Calendar of AMS Meetings and Conferences

This calendar lists all meetings and conferences approved prior to the date this issue went to press. The summer and annual meetings are joint meetings of the Mathematical Association of America and the American Mathematical Society. The meeting dates which fall rather far in the future are subject to change; this is particularly true of meetings to which no numbers have been assigned. Programs of the meetings will appear in the issues indicated below. First and supplementary announcements of the meetings will have appeared in earlier issues. Abstracts of papers presented at a meeting of the Society are published in the journal Abstracts of papers presented to the American Mathematical Society in the issue corresponding to that of the Notices which contains the program of the meeting, insofar as is possible. Abstracts should be submitted on special forms which are available in many departments of mathematics and from the headquarters office of the Society. Abstracts of papers to be presented at the meeting must be received at the headquarters of the Society in Providence, Rhode Island, on or before the deadline given below for the meeting. The abstract deadlines listed below should be carefully reviewed since an abstract deadline may expire before publication of a first announcement. Note that the deadline for abstracts for consideration for presentation at special sessions is usually three weeks earlier than that specified below. For additional information, consult the meeting announcements and the list of special sessions.

Meetings

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<td>November 3–4, 1995</td>
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* Please refer to page 43 for listing of Special Sessions.

Conferences

June 7–18, 1993: AMS-SIAM Summer Seminar in Applied Mathematics on Tomography, Impedance Imaging, and Integral Geometry, Mount Holyoke College, South Hadley, Massachusetts.


Other Events Cosponsored by the Society

February 11–16, 1993: Section A (Mathematics) Sessions at the AAAS Annual Meeting, Boston, Massachusetts.


Deadlines

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

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

3 Flat-Rate Research Funding: Two Views
What are the advantages and problems associated with instituting a flat-rate grant scheme at the NSF? This article presents two opposing viewpoints on this controversial issue, one written by former Division of Mathematical Sciences (DMS) program officer Robert Molzon and one written by former DMS director John Polking.

6 The Endless Frontier Meets Today's Realities Richard H. Herman
The federal government and the general public are asking tough questions about how well higher education and scientific research are serving the needs of the nation. This scrutiny comes at a time of dwindling resources for mathematics departments and for academia in general. This speech, delivered at the annual Chairs' Colloquium last October, explores how departments can respond to the changing climate.

9 MSEB Comes of Age
The Mathematical Sciences Education Board (MSEB) has been a major player in the mathematics education reform movement. With a new executive director, Lynn Steen, and a number of other new senior staff members, the MSEB is moving beyond just writing reports to taking a more active role in the implementation of reforms. Allyn Jackson reports on some of the current activities of the MSEB.

FEATURE COLUMNS

15 Computers and Mathematics Keith Devlin
In this month's feature article, Larry Wos of the Argonne National Laboratory describes his experiences in developing and using the automated reasoning system OTTER. Following the article, William Ruckle reviews Mathcad, Suzanne Molnar takes a look at Matrix Algebra, and Roger Pinkham road tests the TI-85 calculator.
AMS SECTIONS

The Society has four Sections: Eastern, Southeastern, Central, and Western. The formal structure attached to each of the Sections consists of an Associate Secretary of the Society and a Section Program Committee. The activities generated by the various Sections are the Sectional Meetings of the AMS, which are generally held in each of the Sections during the spring and fall. Sectional Meetings are organized by the Associate Secretaries, with the Section Program Committees assisting in the selection of speakers and special sessions.

The programs at Sectional Meetings model the core of the scientific program at national meetings and are designed around a number of invited addresses, associated special sessions, contributed special sessions, and sessions on contributed papers. This format supports a very important mission of the Society, communicating mathematics, and provides a forum for mathematicians to report their research. Sectional Meetings are considered quite successful in this regard.

The goals of the Society include broadening participation in AMS activities and improving AMS support of mathematics and services to mathematicians. One way to advance these goals is to use the sectional structure of the Society, broadening the character of Sectional Meetings and providing mechanisms for greater participation. Most discussion has centered on expanding programs at Sectional Meetings.

Suggestions for enhancing the scientific programs include exposition accessible to a wider audience, including history of mathematics and lectures modeled on the AMS Progress in Mathematics Lectures; (graduate) student paper sessions; expository lectures targeted at graduate students; and special sessions on mathematics education and the history of mathematics.

There are numerous possibilities for broadening the nonscientific program. These include introducing panel discussions and talks on science policy-related issues, such as federal support of mathematics, national reports related to mathematics, employment in the mathematical sciences, projects and activities of the Society, and so on. There are increasing concerns about mathematics education and how mathematicians can contribute to mathematics education. The Sectional Meetings could provide forums for mathematicians to discuss curricular reform, technology in mathematics education, education of graduate students, etc. Sectional Meetings could also provide a mechanism for broader participation in, and generation of, new ideas leading to national actions. In addition, they provide a natural venue for bringing together department heads and directors of graduate programs to exchange information and discuss issues of mutual concern. Employment information and discussions of professional issues of interest to students could be incorporated into the meetings. The list of possibilities is quite long.

Expanding Sectional Meetings and incorporating activities that might conflict with the schedule of the scientific program would change the character of Sectional Meetings. Such activities also increase the meetings' complexity, which will increase the amount of time required to plan and organize the meetings, as well as the facilities and support needed to hold the meetings.

The programs of National Joint Meetings are being gradually broadened to include many of those aspects mentioned above. They provide models to consider for broadening Sectional Meetings. There are tremendous possibilities to advance the goals of the Society and mathematics through wider participation of our membership and volunteers in the Sections.

William Jaco
Flat-Rate Research Funding: Two Views

In the early fall of 1992, the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) announced that it would institute a "flat-rate" funding demonstration project. This experiment would have moved the DMS to a two-tiered grant system, in which grantees would receive either $20,000 or $30,000, depending on seniority, with additional fixed-rate supplements for graduate students and postdoctoral researchers (see "NSF Proposes Changes in Funding Mode for Mathematics", Notices, November 1992, page 1091, for more details on the project). Under pressure from the mathematics community, the DMS decided to put the project on hold. Another strong move against the project came when the NSF's Advisory Committee for the Mathematical Sciences passed a resolution saying they did not support implementation of the project at this time (see "Flat-Rate Funding Project at NSF", Notices, December 1992, page 1171).

Although it appears that the flat-rate project will not be instituted in the near future, there has been a great deal of discussion within the community about the advantages and disadvantages of such a grant system. The following two articles present arguments on both sides of the flat-rate funding issue. The first article is by Robert Molzon, currently on leave at the University of Nevada at Las Vegas from the University of Kentucky. In August 1992, Molzon finished a two-year tour of duty as program director for Geometric Analysis in the DMS. The second article is by John C. Polking of Rice University. Polking served as director of the DMS from 1984 to 1987.

For Flat-Rate Funding:
Best Use of Budget to Support Mathematics
Robert Molzon

Approximately two years ago, the Advisory Committee to DMS made a preliminary recommendation that DMS consider unlinking to some extent the size of the NSF awards from Principal Investigator (PI) institution salary. Although this idea may have been presented in a somewhat new guise, the concept had been previously discussed within the mathematics community and the NSF. In fact, the NSF has been using a funding mechanism along these lines for postdoctoral support for years. The Presidential Young Investigator (now called the National Science Foundation Young Investigator award) and the Research Opportunities for Women planning grants are also fixed awards of $25,000 and $18,000 respectively. These awards support a wide range of research activities and do not follow a two-ninths formula. Some programs, such as the Scientific Computing Research Equipment in the Mathematical Sciences program, have been set up to provide support independent of salary. These programs have operated to a large extent outside of the traditional disciplinary programs in the DMS. The tradition within the disciplinary programs in the DMS was to make awards very closely linked to a PI institution salary for the academic year, and the Advisory Committee, in making a recommendation that the DMS reconsider this close link between award size and salary, was certainly departing from tradition, but was not charting completely unknown territory.

At its Spring 1992 meeting, the Advisory Committee moved more firmly in this direction with a recommendation that the DMS set up a tiered award system. The article "Flat-Rate Funding Project at NSF" (Notices, December 1992, page 1171) discussed the history of the DMS response to that recommendation and the subsequent response from the mathematics community. The discussion which led to the recommendation by the Advisory Committee that the NSF establish the tiered system focused on the best possible uses of funds currently available to the NSF. Proposals to unlink award size from PI institution salary have generally been driven by a perceived need to provide research support for a broader base of individuals and for the need for research support outside the area of salary. The Committee seemed to feel that changes could be made which would enable excellent mathematicians to continue strong research and make it possible for other excellent mathematicians not currently supported to carry out research. Of course, whenever there is a shift of support, there will be a negative impact on someone. The Committee seemed to be trying to balance the negative impact of decreasing some salary support with the positive impact of enabling excellent people to carry out research. Any reasonable attempt to make the best use of currently available funds must involve such a balance. Marginal costs and benefits must be considered in allocating resources under the present circumstances, in which strong and important research is not receiving even minimal support.

The Divisions within the NSF that have received substantial increases in funding used an approach that did not focus on the bottom line of PI salary, but on the importance of science or science education in the context of the total scientific and economic development of the country. The Division...
of Materials Research won large increases in funding not by showing that PIs in Materials Research need to be well paid, but by showing that the research could have a strong economic impact. Education did not win big increases because educators are well paid, but because someone convinced the Administration and the Congress that a strong education program was vital to the national interest. If we wish to increase funding support for mathematics, then we might do well to focus on convincing the public, the Administration, the Congress, and colleagues in other sciences that support for mathematical research is in their best interests.

The rationale for continuing to tie the award size to institution salary even under today's dire funding situation seems to be based primarily on two arguments, the "you get what you pay for" argument and the "cheap science" argument. The "you get what you pay for" argument maintains that if the NSF wants research done well then it must be willing to pay for it. Supporters of the traditional "two-ninths summer salary" mode of support apparently feel that this implies that the price the federal government should pay for work well done is to be set independently by the researcher and university. The argument fails to make even the most basic marginal cost-benefit analysis. It is highly unlikely that the NSF would get the most research for the dollar by paying salary at an arbitrarily high level on one proposal and turning down other proposals that reviewed in the "Very Good" to "Excellent" range. That this strategy would not be optimal becomes even clearer when one realizes that it is essentially impossible to linearly rank proposals in terms of mathematical quality. Few seriously believe that there was a great surge forward in the research accomplished by mathematicians when the salary cap was lifted a few years ago, but this is exactly what the "you get what you pay for" advocates would have us swallow.

The "cheap science" argument as used to bolster the traditional two-ninths salary rule claims that if the DMS does not pay the traditional two-ninths salary then mathematics will be viewed as a cheap science. This of course completely ignores the possibility that mathematics may be viewed as a cheap science if the DMS sends a message that only a few people are needed to carry out research. It also focuses very heavily on salary (salary supplements) to relatively few individuals. It ignores the adjustments other Divisions at the NSF are making with respect to salary in an attempt to deal with a need that cannot be completely met with the present NSF budget. When other sciences can so effectively argue that there are many needs beside salary in effective research programs, the message that the primary need of the mathematics community is salary supplement for relatively few individuals does not seem to be a strong one for support of mathematics. One will not convince the higher administration at the NSF or the Congress that mathematics should receive more support by sending a message to the DMS that a great deal of excellent mathematics is worthless.

The proposed "flat rate" plan is, at the time of this writing, on hold. Various modifications to the plan have been suggested, and the NSF is apparently willing to consider alternatives. There has been a strong push by some in the mathematics community to return to funding proposals at two-ninths the academic year salary regardless of the number of awards that would have to be cut to do so. This would send a discouraging message to young mathematicians that the chances for funding will be remote. If Geometric Analysis had not limited salary the past two years, approximately ten to fifteen percent fewer proposals that reviewed in the "Very Good" to "Excellent" range would have been funded. There is not a scintilla of evidence that indicates that an increase in salary support to a limited number of individuals would result in increased funding for mathematics. Although there has been substantial discussion of the question of funding mode, relatively few mathematicians seem willing to play a more active role in the issue. If people are concerned about the direction the NSF funding is to take, they must begin to become more politically active. They must write as individuals and as groups to the NSF and to officers of the AMS.

In order to win increased support for mathematics the community must become more politically active in another way. Individual mathematicians must make their work more accessible to other scientific communities, to the business community, and the public. There have been numerous articles written on how this might be accomplished, and it is not necessary to repeat that advice here. The budget figures coming out of Washington indicate that other sciences and education are successfully stating their case in terms that Congress and the educated public understand. If mathematicians do not wish to write about problems outside their immediate field of interest, they probably cannot expect the outside support they would receive if they took an active interest in a broader range of activities. This does not mean mathematicians should stop doing the work on which they thrive; it simply recognizes that funding is going to be tied to a perception of benefit for the party providing the funds. Redistribution of currently available resources to pay higher salary support for fewer individuals provides a perception of benefit only to those who receive the salaries. The mathematical community is more likely to convince the economic interests in the country that research in mathematics is important if there is a strong and diverse group of mathematicians active in research. Shrinking the size of that group is a step in the wrong direction for the long-term health of the field.

Against Flat-Rate Funding:
Deleterious Long-Term Effects
John C. Polking
The recent announcement by the Division of Mathematical Sciences (DMS) at the National Science Foundation (NSF) of an experimental, flat-rate funding system for the mathematical sciences has taken most of the community by surprise. Suggestions to move in this direction have been made by mathematicians at time to time, but the community as a whole has not discussed it seriously. I am writing this article to start that serious discussion.
As I write these paragraphs, the proposed NSF program is on hold. At its latest meeting in October, the Advisory Committee to the DMS failed to endorse the experiment. The issue is probably not dead, but the program is far from being well defined at the moment. For that reason I will keep my discussion fairly general. What I will discuss is any program that would have the effect of untying the level of compensation for research time from the academic salary of the researcher. The basic assumption that I am making about the program is that it will reduce the salary compensation of many researchers, and, just as importantly, reduce the compensation of mathematical scientists without affecting that of other scientists and engineers.

The primary reason that many mathematical scientists favor such a program is that seemingly these schemes will allow more researchers to be funded. Since so few of our colleagues are currently funded in comparison to other fields, such proposals have wide appeal. I will argue that such a program undervalues research in the mathematical sciences, and as a result will have serious deleterious long-term effects on the mathematical sciences community.

One of the principal findings of the David Report, published in 1984, was that it was necessary for the health of our community that support for mathematics be comparable to that in other fields. The report made it clear that parity was needed in the support for individuals as well as for the community as a whole. In fact it pointed to support for research time as one of the most important needs of mathematicians, as it is for all scientists.

In comparison to other fields, individual mathematics researchers are already underfunded. If we examine the support level of our colleagues in other fields, we discover that many of them receive as much as three months salary in support of their efforts. Many of them get academic year support as well. Of course these researchers are not limited to the NSF as a source for their funding. Very few of our mathematical colleagues receive support like this. In fact, the NSF’s Division of Mathematical Sciences has slowly been reducing the number of months of salary support that it provides to its average awardee.

The long-range effect of reduced levels of support is that fewer people are attracted into the mathematical sciences. We already have difficulty competing with our scientific and engineering colleagues, especially for the best students. The fact that the number of American citizen Ph.D.s produced each year is at the same level as it was in the early 1960s is, in large part, a reflection of the lack of parity in federal support for research in the mathematical sciences. In my opinion, reducing the individual level of support further will only make this situation worse.

It is the hope that more investigators will be supported that motivates program officers in the DMS and many of our colleagues to support this program. However, it is not clear to me that this will actually happen. In fact, I predict that, after a brief transition period, the effect on the number of investigators supported will be negligible. In examining this point, we have to look to the motivations of the people who will be making the decisions—in particular, to the upper administration of the NSF. Administrators at this level have many goals, including maintaining the general health of the various scientific communities. The goal that has received the most attention lately has been improving the contribution of basic research to the economic well-being of the nation. The mathematician’s goal to increase the number of mathematicians supported is not a direct goal of research administrators. When mathematicians tell administrators that individual mathematicians need less support per individual than do other researchers, the administrators are as likely to decrease the number of mathematicians supported as to increase that number.

To me, the situation is similar to what occurred in the early 1970s. At that time, many graduate students, in mathematics as well as in other fields, were supported through special programs that made grants directly to departments for this purpose. It was decided to end these programs, and, to continue support for graduate students, some of the funds previously allocated to these special programs were assigned to the research divisions at the NSF, except in mathematics. Mathematicians advised the NSF that because mathematics students could be supported as teaching assistants, the DMS would need no new money to support graduate students. It was later realized that this was a mistake, but it was too late. The DMS has never recovered from that loss, and to this day there is too little money provided by the DMS to support mathematics graduate students.

The program proposed by the NSF is called an experiment, but I think that if it is ever officially a policy that mathematicians do not need salary compensation at the same level as others, it will be very difficult to recover the loss.

It is distressing that this experiment is proposed at this particular moment in time. The entire science and engineering community is faced with major challenges and decisions arising from the changing mission of the NSF and of federal funding for academic research in general. There seems to be a consensus developing among the leadership of the NSF, the National Science Board [the policy-making body of the NSF], and Congress, as well as the administration, that the NSF and other funding agencies should take a much larger role in fostering connections between research and technology. I strongly support efforts to develop links between the academic research community and industry. That said, I do worry that this change at the NSF will undercut the funding for mathematics and the funding for undirected scientific research in general.

The possible redirection of the mission of federal funding for academic research is the issue that should have the full attention of the mathematics community. As important as the new funding experiment by the DMS is, it should not be allowed to distract the community from the more important issue of federal funding for academic research.
What I tell you three times is true.
—"Hunting the Snark," Lewis Carroll

Today, I shall speak to you both as a concerned member of the mathematical sciences community and as a dean. It is my view that the community needs to bring about substantive changes in itself before we are brought to an untenable position. We have missed opportunities which have been presented in the past. You, the department chairs, have always been in a position to play a pivotal role not just in the future of your own department but, as I will argue, in the future of the community. I served as one of you for five years—as a department chair at Penn State—and, contrary to popular wisdom, I am willing to admit that I enjoyed it.

I want to delineate the choices facing the mathematical sciences community, especially at universities. Broadly speaking, I will break my comments into three categories:

1) problems at universities—pressures from constituencies,
2) the mathematics department as part of the university, and
3) opportunities for the future.

The following quotation captures the essence of some substantial recent criticism of universities: “The discipline of colleges and universities is, in general, contrived, not for the benefit of the students, but for the interest, or more properly speaking, for the ease of the masters.”

Of course the last word gives away the time of this remark. Indeed, the quotation is from the early 1700s and is due to Adam Smith. For a more up-to-date version of this comment just pick up your local newspaper. Here is one from mine, The Washington Post. Robert Samuelson, in an article entitled “The Low State of Higher Ed”, writes the following: “Higher Education is a bloated enterprise. Too many professors do too little teaching to too many ill-prepared students. Costs can be cut and quality improved without reducing the number of graduates. Many colleges and universities should shrink. Some should go out of business.”

Samuelson’s voice is bellicose, but when he lists his complaints—low admission standards, high dropout rates, decreasing teaching loads for faculty, and an explosion of graduate degrees—we all know that this is part of the reason we are in the dock accused of a lack of social responsibility. His comments are skewed to the extreme, yet the less polemical comments of former New Jersey Governor Thomas Kean do not provide a source of comfort: “Here is the reality, plain and simple. Our ivory tower is under siege. People are questioning our mission and questioning who we are. They claim we cost too much, spend carelessly, teach poorly, plan myopically, and when we are questioned, act defensively.” To the last point we might examine the present “overhead wars” and Don Kennedy’s response, and the allegations of price-fixing in the Ivy League.

In summary, we have lost the public trust. Now couple this with the recession and remember that in most states the funding of universities appears as a healthy portion of the discretionary funds. The result is that we are suffering severe cuts while being subject to calls from the state for greater accountability and visible signs that we are delivering on promises implicit to our existence.

Continuing with pressures on the university, let me turn to the government-university partnership. Most of us hearken back to the beginning of it all, Vannevar Bush’s report Science-The Endless Frontier. This report, delivered to President Truman in 1945, and its progenitors are ultimately responsible for today’s science policy. We need to turn to some recent policy statements to understand how things have changed.

Congressman George Brown, in an article for the Los Angeles Times, points out that “Science, Inexplicably, has come to occupy a place in American culture alongside Plymouth Rock, Johnny Appleseed, and the Bill of Rights.” Brown says that society needs to negotiate a new contract with the scientific community. He suggests that we need to require the application of science to the critical problems in the civilian sector. In any event he points out in a carefully reasoned way that while science has arrived at a position of world leadership by many standards, other countries have radically different science policies which have afforded them greater success in linking research with national goals. The call
for change comes from one of science's biggest supporters.

Additional evidence for change can be found in Walter Massey's remarks to the National Science Board. Hopefully, as George Brown proposes, there will first be "carefully defined and modular experiments to avoid throwing out the good with the bad." So, as a new contract is being drawn, and surely it will be, it is necessary for us to help guide the process. This will entail making some changes at universities, accepting further responsibilities in a way consistent with preserving "the taproot", the research effort that has brought us a justifiably high world reputation. Peter Likins, speaking on these issues, closed with a challenge to his audience "to draft their own rules and try to establish a new social contract."

For a reaction to some budget reversions, I will recount some of my own experiences as a dean at the University of Maryland. Over the past several years Maryland has suffered considerable cuts in its state budget. In an effort to improve communication, I went around to departments in the college, made a presentation on the finances, and then allowed for a discussion period. In one department I was greeted with a question by one of the best researchers—more of a complaint actually.

"A few years ago things were very different," he said, and asked, "When do you see a return to those times?" Actually he was pointing out that in the budget reversions a good deal of the traditional ability of the department to follow its own nose had been lost. Several responses came to mind. I tried to imagine what he was thinking; for example: a) in a couple of years things will get better (so let's ignore the situation), b) as soon as we get rid of this dean, c) never. In a very real sense "never" is the right answer, and perhaps that is optimistic.

Let us recall some major changes that have taken place over the years and how they have affected mathematics. In the late 1960s the Department of Defense, in response to the Mansfield amendment, increased emphasis on goal-oriented programs and decreased support of the mathematical sciences. At the same time, as pointed out in David 1, there were reductions in federal fellowships for graduate students and postdoctorals. Shortly thereafter, financial problems hit universities causing a tightening in the job market. At the same time mathematics enrollments doubled. We reacted by stemming the flow of Ph.D.s, and many university mathematics departments succumbed to the view of themselves as service departments by offering calculus in large, larger, and largest sections. Simultaneously, folks in English made a convincing case that composition should be taught in small sections. Perhaps we missed an opportunity. We certainly did not turn "the close identification of mathematics departments with teaching" to our own advantage. Likewise, we paid little attention to creating new opportunities for Ph.D.s.

