FOCUS

Volume 12, Number 4 THE NEWSLETTER OF THE MATHEMATICAL ASSOCIATION OF AMERICA September 1992

There are Infinitely Many Carmichael Numbers

Keith Devlin

There are infinitely many Carmichael numbers. This was established earlier this year by three mathematicians from the University of Georgia in Athens, Georgia: Red Alford, Andrew Granville, and Carl Pomerance.

The story that leads to Carmichael numbers has its origin in a letter written by Fermat to his colleague Frenicle on 18th October, 1640, in which he stated what is nowadays known as *Fermat's Little Theorem*: if p is a prime number, then for any number n, p divides n^p-n.

Fermat's Little Theorem provides a useful way to test that a given number p is composite: see if p divides 2^p-2. If it does not, you know at once that p is composite. Since performing this test only requires computation of the number 2^p mod p, a task can be performed very quickly on a modern digital computer for numbers with hundreds of digits (the size required for present-day encryption systems that make use of large prime numbers), this provides a very efficient way to test for compositionality. But it fails to provide a reliable primality test, since there are non-prime numbers p for which p divides 2^p-2; the smallest such number is 341 (= 11 x 31).

A composite number p for which p divides 2^p -2 is called a *2-pseudoprime*. More generally, for any number b, a composite number p for which p divides b^p - b is called a *b-pseudoprime*. The creation of a reliable primality test based on Fermat's Little Theorem by computing (b^p - b) mod p for a number of different values of b is confounded by the existence of composite numbers p that are *b-pseudoprimes* for all values of b. The smallest such number, 561 (= 3 x 11 x 17), was discovered to have this property in 1910 by Carmichael, after whom such numbers are now named.

Carmichael numbers are fairly rare. The only one less than 1,000 is 561; there are six more below 10,000 and 43 less than 1 million. A recent computer search carried out by Pinch at Cambridge University counted 105,212 less that 10^{15}.

In 1899 (that is prior to Carmichael's work on the subject), Korselt observed the following results, now known as *Korselt's criterion*:

A number n is Carmichael if and only if n is squarefree and p -1 divides n -1 for all primes p dividing n.

Using Korselt's criterion, to determine whether n is Carmichael, one need only verify a few simple properties of its prime factors. Korselt did

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MAA Sets Its Sights on the Information Age

At a small workshop held at MAA headquarters in Washington, D.C. in March of this year, the MAA began to plan for the introduction of electronic services to the membership, to follow the electronic networking of the Dolciani Center and the associated connection of the MAA headquarters to the Internet, projects that are currently nearing completion.

MAA member participants Fred Bowers, Keith Devlin, Susan Forman, Eugene Herman, Marjorie Hobbs, Roger Horn, Donald Kreider, Arnold Ostabee, Gerald Porter, Lynn Steen (chair), Andrew Sterrett, Elizabeth Teles, along with MAA staff members Donald Albers, Rhoda Goldstein, William Hawkins, Marcia Sward, and David Watts, were joined by William Woolf who runs the AMS's e-MATH electronic information service.

While many of the discussions dealt with technical issues, including the need to coordinate developments with those at the AMS, and avoid duplication or the re-invention of the wheel, a great deal of attention was paid to the issue of educating members as to the why, the how, and the cost of Internet access and the electronic services it can bring.

It was this latter aspect that will first become visible to readers of FOCUS. One of the recommendations to come from the workshop was to use FOCUS as a primary vehicle for providing members with

please see ***Information Age*** *on page 8*

Correction

In the June 1992 FOCUS, the dates for the 1992 AMS-MAA meeting in San Antonio, Texas, were misprinted. The correct dates are

13-16 January 1993

FOCUS regrets any confusion this error may have caused. For additional information on the January AMS-MAA meeting, please see page 5.

Mathematics in the Elementary School

On the Mathematical Preparation of Elementary School Teachers is the title of a report just published by the University of Chicago, based on a two-part conference held there in January and May of 1991. Funded by the Exxon Education Foundation and the NSF, the goal of the conference was to identify specific steps that could be taken at the college level to improve the mathematical preparation of the nation's elementary school teachers.

Among the recommendations proposed in the report are:

• A large-scale, national effort to develop a college mathematics program appropriate for the mathematical preparation of elementary school teachers.

• A 12 semester-hour minimum for the mathematical preparation of elementary school teachers.

• Professional teaching standards for college-level mathematics teachers, analogous to the NCTM Teaching Standards for school mathematics.

• Explicit recognition by the mathematics community of the importance of its critical role in preparing elementary school teachers to guide children's mathematics learning.

The report begins by noting the well-documented fall in both interest and ability in mathematics in the nation's schoolchildren. An overemphasis on rote memorization of facts and procedures is cited as one of the major culprits. And, the report suggests, the cause of that, as well as the key to a solution to the problem, can be found in the colleges that educate those teachers.

"Simply put, we have failed to give elementary school teachers the kinds of mathematical experiences that will equip them to teach mathematics effectively," the writers state. "The courses they typically take in college neither contain a serious treatment of the arithmetic and geometric ideas central to elementary mathematics, nor are they taught in ways that model effective teaching." This is most frustrating in view of the fact that, whereas most people's need for mathematics is indirect, "elementary school teachers', need is obvious: They teach something called 'math' every day."

Given that most teachers tend to teach the way they were taught, and are in any case often subject to the considerable control of the local district bureaucracy, the way to break out of an endless cycle of mediocrity is, the report suggests, at the college-level, where:

"The goal of a college curriculum for teachers should be to develop adult-level insights into the mathematics that they will be teaching to children. There are serious and sophisticated ideas underlying this mathematics. These ideas are deep, but they are also accessible, provided they are taught properly and not squeezed into a rapid-fire syllabus."

The report continues "The MAA's *A Call for Change* has gone a long way toward describing what college mathematics courses for prospective teachers should seek to accomplish. The challenge now is to answer that call."

The report writers have little doubt that such a process of change will require the significant input of the professional mathematics community. As conference participant Merlyn Behr of Northern Illinois University remarks, "not many mathematicians think about elementary school mathematics, but if they did, they might prove to be a valuable resource."

Adds conference attendee Gary Musser of Oregon State University: "All mathematics departments should have faculty members whose primary interest is in the mathematical preparation of elementary school teachers."

"Much of the responsibility for the mathematics instruction of prospective teachers rests in departments of mathematics, and we strongly believe that that's where it belongs," echoes the report. "Mathematicians have insights into mathematics that can be valuable to school teachers, and they can be the best models of mathematical thinking and discourse."

But as the report's writers are keen to emphasize, it is not just a matter of getting mathematicians involved. What those mathematicians teach is just as important. "The single math courses many prospective teachers take—typically a smorgasbord-style course offering a little of this, and a little of that—is not enough to counteract their preconceived notions of mathematics. If anything it only confirms them."

The final thrust of the report is directed at the membership of the two major academic mathematics associations:

please see ***Elementary School*** *on page 4*

Carmichael Numbers *continued from front page*

not exhibit an example of such an integer n, and he might have thought that no such n exists. But had he just done a few computations, he would doubtless have found one, and such numbers would have become known as Korselt numbers! As it was, this honor was left to Carmichael ten years later.

The first few Carmichael numbers are:

$$561 = 3 \times 11 \times 17$$
$$1105 = 5 \times 13 \times 17$$
$$1729 = 7 \times 13 \times 19$$
$$2465 = 5 \times 17 \times 29$$
$$2821 = 7 \times 13 \times 31$$

Interestingly, the third number in this list, 1729 is best-known from the story of when Hardy visited Ramanujan in hospital, and pronounced his taxicab number, 1729, to be a dull number. Ramanujan refuted this by noting that it is the smallest number which is the sum of two cubes in two different ways. What Ramanujan failed to note was that 1729 is also interesting as being the third smallest Carmichael number! Carl Pomerance has further observed that not only is 1729 both the third smallest Carmichael number and equal to the sum of two cubes in more ways than any preceding number, but also 1105, the second smallest Carmichael number, is the sum of two squares in more ways than any preceding number.

Carmichael computed fifteen such numbers in his 1912 paper on the subject, and stated that *'this list might be indefinitely extended.'* Indeed it can, but it has taken eighty years to settle the issue definitively. Stated precisely, the result earlier this year by the Georgia team reads as follows.

For sufficiently large values of N, there are more than $N^{2/7}$ Carmichael numbers less than N.

For further details of this result, and the work that led up to it, see the article *Primality Testing and Carmichael Numbers* by Andrew Granville in the 'Computers and Mathematics' section of the September issue of the *Notices of the AMS*.

Why the Salesman's Job is a Hard One?

In the previous issue of FOCUS, Làszlò Babai described the concept of "transparent proofs," proofs that can be verified by a small number of random spot-checks. In this second article he goes on to tell us the most recent, surprising twists of the story, adding up to a remarkable collective achievement by dozens of theoretical computer scientists in recent years.

A less technical description of the story appeared in SIAM News, 25/3 (May 92): *Theoretical Computer Scientists Develop Transparent Proof Techniques*, by Barry A. Cipra.

The technical details of the improved transparent proofs and their connection to approximate optimization Babai discusses in his article are described in the following three papers:

U. Feige, S. Goldwasser, L. Lovàsz, S. Safra, M. Szegedy: Approximating clique is almost NP-complete in: *Proc. 32nd IEEE Symposium on Foundations of Computer Science*, 1991, pp. 2-12.

S. Arora, S. Safra: Approximating clique is NP-complete, manuscript, January 1992.

S. Arora, C. Lund, R. Motwani, M. Sudan, M. Szegedy: Proof verification and intractability of approximation problems, manuscripts, March 1992.

(The latter two papers are likely to appear in the *Proc. 32nd IEEE Symposium on Foundations of Computer Science*, Pittsburgh, PA, October 1992.)

Keith Devlin

Combinatorial Optimization Is Hard

Làszlò Babai

How hard is it to determine the shortest route of a salesman traveling through a metric space and wishing to reach each destination on a given finite list? This is the "metric traveling salesman problem" (MTSP), one of the famed NP-hard combinatorial optimization problems. We have known for two decades that the difficulty of finding an efficient algorithm to solve the MTSP is not a coincidence. If the length of shortest tour could be found in polynomial time then "P = NP" would follow, a statement with far reaching consequences, widely believed to be false.

If P = NP then for any mathematical statement φ, it is possible to decide in time polynomial in the integer n and the length of φ, whether or not φ has a formal proof of length $\leq n$. In the words of Kurt Gödel[1], in a letter to J. von Neumann in March 1956, this would

"clearly indicate that, despite the unsolvability of the *Entscheidungsproblem*, the mental effort of the mathematician could be completely (Gödel's footnote: apart from the postulation of axioms) replaced by machines. One would indeed have to simply select an n so large that, if the machine yields no result, there would then be no reason to think further about the problem."

If finding the salesman's exact optimum route is so hard, why not search for an *approximate optimum*. Presumably, getting within say 1% of the optimum would be as good for all practical purposes.

Alas, this may be *no easier than finding the exact optimum*. Approximate optima for MTSP and a host of other combinatorial optimization problems *cannot be found in polynomial time, unless* P = NP.

This definitive result appears in a brand new paper by five young authors: graduate students Sanjeev Arora and Madhu Sudan (UC Berkeley), postdocs Carsten Lund and Mario Szegedy (AT&T Bell Laboratories, recent graduates of the University of Chicago), and Rajeev Motwani (Stanford); and its immediate precursor by Arora and S. Safra (Stanford and IBM Almaden). A striking feature of the paper is that it builds directly on recent work of at least two dozen theoretical computer scientists from fields so diverse that many of them (including myself) did not even suspect that they had contributed to the theory of approximate combinatorial optimization.

***Làszlò Babai** is Professor of Computer Science at the University of Chicago and Professor of Mathematics at Eötvös University in Budapest.*

POLYNOMIAL TIME

In the theory of computing, the complexity of an algorithm is measured by the number of computational steps required, as a function of the number of bits of input. An algorithm is said to run in *polynomial time* if on every input of length n (bits), the computation terminates within time n^c, for some constant c which depends on the algorithm but not on n. We take the *asymptotic* point of view: we compare complexity bounds by their behavior for *large n*. For instance, *exponential time* (say 2^n or $2^{\sqrt{n}}$) is much worse than polynomial time. Time bounds like $n^{\log n}$, or more generally, $\exp((\log n)^c)$, are called *quasi-polynomial*. While they are worse than polynomial, they are far better than exponential.

Computation theorists love "polynomial time". To them, it is the theoretical threshold that separates "tractable" from "intractable" problems.

In judging practical merits, this view should be taken with a grain of salt. A polynomial time algorithm running in n^9 steps is certainly less feasible than an exponential time algorithm taking $2^{\sqrt{n}}$. Yet, the polynomial time paradigm has provided the framework for decisive progress in many areas of the theory of computing over the past decades, with such practical dividends as efficient data structures for combinatorial algorithms, public-key cryptography, Karmarkar's linear programming algorithm, and Lovàsz's method of simultaneous diophantine approximation.

COMBINATORIAL OPTIMIZATION

Problems in discrete applied mathematics ranging from scheduling airlines or rationing radio wave frequencies, to data compression and DNA sequencing often lead to "combinatorial optimization problems," exemplified by the MTSP problem or the question of determining the size of the *largest clique* in a graph. (A clique is a subset of mutually

please see ***Transparent Proofs*** *on page 6*

United States Places Second at the 33rd International Mathematical Olympiad in Moscow

Competing in Moscow against students representing 52 countries, in this year's International Mathematical Olympiad, six mathematically talented students from the U.S.A. have won three gold and three silver medals and obtained a total score second only to China. Students earning medals were:

Wei-Hwa Huang of North Potomac, MD

Kiran Kedlaya of Silver Spring, MD

Robert Kleinberg of Wales Center, NY

Sergey Levin of Providence, RI

Lenhard Ng of Chapel Hill, NC

Andrew Schultz of Evanston, IL

Kedlaya, Kleinberg and Ng won gold medals while Huang, Levin and Schultz won silver. Countries obtaining the highest scores (an unofficial measure in the competition) were, in order: China, USA, Romania, Commonwealth of Independent States, and the United Kingdom.

Here is one of the problems:

Consider 9 points in space, no 4 of which are coplanar. Each pair of points is joined by an edge (that is, a line segment) and each edge is either colored blue or red or left uncolored. Find the smallest value of n such that, whenever exactly n edges are colored, the set of colored edges necessarily contains a triangle all of whose edges have the same color.

Prior to the competition, the U.S. students participated in a month long training session held at the U.S. Naval Academy directed by Professor Cecil Rousseau of Memphis State University, Professor Dan Ullman of George Washington University, and Professor Anne Hudson of Armstrong State College. Professors Rousseau and Ullman, and Walter E. Mientka, University of Nebraska, Executive Director of the American Mathematics Competitions, accompanied the team to Moscow.

Speaking on behalf of the delegation, Professor Ullman expressed satisfaction with the competition and with the U.S. performance. "We are all happy to participate in this international celebration of extraordinary mathematical talent. I am thrilled with the success of this uniformly strong American team."

Members of the 1992 USA team, pictured with MAA President, Deborah Tepper Haimo, in front of the Einstein Statue, at the National Academy of Sciences. Front row, left to right, Lenhard Ng, Robert Kleinberg, Akira Nego, Andrew Schultz, MAA President Deborah Tepper Haimo. Back row, Wei-Hwa Huang, Kiran Kedlaya, Sergey Levin, Michail Sunitsky.

Elementary School *from page 2*

"In particular, the mathematics community—specifically the AMS and the MAA—must go clearly and explicitly on record as recognizing the importance of their critical role in preparing elementary school teachers to teach mathematics."

"The MAA has already taken many worthy steps in this direction, and the Strategic Planning Task Force of the AMS cites increased involvement in educational activities as one goal for the Society. But there is little evidence that the message has gotten through to the membership. The leaders of the mathematics community must do more to convince the profession that teaching mathematics to elementary teachers, and teaching it well, is an activity worthy of their attention."

FOCUS

ISSN: 0731-2040

FOCUS is published by The Mathematical Association of America, 1529 Eighteenth Street Northwest, Washington, DC 20036-1385, six times a year: February, April, June, September, October, and December.

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The annual FOCUS subscription price to individual members of the Association is $6.00, included in the annual dues. (Annual dues for regular members, exclusive of annual subscription prices for MAA journals, are $68.00. Student and unemployed members receive a 66 percent discount; emeritus members receive a 50 percent discount; new members receive a 40 percent discount for the first two membership years.)

