities provide excellent computational support.

Applications will be accepted until approved positions are filled. Letters of application (accompanied by curriculum vitae and names and telephone numbers of at least three references), nominations and requests for further information should be addressed to:

Prof. John D. Fulton, Head
Department of Mathematical Sciences
Clemson, SC 29634-1907

Clemson University is an affirmative action/equal opportunity employer.

ST. OLAF COLLEGE
Department of Mathematics
Northfield, Minnesota 55057

Fall, 1987. The Department of Mathematics anticipates several positions at the assistant professor level. One of these is potentially tenure track. The remaining positions will be for at least two years. Applicants must have a clear commitment to excellence in teaching and an appreciation for the value of the liberal arts. Send a resume, three letters of recommendation, and a statement of professional goals and interests to: Paul D. Humke, Chair, Department of Mathematics. The selection procedure will begin in early January. Applications for visiting positions at all ranks are sought.

St. Olaf, a college of The American Lutheran Church, is an equal opportunity employer and specifically invites applications from women and minorities.

The Mathematics Department invites application for two tenure track Assistant Professorships from mathematicians with strong research records. Preference will be given to those fields which complement the present faculty. However, for one position, special attention will be given to those applicants in the field of Partial Differential Equations.

Applications should include a curriculum vitae, a list of publications, and should have three reference letters forwarded to the department.

Northwestern University is an equal opportunity/affirmative action employer; minorities and women are encouraged to apply. Inquiries and applications should be addressed to: Chairman, Personnel Committee, Department of Mathematics, Northwestern University, Evanston, IL 60201.

POSITIONS AVAILABLE

ST. OLAF COLLEGE
Mathematics/Paracollege
Northfield, Minnesota 55057

The Department of Mathematics has a tenure track position beginning September, 1987 to teach 2/3 time in the St. Olaf Paracollege and 1/3 time in the department. The Paracollege is a parallel track to the B.A. degree specializing in interdisciplinary seminars and individual tutorials. Students design their own integrated majors involving at least three disciplines. An interest in the history of mathematics and/or philosophy of science is desirable. We anticipate hiring at the assistant professor level, however, more experienced persons are encouraged to apply and will be seriously considered. Please send 3 letters of recommendation, a resume, and a statement of professional goals and interests to: C. Gengenbach, Chair, Mathematics/Paracollege Search Committee, Department of Mathematics. The selection procedure will begin in early January.

St. Olaf, a college of The American Lutheran Church, is an equal opportunity employer and specifically invites applications from women and minorities.

University of North Carolina at Greensboro

Applications are invited for two tenure track assistant professor positions: one in Mathematics, one in Computer Science; beginning August 1, 1987.

Applicants for the position in Mathematics should have a Ph.D. in Mathematics; preference will be given to candidates with demonstrated research ability in Algebra/Number Theory and teaching experience at the university level. Applicants for the position in Computer Science should have a Ph.D. in Computer Science or a Ph.D. in a related area and an M.S. in Computer Science. Candidates for both positions are expected to have a strong commitment to teaching and research. Salaries are competitive.

Applications should include a resume and names, addresses, and phone numbers of three references. Applications should be sent to Search Committee, Mathematics Department, UNCG, Greensboro, NC 27412. For full consideration, applications should be received by January 15, 1987. AA/EOE. Women and minority candidates are encouraged to apply.

UTAH STATE UNIVERSITY
DEPARTMENT OF MATHEMATICS

The Department of Mathematics at Utah State University seeks applications from research mathematicians for possible positions in the fall of 1987. Applicants in all areas and at all ranks will be considered. Those specializing in nonlinear and applied analysis and numerical analysis will be especially welcome.

Excellence in research and a demonstrated commitment to both graduate and undergraduate teaching are sought. Successful candidates will be expected to contribute to the implementation of the new doctoral degree program in mathematics and to interact professionally with the mathematics and applied science faculty at USU. The ability to provide broad mathematical leadership is essential for senior level applicants.

Utah State University, located in the Wasatch Range of the Rocky Mountains, offers competitive salaries and excellent medical, retirement, and professional benefits.

Applications, including curriculum vitae and three letters of reference, should be submitted to: Search Committee, Department of Mathematics, Utah State University, Logan, UT 84322-4125.

Utah State University is an Equal Opportunity/Affirmative Action employer.

Department of Mathematics
John Jay College of Criminal Justice
The City University of New York

Assistant Professor, tenure-track position, 9/1/87. Requirements: Ph.D.; demonstrated potential for research; strong commitment to teaching. Computer science, numerical analysis or operations research background preferred. John Jay College of Criminal Justice, located in Manhattan, is a senior college in CUNY. Send resume, graduate transcript, relevant reprints, dissertation abstract and three letters of reference to Samuel Graff, Chairperson, Department of Mathematics, John Jay College of Criminal Justice, 445 West 59th Street, N.Y., N.Y. 10019 by April 1, 1987. AA/EOE Employer.

WHITTIER COLLEGE

The Department of Mathematics invites applications for a tenure track position beginning Fall 1987. Rank is open. The five members of the department teach a wide range of undergraduate courses in mathematics and computer science. Ph.D. in Mathematics preferred, but no particular field is required. A background in Computer Science would be most welcome. Candidates should submit a vita, graduate transcripts and three letters of recommendation by February 1 to Dr. Fritz Smith, Department of Mathematics, Whittier College, Whittier, California 90608. EO/AAE.

KENT STATE UNIVERSITY
DEPARTMENT OF MATHEMATICAL SCIENCES

Applications are invited for a tenure track faculty position in Numerical Analysis and Computational Mathematics at the assistant or associate professor levels beginning September 1987. Applicants should expect to have a Ph.D. in numerical analysis or a closely related field by the starting date. Salary is competitive and negotiable.

The Department operates a computer laboratory with a VAX 11/780 (on CSNET), and a VAX 11/750, both under UNIX; a STARAN-E 512 processors parallel SIMD computer; four fully configured HP Labs AI 9000/300 workstations with the latest software; a Tektronix 4404 advanced AI workstation, all connected on a local area network with the VAX computers; and other micro computers and peripheral equipment. University facilities include an IBM 3081D (on BITNET); a cluster of two VAX 11/780s under VMS; a Honeywell DPS 66; and other equipment.

The Institute for Computational Mathematics was established in 1980 within the Mathematical Science Department to focus on research in computational linear algebra and approximation theory; computational chemistry; symbolic computation; and other areas of scientific computation. The Institute provides industrial, government, and university funding support for a wide range of research in computational mathematics. The Department supports research in both mathematics and computer science.

Application deadline is March 2, 1987. If the position is not filled by March 2, 1987, the deadline will be extended until the position is filled or until August 17, 1987, whichever occurs first.

Applicants should submit a resume, and arrange to have three letters of recommendations sent to O. P. Stackelberg, Chairman, Department of Mathematical Sciences, Kent State University, Kent, Ohio 44242, USA. Kent State University is an Affirmative Action/Equal Opportunity Employer.

POSITIONS AVAILABLE

LEWIS AND CLARK COLLEGE
Portland, Oregon

The Department of Mathematics invites applications for a new tenure-track position beginning in September 1987. Appointment will be made at the assistant professor level and preference will be given to applicants in geometry, graph theory, and/or combinatorics. A Ph.D. is required and experience teaching undergraduates, commitment to a liberal arts educational environment, and a continuing research interest is essential.

The usual teaching load averages 10 hours per week with two (or occasionally three) preparations.

Applications should consist of a letter of introduction indicating career interests, priorities, and goals; a resume; and three letters of recommendation. Please send application materials to: Professor Roger B. Nelsen, Chair, Department of Mathematics, Box 110, Lewis and Clark College, Portland, OR 97219. The deadline for completion of applications is February 13, 1987.

Lewis and Clark College is an Equal Opportunity employer and encourages the application of women and minority candidates.

Department of Mathematics
University of Toronto

Applications are invited from recent Ph.D.'s for a limited term Assistant Professorship, subject to budget approval, beginning July 1, 1987, for a term of up to three years. Duties consist of research and teaching and candidates must demonstrate clear strength in both. The University of Toronto encourages both men and women to apply for this position.

Applicants should send their complete curriculum vitae, together with list of publications, and arrange to have at least three recent letters of reference sent directly to:

Professor D. K. Sen
Associate Chairman
Department of Mathematics
University of Toronto
Toronto, Canada M5S 1A1

To insure consideration, applications and letters of reference should be received by February 15, 1987. In accordance with Canadian Immigration requirements this advertisement is directed to Canadian citizens and permanent residents in Canada only.

DEPARTMENT OF MATHEMATICAL SCIENCES
MEMPHIS STATE UNIVERSITY

The Department of Mathematical Sciences invites applications for tenure track positions at all ranks in all areas of the mathematical sciences (including mathematics, computer sciences, and statistics) for Fall 1987. Applicants must have a Ph.D. by September 1, 1987, and a strong potential for excellence in teaching and research.

The Department offers degrees at all levels including the Ph.D., and provides a very favorable research environment in terms of library and computing facilities, teaching load, travel opportunities, etc.

Selection will begin on February 1, 1987. Applications will continue to be accepted until all positions are filled. Applicants should submit a resume and direct three letters of reference to:

Ralph Faudree, Chairman
Department of Mathematical Sciences
Memphis State University
Memphis, TN 38152

An Equal Opportunity/Affirmative Action Employer.

CENTRAL MICHIGAN UNIVERSITY
Chairperson
Computer Science Department

The Department of Computer Science at Central Michigan University is seeking applicants for the position of chairperson. Responsibilities of the chairperson include all aspects of administration of the department, teaching, development and strengthening of the undergraduate and graduate programs, supervision of graduate students, and research development and support. Applicants must have a doctorate (or equivalent degree) in computer science or a related field. Candidates are expected to have demonstrated expertise in teaching, development of research, and administrative skills in a computer science setting. Salary and rank will be commensurate with qualifications.