What can you as a department chair do to ensure resources for the department when your entire university is under extreme pressure? Well, you can go to your dean and argue that the mathematical sciences are important in and of themselves, that applications of pure mathematics, applied mathematics, statistics, operations research, etc., are no surprise considering the founding of the discipline, and that you play an important role in the university. These arguments need to be made continually, but ask yourself if this differs from the physics chair who goes to the same dean and says virtually the same thing, points to the importance of superconductivity, and perhaps speaks to the exciting nature of the Superconducting Super Collider and the hopes of the field to make discoveries of a fundamental nature (and then argues for another condensed matter theorist). On the assumption that both departments are equally regarded, it is more than likely that the long-term distribution of resources will be split and equal attention (or lack thereof) will be given to both arguments.

Suppose we try a different approach. Try to imagine what the pressures are on this administrator. As Phil Griffiths has pointed out, "Universities will either emerge from this decade leaner, more focused on teaching, more socially relevant, and able to do fewer things better, or they will further erode their sources of support and end up weaker."

Instead of taking the view that your job as chair is to "protect the department", why not ask yourself how the department can help the university meet the pressures on it. Think then of the department as the "minimal corporate unit". So, if the mission of the university is teaching, research, and service, the department as a whole must address all of these issues.

Let us turn to one of these pressure points. Many students do poorly in early mathematics courses in college—with the overall withdrawal and failure rate being quite large at some institutions. And this says nothing of repeats. The causes are many and certainly include admission standards. Nevertheless, we can certainly do better with a very likely long-term effect. First, I would suggest that success in these courses translates into success elsewhere and ultimately could change the graduation and retention rates at your university. This has a long-term effect on funding for your (state) university and certainly on recruiting—think of the headlines when your graduation and retention rates go from 55% to 65%. Yes, it is labor intensive in the freshman and sophomore years, and perhaps it means shifting departmental resources a bit to accomplish this. However, your administration would dearly love to have this done (as should you), since efforts lavished in the first two years will reward the department with strong enrollments and strong students in the upper division and graduate courses. But what is the approach to this dean? (The view of deans is sometimes intriguing. Frank Warner tells the story of a phone call from an irate mother who called to complain about a grade for her son in a math course. On picking up the phone he was asked who he was. On informing the parent that he was chair of the Math Department, he was told that the mother expected that she would speak to no one lower than a dean. Frank, being quick of mind, offered that there was no one lower than a dean!) Let me tell you how I have been approached on occasion (not on this issue and not about the math department). "Well if it is so important, why doesn't the university provide the resources?" Wrong! The department is part of the university. Run a pilot program on your own, get it to succeed, and then appeal to the administration to share the long-term costs.
But you say resources are decreasing. You are right, but that is unimportant. There is always a certain amount of money for important things. (And the issue of graduation and retention is central to the university existence.) Recently, at a major state university, a decision was made by the administration to provide [Teaching Assistants] TAs based on overall enrollment—with a lag time built in. Math enrollments are decreasing, and the department is thus concerned. Why not offer to run a “Treisman-like program” with its success—using TAs. If that department only improved success rates in calculus, the argument for the extra TAs would be made.

Continuing on the education front, I would observe that leading mathematics departments have not often exercised effective leadership in the preparation of mathematics teachers. This is probably one of the hottest issues of the day, and history does not position us well. Moreover, the answer is not as simple as “just let them take the usual math major courses and everything will work out fine.” If the teachers teach their students mathematics the way we teach them (“sit and git”), they will not succeed. There should be some changes. Again, here is an opportunity to make a real difference. Keep in mind that the half-life of school teachers is seven years, so that if colleges and universities produce strong teachers ready to involve students as recommended in the [National Council of Teachers of Mathematics] NCTM “Standards”, we could turn around the entire school mathematics program in one generation.

Now, what type of graduates are we producing? By this I mean masters or Ph.D.s. We still produce for academe. There are some isolated instances of the contrary. Are we doing those who study mathematics a service by continuing to clone ourselves? Are we paying attention to areas of national need? Now do not, please, confuse my comments with the idea of discipline bashing. But over the years we have permitted ourselves? Are we paying attention to areas of national need? (We know a lot more now as the programs at the Institute for Advanced Study have shown us.) Here are Young’s closing remarks: “What I do believe is that we must make fundamental changes in the nature of graduate work in mathematics which will prepare most of our students for something other than academic life.”

Compare this to a comment from the 1992 AMS Task Force on Employment, chaired by Don Lewis. It says that the American Mathematical Society should “advocate for the broadening of doctoral programs in mathematics to recognize the value of nonacademic employment and the matching of talent with the teaching needs of the community, to produce doctorates with wider employment options.”

Sound familiar? Arguably, the situation now is more serious than it was in 1971, and hopefully we will not have to wait as long as a generation to take some definitive action.
MSEB Comes of Age

The Mathematical Sciences Education Board (MSEB) of the National Research Council (NRC) was established in 1985 to advocate for and stimulate reform in mathematics education. Currently, Alvin W. Trivelpiece, director of Oak Ridge National Laboratory, is chair of the Board. Lynn A. Steen of St. Olaf College became executive director of the MSEB in September 1992. He succeeds Ray C. Shiflett, who has returned to California State Polytechnic University at Pomona. Other new MSEB staff include Susan Forman of Bronx Community College of the City University of New York, who is directing college and university programs; and J. Arthur Jones of Futura Technologies, who serves as director of minority programs. Other senior staff members are: Linda Rosen, director of policy studies; Robert Kansky, project director of educational networks; Joan Donahue, director of state coalitions; Ann Kahn, director of organizational relations; Kathleen Holmay, consultant for public information; and Claudia Dissel, director of the Corporate Council for Mathematics and Science.

MSEB is located at 2001 Wisconsin Avenue, NW, Washington, DC 20007. MSEB can be reached by telephone at 202-334-3294; by email at mseb@nas.edu; by fax at 202-334-1453; and by mail at 2101 Constitution Avenue Ave., NW, HA 476, Washington, DC 20418. Individual staff email addresses are of the form iname@nas.edu, where “i” is the initial of the first name and “name” is the full last name.

In the past year, 1,000,000 copies of a brochure about mathematics were distributed to parents, teachers, school administrators, guidance counselors—anyone interested in encouraging youngsters in mathematics. This is no high-tech publication, just a simple 8 1/2" by 11" piece of paper, folded into three sections, that presents a number of simple mathematical games and experiments kids can have fun with. The brochure, entitled “Yes You Can!”, presents a view of mathematics different from that held by most of the general public; it shows how mathematics permeates the activities of everyday life, from traveling in a car, to cutting up a pizza for friends, to daydreaming about the patterns in kitchen floor tiles.

This brochure was a collaborative effort of the Mathematical Sciences Education Board of the National Research Council and the Children’s Television Workshop, based on an earlier kit, “Math Matters,” which was developed jointly with the national PTA. The scale of the distribution illustrates the reach of the MSEB as it comes of age at a time of increasing interest—and increasing political heat—in education. In addition, the brochure exemplifies the MSEB’s large-scale efforts to get the general public to view mathematics differently. With connections to a dizzying array of constituencies having an interest in mathematics education, the MSEB has become an increasingly sophisticated organization that’s charting a new course for itself in the mathematics education reform movement.

From Reports to Implementation
The reports MSEB has produced over the last several years, starting with “Everybody Counts” in 1989, have gone a long way toward building consensus on the need for change in mathematics education. Together with the “Curriculum and Evaluation Standards for School Mathematics”, issued in 1989 by the National Council of Teachers of Mathematics (NCTM), the MSEB reports have spurred a great deal of national discussion about mathematics education. They have also outlined the basic shape of the reforms: appropriate use of computers and calculators, more student-centered learning, less rote memorization, an emphasis on problem solving, a wider and richer menu of mathematical topics, and so on.

Now that the first wave of reports is out and there is general agreement on the broad outlines for change, the MSEB has been rethinking its role. “The MSEB has moved beyond just writing reports to an activist, political stance to bring about implementation of the recommendations in the reports,” notes Steen. But this doesn’t mean that the MSEB staff will start writing worksheets for fourth-grade classes and software to help teach geometry; the MSEB has never been involved at that nitty-gritty level. That’s the bailiwick of agencies like the National Science Foundation, whose education budget has risen dramatically over the last several years. So there is no shortage of ideas for reform, but the schools have to start using them. “Some communities have been content to keep operating the way they have been,” Steen says. “They haven’t yet bought into the national agenda.” One role for the MSEB
to play is as a kind of national coordinator to make sure that the relevant organizations have the knowledge, means, support, and encouragement to bring about change. This kind of outreach is at the heart of MSEB's "implementation" activities.

Part of this effort is to get schools to start thinking in terms of national standards. "We want to get the expectations of a standards-based curriculum embedded in the decision-making processes of schools," says Steen, so that change does not always require an outside impetus. "The strategy of the MSEB with regard to standards is that the standards represent goals, but there are many different curricula that might get you there... We don't say one is right, and one is wrong." For example, what works in one community might not work, for historical, cultural, social, or economic reasons, in another community. It's tricky to judge a curriculum in isolation, he says, but it is possible to develop standards by which a variety of curricula can be measured—this is what the NCTM "Standards" have tried to do.

The MSEB will also strengthen ties to science education. A group at the NRC is developing standards for science education analogous to the NCTM "Standards". Although coordinating mathematics and science education has some clear advantages, Steen notes that "mathematicians hesitate to lose their discipline's identity to science." However, he notes that the science standards are picking up on some of the same intellectual themes in the NCTM "Standards", so philosophically the two are unlikely to be far apart. "The fact that the science standards are coming out compels us to coordinate with what they're doing," says Steen. "And the political reality dictates that we need a 'big tent'."

Another area of focus for the MSEB is teacher preparation. Steen points out that it is only through change in the undergraduate preparation of teachers that reform will be sustained. "If you don't get at this problem, everything else you do, like in-service programs, is in effect patching up things that weren't done right to begin with." Steen calls for a "thorough change" in undergraduate mathematics courses, so that the teachers of the future are themselves taught with the methods they will be expected to use in the classroom: more student interaction, less lecturing and memorization, open-ended problem solving, and so on. This means that college and university professors, those who train future school teachers, need to change their own teaching methods. The MSEB office of college and university programs is beginning to explore the kinds of source materials that would be useful to faculty interested in changing their teaching methods. Effective materials would document examples of teaching that model alternative methods that faculty may wish to incorporate into their repertoire of classroom strategies.

Although the MSEB has always had research mathematicians among its members, the voice of the mathematics research community is generally a minority among the broader educational interests represented on the Board. The community has little experience with the MSEB's efforts with school boards, PTAs, and state education departments. However, notes Linda Rosen, director of the MSEB's policy studies program, they can make important intellectual contributions to the reform effort. She says she has heard "lots of compliments but not much substantive discussion" about such MSEB projects as "On the Shoulders of Giants", which explored new intellectual bases for school mathematics curricula. As former MSEB chair Shirley Hill put it, if you take the "spine"—namely, arithmetic—out of school mathematics, what should take its place? "We would like to engage mathematicians in rethinking what mathematics is in order to provide rich frameworks for curriculum development, teacher training, and so on," says Rosen, "so we insure that the beauty and breadth of mathematics is well represented."

MSEB Projects

The various projects under the MSEB umbrella have very different flavors and very different sets of activities. Rosen's program on policy studies tries to develop a message about mathematics education reform that's based on research—either traditional educational research or "research in practice", that is, the accumulated wisdom of experts. One area Rosen has been looking at is the international arena. Every so often yet another dire report comes out showing how American youngsters are trailing in mathematics achievement when compared to their counterparts in other countries. Rosen points out that, while such comparisons are useful, many believe that the tests do not reflect the consensus in this country about what is valued in reform. Rather than preparing students for "international horse races", she says, educators should be taking a close look at what other countries are doing in education and what could be useful here. "Everyone has the same questions about mathematics education worldwide, but different countries have different answers," she says. "Some answers will translate, some will not."

In fact, there has been a great deal of contention over the issue of testing just within this country. Currently, standardized tests are given to students in virtually every grade; national samples are gathered in grades four, eight, and twelve. Considering the influence these tests have on curricula, teacher accountability, funding for schools, and so on, it is important that the tests reflect current thinking about what students should be learning. One project under Rosen's program is a set of prototype assessment tasks at the fourth grade level. These tasks were pilot-tested last spring and fall, and a report about them, called "Measuring Up", was issued in December 1992. The assessment tasks do not themselves constitute a standardized test, nor do they cover the whole fourth grade curriculum, Rosen notes, but they do provide some exemplars of good assessment materials and indicate directions to move in. This project is part of a larger MSEB effort in assessment, which includes a major report, scheduled for fall of 1993, called "Measuring What Counts", a guide to state and local school districts that want to change their use of assessment.

In addition to these projects, others having policy implications are just getting off the ground. Susan Forman's office of college and university programs will be working with a task force charged with starting to formulate a study of the impact of calculus in high schools to examine, for example,
how successful completion of AP calculus affects students' later choices about what mathematics to take in college or how having a calculus program affects a high school's overall mathematics curriculum. "We may find that there are 'unexpected outcomes' of offering calculus in high school and, as a result, may want to think about alternative courses," notes Forman. In addition, the office of college and university programs hosted a meeting of presidents-elect and executive directors of the AMS, the American Mathematical Association of Two-Year Colleges (AMATYC), the Mathematical Association of America (MAA), the NCTM, and the Society for Industrial and Applied Mathematics (SIAM) to discuss issues of common concern contained in their long-range plans and explore ways in which the societies might cooperate to advance their agenda.

J. Arthur Jones' program on equity and diversity is starting work on a systematic study of existing programs for minorities in mathematics, to guide policy leaders in understanding what kinds of programs are effective and what issues they should address. Jones is particularly interested in improving minority achievement in the early grades because he believes that without a solid early training, "we won't have anything to do in college [mathematics] because there won't be any minority students."

**Outreach a Major Focus**

Outreach is a centerpiece of the MSEB's efforts—in fact, four MSEB programs are primarily concerned with outreach. One of these is the state coalitions project, directed by Joan Donahue. Begun in 1989, this program has now established coalitions in all fifty states and the District of Columbia. The purpose is to develop a national network of independent organizations to work toward reform in mathematics education at the state level. The coalitions include classroom educators and mathematicians as well as representatives from business and industry and government. The coalitions are at various stages of development, and their activities, says Donahue, are "all over the place". They vary from organizing teacher in-service programs to working with politicians to change educational policies at the state level. In addition, some of the coalitions work to establish strong links to business and industry, and some are combining their efforts with work in science education reform.

The advantage of having coalitions at the state level is that they can more directly influence school boards, parent groups, teachers, and so on, than can the MSEB, which sits at the more rarified level of the National Academy of Sciences. Your typical parent, for example, is unlikely to read "Everybody Counts". "The coalitions know they're dealing with Mr. and Mrs. Average American and their kids," says Donahue. "How do you convince them of the importance of mathematics?" Having the state coalitions establishes a local link that brings in many groups who otherwise might not be convinced that change is needed. "There needs to be a huge effort to educate the public on what needs to be done, what kind of mathematics we're talking about," says Donahue.

The MSEB also helps to bring together groups whose primary interest is not necessarily mathematics education, but which have some stake in seeing improvements in this area. For example, Jones coordinates the Alliance to Involve Minorities in Mathematics (AIMM), which comprises fifty-six organizations, from federal agencies, to community-based organizations, to professional societies. Jones says AIMM seeks to address cross-cutting issues that depend on many different groups working in a coordinated way. "These issues are the responsibility of many who don't work directly in education but who have indirect influence on it," Jones notes. For example, there are media representatives on AIMM, because the media can exert an influence on attitudes about mathematics. Jones says that he is also working on a clearinghouse of information on successful programs for minorities in mathematics.

**Predicting the Future**

Steen says that, as work on reform proceeds, the MSEB will have to focus on the transition to new ways of teaching and learning mathematics. "The number of variables is so huge, and the pressures are so great, that we will go through a transition period in which the old ways of doing things get thrown out or modified, but no one knows what will take their place," he notes. Part of the difficulty is that the issues unique to mathematics education are only a small part of the whole education scene. Organizations like the MSEB have to work for change amid battles over school management, control of curricula, pressures to assess teachers' competence, school choice, and so on. Just what's next leaves everyone guessing, including Steen. "In that context," he says, "it would be foolhardy to predict the future."

Allyn Jackson
Staff Writer
The Forum section publishes short articles on issues that are of interest to the mathematical community. Articles should be between 1000 and 2500 words long. Readers are invited to submit articles for possible inclusion in Forum to:

*Notices* Forum Editor  
American Mathematical Society  
P.O. Box 6248  
Providence, RI 02940  
or electronically to notices@math.ams.org

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**Some Remarks about Shafarevich’s Book Russophobia**  
**Boris A. Kushner**  
*University of Pittsburgh at Johnstown*

I was asked by Professor Carolyn Gordon, the Editor of the Forum, to present my personal opinions concerning the well-known controversy surrounding Professor I. R. Shafarevich and his book *Russophobia*.

I read this book (in a *samizdat* copy) in Moscow in the spring of 1987. There is no room here to present at length the contents of the book and its central concept of the “lesser people” (*malyi narod*). The author discovered this concept in works of the French historian A. Cochin and found it an indispensable tool for explaining fundamental historical events, especially events of a revolutionary nature. Applying this concept to the modern and recent history of Russia, Professor Shafarevich discovers a “lesser people” behind the scenes. A “lesser people” organized the catastrophic Revolution of 1917; a “lesser people” is trying right now to alter the natural course of historical development in Russia. As in previous historical manifestations of the phenomenon, the spiritual values and aspirations of the “Russian lesser people” are completely alien, even hostile, to those of the “greater people”. Inevitably, the “lesser people” despises, even hates, the “greater people” and regards them as material for social experiments. The presence of and the dangerous activities of this “lesser people” in contemporary Russia can be recognized, according to Professor Shafarevich, in writings of certain publicists and writers, mostly of Jewish origin and mostly emigrants. Those writings present Russian history and the Russian national character itself in a distorted and humiliating way.

Although these writers and their literary output are mostly known in quite restricted circles of intellectuals, they still can somehow have a fatal effect on the Russian People. They are “deadly dangerous for the Russian People, since they deprive it of self-confidence”.

I would like to say at once that I respect all peoples, including the great Russian People. So it goes without saying that I respect the national feelings of Shafarevich, his devotion to his people, his sorrow about the tragic events in its past, and his concern with its future. I disapprove of the statements of some Jewish authors about the Russian People that Professor Shafarevich has cited. Even if these citations are possibly taken out of context, they are regrettable.

It is rather difficult for me to discuss the part of Russophobia related especially to Russian national problems. Being Jewish and feeling myself Jewish, I abstain from such discussions. Problems that touch sensitive points of the Russian national self-consciousness are not for outsiders. So, I would rather dwell on the part of Shafarevich’s writings that in some way is addressed to me.

It is astonishing to observe how a man, who just a few pages before defended the national dignity of his people, can launch a violent attack against another people. After arriving at the conclusion that persons of Jewish origin form the kernel of the Russian “lesser people”, Shafarevich undertakes an all-out search to find reasons for it. This search involves a sort of essay about Jewish history, national traditions, and national character, beginning from Biblical times and finishing in our century. I presented my criticism of and my feelings about this essay at length in my open letter to Professor Shafarevich. This letter was distributed in *samizdat* in 1987 when I was still a resident of Moscow. Later, it was widely published and broadcast by the Russian-language media in the West. Now this document is available in English in an excellent translation by Professor David Webb.

It is general knowledge that the Bible is a document of unparalleled significance and complexity. It is as rich and as complicated as life itself. It leaves freedom of choice to everyone who reads it. Professor Shafarevich uses this
freedom of choice to assemble a list of citations of a pejorative character taken completely out of their theological, historical, and poetic contexts. For example, in Isaiah he did not notice, say, 2.4:

“And He shall judge among the nations, and shall rebuke many people: and they shall beat their swords into plowshares, and their spears into pruninghooks: nation shall not lift up sword against nation, neither shall they learn war any more.”

... but he did find 61.5:

“And strangers shall stand and feed your flocks, and the sons of the alien shall be your plowmen and your vine dressers.”

It is supposed that for centuries and centuries Jewish educators somehow used something similar to Shafarevich’s list to educate new generations of the Jewish People. Negative sides of the Jewish national character which manifest themselves in the “Russian lesser people” are ostensibly results of such an education.

I find it amazing that a person who professes to be a Christian can treat the Old Testament, a sacred book of both the Jewish and Christian Religions, in such a blasphemous way. The manner in which Professor Shafarevich performs his surgery on the Old Testament reminds me of the worst excesses of Soviet atheist agitators (like the notorious Emel’yan Yaroslavskii).

The Talmud, not being a sacred book for Christians, is still widely recognized as a very important and complex historical and theological document. It is a shame to see an excellent scientist-mathematician launching a cavalier attack on this tremendous work of many generations. One can imagine my feelings when I read that Jews were permitted to desecrate non-Jewish graves. As I was reading it, I could see directly from the windows of my Moscow apartment a Jewish cemetery (Vostryakovo Cemetery) with desecrated Jewish graves. Incidentally, Professor Shafarevich is rather vague about the sources of his talmudic erudition. I found an excellent scientist-mathematician launching a cavalier attack on this tremendous work of many generations.

Professor Shafarevich, being widely recognized as an excellent mathematician, probably wants to be considered as a distinguished historian as well. He has resources for it: erudition, phenomenal memory, and a strong critical mind. But one crucial thing is missing: the heart. He treats awful human tragedies exactly like polynomials in his mathematical works. In the entire text of Russophobia anti-Semitism, a tragedy that began long before, say, the conscious life of the Russian People and that still goes on, is denounced in exactly one passing sentence—and this in a book where Jews are at the center of the investigation! On the other hand, one can read that anti-Semitism is “a concept” (“an empty political slogan” in Shafarevich’s latest writings), the main essence of which is the presumption of national (Jewish) innocence, and that this concept is designed to silence non-conformists and to manipulate public opinion (the favorite trick of all “lesser peoples” in history) by distracting it from more important problems. As examples of such manipulations, Professor Shafarevich mentions the well-known cases of Dreyfus (in France) and Beilis (a blood libel case in Russia). A reader is left to guess whether the Jews themselves manufactured these incidents in order to attain some national goal or to influence political developments in the relevant countries.