Second-class postage paid at Washington, DC and additional mailing offices. Postmaster: Address changes to FOCUS, Membership and Subscriptions Department, The Mathematical Association of America, 1529 Eighteenth Street Northwest, Washington, DC 20036-1385.

Printed in the United States of America.

All Star Meeting Scheduled for the Lone Star State

Joint Mathematics Meetings San Antonio, Texas 13-16 January 1993

The 1993 Joint Meetings of the MAA and the AMS, the Seventy-Sixth Annual Meeting of the Association, will doubtless draw a large attendance from more northerly states, as members seek a brief respite from the winter cold. But whatever your home base, you will certainly receive a warm Texas welcome in San Antonio, next 13-16 January.

You will also be faced with an exciting and varied program, highlighted by the fact that 1993 sees the 100th year of publication of the *American Mathematical Monthly*, an occasion that will be marked by a number of special events. Among these, Robert A. Rosenbaum, a past editor of the *Monthly*, will speak about its birth, and Paul Halmos, another past editor, will discuss the question *"Do Mathematicians Read the Monthly? — Then and Now."* Present *Monthly* editor John Ewing will be Master of Ceremonies at the *Monthly* Centennial Celebration Banquet on the Friday evening.

For one of the four joint MAA—AMS addresses, George Andrews has chosen the title *"Ramanujan, the Lost Notebook and I"*; the other three invited joint addresses will be given by Richard A. Brualdi, Robert Osserman, and Mary Wheeler.

Peter Borwein's MAA invited address reflects the growing use of computers in mathematics; his title is *"I am ashamed to tell you to how many figures I carried these computations, having no other business at the time."*

Following its hugely successful inauguration at last year's joint meetings, the two societies will again sponsor a reception for the first-time attendees at a national meeting, enabling newcomers to pick up tips on how to get the most out of the meeting and live to tell the tale.

Other events of note include an MAA session on *Mathematical Life Outside Academia: Common Problems, Common Goals and Objectives*, moderated by Nathaniel Dean of Bellcore, and a panel discussion on *Progress in Mathematics Education using Computer Graphics.*

Once again, the various committees that organize the joint meetings have done a tremendous job and have put together what promises to be a meeting not to be missed. See you there!

Photo Courtesy of San Antonio Convention & Visitors Bureau

The Alamo— Shrine of Texas Liberty. This building, the old chapel of Mission San Antonio de Valero, is one of the many beautiful sites in San Antonio.

Contributed Papers

The following are the correct dates for the contributed Papers for the Joint Mathematics Meeting, 13-16 January 1993. Proposals should be forwarded to the organizer listed. For complete descriptions of the sessions, please see FOCUS June 1992.

ASSESSMENT PROGRAMS FOR THE UNDERGRADUATE MAJOR
Friday morning, 15 January 1993, and Saturday afternoon, 16 January 1993
Charles F. Peltier, (219) 284-4498

"CAPSTONE" COURSES FOR SENIOR MATHEMATICS MAJORS
Wednesday and Thursday mornings, 13 and 14 January 1993
Pamela Crawford, (804) 752-7372

EMPOWERING THE MATHEMATICAL COMMUNITY
Wednesday morning, 13 January 1993 and Thursday afternoon, 14 January 1993
Gloria Gilmer, (414) 933-2323

IMPACT OF NONTRADITIONAL INSTRUCTIONAL METHODS ON TESTING AND EVALUATION
Wednesday and Thursday afternoons, 13 and 14 January 1993
Linda H. Boyd, (404) 299-4167

INTERACTIVE LEARNING ENVIRONMENTS
Wednesday and Thursday mornings, 13 and 14 January 1993
Katherine L. Pedersen
435 South Chapelle, Pierre, SD 57501

LINEAR ALGEBRA
Wednesday afternoon, 13 January 1993, Thursday evening 14 January 1993, and Friday afternoon, 15 January 1993
Donald R. LaTorre, (803) 656-3434

MATHEMATICS AND THE ARTS
Thursday afternoon, 14 January 1993, and Saturday morning, 16 January 1993
JoAnne S. Growney, (717) 389-4503

RECREATIONAL MATHEMATICAL COMPUTING
Friday morning, 15 January 1993, and Saturday afternoon, 16 January 1993
Dr. Michael W. Ecker, (717) 586-2784

RECRUITMENT AND RETENTION OF WOMEN IN MATHEMATICS REVISITED
Saturday morning and afternoon, 16 January 1993
Marcelle Bessman, (301) 689-4453

TEACHING MATHEMATICS TO MULTICULTURAL AND MULTILINGUAL STUDENTS
Friday morning and afternoon, 15 January 1993
Richard C. O'Lander, (718) 990-6471

USE OF VISUALIZATION IN THE TEACHING OF MATHEMATICS
Friday morning, 15 January 1993, and Saturday afternoon, 16 January 1993
Howard Lewis Penn, (410) 267-3892

USING DATA AND COMPUTERS IN TEACHING STATISTICS
Wednesday morning, 13 January 1993, and Thursday afternoon, 14 January 1993
Mary R. Parker, (512) 483-7000

Transparent Proofs *from page 3*

adjacent nodes in the graph.)

A further important example is the MAX 3-SAT problem, defined as follows. Suppose we are given a list of Boolean variables $x_1, ..., x_r$ (which can take values 0 or 1 only) and a list $C_1, ..., C_m$ of "disjunctive 3-clauses," i.e. expressions of the form $(t_1 v\, t_2 v\, t_3)$ where each t_j is either a variable x_j or its negation $\overline{x}_j$. Any of the 2^r *truth assignments* (assignments of values 0 or 1 to each variable) may satisfy some of the clauses (make them "true") and not satisfy others. The problem is to maximize the number of simultaneously satisfied clauses.

Exhaustive search of all truth assignments (or traveling salesman tours, subgraphs, etc.) will clearly reveal the optimum in each case; but this takes exponential time. These are examples of the *hardest* combinatorial optimization problems: if any one of them could be solved by a polynomial time algorithm, then all problems of this type could. This latter, unlikely circumstance is expressed by the statement "P = NP". Being able to prove that a "statement *A* holds unless P = NP" is the next best thing to proving *A* itself. It is analogous to proving a number theoretic statement assuming Riemann's Hypothesis.

The new developments say nothing about the validity of the P ≠ NP conjecture. But they tell us a lot about the complexity of optimization as long as we are willing to accept the P ≠ NP conjecture.

We have known since the seminal papers of Cook, Levin, and Karp in 1971-72, that most of the interesting combinatorial optimization problems are NP-hard, i.e., cannot be solved in polynomial time *unless* P = NP.

What we have learned recently is that finding *approximate optima* to many of these problems is no less difficult. And paradoxically, these *negative results* follow rather easily from new *positive* results on *transparent proofs.*[2]

NP-HARD APPROXIMATION PROBLEMS

If we cannot tell exactly how many items on a given list of *m* disjunctive 3-clause are simultaneously satisfiable, can we calculate this maximum at least approximately, say within an error of 10%? Certainly we can (without even looking at the list), observing that the optimum is between $7m/8$ and m (a random assignment of truth values is expected to satisfy 7 out of 8 clauses). Can we compute the value within 1%? This looks much harder. Does there exist, for every $\varepsilon > 0$, a polynomial time algorithm which computes the optimum value within relative error ε? Such a family of algorithms would be a "polynomial time approximation scheme" (PTAS). For practical purposes, a PTAS would seem as good as a polynomial time algorithm. (Take this with another grain of salt).

The paper of Arora et al. dashes the hopes for good approximations: they show that MAX3-SAT has no PTAS, unless P = NP.

The significance of this result stems from the central role played by MAX 3–SAT in combinatorial optimization. It is the archetype of certain hard-to-approximate combinatorial optimization problems, as shown in a 1988 paper by C. Papadimitriou (University of California at San Diego) and M. Yannakakis (AT&T), which formalized the "approximation problem" analog of NP-completeness.

The results of that paper and the body of work it has inspired, combined with the result of Arora et al., imply that there is a vast number of important combinatorial optimization problems without PTAS, showing that there is *an absolute limit to our ability to compute approximate optima in polynomial time, unless* P = NP.

Here are some more examples of hard-to-approximate problems (no PTAS unless P = NP):

- MAX CUT (divide the set of nodes of a graph into two, such as to maximize the number of edges connecting the two parts,
- MAX 2-SAT (!),
- MTSP, even if the metric space has distances 1 and 2 only,
- "shortest superstring" (given a list of strings of symbols, find the shortest string which contains each of the given strings as contiguous substrings).

At least in all these cases, one can quickly find an approximation within some constant factor (e.g. in the case of the MTSP, one can find a tour which is at most 50% longer than the optimum).

For some other problems, the situation is worse. The *longest path* in a graph cannot be approximated (in polynomial time) within *any constant factor*, nor can the maximum clique size (unless P = NP). In fact, the *maximum clique size* cannot be approximated even within a factor of n^c, for some fixed $c > 0$, where n is the number of nodes.

TRANSPARENT (HOLOGRAPHIC) PROOFS

Every formal mathematical proof can be transformed into a somewhat longer *transparent* (or *holographic*) proof[3], which in turn can be checked by *randomly sampling just a few of its bits.* A correct proof will always be accepted, while a purported proof of a false statement has negligible chance of acceptance. (See FOCUS, June 92).

Originally, "a few bits" meant about $(\log n)^4$ places to be spot-checked, indeed a tiny fraction of the n-bit proof. In a sequence of three papers involving nine authors and culminating in the Arora et al. paper, the *number of spot-checks was reduced* phenomenally (at a cost of a polynomial increase in the length of the holographic proof) to a *constant* that no longer depends on the length of the proof. (It depends on the degree of certainty we seek.) So in a sense, proofs of arbitrary length are equally easy to check (as long as we have random access to the proof bits).

This counterintuitive fact is the basis of the new results on approximate optimization. Just how are these two subjects related? The discovery of a connection by Uri Feige et al. in 1991 at Princeton was perhaps the most exciting moment in this story.

TURNING THE GOOD NEWS INTO BAD

What Feige et al. discovered was that the information structure of *holographic proofs* can be modeled by *clique sizes* in a graph. Out of any holographic proof checker, they constructed a not-too-large graph *G* with the following property: if a correct holographic proof of the given statement exists then the graph has cliques of a certain large size; otherwise, all cliques in the graph are *much* smaller.

If an efficient algorithm could give us a rough idea of the maximum clique size, then we could decide which alternative holds; therefore *we could solve any NP-complete decision problem efficiently* (since "yes" instances of such problems have short proofs). "Efficient" in the paper by Feige et al. meant quasipolynomial time, which was subsequently improved to *polynomial time* by Arora and Safra.

How do Feige et al. construct the graph *G*? The nodes correspond to all conceivable spot-check lists accepted by the checker. (A typical item on such a list says that "the j^{th} bit of the proof is ε"). If the checker requires to spot-check k bits of a proof of length n, then the number of conceivable outcomes is $2^k n^k$, so this is an upper bound on the num

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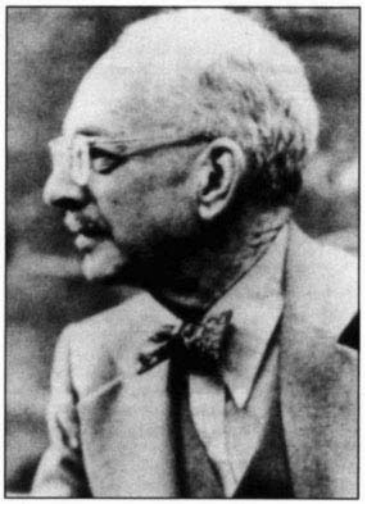
Ralph P. Boas, Former MAA President, Dies at Age 79

Ralph P. Boas Jr., former President of the MAA and a former editor of the *Monthly*, died in Seattle on Saturday, 25 July 1992. He had been a member of the MAA for 56 years. Though his health had been fragile over the past several years, he continued to work on a number of projects and up to a few days before his death, he was hard at work on the fourth edition of his Carus Monograph, *A Primer of Real Functions*, an all-time best seller in the series. The new edition will be completed by Boas's son, Harold, and will be published by the MAA in 1993.



Boas was born in Walla Walla, Washington, on 8 August 1912. After receiving his A.B. in 1933 and his Ph.D. in 1937 from Harvard (where his dissertation advisor was D.V. Widder), he went to Princeton on a National Research Fellowship in order to work with Salmon Bochner. After an additional year on a Fellowship at Cambridge University, he joined the faculty of Duke University. In 1945 he became Editor of *Mathematical Reviews* and, in 1950 he moved to Northwestern University, where he served as Department Chair for many years. At the time of his retirement from Northwestern, he was the Henry S. Noyes Professor. Boas was the author of a number of books, among them *Entire Functions* (1954), *A Primer of Real Functions* (1960), *Polynomial Expansions of Analytic Functions* (with R.C. Buck, 1964), *Integrability Theorems for Trigonometric Transformations* (1967), and *Invitation to Complex Analysis* (1987). He also edited the papers of Hidehiko Yamabe and two volumes of the collected papers of George Pólya. In addition to being editor of the *Monthly*, he edited the *Selecta Mathematica Sovietica* and the *Journal of Mathematical Analysis and Applications*. He long had an interest in translations from Russian and in the last few years had devoted great attention to the American Mathematical Society's revision of the *Russian-English Dictionary of the Mathematical Sciences*.

For the MAA he served on many committees, including the Committee on the Undergraduate Program in Mathematics, which he chaired between 1968 and 1970. He was active on the Committee on Publications and chaired the Carus Subcommittee until early July 1992. He was President of the Association in 1973-74 and editor of the *Monthly* from 1977 to 1981. That same year he received the Association's most prestigious honor, the Award for Distinguished Service to Mathematics.

A recitation of the various positions he occupied fails, however, to indicate Boas's effectiveness and influence. His period as editor of *Mathematical Reviews* was a critical one in the development of that publication. He presided over significant growth and development of the Mathematics Department at Northwestern during his tenure as chair. And during his editorship, the *Monthly* took on a new look. He brought to all of his tasks a breadth of interests not always seen in fine research mathematicians. He may have been influenced by his parents, both of whom were teachers and writers. His father had been on the English faculty of Whitman College, Mt. Holyoke and Wheaton, and Boas's papers include one on *Shapespeare's Twelfth Night*, co-authored with his father. With Frank Smithies of Cambridge, Boas co-authored, under the pseudonym H. Pétard, a witty and well-known article on the mathematical theory of big game hunting, published in the *Monthly* in 1938. Boas wrote over 150 papers on mathematics plus many others on mathematics education and other topics. The Association plans to publish a collection of Boas's mathematical and non-mathematical work in the near future.

Over the past few years, Boas's friends have shown their appreciation of the man and his work by funding the Ralph P. Boas, Jr. Room in the headquarters complex of the MAA in Washington, DC.

MODEL PROGRAMS SOUGHT

The Mathematical Association of America has received funding from the National Science Foundation to prepare, for the mathematical community, descriptions of highly successful undergraduate mathematical sciences programs. We are searching for programs that enhance recruitment and retention of mathematics majors; programs that prepare a substantial number of students effectively for teaching school mathematics or for continued graduate study; or programs that are particularly effective in attracting, and addressing the needs of, groups traditionally underrepresented in mathematics.

Alan Tucker, chair of MAA's Education Coordinating Council, is the project director. We invite readers to nominate programs (including their own) for possible inclusion in this case studies project.

Send your nomination letter to Professor Alan C. Tucker, Applied Mathematics Department, SUNY- Stony Brook, Stony Brook, NY 11794 (e-mail: atucker@sbccmail.bitnet).

Mathematics Awareness Week

25 April - 1 May 1993

Mathematics and Manufacturing

Mark Your Calendars Now!

Every year, Mathematics Awareness Week celebrates the richness and relevance of mathematics and provides an excellent opportunity to convey this message through local events. During a week-long celebration, from Sunday, April 25 - Saturday, May 1 1993, the festivities will highlight MATHEMATICS AND MANUFACTURING.

Mark your calendars now and plan to observe Mathematics Awareness Week in your area, school, or organization. Look for further information from the Joint Policy Board for Mathematics, national sponsor of Mathematics Awareness Week, in future issues of FOCUS.

Differentiating Between the Presidential Candidates

Susan Jane Colley

Politicians seem to routinely confuse the public about higher derivatives, and in an election year, like this one, the confusion can get pretty intense. Our students, however, should know how to use mathematics to clarify apparently qualitative discussions. And, in my experience, they enjoy learning to do so. Invite them (and yourself) to 'mathematize' various situations in politics or world events and see what happens in the classroom. As an example of what I mean, here is an entirely hypothetical "Larry King Live" debate to consider, followed by a mathematical — rather than the usual political — analysis of it.