The department offers bachelor's and master's degrees in computer science. Computing facilities include a Cyber 170-730, a Burroughs XE550 running UNIX, and IBM PC and Macintosh micro labs. In addition, the University has just committed itself to a major upgrade, including a new mainframe and substantial increases in the numbers of micros. Faculty teaching and research interests include languages, compilers, database management systems, computer graphics, pattern recognition, software engineering, operating systems, artificial intelligence, computer vision, algorithms and complexity, and networks. The department has about 20 FTE positions, with teaching assignments of 15 hours per academic year (ordinarily 3 courses one semester and 2 the other.) The chairperson has a 9 hour per year teaching assignment.

The University is located in a community of about 24,000, sixty miles north of Lansing, at the edge of Michigan's lakes, hills and woodlands. The student enrollment has held steady at about 16,000 for several years. The University offers outstanding faculty benefits, including a 12% fully paid TIAA-CREF contribution.

Qualified applicants should submit a detailed resume and three letters of reference to

Dr. Jerald A. Kabell
Acting Chairman
Department of Computer Science
Central Michigan University
Mt. Pleasant, MI 48859

Applications will be accepted until 1 Mar 87 or until the position is filled, whichever is later. Central Michigan University is an Affirmative Action/Equal Opportunity institution. Women and minorities are especially encouraged to apply.

UNIVERSITY OF BRITISH COLUMBIA–DEPT. OF MATH. Applications are invited for two tenure track positions in the Department of Mathematics at the level of Assistant or Associate Professor for the academic year beginning 1 July 1987. One position will be in the area of Differential Equations-Dynamical Systems. The second position will be in the area of Control Theory and Optimization. The positions are subject to final budgetary approval. Candidates must have a Ph.D. and demonstrated potential for excellent research and the ability to teach undergraduate and graduate courses in the department. The level of appointment and salary will be based on experience and research record. Applicants must include a complete C.V. and arrange for at least 3 letters of reference to be mailed directly to:

Head,
Department of Mathematics,
The University of British Columbia,
Vancouver, Canada V6T 1Y4

Applications received after February 28, 1987 will be considered only if a position remains unfilled.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

POSITIONS AVAILABLE

LECTURERS, MATHEMATICS. Teach three courses per semester; perform research and other duties as assigned by the Department Chair. Position normally renewed for a second year upon satisfactory performance of teaching and research. Ph.D. in Mathematics required (or near completion). Preference given to applicants who can interact with the research interests of the Department. Strong commitment to teaching and research is required. Submit a letter of application, vitae and three letters of reference concerning teaching and research abilities by March 2, 1987 to: Robert Sine, Search Committee Chair, Lecturer, Mathematics (020267) position, THE UNIVERSITY OF RHODE ISLAND, P. O. Box G, Kingston, R.I. 02881. An affirmative action/equal opportunity employer m/f.

DUKE UNIVERSITY
Department of Computer Science

The Duke University Department of Computer Science, a 1983 recipient of an NSF CER Grant, has faculty positions available at all ranks. Applications are solicited from all areas of computer science. Applicants for senior positions must demonstrate excellence in research, while applicants for junior positions must exhibit the promise of excellence.

The Department currently has seventeen tenure track faculty, approximately 300 undergraduate majors and 50 graduate students pursuing master's and/or doctoral degrees.

The Department has major research efforts in scientific computing with emphasis on numerical linear algebra, the solution of PDEs, and VLSI simulation; computer systems with emphasis on computer architectures, modeling of fault-tolerant systems, systems performance, and communications; artificial intelligence, particularly in the areas of natural language interface, search methodologies, and expert systems; and theory and algorithms with emphasis on combinatorial and graph-theoretic studies. Special motivation for the research efforts comes from the areas of medical applications (in collaboration with the Duke Medical Center), and VLSI (in collaboration with the Microelectronics Center of North Carolina, of which Duke is a Participating Institution).

Interested applicants should send copies of their resumes and other supporting material to

Professor Donald J. Rose
Department of Computer Science
Duke University
Durham, NC 27706

Duke University is an affirmative action, equal opportunity employer.

Mathematics Department
California State University
Northridge, California 91330

Three tenure track positions are available. Requirements are a Ph.D. in Mathematics, evidence of teaching excellence, and research activity in one of the following fields: analysis, applied mathematics, foundations of mathematics, or mathematics education. Applications will be considered for appointment at the assistant, associate, or full professor rank. Salary range: $25,811 to $49,546.

Starting date for all positions is August 31, 1987. Send a cover letter and resume by February 1, 1987 to D. H. Potts, Chair, Department of Mathematics, California State University, Northridge, California, 91330.

California State University is an Equal Opportunity, Affirmative-Action, Handicapped Title IX Employer.

DEAN, COLLEGE of ENGINEERING and APPLIED SCIENCE

UNIVERSITY OF COLORADO: Located at base of Pikes Peak in dynamic area of cultural and professional opportunities, the University of Colorado at Colorado Springs (UCCS) invites applications for Dean of the College of Engineering and Applied Science, consisting of Departments of Computer Science (B.S., M.S.), Electrical Engineering (B.S., M.S., Ph.D.), and Mathematics (B.S., M.S.). Position reports to Vice Chancellor for Academic Affairs. College has recently occupied a new 50,000 sq. ft. building with offices, classrooms, and labs, including a class 10 microelectronics clean room, a state-of-the-art VLSI design lab, and an anechoic chamber. Extensive computer facilities and other labs support dual teaching and research missions. Responsibilities include overall leadership and direction of College and of associated Microelectronics Research Lab, Software Engineering Lab, and Space and Flight Systems Lab; close liaison with regional industrial/military interests. Applicants should have outstanding research, administrative, and academic background; hold Ph.D.; show demonstrated ability to lead in development of graduate programs and to foster collaborative relationships with space and high-tech industries. Salary competitive. Applicants should send complete cv and names of three references to: Dean's Search Committee, College of Engineering and Applied Science, University of Colorado at Colorado Springs, P.O. Box 7150, Colorado Springs, CO 80933-7150. Closing postmark date for nominations or applications is February 2, 1987. UCCS is an EEO/AA employer.

WEST VIRGINIA UNIVERSITY
DEPT. OF MATHEMATICS

The Department of Mathematics invites applications for tenure track positions at the Assistant/Associate Professor rank, beginning Fall 1987. Applicants must have a Ph.D. degree, a strong commitment to teaching and research. Fields of preferred interest include numerical analysis, applied analysis, combinatorics, algebra. Preference will be given to applicants who can participate in the department's research program involving interdisciplinary ties. Send vita and arrange for three letters of recommendation to be sent to: Prof. Alphonse Baartmans, Chair/Dept. of Mathematics, West Virginia University, Morgantown, WV 26506. For information regarding these positions, please write or call (304) 293–2011. Review of applications will begin Feb. 1, 1987 and continue until the positions are filled. WVU is an AA/EO employer.

UNIVERSITY OF SOUTHERN CALIFORNIA
Department of Mathematics
Los Angeles, CA 90089-1113

Applications are invited for several tenure track Assistant Professorships, beginning September 1987, and for possible tenured positions at the ranks of Professor and Associate Professor. Visiting Professorships and Visiting Associate Professorships will also be available.

Assistant Professors are expected to teach two courses per semester, and must show strong research promise. Applicants for senior positions should have an outstanding record of research and scholastic achievement. Specialists in Statistics, Partial Differential Equations, Combinatorial Analysis and areas of Applied Mathematics such as Numerical Analysis are especially encouraged to apply, but other areas will be considered.

Applications should be addressed to: Chairman, Search Committee, Department of Mathematics-DRB 306, University of Southern California, Los Angeles, CA 90089-1113.

U.S.C. is an Equal Opportunity/Affirmative Action employer.

POSITIONS AVAILABLE

UNIVERSITY OF SOUTH FLORIDA
Department of Mathematics

Tenure-track teaching and research positions are available beginning August 1987. Applicants must possess a Ph.D. degree. Applicants specializing in Approximation Theory, Computer Science, Control Theory, Differential Equations, Logic, Numerical Analysis, Probability, or Statistics are preferred. Rank and salary will depend on credentials. To apply send curriculum vitae and have three letters of recommendation sent to Kenneth L. Pothoven, Chairman, Tampa, FL 33620-5700. Application Deadline: Feb 10, 1987. The University of South Florida is an equal opportunity employer.

DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE CALIFORNIA STATE UNIVERSITY, LA LOS ANGELES, CALIFORNIA 90032

Tenure-track positions, any rank. Ph.D. in Math, Math Ed or Ph.D. in Computer Science with a background in Mathematics required. Strong computer science background desirable and ABD toward Ph.D. in CS will be considered for one year temporary. One year visiting position also available in Math with Ph.D. and strong record. Starting date: September 1987 Salary: 28300–53500 with additional summer employment possibilities. Evaluation of applicants will begin February 1, 1987. Send inquiries to Wayne Bishop, Chair at the above address. An Equal Opportunity, Affirmative-Action, Handicapped, Title IX, Employer.

COMPUTER SCIENCE

The department of Computer Science at New England College, with campuses in South Central New Hampshire and Arundel, England, will have a teaching position available in the fall at the American Campus for an Assistant Professor of Computer Science. Responsibilities require teaching 4 courses per semester in Computer Science/Math, advise C. S. majors and supervise senior projects, develop changes/additions to program, and assist in managing the Academic Computer Center.

The program's goal is maximum interaction with students and emphasizes understanding of the functioning of both hardware and software from the individual component level to the system level.

M.S. required, PhD preferred in Computer Science or related field. Send vita, transcript and three references to: Dr. Laurence I. Taylor, Acting Vice President of Academic Affairs and Dean of Faculty, New England College, Henniker, New Hampshire 03292-0798.

BRYN MAWR COLLEGE

Bryn Mawr College announces a three-year (possibly renewable as a tenure-track) Assistant Professorship in Mathematics and Computer Science, beginning September 1, 1987. Applicants should have a Ph.D. degree in one of the two fields with competence to teach intermediate and advanced undergraduate level courses in both. The selection among qualified candidates will be based on teaching effectiveness and research promise. Letters of recommendation should emphasize all these components of the candidate's training, ability and potential. Send a letter of application, a resume and arrange to have at least three letters of reference sent to Professor Mario Martelli, Mathematics Department, Bryn Mawr College, Bryn Mawr, PA 19010. The Search Committee will begin the selection February 1, 1987. Applications will be accepted until the position is filled. Bryn Mawr College is an AA/EOE.