Need I comment on this?

After reading this summer the above-mentioned work of Shafarevich, Russophobia: 10 years later, I felt myself obliged to defend the national dignity of my people again. My second open letter to Professor Shafarevich is available in an elevated, even poetic way, envisioning future generations reading it, and so forth. It is amazing: the world is collapsing all around, already
the "greater people" is becoming (literally) a "lesser one" here and there in the former Soviet empire, but Professor Shafarevich continues in the midst of this tragedy his holy war against a small handful of (mostly) second-rate literati.

Through private correspondence with my friends in Russia and via the Russian-language media, I am aware that unfortunately Professor Shafarevich has recently lent his name more and more to certain circles of an extremist, nationalistic character. For example, he is listed as a member of the Editorial Board of the magazine *Nash Sovremennik (Our Contemporary)*; the direction and the level of this monthly are only too well-known. It is worth mentioning that one can enjoy yet another literary fulmination on the subject of the "universal Jewish-Masonic conspiracy" in the very issue of the magazine in which *Russophobia: 10 years later* is published.

To conclude these necessarily short notes, I would like to say a few words about recent developments concerning Professor Shafarevich that have to some extent polarized the mathematical community. I am not in a position to discuss questions of membership in the National Academy of Sciences, but I am not sure that ousting members is the best way of solving moral problems. At the same time I can not believe that any self-respecting scientific body can accept the principle proclaimed by some scientists that "only scientific work counts". Answering the open letter of a group of colleagues, Professor Shafarevich deplores dwindling American freedom of speech and opinion, supposedly so fatally undermined by the above open letter. The situation is hardly so tragic: after all, Professor Shafarevich was able to publish his answer in these very *Notices*, where the open letter appeared. Moreover, the open letter, signed by a few hundred mathematicians, was published as "an advertisement", while Shafarevich's reply found a much more prominent place in the magazine. I would like to add that allusions to former Soviet practices made by Professor Shafarevich in his answer rely upon the naivety of a reader completely unfamiliar with Soviet reality. Those who lived in the (former) USSR can only laugh when reading these passages. When was a victim of communist persecution allowed to defend his convictions and his dignity in public? The fate of those victims is only too well known.

I have to admit that reading *Russophobia* was a really painful experience for me. I was once among Shafarevich's students at Moscow University; I used to see him in the corridors and halls of that University, in libraries, and in the Great Hall of the Moscow Conservatory. I deeply respected him as an outstanding mathematician and teacher. A hatred loves a hatred. There is a strong temptation to pay back in the same currency. I will not do it. I am simply infinitely sad.
Edited by Keith Devlin

This month’s column
In November’s “Computers and Mathematics” column, Donald Mackenzie discussed the nature of mathematical proof, the role of computers in the proof-process, and the growing likelihood that the use of computer-produced or computer-aided proofs to verify software systems will result in some mathematicians finding themselves in the law courts any day now. In this month’s feature article, Larry Wos of the Argonne National Laboratory describes his own experiences in developing and using the automated reasoning system OTTER.

Following the Wos article, William Ruckle reviews Mathcad, Suzanne Molnar takes a look at Matrix Algebra 2.2, and Roger Pinkham road tests the TI-85 calculator.

Automated Reasoning
Answers Open Questions

Larry Wos*

An Automated Research Assistant
When a computer program applies logical reasoning so effectively that the program yields proofs that are published in mathematics and in logic journals, an important landmark has been reached. That landmark has been reached by various automated reasoning programs. Their use has led to answers to open questions from fields that include group theory, combinatorial logic, finite semigroup theory, Robbins algebra, propositional calculus, and equivalential calculus. Among the successes, automated reasoning programs have answered questions posed by Irving Kaplansky, Dana Scott, Raymond Smullyan, and John Kalman. In addition to proving significant theorems, a single automated reasoning program is used to construct a needed specific object or structure, to find an appropriate model or counterexample, to supply a new axiom system, to check a given proof, to discover a more elegant proof, and to settle conjectures—positively or negatively.

Noting that such powerful and versatile automated reasoning programs exist, one naturally wonders about the ease of using such a program and which program is recommended. The program I recommend is the one that continues to play a vital role in my research: Its name is OTTER [3]. OTTER is rather easy to use, requiring one to prepare an input file that contains no more than a statement of the problem under attack and an instruction concerning the type of reasoning to employ—when the choice is simply to rely on the program’s defaults. (Because the presentation of a question or problem is ordinarily the most burdensome aspect of using a program that reasons logically, I postpone its discussion until after introducing the five elements of automated reasoning.) Of course—as one expects with an increase in the challenge of research, games, or puzzles—to complete assignments of increased complexity demands an increase in the sophistication of program use. Fortunately, however, increased complexity and required sophistication are not commensurate: An increase of a factor of 1000 in complexity is frequently reflected in an increase in sophistication of only a factor of 10. For overcoming the obstacle of ever-growing complexity, the program OTTER offers the use of strategy of various types. Researchers, poker players, chess players, each can attest to the appeal and intrigue of using strategy. To further aid the user of OTTER, the program offers (through use of the chosen output file) some assistance in verifying that all is in order regarding one’s attempt to solve a problem or answer a question. In addition to echoing in the output the various options from which one can choose, for each deduced conclusion the program presents the precise history of its origin. An examination of such histories enables one to determine the accuracy of the chosen representation and to evaluate the wisdom of the choices regarding strategy, type of reasoning, and parameter settings.

To facilitate and encourage both the use of the recommended program and the reliance on automated reasoning to assist in research, written material is available: a taste offered

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by this article, a meal offered by a problem database accessi-
ble electronically, and a veritable banquet offered by the new
McGraw-Hill book Automated Reasoning: Introduction and
Applications, by Wos and coauthors [13]. With the tutorial
given in Chapter 16 and with the program OTTER provided
on diskette in that book, one can soon experience the use of
an automated reasoning program as a valuable research as-
sistant. OTTER runs well on workstations, (IBM-compatible)
personal computers, and Macintoshes.

One might now wish some insight into the difficulty of
the questions answerable with the assistance of OTTER. To
fulfill such a wish, I prefer and enjoy offering conjectures that
were settled by using the program, and, for added interest, I
suggest (as a possibly intriguing contest) that the researcher
attempt to settle the conjectures unaided. I have selected three
conjectures for consideration: one conjecture from group
theory, one from combinatory logic, and one from two-valued
sentential calculus (also known as propositional calculus). In
the following, lower-case $u$ through $z$ are variables.

Conjectures to Settle, a Friendly Contest between Re-
searcher and OTTER

Conjecture 1. The following equation fails to provide a
complete axiomatization for the variety of groups of exponent
5, all of those groups in which, for all $x$, the fifth power of $x$
is the identity $e$:

\[(x(x((x(xy)z)))(e(x(xz)))))))) = y.\]

The preceding conjecture can be viewed as asserting that
equation (1) fails to imply at least one of the following: product
is associative, $ex = x = xe$, the fifth power of $x$ (for all $x$)
is the identity. One need not be concerned with inverse,
for the inverse of $x$ is simply equal to the fourth power of $x$
for groups of the type under consideration.

Conjecture 2. Using the following two equations for the
combinators $B$ and $N$, one can show that there exists a fixed
point combinator $F$ expressed solely in terms of $B$ and $N$,
where a fixed point combinator $F$ is a combinator such that
$Fx = x(Fx)$:

\[(Bx)yz = x(yz),\]
\[(Nx)yz = ((zx)yz).\]

Conjecture 3. Where "\(-\)" can be interpreted as implica-
tion and "\(-\)" as negation in the following six formulas, one
can show that there exists a model that satisfies condensed
detachment (to be defined almost immediately) and formulas
(4), (5), and (6) and that fails to satisfy at least one of (7), (8),
and (9):

\[(((x \to y) \to z) \to (y \to z)),\]
\[(((x \to y) \to z) \to (\neg(x) \to z)),\]
\[((u \to (\neg(x) \to z)) \to (u \to ((y \to z) \to ((x \to y) \to z)))),\]
\[(((x \to y) \to ((y \to z) \to (x \to z))),\]
\[(((\neg(x) \to x) \to z),\]
\[(x \to (\neg(x) \to y)).\]

For this area of logic, condensed detachment considers
two formulas, $(A \to B)$ and $C$, and, if $C$ unifies with $A$, yields
the formula $D$, where $D$ is obtained by applying to $B$ the most
general unifier of $C$ and $A$. Unification is a procedure that
considers two expressions and seeks to find the most general
substitution that makes the two identical; unification will be
discussed further in the section on the elements of automated
reasoning.

Coming Attractions

For the curious and for those who have been tempted to
consider the three given conjectures, in this article I settle
each, touching briefly on the role the program OTTER played
and drawing on earlier research. Because the brevity of that
discussion may leave various questions unanswered, I focus
in greater detail later in this article on the basic elements of
automated reasoning, enabling the researcher to gain a fuller
appreciation for how OTTER attacks a question or problem;
the use of strategy may be of particular interest. One learns
that, in contrast to the programs that are symbolic calculators
for integration and the like, the type of program in focus
in this article applies logical reasoning, rather reminiscent
of that found in mathematics—and sometimes with totally
unexpected and intriguing results that are publishable.

To complete the picture, I discuss the general type of
problem for which OTTER provides valuable assistance and
feature specific open questions that were answered. The focus
is mainly on the research at Argonne National Laboratory, for,
more than any other effort concerned with the automation of
reasoning, my colleagues and I at Argonne have emphasized
the study of open questions. As one learns in this article,
our approach to the automation of reasoning differs sharply
from approaches one often finds in artificial intelligence;
indeed, our paradigm relies on types of reasoning and other
procedures that are not easily or naturally applied by a person.

To complement the successes reported here, I pose ad-
ditional open questions and offer challenges, each focusing
on some area of mathematics or logic. As may already be
obvious, I conjecture that the use of the program OTTER
provides substantial potential for an attack on the posed
questions and the offered challenges, as well as an attack
on other questions of which I have no knowledge. If one is
interested in research and challenges concerned directly with
automated reasoning, the cited program will also serve well
in that regard; a good source for appropriate research problems
is the book Automated Reasoning: 33 Basic Research Problems
[11]. Therefore, for those who may be interested in using
this new research assistant, this article provides the details
for obtaining a copy of the program. Should researchers use
OTTER profitably, I would enjoy hearing of the results; the
appropriate electronic mail address is wos@mcs.anl.gov. I
also encourage researchers to send additional open questions
to consider.

Open Questions Answered and Challenges Offered
To add to the temptation of using an automated reasoning
program and of suggesting other areas to explore, I now turn
to various open questions that were answered with heavy assistance from OTTER and its predecessors. As for areas of mathematics and logic totally unrelated to those of concern in this article, they are also amenable to study with an automated reasoning program—for example, set theory [6, 11], number theory [8], and Tarskian geometry [7]. Although this article focuses mainly on recent studies of group theory, combinatory logic, and various logic calculi, it also touches on questions answered little more than a decade ago, for they serve nicely to illustrate types of problems that can be attacked with a reasoning program. At least from the historical perspective, the successful use of an automated reasoning program to answer open questions is simply astounding.

Indeed, to see how pessimistic was the view concerning the possibility of automating logical reasoning so successfully as to permit proving interesting theorems—or, for that matter, proving even simple theorems—one need only glance at the following quote taken from a 1948 paper by the eminent logician J. Lukasiewicz [2]: “A formalized proof can be checked mechanically but cannot be mechanically discovered.” Obviously—and most fortunately—as this article repeatedly demonstrates, Lukasiewicz was mistaken. That such a famous logician held this position is completely understandable; indeed, to have believed otherwise in 1948 might have required clairvoyance. Even further, but four decades ago, how could any mathematician or logician have conjectured with conviction that the late 1980s and early 1990s would find that computer programs not only “discover” significant proofs, but often discover such proofs in astonishingly little computer time?

I begin with questions taken from pre-OTTER history, questions answered with a predecessor of this newest automated reasoning program.

**Ternary Boolean Algebra**

The first example focuses on the esoteric field of ternary Boolean algebra and the question that marked Argonne’s entrance into the use of an automated reasoning program to attempt to answer open questions. The question asks which, if any, of the first three of the following five axioms is independent of the remaining four:

\[(TBA1) \quad f(f(v, w, x), y, f(v, w, z)) = f(v, w, f(x, y, z)),\]

\[(TBA2) \quad f(y, x, x) = x,\]

\[(TBA3) \quad f(x, y, g(y)) = x,\]

\[(TBA4) \quad f(x, x, y) = x,\]

\[(TBA5) \quad f(g(y), y, x) = x.\]

A nonempty set satisfying these five axioms is a ternary Boolean algebra. It was known that the fourth and fifth axioms are dependent on the remaining four, no proofs were obtained. Fortunately, Steve Winker (a member of the Argonne group) then devised a method enabling one of our reasoning programs to generate models [9]. By using a program (whose design preceded that of OTTER) to apply Winker’s method, we quickly established the independence of each of the first three axioms. Although the models that suffice are disappointingly small—each consisting of four or fewer elements—we had, nevertheless, succeeded for the first time in our research in using an automated reasoning program to answer an open question. (For those interested in history, I note that, prior to our attempt at Argonne National Laboratory to answer open questions, the only successful use of a reasoning program in that context is the one concerning SAM’s lemma in the theory of modular lattices [1]. I also note that our programs are still not very effective for model generation.)

**Finite Semigroups**

To obtain a question from a field of far greater interest than offered by ternary Boolean algebra, we turned for an appropriate challenge to Irving Kaplansky. He suggested seeking an answer to the following.

Does there exist a finite semigroup that admits a nontrivial antiautomorphism but that does not admit any nontrivial involutions?

A nontrivial antiautomorphism is a one-to-one onto mapping \(h\) such that \(h(xy) = h(y)h(x)\) and such that \(h\) is not the identity mapping. A nontrivial involution is a nontrivial antiautomorphism \(j\) such that \(j(j(x)) = x\).

The nature of the Kaplansky question suggested the avoidance of an exhaustive search. After all, there exist more than 800,000 semigroups of order 7 alone, no two of which are isomorphic. Recognizing the difficulty of telling a reasoning program that the sought-after structure must be finite, we chose to have the program explore candidate semigroups, keying on various sets of generators and relations. The study succeeded: An appropriate semigroup was found, one of order 83 [10]. To attempt to find a smaller semigroup of the desired type, we had the program proceed more or less as one would in the study of quotient groups. Again success: One of order 7 was found, and, later, it was proved that there exist four nonisomorphic semigroups of that order and none of smaller order.

**Equivalential Calculus**

The third success focuses on a field of logic known as equivalential calculus and on questions that proved to be far more difficult to answer. The formulas of equivalential calculus are the set of expressions in the two-place function \(e\) (for equivalent) and the variables \(x, y, z\), and so on. Fortuitously, from the viewpoint of automated reasoning, the unification procedure can be relied upon, that procedure (as defined earlier) that considers two expressions and seeks to find the most general substitution that makes the two identical; unification is illustrated later, in the discussion of the elements of automated reasoning. The inference rule that is
often employed to prove theorems is **condensed detachment.** For this area of logic—similarly to the use in two-valued sentential calculus—condensed detachment considers two formulas, \( e(A, B) \) and \( C \), and, if \( C \) unifies with \( A \), yields the formula \( D \), where \( D \) is obtained by applying to \( B \) the most general unifier of \( C \) and \( A \).

Encouraged by John Kalman (the University of Auckland), who had heard of our prowess in proving theorems, we began the study of seven open questions: Which, if any, of the following seven formulas provides a complete axiomatization of equivalential calculus (a formula is a single axiom if and only if one can use it with condensed detachment to deduce all formulas in which variables occur twice):

\[
\begin{align*}
(XJL) & \ e(x, e(y, e(e(z, y), z))), \\
(XKE) & \ e(x, e(y, e(x, e(z, y)), z))), \\
(XAK) & \ e(x, e(e(e(y, z), z), y)), \\
(BXO) & \ e(e(x, e(y, z)), e(y, z), x), \\
(XCB) & \ e(x, e(e(x, y), e(z, y))), \\
(XHK) & \ e(x, e(e(y, z), e(x, z), y))), \\
(XHN) & \ e(x, e(e(y, z), e(x, z), y))).
\end{align*}
\]

To attack each of the seven questions, as is obvious, one could seek an appropriate proof or one could seek an appropriate model. Since the conjecture was that none of the seven was strong enough to be a single axiom for the calculus, the path that appeared best to pursue was to seek appropriate models. Unfortunately, from what we were told, to seek a model might entail the examination of too many candidates. Since our programs have never demonstrated marked power for model generation, the path concerned with establishing a formula too weak to be a single axiom would almost certainly require the formulation of a new approach. Our discovery of the needed approach nicely illustrates the symbiosis that sometimes exists between a researcher and an automated reasoning program, and it also illustrates that luck often plays a key role in science.

Our foray into equivalential calculus began with the study of the formula XBB:

\[
(XBB) \ e(x, e(e(x, e(y, z)), y), z)).
\]

We chose that formula more or less arbitrarily, motivated by the belief that it corresponded to an open question. Using condensed detachment as an inference rule and using various known single axioms as targets to establish assignment completion, we instructed OTTER to study the formula XBB. If the program was to succeed in deducing any of the target formulas, then we would have a proof that XBB is a single axiom—but such did not occur. Instead, an examination of the program’s output revealed that the deduced formulas steadily grew in symbol count.

Closer inspection showed that the handful of deduced formulas could be described with a single iterative pattern, which led us to conjecture that all theorems deducible from XBB would satisfy the pattern. On the one hand, we quickly proved our conjecture; on the other hand, we shortly learned that this formula held no interest for logicians, for it was already known to be too weak to be a single axiom.

But luck was with us: we had already answered some of the seven open questions of concern before we learned of the lack of interest in XBB. Even better, the approach gleaned from our use of our program proved to play the key role in completing the study, the approach of identifying some number of patterns to describe all deducible formulas from a given formula [15,14]. Each of the first five of the seven formulas is too weak to serve as a single axiom; but, contrary to conjecture, the last two, XHK and XHN, were proved strong enough.

**Group Theory and the Era of OTTER**

Having covered the pre-OTTER history of our attempts to answer open questions, I now turn to the era of OTTER. My colleagues and I used this automated reasoning program to settle the three conjectures posed earlier and to answer various related open questions, some of which I discuss in this article. Although the questions taken from group theory were studied most recently, I nevertheless begin with them [5].

One often studies group theory as a whole structure, closed under an associative operation, in which a (two-sided) identity exists, and in which, for every \( x \), a (two-sided) inverse exists. Instead, one often studies a class or variety of groups in which an additional equation is assumed to hold. For example, when \( xy = yx \), one has the variety of commutative groups, and when \( x^2 = e \) (the identity), one has Boolean groups. Here I shall confine my attention to varieties of groups of odd exponent—all groups in which the cube of \( e \) equals the identity, the fifth power equals the identity, the seventh power equals the identity, and the like. For a given variety, I focus on the search for a single equation that axiomatizes all groups in the variety; in particular, I show how my colleagues and I settled the first conjecture.

When the focus is on all of group theory, Alfred Tarski proved that, if constrained to rely explicitly on product, inverse, and identity, one cannot find a single equation to serve as a complete axiom system. If the focus is switched from all of group theory to some variety obtained by adding one equation, Ken Kunen (University of Wisconsin) has outlined a proof that again one cannot find an axiom system of the type discussed by Tarski. (Historical note: Kunen supplied us with his proof after we had completed the research reported here and after we had answered various other related questions.) If one drops the requirement of the explicit use of the identity \( e \), then B. H. Neumann has provided a schema for obtaining a single axiomatizing equation. However, because our interest concerns the axiomatic question when the identity is explicitly present, the Neumann schema is of no assistance.

I begin with groups of exponent 3, those in which the third power of \( x \) (for all \( x \)) is the identity \( e \), then settle the first conjecture, and close with a result that focuses on all varieties of odd exponent. William McCune (also an Argonne scientist) had used OTTER to successfully study other varieties. His research focused on single equations in which \( e \) is absent. Nevertheless, his work was clearly the impetus for asking the
following question. Does there exist a single equation in which only the product and the constant $e$ occur such that it serves as a complete axiomatization for groups of exponent 3? Given a candidate equation of the desired syntactic form, one must use it to prove that product is associative, that the constant $e$ is in fact an identity, and that the third power of $x$ (for all $x$) is equal to $e$. By using the inference rule paramodulation and the procedure demodulation (for canonicalization), in the style of Knuth-Bendix, OTTER succeeded in finding the following desired equation:

$$(x)((x((xy)z))(e(zz)))) = y.$$  

(Paramodulation and demodulation are discussed in the section on the elements of automated reasoning.) When we turned our attention to groups of exponent 5—and hence to the first conjecture—OTTER again succeeded, finding the following:

$$(x((x((x((xy)z))(e(zz))))))(e(zz))) = y.$$  

In other words, the first conjecture was refuted.

To be precise, we had actually conjectured that the preceding equation does provide an axiomatization for groups of exponent 5 and, further, that it is a member of a family of closely coupled equations for groups of odd exponent. To test our more general conjecture, we had OTTER study groups of exponent 7, 9, 11, 13, 15, and 17, each with the appropriate member of the family we had in mind. We were thus using our program as a research assistant; without such an assistant, a researcher might find this study more than cumbersome.

Although we were forced to experiment to find the appropriate parameter settings for the different cases under study, OTTER succeeded eventually in all six. To provide some insight into the magnitude of OTTER’s achievement, I note that the case focusing on exponent 17 required more than 23 CPU hours on a SPARCstation 2, producing a proof (for associativity alone) consisting of 181 applications of paramodulation. For those who may wish to use some other reasoning program to consider the same precise question, I note that excluded from the cited proof length count are the hundreds of canonicalization steps. I also note that, were the proof written out in its fullest, it would contain equations with more than 4,000 symbols.