• • • • • •

King: The economy — that is, the rate of growth of the GNP — is running downhill, and has been for some time now.

Bush: How can you say that? The gross national product last year increased by 4%. Furthermore, this has been achieved by keeping the poverty rate below 5% annually.

Clinton: Yes, but the rate itself is going up, Mr. President. And what about unemployment ...

Bush: I've got you there, Mr. Clinton. During the course of my administration, the unemployment rate fell by 2 million workers per year.

King: Wait a minute. The Bureau of Labor Statistics has just revealed that the current unemployment is actually ***increasing*** by 1.2 million workers per year. Explain how you dare make such an outrageous claim, Mr. President.

Bush: I don't know how you developed your figures, Larry. But I care about jobs; I care deeply about Americans — all Americans. They're good people — deserve the best.

Clinton: Fine, Mr. President. Let's change the subject then. Let's talk about government spending ...

Bush: I'm glad you mentioned that, Bill. I am hopeful that, in my next term, we can reduce the rate of increase of the deficit.

Clinton: Don't you want simply to reduce the deficit altogether? Or, even better, how about reducing the national debt? It seems to me that this is the source of our runaway economy.

Ask your students to analyze this debate using differential calculus. A suitable translation into mathematics might look something like this:

King: d/dt (*rate of growth of GNP*) = $GNP''(t) < 0$ for $t \leq 1992$.

Bush: How can you say that? $GNP'(1991) = 0.04\, GNP(1991) > 0$. Moreover, $poverty'(1991) < 0.05\, poverty(1991)$.

Clinton: Yes, but $poverty'(t) > 0$! What about unemployment?

Bush:

$$\frac{\Delta\ unemployed}{\Delta t} = \frac{unemployed\ (1992) - unemployed\ (1989)}{3\ years}$$

$$= -2{,}000{,}000\ workers\ /\ years$$

King: Wait ... isn't it the case that $unemployed'(1992) = +1{,}200{,}000$ workers / year?

Bush: ??

Note: Try having your students construct an example of an unemployment function that exhibits this phenomenon.

Clinton: On to government spending.

Bush: I hope that, in the future, d/dt (*increase in deficit*) < 0. That is, my goal is to have $deficit''(t) < 0$ for $t \geq 1993$.

Clinton: But $deficit(t) = debt'(t)$, so $deficit''(t) = debt'''(t)$. Wouldn't you prefer to have $deficit'(t) < 0$? Or better still, why not work to make $deficit(t) < 0$?

• • • • • •

My thanks to Steven Izen of Case Western Reserve University for alerting me to some of the ideas presented here.

Author's address: Department of Mathematics, Oberlin College, Oberlin, OH 44074-1095. e-mail sjc@occs.cs.oberlin.edu .

Information Age *from the front page*

information about what services are currently available on the electronic networks, and how institutions can gain access to those services. Starting next month, FOCUS will include a regular section *Networks in Focus*. The intention is to have articles ranging from very simple "how to" pieces, aimed at those who have never accessed an electronic network before, through hints on how to persuade a reluctant administration to take the plunge and establish a network connection, to articles aimed at those with some experience. The only group we shall largely ignore is the electronic cogniscenti, who already have the expertise to obtain what information they need in the Twenty-First Century manner—from the network.

At this stage, FOCUS is asking any member with recent experience of establishing an Internet connection, to submit an article describing that experience. What were the technical difficulties you encountered, and how did you overcome them? What political issues were involved in persuading your institution to support or provide the connection? What benefits did you expect such connection to bring, and what benefits did in fact follow? How do you see future growth in network use at your institution? And so on.

Send contributions to Keith Devlin, FOCUS editor, Department of Mathematics and Computer Science, Colby College, Waterville, Maine 04901. Or even better, send your article by electronic mail to my Internet address: kjdevlin@colby.edu.

Zvezdelina E. Stankova Receives Third Annual Alice T. Schafer Mathematics Prize

Zvezdelina E. Stankova, Bryn Mawr College, has been named the recipient of the third annual Alice T. Schafer Mathematics Prize. Sponsored by the Association for Women in Mathematics (AWM), the prize is given to an undergraduate woman in recognition of excellence in mathematics, and carries with it a stipend of $1000. The criteria for selection include, but are not limited to, the quality of the nominee's performance, interest in mathematics, ability to do independent work, and performance in any mathematical competitions.

The prize was named to honor Alice T. Schafer, a former AWM President and a founding member of the organization, who has taken a special interest in supporting women at the start of their careers in mathematics. The 1992 prize committee consisted of Alice T. Schafer, Marymount University, Jill P. Mesirov, Thinking Machines Corporation, and Ann K. Stehney, Center for Communications Research.

The committee noted that the field of thirty-two candidates seemed especially strong. In addition to their impressive achievements in course work, independent study, competitions, and undergraduate research programs, the 1992 nominees devoted themselves to numerous projects on behalf of the mathematical life of undergraduates at their institutions. Each candidate is a talented young woman who can take pride in her accomplishments and the commendation of her professors.

The prize committee has also named Julie B. Kerr of Washington State University as Runner-Up and selected nine other nominees for Honorable Mention. The awards were made at the annual meeting of the Society for Industrial and Applied Mathematics (SIAM) in Los Angeles in July.

Zvezdelina E. Stankova, a 1992 graduate of Bryn Mawr College, has earned wide recognition for her research and performance in mathematical competitions. Last summer she participated in the Research Experiences for Undergraduates (REU) at the University of Minnesota at Duluth, where her research on classifying permutations with forbidden subsequences of length 4 was praised as impressive work on a difficult problem. Her paper on the subject was well received at the joint mathematics meeting of the American Mathematical Society and the Mathematical Association of America in Baltimore in January. In addition to her research in combinatorics, she has done advanced work in a number of areas. In nominating Stankova, Professor Rhonda Hughes of Bryn Mawr wrote, "Her results are strikingly original and one is always reminded that her work is that of an extraordinary mathematician." A two-time silver medalist on the International Mathematics Olympiad team for her native Bulgaria, known as both an excellent problem-solver and a first-rate expositor, Stankova was the runner-up for the Schafer Prize in 1991. She will return to the REU Program in Duluth this summer before beginning graduate work in mathematics at Harvard University in the fall.

Julie B. Kerr, this year's Runner-Up, will graduate in December from Washington State University. She received Special Recognition from the 1990 Schafer Prize committee for her early achievements, including distinction in her graduate courses as a first-year student. In each of the last two years, she finished in the top sixty students on the nationwide Putnam Examination for undergraduates. Following a Budapest Semester in Mathematics as a sophomore, Kerr participated in the 1991 NSF-sponsored Mills Summer Mathematics Institute, and she will work this summer in computational number theory at the REU at Rose-Hulman Institute of Technology. An aspiring teacher, Kerr also finds time to tutor in mathematics.

The AWM is pleased to award Honorable Mention in the competition to the following outstanding candidates.

Marcia Joyce Geiger Isakson graduated this year with a rare double major in applied mathematics and physics at the U.S. Military Academy (USMA). Among her honors in the Department of Mathematical Sciences, she won the Top Cadet Award for work done in the Research Seminar in Applied Mathematical Projects for work done in the semester at Brookhaven National Laboratory. She was a member of the USMA team that earned Honorable Mention in the 1992 Mathematical Contest in Modeling, sponsored by COMAP. Recipient of a Hertz Fellowship, Geiger will be a graduate student in physics at the University of Texas at Austin in the fall.

Cheryl P. Grood graduated from the University of Michigan this year, having been a central figure in the Undergraduate Mathematics Club and the MAA Student Chapter. A 1990 participant in the REU at Rose-Hulman Institute, Grood won an Honorable Mention in the 1991 Schafer Prize competition as a junior. She spent last summer at the Mills Summer Mathematics Institute, where she will return by invitation as a student assistant this summer before entering graduate school at the University of Wisconsin in Madison.

Kristine Hauser, a 1992 graduate of Grinnell College, was cited for her maturity in both courses and independent work. She spent two summers doing research on the word problem in cycle-free groups with faculty member Royce Wolf, and she presented their results at this year's Conference on Undergraduate Mathematics at the Rose-Hulman Institute of Technology. Hauser will be a graduate student at the University of Chicago this fall.

Laura Hegerle, who graduated this year from Colorado College, was chosen to participate in the undergraduate research program at Harvey Mudd College after her sophomore year. Since then, she has maintained an interest in graph theory, speaking on her work at a regional MAA meeting and a university seminar in the field. Hegerle plans to go to graduate school after teaching mathematics in the Peace Corps.

Eugenie Hunsicker graduates this year from Haverford College, having spent her junior year immersed in a "broad array" of mathematical subjects at Oxford University. She devoted two summers to doing research in algebraic combinatorics with faculty member Curtis Greene, and she presented their results at a recent MAA session of student papers. Hunsicker will enter graduate school in mathematics at the University of Chicago this fall.

*Please see **Schafer Prize** on page 10*

MAA– Part of THE MATH CONNECTION

The Mathematical Association of America (MAA) is an active participant in an exciting new consortium, THE MATH CONNECTION. A primary goal of THE MATH CONNECTION is to bring the expertise and knowledge base of the mathematical community to bear on the mathematics reform efforts of the non-discipline participating organizations.

The MAA joins the Mathematical Sciences Education Board, the National Council of Teachers of Mathematics, and six other professional education organizations (*) in this new endeavor. The partnership, under the administrative leadership of the Mathematical Sciences Education Board, was created six months ago. It is currently seeking funds to develop and disseminate resource materials that will help schools move forward in changing classroom practice to more closely match the vision of the NCTM Standards. By listening to, and working with, key leaders in the school setting; principals, school boards, PTA's, and state boards of education; THE MATH CONNECTION plans to have direct impact on the restructuring of mathematics education in the schools.

Some of the anticipated ventures include:

• A series of short and feature-length articles written for the non-mathematics and science constituencies. These will be directed primarily to the "in house" news organs of the participating organizations with the idea of assuring a consistent message concerning the efforts of mathematics education reform.

• Preparation of materials, probably including video tapes, that address "generic" change processes within school systems. Also under discussion is a series of teleconferences to achieve these same goals.

• Sharing speakers at regional and national meetings. This is built on the idea that a messenger who is "one of your own" carries significant credibility with the audience.

Already several other education groups are looking at THE MATH CONNECTION as a blueprint for implementing successful educational change in their disciplines. From time to time, FOCUS will report on the activities of the consortium.

(*) Other participating organizations: American Association of School Administrators, American Association of Colleges for Teacher Education, National Association of Elementary School Principals, National Association of Secondary School Principals, National School Boards Association, and the National Association of State Boards of Education.

Schafer Prize *from page 9*

Mary C. Joyce, a 1992 graduate of the University of Massachusetts at Amherst, wrote a senior honors thesis on statistical estimation with censored data. She spent her junior year at the University of Freiburg, and this year she was a member of the UMass team that won Honorable Mention in the Mathematical Contest in Modeling sponsored by COMAP. In the fall, Joyce will enter the University of Illinois at Urbana-Champaign for graduate work in applied mathematics.

Martha J. Mancewicz, who graduated from Kalamazoo College this year, spent part of her junior year with the Budapest Semester in Mathematics program and part of her senior year in the Mathematics Department of the General Motors Research Laboratory. Her work at GM on developable surfaces was presented to mathematicians, engineers, and visiting high school students, and also to a meeting of MAA Student Chapters. Mancewitz will attend the University of North Carolina next year as a graduate student in biostatistics.

Jennifer Williams is currently writing her senior honors thesis and expects to graduate this summer from Oklahoma State University. A veteran Putnam Exam entrant, Williams provided the impetus for a Problem Solving Seminar in her department. She was a member of OSU's 1992 Mathematical Contest in Modeling team, whose solution to the "Emergency Power Restoration System Problem" was judged Outstanding (one of only five such awards in the contest as a whole). The team also won the SIAM prize for that problem, and their faculty advisor cites Williams' creative leadership as a significant factor in their success.

Virginia E. Wright completed a joint B.S./M.S. program this year at Emory University. She spent two summers in REU programs, working in number theory and cryptography at Florida State University (1990) and in graph theory at the University of Minnesota at Duluth (1991). She continued her research on n-tuple vertex graphs in the past year and spoke on her results at a number of conferences. Wright has been awarded a Marshall Scholarship to study mathematics at Trinity College, Cambridge.

Math Placement Articles Wanted

Wanted: Manuscripts on college math placement for the MAA's Placement Test Newsletter. One to ten pages (double spaced). Opinions, research, descriptions of current practice, even cartoons. Please send to:

Geoffrey Akst
Mathematics Department
Manhattan Community College / CUNY
199 Chambers Street, New York, NY 10007
212/346-8530, e-mail: GRABM@CUNYVM.CUNY.EDU

Small College Computing Conference

The Sixth Annual Southeastern Small College Computing Conference will be held at Carson-Newman College in Jefferson City, Tennessee, on 6 and 7 November 1992. The conference theme is ***"In Support of Computing in the Small Colleges."*** The keynote address will be given by Dr. Thom Luce, Ohio University, and is entitled "Expert Systems and Business Using VP-Expert." The banquet address will be given by Dr. Angela Shiflet, Wofford College, and is entitled "The Publication Process for Computer Science Textbooks." The conference sponsor is The Consortium for Computing in Small Colleges. For further information or for registration materials, contact:

Dr. Frank Cheatham
CPO 1321
Campbellsville College
Campbellsville, KY 42718-2799
(502) 465-8158

Thanks for Responding

REPORT ON RESPONSES TO THE MAA MEMBER QUESTIONNAIRE

The Strategic Planning Task Force, under the leadership of Thomas W. Tucker, Colgate Universty, developed an all-member questionnaire that was attached to the February issue of FOCUS. More than 2,500 responses were received by the deadline of 16 March 1992. The responses have been very useful to the Task Force in developing a strategic plan for the Association. Questionnaires were processed in Lincoln, Nebraska under the direction of Walter Mientka. Several sorts of the responses were done according to the following categories:

- ▲ All Respondents
- ▲ Men
- ▲ Women
- ▲ Students
- ▲ Graduate Students
- ▲ Faculty
- ▲ University Faculty
- ▲ Four-Year College Faculty
- ▲ Two-Year College Faculty
- ▲ High School Teachers
- ▲ Business, Industry, Government
- ▲ Retired
- ▲ Under Age 35
- ▲ Ages 35-49
- ▲ Over Age 50
- ▲ By Section

Each sort summary is three pages long. This report focuses on two sorts, All Respondents and Faculty. In reading the All Respondents data, it is very important to bear in mind the following points:

- The Association is a diverse organization made up of faculty, students and mathematicians in business, industry, and government.
- The responses should **not** be stated as generalizations about a particular group or the entire MAA membership. What is presented are analyses of those who responded, less than 10% of the entire membership.
- Respondents were asked to check an item **only** if it was "highly important."
- Respondents have a well-developed sense of community, often citing items as being "highly important to the community," but not to themselves. For example, more than half of all faculty respondents cited student chapters as being "highly important to the community," while only 12% regarded chapters as being "highly important to themselves."

*Prepared by **Donald J. Albers**, MAA Associate Executive Director and Director of Publications and Programs.*

WITH THESE CAVEATS, THE FOLLOWING HAS BEEN OBSERVED:

- ❑ About 20% of respondents are women.
- ❑ Slightly more than 50% of respondents regarded the MAA as their primary organization.
- ❑ About 70% of respondents identify themselves as faculty members.
- ❑ Among faculty, 46% are employed by universities, 32% by four-year colleges, 13% by two-year colleges, and 8% by high schools.
- ❑ E-mail **access** is highest among faculty, running to 66% among those under age 35. E-mail **usage** is 37% overall, and highest among graduate students at 60%.
- ❑ Respondents largely reaffirmed the importance of current MAA activities, particularly in the sense of being "highly important to the community."
- ❑ FOCUS, in terms of importance to individuals, leads all current activities. *The Monthly,* books, and Recommendations on Curriculum/Teaching follow.
- ❑ Proposed Goals also received strong support by All Respondents, with slightly more support shown by Faculty.
- ❑ Among Faculty Needs, on a community basis, Special Interest Groups ranked low among all groups. Electronic Services was much more popular among students and those under age 35. A magazine for undergraduate students interested in mathematics led all Future Needs.
- ❑ Faculty ranked classroom resource materials as the number one Future Need for themselves, followed closely by increased opportunities for professional development.
- ❑ Standards for Mathematics Departments, a magazine for undergraduate students, and increased opportunities for professional development were each cited by about half the faculty as being "highly important to the community."
- ❑ Differences among responding groups often were striking.
- ❑ Respondents also provided many useful written comments.