MATHEMATICS: Jacksonville University, Jacksonville, Florida, seeks candidates for tenure track position in mathematics, starting in September, 1987. Ph.D. in applied mathematics preferred. Application deadline is January 30, 1987. Send resume to: Dr. Sidney Kung, Chair, Search Committee, Department of Mathematics, Jacksonville University, Jacksonville, Florida 32211. Jacksonville University is an Affirmative Action/Equal Employment Opportunity Institution.

UNIVERSITY OF NORTH CAROLINA AT CHARLOTTE DEPARTMENT OF MATHEMATICS, CHARLOTTE, N.C. 28223

Tenure-track positions available, one or two Assoc/Full Prof. and one (probably) at Asst/Assoc. Prof., others possible. Ph.D. required. Preference given to candidates in the areas of OR/applied prob., numerical anal., dynamical sys/ODE, combinatorics, optimization, prob/analysis, PDE, math. Ed. Strong candidates in other areas are encouraged to apply. Also possible are visiting and lecturer (one or two year renewable non-tenure-track; MA/MS required) positions. Send vita and 4 letters of recommendation to Prof. Evan G. Houston at the above address. Letters must be specifically addressed to Prof. Houston. Closing date: Feb. 3, 1987 and every two weeks thereafter until positions are filled. UNCC IS AN EQUAL OPPORTUNITY EMPLOYER.

UNIVERSITY OF VERMONT DEPARTMENT OF MATH. & STAT. BURLINGTON, VERMONT 05405

Applications and nominations are invited for two visiting professors or associate professor positions available beginning Fall 1987. Candidates must have strong records of research in Algebraic Number Theory, Approximation Theory, Combinatorics, Harmonic Analysis, Numerical Analysis or related areas. Experience with funding and departmental administration are desirable.

Send detailed resumé and names of three references to Dr. Donald Moser. U.V.M. is an AA/EOE employer.

TRINITY COLLEGE
Hartford, Connecticut 06106
Department of Mathematics

The Department of Mathematics at Trinity College invites applications for a tenure-track position at the rank of Assistant Professor, to begin in the academic year 1987-88.

The requirements for the position are a Ph.D. in one of the mathematical sciences and demonstrated excellence as a teacher. Applicants with any specialty will be considered; however, we are especially interested in those with a specialty in: Complex analysis, differential equations, numerical analysis, applied mathematics, or computer science.

The normal teaching load is 5 courses per year (two semesters).

Trinity College is an Equal Opportunity/Affirmative Action employer. Applications from members of groups affected by affirmative action guidelines are invited.

Applicants should submit a detailed curriculum vitae, an academic record, and at least three letters of reference to:

D. A. Robbins, Chairman
Department of Mathematics
Trinity College
Hartford, CT 06106

Applications should be received by 30 January 1987; all applications will be acknowledged.

Representatives of the Department will be at the AMS meeting in January.

POSITIONS AVAILABLE

Arizona State University
Department of Mathematics

Applications are invited for a tenure track position in the area of applied differential equations at the Assistant Professor level beginning in August of 1987. Candidates should have a strong research record or superior potential. Preference will be given to candidates with post-doctoral experience.

The Mathematics Department currently has applied researchers active in areas such as control theory, nonlinear partial differential equations, mathematical biology, dynamical systems, special functions and numerical analysis.

Applicants should send a vita and have three letters of reference directed to: Hal Smith, Applied Differential Equations Search Committee, Department of Mathematics, Tempe, Arizona, 85287. Closing date for applications is February 16, 1987 or until filled.

Arizona State University is an Equal Employment Opportunity/Affirmative Action Title IX Employer. Women and minorities are encouraged to apply.

DEAN
College of Computer, Mathematical, and Physical Sciences
UNIVERSITY OF MARYLAND, COLLEGE PARK

Applications and nominations are invited for the position of Dean of the College of Computer, Mathematical, and Physical Sciences at the University of Maryland, College Park campus. The Dean of the College provides both academic and administrative leadership to the College and reports directly to the Vice Chancellor for Academic Affairs and Provost.

The College of Computer, Mathematical, and Physical Sciences consists of the departments of Computer Science, Geology, Mathematics, Meteorology, and Physics and Astronomy, as well as the Applied Mathematics Program, the Center for Automation Research, the Chemical Physics program, the Institute for Physical Science and Technology, the Institute for Advanced Computer Studies, and (jointly with Engineering) the Laboratory for Plasma and Fusion Energy Studies. The College employs 460 faculty members and approximately 800 support personnel. Presently about 3000 undergraduate students and 800 graduate students are enrolled in degree programs within the College. In 1985-86 researchers in the College were awarded approximately $29,000,000 in external grants and contracts. The state-supported budget for the College for this period was about $20,000,000.

A candidate should have an earned doctorate and be eligible for appointment as a faculty member in a department of the College at the rank of Professor with tenure. He or she should have successful experience as a teacher at the undergraduate and graduate levels and a distinguished record of scholarly research. Candidates should also have demonstrated leadership ability and management skills.

Applications or nominations for the position are invited. Applications should include a complete resume or curriculum vitae and the names and addresses of at least four references. All applications and nominations should be submitted before January 15, 1987 to:

William W. Destler
C.M.P.S. Dean Search Committee
Electrical Engineering Department
University of Maryland
College Park, Maryland 20742

The University of Maryland is an equal opportunity/affirmative action employer. Women and minority candidates are encouraged to apply.

The Department of Mathematical Sciences at Portland State University invites applications for 3 tenure track positions at the assistant professor level to begin fall 1987. Candidates must have a doctoral degree in mathematics or a related field and show both a research potential and a commitment to good teaching. The current salary range for assistant professorships is $23,000–$26,627. Priority will be given to applicants whose research interests are closely related to research by current faculty in pure and applied mathematics and statistics.

The department has bachelors and masters level programs and has been newly authorized to offer a PhD in System Science/Mathematics. Applicants are sought who will participate in the further development of the graduate program. Consideration of applications will begin on **February 15, 1987**, but applications will be accepted until the positions are filled.

Applicants should send vita and at least three letters of recommendation to

Prof. Bruce Jensen, Head
Department of Mathematical Sciences
PO Box 752
Portland, OR 97207

Portland State University is an Equal Opportunity Affirmative Action Employer. Qualified minorities, women, and members of other protected groups are encouraged to apply.

APPLIED/COMPUTATIONAL MATHEMATICS. Tenure-track asst or assoc. Start 9/1/87. Teach 2 courses per quarter at undergrad and grad level; assist in master's level program; conduct research; dept and college responsibilities. Requirements: PhD in math or related field by 9/1/87. For TT assoc, also 5 years' professional experience and distinction in research. For tenured assoc, the above and demonstrated effectiveness in teaching and advising. Send resume, graduate transcripts, and 3 letters of reference to Harlan Stech, Math & Stat, MG 320, 10 University Drive, University of Minnesota, Duluth, Duluth, MN 55812, by 2/1/87. (218-726-8272) THE UNIVERSITY OF MINNESOTA IS AN EQUAL OPPORTUNITY EDUCATOR AND EMPLOYER AND SPECIFICALLY INVITES AND ENCOURAGES APPLICATIONS FROM WOMEN AND MINORITIES.

University of Georgia
Department of Mathematics
Athens, GA 30602

We may have some tenure track positions for the 1987-88 academic year. The rank and salary will be commensurate with the applicants abilities and experience. The principal requirements are excellence in teaching and research. Some preference will be given to areas in which the department is already well represented. Send curriculum vitae and four letters of recommendation to Ray A. Kunze, Head (address above) by April 30, 1987. UGA is an Equal Opportunity/Affirmative Action Employer.

Marquette University

Applications are invited for tenure-track positions beginning August 1987, Ph.D. required. Preference given to candidates in numerical analysis or mathematical statistics. Applications are also invited for possible visiting positions of one or two semesters beginning August 1987 from faculty with the doctorate who wish to spend sabbatical leave at Marquette. Preference given to applicants whose research areas match faculty interests. Apply by January 31, 1987 by sending vita, transcripts, and arranging for 3 letters of recommendation to be sent to Douglas Harris (Chairman), Department of Mathematics, Statistics and Computer Science, Marquette University, Milwaukee, WI 53233. Marquette Universiity is an EEO/AA employer.

POSITIONS AVAILABLE

UNIVERSITY OF KENTUCKY
DEPARTMENT OF MATHEMATICS
LEXINGTON, KENTUCKY 40506-0027

Several openings at the assistant professor level are anticipated. We are particularly interested in Operations Research/Optimization, Numerical Analysis/Numerical Linear Algebra, Applied Analysis/Partial Differential Equations, Algebra/Algebraic Geometry. We also anticipate a specially funded visiting position in Partial Differential Equations. However, outstanding scholars in all areas at all levels are encouraged to apply. To apply, send vitae and have three or four letters of recommendation sent to Ronald Gariepy, Chairman.

EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER

FAIRFIELD UNIVERSITY
Assistant/Associate Professor of Computer Science

Fairfield University is a Jesuit school located near Long Island Sound, about 60 miles from New York City and 30 miles from New Haven. This is a tenure-track position requiring an average of 10 hours teaching per week and continued research. Rank and salary are competitive and will depend on qualifications. Preferred qualifications include a Ph.D. in Computer Science or a Ph.D. in a related area with a Masters in Computer Science. Applications will be accepted until the position is filled. Starting date is September 1987. To apply, please send a curriculum vitae including the names and phone numbers of three references to:

Joseph B. Dennin, Chair
Department of Mathematics &
Computer Science
Fairfield University
Fairfield, CT 06430

Fairfield University is an Equal Opportunity/Affirmative Action Employer.