One of the charming properties of the family of single axioms for the various varieties of groups of odd exponent is that no need exists for recursion; instead, given an odd exponent, one can immediately provide the desired single axiom—or so it appears. Since an appropriate proof has not yet been completed, I offer for research the conjecture that, for all odd exponents, the type of equation we have exhibited for exponents 3 and 5 generalizes. In that regard, I now give the corresponding equation for exponent 17:

$$(x(x(x(x(x(x(x(x((x((xy)z))))))))))))((e(zz))) = y.$$  

**Combinatory Logic**

The second conjecture focuses on the adequacy of the combinators $B$ and $N$ for constructing a fixed point combinator $F$, a combinator expressed solely in terms of $B$ and $N$ with $Fz = x(Fz)$. From what we know, no systematic approach with or without the aid of a computer exists for attacking this type of question—other than those we formulated when we studied combinatory logic with OTTER.

Barendregt defines combinatory logic as an equational system satisfying the combinators $S$ and $K$ with $(Sx)yz = (xz)(yz)$ and $(Kx)y = x$; the set consisting of $S$ and $K$ provides a basis for all of combinatory logic. Rather than studying all of the logic, logicians often focus on fragments of the logic, subsets whose basis is obtained by replacing $S$ or $K$ or both by other combinators. Where $A$ is a given fragment with basis $B$, the strong fixed point property holds for $A$ if and only if there exists a combinator $y$ such that, for all combinators $x$, $yx = x(yx)$, where $y$ is expressed purely in terms of elements of $B$. The weak fixed point property holds for $A$ if and only if for all combinators $x$ there exists a combinator $y$ such that $yx = xy$, where $y$ is expressed purely in terms of the elements of $B$ and the combinator $x$. Therefore, the focus of attention for the second conjecture is the possible presence of the strong fixed point property for the fragment with basis consisting of $B$ and $N$ alone.

As for the second conjecture, use of OTTER settles it in the affirmative by constructing the following combinator:

$$B(B(N(B(N(BBN)N))N)B)B.$$  

Of far greater interest is the manner in which the combinator is constructed. Indeed, this combinator, as well as various others that answered open questions of the type on which the second conjecture focuses, was constructed by applying a new strategy, the kernel strategy [4, 12]. This strategy is what I had in mind when I remarked about the lack, prior to our research, of a systematic approach to answering the type of question under discussion. For a given fragment, the application by OTTER of the kernel strategy often settles the question concerning the presence of either fixed point property in less than 3 CPU seconds on a SPARCStation 2—by constructing an appropriate object—or suggests what is needed for an argument to show that the desired property is absent.

Immediately, two queries demand attention: (1) from where does the kernel strategy derive its power, and (2) how might one explain its formulation by researchers in automated reasoning rather than by researchers in combinatory logic? The power of the strategy rests mainly on three aspects. First, the strategy relies on the use of the inference rule paramodulation (to be discussed later), a rule that generalizes equality substitution and in a manner not reminiscent of some researcher’s reasoning. Second, various strategies are used to control the application of paramodulation to deter the program from deducing unneeded information. Third, when the question under study concerns the strong fixed point property, the kernel strategy attacks it in two stages, in the first stage attacking the easier-to-answer question concerning the weak fixed point property and, if the answer is in the affirmative, in the second stage using only the relevant results to attack the harder question. In particular, the second stage of
the strategy relies heavily and directly on the results (obtained in the first stage) that establish the presence of the weak fixed point property, gaining marked effectiveness by ignoring all other information produced by the first stage. Regarding the researchers who formulated the kernel strategy, we had the distinct advantages of access to a powerful reasoning program and detailed knowledge concerning its elements, such as paramodulation, unification, and demodulation (a procedure for automatically canonicalizing deduced conclusions).

Our entrance into combinatory logic was indirectly prompted by Raymond Smullyan, with whom we later communicated moderately often. That communication led to his posing various open questions, questions we answered before our study of B and N, but during our formulation of the kernel strategy. In response to his question, we proved that the fragment with basis consisting of B and L alone does not satisfy the strong fixed point property, where \((Lx)y = x(yy)\). Again prompted by Smullyan, we then proved that the fragment with basis consisting of L and Q alone fails to satisfy the strong fixed point property, where \((Qx)y)z = y(xz)\). Each of the cited fragments does satisfy the weak fixed point property, proved by considering the expression \((Lx)(Lx)\). (For the curious, I note that the preceding expression is a kernel.) As part of our research, we also showed that, from B and W alone, one can construct an infinite class of infinite sets of fixed point combinators. As it turns out, the same is true for B and N. The reported successes provide yet more evidence of the value of relying on an automated reasoning program as a research assistant, for the program played a key role in all of the results cited here and in many not cited.

Of course, many fascinating research questions concerning the strong fixed point property remain open, providing challenges for the team of a researcher and an automated reasoning program. Of the more interesting is one posed by Smullyan: Does the fragment with basis consisting of B and M alone satisfy the strong fixed point property, where \(Mx = xx\)? By considering the expression \(M(BzM)\)—another kernel—one quickly sees that this fragment satisfies the weak fixed point property. Especially if one is interested in an open question focusing on the weak fixed point property, I offer the following two questions. Does the fragment with basis consisting of B and S alone satisfy the weak fixed point property? Does the fragment with basis consisting of B and \(\bar{N}1\) alone satisfy the weak fixed point property, where \((\bar{N}1x)y)z = (xy)y)z)? One can immediately prove that the presence of the strong fixed point property implies the presence of the weak. For a different type of open question to consider, I suggest that one attempt to find a finite model that satisfies the equations for B and L but fails to satisfy the strong fixed point property. That some model exists follows from our earlier cited result; but it is not known whether a finite model exists. For additional open questions and for a detailed treatment of the kernel strategy and numerous results of its use, see [12].

Two-Valued Sentential Calculus

Regarding the third conjecture, which focuses on two-valued sentential (or propositional) calculus, I thank Dana Scott, for it was his interest in our research and in OTTER that eventually (though indirectly) led to our study of the conjecture. The path to that study began with a challenge from Scott: See whether OTTER can prove all of the 68 theorems he selected from two-valued sentential calculus. Although our first attempt to prove all 68 yielded proofs of only 33 of the theorems—a result that many researchers might indeed consider rather impressive—the story has a beautiful ending.

Indeed, prompted in part by greed—manifested in the objective of proving all 68 theorems in one run—and in part by curiosity concerning a possible new approach, we formulated a new strategy, called the resonance strategy, which sharply differs from any other with which we were acquainted at the time. In the context of the Scott challenge, the strategy in effect says to OTTER: if the theorem T is proved and if T matches at the function occurrence level any of the 68 theorems to be proved, then focus heavily on T to direct the attack. When the new strategy was put to the test, OTTER proved all 68 theorems in a single run in less than 16 CPU minutes on a SPARCstation I+.

One significant criterion for measuring the power of a strategy is its effectiveness when used to study problems other than those that prompted its formulation. The resonance strategy meets that criterion. The new context is that of finding more elegant proofs, especially where elegance is reflected in proof length. One of our more satisfying successes focuses on two-valued sentential calculus and on the following axiomatization supplied by Lukasiewicz:

\[
\begin{align*}
(L1) & \quad ((x \rightarrow y) \rightarrow ((y \rightarrow z) \rightarrow (x \rightarrow z))), \\
(L2) & \quad ((\neg x) \rightarrow x), \\
(L3) & \quad (x \rightarrow (\neg(x \rightarrow y))).
\end{align*}
\]

The three formulas are, respectively, (7), (8), and (9) of the third conjecture.

The Lukasiewicz proof that (L1) through (L3) axiomatizes the calculus consists of 33 steps, each an application of condensed detachment. With the goal of finding a shorter and more elegant proof of the Lukasiewicz result, we decided to base our attack on the use of the resonance strategy and on the use of a feature in OTTER that, for each conclusion that is reached more than once, compares the proof lengths and gives preference to the shorter. Therefore, at the beginning of the attack, we instructed OTTER to focus heavily on any formula that is similar to one of the 33 steps in the Lukasiewicz proof. We iterated, on the whole finding shorter and still shorter proofs. For each step of the iteration—some of which yielded nothing of added interest—we changed various parameters and, more important, keyed OTTER's attack on the resonance strategy to focus heavily on any formula that is similar to one of the steps of the shortest proof available. We were rewarded: OTTER eventually found a 22-step proof establishing that (L1) through (L3) axiomatizes two-valued sentential calculus.

During our study of this area of logic, we used OTTER to focus profitably on other axiom systems, including that
of Frege, Hilbert, and Church. One of the benefits resulting from the corresponding research was the accrual of additional evidence (to be cited shortly) of the value of using an automated reasoning program as a research colleague. Indeed, as a result of an odd concatenation of circumstances, we were driven to seek a new axiom system—the motivating force for the third conjecture. The conjecture asserts that failure results from an attempt to use condensed detachment to show that the formulas I numbered (4), (5), and (6) provide an axiomatization for two-valued sentential calculus, where the specific objective is to deduce (7), (8), and (9), which are, respectively, (L1), (L2), and (L3). As one may have correctly surmised from the current discussion, our goal was actually to refute the conjecture and, instead, show that we had an axiom system—a new axiom system.

Rather than considering the conjecture as stated and seeking to deduce (7), (8), and (9) from (4), (5), and (6), we chose what we suspected to be an easier question to attempt to answer. In particular, we had learned (from browsing in various papers of Lukasiewicz) of yet another axiom system, one that shares (with the system under study) the formulas numbered (4) and (5). In place of (6), the system has (\((\sim(x \rightarrow y) \rightarrow ((x \rightarrow y) \rightarrow (x \rightarrow z))\)) as its third member; Lukasiewicz calls this formula thesis 59. In fact, our choice of (4), (5), and (6) was an intuitive one, based on knowledge of the cited closely related system.

Here is the “additional evidence” alluded to earlier: From (4), (5), and (6), OTTER deduced thesis 59, and we had found a new axiom system. Therefore, as a bonus, we refuted the third conjecture. Then, from curiosity, we had OTTER seek to prove (7), (8), and (9) directly. Success: The shortest proof obtained consists of 23 applications of condensed detachment.

Returning to thesis 59 with the objective of adding to the intrigue of using an automated reasoning program, I now present an elegant proof found by OTTER, a proof that Scott commented is the type that a person might never have discovered. (Since the following proof relies on unification in a nontrivial way, one might wish to delay its detailed examination until briefly studying the examples given in the review of the elements of automated reasoning.) In the following proof, the steps are numbered based on the OTTER run, where “...” means not, “\(\wedge\)” means or, and the predicate \(P\) can be interpreted as “is deducible”. Also, \([\text{hyper},1,j,k]\) means that the inference rule \(\text{hyperresolution}\) (exemplified later) is used with clause \((1)\) to capture condensed detachment, that the clause numbered \(j\) is the major premise used with the first literal of \((1)\), and that the clause numbered \(k\) is the minor premise used with the second literal of \((1)\). In the proof, \(a\), \(b\), and \(c\) are constants, the function \(i\) is used for \(\rightarrow\), and the function \(n\) is used for \(\sim\).

**An Elegant Proof**

<table>
<thead>
<tr>
<th>Step</th>
<th>Formula</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>(\sim(i(i(x,y)), P(x, y)))</td>
</tr>
<tr>
<td>3</td>
<td>(\sim(i(i(x,y), z), i(y, z)))</td>
</tr>
<tr>
<td>4</td>
<td>(\sim(i(i(x,y), z), i(i(x,z), y)))</td>
</tr>
<tr>
<td>5</td>
<td>(\sim(i(i(x,y), z), i(i(x,z), y)))</td>
</tr>
<tr>
<td>6</td>
<td>(\sim(i(i(x,y), z), i(i(x,z), y)))</td>
</tr>
</tbody>
</table>

39 \([\text{hyper},1,10,9]\) \(i(i(i(x,y), z), i(i(x,u), z)))\).  
51 \([\text{hyper},1,39,8]\) \(i(i(i(x,y), z), i(i((x,y), x), y))\).  
212 \([\text{hyper},1,51,8]\) \(i(i(i(x,y), z), i(i(i(x,y), u), i(y, u)))\).  
8405 \([\text{hyper},1,212,10]\) \(i(i(n(x), y), i((i(y,z), i(i(x,z), y)))\)).

Clause (8405) contradicts clause (25), and the proof is complete, requiring approximately 108 CPU seconds on a SPARCstation 2.

In the context of elegant proofs, one might find intriguing the challenge of seeking, if possible, proofs shorter than the three cited here of respective lengths 22, 23, and 4, where length is measured strictly in terms of the number of applications of condensed detachment.

**The Five Elements of Automated Reasoning, a Short Course**

At this point, I will briefly review the five basic elements of automated reasoning: representation of information, inference rules for drawing conclusions, strategy for controlling the reasoning, a means for canonicalization, and a means for purging trivial information. I will concentrate on the features found in what might be called the Argonne paradigm \([11, 13]\). Among those features are the retention of deduced conclusions, the emphasis on strategy, the use of various inference rules, the control of redundancy, and the detection of assignment completion almost always by completing a proof by contradiction. At the most general level, since my entrance into the field in 1963, these features have played a key role in Argonne’s research and in Argonne’s design of reasoning programs.

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**Figure 1: Progress in Automated Reasoning 1960-1991**

Compared to the paradigm now reviewed, I have never believed there existed as much potential in seeking to emulate person-oriented reasoning, a common theme found in artificial intelligence. That belief perhaps explains my introduction of
the explicit use of strategy (in the early 1960s), my formulation of the inference rule paramodulation, and my endorsement of the use of the clause language to present questions and problems to a reasoning program. For a small taste of my position, I note that people find instantiation to be a powerful and useful inference rule; however, I recommend against its use by a computer program. Indeed, where the researcher can and typically does choose well which instance of a fact to use—for example, profitably choosing the instance $(yz)(yz) = e$ of the equation $x = e$ when seeking to prove commutativity for Boolean programs—I conjecture that countless years will pass before a means will exist for a program to apply instantiation wisely.

Nor am I in favor of the currently popular approach (to the automation of reasoning) based on logic programming, especially when the question or problem under study is even moderately deep. Indeed, for the type of question of greatest interest to me—questions from mathematics and logic are my favorites—I consider it essential to retain deduced conclusions, of course, filtered greatly to control redundancy and to emphasize significance. I maintain this view—or bias?—in part because of making various comparisons among reasoning programs. As those who are familiar with my research can attest, my conviction continues to grow concerning the potential of the paradigm I now discuss.

Representation and Unification

Regarding the clause language for communicating with OTTER, the following example serves well for introducing it and for providing a minute taste of unification, the procedure so crucial to so many procedures used by the program. Were OTTER to deduce the following two clauses, it would immediately "know" that a proof by contradiction had been completed.

\[
\begin{align*}
GT(a,x),
\quad -GT(y,b).
\end{align*}
\]

Of course, strictly speaking, neither clause has any semantic content. But one can interpret them, respectively, in the following way. "For all $x$, the constant $a$ is greater than $x$." "For all $y$, $y$ is not greater than the constant $b$." OTTER detects a contradiction by using unification, substituting $b$ for $x$ in the first clause and $a$ for $y$ in the second. Unification is that procedure that finds, if one exists, a most general substitution for two given expressions such that, when applied, the resulting expressions become identical. In the given example, the two expressions are the clauses with the not sign ignored.

Inference Rules and Unification in Greater Detail

In contrast to considering just two clauses at a time, OTTER also uses inference rules that consider three (or more) clauses at a time—as suggested by the 4-step proof given earlier. For an example of this type of reasoning—actually, an example of hyperresolution— I select the first deduced conclusion in the 4-step proof cited earlier as evidence of elegance; let us examine how it is obtained. Of the following four clauses, OTTER attempts to find a substitution for variables to simultaneously apply to the first three clauses to yield the fourth. The variables are renamed for convenience.

\[
\begin{align*}
1 &\quad -P(i(i(x,3),y)), -P(x,3), P(y,3).
9 &\quad P(i(i(i(x,1),y,1),z,1),i(n(x),1,1)).
10 &\quad P(i(i(i(u,2),i(n(x,2),z,2)),i(u,2,i(i(i(y,2),z,2),i(i(x,2),y,2),z,2)))
39 &\quad P(i(i(i(x,2),y,z),i(i(i(u),z),i(i(x,2),u,z)))
\end{align*}
\]

The desired substitution that will (ignoring sign) unify clause (10) with the first literal of clause (1) and at the same time unify clause (9) with the second literal of clause (1) is $x$ for $x_1$, $y$ for $y_1$, $z$ for $z_1$, $i(i(x,y),z)$ for $u_2$, $x$ for $x_2$, $u$ for $y_2$, $z$ for $z_2$, $i(i(i(x,y),z),i(n(x),z))$ for $x_3$, and $i(i(i(x,y),z),i(i(u),z),i(i(x,u),z))$ for $y_3$. After the substitution is applied simultaneously to clauses (1), (9), and (10), the cited literal pairs (ignoring sign) become identical and, because of being opposite in sign, are canceled to yield clause (39).

Although logicians with diverse interests have for years applied condensed detachment by hand, we have a good illustration of why a program such as OTTER finds its application far less of a burden. For a more powerful illustration—showing why the cited 4-step proof might indeed not have been discovered by a person—one need only complete a detailed analysis of the last three steps of that proof with the objective of obtaining the appropriate sets of substitutions for the various variables. The fourth step is particularly interesting, for it rests on the use of nontrivial variable replacement in all three of its ancestors.

Let me now illustrate the use of paramodulation in the case where one is permitted to make nontrivial replacement of terms for variables in both the from statement and the into statement. For an example of the latitude permitted in the use of paramodulation—an example showing how this inference rule generalizes the usual notion of equality substitution—consider the following three clauses and apply paramodulation from the first into the second to yield the third; from the viewpoint of mathematics, paramodulation applied to both the equation $x + (-x) = 0$ and the equation $y + (-y + z) = z$ yields in a single step the conclusion $y + 0 = (-y)$.

\[
\begin{align*}
\text{EQUAL}(\text{sum}(x,\text{minus}(x)),0).
\text{EQUAL}(\text{sum}(y,\text{sum}(\text{minus}(y),z)),z).
\text{EQUAL}(\text{sum}(y,0),\text{minus}(\text{minus}(y))).
\end{align*}
\]

To see that this last clause is in fact a logical consequence of its two parents, one unifies the argument $\text{sum}(x, \text{minus}(x))$ with the term $\text{sum}(\text{minus}(y), z)$, applies the corresponding substitution to both the from and into clauses, and then makes the appropriate term replacement justified by the typical use of equality. The substitution found by the attempt to unify the given argument and given term requires substituting $\text{minus}(y)$ for $x$ and $\text{minus}(\text{minus}(y))$ for $z$. To prepare for the (standard) use of equality in this example—and here one encounters a
key feature of paramodulation—a nontrivial substitution for variables in both the from and the into clauses is required, which illustrates how paramodulation generalizes the usual notion of equality substitution. I also note that, most likely, a researcher would not find delight in applying paramodulation by hand: This inference rule is not particularly reminiscent of person-oriented reasoning.

Strategy
Having touched on the language and some of the inference rules used by OTTER, I turn next to strategy. In view of some of the current efforts in automated reasoning, apparently many still feel that strategy is unneeded or believe that the simplest of strategies suffices. Obviously, I do not share this view, at least when the domain of study concerns even moderately deep questions from mathematics or logic. Certainly, excellence in program design and implementation is required—as one finds in McCune's program OTTER—and also required is a language possessing representation adequacy, as is offered by the clause language. Also, one must have access to inference rules whose use, in addition to drawing conclusions only if they follow logically, contributes significantly to program effectiveness. However, far more is required, for the heavy sword of potential combinatoric explosion always hangs over the head of the program attempting to answer a deep question. Indeed, as observed by Woody Bledsoe (University of Texas), for hard problems from mathematics even access to 10,000 times more computing power will not suffice. One thus sees why I and others are so interested in some means to address the potential combinatoric explosion—and strategy to control the program's reasoning seems to offer by far the best attack against this obstacle.

At the most general level, strategy can be classified into two types: one type to restrict the search for information and one type to direct the search. If history is a good teacher, powerful restriction strategies are of far greater value than are powerful direction strategies—because the former offer a greater reward by directly addressing the potential of combinatoric explosion and the latter address this obstacle only indirectly. Especially for the following discussion, recall that, almost always, seeking a proof by contradiction is not a safe if the identity that the purported theorem under study is not satisfiable and, therefore, has a model.

Of a totally different nature is the restriction strategy known as weighting. One use of this strategy enables the researcher to assign a maximum on the complexity of information to be retained. One can, for example, instruct the program to immediately discard any conclusion if it contains a term of the form \( f(f(q, r), s), t) \) for terms \( q, r, s \), and \( t \), where, for example, the function \( f \) might be used for product. Of course, as one would suspect, weighting permits the use of far more complex templates, giving the researcher the opportunity of providing little or much advice concerning the undesirability of expressions. Undesirable expressions as defined by the researcher—those whose weight, based on the given templates, exceeds the user-assigned maximum—are immediately purged by the program; where templates are not applicable, the program simply uses symbol count to determine the weight of a deduced conclusion.

Weighting can also be used to direct a program's search. Indeed, if one wishes the program to choose (as the focus of attention) information by substituting for symbol count a different measure of complexity, one includes (in the input) templates with assigned values to enable the program to place priorities on each item of retained information. The smaller the weight of an item (a clause), the higher the priority it has. For example, for questions focusing on group theory, the researcher can cause the program to prefer statements concerned with inverse over those concerned with the identity. For questions taken from propositional calculus, a researcher can cause the program to emphasize the role of formulas containing a term of the form \( n(i(x, y)) \) while placing far less emphasis on those containing a term of the form \( i(n(x), y) \). Thus, by judicious choice of the weight templates, if desired, the researcher can have an automated reasoning program direct its search based on the researcher's intuition and expertise.

Of a different flavor, one can instruct a reasoning program to make a breadth-first search, considering each item of information in the order it is retained. I note that for many years I considered this strategy, called level saturation, to be naive and of little value for answering interesting questions. However, despite numerous experiments supporting that original position, I have recently modified my stand, for...
my colleagues and I have put this simple strategy to good use, obtaining some shockingly short proofs. Were it not for the ease of having OTTER apply level saturation, I almost certainly would have missed this opportunity of revising and updating my views and, therefore, missed the corresponding amusement—a glance in the mirror of history does sometimes produce laughter. For the curious, I note that the implied conclusion is correct: In the vast majority of cases, weighting is a far more effective direction strategy than is level saturation. But there exists a strategy, the ratio strategy, that combines some of the advantages of the two strategies just compared. Its use permits a program to occasionally use very complex formulas—however complexity is defined by the researcher—while mainly concentrating on the less complex. The ratio strategy is of particular value when a proof requires getting over a hump whose form is a long, long clause.