FOCUS EDITORIAL

If Euclid submitted his proof of the infinitude of the primes to one of today's leading mathematical journals, would it be accepted for publication?

I fear the answer is "no," that it would be rejected as being too simple. "Hard proofs" are the order of the day; even better, *long*, hard proofs, involving notions of great abstraction, accessible only to those who have served a long apprenticeship. But what of elegance and simplicity? For many of us, it was the logical beauty—that "beauty cold and austere" to use Bertrand Russell's words—that first attracted us to mathematics.

Now I have nothing against abstraction, complexity, and long, hard proofs. Like many mathematicians, I have spent a large part of my professional life working on hard, technical problems, and I got a huge kick a few years back from the completion of one proof that stretched over twenty pages or so. But this is just one aspect of mathematics, and certainly not, I would maintain, the most central aspect. Judging mathematics by the length or complexity of a proof or the number of Greek symbols used, is analogous to choosing your computer by looking at the layout of the logic-circuits. What of elegance, simplicity, accessibility, applicability, and aesthetic appeal?

I was prompted to think of these issues by a conversation I had with the sculptor Brent Collins, whom I met at the American Association for the Advancement of Science meeting in Chicago earlier this year.

Collins, who hails from Oakland, Illinois, was there to display some of his wood carvings, pieces that vary in size from 18 inches or so to some over eight feet tall, and which, as I am sure the picture shown opposite will indicate, cry out "mathematics."

My initial assumption when I saw this display was that Collins was a mathematician who carved wood-sculptures as a hobby, much like Helaman Ferguson, whose *Umbilic Torus NC* graces the entrance hall at the MAA's Washington headquarters. (See FOCUS 11/1, January—February 1990 and FOCUS 11/4, September 1991.) Minimal surfaces were, I assumed, the focus of Collins' display.

But, no, he was by no means a mathematician, Collins emphasized when I introduced myself. His mathematical training ended with the utilitarian courses he took as a social science and biology undergraduate at Illinois State University a couple of decades ago. Though the literature that nowadays accompanies his work contains many references to mathematical form, this is largely provided by University of Illinois topologist George Francis, an early admirer of Collins' work and now a close friend. When one of Collins' sculptures turns out to bear a close resemblance to a computer visualization of a mathematical surface specified by equations he does not pretend to understand, Collins puts it down to coincidence. But it is a coincidence not without reason, and one that makes me wonder if he, and we, are correct in declaring so categorically that he is not a mathematician.

According to Collins, what he does is seek out the basic, "geometric" forms he sees in nature, the smoothness, the symmetry, the elegance, the simplicity. Guided by intuition, he uses wood to describe what he sees. But isn't that what mathematicians do, apart from the fact that we use abstract symbols and equations instead of physical media such as wood, and are constrained by the rules of logic rather than the limits of what can be done with wood? Is it really the case that a person such as Collins is not a mathematician?

Well, I am not suggesting that we should start awarding mathematics PhDs to sculptors, so to some extent I would have to agree that what he does is not mathematics, however broadly you choose to define the subject. But when you move away from the rather narrow, proof-centered definition of mathematics currently in vogue, and think of it as a search for pattern and structure in nature, then it becomes far harder to draw a line that se*parates* Collins from mathematics. It seems to me that he shares the same overall goal as does mathematics; the only difference is the means he chooses to carry out his investigation and describe his results. So, in a strange way, I feel that his reliance on the elegant shapes that can be wrought in wood brings him closer to the real heart of mathematics than those for whom the complexity of the proof is the sole arbitrator of what is and what is not good mathematics. Perhaps it is not he who should apologize for his lack of mathematical training, but those of us who have allowed the view to develop, that mathematics is solely about the solution of difficult, abstract problems.

The above is the opinion of the FOCUS editor, and does not necessarily represent the official view of the MAA

Brent Collins can be contacted at RR#1, Box 146, Oakland, Illinois 61943.

Woman Mathematician Testifies to Congress

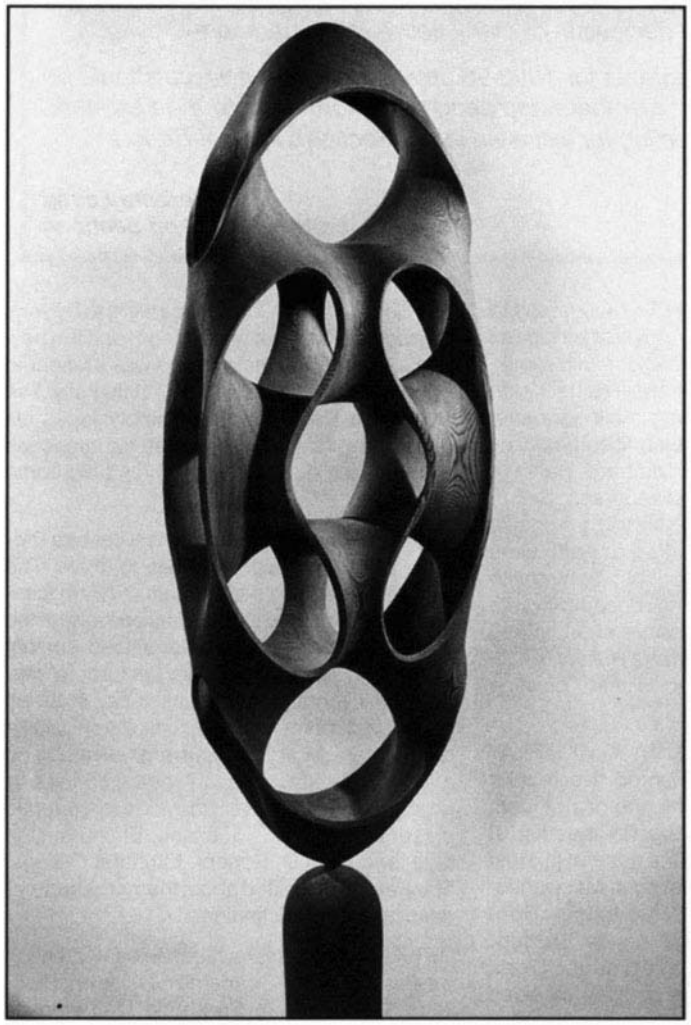
Lisa A. Thompson

On 25 June of this year, the Employment Opportunities Subcommittee of the House Education and Labor Committee held a hearing on sexual harassment and discrimination in nontraditional occupations, which included those in science and engineering as well as the skilled trades. The panel is considering two bills on the issue, one of which would establish a commission to study the barriers to the retention and advancement of qualified women in science and engineering.

Lisa A. Thompson is Assistant for Governmental Affairs, Joint Policy Board for Mathematics, Washington, DC 202/234-9570, FAX 202/462-7877, e-mail, jpbm@math.umd.edu.

Mathematician Jenny Harrison testified about her experiences with the Berkeley Mathematics Department and her pending lawsuit against the University of California.

In all, four women described the opposition they encountered while undertaking nontraditional occupations, and fortunately science came out looking a little better then the other male-dominated fields discussed, garbage truck driving and heavy appliance maintenance. Apparently the dearth of women science and engineering faculty is something Congress intends to keep a closer eye on. Mention was made two or three times during the hearing that, of the more than 300 tenured faculty at the top ten math departments, fewer than five are women.



"As a student in the American public schools I regrettably never quickened to the intellectual challenge or essential beauty of mathematics. Responding to felt needs I have, however, come to them in a different way as a self-taught artist."

—Brent Collins

Call for Calculus Proposals

National Science Foundation

As part of an overall plan to strengthen undergraduate education in science, engineering, and mathematics, the National Science Foundation (NSF) is continuing its program *Curriculum Development in Mathematics: Calculus and Bridge to Calculus.* This program is designed to stimulate the development of projects in response to the need for revision and renewal in the calculus and pre-calculus curricula. So far, support has been provided for projects that deal with all the topics of one and two-year calculus sequences, including linear algebra and differential equations. The program has recently been expanded to include pre-calculus.

Proposals are solicited in three general categories: 1) projects proposing to revitalize calculus instruction on a large scale, involving students at the collegiate and/or secondary levels; 2) new curriculum development projects, particularly for the second year of calculus, including linear algebra and differential equations; and 3) curriculum development projects on preparation for calculus.

In recent years, faculty nationwide have implemented major changes in calculus instruction. Approaches have varied greatly, including emphasis on problem solving skills, analytical and transference skills, the introduction of methods that reduce tedious calculations and place students more in the role of an active learner, student projects, cooperative learning, writing, and an increased emphasis on numerical and graphical viewpoints. Some projects have had NSF support, some have received other external support, and many have been developed with only local institutional support. Information concerning more than 70 projects is included in the MAA CRAFTY report, *Priming the Calculus Pump: Innovations and Resources.*

Additional reports are included in issues of UME TRENDS, and have been presented at conferences and at sessions of meetings of professional societies. The challenge now is to include large numbers of students in these redesigned calculus courses. Proposals are sought for projects that seek to meet this aim.

The closing date for proposals is 7 December 1992. The program announcement is expected to be available in late August. The program will be managed by the Division of Undergraduate Education (DUE), with the cooperation of the Division of Mathematical Sciences and the Division of Elementary, Secondary, and Informal Science Education. The program director is James Lightbourne, DUE, Room 1210, NSF, 1800 G Street, NW, Washington, DC 20550.

Focus on MAA Sections

*This edition of **FOCUS on Sections** summarizes activities and programs as reported in the Annual Reports and Section Newsletters. The variety, the excellence, and the dedication of many active MAA members is evident.*

As your Section programs for 1992-93 unfold, think about which should be shared with all your members and send that information to the secretary/ treasurer of your Section for inclusion in the Section's Annual Report.

Barbara Faires
Editor, FOCUS on Sections

ALLEGHENY MOUNTAIN The annual spring meeting at Slippery Rock University included four outstanding invited addresses with speakers David Bressoud, Pennsylvania State University; Julian Weissglass, Acting Director of Minority Affairs at the Mathematical Sciences Education Board; William Dunham, Hanover College; and Gerald L. Alexanderson, Secretary of the MAA. Contributed talks by students and faculty and the annual pizza party were also highlights. The Section experimented with holding the business meeting concurrently with a breakfast buffet. The summer short course sponsored by the Section was a History of Calculus with Professor Fred Rickey, Bowling Green State University.

EASTERN PENNSYLVANIA AND DELAWARE The Section sponsored two regular meetings and an additional one-day student conference on careers. The fall meeting at Drexel was organized around general interest topics while the spring meeting at Messiah focused on mathematical modeling. Both meetings included sessions for student contributed papers. Professor Doris Schattschneider, Moravian College, received the Section's Distinguished Teaching Award at the spring meeting.

In September the Section sponsored a one-day student conference on careers coordinated by Deborah A. Frantz, Kutztown University. Video tapes of the sessions are being circulated to student chapters. Another student day is planned for September 1993. Three one-week workshops funded by NSF and coordinated by Marvin L. Brubaker and Carl L. Leinbach were held this summer.

FLORIDA 193 MAA members registered for the 25th Annual Meeting of the Florida Section held at the University of North Florida. Steven G. Krantz from Washington University, Louis N. Howard, Florida State, and John Kenelly, Clemson University spoke at plenary sessions. The in-state invited addresses included papers by Larry C. Andrews, University of Central Florida; Patricia A. Dyer, Palm Beach Community College; and Roselyn E. Williams, Florida A&M University. Outstanding workshops, panel discussions, contributed papers, and the Friday night party contributed to this action-packed two-day meeting.

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The Section Award for Service went to Beverly L. Brechner, University of Florida, and the new Distinguished Teaching Award was presented to Donald M. Hill, Florida A & M University. The citation for Donald M. Hill acknowledges his outstanding teaching as well as his impact on mathematics education far beyond his home school.

ILLINOIS The Secondary School Lecture Program of this Section continues to thrive. The annual meeting on the campus of North Central College marked the 75th anniversary of the Section. The program emphasized current trends and included a Pólya Lecturer, a session on Illinois Section activities, student papers, a student pizza party, sessions for classroom notes, six areas of current research and an AWM breakfast. A short course on the use of graphs and calculators in the classroom was presented by Jon L. Johnson, Elmhurst College, and Allen D. Rogers, Elmhurst College. The Section is excited about the increased student chapter participation.

INDIANA The Indiana Section's fall meeting was highlighted by a panel discussion on "Problems and Issues in Preparing Mathematics Teachers" and an invited address by James Leitzel, MAA National Office, on the MAA COMET Report. Student activities included a special presentation on "NASA's JOVE Project" by James Caristi.

The 27th Annual Indiana College Mathematics Competition was held at the spring section meeting. Winning teams represented Rose-Hulman (first place), Indiana University at Fort Wayne (second place), and Purdue University (third place). The 28th annual competition will be held at the joint meeting of the Illinois, Indiana, and Michigan Sections in April 1993.

INTERMOUNTAIN The spring meeting, held on the campus of Weber State University, featured speakers John Kenelly, Clemson University, on educational testing and technology in education, James W. Cannon, Brigham Young University, on the combinatorial Riemann mapping theorem, and Patricia P. Henry, Weber State, on computers in the curriculum. Roland H. Lamberson, Humboldt State, offered a minicourse on mathematical models for conservation and resource management. A presentation and a panel discussion addressed the issue of obtaining grants to prime the pump for curricular change. Professor Henry received the Intermountain Section Award for Distinguished Teaching of Mathematics.

IOWA The Iowa Association of Two-Year Colleges joined the Iowa MAA Section for their annual meeting at Graceland College. Student and faculty contributed papers, invited speaker Gerald Alexanderson, MAA Secretary, Friday evening social, and the display and sale of MAA books contributed to the success of this meeting.

KANSAS The Joint Mathematics Spring Conference co-sponsored by the Kansas Section, the Kansas Association of Teachers of Mathematics, the South Central Kansas Association of Teachers of Mathematics, and the Kansas Association of Mathematics Teachers in Two-Year Colleges opened with five workshops. These workshops included something for everyone: Usage of DERIVE; Geometry Models and Activities (K-6); Visual Paradoxes and Optical Illusions; Setting Up a Summer Mathematics Camp; Calculus Problems on the Casio fx-7700G. The Friday evening session concluded with a talk by John H. Ewing, Pólya Lecturer, and a reception. The Saturday morning session opened with a breakfast discussion of the strategic plan of the MAA. Panel discussions, contributed papers and the business meetings of each of the organizations filled most of Saturday.

KENTUCKY The annual meeting included two panel discussions specifically for students, one on graduate education and another on careers in mathematics. A two-part short course, presented by Arthur Knoebel, New Mexico State University demonstrated the use of challenging problems in calculus to enhance student interest and independent learning. Following invited addresses by Joseph A. Gallian, University of Minnesota at Duluth, and William W. Dunham, Hanover College, was the social "aftermath." Informal announcements and discussions were a part of the breakfast meeting on Saturday morning.

The Kentucky Section has witnessed increased participation by faculty from two-year colleges. This may well be credited to the cooperative newsletter which is published jointly by the Kentucky Mathematics Association of Two-Year Colleges and the Kentucky Section of the MAA.

LOUISIANA-MISSISSIPPI Approximately 75 students attended the annual meeting of the Section held at Louisiana State University. There were 11 student papers and 18 teams from member institutions participated in the problem-solving competition. John H. Ewing, Pólya Lecturer, gave two outstanding addresses "Can We See The Mandelbrot Set?" and "Mathematics and Modems." Saturday morning sessions included a panel discussion on pre-service teacher training in light of the NCTM *Standards* and *A Call for Change*.

MARYLAND-DISTRICT OF COLUMBIA-VIRGINIA The fall meeting at Marymount University and the spring meeting at the University of Virginia each had an attendance of approximately 120. The Section believes that their good mini-courses are a drawing card. This year, the section sponsored mini-courses at each of their meetings; topics were DERIVE, MicroCalc, EXP, and SUMMA. A Friday evening session provided the opportunity for prospective graduate students and those who advise them to learn about graduate study in a relaxing, informal setting with light refreshments.

METROPOLITAN NEW YORK The successful annual meeting, held at the Webb Institute of Naval Architecture, included an invited lecture by Harold Shapiro, Courant Institute, on the ABC Conjecture. A panel with members Kenneth Goldberg, New York University, Edward H. Grossman, The City College of New York, Maria A. Reid, Borough of Manhattan Community College, and Alan C. Tucker, SUNY at Stony Brook, discussed alternative learning strategies in teaching mathematics. The 1992 Metropolitan New York Math Fair, held at Pace University, attracted 510 papers from high school students.