CHAIR–DEPARTMENT OF MATHEMATICS
UNIVERSITY OF MAINE

The University of Maine, the land- and sea-grant institution of the State of Maine, is seeking a leader for a diverse department of 30 faculty. The department resides in the College of Arts and Sciences and serves all areas of the university, including the Department of Computer Science and the College of Engineering and Science. The chair will be expected to strengthen an established graduate program at the Masters level as well as the program for undergraduate majors, and maintain and update the department's large service commitment. The successful candidate will have a record of teaching and scholarship that will qualify him or her for a senior tenurable appointment. He or she will have a demonstrated record of interpersonal skills and the ability to communicate well. Administrative experience is desirable. The University of Maine, located 8 miles north of Bangor, enrolls 11000 students in 7 colleges in programs ranging from the associate degree to the doctorate. Screening of applications will begin February 1, 1987. Applications will be considered until the position is filled. The university is an affirmative action/equal opportunity employer. Women and minority candidates are encouraged to apply. Vitae with 3 letters of recommendation, or nominations, should be sent to: Michael C. Gemignani, Dean, College of Arts and Sciences, Stevens 100, The University of Maine, Orono, ME 04469.

University of California, Irvine

The School of Social Sciences has a tenure track Assistant Professor position in mathematical social science to begin July 1987. Requires Ph.D. in some field of the social or mathematical sciences, an exceptionally strong research potential, and an interest and ability in a broad range of methodological and formal modeling techniques in the social sciences. Candidate will join a unit with faculty formally trained in anthropology, economics, geography, psychology, and sociology. Teaching will be at both the graduate and undergraduate levels including courses in quantitative and computer methods and undergraduate courses in some social science major. Applicants should submit letter of interest, resume, publications, and the names of three references by February 1, 1987. An equal opportunity/affirmative action employer. Contact Dr. William H. Batchelder, Chair Mathematical Social Science, School of Social Sciences, University of California, Irvine, CA 92717.

SOUTHWEST MISSOURI STATE UNIVERSITY
DEPARTMENT OF MATHEMATICS

Applications are invited from suitably qualified candidates: (1) to fill an existing vacancy at the rank of Assistant or Associate Professor; (2) to fill three newly created positions at the rank of Assistant Professor or higher. The University is continuing its program, begun last year, of strengthening the mathematics department. Recent appointees have research interests in functional analysis, abstract and classical harmonic analysis, differential equations, and statistics.

A doctoral degree or research credentials equivalent to a doctorate and a commitment to teaching are required for all positions. For associate professor and professor appointments established research and teaching records are required. Salary is negotiable depending on qualifications.

All areas of specialization will be considered but some priority may be given to candidates in algebra, applied mathematics, and analysis. Screening of candidates will begin on January 15, 1987, and continue until the positions are filled or the search is discontinued. The right to leave any position unfilled is reserved. The starting date for these positions is August 19, 1987. Applicants should send a complete Curriculum Vitae and arrange for at least three letters of recommendation to be sent to: Simon J. Bernau, Department of Mathematics, Southwest Missouri State University, Springfield, Missouri 65804-0094. Telephone enquiries should be directed to Professor Bernau at (417)836-5112.

Southwest Missouri State University is an equal opportunity affirmative action employer.

RICE UNIVERSITY
Department of Mathematical Sciences

The Department of Mathematical Sciences seeks applications for a tenure-track opening in Operations Research for Fall, 1987. Applications at all levels and in all areas of Operations Research will be considered, however preference will be given to junior applicants with interests in the combinatorial aspects of optimization. Candidates are sought with demonstrated potential in both teaching and research. Applications should be submitted to Professor John E. Dennis, Jr., Department of Mathematical Sciences, P. O. Box 1892, Rice University, Houston, Texas 77251. Application materials should include a statement of research interests and the names of at least three individuals to serve as references.

Rice is an affirmative action/equal opportunity employer.

POSITIONS AVAILABLE

FLORIDA ATLANTIC UNIVERSITY

The Department of Mathematics is recruiting faculty for a new Ph.D. program. Applications are invited for positions beginning August 1987. Rank and salary will depend on qualifications. The Ph.D., or Ph.D. dissertation accepted with only formalities to be completed, is required. Significant research accomplishments or demonstrated research potential and a commitment to excellence in teaching are required of all candidates. The field is unrestricted, but preference will be given to those areas within algebra, analysis, and combinatorics which best match the research interests of the current faculty. The closing date is March 1, 1987. Applicants should send a curriculum vita and have three letters of recommendation sent to

James W. Brewer, Chairman
Department of Mathematics
Florida Atlantic University
Boca Raton, Florida 33431

Florida Atlantic University is an equal opportunity/affirmative action employer.

SUNY COLLEGE AT BROCKPORT

Tenure-track assistant/associate professorship in Mathematics anticipated September 1987. Applicants should have a Ph.D. in Mathematics with expertise in Discrete Mathematics, Probability, Applied Mathematics, or Operations Research, and a strong commitment to the teaching of Mathematics at the Undergraduate and Masters' level. For more information, contact Dr. K. Nakano, Chairperson, Department of Mathematics/Computer Science (phone: 716-395-2194). To apply, send a letter of application and resume, and have three letters of reference sent by February 6 to the Office of Faculty/Staff Relations, SUNY College at Brockport, Brockport, NY 14420. EO/AAE

SUNY COLLEGE AT BROCKPORT

Tenure-track position in Computer Science available September 1987. Candidates should have strong commitment to Computer Science education. Ph.D. in Computer Science or related area required. Masters' level expertise in Computer Science necessary. Preferred specialization in Operating Systems, Microprocessors, Networking, or Computer Graphics. For particulars contact: Dr. K. Nakano, Chairperson, Department of Mathematics/Computer Science (phone: 716-395-2194). To apply, send a letter of application and resume, and have three letters of reference sent to the Office of Faculty/Staff Relations, SUNY College at Brockport, Brockport, NY 14420. EO/AAE

UNIVERSITY OF WISCONSIN-MILWAUKEE Department of Mathematical Sciences

Applications are invited for at least one and possibly two tenure track assistant professorships beginning Fall 1987. We especially seek candidates in applied analysis, including ordinary and partial differential equations and numerical methods. Candidates should have proven ability or demonstrated potential for research as well as good teaching qualifications. Please send credentials and three letters of recommendation by Feb. 1 to Robert H. Moore, Chairman, Department of Mathematical Sciences, University of Wisconsin-Milwaukee, P. O. Box 413, Milwaukee, WI 53201.

The University of Wisconsin-Milwaukee is an affirmative action/equal opportunity employer.

ST. MARY'S COLLEGE OF CALIFORNIA

Tenure track position at Assistant Professor level, beginning in fall, 1987. A Ph.D., commitment to liberal arts education, and continued research are required of candidates to join a young and growing department. Area of expertise should supplement those already represented: analysis, formal languages, geometric inequalities and number theory. Current salary range is $23,741–$28,256; a salary increase is anticipated for the academic year of 1987-88.

Send resume and 3 letters of recommendation to:

J. R. Sangwine-Yager, Chairperson
Department of Mathematical Sciences
St. Mary's College
Moraga, CA 94575

Deadline, February 1, 1987. Interviews will be held at the AMS meeting in San Antonio, January 1987. EOE, M/F/V/H

DEPARTMENT OF MATHEMATICS UNIVERSITY OF HOUSTON HOUSTON, TEXAS 77004

The Department of Mathematics will have both permanent and visiting positions available for the 1987-88 academic year.

Openings for permanent appointments are at the Assistant Professor level. Candidates must have a Ph.D. degree in Mathematics and a strong commitment to research and teaching. Special consideration will be given to applicants in numerical analysis or dynamical systems. Vitae and at least three letters of recommendation should be sent to: Professor G. J. Etgen, Chairman, Department of Mathematics, University of Houston, Houston, Texas 77004. Telephone: 713-749-4827.

The department will have one or two D. G. Bourgin Visiting Scholar positions available for visits of either one or two semesters. Some teaching duties will be required, but the main purpose of these positions is collaboration with the permanent faculty. Interested persons should send a vitae and three letters of recommendation by February 15, 1987, to Professor Vern Paulsen, Department of Mathematics, University of Houston, Houston, Texas 77004. Telephone: 713-749-2122.

The University of Houston is an equal opportunity/affirmative action employer.

MATHEMATICS/COMPUTER SCIENCE

GETTYSBURG COLLEGE invites applications for a tenure-track, assistant professor position to teach mathematics and computer science starting September 1987. Completion of a Ph.D. in mathematics and a commitment both to excellence in teaching and to continued research are essential. Preference will be given to those applicants with a masters in computer science or equivalent background. Salary is competitive.

Gettysburg College is a selective liberal arts college historically related to the Lutheran Church in America. The college has approximately 1800 students and a student-faculty ratio of 13:1. The normal teaching load is three courses per semester on an early semester calendar. Extensive computing facilities include a Burroughs 5920 and microcomputer laboratory. The town of Gettysburg is in south-central Pennsylvania with proximity to Baltimore and Washington, D.C.

Send résumé and three letters of reference to David E. Flesner, Department of Mathematics, Gettysburg College, Gettysburg, PA 17325. To insure consideration, submit application by February 15, 1987. Gettysburg College is an Equal Opportunity/Affirmative Action Employer; women and minorities are encouraged to apply.

POSITIONS AVAILABLE

LEHMAN COLLEGE

Tenure track positions anticipated. Particularly sought are applicants who can participate in both mathematics programs and computer science programs. Doctorate and strong commitment to teaching and research required. Rank and salary commensurate with qualifications. Send resume to:

Professor Robert Feinerman, Chairman
Department of Mathematics and Computer Science
Lehman College
The City University of New York
Bronx, New York 10468

AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER

DEPARTMENT OF MATHEMATICS
California State University, Chico
Assistant Professor, Associate Professor, or Professor of Mathematics

The Department of Mathematics at California State University, Chico is seeking mathematicians or statisticians for one or more one-year temporary leave replacement positions beginning Fall, 1987. A Ph.D. in Mathematics or Statistics and evidence of teaching excellence are required. The salary is $25,812–$49,548. Duties include teaching undergraduate mathematics courses and carrying out scholarly research.