Redundancy Control

Even though a program such as OTTER offers various other useful strategies—some of which powerfully restrict the application of paramodulation—the obstacle of redundancy nevertheless exists. The same conclusion can be reached repeatedly, and no reason exists for retaining more than one copy. Further, a more general conclusion can be reached, either before or after instances of it are deduced. Ordinarily, no need exists for retaining the less general conclusions. A somewhat subtler form of redundancy is that found in a set of expressions all of whose members can be canonicalized to a common expression. The subtler obstacle is addressed in the Argonne paradigm by using demodulation to canonicalize and simplify conclusions through the use of demodulators (rewrite rules). The researcher can supply the demodulators or OTTER can find them by applying user chosen criteria. Regarding the more blatant form of redundancy, the program relies on subsumption to identify and purge statements (clauses) that are captured as corollaries of other statements.

The Challenge of Problem Presentation

At this point, I fulfill my earlier promise concerning the discussion of the sometimes burdensome aspect of presenting a question or a problem to an automated reasoning program and, more specifically, answer the natural question concerning the difficulty of producing the clauses needed to convey to OTTER the nature of the intended study. When the area of interest is one that has been the subject of numerous experiments in automated reasoning, little difficulty is encountered, at least at the start. For example, if the area is group theory, ring theory, lattice theory, Tarskian geometry, or equivalential calculus, the book Automated Reasoning: 33 Basic Research Problems [11] provides the researcher with a decent start. For clauses to study combinatory logic—especially in the context of the kernel strategy—I suggest [12]. As for set theory, although a nice start is provided by [6] and by [11], experimentation quickly leads to the conclusion that far more is desired—in particular, when the context is more proof finding than proof checking. Indeed, experiments with OTTER suggest that an intriguing challenge exists: Find, if possible, a small set of clauses—perhaps 14 or fewer—that the program can use to easily prove numerous simple theorems and, in the main, without guidance from the researcher. Clearly, I am implying that finding proofs rather than checking proofs is more useful, more satisfying, and more demanding.

Regarding the use of OTTER for the study of areas of mathematics and logic for which no template exists, the researcher finds a substantial challenge—but a challenge that, almost certainly, can be met. Even in the context of proof checking, which is less taxing than is proof finding, one may be required (for a new area of study) to make a substantial effort to produce clauses that the program can use effectively. Although not at all obvious, regarding proof checking, the vast majority of theorems is within range of automated reasoning, at least in principle. In particular, although exceedingly far from delectable, one can always fall back on the use of clauses for G"odel’s finite axiomatization of set theory [11].

Instead, for each new venture, I conjecture that—riskily though it clearly is—the possible reward merits an attempt at finding suitable clauses that avoid the use of G"odel’s axioms, and, further, of finding clauses that OTTER can use effectively in the context of finding proofs. The important point to keep in mind is that neither the use of the clause language nor the use of OTTER limits the researcher to those areas of mathematics and logic contained within the convex hull of what has been studied (to this point in 1992) with the assistance of an automated reasoning program.

If one wishes to use OTTER as a research assistant, but prefers to avoid the task of producing appropriate clauses, the program does offer an alternative—at least, for those who know first-order predicate calculus. In particular, one can present to OTTER a question or problem in the form of a fully quantified formula relying on the various connectives of the calculus, and the program will translate the formula into acceptable clauses. Regardless of how clauses are produced, an important distinction exists between an accurate representation of the question or problem under study and an effective representation. Indeed, because the representation admits various choices—as in mathematics and in logic, uniqueness of representation is absent—to be effective, one best take into account the inference rule and strategy that the program is instructed to use.

For an illustration, I focus on group theory, choosing as the inference rule paramodulation, a rule that treats equality as a built-in concept. Once paramodulation is chosen from among the inference rules offered by OTTER, the representational choice is virtually dictated, if effectiveness is of paramount consideration. For the respective clauses for the existence of a two-sided identity, a two-sided inverse, and associativity—and the often overlooked reflexive property of equality—I recommend the following, given in OTTER notation.

(1) \(\text{EQUAL}(\text{prod}(e,x),x)\).
(2) \(\text{EQUAL}(\text{prod}(x,e),x)\).
(3) \(\text{EQUAL}(\text{prod}(\text{inv}(x),x),e)\).
(4) EQUAL(prod(x,inv(x)),e).
(5) EQUAL(prod(prod(x,y),z),prod(x,prod(y,z))).
(6) EQUAL(x,x).

If one then assumes that the theorem to be proved asserts that Boolean groups (those in which, for all \( x \), the square of \( x \) is the identity \( e \)) are commutative, one would add to the input the following clauses.

(7) EQUAL(prod(x,x),e).
(8) -EQUAL(prod(a,b),prod(b,a)).

Motivated by the intention of seeking a proof by contradiction, I include clause (8), asserting that commutativity is absent—absent for at least two elements. As for strategy, I recommend the set of support strategy, instructing OTTER to follow only those lines of reasoning that begin with clause (7) or clause (8), using the other six clauses to complete applications of paramodulation. To gain some familiarity with the use of the chosen inference rule and the chosen strategy—or simply for entertainment—one might attempt to use the eight clauses in the prescribed fashion to find a proof by hand; in other words, the use of instantiation is not permitted.

Summary and Conclusions
Rather than releasing a torrent of information and evidence, I have instead presented little more than a trickle to suggest how an automated reasoning program serves well as a research assistant. In that regard, my colleagues and I have used such a program to prove theorems, test and suggest conjectures, construct objects, produce more elegant proofs than previously known, and—clearly of greatest satisfaction—answer open questions from various unrelated fields of mathematics and logic. Through the use of automated reasoning—and mainly through the use of the automated reasoning program OTTER—we have answered questions from group theory, combinatory logic, finite semigroup theory, and various logic calculi. Some of the questions were posed by Irving Kaplansky, some by Raymond Smullyan, and some by John Kalman.

Our successes motivate my recommendation that researchers be at least skeptical when reading articles such as “Computers Still Can’t Do Beautiful Mathematics” (New York Times, July 14, 1991, Week in Review). Indeed, to see that beautiful mathematics sometimes results from the use of an automated reasoning program, one need only consider the three conjectures offered at the beginning of this article, review OTTER’s approach to settling each, and study the additional open questions whose answers I cite. Were one to apply a Turing-like test to the results produced by OTTER—a test that asks if an observer can know whether a computer or a researcher produced them, emphasizing quality, significance, and elegance—I suspect that rather high marks would be given.

Whether the turn of the century will find many open questions under attack by a team consisting of a researcher and an automated reasoning program is left to time to settle. Clearly, the preceding decade has witnessed a sharp increase in that regard, sometimes culminating in the answer to a question that had remained open for decades. Thus we have evidence that an automated reasoning program can and occasionally does contribute to mathematics and logic.

The field of automated reasoning is relatively young (dated by some as beginning in the early 1960s) and, fortunately, still most challenging. Approximately 40 years ago, one might indeed have wondered how research could possibly address the three main obstacles to the automation of logical reasoning: a language to present to a computer the specific question of interest, a means for the computer to draw sound conclusions, and a strategy for sufficiently controlling the reasoning to permit the computer to complete the underlying research. In this article, I show how these obstacles and others that were eventually identified were overcome, focusing mainly on the approach taken within the Mathematics and Computer Science Division of Argonne National Laboratory. Because open questions have played such a key role in the development of our approach, I eagerly seek additional open questions to attack with our newest program OTTER.

Although at the simplest level an automated reasoning program (of the type featured in this article) just accurses conclusions with no understanding of their meaning, I show in this article how the program’s use of strategy can totally change the game. Indeed, strategy plays a key role in our paradigm. The paradigm also relies on the use of a number of inference rules, some of which are clearly oriented to application by a computer rather than by a person—for example, paramodulation, which effectively generalizes equality substitution. Thus a program such as OTTER is far more than a symbolic calculator offering impressive speed and accuracy: Such a program reasons logically, sometimes so effectively that the results are published in mathematics and in logic journals.

Rather than ever being a replacement for the mathematician or logician, automated reasoning programs nicely complement the researcher. Indeed, their value as research assistants should continue to grow—and perhaps at an increasing rate.

Source Material
More than any other reasoning program of which I have knowledge, we recommend McCune’s program OTTER, which runs effectively on workstations, (IBM-compatible) personal computers, and Macintoshes. Among its excellent features, its use produces proofs that include all steps and the corresponding justification, permitting one to follow the typical practice in mathematics and logic of a thorough reading, occasionally gleaning from one of the proofs unexpected insight into the field under study.

Consistent with my objective of encouraging researchers to use an automated reasoning program and my objective...
of accruing additional open questions to attack—awkward though it may be—I recommend consideration of my newest book *Automated Reasoning: Introduction and Applications*, second edition [13]. This McGraw-Hill volume contains a copy of OTTER on diskette, the source for workstations, and load modules for personal computers. The sixteenth chapter is devoted solely to a tutorial on the use of OTTER, and useful input files are found throughout the book. Also, information for obtaining a copy of OTTER is available by sending email to otter@mcs.anl.gov, and information for accessing a database of problems and proofs is available electronically, by accessing info.mcs.anl.gov via anonymous FTP.

References


Mathcad 3.1:
Calculations for the Rest of Us
Reviewed by William H. Ruckle*

Contributors to this column sometimes give me the impression that computational power is the only legitimate goal of mathematical software. If you believe this, then you need only know that Mathcad is not in the same league as Mathematica or Maple and let the matter rest. Maybe you also open cans with a chain saw instead of a can opener, because the chain saw is a more powerful tool—I don’t know. Obviously you want a program that can do all the computing that your research requires, but you don’t want to spend extra time programming the tool and organizing the output. Mathcad emphasizes convenience and attractive output. The screen display looks like standard mathematics: two story fractions, derivatives \( \frac{dy}{dx} \), integral signs \( \int_{a}^{b} \), matrices with brackets around them, summation symbols, etc. You can add commentary with a rudimentary word processor. You can create attractive graphics. You can organize your calculations and comments and create a nice-looking printed output. The figures on the next page match the screen except they lack color and the printing is better.

Mathcad 3.1 runs as a Windows application. In addition to a Windows configuration, it requires an 80286 or better CPU, at least 2 megabytes of memory (you need this for Windows 3.0 anyway), and at least 7 megabytes on your hard disk. A mathematics coprocessor is recommended. I ran the review copy on a generic (V-Com) 80486 with 4 megabytes of ram running at 33 megahertz. The printer was an Epson Action Laser II configured as a Hewlett Packard IIP.

The most significant addition in the present edition of Mathcad is a symbolic calculator utilizing the Maple engine. A nice test of the power of Maple is to take the determinant of an \( 8 \times 8 \) skew symmetric matrix and then factor it to see that it is a perfect square. Mathcad did this for a \( 4 \times 4 \), but for a \( 6 \times 6 \) gave me the message “discarding huge symbolic result” when I tried to take the determinant. I would have liked to factor this “huge symbolic result”, for then it wouldn’t have been so huge. Mathcad did give the correct result 0 for the determinant of a \( 5 \times 5 \) general skew symmetric matrix.

Another notable Mathcad feature is a set of electronic handbooks which you can open within Mathcad. You can paste material including diagrams and formulas from a handbook into your worksheet and manipulate it. This seems useful for an engineer writing a report or a student doing an assignment. There are two ways to summarize Mathcad’s capabilities.

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Examples of Mathcad

1. A simple equation. \[ x := 1.1 \quad \text{root}(e^x + x - 2, x) = 0.443 \]

2. The determinant of a general four by four skew symmetric matrix using Maple. It failed on a 6 by 6, but did show that a five by five has determinant 0.

You first enter the matrix.

\[
\begin{bmatrix}
0 & -a & b & -c \\
a & 0 & -d & -r \\
b & d & 0 & -f \\
c & r & f & 0
\end{bmatrix}
\]

Then you ask for the determinant.

\[ a^2 f^2 + 2a b c f - 2a r b f + b^2 r^2 - 2b r c d + c^2 d^2 \]

Then you factor the determinant to see it is a perfect square.

\[ (f a + d c - b r)^2 \]

3. A rose of many petals

\[ N := 300 \]
\[ \theta := 0, 2 \frac{\pi}{N} \ldots 10 \cdot \pi \]
\[ r(\theta) := \cos(3.2 \cdot \theta) \]
\[ x(\theta) := r(\theta) \cdot \cos(\theta) \]
\[ y(\theta) := r(\theta) \cdot \sin(\theta) \]

4. A Surface Plot - Sombrero Function

\[ N := 40 \quad i := 0 \ldots N \quad j := 0 \ldots N \quad x_i := -4 + \frac{i}{5} \quad y_j := -4 + \frac{j}{5} \]

\[ f(x, y) := \frac{\cos(x^2 + y^2)}{1 + x^2 + y^2} \]

\[ M_{(i,j)} := f(x_i, y_j) \]
• It's like an undergraduate engineering student who can
draw beautiful graphs and can make A's in all her math
courses except differential equations.
• It does everything a symbolic calculator can do; can do it
faster, easier and better; and can also give you an attractive
annotated printout.

The User's Guide is clearly written, but you can't always
find what you want in the index. It is easy to start using
Mathcad for routine things, and you can often discover how to
do more complicated things by trial and error. There are a few
quirks. For example, you can obtain subscripts by entering a
period after a letter or by clicking on a subscript with a mouse;
but the first kind of subscript is not the same as the second
kind and behaves differently. The mouse operation borders
on the erratic; a performance which drove me away from the
early Macintoshes. When you click outside a formula you can
obtain at least four different actions depending on the position
of the cursor. There is no way to keep this from slowing you
down. Combining graphic interface and wysiwyg makes it
difficult for the user to align regions of text and mathematics
as he or she really wants them. The manufacturers might add
guidelines in a future edition. A real "math scratch pad" has
lines or even a grid. The symbolic tool seems not to like
subscripts; sometimes it gave me the wrong symbolic solution
to equations containing subscripted variables.

From my comments you can rightly conclude that Mathcad
will appeal to engineers, scientists, technicians, and all sorts
of students in technology. It is also good for the everyday
calculational and educational needs of mathematicians. In
my opinion, it is more appropriate than Mathematica as an
instructional tool in calculus since it requires less hardware,
provides an intuitive interface, and gives a readable output. It
is easier to use than a symbolic calculator, even though you
can't put it in your pocket.

A good problem for a computationally oriented student is
to find the value of the integral

\[ \int_0^1 \sqrt{1 - x^{17}} - \sqrt{1 - x^9} \, dx. \]

A student with insight may see the value is 0 because
the graph of the second function is just the graph of the first
rotated through 90 degrees, and so they have the same area
under them. I have never received this answer from one of
my students. Mathcad and a programmable calculator will
give an answer of the order 10^{-8}. I have often received this
answer with no indication that the tiny answer has given the
student a clue about the truth. Mathematica gives the correct
answer 0, possibly by finding an antiderivative in terms of
 gamma functions; but, strangely, students (usually graduate
students) who report this call it an "approximate" answer.
Another popular way of doing this problem is simply to find
the wrong antiderivative.

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Matrix Algebra Version 2.2
Reviewed by Suzanne M. Molnar*

Matrix Algebra is a program for aiding students to solve certain
linear algebra problems. Developed by Bernard Kolman and
Todd Rimmer of Drexel University, it is available from Intellimation Library™ for the Macintosh, P.O. Box
1922, Santa Barbara, CA 93116-1922, phone: 805-968-2291.
The program comes with a 36-page manual which clearly
documents the operation of the program. The small system
requirements for the program are one of its main features,
namely, minimum memory of 128K and System 3.2 or later.

The program is designed to be used in a course in which
basic matrix manipulation is a topic. It emphasizes the tech­
nique of Gauss-Jordan reduction, and as the manual admits,
the "program is not as thorough" in matrix multiplication.
Specifically, Matrix Algebra transforms a matrix to reduced
row echelon form, solves a linear system, multiplies two
matrices, finds the inverse of a matrix, and offers explanations
if requested. The maximum size of a matrix is 6 x 12, which
has the effect of being able to solve a linear system of up to
6 equations in 11 unknowns. Improvements over a previous
version include the ability to save matrices and equations
on a disk, improved accuracy and range of values, expanded
documentation and, for numerical analysis, partial pivoting
and control over format of numbers.

Input to the program is easily accomplished by well­
designed dialog boxes that allow the user to input a matrix,
system of equations, or two matrices to multiply. A wel­
come feature is that scripting is accomplished easily for
WYSIWYG-looking linear systems. A not-so-welcome fea­
ture is that all input must be in the form of rational numbers.
This gets a bit tedious when one enters 21.38 as, say, 2138/100,
which the program happily reduces. Things get more dicey
when using the program to enter 0.00609 in its rational
equivalent. An unexpected plus is that students may learn how
to convert from a decimal to its rational equivalent! When
entering data into a dialog box, the program is very good at
alerting the user to unacceptable input.

Figures 1 and 2 are two snapshots of the screen as one
proceeds to solve a system of equations by row reduction.
Figure 2 clearly shows all seven movable/resizable windows;
their functions are self-evident from their titles. Three win­
dows (Prior Matrix, Prior System, and Floating Point) may
be hidden via the Controls menu. Although matrix input
must be in rational format, the floating point format can be
seen in the output. Matrix Algebra allows the user to step
through a row reduction. The Row Reduce menu allows one
to choose an elementary row operation to perform on the
given matrix/system. Figure 1 shows the dialog box for such
an operation; here, the user selects the row and scalar. Figure
2 shows the results of that operation in Prior Matrix/System

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windows. One can also choose an explanation of the next step from the Explain menu; that step is then performed without user intervention. This is illustrated in Figure 2 with results shown in Current Matrix/System windows. There is also an option to automatically row reduce. The Extras menu includes Inverse and Multiply options.

<table>
<thead>
<tr>
<th>Explained</th>
<th>Current Matrix</th>
</tr>
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<tbody>
<tr>
<td>4/5</td>
<td>-1/2</td>
</tr>
<tr>
<td>-2/5</td>
<td>9/10</td>
</tr>
<tr>
<td>1</td>
<td>-1/2</td>
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<tr>
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<td>4/5</td>
<td>-1/2</td>
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<td>-2/5</td>
<td>9/10</td>
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<tr>
<td>1</td>
<td>-1/2</td>
</tr>
</tbody>
</table>

Figure 1

Another feature is the Partial Pivoting option under the Controls menu. When this option is selected, partial pivoting is used to determine the inverse of a matrix and to perform automatic row reduction. Normal pivoting will continue to be used for explanations, so as not to confuse “the beginner”. With suitably chosen ill-conditioned matrices, this feature allows one to get an introduction to numeric issues involving finding inverses and solutions to linear systems.

In conclusion, this program has very low overhead both in terms of ease of use (no syntax to learn) and hardware requirements (minimal). Although limited in the scope of problems it can solve, it can serve as a useful aid to student understanding of elementary matrix operations and give them a glimpse of some of the problems faced when one must implement real-world problems on real-world machines.

Perhaps the program could serve as a stepping stone to more general purpose packages such as MATLAB or Mathematica.

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**The TI-85**

Reviewed by Roger Pinkham*

As chips grow smaller and some are designed for special purposes, the distinction between software and hardware becomes increasingly blurred. “One man’s ceiling” is indeed “another man’s floor”.

For purposes of this review I treat the TI-85 as a piece of very clever software. The case is the same size and weight

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as the TI-81, but black in color. By means of a small cable you can send and receive programs, data, variables, etc., between one TI-85 and another. By means of special software (LINK-85) and another little cable you can send and receive between a PC and the TI-85, thereby storing, recovering, and printing pictures, programs, data, etc.

Although the same size as a TI-81, this handheld has 32K bytes of memory of which some 28,226 bytes are available to the user. Everything is menu driven, and the user machine interface is a very convenient design.

You can effortlessly graph just about anything, zoom in, zoom out, trace along a curve, store, and recall. You can turn pixels on and off, draw circles and lines, and shade figures at will. The menus allow the user to find slopes and local extrema without effort. There is also a numerical integration routine which works easily and well.

In contrast to the TI-81 there is a proper polar graphing mode as well as parametric graphs. Variables can be real or complex. Strings, lists, vectors, and matrices are all supported data types. There is a matrix editor to make entry and modification easy, and the only restriction is that one may not have more than 255 rows or 255 columns (!). The TI-85 will give the determinant, exponential, sine, or cosine of a square matrix. It will also give the integer part or fractional part element by element of any matrix. You may also have, at the punch of a button, the LU decomposition, eigenvectors, eigenvalues, the condition number, and a variety of norms.

You may also swap rows, multiply a row by a constant and add to yet another row, or concatenate two matrices together. Just as the software admits adding, multiplying, etc., matrices, so does it give dot products, addition, conjugates, absolute value, etc., of vectors.

The SOLVER menu automatically finds zeroes of equations of the form \( f(x) = 0 \) or \( f(x) = g(x) \). A special feature finds roots of polynomials up to degree 30 (real or complex). The SIMULT menu effortlessly handles the solution of systems of simultaneous linear equations up to 30 by 30.

There is a full complement of tools for entering and analyzing statistical data. You may have linear, exponential, or logarithmic regressions with all the attendant means, variances, and correlations. There is a built-in sort routine, scatter plots, and histograms. When I get a machine of my own I shall certainly add a boxplot routine, some smoothers, and something to give tail areas of the normal.

An unexpected and very useful feature is the ability to solve up to 9 simultaneous differential equations numerically and view the output graphically.

Like the TI-81, the 85 provides the opportunity to write your own programs, but now the language has been enlarged to include For loops, While and Repeat statements, as well as If-Then-Else constructions.

I am told the handheld will list for around $120 and the LINK-85 software and cable for around $65. (The latter is not yet commercially available, but the prototype I exercised worked well). Yesterday I ordered my own TI-85 from a dealer for $109.95. This is an enormous functionality for $110 (much of which I have not described). Teachers can even get a $20 rebate from TI! This machine will certainly give Hewlett-Packard's HP48S and HP48SX a run for the money.

A very good calculus course, numerical linear algebra class, or numerical methods course could be built around the use of this machine.

My only complaint in testing the software was that once a variable was created by assigning a value to it in the midst of a program, I could find no way to purge the variable from within the program when it was no longer needed.

In summary I find this a remarkable piece of software for the money and an ideal tool for the college crowd.