MICHIGAN The annual meeting held at Saginaw Valley State University included MAA speaker Tom Tucker, and Deborah Lockhart of the National Science Foundation (NSF) who spoke on NSF directions and opportunities. Florence Fasanelli, of MAA's SUMMA project, led a workshop on writing proposals for projects to draw more members of under represented groups into mathematics. The Student Chapters Conference was held jointly with the Section meeting and included a speaker invited especially for students, student presentations, and a Friday evening bowling party hosted by the Saginaw Valley State University student chapter.

Elliot A. Tanis, Hope College, was selected as the first recipient of the Michigan Section's Award for Distinguished Teaching. Wilfred Kaplan, emeritus professor, University of Michigan, received the Section's sixth Distinguished Service Award for his many contributions to the Michigan Section during a distinguished career as a teacher, scholar, and author, which extends over 50 years.

MISSOURI The annual meeting was organized as a joint meeting with the Missouri Council of Teachers of Mathematics and the Missouri Mathematics Association for the Advancement of Teacher Training. The joint meeting resulted in increased participation by educators from elementary through graduate level. The diversity of participation was especially noticeable during the panel discussion, Coalescing: "A Panel Discussion Connecting All Levels of Mathematics Education." The banquet address, "Addressing the Call for Change," was given by James R.C. Leitzel of the MAA Office and Editor of the MAA publication, *A Call for Change*. The Saturday morning session began early with a 5K run at 6:30 a.m., followed by a department chairs breakfast and an MAA representatives breakfast. The Section participated in the SUMMA opportunity of a workshop on writing successful proposals.

NEBRASKA-SOUTHEAST SOUTH DAKOTA The annual meeting was held at Hastings College. The invited address on Calculus Reform by Tom W. Tucker, Colgate University was followed by a respondents panel and open discussion. Contributed papers, followed by a social hour and buffet, concluded the Friday evening session. Concurrent Saturday morning sessions in the computer labs offered participants the opportunity to explore exercises in calculus using ISETL and experiment with Theorist as a tool for students of calculus and beyond.

NEW JERSEY Activities at the two section meetings held at the County College of Morris and at DIMACS, Rutgers University have greatly expanded. The Section is grateful to the innovations which have been suggested and implemented by Theresa C. Michnowicz, Jersey City State College. The spring joint meeting with the Mathematical Association of Two-Year Colleges of New Jersey included invited addresses by Mary Ellen Rudin, University of Wisconsin, on General Topology for the 1990s and Ronald L. Graham, AT&T Bell Laboratories, on Juggling Drops and Descents. The support of publishers, who had display booths at the meetings, enabled the Section to give door prizes this year.

Members of the Section participated in mathematics awareness activities which were coordinated by the New Jersey Mathematics Coalition. Family math workshops were planned at sites around the state aimed at families of elementary and middle school students.

The 1992 New Jersey Section Award for Distinguished Teaching of Mathematics was presented to Sister M. Stephanie Sloyan, Georgian Court College.

NORTH CENTRAL Although the North Central Section is pleased with its meeting programs and activities, it is seeking to improve and is actively seeking suggestions for activities to increase participation among its members. The Section plans a summer seminar and a joint spring 1993 meeting with the Minnesota MATYC.

The two section meetings, held at Bemidji State University and Gustavus Adolphus College, included presentations which excited much discussion and interest. Robert W. Earles, St. Cloud State University, spoke on "A Search for Mathematics in American Museums," Michael B. Gregory, University of North Dakota, delivered a lecture on "Functions That Operate" and Marepalli Rao, North Dakota State, in statistical talks. Joseph H. Gallian, University of Minnesota-Duluth, was named the Section's first recipient of the Award for Distinguished Teaching of Mathematics.

The Section is making plans to honor one of five long-time supporters, Joseph D.E. Konhauser.

NORTHERN CALIFORNIA The one-day annual meeting, held at the University of Pacific,

included participants from industry as well as from a variety of colleges and universities. An invited address presented by Mel Slugbate, a real estate broker, had the intriguing title "Real Estate in Hyperbolic Space: Investment Opportunities for the 90s." The Section continued its successful program of five invited addresses, including E. Donald Chakerian, University of California, who was honored with the Section's first Award for Distinguished Teaching of Mathematics. The Section laments the passing during this past year of two particularly active members, Derrick H. Lehmer, professor emeritus, Berkeley, and David E. Logothetti, Santa Clara University.

NORTHEASTERN This past spring, the Northeastern Section initiated a program of regional dinner meetings which attracted a wide variety of participants to discussions of mathematics and mathematics education. In addition to workshops at the fall meeting, the Northeastern Section hosted a separate one-day minicourse, "Challenging Students with Research Projects in Calculus" which featured David J. Pengelley, New Mexico State University, and Edward D. Gaughan of New Mexico State University.

The University of Maine was the site of the Section's one-week short course in June on Exploratory Data Analysis presented by Col. Ricky A. Kolb, US Military Academy. In addition to the academic enrichments, participants in the short course were treated to a traditional lobster feast, in celebration of the completion of the course.

Successful meetings at Providence and at Merrimack Colleges included expanded programs for students. The Student Chapter Session at the spring meeting included a presentation on "Group Theoryplay" by Thomas E. Moore, Bridgewater State College. Sonja I. Sandberg, Framingham State College, gave a student mini-course on Mathematical Models of Epidemics. At the spring meeting the discussion of "Soap Bubbles, Metals and Undergraduate Research" by Frank Morgan, Williams College was followed by the presentation to him of the Section's Award for Distinguished Teaching of Mathematics.

OHIO The spring meeting at the University of Dayton included the MAA Pólya Lecturer, John Ewing, a special session of contributed papers on fractals, and James R.C. Leitzel, MAA National Office, discussed the latest MAA recommendations on the mathematical preparation of teachers. A contributed paper session was dedicated to curricular changes in undergraduate mathematics. The Section continued its tradition of the outgoing Section President's Address with David E. Kullman speaking on "Variations on a Spiral."

In addition to contributed paper sessions for students other student activities included a pizza party, a graduate school representatives session, and a workshop on kaleidoscopes.

The 1992 Summer Short Course at Bowling Green State University was presented by Robert L. DeVaney, Boston University, and provided an overview of work on fractals and chaos, making connections between these concepts and the field of dynamical systems. The course included discussion of how the topics might be integrated into work which is usually required of the undergraduate mathematics major.

OKLAHOMA-ARKANSAS The 54th Annual Oklahoma-Arkansas Section Meeting was held at Henderson State University in Arkadelphia, Arkansas. The meeting attracted 196 participants, including 28 graduate students and 55 undergraduates. There were 15 separate sessions of talks totalling 76 in number of which 14 were delivered by undergraduates.

The Annual Nathan A. Court Lecturer was Professor Albert Marden, Director of the Geometry Center, University of Minnesota who spoke on the center and showed their video "Not Knot." The free student workshop "Math Models in Ecology" featured Paul Waltman, Emory University. Support for this year's workshop was provided by a grant to the MAA from the Exxon Foundation. Professor emeritus Edward D. Gaughan, New Mexico State University presented the faculty workshop on "Challenging Students with Projects in Calculus." This workshop was jointly sponsored by the National Science Foundation and the Section. The Section continued its tradition of recognizing outstanding high school teachers and presented its first award for Distinguished College or University Teaching of Mathematics.

PACIFIC NORTHWEST The annual meeting was a success with approximately ninety participants at a three day meeting at the University of Montanta in Missoula. In addition to mathematical content, several opportunities for informal discussion afforded by the pre-meeting reception, the field trip to Bison Range and the Banquet continue to be attractive.

The Section supports all students that give papers at the Section Meeting with free registration, meals, and lodging for two nights in the host school's residence halls. The Section plans to initiate a student modeling competition in 1993.

Mid-afternoon on Friday, participants boarded a bus to travel to the National Bison Range and the barbecue banquet. Banquet speaker Bruce Berendt, University of Illinois talked on "The Life and Legacy of India's Greatest Mathematician, Srinivasa Ramanujan." Short courses at the meeting were presented by William McCallem on "Teaching Reformed Calculus" and by William Hawkins on developing an intervention program for minority middle and high school students.

The first annual winner of the Distinguished College or University Teaching of Mathematics Award in this Section was André L. Yandl, Seattle University.

ROCKY MOUNTAIN Three panels, Calculus Reform, Mathematics Programs for Underrepresented Groups, and Student Research, contributed to the success of the spring meeting at Colorado College in Colorado Springs. The meeting opened with a special talk by Steven Janke of Colorado College who presented a survey of models used to determine the growth of AIDS. Leonard Gillman, University of Texas and former president of the MAA, gave both the banquet talk and the main address on Saturday morning.

SEAWAY The expanded programming of the two Section meetings provided a variety of topics from mathematics, mathematics education, instructional concerns, and student needs. A special afternoon session at the fall meeting which was held at SUNY at Fredonia, was devoted to students and student chapters, and featured a mathematical talk, discussion among students and chapter advisors, and a session on careers and graduate schools. The spring meeting was held at Queens University in conjunction with the 91st Ontario Mathematics Meeting. The Seaway Section has special lectures: a mathematics education lecture in the fall which, in 1991, was presented by Robin Locke, St. Lawrence University, on "The Role of Statistics in Small College Curriculum," and the Gehman Lecture which in the spring of 1992 was presented by Jonathan Borwein of the University of Waterloo on "Computer Experimentation in Mathematics - Oiler Mahler, Ramanujan and Maple."

The Section Award for Distinguished Teaching of Mathematics was presented at the spring banquet to Peter Taylor, Queens University.

SOUTHERN CALIFORNIA The Section had two particularly successful meetings this year, which were attractive to both students and faculty. The fall meeting at the University of California, Santa Barbara and spring meeting at the California State Polytechnic University in Pomona, included a special "student strands." At the fall meeting this strand included a panel of recent graduates speaking on various careers in mathematics, entitled "Is There Life After A Bachelor's Degree in Mathematics?" followed by a presentation by Arthur T. Benjamin on the "Art of Mental Calculation." In addition to a session for student contributed papers, the spring meeting included a special half-hour talk on Ramanujan's Mathematics by UCLA Professor Basil Gordon, followed by a showing of the PBS NOVA video program on Ramanujan's life.

The selection of Professor Harris S. Shultz of California State University to receive the Section's Award for Distinguished Teaching of Mathematics was announced at the spring meeting. Professor Shultz will give an invited address at the fall 1993 meeting at the University of Southern California.

SOUTHEASTERN The Section had three excellent invited speakers for the Annual Meeting: Carl Pomerance, University of Georgia, who spoke about "The Factorization of the Ninth

Fermat Number," Marcia Sward, MAA Executive Director, who chose as her topic "Shifting the Paradigms of Collegiate Mathematics," and John H. Ewing, first Pólya Lecturer and Editor of the Monthly whose title was the question "Can We See the Mandlebrot Set?" There was excellent response to the three short courses: Earth Algebra by Nancy Zumoff and Chris B. Schaufele, Kennesaw State College; Statistics with the TI-81 Graphing Calculator by Iris Fetta, Clemson University and Richard L. Stephens, Western Carolina University; and Implementing Calculus as Formal Laboratory Courses Using Mathematica by Martha L. Abell, James P. Davenport, James Braselton, Arthur G. Sparks, Georgia Southern University.

The Section was pleased to present $100.00 to Jeff Vanderkam, Duke University, as the student from the Section with the highest score on the Putnam exam (second year in a row).

The Section Distinguished Service Award was presented to Billy F. Bryant, Vanderbilt University, and the Section's first award for Distinguished Teaching of Mathematics went to Anne L. Hudson, Armstrong State College.

SOUTHWESTERN The annual meeting of the Section at the University of Arizona included a meeting of the Arizona Mathematics Consortium. Lawrence C. Moore Jr., Duke University, gave a presentation on calculus as a laboratory course and Bruce Bailey, University of Arizona, gave an interesting talk entitled, "Dynamics of Musical Instruments." David Lovelock, University of Arizona, shared some actual experiences with the participants in his talk on "Search and Rescue." David was recognized with the Section's Award for Distinguished Teaching of Mathematics.

TEXAS The Annual Meeting attracted 285 participants and featured two short courses, Some Mathematical Problems in Artificial Intelligence by André de Korvin, University of Houston-Downtown, and New Mexico State University Student Research Projects in Calculus by Douglas Kurtz. There were four invited addresses, 43 contributed papers, sixteen student papers, and a student workshop, "Hard Problems You Wish Your Professor Had Assigned" presented by Douglas Kurtz. In addition, department heads, institutional representatives, two-year college members, and MAA student chapter advisors met in special sessions. Graduate school representatives were available to interview prospective students during a 90-minute session.

Professor Robert S. Doran, Texas Christian University, received the Section's Distinguished Teaching of Mathematics Award. Professor emeritus Landon A. Colquitt, Texas Christian University, was honored posthumously with the Section's Distinguished Service Award. Professor Joe E. Cude, Tarleton State University was also presented with a Section Distinguished Service Award.

WISCONSIN The 60th annual meeting was held at the University of Wisconsin-Whitewater. A workshop on Research Projects in Calculus by Edward D. Gaughan, New Mexico State University, began the day preceding the meeting. On the first day of the meeting, a SUMMA workshop on intervention for minority secondary school students was given by William Hawkins. In an ongoing effort to increase cooperation between secondary school and college teachers of mathematics, the Wisconsin Section and the Wisconsin Mathematics Council will co-sponsor a meeting at the University of Wisconsin-La Crosse on 3 October 1992.

Several initiatives have been undertaken by the Executive Committee: contacting mathematicians in Nicaragua to assess needs of the mathematics community in that country; exploring the possibility of a scholarship program based on the Section's high school contest; and a drive to collect funds to name a room in the MAA national headquarters in honor of Mary Ellen and Walter Rudin.

Joint Meeting of Illinois, Indiana and Michigan Sections to Observe Golden Anniversary

Steve Carlson
Rose-Hulman Institute of Technology

In the spring of 1943 the MAA was in its twenty-eighth year and faced the prospect of promoting the interests of mathematics in America through an enduring period of world war, the second since the Association's founding at Ohio State University in December of 1915. The activities of the sections were influenced by the crisis, and that spring the Illinois, Indiana, and Michigan Sections met jointly, for the first time, to hear a program which pooled the efforts of some of the most outstanding mathematicians from the three states and included topics relevant to the war effort. The meeting took place at the University of Notre Dame.

This event, archived for nearly fifty years in the Section Meetings Reports of the November 1943 *Monthly*, was discovered during research into the history of the Indiana Section. Since no such joint meeting has occurred since 1943, representatives from the sections quickly agreed to combine their efforts during the spring of 1993 and commenced planning for a *second* Joint Meeting of the Illinois, Indiana, and Michigan Sections, exactly fifty years after the first. Saint Mary's College of Notre Dame, Indiana, has agreed to host the meeting on Friday and Saturday, 23 and 24 April 1993.

"This gives us a wonderful opportunity to cut across section borders and share ideas and expertise with individuals we don't often work with at the local level," reports Daniel P. Maki, recently elected chair of the Indiana Section. "There's a lot of mathematical talent and enthusiasm among the members of the three sections. That along with combined resources of the sections, should enable us to plan a very special event." Maki, along with Richard J. Fleming of the Michigan Section and Robert G. Kuller of the Illinois Section, will be in charge of planning for the meeting; local arrangements at Saint Mary's are being coordinated by Donald Miller, chair of the department.

The list of forty-six registrants at the 1943 meeting includes names of many well-known MAA members who had, or would subsequently have, influence on mathematics and the MAA. Lester R. Ford of the Illinois Institute of Technology, who at the time was editor of the *Monthly*, presented a paper on *Nomagraphy*; Ford would serve as President of the MAA in 1947-48. A lecture entitled *On the Theory of Complex Functions* was presented by Emil Artin, then at Indiana University. At the meeting, Artin was elected Vice-Chairman of the Indiana Section. Also attending the meeting was a young University of Chicago PhD named Ivan Niven, who would go on to serve the MAA as 1st Vice President in 1974-75 and as President in 1983-84. There are many other familiar names among the thirty MAA members on the list, including, for example, R.M. Thrall of the University of Michigan and W.L. Ayres of Purdue University.

Plans for the 1993 event at Saint Mary's College call for an array of invited speakers, contributed paper sessions, panel discussions, and student activities. As plans have developed, section representatives have kept the 1943 meeting program close at hand and observed that the very topics of interest then, as now, involve such notions as pedagogical concerns in the calculus classroom and applications of mathematics at various levels. The surviving attendees of the 1943 meeting will be invited to attend as special guests of the three sections or to contribute in some way to the meeting. They will be honored, along with recipients of the three sections' service and distinguished teaching awards, at a banquet dinner celebrating the golden anniversary.