Qualified candidates should submit a resume, transcripts, supporting documents, and at least three letters of recommendation to:

Thomas A. McCready, Chair
Department of Mathematics
California State University, Chico
Chico, CA 95929-0525

The closing date for applications is March 15, 1987. CSU, Chico is an Equal Opportunity, Affirmative Action employer.

Mathematics: Kutztown University announces two tenure track positions in mathematics. Applicants must have a background in either pure or applied mathematics. The department offers both a B.A. and a B. S. in mathematics, a B.S. in secondary education, an M.A. in mathematics and a mathematics specialization in a Master of Education program. In addition, the department offers a B.S. in computer and information science and is seeking approval of a Masters of Science degree in computer science. Research and instructional facilities include a Burroughs A9 mainframe; several high performance graphics terminals; an M68000-based multi-user, dual-processor microcomputer; and several well-equipped microcomputer laboratories. A Ph.D. in mathematics is preferred; however, candidates with a strong Master's degree will be considered. Candidates are expected to participate in curriculum development, student advisement, at the graduate and undergraduate level, teach basic service mathematics courses as well as advanced undergraduate and graduate courses. Rank and salary are commensurate with qualifications. Starting date is September 1987. Applications, including graduate transcripts and three letters of recommendation, should be sent to Dr. Larry Mugridge, Dept. of Mathematics and Computer Science, Kutztown University, Kutztown, PA 19530. Deadline for applications is February 15, 1987. Kutzown University is an Affirmative Action/Equal Opportunity Employer and actively solicits application from qualified minority and women applicants.

DEPARTMENT OF MATHEMATICS
California State University, Chico
Assistant Professor of Mathematics

The Department of Mathematics at California State University, Chico is seeking a specialist in applied mathematics for a full-time tenure-track position beginning Fall, 1987.

A Ph.D. in Mathematics and the potential for teaching excellence are required. Duties include teaching undergraduate mathematics courses, developing and teaching courses in applied mathematics and mathematical modeling, and carrying out scholarly research. The salary range is $25,812–$31,044.

Qualified candidates should submit a resume, transcripts, supporting documents, and at least three letters of recommendation to:

Thomas A. McCready, Chair
Department of Mathematics
California State University, Chico
Chico, CA 95929-0525

The closing date for applications is February 1, 1987. CSU, Chico is an Equal Opportunity, Affirmative Action employer.

DEPARTMENT OF MATHEMATICS
California State University, Chico
Assistant Professor of Mathematics

The Department of Mathematics is seeking a specialist in mathematics education to fill a full-time tenure-track position beginning Fall, 1987

A Ph.D. or Ed.D. in Mathematics or Mathematics Education, with a strong background in mathematics and evidence of teaching excellence, is required. Duties include teaching undergraduate mathematics courses, preparing and implementing grant applications in mathematics education, and carrying out scholarly research in mathematics education. The salary range is $25,812–$31,044.

Qualified candidates should submit a resume, transcripts, supporting documents, and at least three letters of recommendation to:

Thomas A. McCready, Chair
Department of Mathematics
California State University, Chico
Chico, CA 95929-0525

The closing date for applications is February 1, 1987. CSU, Chico is an Equal Opportunity, Affirmative Action employer.

DEPARTMENT OF MATHEMATICS
NORTHERN ARIZONA UNIVERSITY

The Department of Mathematics is seeking candidates for two tenure track positions which start August 24, 1987. Qualifications include a Ph.D. in mathematics or mathematical statistics, evidence of teaching effectiveness and potential for an active mathematical research program. The first position is at the assistant professor level and preference will be given first to qualified candidates in statistics and second to those in combinatorial algebra or geometry, or qualitative theory of differential equations. The other position, at the assistant or associate professor level, requires a specialty in combinatorial algebra or geometry, qualitative theory of differential equations, or geometric topology. NAU is located in Flagstaff amidst pine forests at an altitude of 7000 feet in the mountains of Northern Arizona. Send resume and direct three letters of recommendation to: Screening Committee, Department of Mathematics, Box 5717, Northern Arizona University, Flagstaff, AZ 86011. The search will remain open until the positions are filled; however, the screening committee will begin reviewing applications on February 16, 1987. NAU is an Equal Opportunity/Affirmative Action Institution. Women and minorities are encouraged to apply.

POSITIONS AVAILABLE

DEPARTMENT OF MATHEMATICS
UNIVERSITY OF CALIFORNIA
RIVERSIDE, CALIFORNIA

Applications are invited for one or more temporary positions beginning in September 1987. These positions are funded at the Assistant Professor level, but there is some slight flexibility in salary. They are open to applicants from all research areas within Mathematics and Computer Science with significant accomplishments or high potential in both research and teaching.

Candidates should send vita and arrange for at least three letters of recommendation to be sent to: Professor B. Wong, Chair, Search Committee, Department of Mathematics and Computer Science, University of California, Riverside, California 92521. The University of California is an Equal Opportunity/Affirmative Action Employer.

California State University, Hayward
Department of Mathematics and Computer Science

The department is now seeking applicants for entry level tenure track Assistant Professor positions in mathematics beginning Fall, 1987.

Applicants should hold the Ph.D. degree in mathematics and should have a commitment to excellence in teaching and a willingness and an ability to participate in curriculum development. Applicants should also exhibit the competence and potential to engage in significant professional activities, including research and publication. All areas of specialization will be considered. The interests of the present faculty include a wide range of fields in mathematics and in computer science.

CSU, Hayward is located in the hills above, and overlooking, the eastern shore of the San Francisco Bay. More than 12,000 students attend this university, which has outstanding programs in arts, letters, science, and business. The Department of Mathematics and Computer Science enrolls nearly 1300 majors in its three degree programs: B.S. in Computer Science, B.S. in Mathematics, and M.S. in Mathematics. An M.S. in Computer Science is being planned.

Interested applicants should send a resume and the names of three references to

William R. Nico, Chair
Department of Mathematics and Computer Science
California State University, Hayward
Hayward, CA 94542

Applications received by February 15, 1987, will be assured full consideration. Applications will be accepted as long as positions remain available.

California State University, Hayward, is an Equal Opportunity/Affirmative Action employer and encourages applications from women and men of all ethnic backgrounds and physical abilities.

UNIV. OF CALIF., SANTA CRUZ,
DEPT. OF MATH,
SANTA CRUZ, CA 95064

The Math Dept. at U.C.S.C. expects to have several visiting positions '87–'88 and invites qualified mathematicians in all fields. Positions are available for one or more quarters. Pref. will be given to entire year appointments. Pending administrative approval two year positions might be available. RANK Approp. Visitor Title–Ph.D in Math with excellent teaching. SALARY commensurate with qualifications. Send vitae, three letters of reference especially on teaching to: Recruiting Committee, Board of Studies in Math., Appl. Sci. Bldg., Univ. of Calif., Santa Cruz, CA 95064. Closing date Feb. 2, 87 ref. #T86-14 EEO/AA

THE UNIVERSITY OF ALABAMA
AT BIRMINGHAM
DEPARTMENT OF MATHEMATICS

Applications are invited for the position of Associate Professor or Professor of Mathematics to begin September 1, 1987. The department is especially interested in establishing a group in Numerical P.D.E./Scientific Computation over the next five years. Other areas which will enhance our proposed Ph.D. in Applied Mathematics will be seriously considered. Demonstrated leadership in research is expected of applicants. Send as soon as possible a curriculum vitae, list of publications, a few selected reprints, and the names of three references to Search Committee, Department of Mathematics, University of Alabama at Birmingham, Birmingham, AL 35294. UAB is an Affirmative Action/Equal Opportunity Employer.

TENNESSEE TECHNOLOGICAL UNIVERSITY
DEPARTMENT OF MATHEMATICS

Applications are invited for a tenure-track position at the Assistant or Associate Professor level, beginning September 1, 1987. The Department is especially interested in finding someone who can contribute to our program in applied mathematics for graduate mathematics and engineering students. However, qualified applicants in all areas are encouraged to apply. Candidates must have a Ph.D. in mathematics, statistics or a related area; a strong commitment to excellence in teaching at both the undergraduate and the graduate levels; and a serious interest in research and scholarly activity.

To apply, send a letter of application, a curriculum vitae (which includes citizenship and/or visa status), and a transcript of graduate work to:

Alice Mason, Chairman
Department of Mathematics
Box 5054, TTU
Cookeville, TN 38505

Applicants should also arrange to have at least three (3) letters of recommendation sent to the above address.

Applications will be reviewed immediately upon completion and will continue to be accepted until the position is filled.

Tennessee Technological University is an AA/EEO Employer.

AUBURN UNIVERSITY
DIVISION OF MATHEMATICS
DEPARTMENT OF FOUNDATIONS, ANALYSIS, AND TOPOLOGY

Several tenure-track and visiting appointments at all ranks are expected for Fall 1987 generally in areas of analysis with emphasis in partial differential equations and numerical solutions of differential equations and also in numerical analysis, applied mathematics, and possibly other fields. Minorities and Women are urged to apply.

Send vita and have three letters of reference sent to George Kozlowski, Department of Foundations, Analysis, and Topology, Auburn University, AL 36849.

AUBURN UNIVERSITY IS AN EQUAL OPPORTUNITY AFFIRMATIVE ACTION EMPLOYER.

APPLIED MATH

Tenure track; Asst./Assoc.; Salary Dep. Qual.; Ph.D. Applied Math. or Math. w/Applied Exp. Req'd; Prefer Teach. Exp., Research, Indus. Exp.; Resume, 3 Ref. Letters, Appl., Official Trans. by 2-1-87. Add'l Info. and to Apply: Applied Search Comm., Math. Dept., Cal. St. Polytech. Univ., Pomona, CA 91768-4033. Cal. St. Polytech. Univ. is an AA/EEO.

POSITIONS AVAILABLE

INDIANA STATE UNIVERSITY DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE

Applications are invited for at least three tenure track positions at the Assistant Professor level beginning September 1987. The Department has 24 full-time faculty members and offers BA and BS degrees in Mathematics and in Computer Science, and the MA and MS in Mathematics. Applicants should possess an earned Ph.D. and potential for teaching and research excellence.