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**Announcement**

**GP/PARI System**

**Fernando Gouvêa**

Fernando Gouvêa reports that, since his article on the GP/PARI system was published here some time ago, he has received several queries about a version that would run on 386-class IBM-compatible machines. Two such versions are now available from ftp at math.ucla.edu. The first is simply a gp executable that will run under DOS on 386 machines. It is offered anonymously with no promise of support. The second is a port of the whole GP/PARI package that includes an executable that will run under both DOS and OS/2 on 386 machines. The latter was prepared by Fernando himself using the "emx" port to OS/2 of the Gnu C compiler. Both versions require an arithmetic coprocessor when running on 386 machines (the 486 chip includes a coprocessor); under OS/2, such a coprocessor is automatically emulated if it is absent, but the emulation will likely render the program unusably slow. While Fernando can offer only limited support for the program, he would like to know of any serious glitches.
News and Announcements

Derrick Henry Lehmer 1905–1991

Derrick Henry Lehmer was born in Berkeley, California on February 23, 1905. One of five children of Derrick Norman Lehmer and [Clara] Eunice Mitchell, he grew up and was educated in the public school system of Berkeley. At that time Berkeley was already becoming an intellectual center, with the new University of California having relocated there from Oakland some twenty-five years earlier. Also, his father had been professor of mathematics at UC Berkeley since 1900 when he had obtained his Ph.D. in mathematics under E. H. Moore at the University of Chicago. (See The National Cyclopedia of American Biography, vol. 28, pp. 78–79, for an excellent biography and photo of this remarkable man.)

When Lehmer was a boy, and later, his father was a major influence in his mathematical education, introducing him to and involving him in the use of the basic algorithms of arithmetic and number theory and the process of sieving to solve various mathematical problems. (For a discussion of a lifetime involvement with the sieving machines D. H. Lehmer designed and used, see paper #155 in Selected Works of D.H. Lehmer, The Charles Babbage Research Centre, P.O. Box 272, St. Norbert Postal Station, Winnipeg, Manitoba, Canada R3V 1L6.)

As an undergraduate at U.C. Berkeley, Lehmer studied mathematics and physics, graduating in physics in 1927. In 1928 he married Emma Markovna Troskaia (born in 1906 in Samara, Russia), a young student who had come to Berkeley from Harbin in 1924 to study engineering, but who, after two years, changed to mathematics and began to assist the two Lehmers in their mathematical work. Emma graduated from Berkeley in mathematics in 1928.

From 1927 to 1930 Lehmer was a graduate student, for one year at the University of Chicago where he met (but did not like working with) L. E. Dickson, and for two years at Brown University where he received his Ph.D. in 1930 under J. D. Tamarkin.

From 1930 to 1933 he was a fellowship student at CalTech (where he studied with E.T. Bell) and at Stanford University (where he became acquainted with J. V. Uspensky). In 1933 his ingenious and powerful photo-electric number sieve became operational in Pasadena. With this sieve he did factorizations and carried out primality tests that were amazing in that era. The sieve was also displayed (nonoperationally) at the Chicago World’s Fair during that summer. He spent the year 1933–1934 on a fellowship at the Institute for Advanced Studies at Princeton.

From 1934 to 1940 Lehmer was on the staff at Lehigh University, with a year’s leave in 1938–1939 on a Guggenheim Fellowship to Cambridge, England. In 1940 he accepted a proffered position in the mathematics department at U.C., Berkeley, a position he held until his retirement in 1972, except for leaves and a two year hiatus (1950–1952) when he left Berkeley in a huff over the loyalty oath and went to UCLA to head the Bureau of Standards’ Institute for Numerical Analysis. From the time of his retirement until he passed away in Berkeley on May 22, 1991, he remained active as a traveler, lecturer, and researcher, publishing some forty-six papers during that period. He had nineteen Ph.D. students.

Lehmer was a transitional figure in computational mathematics whose early prominence was gained by his work with sieves and his impressive computing with hand calculators combined with theoretical developments. In his later mathematical research, he did his computing on the ENIAC and the SWAC, and after that the IBM 701, 704, 709, 7090, 7094, 360, and the CDC 6400. He also used the Illiac 4, well utilizing the parallelism in that machine, a kind of computing he had espoused even from the time of the ENIAC.

The Lehmers, as a life-long research team (they were married for some sixty-two years and were joint authors of twenty-one papers), were always direct and very independent. He was a master of computing and was aggravated in recent years when algorithm theorists, who were ignorant and had not bothered to read the literature or talk to computing experts, would rediscover and publish (often with a new name attached) what he and other computational number theorists had known and used for years.

Lehmer was a wonderful teacher and lecturer. Witty and urbane, he always put his audience at ease through his amiability, knowledgableness, and clear presentations. He savored the basic arithmetic and combinatorial nature of his mathematics, leaving it to others to recast his results or to fit them into more general settings.

From 1953–1957 he was Chairman of the Mathematics Department at U.C. Berkeley. He was also Vice President
of the American Mathematical Society from 1953–1954 and Vice President of the American Association for the Advancement of Science from 1955–1956. In 1965 he delivered the Gibbs Lecture in Denver.

Lehmer was an editor of *MTAC* (later *Mathematics of Computation*) from 1943 to 1954 and a member of the Advisory Board of *Acta Arithmetica* from 1958 until his death. In 1975 *Mathematics of Computation* dedicated an issue to him in honor of his 70th birthday. (There is a fine color photo of him in this issue.) In 1993 *Mathematics of Computation* will publish an issue in his memory. He was a reviewer for *Mathematical Reviews* for over 50 years.

The complete bibliography of Lehmer’s 181 major publications, as well as a review of his *Selected Works* and a list of his nineteen Ph.D. students, will be published in 1993 by *Acta Arithmetica*. His twenty-three mathematical notebooks and other personal papers are now permanently housed at the Bancroft Library at U.C. Berkeley. Dr. Robin Rider of the Bancroft Library has stated that the library is interested in obtaining any Lehmer correspondence that anyone may wish to donate to the permanent collection at the library.

John Brillhart
University of Arizona

**AAUW Awards Grants to Women**

The American Association of University Women (AAUW) Educational Foundation has awarded fellowships and grants from under $1000 to $25,000 to 101 women. The awardees will do postdoctoral research, complete doctoral dissertations, or work on graduate degrees in professional fields in which female participation has traditionally been low.

Among the awardees are three in the mathematical sciences who received dissertation fellowships. Elsa Newman of Emory University is working on some direct and inverse problems in geometric optics; Rebekah Valdivia of Washington State University is working on a reaction-diffusion model of transdermal drug delivery; and Janet Woodland of the State University of New York at Stony Brook is working on geometric and statistical methods in the computation of topological invariants of lattice-gauge fields.

Information on how to apply for these fellowships and grants may be found in the Stipends for Study and Travel section in the October 1992 issue of the *Notices*.

**Mathematics Awareness Week 1993**

Mathematics Awareness Week (MAW), an annual nationwide event, will be held April 25 to May 1, 1993. The theme for MAW 1993 is Mathematics and Manufacturing, a timely and appropriate topic for communicating the beauty and utility of mathematics to a wide audience.

A number of recent reports have touched on the uses of mathematics in manufacturing: two examples are “The Mathematical and Computational Sciences in Emerging Manufacturing Technologies and Management Practices”, published by the Society for Industrial and Applied Mathematics; and “Mathematical Sciences, Technology, and Economic Competitiveness”, published by the National Research Council. These reports describe some of the contributions mathematics has made to manufacturing. In addition, the *Notices* carried the article, “Scientific Issues in Manufacturing” (May/June 1992, page 404), which described a recent meeting examining how mathematics can be used to solve problems in manufacturing and industry.

In November 1992, the Joint Policy Board for Mathematics sent information packets containing ideas for MAW 1993 to a wide segment of the mathematical sciences community, including all department chairs. Last year, there were numerous radio and television spots about MAW, as well as news articles and editorials in local newspapers. The mathematical sciences community is urged to participate in this important and exciting event. For more information on MAW, contact the Joint Policy Board for Mathematics, Office of Governmental and Public Affairs, 1529 Eighteenth Street, NW, Washington, DC 20036; telephone 202-234-9570.

**Report on the Mathematical Preparation of Teachers**

The Consortium for Mathematics and its Applications (COMAP) has released a report entitled, “In the Beginning: Mathematical Preparation for Elementary School Teachers”. Written by Solomon Garfunkel, executive director of COMAP, and Gail S. Young, an educational consultant, the report provides a great deal of insight on how much mathematics background is supplied in the training of elementary school teachers. Improvements in teacher training are clearly needed if mathematics education reform efforts are to succeed. But, considering the findings of this report, the barriers to such improvements are deep, wide, and firmly planted.

The report is based on the results of a questionnaire sent to mathematics departments and education departments or schools of 400 colleges; there was at least one answer from 199 schools. Because the questionnaire resulted in a tremendous variety of responses, the writers decided not to simply tabulate the results, but to also provide quotes from many of the responses. Some of these quotes indicate just how severe the problems are.

For example, in one section of the report, respondents were asked about the quality of the students in elementary education majors, and the perspectives varied widely. One respondent said that “many of our elementary preservice teachers are the worst of their high school classes... [T]hese people have math anxiety in addition to their already low achievement level.” Another pointed to a “lack of intellectual curiosity” and an undeveloped sense of personal standards exemplified by the students’ desire for “detailed directions for each task in terms of what is acceptable or required.”

Other responses faulted not the students but the mathematics department. One noted that a course taught by the mathematics department was dropped from the elementary education curriculum because “it was doing great harm to the students’ attitude toward math—and nothing to increase their knowledge (at least in appropriate ways).” Another said that such courses are “generally a
ICMI Study on Gender and Mathematics Education

The International Commission on Mathematical Instruction (ICMI) will hold a Study Conference on Gender and Mathematics Education in Sweden in October 1993. Gila Hanna of the Ontario Institute for Studies in Education at the University of Toronto chairs the Program Committee.

A discussion document, entitled “Gender and Mathematics Education: Key Issues and Questions”, outlines the main issues the conference will deal with. Individuals and groups are invited to submit contributions to the study for consideration by the Committee no later than February 1, 1993. Contributions should be related to the problems and issues identified in the discussion document but need not be limited to addressing only these. Participation in the conference is by invitation only.

For more information, contact: Gila Hanna, MECA, Ontario Institute for Studies in Education, 252 Bloor Street West, Toronto, Ontario MSS 1V6, Canada; tel: 416-923-6641; fax 416-926-4725; email g.hanna@utoroisse.bitnet.

Summer Geometry Institute

Pending funding, a Summer Geometry Institute sponsored by the National Science Foundation will be held in Park City, Utah, from Sunday, June 20, through Saturday, July 17, 1993. The Institute incorporates learning, teaching and research activities, and interactions in geometry for high school geometry teachers, undergraduate math majors, graduate students, and university teachers and researchers. High school teachers, in partnership with university mathematicians and students, will explore the evolution of classical geometry to modern geometry on curved spaces, and will discuss issues of geometry education at all levels. Undergraduates and graduate students will be offered an intense, yet accessible introduction to areas of geometry research and application by nationally and internationally respected leaders in algebraic geometry and related fields. The Research and Graduate Summer School topic for the 1993 Summer Institute is “Higher Dimensional Complex Geometry”. A full range of computer activities and problems in classical geometry and elementary algebraic geometry will be explored by the various participants.

Also pending funding, a highlight of the 1993 Summer Institute will be a special joint program with the Mathematical Sciences Research Institute (MSRI) in Berkeley, California, for undergraduate and graduate student women. The program is specifically designed to invite talented young women to consider a career in pure mathematics in general and in the area of algebraic geometry in particular. Women students admitted to the Summer Geometry Institute in Park City will also be invited to attend a special two-week program at MSRI in May 1993. There they will be offered a program of introduction to algebraic geometry and participation in small working groups with individual mentoring, organized especially for them by participants of the Special Year in Algebraic Geometry at MSRI. Mentors from this program will then accompany the group to the Summer Institute in Park City in June and July to continue their support activities.

For more information about the women’s joint program with MSRI, please write to either Professor Karen Uhlenbeck, Department of Mathematics, University of Texas, Austin, TX 78712, or uhlen@math.utexas.edu; or Professor Robert Bryant, Department of Mathematics, Duke University, Durham, NC 27706, or bryant@math.duke.edu. Please include your email address, mailing address, and daytime phone number.

For general information about the Summer Geometry Institute and application forms, please contact the Regional Geometry Institute, 18C de Trobiand Street, Fort Douglas, Salt Lake City, UT 84113. Phone: 801-585-3488. Fax: 801-585-5793. Email: rgi@math.utah.edu.

The Summer Geometry Institute specifically invites applications from women and members of minority groups.

News from the Centre de Recherches Mathématiques

During 1993–1994 the Centre de Recherches Mathématiques (CRM) of l’Université de Montréal will host a theme
year in Dynamical Systems consisting of the following activities:


Aisenstadt Chair: Prof. David Ruelle of IHES will be in residence during the fall semester as André Aisenstadt Professor.


Courses offered by the ISM, Institut des Sciences Mathématiques, a consortium of the mathematics departments of Montreal's universities. A variety of credit/noncredit graduate and postgraduate courses will be offered, including: Introduction to Dynamical Systems, Équations différentielles nonlinéaires, and a Seminar in theoretical biology.

Junior and Senior Visiting Fellowships are available.

Those wishing to participate in the above activities are invited to write to M. Louis Pelletier, CRM, Université de Montréal, C.P. 6128, Succursale A, Montréal, Québec, H3C 3J7, Canada, or email to pellet1@cre.umontreal.ca.

News from the Institute for Mathematics and its Applications University of Minnesota


The spring program will begin with a Tutorial, April 5–9, 1993 which will cover the design and analysis of adaptive systems. The tutorial speakers will be K.J. Åström, G.C. Goodwin, and P.R. Kumar. This program will be followed immediately by the workshop Adaptive Control, Filtering, and Signal Processing, April 12–16, 1993, organized by the tutorial speakers. The area of adaptive systems has been one of the most active of the past decade. Since adaptive controllers are fundamentally nonlinear controllers which are applied to nominally linear, possibly stochastic, and time-varying systems, their theoretical analysis is usually very difficult. The workshop will concentrate on recent progress concerning the stability, convergence, performance, and robustness of adaptive controllers, as well as practical applications. Also attention will be paid to reexamining the fundamental principles of adaptive system design, especially from the viewpoint of robustness.

The minisymposium Fuzzy Control will be held April 19–20, 1993. In recent years many successful designs based on fuzzy control have been reported; our aim here is to obtain first-hand accounts of some of these control systems from their designers: S. Kawaji, K. Tanaka, T. Yamakawa, and S. Yasunobu. The topics to be covered include the role envisaged by the designers for the fuzzy control methodology, a clear and step-by-step description of the fuzzy control approach to control system design, and a description of some of the successful fuzzy control designs for trains, washing machines, cameras, automobiles, etc. Finally, there will be a roundtable discussion featuring both experts in fuzzy control system design and other approaches, for the purpose of assessing the utility of the fuzzy approach to control system design and comparing it to other alternative control system design methodologies.

P.R. Kumar and P. Varaiya are organizing a Tutorial, May 3–7, 1993 which will cover verification issues in discrete event systems, as well as performance and control. They are also the organizers of the workshop immediately following: Discrete Event Systems, Manufacturing Systems, and Communication Networks, May 10–14, 1993. Mathematical systems theory traditionally has been concerned with systems of continuous variables modeled by difference or differential equations. However, there is a growing need for dynamical models of systems whose states have logical or symbolic, rather than numerical, values. We call these systems discrete event dynamical systems (DEDS). The study of DEDS has become rapidly popular among researchers in systems and control, in communication networks, in manufacturing, and in distributed computing. This development has created problems due to the veritable Babel of languages and approaches among the competing groups and due to the different traditions and experiences that scholars bring to their study of DEDS, depending on whether they come from control, communication, computer science, or mathematical logic. The purpose of the DEDS Workshop is to promote exchange among scholars representing some of the major "schools" of thought in DEDS. It is hoped that (1) greater clarity will be achieved and (2) cross-fertilization will lead to more fruitful questions.

D. Duffie and I. Karatzas are organizing a Tutorial, June 7–11, 1993 that will outline the mathematical theory which has become an integral part of
modern financial economics. This theory will be complemented by a series of lectures on the important issues in finance and demonstrations of how the mathematical theory can be brought to bear on them. Following this will be held the workshop Mathematical Finance, June 14 – June 18, 1993, organized by M.H.A. Davis, D. Duffie, and S. Shreve. As the world has become more interdependent and the pace of financial decision-making has quickened, it has become apparent that our inability to understand many of the underlying instruments and determine their riskiness has risen precipitously. The single most notable event in this development was the invention of the Black-Scholes option pricing formula, which allowed traders to discover “incorrect” option prices and subsequently move to take advantage of this “incorrectness”. These advances have involved a high level of mathematical sophistication, including stochastic optimal control, nonlinear and quasi-linear parabolic equations, optimal stopping and free boundary problems, martingale representations, fixed point theory, singular stochastic control, stochastic differential games, and approximation theory for stochastic integrals. The workshop will bring together mathematicians and people working in finance to discuss these developments and their implications.

For more information about IMA activities, see the Meetings and Conferences section of this issue or contact the IMA: ima_staff@ima.umn.edu. Also, weekly IMA seminar schedules with titles and abstracts are available on Usenet: umn.math.dept and by fingerering seminar@ima.umn.edu, and \TeX files for the Newsletter and the Update are available via anonymous ftp at ima.umn.edu.

Ulam Quarterly Available Online

The Ulam Quarterly is now available electronically. This refereed journal, established in January 1992 as a memorial to Stanislaw Ulam, is available online in either \LaTeX or Postscript form. It is offered without charge, courtesy of the mathematics department of Palm Beach Atlantic College, with support from the University of Florida. The first two issues include a significant and unpublished work of N. Jacobson and an interpretation of Alexandre Grothendieck’s prenotes for EGA V on Bertini type theorems.

The Ulam Quarterly is available using anonymous FTP from math.ufl.edu or goliath.pbac.edu in the directory pub/ulam/vol1. For more information, contact Piotr Blass, Department of Mathematics, Palm Beach Atlantic College, telephone 407-835-4353, email blass@goliath.pbac.edu.

New Bank Address for AMS

Please note that, effective January 1, 1993, the AMS has new bank addresses for payments and wire transfers. Checks and money orders should now be sent to: American Mathematical Society, P. O. Box 5904, Boston, MA 02206-5904. For foreign bank wire transfers, the address is: State Street Bank & Trust Company, 225 Franklin Street, ABA #011000028, Account #0128-2623, Boston, MA 02110.

Volume 1

CRM MONOGRAPH SERIES

Free Random Variables
D. V. Voiculescu, K. J. Dykema, and A. Nica

This book presents the first comprehensive introduction to free probability theory, a highly noncommutative probability theory with independence based on free products instead of tensor products. Basic examples of this kind of theory are provided by convolution operators on free groups and by the asymptotic behavior of large Gaussian random matrices. The book is ideally suited as a textbook for an advanced graduate course and could also provide material for a seminar. In addition to researchers and graduate students in mathematics, this book will be of interest to physicists and others who use random matrices.

1991 Mathematics Subject Classification: 46; 47; 60
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Funding Information
for the Mathematical Sciences

NSF Young Investigators Program
The National Science Foundation (NSF) has announced the opening of the competition for the NSF Young Investigator (NYI) Awards. The NYI program recognizes outstanding young faculty in science and engineering by providing support for research and educational activities. The NYI program replaces the Presidential Young Investigators program, which operated from 1984 to 1991.

Approximately 150 NYI awards will be made in this competition. Awards are for up to five years. Each consists of an annual base grant of $25,000 from the NSF plus up to $37,500 in additional funds per year on a dollar-for-dollar matching basis from industrial and not-for-profit sources, resulting in total annual support of up to $100,000. For a list of last year's NYI awardees in the mathematical sciences, see "Faculty Fellows Announced," Notices, October 1992, page 849.

Nominations for the awards must be made by academic departments. The deadline for receipt of nominations is January 29, 1993. More information on the NYI program may be obtained from the Division of Mathematical Sciences (OMS) at the NSF. Two program officers have been assigned to handle the NYI program in OMS: Alan Izenman, telephone 202-357-3693, email aizenman@nsf.gov (Internet) and aizenman@nsf (Bitnet); and Joe Jenkins, telephone 202-357-3697, email jenkins@nsf.gov (Internet) and jenkins@nsf (Bitnet). The mailing address is Division of Mathematical Sciences, National Science Foundation, Room 339, 1800 G Street, NW, Washington, DC 20550. Copies of the program announcement may be obtained by requesting the publication "NSF 92-116—NSF Young Investigator Awards Program Guidelines" from the Forms and Publication Unit of NSF, telephone 202-357-7861. Email requests can be sent to pubs@nsf (Bitnet) or pubs@nsf.gov (Internet). In the request, be sure to include your name, your complete mailing address, and the number of copies you need. Information is also available on STIS, NSF's online information system. For an electronic copy of information about STIS, send email to stisflyer@nsf.gov (Internet) or stisflyer@nsf (Bitnet).

DIMACS: Series in Discrete Mathematics and Theoretical Computer Science

Mathematical Methods of Analysis of Biopolymer Sequences
S. G. Gindikin, Editor
Volume 8

This collection contains papers by participants in the seminar on mathematical methods in molecular biology who worked for several years at Moscow State University. The seminar united mathematicians and biologists around the problems of biological sequences. The collection includes original results as well as expository material and spans a range of perspectives, from purely mathematical problems to algorithms and their computer realizations. For this reason, the book is of interest to mathematicians, statisticians, biologists, and computational scientists who work with biopolymer sequences.

1991 Mathematics Subject Classification: 62, 90, 92; 05, 94
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1993 AMS Elections

Nominations by Petition

Vice-President or Member-at-Large

One position of vice-president and member of the Council ex officio for a term of three years is to be filled in the election of 1993. The Council intends to nominate at least two candidates, among whom may be candidates nominated by petition as described in the rules and procedures.

Five positions of member-at-large of the Council for a term of three years are to be filled in the same election. The Council intends to nominate at least ten candidates, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

Petitions are presented to the Council, which, according to Section 2 of Article VII of the bylaws, makes the nominations.

The Council of 23 January 1979 stated the intent of the Council of nominating all persons on whose behalf there were valid petitions.

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

Editorial Boards Committee

Two places on the Editorial Boards Committee will be filled by election. There will be four continuing members of the Editorial Boards Committee.