"Putting an event like this together requires a lot of initiative, cooperation, and hard work — all worthwhile," observes Maki. "But then, we only do it every fifty years."

1992 Mathematical Sciences Department Chairs Colloquium

16 -17 October 1992, Arlington, Virginia

The Theme of the 1992 Colloquium is "Chairing the Changing Mathematical Sciences Department of the 1990's." The keynote speaker will be D. Allan Bromley, Assistant to the President for Science and Technology. The speakers and panel members at the Colloquium will include chairs of mathematical sciences departments, university administrators who come from the mathematical sciences community, staff from the House Science Subcommittee, representatives of the Federal Coordinating Council for Science, Engineering and Technology (FCCSET), and representatives of federal research and education programs.

The goal of the Colloquium is to provide department chairs and candidates for appointment as chairs with current information on the changing interaction between research and education in core mathematics, applied mathematics, statistics, and operations research and on the trends in Washington that affect mathematical sciences departments.

For more information contact: Board on Mathematical Sciences, National Research Council, NAS 312, 2101 Constitution Avenue, NW, Washington, DC 20418, (202) 334-2421, FAX (202) 334-1597, INTERNET: bms@nas.edu, BITNET: bms@nas.bitnet .

Interactive Mathematics Project Seeks Sites for Regional Centers

The Interactive Mathematics Project (IMP) has received a five year grant from the National Science Foundation to evaluate, refine, and disseminate its innovative, problem-based, high school mathematics curriculum. One component of this project is the establishment of regional centers to direct the implementation of the curriculum in individual high schools.

One of the regional centers, which has already begun operation, is a state-wide project in California, which will extend and expand the work begun there during IMP's first three years. Current funding provides for two-non California centers to begin work in Spring 1993, with an additional center beginning in Spring 1994. Funds will continue through the end of the grant in August 1997.

IMP invites teams of mathematics educators to apply to set up and direct these non-California centers. Funds for the operation of the centers will come primarily from the NSF grant, but additional funds would need to be found by the individual centers.

It is anticipated that each center will include a team of three half time directors and intensive involvement of three "focus" high schools with varying student populations. Support of administrators and teachers at these schools is essential. Other "satellite" schools would be brought into relationship with the center in subsequent years.

For further details, leave name and address at 1-415-338-1805. Deadline for preliminary application is 1 November 1992.

Transparent Proofs *from page 6*

ber of nodes of G. Now we join two such nodes if they don't plainly contradict one another by asserting a different bit in the same position.

If there is an acceptable holographic proof (of length n), this gives rise to n^k pairwise compatible acceptable spot-check lists (all ordered k-tuples from the holographic proof). Otherwise, any purported holographic proof fails on most of the spot-check lists, so the largest clique in G may have only a fraction of n^k nodes.

This simple idea shows how the *easy proof-checking* leads to the *hardness* of approximating the clique size (unless P = NP).

At this point it still seemed that the approximate clique problem was an isolated case, particularly well suited to capture the key facts about holographic proofs: that the checker needs *very little information* about the proof to decide whether or not to accept it; and there is a *large gap* between acceptance probabilities for correct and phony proofs.

Then came an entirely different but no less simple reduction by Arora et al. showing that the same features can be modeled by close approximations of MAX 3-SAT, thus opening the way to proofs that most combinatorial optimization problems of interest have no PTAS.

The excitement continues, with new approximate optimization problems turning out to be hard in one sense or another. A most recent, very general example by Lund and Yannakakis asserts that the size of the largest planar subgraph of a graph, the largest bipartite subgraph, or the largest subgraph with any nontrivial property preserved under node deletion, cannot be approximated within any constant factor, unless all NP problems can be solved in *quasipolynomial* time.

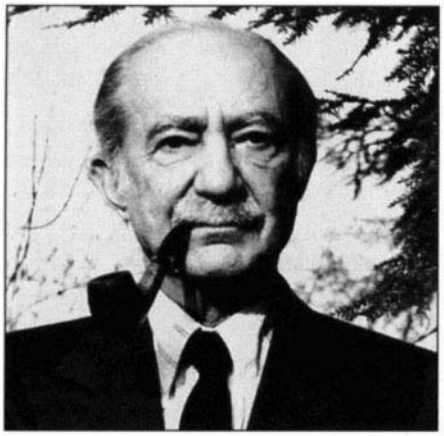
What are such results good for? They don't give us any new, fast algorithms. Yet, they may have a profound philosophical effect. They tell us, what not to expect. They create new order. Like the transcendence of π. We no longer try to square the circle. And now we know what we are up against if we try to approximate the maximum clique size.

NOTES

[1] Gödel does not define "polynomial time"; instead, he says "Kn, or even Kn^2 ... machine steps" (K is a constant). [Quoted from M. Sipser: "The History and Status of the P versus NP Question," Proc. 24th ACM Symp. on Theory of Computing, p. 612.].

[2] Things like this have happened before. A prime example is Gödel's Completeness Theorem, which says, roughly, that whatever is true (in all models of a set of axioms) is formally provable. "First order logic captures mathematical truth." An immediate consequence is the existence of non-standard models of arithmetic (even under a nonrecursive, complete set of axioms), demonstrating the utter failure of first order logic to "capture mathematical truth."

[3] Both the term "transparent proof," used in the original [BFLS] paper (cf. FOCUS 92/3), and the more recent term "holographic proof" were coined by L. Levin. The term "transparent" refers to the ease of checking (finding an error); the "hologram" image is conjured up by the feature of the "holographic proof" that most of their small chunks contain information about the entire original proof. Discussions in the past weeks have convinced me that "holographic" has a broader appeal.



Morris Kline, Former MAA Board of Governors Member, dies at age 84

Morris Kline, Professor Emeritus of Mathematics at the Courant Institute, died 11 June 1992 in a Brooklyn hospital of heart failure. He was born in Brooklyn in 1908 and had been a member of the MAA for 51 years. He earned his bachelor's, master's, and doctoral degrees at New York University, where he taught for most of his life. Educated as a topologist-he was assistant to J. W. Alexander at the Institute for Advanced Study from 1936 to 1938-he did research mainly in differential equations and applied mathematics. He had been both a Fulbright and Guggenheim Fellow.

Kline had unusually broad intellectual interests and was a prolific writer. His books, thirteen in all, include monographs on electromagnetic theory and a text on calculus, as well as books on mathematics in society (*Mathematics in Western Culture; Mathematics and the Physical World*), on the history and influence of mathematics (*Mathematical Thought from Ancient to Modern Times; Mathematics: the Loss of Certainty; Mathematics and the Search for Knowledge*) and on mathematics education (*Why Johnny Can't Add: The Failure of the New Math; Why the Professor Can't Teach: Mathematics and the Dilemma of University Education*). His criticism of the "new math" and his strong advocacy of applied mathematics, particularly in the classroom, provoked controversy and debate. At the same time he wrote extensively on the relationship between mathematics and general culture, the arts, philosophy and literature. On teaching he wrote in 1966: "Instead of presenting mathematics as rigorously as possible, present it as intuitively as possible." His books on mathematical culture and on mathematics education were among the most widely read in recent decades.

For the MAA he served on committees, as associate editor of *Mathematics Magazine* (1976-1980) and as an at-large member of the Board of Governors (1959-1961).

In Memoriam

Hansen Ball, Retired Professor, US Naval Academy, died in December 1991, at the age of 84. He was a MAA member for 61 years.

James C. Brooks, Retired Professor, Georgia Institute of Technology, died 28 February 1992. He was a MAA member for 40 years.

William H. Dannacher, Retired Assistant Professor, Villanova University, died 5 June 1992 at the age of 74. He was a MAA member for 33 years.

Charles R. DePrima, Professor Emeritus, California Institute of Technology, died 10 November 1991 at the age of 73. He was a MAA member for 39 years.

Karl Folley, Retired professor, Farmington Hills, MI, died 15 February 1991. He was a MAA member for 63 years.

H. W. Godderz, Professor Emeritus, Union College, died at the age of 83, he was a MAA member for 44 years.

Charles J. Lewis, Professor, Georgian Court College, died at the age of 74. He was a MAA member for 47 years.

Derrick H. Lehmer, Professor Emeritus, University of California at Berkeley, died 22 May 1991 at the age of 86. He was a MAA member for 63 years.

Jurgen Kraft, Associate Professor, University of Puerto Rico, died 18 January 1992, at the age of 38. He was a MAA member for 6 years.

I.I. Hirschman, Retired Professor, Washington University, St. Louis, MO,has died. He was a MAA member for 43 years

Dis Maly, Professor Emeritus, Rensselaer Polytech, died 31 July 1989. Professor Maly was a MAA member for 41 years.

Elmer Tolsted, Retired Professor, Pomona College, died 23 June 1992. He was a MAA member for 40 years.

Gilbert Ulmer, Retired Professor, University of Kansas, has died. He was a MAA member for 52 years

Irene Wente, Professor Emeritus, South Dakota State University, died 14 May 1992, at the age of 89. She was a MAA member for 60 years.

Hack Arroe, Retired Professor, State University of New York at Fredonia, a MAA member for 33 years has died.

Lawrence Morscher, Retired Professor, University of Maryland, a MAA member for 22 years.

New From the MAA

Heeding the Call For Change: Suggestions for Curricular Action

Lynn Arthur Steen, Editor

In 1991 the MAA Board of Governors issued the publication of a MAA Report, A CALL FOR CHANGE, which heralded sweeping reform in all aspects of collegiate mathematics.

Just published, HEEDING THE CALL FOR CHANGE provides the first in a series of challenges concerning where and how to begin the process of change. The themes covered in this volume are quite diverse, ranging from disciplinary discussions (e.g., statistics, geometry) to curricular systems (e.g., the undergraduate major), from administrative concerns (e.g. assessment) to policy debates (e.g., multiculturalism). Yet beneath the surface of these varied papers lie many of the fundamental themes found in A CALL FOR CHANGE; that instruction needs to become an active, constructive process in which students learn to communicate about mathematics, to build mathematical models, and to connect mathematical ideas with the world around them.

260 pp., 1992, Paperbound
ISBN-0-88385-079-6
List: $20.00

Catalog Number NTE-22

From Zero to Infinity
Fourth Edition

Constance Reid

FROM ZERO TO INFINITY has dazzled readers with its freshness and clarity since being published in 1955. It shows how interesting the everyday natural numbers 0, 1, 2, 3,...have been for over two thousand years, and still are today. It combines the mathematics and the history of number theory with descriptions of the mystique that has on occasion surrounded numbers even among great mathematicians.

Each chapter takes one of the ten digits as a starting point. In some cases, as with 0 and 1, the numbers are in themselves special and unique. In other cases, as with 4 (the first square) or 6 (the first perfect number), each digit serves to inroduce an infinite series of very interesting numbers and very interesting mathematical questions that arise in connection with them.

Constance Reid has written many highly acclaimed books on mathematicians and mathematics, but this little classic—her first book—has earned a special place in popular mathematical literature.

200 pp., Paperbound, 1992
ISBN 0-88385-505-4
List: $19.00 MAA Members: $14.00

Catalog Number ZTI

Problems For Mathematicians: Young and Old

Paul R. Halmos

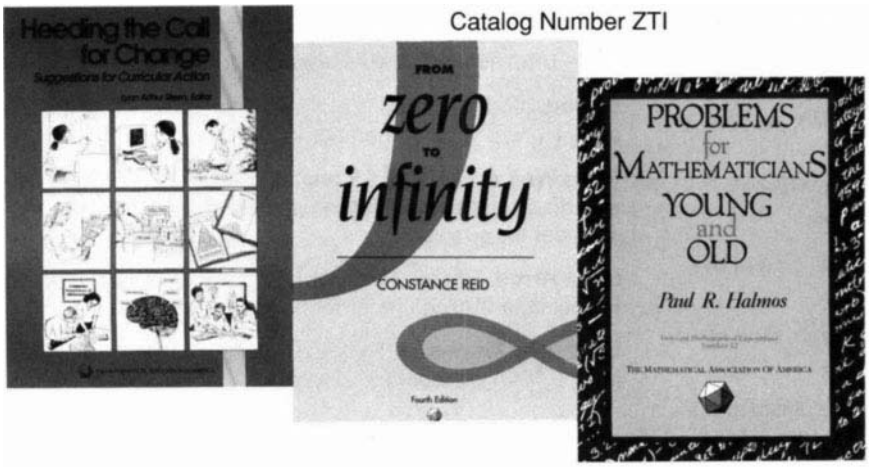
This is a book of problems for mathematicians at all levels. Halmos says: "I wrote this book for fun. It was fun indeed—the book almost wrote itself. It consists of some of the many problems that I started saving and treasuring a long time ago. Problems came up in conversations with friends, and in correspondence, and in books and in lectures. I enjoyed them, thought about them, tried to solve them, tried to change them, and tried to think of new ones, and then I tried to organize and write down the ones I was fondest of—and this book is the result."

The problems come complete with their statements, hints, and solutions. The purpose of the statements is to stimulate thought. The reader is asked to think of extensions and improvements of the results asked for. The hints are intended to get the reader to look in a possibly profitable direction.

Some of the problems can be solved by high school students. Others require the maturity of a professional mathematician, who can be a second year graduate student or someone who has been earning a living by thinking about mathematics for a long time. All of them are challenging and fun.

328 pp., 1991, Paperbound
ISBN 0-88385-321-3
List: $24.00 MAA Member: $16.00

Catalog Number DOL-12



(Order form on page 27)

New From the MAA

Perspectives on Contemporary Statistics

David C. Hoaglin and
David S. Moore, Editors

This book is a must for anyone who teaches statistics, particularly those who teach beginning statistics–mathematicians, social scientists, engineers–as well as for graduate students and others new to the field. The authors focus on topics central to the teaching of statistics to beginners, and they offer expositions that are guided by the current state of statistical research and practice.

Statistical practice has changed radically during the past generation under the impact of ever cheaper and more accessible computing power. Beginning instruction has lagged behind the evolution of the field. Software now enables students to shortcut unpleasant calculations, but this is only the most obvious consequence of changing statistical practice. The content and emphasis of statistics instruction still needs much rethinking.

The book opens with a contemporary overview of statistics as the science of data–a view much broader than the "inference from data" emphasized by much traditional teaching. The next two chapters discuss the philosophy and some of the tools used in data analysis and inference, and its implications for teaching. Other chapters examine the science of survey sampling, essential concepts of statistical design of experimentation, contemporary ideas of probability, and the reasoning of formal inference. The book concludes with introductions to diagnostics and to the alternative approach embodied in resistant and robust procedures.

252 pp., Paperbound, 1991
ISBN 0-88385-075-3
Price: $20.00

Catalog Number: NTE-21

Student Research Projects in Calculus

Marcus Cohen, Edward D. Gaughan,
Arthur Knoebel, Douglas S. Kurtz,
and David Pengelley

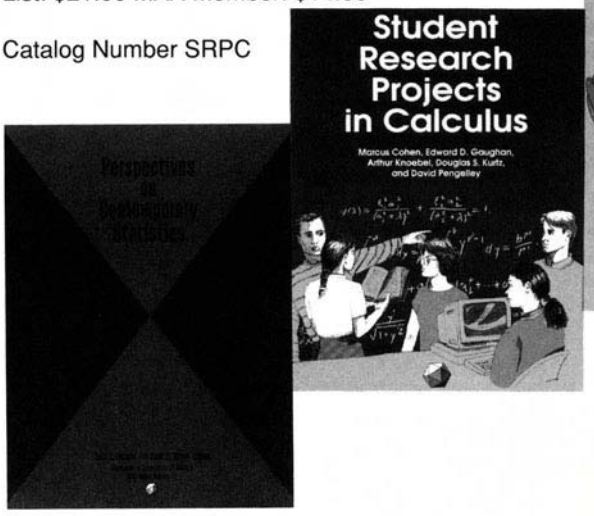
Changing the way students learn calculus was the goal of five mathematicians at New Mexico State University. In the Spring of 1988, they began work on a student project approach to teaching calculus.

You can use their methods in teaching your own calculus courses. Over 100 projects are presented, all of them ready to assign to students in single and multivariable calculus. The projects were designed with one goal in mind: to get students to think for themselves. Each project is a multistep, take-home problem allowing students to work both individually and in groups.