Indiana State University has extensive computing facilities, including a CYBER 830, an IBM 4361, two PRIME 750's and several microcomputer laboratories. The Department operates its own microcomputer laboratory and a VAX-11/750 with both Bell and Berkeley UNIX available.

Send vita and three letters of recommendation to:

Dr. Donald F. Reynolds, Chairman
Department of Mathematics and Computer Science
Indiana State University
Terre Haute, IN 47809

Applicants should be U.S. citizens or hold a resident visa. Applications received after February 13, 1987, cannot be guaranteed consideration. Indiana State University is an EO/AA employer.

Assistant Professorship in Systems and Control

The Department of Mathematics at the Arizona State University invites applications for a tenure track position in the area of systems and control theory, beginning in August, 1987. Preference will be given to those candidates with demonstrated research potential and with the ability to teach university mathematics effectively. Salary will be competitive. Applications must include a current curriculum vita and at least four letters of recommendation which are to be sent to:

Professor Christopher I. Byrnes
Chair, Search Committee in Systems and Control
Department of Mathematics
Arizona State University
Tempe, Arizona 85287

Complete applications must be received no later than February 28, 1987.

The interdisciplinary systems and control group at Arizona State University currently contains members active in many areas, including adaptive control, computational and numerical methods, control of rigid and flexible spacecraft, infinite dimensional systems, intelligent control, linear systems, mathematical programming, nonlinear filtering, nonlinear systems and control, robotics, signal processing, and stochastic system theory.

Arizona State University is an AA/EEO employer.

STOCKTON STATE COLLEGE

Tenure-track position in mathematics is available for Fall 1987 at Assistant Professor or Instructor level. Ph.D. required for Assistant Professorship ($23,979–$27,577). A.B.D. required for Instructorship ($19,727–$22,685). We seek an excellent, versatile teacher to be part of a strong, nine-person department in a young, liberal arts college in rural South Jersey. Area of specialty open, but interest in computer science a plus. Screening will begin on January 12, 1987. Send resume and three letters of reference to Dr. Donald Plank, Chairman; Division of Natural Sciences and Mathematics; Stockton State College; Pomona, NJ 08240. Stockton is an AA/EO Employer. Women and minorities are encouraged to apply.

FAIRFIELD UNIVERSITY
Assistant Professor of Mathematics

Fairfield is a Jesuit university located near Long Island Sound, about 50 miles from New York and 25 miles from New Haven. This is a tenure-track position requiring an average of 10 hours teaching per week and continued research. Salary is competitive and will depend on qualifications. Qualifications include a Ph.D. in some area of Mathematics. Teaching expertise in Numerical Analysis or Statistics is desirable. Starting date is September 1987. To apply, please send a curriculum vitae, three letters of recommendation and data on teaching performance to:

Joseph B. Dennin, Chair
Department of Mathematics &
Computer Science
Fairfield University
Fairfield, CT 06430

For full consideration, applications should be received by March 1, 1987. Fairfield University is an Equal Opportunity/Affirmative Action Employer.

McMASTER UNIVERSITY DEPARTMENT OF MATHEMATICS AND STATISTICS

The Department of Mathematics & Statistics, McMaster University, invites applications for a tenure track Assistant Professorship starting July 1, 1987.

Candidates should have a Ph.D. and proven research ability in some area of Mathematics related to Analysis, as well as capability in teaching. Salary based on qualifications and experience. 1986/87 minimum is $27,639.

Please send curriculum vitae and arrange for three letters of reference to:

B. Banaschewski, Chairman
Mathematics & Statistics
McMaster University
Hamilton, Ontario
L8S 4K1 Canada

In accordance with Canadian Immigration requirements, this advertisement is directed to Canadian Citizens and permanent residents.

MATH ED

Tenure track; Salary Dep. Qual.; Doctorate Math. Ed. or Math.; Sec. Teaching Exp. Req'd; Related Research Desired; Resume, 3 Refs., Appl., Official Trans. by 2-1-87. Add'l Info. or Apply: Math. Ed. Search Comm., Math. Dept., Cal. St. Polytech. Univ., Pomona, CA 91768-4033. Cal. St. Polytech. Univ. is an AA/EEO.

ARIZONA STATE UNIVERSITY DEPARTMENT OF MATHEMATICS

Tenure-track position in applied mathematics at the assistant professor level available starting fall 1987. A doctorate in mathematics or statistics is required. A commitment to excellence in teaching is expected of all candidates as is evidence of strong research potential. Research areas must include at least one of applied probability, computational mathematics, discrete mathematics or stochastic processes. Salary competitive. ASU is located in sun-drenched rapidly growing metropolitan Phoenix. Send vita and arrange for three letters of reference to be mailed to

Prof. B. A. Anderson, Search Committee
Department of Mathematics
Arizona State University
Tempe, AZ 85287

Deadline February 16, 1987, or until filled. Women and minorities are encouraged to apply. AA/EOE/T9

POSITIONS AVAILABLE

UNIVERSITY OF NORTH FLORIDA DEPARTMENT OF MATHEMATICAL SCIENCES

Applications are invited for anticipated tenure track positions at the Assistant and Associate Professor levels. Visiting positions may be available. Candidates must have a Ph.D. in Mathematics or Statistics, strong teaching ability and continuing scholarly activity. Candidates for Associate Professor must have a record of outstanding teaching and substantial research. Duties include teaching major graduate and service courses. The department offers the BA and BS degrees in Mathematics and Statistics and the MA degree with tracks in mathematics, statistics and computer science. The University which is currently adding an engineering program is a growing institution in the State University system of Florida. Send resume, 3 letters of recommendation and transcript by February 15, 1987 to Leonard J. Lipkin, Chairperson, Department of Mathematical Sciences, University of North Florida, 4567 St. Johns Bluff Road, Jacksonville, Florida, 32216. An AA/EOE Employer.

THE EMMY NOETHER LECTURESHIP AT BRYN MAWR COLLEGE

The Department of Mathematics at Bryn Mawr College invites applications for the Emmy Noether Lectureship, to be awarded for one semester in 1987–88. The Lectureship is financially supported by the Noether Fund, which was established at the time of Emmy Noether's death, and has been augmented by generous contributions since the Noether Symposium at Bryn Mawr in 1982. The award is given in this form for the first time.

Candidates must be women having a Ph.D. in Mathematics. The Lecturer is expected to teach one graduate/advanced undergraduate course at Bryn Mawr College and to actively pursue her research interests.

The salary will depend upon the candidate's qualifications.

Applicants should submit a vita, a plan of research, and have three letters of recommendation sent to:

Frederic Cunningham, Jr.
Chairman, Selection Committee
Department of Mathematics
Bryn Mawr College
Bryn Mawr, PA 19010

Selection will be made no earlier than February 1, 1987. Bryn Mawr is an AA/EOE.

GOTHENBURG UNIVERSITY AND CHALMERS UNIVERSITY OF TECHNOLOGY

The Joint Department of Mathematics of the Chalmers and Gothenburg Universities has seven professorial chairs, some thirty positions as readers, lecturers or research assistants and a similar number of graduate students. The department has active research groups in complex and harmonic analysis, approximation theory, partial differential equations and finite element methods, algebra, probability theory and statistics. Professorships will soon be open by retirement.

The department welcomes applications from mathematicians, well qualified in these areas or in other fields.

Swedish Professors are appointed with tenure by government, after a special screening procedure. Those interested could contact Professor Peter Jagers or Professor Vidar Thomee, Department of Mathematics, Chalmers S-412 96 G # Teborg, Sweden. Tel 46-31-81 01 090.

Applications can be sent to this address and should contain a curriculum vitae, list of publications and reprints (four copies of each). All documents must reach the department by January 30, 1987.

THE DEPARTMENT OF MATHEMATICAL SCIENCES OAKLAND UNIVERSITY ROCHESTER, MICHIGAN 48063

Applications are invited for one-year visiting positions beginning Fall 1987 and later. It is anticipated there will be visiting positions in future years. The level will depend upon the qualifications and record of the successful applicant. A Ph.D. is required with a demonstrated excellent record in research or with strong potential in research. Preference will be given to an applicant whose interests coincide with the research interests and goals of the Department. Duties include teaching two courses each semester. Oakland University is a state-supported university with about 12,000 students located 30 miles north of Detroit. The faculty of the Department is strongly committed to research. The Department offers master's degrees in the mathematical sciences, including statistics. Applicants should send a resume and two letters of reference to Donald E. G. Malm, Chair. To be given full consideration, applications must be received by 10 February 1987. Late applications will be considered if the positions are not filled. Oakland University is an affirmative action/equal opportunity employer and encourages applications from women and minorities.

POSITION AVAILABLE IN NUMERICAL ANALYSIS AT ECOLE POLYTECHNIQUE – PALAISEAU – FRANCE

Applications are invited from French-speaking top level mathematicians for a two-year professorship in the field of "Numerical Analysis", with the possibility of further five-year contracts.

This professor will give courses in numerical analysis at the (undergraduate level) and also courses in this field at the graduate level. He will also be in charge of organization responsibilities in cooperation with the other professors in pure and applied mathematics.

This professor is also expected to be active in research in his own field and to cooperate with other research groups at Ecole Polytechnique.

Applicants may address inquiries on the position to:

Monsieur le Directeur de l'Enseignement
et de la Recherche
ECOLE POLYTECHNIQUE
91128 – PALAISEAU Cedex, France
Tel: (1) 60.19.40.21

The final application should be made by January 30, 1987.

MILLS COLLEGE
Department of Mathematics and Computer Science
Oakland, California 94613

Mills College is seeking outstanding candidates for a tenure-track position as Assistant, Associate or Full Professor of Mathematics commencing Fall, 1987. Successful candidates must have demonstrated superior teaching and research abilities and a commitment to become involved in a highly innovative and energetic department. Rank and salary will depend on experience and qualifications. The initial contract will be for three years, subject to final administrative approval. Mills College is an Affirmative Action/Equal Opportunity Employer.

Send vita and direct three letters of reference to:

Professor Diane McEntyre
Mathematics Search Committee
Mills College
Oakland, CA 94613

POSITIONS AVAILABLE

WESTERN WASHINGTON UNIVERSITY
Department of Mathematics

Applications are invited for tenure-track and visiting positions in the Department of Mathematics to begin Fall, 1987. A Ph.D. in Mathematics is required.