The President will name at least four candidates for these two places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate’s assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and operational considerations, described below, should be followed.

Nominating Committee

Three places on the Nominating Committee will be filled by election. There will be six continuing members of the Nominating Committee.

The President will name at least six candidates for these three places, among whom may be candidates nominated by petition in the manner described in the rules and procedures.

The candidate’s assent and petitions bearing at least 100 valid signatures are required for a name to be placed on the ballot. In addition, several other rules and operational considerations, described below, should be followed.

Rules and Procedures

Use separate copies of the form for each candidate for vice-president, member-at-large, or member of the Nominating and Editorial Boards Committees.

1. To be considered, petitions must be addressed to Robert M. Fossum, Secretary, P. O. Box 6248, Providence, Rhode Island 02940, and must arrive by 28 February 1993.

2. The name of the candidate must be given as it appears in the Combined Membership List (CML). If the name does not appear in the list, as in the case of a new member or by error, it must be as it appears in the mailing lists, for example on the mailing label of the Notices. If the name does not identify the candidate uniquely, append the member code, which may be obtained from the candidate’s mailing label or the Providence office.

3. The petition for a single candidate may consist of several sheets each bearing the statement of the petition, including the name of the position, and signatures. The name of the candidate must be exactly the same on all sheets.

4. On the next page is a sample form for petitions. Copies may be obtained from the Secretary; however, petitioners may make and use photocopies or reasonable facsimiles.

5. A signature is valid when it is clearly that of the member whose name and address is given in the left-hand column.

6. The signature may be in the style chosen by the signer. However, the printed name and address will be checked against the Combined Membership List and the mailing lists. No attempt will be made to match variants of names with the form of name in the CML. A name neither in the CML nor on the mailing lists is not that of a member. Example: The name Robert M. Fossum is that of a member. The name R. Fossum appears not to be.

7. When a petition meeting these various requirements appears, the Secretary will ask the candidate whether he is willing to have his name on the ballot. Petitioners can facilitate the procedure by accompanying the petitions with a signed statement from the candidate giving his consent.
NOMINATION PETITION FOR 1993 ELECTION

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

____________________________________

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

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


Name and Address (printed or typed)

____________________________________

Signature

____________________________________

Signature

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Signature

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Signature

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Signature

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Signature

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Signature
CALL FOR SUGGESTIONS

There will be a number of contested seats in the 1993 AMS elections. Your suggestions are wanted by

THE NOMINATING COMMITTEE
for president-elect, vice-president, trustee, and five members-at-large of the council
and by

THE PRESIDENT
for three Nominating Committee members and two Editorial Boards Committee members.

In Addition

THE EDITORIAL BOARDS COMMITTEE
requests suggestions for appointments to various editorial boards of Society publications.

Send your suggestions for any of the above to:

Robert M. Fossum, Secretary
American Mathematical Society
Department of Mathematics
University of Illinois
1409 West Green Street
Urbana, Illinois 61801
Journal of the American Mathematical Society

When the Journal of the American Mathematical Society first appeared in 1988, it gained instant respect for its careful selection of relevant, important, and timely research. The editors are devoted to publishing research articles of the highest quality in all areas of pure and applied mathematics. Editors of this journal include: Michael Artin, H. Blaine Lawson, Jr., Richard Melrose, Wilfried Schmid, and Robert E. Tarjan.

1993 Subscription Prices  List $144*, Institutional member $115*, Individual member $86* (ISSN 0894-0347). Back volumes are also available. Call AMS Customer Services for prices. Your ordering code is 93JAMS/NA

Transactions of the American Mathematical Society

American Mathematical Society journals are respected worldwide for publishing high-quality research. Transactions of the American Mathematical Society features well-written papers devoted to pure and applied mathematics. This important monthly journal was first published in 1900.

1993 Subscription Prices  List $893**, Institutional member $714** (ISSN 0002-9947). Back volumes are also available. Call AMS Customer Services for prices. Your ordering code is 93TRAN/NA

*Postage surcharge: India $18; other foreign $8  Optional delivery: First class $13; airmail $36, **Postage surcharge: India $50; other foreign $27  Optional delivery: First class $38; airmail $127. All prices subject to change. Prepayment required. Order from: American Mathematical Society, P.O. Box 5904, Boston, MA 02206-5904, or call toll free 800-321-4AMS in the U.S. and Canada to charge with VISA or MasterCard. Residents of Canada, please include 7% GST.
First Announcement

The eight-hundred-and-seventy-ninth meeting of the American Mathematical Society will be held on the campus of the University of Tennessee, Knoxville, Tennessee on Friday, March 26 and Saturday, March 27, 1993. All sessions and invited addresses will be in the Humanities and Social Sciences Building.

Invited Addresses

By invitation of the Southeastern Section Program Committee, there will be four invited one-hour addresses. The speakers, their affiliations, and the titles of their talks where available are:

Paul R. Blanchard, Boston University, title to be announced.

Olav Kallenberg, Auburn University, On basic symmetries in probability theory.

Richard Tapia, Rice University, The historical development of computational optimization.

Michelle L. Wachs, University of Miami, Homology of partially ordered sets of partitions.

Special Sessions

By invitation of the same committee, there will be nine special sessions of selected twenty-minute papers. The topics of these sessions, and the names and affiliations of the organizers, are as follows:

Commutative ring theory, David F. Anderson and David E. Dobbs, University of Tennessee, Knoxville.

Interventions to assure success: calculus through junior faculty, Bettye Anne Case, Florida State University.

Optimal control and applications, Ben G. Fitzpatrick and Suzanne M. Lenhart, University of Tennessee, Knoxville.

Variational problems in geometry, Alexandre S. Freire and Conrad P. Plaut, University of Tennessee, Knoxville.

Sturm-Liouville operators, applications, and extensions, Don B. Hinton and Kenneth Shaw, University of Tennessee, Knoxville.

Numerical methods in optimization, Tim Kelley, North Carolina State University.

Continua theory and dynamical systems, John C. Mayer, University of Alabama-Birmingham.

Stochastic processes, Balram S. Rajput and Jan Rosinski, University of Tennessee, Knoxville.

Algebraic combinatorics, Michelle L. Wachs.

Abstracts for consideration for these sessions should have been submitted by the June 26, 1992 deadline. This deadline was previously published in the Calendar of AMS Meetings and Conferences and in the Invited Speakers and Special Sessions section of the Notices.

Contributed Papers

There will also be sessions for contributed ten-minute papers. Abstracts should have been submitted by the January 5, 1993 deadline previously published in the Calendar of AMS Meetings and Conferences. Late papers will not be accommodated.

Registration

The meeting registration desk will be located in the second floor lobby of the Humanities and Social Sciences Building and will be open from 8:00 a.m. to 5:00 p.m. on Friday, March 26, and 8:00 a.m. to noon on Saturday, March 27. The registration fees are $30 for members of the AMS, $45 for nonmembers, and $10 for emeritus members, students, or unemployed mathematicians.

Social Event

A cash-bar reception is planned for 8:00 p.m. to 10:00 p.m. on Friday, March 26 at the Campus Inn.

Accommodations

Rooms have been blocked for participants at the Campus Inn, Knoxville Hilton, and Radisson Hotel Knoxville. The Campus Inn is adjacent to the university campus and is a short walk from the Humanities and Social Sciences Building (HSS). The Knoxville Hilton and Radisson Hotel Knoxville are located downtown and are approximately three-quarters of a mile from the HSS Building; morning and evening van transportation will be provided between these hotels and the HSS Building. Participants should make their own
Meetings

arrangements with the hotel of their choice and ask for the AMS conference rate. All rates are subject to a 13.25% tax. The AMS is not responsible for rate changes or the quality of the accommodations offered by these hotels/motels.

Campus Inn
1706 Cumberland Avenue, Knoxville, TN 37916
Telephone: 615-521-5000
The deadline for reservations is March 11, 1993.
Single $39 Double $42

Knoxville Hilton
501 Church Avenue, S.W., Knoxville, TN 37902-2591
Telephone: 615-523-2300
The deadline for reservations is March 3, 1993.
Single $59 Double $69

Radisson Hotel Knoxville
401 Summit Hill Drive, Knoxville, TN 37902
Telephone: 615-522-2600
The deadline for reservations is March 11, 1993.
Single $69 Double $65

Food Service
Numerous eating establishments from diners and national fast food chains to finer restaurants are located along Cumberland Avenue within walking distance of the HSS Building. Additional restaurants are located approximately one mile away in the downtown area and from three to fifteen miles west along Kingston Pike, an extension of Cumberland Avenue. The University Center will offer only limited food service because UTK will be on spring break during the meeting.

Parking
Parking will be available in the University Center Parking Garage at a reduced rate of $3.00 per day (no in-and-out privileges) if the parking ticket is validated at the registration table. The garage is accessed from Stadium Drive.

Travel and Local Information
The University of Tennessee, Knoxville campus is located approximately twelve miles from the Knoxville McGhee-Tyson Airport, which is served by most major airlines (including American, Delta, Northwest, United, and USAir). Participants also can arrive by Greyhound-Trailways Bus Lines.

Participants traveling by car from the north on I-75 first should take I-275 and then follow, in order, the signs for I-40 West/I-75 South, 17th Street, and the university. Those traveling by car from the west or east on I-40 or from the south on I-75 may use the 17th Street exit and follow 17th Street south to the campus.

Weather and Local Attractions
The weather in Knoxville in late March is variable. The normal daily low in March is 39.3°F, the normal daily high is 60.1°F, and the normal rainfall for the month is 5.49 inches.

Knoxville and the surrounding area offer many interesting attractions, including historical sites, museums, galleries, an outstanding zoo, the vacation towns of Pigeon Forge and Gatlingburg, the “Atomic City” of Oak Ridge, the Great Smoky Mountains National Park, and Big South Fork National River and Recreation Area. Nightlife offerings include lounges, sports bars, comedy clubs, and the “Old City”, a restored historic neighborhood featuring restaurants and saloons with live music, antiques stores, and other shops.
Invited Addresses

at AMS Meetings

The individuals listed below have accepted invitations to address the Society at the times and places indicated. For some meetings, the list of speakers is incomplete. Invited addresses at Sectional Meetings are selected by the Section Program Committee, usually twelve to eighteen months in advance of a meeting. Members wishing to nominate candidates for invited addresses should send the relevant information to the Associate Secretary for the Section who will forward it to the Section Program Committee.

Knoxville, TN, March 1993

Please see the first announcement of this meeting elsewhere in this issue.

Salt Lake City, UT, April 1993

Michael Christ
Kenneth M. Golden
Robert M. Guralnick
Michael S. Waterman

Washington, DC, April 1993

Fan R. K. Chung
Leopold Flatto
Joel Spruck
A. Zamolodchikov

DeKalb, IL, May 1993

Susan J. Friedlander
Russell D. Lyons
Clark Robinson

Vancouver, British Columbia, Canada

August 1993

Armand Borel
(Progress in Mathematics Lecture)
Avner Friedman
(Progress in Mathematics Lecture)
Robert E. Gompf (AMS-CMS)
H. Blaine Lawson (AMS-CMS)
Yuri Manin (Colloquium Lectures)
Curt McMullen (AMS-CMS)
Louis Nirenberg (AMS-CMS)
Jill Pipher (AMS-CMS)

Sydney, NY, September 1993

Tadeusz Iwaniec
Charles A. McGibbon
James M. Renegar
Alvany Rocha

Heidelberg, Germany, October 1993

Gerd Faltings

College Station, TX, October 1993

Steven P. Lalley
Gilles Pisier
Theodore A. Slaman
Stephan A. Stolz

Organizers and Topics of Special Sessions

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

March 1993 Meeting in Knoxville, Tennessee

Southeastern Section
Associate Secretary:
Joseph A. Cima (until 1/31/93)
Robert J. Daverman (after 1/31/93)
Deadline for organizers: Expired
Deadline for consideration: Expired

Please see the first announcement of this meeting elsewhere in this issue.

April 1993 Meeting in Salt Lake City, Utah

Western Section
Associate Secretary: Lance W. Small
Deadline for organizers: Expired
Deadline for consideration: Expired

M. Salah Baouendi and Linda P. Rothschild, Partial differential equations and several complex variables
Andrej Cherkaev and Kenneth M. Golden, Effective properties of inhomogeneous materials
Davida Fischman, Hopf algebras and Hopf algebra actions
Naomi Fisher and Hugo Rossi, Mathematics and education reform
Libin Mou and Nat Smale, Singularities of geometric partial differential equations
Paul C. Roberts, Roger A. Wiegand, and Sylvia M. Wiegand, Commutative algebra and modules
Simon Tavare, Stochastic processes in population genetics

April 1993 Meeting in Washington, DC
Associated Secretary: W. Wistar Comfort (until 1/31/93)
Lesley M. Sibner (after 1/31/93)
Deadline for organizers: Expired
Deadline for consideration: Expired

Roy L. Adler and Leopold Flatto, Geodesic flows, hyperbolic geometry, and symbolic dynamics
Joseph A. Ball and Cora S. Sadosky, Dilation and interpolation: operator theoretic methods
John J. Benedetto and Rodney B. Kerby, Wavelets in sampling theory and signal processing
Joseph E. Bonin, Geometric methods in combinatorics
Nathaniel Dean, Mathematics of two-dimensional quantum field theory
Anant P. Godbole and Gary J. Sherman, Undergraduate research in applied mathematics
Valentina S. Harizanov and James C. Owings, Pure and applied recursion theory
Kevin G. Hockett and E. Arthur Robinson, Ergodic theory, dynamical systems, and applications
Victor J. Katz, History of mathematics
Yongwu Rong, Low dimensional topology
Joel Spruck, Nonlinear elliptic problems in geometry and physics

May 1993 Meeting in DeKalb, Illinois
Associated Secretary: Andy R. Magid
Deadline for organizers: Expired
Deadline for consideration: February 3, 1993
Gregory S. Ammar, Advances in linear algebra: theory, computation, application
Michael A. Filaseta and Carl Pomerance, Number theory
Susan J. Friedlander, Mathematical topics in fluid dynamics
Zoltan Furedi, Combinatorics
Andrew J. Granville, Analytic number theory
Frank Harary, Beautiful graph theory
Mohsen Pourahmadi, Stochastic processes
Jeanne LaDuke, History of mathematics
Linda R. Sons, Function theory
Joel H. Spencer, Probabilistic methods
Peter Waterman, Discrete groups

August 1993 Meeting in Vancouver, British Columbia, Canada
Associated Secretary: Lance W. Small
Deadline for organizers: Expired
Deadline for consideration: April 27, 1993
David M. Austin, Four-manifolds (AMS-CMS)

Nassif Ghoussoub, Variational methods in partial differential equations (AMS-CMS)
Linda Keen, Dynamical systems (AMS-CMS)
James L. Lewis and Barry Mazur, Algebraic cycles (AMS-CMS)
Ram M. Murty and Rajiv Gupta, Number theory (AMS-CMS)
Gregory Verchota, Harmonic analysis techniques in partial differential equations (AMS-CMS)

September 1993 Meeting in Syracuse, New York
Associated Secretary: Lesley M. Sibner
Deadline for organizers: Expired
Deadline for consideration: April 27, 1993

Douglas R. Anderson, Geometric topology
Steven P. Diaz and Anthony V. Geramita, Commutative algebra and algebraic geometry
Wu-Teh Hsiang, Differential geometry and global analysis
Mark Kleiner and Dan Zacharia, Representations of finite dimensional algebras
Juan J. Manfredi, Nonlinear potential theory
Terry R. McConnell, Topics in probability
Robert S. Strichartz, Harmonic analysis

October 1993 Meeting in Heidelberg, Germany
(Joint Meeting with the Deutsche Mathematiker-Vereinigung e.V.)
Associated Secretary: Robert M. Fossum
Deadline for organizers: Expired
Deadline for consideration: April 27, 1993

October 1993 Meeting in College Station, Texas
Central Section
Associated Secretary: Andy R. Magid
Deadline for organizers: January 22, 1993
Deadline for consideration: July 14, 1993
Harold P. Boas, Al Boggess, and Emil J. Straube, Several complex variables
Randall K. Campbell-Wright, Carl C. Cowen, and Barbara D. MacCluer, Composition operators on spaces of analytic functions
David R. Larson, Non self adjoint operator algebras
John C. Meakin, Amitai Regev, Mark V. Sapir, and Samuel M. Vovsi, Identities and varieties of algebraic structures
Efton L. Park, Noncommutative differential geometry
Gilles Pisier and Thomas Schlumprecht, The geometry of Banach spaces and operator spaces
Sung Yell Song and Paul M. Terwilliger, Algebraic combinatorics

November 1993 Meeting in Claremont, California
Western Section
Associated Secretary: Lance W. Small
Deadline for organizers: February 5, 1993
Deadline for consideration: July 14, 1993
Invited Addresses and Special Sessions

January 1994 Meeting in Cincinnati, Ohio
Associate Secretary:
Joseph A. Cima (until 1/31/93)
Robert J. Daverman (after 1/31/93)
Deadline for organizers: April 5, 1993
Deadline for consideration: September 23, 1993

March 1994 Meeting in Lexington, Kentucky
Southeastern Section
Associate Secretary:
Joseph A. Cima (until 1/31/93)
Robert J. Daverman (after 1/31/93)
Deadline for organizers: June 18, 1993
Deadline for consideration: To be announced

March 1994 Meeting in Manhattan, Kansas
Central Section
Associate Secretary: Andy R. Magid
Deadline for organizers: June 25, 1993
Deadline for consideration: To be announced

April 1994 Meeting in Brooklyn, New York
Eastern Section
Associate Secretary: Lesley M. Sibner
Deadline for organizers: July 9, 1993
Deadline for consideration: To be announced

June 1994 Meeting in Eugene, Oregon
Western Section
Associate Secretary: Lance W. Small
Deadline for organizers: September 7, 1993
Deadline for consideration: To be announced

October 1994 Meeting in Stillwater, Oklahoma
Central Section
Associate Secretary: Andy R. Magid
Deadline for organizers: January 28, 1994
Deadline for consideration: To be announced

January 1995 Meeting in Denver, Colorado
Central Section
Associate Secretary: Andy R. Magid
Deadline for consideration: To be announced

March 1995 Meeting in Chicago, Illinois
Central Section
Associate Secretary: Andy R. Magid
Deadline for consideration: To be announced

November 1995 Meeting in Kent, Ohio
Central Section
Associate Secretary: Andy R. Magid
Deadline for consideration: To be announced

January 1996 Meeting in Orlando, Florida
Associate Secretary: Lance W. Small
Deadline for consideration: To be announced

March 1996 Meeting in Iowa City, Iowa
Central Section
Associate Secretary: Andy R. Magid
Deadline for organizers: June 22, 1995
Deadline for consideration: To be announced

Information for Organizers

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

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

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

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

Special Sessions are very effective at Sectional Meetings and can usually be accommodated. The processing of proposals for Special Sessions for Sectional Meetings is handled in essentially the same manner as for Annual and Summer Meetings by the Section Program Committee. Again, no Special Session at a Sectional Meeting may be approved so late that its announcement appears past the deadline after which members can no longer send abstracts for consideration for presentation in that Special Session.

The Society reserves the right of first refusal for the publication of proceedings of any Special Session. These proceedings appear in the book series Contemporary Mathematics.
More precise details concerning proposals for and organizing of Special Sessions may be found in the "Rules for Special Sessions" or may be obtained from any Associate Secretary.

**Proposals for Special Sessions to the Associate Secretaries**

The programs of Sectional Meetings are arranged by the Associate Secretary for the section in question:

**Western Section**
- Lance W. Small, Associate Secretary
  - Department of Mathematics
  - University of California, San Diego
  - La Jolla, CA 92039
  - Electronic mail: g.small@math.ams.org
  - (Telephone 619–534–3590)

**Central Section**
- Andy R. Magid, Associate Secretary
  - Department of Mathematics
  - University of Oklahoma
  - 601 Elm PHSC 423
  - Norman, OK 73019
  - Electronic mail: g.magid@math.ams.org
  - (Telephone 405–325–6711)

**Eastern Section**
- W. Wistar Comfort, Associate Secretary (until January 31, 1993)
  - Department of Mathematics
  - Wesleyan University
  - Middletown, CT 06457
  - Electronic mail: g.comfort@math.ams.org
  - (Telephone 203–347–9411)
- Lesley M. Sibner, Associate Secretary (beginning February 1, 1993)
  - Department of Mathematics
  - Polytech University of New York
  - Brooklyn, NY 11201–2990
  - Electronic mail: g.sibner@math.ams.org
  - (Telephone 718–260–3505)

**Southeastern Section**
- Joseph A. Cima, Associate Secretary (until January 31, 1993)
  - Department of Mathematics
  - University of North Carolina, Chapel Hill
  - Chapel Hill, NC 27599–3092
  - Electronic mail: g.cima@math.ams.com
  - (Telephone 919–962–1050)
- Robert J. Daverman, Associate Secretary (beginning February 1, 1993)
  - Department of Mathematics
  - University of Tennessee
  - Knoxville, TN 37996–1300
  - Electronic mail: g.daverman@math.ams.org
  - (Telephone 615–974–6577)

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

**Proposals for Special Sessions** at the October 1–3, 1993 meeting in Heidelberg, Germany, only, should be sent to Robert M. Fossum at the Department of Mathematics, University of Illinois, Urbana, IL 61801, Telephone: 217-244-1741, email: rmf@math.ams.org.

**Information for Speakers**

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

Abstracts of papers submitted for consideration for presentation at a Special Session must be received by the Providence office (Abstracts Coordinator, Meetings Department, American Mathematical Society, P. O. Box 6887, Providence, RI 02940) by the special deadline for Special Sessions, which is usually three weeks earlier than the deadline for contributed papers for the same meeting. The Council has decreed that no paper, whether invited or contributed, may be listed in the program of a meeting of the Society unless an abstract of the paper has been received in Providence prior to the deadline.

Electronic submission of abstracts is available to those who use the \TeX\ typesetting system. Requests to receive the electronic package of files via email should be sent to abs-request@math.ams.org. Users may also obtain the package on IBM or Macintosh diskettes, available free of charge by writing to: Electronic Abstracts, American Mathematical Society, Meetings Department, P.O. Box 6887, Providence, RI 02940, USA. When requesting the abstracts package, users should be sure to specify whether they want the plain \TeX, \LaTeX, or the \LaTeX\ package. Requests for general information concerning abstracts may be sent to abs-misc@math.ams.org.