Each project has accompanying notes to the instructor, reporting students' experiences. The notes contain information on prerequisites, list the main topics the project explores, and suggest helpful hints. The authors have also provided several introductory chapters to help instructors use projects successfully in their classes and begin to create their own.

232 pp., 1992, Paperbound
ISBN 0-88385-503-8
List: $21.00 MAA Member: $14.00

Catalog Number SRPC



Old and New Unsolved Problems in Plane Geometry and Number Theory

Victor Klee and Stan Wagon

Part of the broad appeal of mathematics is that there are simply stated questions that have not yet been answered. These questions are plentiful in the areas of plane geometry and number theory, and the purpose of this book is to discuss some unsolved problems in these fields. Many of the questions can be understood by readers with a very modest mathematical background.

The presentation is organized around 24 central problems, many of which are accompanied by other, related problems. The authors place each problem in its historical and mathematical context, and the discussion is at the level of undergraduate mathematics.

352 pp., Paperbound, 1991
ISBN 0-88385-315-9
List: $22.00 MAA Member: $16.00

Catalog Number DOL-11

(Order form on page 27)

New From the MAA

Mathematical Circus

Drawn from Martin Gardner's "Mathematical Games" column in SCIENTIFIC AMERICAN

Martin Gardner

A circus suggests fun and enjoyment and there is plenty of both to be found here. The book should certainly be in the school library. It will also be a valuable resource for the teacher.

The Mathematical Gazette

His puzzles exercise the mind and not only fascinate puzzle fanatics but are also capable of amusing and intriguing serious professional mathematicians, scientists, and astronomers.

Science Reporter

Martin Gardner is once again the skillful ringmaster of a fast-paced variety show. There is something here for everyone; indeed, there are dozens of things here for everyone. The twenty chapters of this book are nicely balanced between all sorts of stimulating ideas, suggested by down-to-earth objects like matchsticks and dollar bills as well as by faraway objects like planets and the infinite random walks. We learn about ancient devices for arithmetic and about modern explanations of artificial intelligence. There are feasts here for the eyes and hands as well as for the brain.

P.T. Barnum correctly observed that people like to be hoodwinked once in awhile, and Martin the Magician is full of tricks and amusing swindles. But the important thing is that he is scrupulously fair. He painstakingly checks all of his facts and provides excellent historical background. These essays are masterpieces of scholarship as well as exposition. They are thoroughly reliable and carefully researched.

300 pp., Paperbound, 1992
ISBN 0-88385-506-2

List: $17.50
MAA Member: $14.50

Catalog Number CIRCUS

A Century of Calculus
In two parts

Part I—1894-1968

T.M. Apostol, H.E. Chrestenson, C.S. Ogilvy, D.E. Richmond, N.J. Schoonmaker
500 pp., Paperbound, 1992,
ISBN 0-88385-205-5
List: $36.00 MAA Member: $25.00

Part II—1969-1991

T.M. Apostol, D.H. Mugler, D.R. Scott, A. Sterrett, Jr., A.E. Watkins
500 pp., Paperbound, 1992,
ISBN 0-88385-206-3
List: $36.00 MAA Member: $25.00

An essential reference for all teachers of calculus.

This two-volume collection of papers on calculus will provide teachers with easy access to a wealth of interesting and informative articles. Many of the papers contain material that has direct application to the classroom and is especially useful for beginning teachers. For example, there are papers on the basic elementary functions and their inverses, maxima and minima, indeterminate forms, integration by parts, polynomial approximations, numerical methods, infinite series, and applications of calculus to geometry and to mechanics. Some articles describe matters of pedagogy or class experiments that have had various degrees of success. Others provide insights, historical background or source material that extends beyond the classroom, or beyond the level of elementary calculus.

Volume I (published in 1969) as SELECTED PAPERS IN CALCULUS contains articles reprinted from the MONTHLY and MATHEMATICS MAGAZINE. Volume II contains articles reprinted from the MONTHLY, MATHEMATICS MAGAZINE, and the COLLEGE MATHEMATICS JOURNAL. It is a collection all calculus teachers will want on their desks.

BUY BOTH VOLUMES
AND SAVE.

List: $61.00
MAA Member: $42.00

(Order form on page 27)

New From the MAA

Symbolic Computation in Undergraduate Mathematics Education

Zaven Karian, Editor

If you are interested in learning about how you can use the computer to help your students learn about important mathematical concepts this book needs to be on your shelf.

The availability of powerful symbolic computing systems on inexpensive micro computers is revolutionizing mathematics instruction in the nation's colleges and universities. This volume developed under the aegis of CUPM (Committee on the Undergraduate Program in Mathematics) brings together many of the facets associated with the pedagogic uses of symbolic computation. Part I consists of articles that deal with general issues of learning mathematics and the role of symbolic computation in that process.

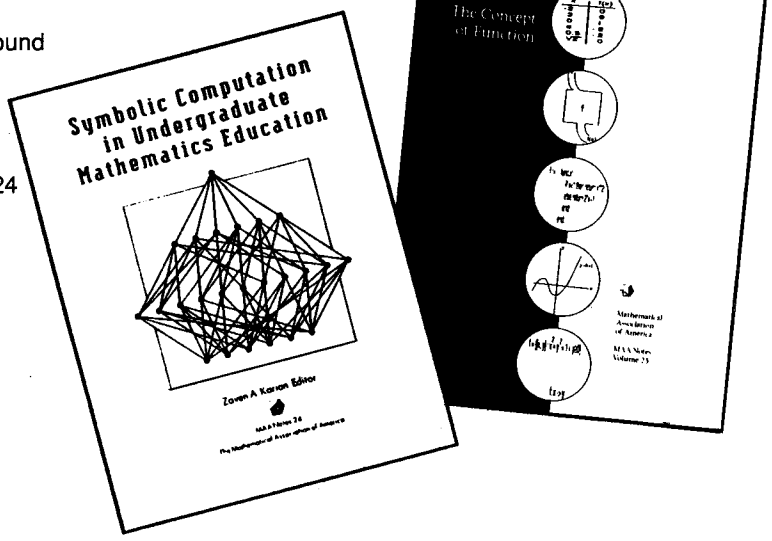
Part II describes the use of symbolic computation in teaching calculus. Articles describe the use of symbolic computation in a laboratory calculus course, the uses of Derive in the instruction of calculus, antidifferentiation and the definite integral, and the experiences and reflections of teachers who have used symbolic computation in calculus instruction.

Part III consists of papers on sophomore-level courses on linear algebra and differential equations. Articles describe the use of CAS in teaching linear algebra and calculus, the use of graphing calculators to enhance the teaching of linear algebra, linear systems of differential equations using MAPLE, and the use of programmable graphics calculators in teaching a course on differential equations. The articles in Part IV describe what can be done in using symbolic computation in teaching combinatorics, probability and statistics courses. The articles and references in Part V will help you get started in using some of these ideas at your own institution.

200 pp., 1992, Paperbound
ISBN 0-88385-082-6

List: $22.00

Catalog Number NTE-24



The Concept of Function Aspects of Epistemology and Pedagogy

Gershon Harel and Ed Dubinsky, Editors

The contributors of this volume probe the idea of what it means to learn the concept of function and how instruction, based on research, could assist teachers in finding ways of helping their students understand this all-important mathematical concept.

There are several major themes that emerge in the pages of this volume. They are theoretical perspectives of development of the function concept, theory-based teaching experiments, conceptions held by students and teachers, and the use of pedagogical software. The volume begins with a summary and overview of the subject and is followed by a brief glossary of terms.

The development of the papers presented in the volume began with a conference held in West Lafayette, Indiana in October 1990 with the support of Purdue University and the Exxon Foundation. This volume is, however, much more than just a conference proceedings. It is a truly cooperative writing effort by a group of dedicated researchers and educators.

350 pp., 1992, Paperbound
ISBN 0-88385-081-8

List: $22.00

Catalog Number NTE-25

(Order form on page 27)

New From the MAA

Statistics for the Twenty-First Century

Florence and Sheldon Gordon, Editors

Teachers of introductory statistics courses will find ideas in this book that suggest innovative ways of bringing a course in statistics to life. All of the articles focus on major themes that pervade significant portions of an introductory statistics course. Learn about current developments in the field and how you can make the subject attractive and relevant to your students. All articles are written by individuals who are creative teachers themselves. They provide suggestions, ideas, and a list of resources to faculty teaching a wide variety of introductory statistics courses.

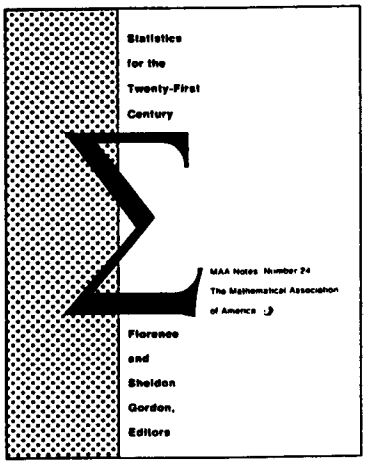
Some of the exciting ideas presented include computer simulations of probabilistic and statistical principles, "real world" experiments with probability models, individual statistical research projects to reinforce statistical methods, and concepts and exploratory data analysis.

This volume will have a significant impact on statistical education by providing the foundations on which future changes in introductory statistics courses will be based. The tone is set here for the types of statistics courses that will be offered as we approach the twenty-first century.

250 pp., 1992, Paperbound
ISBN 0-88385-078-8

List: $22.00

Catalog Number NTE-26



**Excursions in Calculus:
an Interplay of the Continuous and Discrete**

Robert M. Young

Printed with eight full–color plates.

The purpose of this book is to explore, within the context of elementary calculus, the rich and elegant interplay that exists between the two main currents of mathematics, the continuous and the discrete. Such fundamental notions in discrete mathematics as induction, recursion, combinatorics, number theory, discrete probability, and the algorithmic point of view as a unifying principle are continually explored as they interact with traditional calculus. The interaction enriches both.

The book is addressed primarily to calculus students and their teachers, but it can serve as a supplement in a traditional calculus course for anyone who wants to see more.

CONTENTS:

- Infinite Ascent, Infinite Descent:
  The Principle of Mathematical Induction
- Patterns, Polynomials, and Primes:
  Three Applications of the Binomial Theorem
- Fibonacci Numbers:
  Function and Form
- On the Average
- Approximation: from Pi to the Prime Number Theorem
- Infinite Sums: A Potpourri

Order your copy now of this important new book.

408 pp., 1992, Paperbound
ISBN 0-88385-317

List: $36.00 MAA Member: $28.00

Catalog Number DOL-13

(Order form on page 27)

Problem Solving Books

Contest Problem Books

Contest Problem Book I: Annual High School Mathematics Examinations (AHSME) 1950—1960
Compilations and solutions
by C.T. Salkind

112 pp., 1961, ISBN 0-88385-605-0
List: $10.00 MAA Member: $8.00

Catalog Number NML-05

Contest Problem Book II: AHSME 1966—1972
Compilations and solutions
by C.T. Salkind

112 pp., 1966, ISBN 0-88385-617-4
List: $10.00 MAA Member: $8.00

Catalog Number NML-17

Contest Problem Book III: AHSME 1966—1972
Compilations and solutions
by C.T. Salkind and J.M. Earl

186 pp., 1973, ISBN 0-88385-625-5
List: $12.00 MAA Member: $9.50

Catalog Number NML-25

Contest Problem Book IV: AHSME 1973—1982
Compilations and solutions by
R.A. Artino, A.M. Gaglione and
Niel Shell

184 pp., 1983, ISBN 0-88385-629-8
List: $13.00 MAA Member: $10.50

Catalog Number NML-29

Mathematical Olympiads

USA Mathematical Olympiads 1972—1986, Problems and Solutions
Compiled by Murray S. Klamkin

Murray Klamkin includes many improvements and extensions to the original USAMO Problems. The problems are coded by subject and solutions are arranged by subject as an aid to those interested in a particular field. contains a glossary of frequently used terms and theorems and a comprehensive bibliography with items numbered and referred to in brackets in the text. A collection of intriguing problems and elegant solutions.

180 pp., 1988, ISBN 0-88385-634-4
List: $14.50 MAA Member: $12.50

Catalog Number NML-33

International Mathematical Olympiads

International Mathematical Olympiads, 1959—1977
Compilation and solutions
by S.L. Greitzer

Compilation of 116 problems of arresting ingenuity given to high school students competing in the International Mathematical Olympiads.

204 pp,. 1978, ISBN 0-88385-627-1
List: $13.95 MAA Member: $10.50

Catalog Number NML-27

International Mathematical Olympiads; and Forty Supplementary Problems, 1978—1985
Compilations, solutions, and 40 additional problems
by Murray S. Klamkin

88 problems in all

150 pp., 1986, ISBN 0-88385-631-X
List: $12.95 MAA Member: $10.50

Catalog Number NML-31

The Putnam Problem Books

The William Lowell Putnam Mathematical Competition: Problems and Solutions: 1938—1964
Compiled by A.M. Gleason,
R.E. Greenwood, and L.M. Kelly.

Ideal for college-level problem solvers.

This volume provides a highly interesting collection of problems of all types, which require in general ingenuity, and deal with all parts of elementary (and less elementary sometimes) mathematics. An extensive index ends the books whose material presentation is excellent.

J. Mawhin in *Zentrallblatt fur Mathematik*

652 pp., Hardbound, 1980,
ISBN 0-88385-428-7
List: $45.00 MAA Member: $25.00

Catalog Number PPB

The William Lowell Putnam Mathematical Competition: Problems and Solutions: 1965—1984

Compiled by Gerald L. Alexanderson,
Leonard Klosinski, and Loren Larson

For those who are involved with problem solving clubs, or who desire a set of intriguing and challenging problems for advanced students to either work or to study the techniques and learn from, then this book is well suited to fit your needs...The book is handsomely done.

Thomas P. Dence in *Mathematics and Computer Education*

151 pp., Hardbound, 1986,
ISBN 0-88385-441-4
List: $27.00 MAA Member: $20.50

Catalog Number PPB-02

(Order form on page 27)

New From the MAA

The Lure of the Integer

Joseph Roberts

In some small way, this book is an introduction to a mythical book called THE BOOK OF INTEGERS. This mythical book has on page *n* ALL of the interesting properties of the integer *n*. This introduction stems from a collection of many year's casual accumulation of numerical facts. Most of the material presented belongs to elementary mathematics in the sense that no deep or profound mathematical background is required in order to follow most of what is said.

Many of the topics are drawn from research activities of contemporary workers. Most of the results are stated without proof. As a general rule, one cannot even tell from the statements of the results whether or not their proofs will be elementary. Indeed, this is a hallmark of mathematics and is one of the things that gives the subject a special flavor and interest. Until one knows that expert practitioners have been stumped by a problem, one does not know that the problem is difficult.

Some of the material will be familiar to people having even a small acquaintance with "the lore of mathematics." Even in these cases, the author provides something new to observe. On the other hand, much of the material is sufficiently out of the main stream of concern that even professional mathematicians will be unfamiliar with the results. In all cases, the many references to the literature will enable a reader to track down further information. In LURE OF THE INTEGER the author has presented a body of material that will prove interesting to the enlightened layman as well as to the professional.

300 p., Paperbound, 1992
ISBN 0-88385-317-5
List: $25.00 MAA Member: $17.50

Catalog Number LURE

Mathematical Cranks

Underwood Dudley

MATHEMATICAL CRANKS is about people who think that they have done something impossible, like trisecting the angle, squaring the circle, duplicating the cube, or proving Euclid's parallel postulate; people who think they have done something that they have not, like proving Fermat's Last Theorem, verifying Goldbach's Conjecture, or finding a simple proof of the Four Color Theorem; people who have eccentric views, from mild (thinking we should count by 12s instead of 10s) to crazy (thinking that second-order differential equations will solve all problems of economics, politics, and philosophy); people who pray in matrices; people who find the American Revolution ruled by the number 57; people who have in common something to do with mathematics and something odd, peculiar, or bizarre.

Cranks and their ideas come in great variety. The book is a collection of examples, designed to give readers an idea of what cranks do and how they do it. Contemplating the odd, peculiar, or bizarre can be entertaining or enlightening. There can be no solution to the problem of mathematical cranks—obsessive people we will always have with us, and some will become obsessed with mathematics—but perhaps viewing the futility of their efforts will turn some prospective cranks toward more fruitful endeavors.

This is a truly unique book, written with wit and style. Kenneth O. May calls the work of mathematical cranks part of folk mathematics that should not pass unrecorded.