Candidates in ordinary or partial differential equations who are able to work with current faculty members, or in geometry with an emphasis on convexity or combinatoric enumeration are especially sought for a tenure-track position. Candidates in other areas will also be considered. All successful candidates will be expected to be active research mathematicians who will interact at the research level with current department members, and to be good teachers.

Rank and salary are open, but a substantial research record will be required for appointments above the Assistant Professor level. The normal teaching load for research faculty is two courses per quarter.

Western Washington University is located on Bellingham Bay in an area of outstanding natural beauty within an hour's drive of the Seattle and Vancouver, B.C. metropolitan areas and the Cascade Mountains. The department has a strong undergraduate program with a somewhat applied flavor and a flourishing Master's program with more than twenty students.

Applications should be sent to Professor Thomas T. Read, Chairman, Department of Mathematics, Western Washington University, Bellingham, WA 98225.

Interested candidates should submit a letter of application, complete transcripts, a vita, and three letters of recommendation. Deadline for applications is February 1, 1987; later applications will be considered if positions remain available. Positions are subject to the continuing availability of funds. Western Washington University is an Equal Opportunity–Affirmative Action Employer.

UNIV. OF CALIF., SANTA CRUZ, DEPT. OF MATH, SANTA CRUZ, CA 95064

The Univ. of Calif. is seeking applications in the area of non-linear analysis, or appl. math. RANK: Full Professor MIN. REQUIREMENTS Ph.D. in Math and strong research & teaching credentials SALARY Commensurate with qualifications and experience EFFECTIVE DATE July 1, 1987 APPLY TO Recruitment Committee, Board of Studies in Math, Applied Sci. Bldg., Univ. of California, Santa Cruz, CA 95064 (Please refer to 36-856 in your reply) EEO/AA CLOSING DATE Feb 1, 1987. Send vitae, four letters of ref on research and teaching.

PUBLICATIONS

Journal of Number Theory

The Journal of Number Theory appears in 3 volumes per year (9 issues) beginning January 1987.

The time between submission of a manuscript that has been accepted by the editors without reservations and its publication in the Journal is now already less than a year. Further reduction of the lead time is expected. Submission of research papers on number theory and allied fields (including automorphic functions and computational number theory) is invited.

H. Zassenhaus
Editor-in-Chief
Journal of Number Theory
Department of Mathematics
The Ohio State University
231 W. 18th. Avenue
Columbus, Ohio 43210-1174

Book of Combinatorial Tables

David Singmaster, Robin J. Wilson and William Wingate are preparing a book of combinatorial tables. This will collect together in one place the basic definitions, formulae, tables, diagrams, etc. for all the standard combinatorial structures.

We need your help!

In order to make the book as useful as possible to you, we would be most grateful for your answers to the following questions.

- What items would be of particular interest to you?
- Do you have, or know of, any tables or other material which could usefully be incorporated (all contributions would, of course, be properly acknowledged in the text)?

If you have any comments or information, or if you would like to have a copy of the draft list of contents to comment on, please write to:

W. J. G. Wingate
Faculty of Mathematics
The Open University
Walton Hall
Milton Keynes, England, MK7 6AA

POSITIONS WANTED

Undergraduate, graduate, postgraduate teaching experience for 23 years. Ph.D. in operator theory. Age 48. Seek position in college or university beginning any time. Permanent resident. Resume and references upon request. Write to Navnit Shah, 603 West Main Street, Norristown, PA 19401.

FOR SALE

MATH SCI PRESS, Robert Hermann, Director, 53 Jordan Rd., Brookline, MA 02146, 617-738-0307. New: **THE CLASSICAL DIFFERENTIAL GEOMETRY OF CURVES AND SURFACES**, by Georges Valiron, translated by James Glazebrook (Lie Groups Series, vol. 15), $50. 39 titles in mathematics, physics, and control theory in print: Write for catalog.

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FOR SALE

Foundations of Semiological Theory of Numbers
H. A. Pogorzelski and W. J. Ryan
Volume 1 (1982), General Semiology, 597 pp., $29.95
Volume 2 (1985), Semio. Functions, 695 pp., $34.95
(Ten Volumes Projected)
UMO Press, Univ. of Maine, Orono, ME 04469
(Post free within US if check included)

Proceedings of the Nineteenth Nordic Congress of Mathematicians, University of Iceland, August 13-17,1984

Detailed advertisement with list of contents in the January 1986 Notices, p. 181. Send order and payment ($20) to: Icelandic Mathematical Society, Science Institute, Dunhaga 3, IS-107 Reykjavik, Iceland.

Special Values of Dirichlet Series, Monodromy, and the Periods of Automorphic Forms

Peter Stiller

This work examines in detail the relationship between classical cusp forms for subgroups of finite index in $SL_2(\mathbf{Z})$ and certain geometrically motivated differential equations. The author develops a relationship between the differential equation's monodromy representation and the special values in the critical strip of the Dirichlet series associated to the cusp form, and uses this to compute the special values in some interesting cases.

Contents

1. Introduction
2. Periods of automorphic forms
3. Locally split extensions of flat vector bundles
3. bis. Automorphic forms attached to the symmetric powers of a second order differential equation and their periods
4. Descent
5. Differential equations associated to automorphic forms
6. Examples

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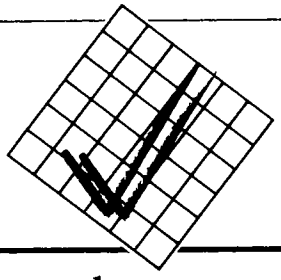

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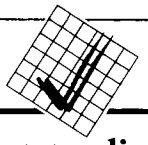

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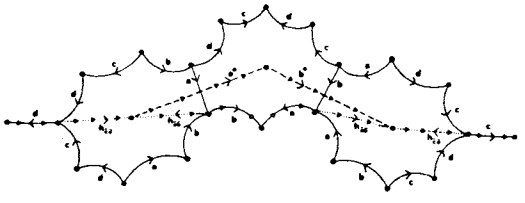

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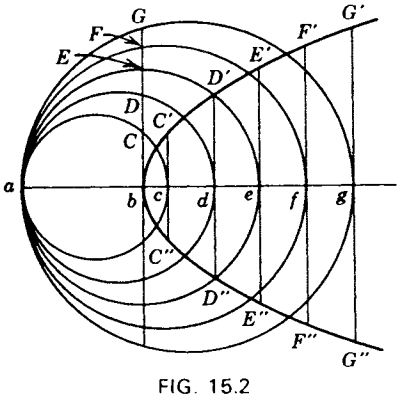

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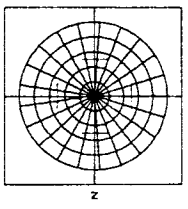

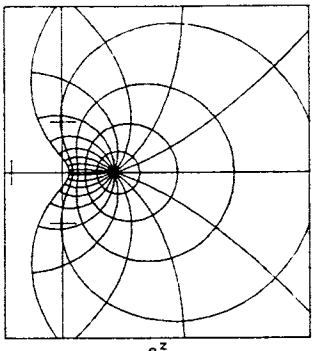

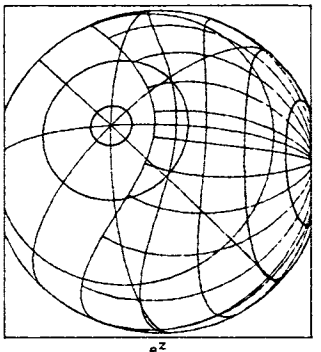

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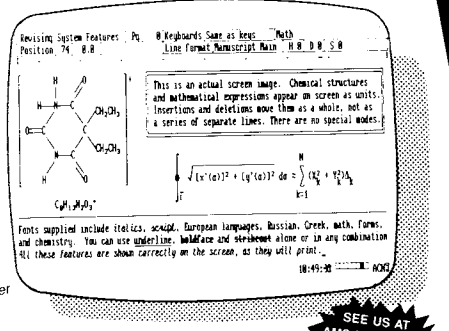

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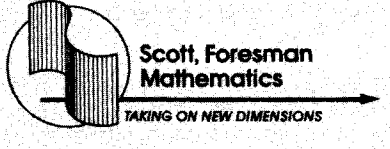

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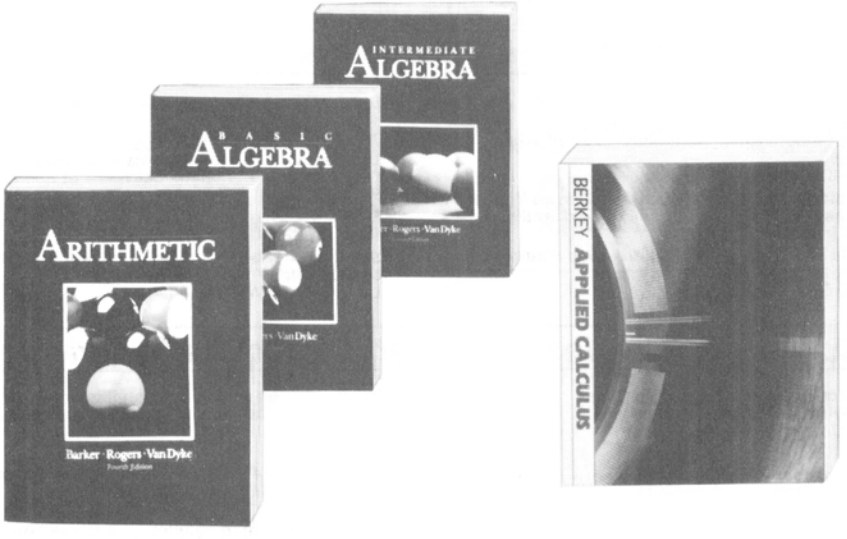

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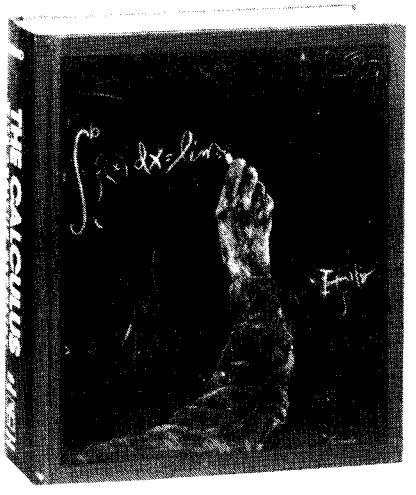

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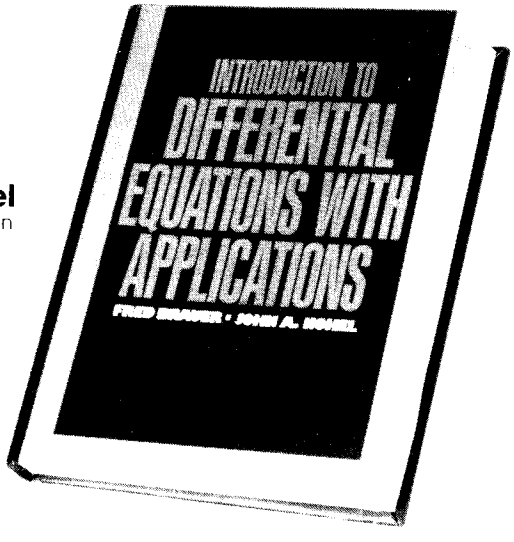

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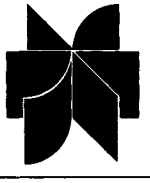

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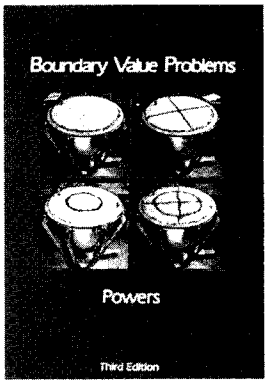

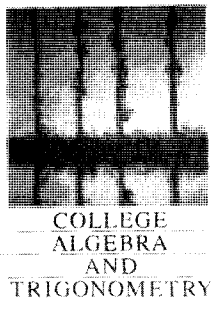

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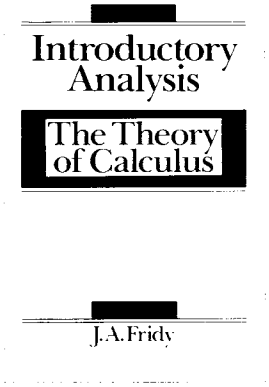

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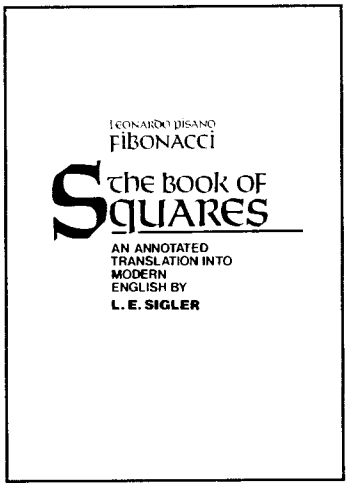

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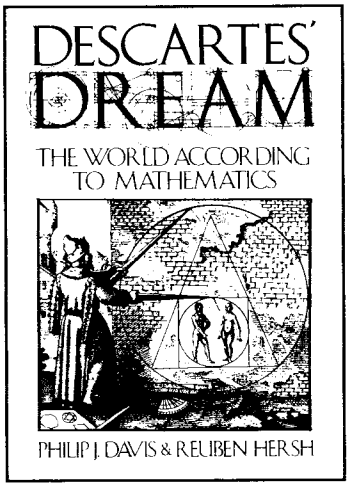

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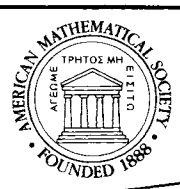

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Book Reviews

Reviews in Graph Theory, edited by William G. Brown, American Mathematical Society, 1980. Volumes I, II, III, IV (paperback).

Certainly one of the foremost tasks facing any researcher is to determine what is already known about his problem. This task is particularly difficult in graph theory research as there are many periodicals that publish such work. Of course the American Mathematical Society has been performing a great service for many years by publishing *Mathematical Reviews*. Thus to a large extent this literature search problem has been solved. However if one is specifically interested in graph theory, then one would need all the volumes from the start in 1940 to the present. In addition, one would have to do a great deal of "hunting" to find the references to his problem. William G. Brown has done that job for everyone by publishing a four-volume paperback edition of *Reviews in Graph Theory*, which covers the first 56 volumes of *Mathematical Reviews* (1940–1978). These 7-inch by 10-inch paperbacks are the most handy and useful tools that any graph theorist could own.

Perhaps the content alone of these four volumes explains how worthwhile they are. However, I shall make a few further comments. Clearly the key to the utility of such a compendium is the classification scheme. It becomes obvious by looking at the contents that Brown gave a great deal of thought to the classification process. The entire subject of graph theory is broken down into 27 major categories and 530 subcategories. These major topics are well chosen and agree with many of the chapter headings that one finds in books on graph theory. Since any two people who tried to compile such a list of major topics would probably arrive at different answers, it seems very foolish to comment on the choice. However, I do think that the choice of categories is excellent. In addition to these graph theory subjects, the four volumes contain a general category which includes books and bibliographies. There is an author index and a subject index. Also it contains a "key" index which gives information on collections, conference proceedings, problem lists, and obituaries. There is an extensive section on "information for the reader" and a form for readers comments.

My own personal experience in using these four volumes during the past few months is that of delight. They have become a very important tool for me, and I recommend that every graph theory researcher own them. Examples abound as to their value. Recently I found the answer to a question that was given as an unsolved problem in one of the famous graph theory books. Since I needed the result for something I was doing, I was very pleased to have found it so easily.

The only fault I could find was the difficulty in learning to use e cross references. For example, in subject category 054 on page 222 of Volume I review numbered 46#5177 refers the reader to an author's related paper only ide fied as 37#5124. No information is given regarding its location. I had to look in author index to find that this other work was located in subject category 290. But is is a very minor complaint since I did find what I wanted. In summary, therefore, I would say that these four volumes are very well organized and an indispensable tool.

I hope that they will be updated periodically.

F. T. Boesch

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57 Manifolds and cell complexes
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92 Biology and behavioral sciences
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M7N0

Membership Categories

Please read the following to determine what membership category you are eligible for, and then indicate below the category for which you are applying.

*For **ordinary members** whose annual professional income is below $26,000, the dues are $64; for those whose annual professional income is $26,000 or more, the dues are $84.*

*For a **joint family membership**, one pays ordinary dues, based on his or her income, and the other pays ordinary dues based on his or her income, less $20. (Only the member paying full dues will receive the* Notices *and the* Bulletin *as a privilege of membership, but both members will be accorded all other privileges of membership.)*

*Minimum dues for **contributing members** are $126.*

*For either **students** or **unemployed individuals**, dues are $21, and annual verification is required.*

*The annual dues for **reciprocity members** who reside outside the U.S. and Canada are $42. 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 ($64 or $84).*

*The annual dues for **external members**, those who reside in developing countries which do not have any mathematical society, are $45.*

*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.*

1987 Dues Schedule

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Ordinary member	○ $64	○ $84	
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Joint family member (reduced rate)	○ $44	○ $64	
Contributing member (minimum $126)	○		
Student member (please verify)[1]	○ $21		
Unemployed member (please verify)[2]	○ $21		
Reciprocity member (please verify)[3]	○ $42	○ $64	○ $84
External member	○ $45		
Multi-year membership	$ ..... for .... years		

1 Student Verification (sign below)

I am a full-time student at .....

..... *currently working toward a degree.*

2 Unemployed Verification (sign below) *I am currently unemployed and actively seeking employment. My unemployment status is not a result of voluntary resignation or of retirement from my last position.*

3 Reciprocity Membership Verification (sign below) *I am currently a member of the society indicated on the right and am therefore eligible for reciprocity membership.*

Reciprocating Societies

- ○ Allahabad Mathematical Society
- ○ Asociación Matemática Española
- ○ Australian Mathematical Society
- ○ Berliner Mathematische Gesellschaft e.V.
- ○ Calcutta Mathematical Society
- ○ Dansk Matematisk Forening
- ○ Deutsche Mathematiker-Vereinigung e.V.
- ○ Edinburgh Mathematical Society
- ○ Gesellschaft für Angewandte Mathematik und Mechanik
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- ○ Íslenzka Staerdfraedafélagid
- ○ Israel Mathematical Union
- ○ Korean Mathematical Society
- ○ London Mathematical Society
- ○ Malaysian Mathematical Society
- ○ Mathematical Society of Japan
- ○ Mathematical Society of the Philippines
- ○ Mathematical Society of the Republic of China
- ○ New Zealand Mathematical Society
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- ○ Norsk Matematisk Forening
- ○ Österreichische Mathematische Gesellschaft
- ○ Polskie Towarzystwo Matematyczne
- ○ Punjab Mathematical Society
- ○ Real Sociedad Matemática Española
- ○ Sociedad Colombiana de Matemática
- ○ Sociedad de Matemática de Chile
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The November, January, March, May, and August issues contain listings of open positions, information for which has been provided by heads of mathematics departments of colleges and universities in the United States, Canada, and overseas. In addition, these issues contain descriptions of open positions within government, industrial, and other nonacademic areas. The December issue contains résumés of job applicants who will be participating in the Employment Register at the January Annual Meeting.

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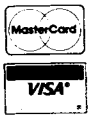

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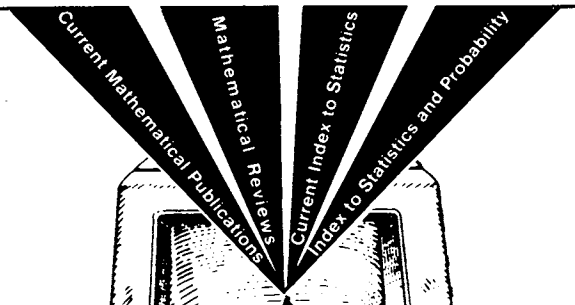

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