300 pp., 1992, Paperbound
ISBN 0-88385-507-0
List: $24.00 MAA Member: $16.50

Catalog Number CRANKS

(Order form on page 27)

MAA VIDEO CLASSICS

Let Us Teach Guessing

George Pólya

"Teaching is not a method, it is not a system. Teaching is not a science—it is an art." With these words, Pólya reveals his approach to teaching mathematics. In a remarkable tour de force, Pólya shows us how to teach guessing. In this classic film, master teacher Pólya leads an undergraduate class to discover the number of parts into which 3—space is divided by five arbitrary planes.

1966, color, 61 minutes
List: $36.95 MAA Member: $29.95
Catalog LTG

John Von Neumann
A Biography

Rare footage and photographs of the legendary von Neumann are to be found in this film biography. Halmos, Morgenstern, Teller, Wigner and Ulam contribute insights about and memories of Johnny. Set theory, computing, game theory, quantum mechanics—how broad were his interests? After viewing this video classic, your picture of von Neumann will enlarge.

1966, b & w, 63 minutes
List: $36.95 MAA Member: $29.95
Catalog Number JVN

Courant in Göttingen and New York

Colleagues of Courant describe his great influence as mathematician, author, and administrator. Part of the film contains footage of Courant in action, lecturing on soap bubbles and minimal surfaces. A significant portion of the film consists of reminiscences of his work at New York University and Göttingen where he succeeded Felix Klein. Forced to flee Hitler's Germany, Courant came to New York University in 1934, where he worked tirelessly to develop the Courant Institute of Mathematical Sciences.

1966, b & w, 43 minutes
List: $36.95 MAA Member: $29.95
Catalog Number CIG

The Moore Method
A Documentary on R.L. Moore

The Moore Method of teaching is presented by Moore himself. In his long career at the University of Texas at Austin, R.L. Moore produced a long list of distinguished mathematicians, and all of them were Moore Method graduates. In this film shot in his classroom, Moore passionately explains his methods of teaching which placed preeminent value on students discovering mathematics on their own. Moore also reflects on the beginnings of his own mathematical education in 1877.

1966, color, 55 minutes
List: $36.95 MAA Member: $29.95
Catalog Number RLM

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❑ Please check if you do not wish this information to be printed in the *Notices* annual listing of contributions.

FSU2

"Geometry in the Machine Age" Video Proceedings

The Five Colleges Geometry Institute, a project of a consortium of educational institutions (Amherst, Hampshire, Holy Cross, Mount Holyoke, Smith and Williams Colleges, and the University of Massachusetts at Amherst) is one of the vertically integrated programs sponsored by the National Science Foundation. Each July, the Institute brings together high school teachers, graduate and undergraduate students, and researchers in geometry in an effort to share scientific advances and revitalize the geometry curriculum at all levels.

Last summer's program,"Geometry in the Machine Age," focused on optimization problems in differential geometry, including: the mathematics of bubbles, films and elastic surfaces; eigenvalue problems; and optimal metrics on manifolds. Part of each day was devoted to Institute-wide seminars and computer workshops.

Among the highlights of these all-Institute activities were the lecture series by Marcel Berger, IHES, Jean-Pierre Bourguignon, Ecole Polytechnique, Herman Gluck, University of Pennsylvania, Hermann Karcher, Bonn, and Frank Morgan, Williams. To reach a wider audience of mathematicians, a number of outstanding lectures were selected by the Institute's Research Director, Rob Kusner, University of Massachusetts at Amherst, for videotaping. The first six tapes are now completed, and tapes featuring Berger, Bourguignon, Gluck and Karcher will be released soon.

"Geometry in the Machine Age" Continues

"Geometry in the Machine Age" continued this summer, under the direction of David Cox, at Amherst College with a program in computational algebraic geometry. Lectures series by John Canny, University of California at Berkeley, David Eisenbud, Brandeis, Marc Guisti, Ecole Polytechnique, Joe Harris, Harvard University, Sheldon Katz, Oklahoma State University, Stein Arild Stromme, Utah, and Bernd Sturmfels, Cornell University, were complemented by many individal talks, small group seminars, and computer workshops featuring the Macaulay and Mathematica symbolic algebra software.

Next July "Geometry in the Machine Age" will be held at Smith College and will focus on discrete and computational geometry, especially tilings and hyperbolic structures. There will be eight week-long courses or workshops. the main speakers are John Conway, Princeton, Charles Radin, Austin, Bob Connelly, Cornell, Ludwig Danzer, Dortmund, Herbert Edelsbrunner, Illinois at Urbana, Scott Drysdale, Dartmouth, Joe O'Rourke, Smith College, and Godfreid Toussaint, McGill. The Institute will also help to implement the new GEOMETRY FORUM, an electronic bulletin board to link mathematicians at high schools, colleges and universities.

The research program will be organized by Colin Adams, Williams, Joe O'Rourke and next year's Institute Director, Marjorie Senechal, Smith. Marty Conway, Longmeadow High School, and Doris Schattschneider, Moravian College will coordinate the teachers' program, while Rob Kusner and Peter Norman, University of Massachusetts at Amherst, will lead the Research Experiences for Undergraduates.

For more information on how to apply, please email: rgi@smith.smith.edu or write: Geometry Institute, Five Colleges, Inc., P.O.Box 740, Amherst MA 01004

These tapes from the 1991 "Geometry in the Machine Age" are now available:

1.Colin Adams, Mel Slugbate's Real Estate Opportunities in Hyperbolic Space (35 min)
Find out why in hyperbolic space the suburbs are so popular and four-sided houses are not. A masterpieceof math fun!

2.Herman Gluck, Calibrations I (51 min)
Calibrations help to detect when a surface has least area among all competitors. (Introduction to a five-lecture series.)

3.Frank Morgan, Soap Bubbles and Mathematics (54 min)
Why are soap bubbles round and soap films saddle-shaped? Learn the principle of area minimization and its remarkable consequences.

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DAVIDSON COLLEGE
Department of Mathematics
P.O. Box 1719, Davidson, NC 28036

Applications are invited for an entry level tenure track position in the Mathematics Department beginning August 1993. Completion or near completion of PhD is required. A candidate must be committed to outstanding teaching and continuing scholarly activity. Some computer science background is desirable. Teaching load will average 5.5 courses per year. Davidson is a liberal arts college with a Presbyterian heritage.

Applications consisting of a statement of professional aspirations and goals, resumè, graduate and undergraduate transcripts, and 3 letters of reference (at least one about teaching) should be sent to **Prof. L.R. King, Chair, at the address above.**

(E-mail: MATH@APOLLO.DAVIDSON.EDU) Applications received by 4 December 1992 will receive first consideration. Davidson College is an Equal Opportunity Employer: women and minorities are encouraged to apply.

THE UNIVERSITY OF THE SOUTH
Department of Mathematics and Computer Science

Tenure-track position in mathematics, to begin Fall 1993, at a highly selective church-related (Episcopal) liberal arts college of 1100 students located on a 10,000-acre forested domain in the Tennessee uplands. Applicants should have an appreciation for the liberal arts and some interest in computing. Applications from women and minorities are especially encouraged. The position is at the level of assistant professor, with excellence in teaching and continued interest in research expected. A complete application will include a letter stating one's professional aims, a resumè, graduate and undergraduate transcripts, and three recommendations. All should be sent to **Sherwood F. Ebey, The University of the South, 735 University Avenue, Sewanee, TN 37375-1000.** Applications received by 27 November will have first consideration.

UNIVERSITY OF ROCHESTER
Department of Biostatistics

The Department of Biostatistics at the University of Rochester invites applications for NIH funded postdoctoral fellowships, beginning 9/1/92. Fellows will participate in the design and analysis of cancer studies, as well as conduct their own independent research. This program requires permanent U.S. resident status or U.S. citizenship. Applicants must possess Ph.D. or equivalent. Applications from women and minorities are encouraged. Contact: **Martin A. Tanner, Dept. of Biostatistics, School of Medicine and Dentistry, University of Rochester, Box 630, Rochester, NY 14642.**

UNIVERSITY OF TENNESSEE, KNOXVILLE
Department of Civil Engineering
Research Associate

The Department of Civil Engineering, The University of Tennessee-Knoxville has an opening at the Research Associate level. Applicants should be qualified to handle overall supervision of hydrologic, soil, and geologic data base development, data formatting and maintenance, statistical analysis of data, spatial analysis of data, and cartography in support of geohydrologic research activities.

Desired qualifications are: MS in mathematics or computer science with emphasis in solution of differential equations. Strong background soil science, physical and chemical aspects of geohydrology including data base development and finite difference models. Application review will begin on 1 September 1992 and continue until the position is filled. Candidates should send a detailed curriculum vitae and the names of three references to: **Dr. Gregory D. Reed, Department of Civil Engineering, 223 Perkins Hall, The University of Tennessee, Knoxville, TN 37996-2010.** UTK is an EEO/AA/Title IX/Section 504/ADA employer.

WILLIAMS COLLEGE
Department of Mathematics
Williamstown, Massachusetts 01267

One or possibly two anticipated positions, one of them preferably in statistics, probably at the rank of assistant professor, for Fall 1993. Strong commitment to both teaching and scholarship is essential.

Please have a vita and three letters of recommendation on teaching and research sent to Hiring Committee. Formal evaluation of applications will begin 15 November 1992, and continue until the positions are filled. AA/EOE.

WASHINGTON AND LEE UNIVERSITY
Department of Mathematics
Lexington, VA 24450
RADFORD PROFESSOR / DEPARTMENT HEAD

The Radford Chair of Mathematics will be filled in September 1993. An applicant should have a background that warrants tenure and the rank of full professor, a record of effective teaching and scholarship, and a commitment to mathematics education in a liberal-arts setting. The Radford Professor will assume the position of department head for a five-year term,

The mathematics faculty numbers seven, all with Ph.D.'s. The University is primarily a liberal-arts college with 1600 undergraduates. It is 240 years old and is located in the lower Shenandoah Valley. Address inquiries to **Prof. T.O. Vinson, Search Committee, Mathematics Department. The selection process will begin in November 1992.**

THE JOHNS HOPKINS UNIVERSITY
Department of Mathematical Sciences

Applications are invited for 3 anticipated faculty positions within the areas of

- **Numerical Linear Algebra**
  (Senior applicants preferred)
- **Statistics**
- **Operations Research**
- **Applied Discrete Mathematics**

Selection is based on demonstration and promise of excellent research, teaching and innovative applications.

Minorities and women are encouraged to apply. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer.

Applicants are asked to furnish a curriculum vitae, transcripts (junior applicants only), reprints (if available), a letter describing professional interests and aspirations, and to arrange for three letters of recommendation to:

Prof. John C. Wierman, chair
Department of Mathematical Sciences
220 Maryland Hall
The Johns Hopkins University
Baltimore, Maryland 21218-2689

Applications are requested by 15 January 1993.

Applicants whose primary research is in algebra, analysis, geometry, logic, number theory, or topology will not be considered.

COLUMBIA COLLEGE
Assistant Professor of Mathematics

Columbia College, one of the ten oldest women's colleges in the country, is seeking a qualified individual to fill the position of assistant professor, tenure track, in the Department of Mathematics beginning fall 1993.

Candidates are required to have a PhD in mathematics, evidence of excellence in teaching and a commitment to continued professional growth. A background in computer science is also desirable. Interested individuals should submit a curriculum vita, a letter of application, statement of teaching philosophy and the names of three references to:

Dr. Laurie Hopkins
Mathematics Department Chair
Columbia College
1301 Columbia College Drive
Columbia, SC 29203

Applications must be postmarked no later than 30 November 1992 for consideration. Columbia College is an affirmative action, equal opportunity employer.

Seventh Annual Pi Mu Epsilon Regional Undergraduate Mathematics Conference

30-31 October 1992
St. Norbert College, DePere, Wisconsin 54115

The conference will feature student papers and also invited talks by James Kasum, Cardinal Stritch College. The conference is open with no registration fee, to all interested students, faculty, and others interested in mathematics. For more information contact: R. Poss, 414/337-3198 (e-mail) Poss@SNCAC.SNC.EDU

Calendar

National MAA Meetings

13-16 January 1993 Seventy-sixth Annual Meeting, San Antonio, Texas (Board of Governors, 12 January 1993)

15-19 August 1993 Sixty-eighth Summer Meeting, Vancouver, British Columbia (Board of Governors, 14 August 1993)

12-15 January 1994 Seventy-seventh Annual Meeting, Cincinnati, Ohio (Board of Governors, 11 January 1994)

Sectional MAA Meetings

Allegheny Mountain Penn State-Behrend Campus, Erie, PA,16-17 April 1993

Eastern PA & Delaware Muhlenberg College, Allentown, PA, 14 November 1992, Villanova University, Villanova, PA, Spring 1993

Florida University of Central Florida, Orlando, FL, 5-6 March 1993

Illinois St. Mary's College, Notre Dame, IN, 23-24 April 1993 (Joint meeting with Indiana & Michigan Sections)

Indiana Indiana University-East, Richmond, IN, 17 October 1992, 23-24 April 1993 (Joint meeting with Illinois & Michigan Sections)

Intermountain University of Utah, Salt Lake City, Utah, 9-10 April 1993

Iowa Luther College, Decorah, IA, Spring 1993

Kansas Emporia State University, Emporia, KS, 19-20 March 1993

Louisiana-Mississippi University of Southern Mississippi, Biloxi, MS, 5-6 March 1993

Maryland-District of Columbia-Virginia Coppin State College, Baltimore, MD, 13-14 November 1992, Christopher Newport College, Newport News, VA, 16-17 April 1993

Metropolitan New York York College, Jamaica, NY, 1 May 1993

Michigan St. Mary's College, Notre Dame, IN, 23-24 April 1993 (Joint meeting with Indiana & Illinois Sections)

Missouri Westminister College, Fulton, MO, 2-3 April 1993

Nebraska University of South Dakota, Vermillion, SD, 16-17 April 1993

New Jersey Drew University, Madison, NJ, 14 November 1992, Middlesex County College, Edison, NJ, 20 March 1993 (Joint meeting with MAAJN & MATYCNJ)

North Central Moorhead State University, Moorhead, MN, 23-24 October 1992, Riverwood Conference Center, Monticello, MN, 30 May—1 April 1993

Northeastern Trinity College, Hartford, CT, 20-21 November 1992, University of Massachusetts/Dartmouth, No., Dartmouth, MA, 11-12 June 1993

Ohio Xavier University, Cincinnati, OH, 30-31 October 1992, Kent State University, OH, 16-17 April 1993

Oklahoma-Arkansas Oral Roberts University, Tulsa, OK, 26-27 March 1993

Pacific Northwest University of Montana, Missoula, MT, 18-20 June 1993

Rocky Mountain Colorado School of Mines, Golden, CO, 2-3 April 1993

Seaway Cornell University, Ithaca, NY 13-14, November 1992, SUNY at Binghamton, Binghamton, NY, 23-24 April 1993

Southeastern University of South Carolina-Conway, Conway, SC, 2-3 April 1993

Southwestern New Mexico Institute of Mining & Technology, Scorro, NM, 16-17 April 1993

Southern California University of Southern California, Los Angeles, CA, 7 November 1992, California State University, San Marcos, CA, 6 March 1993

Texas Abilene Christian University, Abilene, TX, 1-3 April 1993

Wisconsin University of Wisconsin- La Crosse, La Crosse, WI, 10 October 1992, University of Wisconsin - Fox Valley, Menasha, WI, 16-17 April 1993

Other Meetings

23-25 April 1993 The 1993 Annual Meeting of New York State Mathematics Association of Two-Year Colleges (NYSMATYC) will be held at the Radison Hotel, Utica Centre, Utica, NY. For additional information contact: Judy Cain, NYSMATYC President-Elect, Tompkins Cortland Community College, 170 North Road, Dryden, NY 13053.

2-4 July 1993 The Global Awareness Society International Annual Meeting, "Global Interdependence" at the Marriott Marquis in New York City. Abstract deadline is December 1 1992. For additional information please contact Jim Pomfret, Department of Mathematics and Computer Science, Bloomsburg University, Bloomsburg, PA 17915.

6-7 November 1992 Sixth Annual Southeastern Small College Computing Conference. For more informaiton please contact Dr. Frank Cheatham, CPO 1321, Campbellsville College, Campbellsville, KY 42718.

16-17 October 1992 The 1992 Mathematical Department Chairs Colloquium, Arlington, VA. For more information please contact the Board on Mathematical Sciences, National Research Council, NAS 312, 2101 Constitution Ave., NW, Washington, DC 20418.

30-31 October 1992 Seventh Annual Pi Mu Epsilon Regional Undergraduate Mathematics Conference. For more information please contact R. Poss at 414/337-3198 or e-mail Poss@SNCAC.SNC.EDU.

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