**Number of Papers Presented**

**Joint Authorship**

Although an individual may present only one ten-minute contributed paper at a meeting, any combination of joint authorship may be accepted, provided no individual speaks more than once. An author can speak by invitation in more than one Special Session at the same meeting.

An individual may contribute only one abstract by title in any one issue of Abstracts, but joint authors are treated as a separate category. Thus, in addition to abstracts from two individual authors, one joint abstract by them may also be accepted for an issue.

**Site Selection for Sectional Meetings**

Sectional Meeting sites are recommended by the Associate Secretary for the Section and approved by the Committee of Associate Secretaries and Secretary. Recommendations are usually made eighteen to twenty-four months in advance. Host departments supply local information, ten to twelve rooms with overhead projectors for contributed paper sessions and Special Sessions, an auditorium with twin overhead projectors for invited addresses, and registration clerks. The Society partially reimburses for the rental of facilities and equipment, and for staffing the registration desk. Most host departments volunteer; to do so, or for more information, contact the Associate Secretary for the Section.
The 1993 Joint Summer Research Conferences in the Mathematical Sciences will be held at the University of Washington, Seattle, from July 10 to August 6. It is anticipated that the series of conferences will be supported by grants from the National Science Foundation and other agencies.

There will be seven conferences in seven different areas of mathematics. The topics and organizers for the conferences were selected by the AMS, the Institute of Mathematical Statistics (IMS), and the Society for Industrial and Applied Mathematics (SIAM) Committee on Joint Summer Research Conferences in the Mathematical Sciences. The selections were based on suggestions made by the members of the committee and individuals submitting proposals. The committee considered it important that the conferences represent diverse areas of mathematical activity, with emphasis on areas currently especially active, and paid careful attention to subjects in which there is important interdisciplinary activity at present.

The conferences emulate the scientific structure of those held throughout the year at Oberwolfach. These conferences are intended to complement the Society’s program of annual Summer Institutes and Summer Seminars, which have a larger attendance and are substantially broader in scope. The conferences are research conferences and are not intended to provide an entree to a field in which a participant has not already worked.

It is expected that funding will be available for a limited number of participants in each conference. Others, in addition to those funded, will be welcome, within the limitations of the facilities of the campus. In the spring a brochure of information will be mailed to all who are requesting to attend the conferences. The brochure will include information on room and board rates, the residence and dining hall facilities, travel, local information, and a Residence Housing Form to request on-campus accommodations. Information on off-campus housing will also be included in the brochure. Participants will be responsible for making their own housing and travel arrangements. Each participant will be required to pay a conference fee.

Those interested in attending one of the conferences should send the following information to the Summer Research Conference Coordinator, Conferences Department, American Mathematical Society, Post Office Box 6887, Providence, RI 02940 or by email cak@math.ams.org.

Please type or print the following:
1. Title and dates of conference desired;
2. Full name;
3. Mailing address;
4. Telephone number and area code for office and home, email addresses, FAX number;
5. A short paragraph describing your scientific background relevant to the topic of the conference;
6. Financial assistance requested; please estimate cost of travel;
7. Indicate if support is not required and if interested in attending even if support is not offered.

The deadline for receipt of requests for information is March 1, 1993. Requests to attend will be forwarded to the Organizing Committee for each conference for consideration after the deadline of March 1. All applicants will receive a formal invitation, Brochure of Information, notification of financial assistance, and a tentative scientific program (if the Chair has prepared one in advance; otherwise, programs will be distributed at on-site registration) from the AMS by May 1. Funds available for these conferences are limited and individuals who can obtain support from other sources should do so. The allocation of grant funds is administered by the AMS office, and the logistical planning for the conferences is also done by the AMS. However, it is the responsibility of the Chair of the Organizing Committee of each conference to determine the amount of support participants will be awarded. This decision is not made by the AMS. Women and minorities are encouraged to apply and participate in these conferences.

Any questions concerning the scientific portion of the conference should be directed to the Chair or any member of the Organizing Committee.

The Joint Summer Research Conferences in the Mathematical Sciences are under the direction of the AMS-IMS-SIAM Committee on Joint Summer Research Conferences in the Mathematical Sciences. The following committee members chose the topics for the 1993 conferences: John A. Burns, Fan R. K. Chung, Leonard Evens, Martin Golubitsky, Anthony W. Knapp, Peter W. K. Li, Stewart B. Priddy, Robert J. Serfling, Michael Shub, and Gregg J. Zuckerman.

N.B. Lectures begin on Sunday morning and run through Thursday. Check-in for housing begins on Saturday. No lectures are held on Saturday.
Joint Summer Research Conferences

Please refer to the complete announcement with descriptions of each conference which appeared in the November Notices.

**Saturday, July 10 to Friday, July 16**

*Curvature equations in conformal geometry*

**Sung-Yung A. Chang** (University of California, Los Angeles), Co-Chair

**Rick Schoen** (Stanford University), Co-Chair

**Saturday, July 10 to Sunday, July 18**

*Multivariable operator theory*

**Raúl E. Curto** (University of Iowa), Co-Chair

**Ronald G. Douglas** (SUNY at Stony Brook), Co-Chair

**Joel D. Pincus** (SUNY at Stony Brook), Co-Chair

**Noberto Salinas** (University of Kansas), Co-Chair

**Saturday, July 17 to Friday, July 23**

*Spectral geometry*

**Robert Brooks** (University of Southern California), Co-Chair

**Carolyn Gordon** (Dartmouth College), Co-Chair

**Peter Perry** (University of Kentucky), Co-Chair

**Saturday, July 17 to Friday, July 23**

*Recent developments in the inverse Galois problem*

**Walter Feit** (Yale University), Chair

**Mike Fried** (University of California, Irvine), Co-Chair

**Saturday, July 24 to Friday, July 30**

*Mathematics of superconductivity*

**M. Gunzburger** (Virginia Tech), Co-Chair

**Rick Schoen** (Stanford University), Co-Chair

**Joel D. Pincus** (SUNY at Stony Brook), Co-Chair

**Michael D. Taylor** (University of Central Florida), Co-Chair

**Saturday, July 31 to Friday, August 6**

*Distributions with fixed marginals, doubly stochastic measures, and Markov operators*

**Howard Sherwood** (University of Central Florida), Co-Chair

**Michael D. Taylor** (University of Central Florida), Co-Chair

**Saturday, July 31 to Friday, August 6**

*Applications of hypergroups and related measure algebras*

**William C. Connett** (University of Missouri, St. Louis), Co-Chair

**Olivier Gebuhrer** (Université Louis Pasteur, Strasbourg), Co-Chair

**Alan L. Schwartz** (University of Missouri, St. Louis), Co-Chair

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**ADVANCES IN SOVIET MATHEMATICS**

**Idempotent Analysis**

V. P. Maslov and S. N. Samborskiı, Editors

*Volume 13*

Idempotent analysis is a new branch of mathematical analysis concerned with functional spaces and their mappings when the algebraic structure is generated by an idempotent operation. The articles in this collection show how idempotent analysis is playing a unifying role in many branches of mathematics related to external phenomena and structures—a role similar to that played by functional analysis in mathematical physics, or numerical methods in partial differential equations. Such a unification necessitates study of the algebraic and analytic structures appearing in spaces of functions with values in idempotent semirings. The papers collected here constitute an advance in this direction.

1991 *Mathematics Subject Classification*: 16, 20, 35, 47, 49, 90; 81

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1993 Summer Seminar in Applied Mathematics

The mathematics of tomography, impedance imaging, and integral geometry

Mount Holyoke College, South Hadley, Massachusetts, June 7–18

The twenty-third AMS-SIAM Summer Seminar in Applied Mathematics will be held June 7–18, 1993, at Mount Holyoke College, South Hadley, Massachusetts. The seminar will be sponsored by the American Mathematical Society and the Society for Industrial and Applied Mathematics. It is anticipated that the seminar will be supported by grants from federal agencies. The proceedings of the seminar will be published by the American Mathematical Society in the Lectures in Applied Mathematics series.

One of the most exciting features of tomography is the strong relationship between high level pure mathematics (such as harmonic analysis, partial differential equations, integral geometry, microlocal analysis, and Lie group theory) and applications to medicine, impedance imaging, radiotherapy, and industrial nondestructive evaluation.

The aim of the conference is to strengthen the connection between the pure and applied aspects of these areas and to facilitate dialogue between researchers in the various areas. The seminar will provide introductory talks on tomography, impedance imaging, and integral geometry intended for younger researchers and other beginners in the field (in the first part of the conference) and a research component in which researchers will have the opportunity to define and articulate the main problems of current interest and to isolate common themes and approaches. A number of the anticipated participants will be experts from foreign countries.

The organizing committee consists of Margaret Cheney, Rensselaer Polytechnic Institute; Simon Gindikin, Rutgers University; Peter Kuchment, Wichita State University; Eric Todd Quinto (Chair), Tufts University; and Lawrence Shepp, Bell Laboratories.

A tentative list of proposed introductory lecturers includes David Barber, Gregory Beylkin*, Allan Cormack, Leon Ehrenpreis*, Simon Gindikin*, Sigurdur Helgason, David Isaacson*, Frank Natterer*, Lawrence Shepp*, and Gunther Uhlmann* (those with * have accepted as of October 21, 1992). It is anticipated they will give research talks as well. A very preliminary and partial list of other possible speakers includes Carlos Berenstein, Jan Boman, Adel Faridani, Josip Globevnik, Fulton Gonzalez, Allan Greenleaf, Eric Grinberg, Alberto Gruenbaum, Gabor Herman, Michael Klibanov, Alfred Louis, Wolodymyr Madych, Ziqi Sun, John Sylvester, and Michael Vogelius.

Those interested in attending the Seminar should send the following information before March 15, 1993, to AMS-SIAM Summer Seminar Conference Coordinator, American Mathematical Society, P.O. Box 6887, Providence, R.I. 02940, email dls@math.ams.org. Please type or print the following:

1. Full name;
2. Mailing address;
3. Telephone number and area code for office and home;
4. email address if available;
5. Anticipated arrival and departure dates;
6. Your scientific background relevant to the topic of the seminar;
7. Financial assistance requested (please estimate cost of travel), indicate if support is not required and if interested in attending even if support is not offered.

Participants who wish to apply for a grant-in-aid should so indicate; however, funds available for the seminar are very limited and individuals who can obtain support from other sources should do so. Graduate students who have completed at least one year of graduate school are encouraged to participate.
1993 Summer Research Institute

Stochastic analysis
Cornell University, Ithaca, New York, July 11–30

The forty-first Summer Research Institute sponsored by the American Mathematical Society will be devoted to Stochastic Analysis and will be held at Cornell University from July 11–30, 1993. The Co-Chairs of the Organizing Committee are Mike Cranston, University of Rochester; Rick Durrett, Cornell University; and Mark Pinsky, Northwestern University. The speakers were selected with the advice of a committee that consists of Rodrigo Banuelos, Purdue University; Peter Baxendale, University of Southern California; Hans Follmer, Universität Bonn; Nobuyuki Ikeda, University of Osaka; Paul Malliavin, Université Pierre et Marie Curie; Alain Sznitman, ETH Zurich; and Ruth Williams, University of California, San Diego.

The topic was selected by the 1992 AMS Committee on Summer Institutes whose members at the time were: Craig Evans, Nicholas Katz, Barbara Lee Keyfitz, Brian Parshall (chair), François Trèves, and Edward Witten.

In recent years there have been exciting interactions between probability theory and analysis, geometry, and mathematical physics, with these three fields furnishing a rich source of problems for probability theory. The conference will highlight recent achievements in the field and promising directions for future research. The meeting will be divided into six two-and-one-half day periods (Sunday morning to Tuesday noon, Wednesday morning to Friday noon, etc.) that will feature the following topics in the order indicated:

1. Stochastic ordinary differential equations (7/11–7/13)
2. Applications to analysis (7/14–7/16)
3. Applications to geometry (7/18–7/20)
4. Stochastic flows (7/21–7/23)
5. Infinite-dimensional problems (7/25–7/27)


It is anticipated that the institute will be partially funded by a grant from the National Science Foundation. Proceedings will be published in the AMS series titled Proceedings of Symposia in Pure Mathematics. It is expected that the papers for the proceedings will closely parallel the content of the lectures and will be distributed to the conference participants at the time of the lectures.

All persons who are interested in this topic are welcome to attend. The organizers anticipate being able to provide partial support for travel and subsistence for young researchers, especially women and minorities. Those interested in receiving an invitation to participate in the institute should send the following information to: Summer Institute Conference Coordinator, American Mathematical Society, P.O. Box 6887, Providence R.I. 02940, prior to April 1, 1993, or through electronic mail to wsd@math.ams.org.

Please type or print the following:
1. Full name;
2. Mailing address;
3. Telephone number and area code for office and home, FAX number, and email address;
4. Which week or weeks you wish to attend;
5. Your scientific background relevant to the institute topic;
6. Financial assistance required (or indicate if no support required).

Information on housing, dining, travel, and the local area will be sent to invited participants in the Spring. Each participant will be required to pay a Conference fee. Questions about the scientific program can be addressed to any of the organizers, preferably by email to cran@uordbv.bitnet, rtd@cornell.bitnet, or m.pinsky@math.nwu.edu. Questions about local arrangements should be sent to Rick Durrett via email or write to him at the Department of Mathematics, White Hall, Cornell University, Ithaca, NY 14853–7901.

Requests for invitations will be forwarded to the Organizing Committee for consideration up to the deadline of April 1. All applicants will receive formal invitations. Participants receiving financial support will be notified beginning in mid-May.
1993 Symposium on Some Mathematical Questions in Biology

Theories for the evolution of haploid-diploid life cycles

Snowbird, Utah

The twenty-seventh annual Symposium on Some Mathematical Questions in Biology, focusing on Theories for the evolution of haploid-diploid life cycles, will be held during the annual meeting of the Society for the Study of Evolution, June 19–23, 1993, in Snowbird, Utah. The symposium is sponsored by the American Mathematical Society, the Society for Industrial and Applied Mathematics (SIAM), and the Society for Mathematical Biology (SMB).

The AMS-SIAM-SMB Committee on Mathematics in the Life Sciences serves as the Organizing Committee for the symposium. The committee members are Jack D. Cowan, James W. Curren, Marcus W. Feldman, Eric S. Lander, Marc Mangel (Chair), and James D. Murray. Mark Kirkpatrick serves as the organizer.

The speakers and their topics are: Graham Bell (McGill University), The comparative biology of the alternation of generations; James Crow (University of Wisconsin), and Alex Kondrashov (University of Oregon), The evolution of haploid-diploid life cycles under deleterious mutation; Cheryl Jenkins (University of Texas), Ecological selection and deleterious mutation in the evolution of life cycles; Richard Michod (University of Arizona), Genetic repair and life cycle evolution; Sarah Otto (Berkeley), Genetic prerequisites and consequences of life cycle evolution; and Veronique Perrot (Universität Basel), Experimental tests of theories for the evolution of haploid-diploid life cycles.

Proceedings of the symposium will be published by the AMS in the series Lectures on Mathematics in the Life Sciences.

For further information on the symposium, contact the Symposium Conference Coordinator, AMS, P.O. Box 6887, Providence, RI 02940, or DLS@MATH.AMS.COM by electronic mail.

Mathematical World

Volume 2

Fixed Points

Yu. A. Shashkin

Shashkin's book contains a popular exposition of fixed point theory. Theorems on fixed points for continuous maps of a segment, a square, a circle, and a two-dimensional sphere are proved. All required notions such as continuity, compactness, and degree of a map are explained. Auxiliary propositions, such as Sperner's lemma, are proved. Applications and exercises are given. Fixed Points is accessible even to students at the high school level.

1991 Mathematics Subject Classification: 01.54
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JANUARY 1993, VOLUME 40, NUMBER 1
1993 Symposium
Mathematics of Computation 1943–1993:
A half-century of computational mathematics
University of British Columbia, Vancouver, Canada, August 9–13, 1993

Under the auspices of the American Mathematical Society (AMS) and in celebration of the 50th anniversary of the journal Mathematics of Computation, an international symposium devoted to all aspects of computational mathematics will take place at the University of British Columbia, Vancouver, Canada, August 9–13, 1993. The symposium will be held immediately prior to the joint AMS/CMS/MAA summer meeting. As part of the meeting there will be a two-session minisymposium on computational number theory dedicated to the memory of D. H. Lehmer. Invited speakers will be presenting survey and state-of-the-art lectures in plenary sessions. There will also be poster sessions and 15-minute contributed paper sessions.

The topic was selected by the 1992 AMS Committee on Summer Institutes and Special Symposia, whose members at the time were: Lawrence Craig Evens, Nicholas Katz, Barbara Lee Keyfitz, Brian Parshall (Chair), Francois Treves, and Edward Witten.

The Organizing Committee for the symposium consists of James H. Bramble, Cornell University; Walter Gautschi, Purdue University (Chair); Eugene Isaacson, New York University; Vidar Thomée, Chalmers University of Technology; and Hugh C. Williams, University of Manitoba.

The invited speakers are: James H. Bramble, Cornell University; Johannes Buchmann, Universität des Saarlandes; Björn Engquist, UCLA; Donald Goldfarb, Columbia University; James N. Lyness, Argonne National Laboratory; J. C. Nédélec, Ecole Polytechnique Palaiseau; Andrew M. Odlyzko, AT&T Bell Laboratories; Frank W. J. Olver, University of Maryland; Carl Pomerance, University of Georgia; Larry L. Schumaker, Vanderbilt University; Hans J. Stetter, Technical University of Vienna; G. W. Stewart, University of Maryland; and Roger Temam, Indiana University.

The deadline for submission of contributed papers is April 1, 1993. Abstracts should be prepared on AMS abstract forms and should indicate whether they are being submitted for a poster session or for a contributed paper session. Abstract forms are available at most universities or obtainable from the AMS upon request. Abstracts should be sent in duplicate to Walter Gautschi, Department of Computer Sciences, Purdue University, West Lafayette, IN 47907, USA. Decisions on acceptances will be made by May 1, 1993. Proceedings will be published by the AMS.

The deadline for preregistration/housing is June 6, 1993. Preregistration and housing forms can be obtained after February 1, 1993 from the Mathematics Meetings Service Bureau, P.O. Box 6887, Providence, RI 02940-6887. There will be a registration fee of $50. Inquiries with regard to registration and housing should be directed to that address or by email to jim@math.ams.org, or telephone: 401-455-4143. Other inquiries should be sent to Walter Gautschi, Chair of the Organizing Committee at the address indicated in the previous paragraph.

It is anticipated that the symposium will be partially supported by a grant from the National Science Foundation. Additional funds for support are being sought from other agencies.
January 1993


15–17. International Conference on Complex Analysis and its Applications, Hong Kong University of Science and Technology, Hong Kong. (Sep. 1992, p. 771)


February 1993

1–3. IMA Minisymposium on Biological Control of Movement, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN. (Nov. 1991, p. 1172)


5–7. Representation Theory and Analysis on Homogeneous Spaces in Memory of Lawrence Corwin, Rutgers University, New Brunswick, NJ. (Dec. 1992, p. 1275)


7–11. The 29th Australian Applied Mathematics Conference (AMC '93), Höchstens, Hahndorf, South Australia. (Sep. 1992, p. 771)


Program: The conference has grown to be the major annual international conference in its disciplines, bringing together mathematicians and others interested in combinatorics, graph theory and computing, and their interactions and applications.
The conference aims to promote better understanding of the role of modern applied mathematics, combinatorics, and computer science to acquaint the investigator in each of these areas with the various techniques and algorithms which are available to assist him in his research.

**Call for Papers:** There will be fifteen-minute sessions for contributed papers throughout the conference. Title and an abstract (10–20 lines single spaced) of each paper be received by February 5, 1993.

**Information:** F. Hoffman, Dept. of Math., 407-367-3345 or 407-367-3341; email: hoffman@fauvax.bitnet or hoffman@acc.fau.edu.


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**March 1993**

*1–5. Géométrie Algébrique en Liberté, CIRM, Marseille, France.*

**Organizer:** A. Hirschowitz (CIMPA, Nice).

**Information:** Centre International de Rencontres Mathématiques, Case 916, 70, Route Léon-Lachamp, 13288 Marseille Cedex 9; tel: (91) 833000.

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*6. Midwest Group Theory Seminar, University of Chicago, IL.*

**Program:** There will be a program of four lectures including talks by G. Malle and P. Symonds.

**Information:** J.L. Alperin, alperin@math.uchicago.edu, 312-702-7393.


*8–12. Equations d’Évolution, Théorie du Contrôle et Biomathématiques, CIRM, Marseille, France.*

**Organizers:** W. Arendt, P. Benilan (U. de Besançon).

**Information:** Centre International de Rencontres Mathématiques, Case 916, 70, Route Léon-Lachamp, 13288 Marseille Cedex 9; tel: (91) 833000.

10–12. Équations d’Évolution, Théorie du Contrôle et Biomathématiques, CIRM, Marseille, France. (Nov. 1992, p. 1115)


**Information:** Sofstat '93, ZUMA, Postfach 12 21 55, W-6800 Mannheim 1, Germany.


15–April 2. Workshop on Representation Theory of Lie Groups, Trieste, Italy.

**Chairmen:** J.H. Rawnsley and J.A. Tirao, Trieste.

**Information:** International Centre for Theoretical Physics, PO. Box 586, I-34100 Trieste.


**Information:** TLCA Secretariat, F. Sni­jders, CWI, P.O. Box 4079, NL-1009 AB Amsterdam.


**19–20. Mississippi State Annual Conference on Differential Equations and Computational Simulations, Mississippi State University, Mississippi State.**


**Call for Papers:** Abstracts for contributed papers due by 1/25/93.

**Information:** R. Shivaji, Dept. of Math. & Stats., Mississippi State U., Mississippi State, MS 39762; tel: 601-325-3414; email: rsi1@ra.msstate.edu; or B.K. Soni, NSF Engineering Research Center, Mississippi State U., Mississippi State, MS 39762; tel: 601-325-8278; bsoni@erc.msstate.edu.

19–20. Ninth Auburn Conference on Real Analysis, Auburn University, Auburn, AL.

**Invited Speakers:** A.S. Kechris, Caltech; A.M. Bruckner, UC Santa Barbara.

**Information:** J. Brown, 228 PKH, Dept. of Math., Auburn Univ., Auburn, AL 36849-5310; 205-844-6565; jbrown@duvax.auburn.edu.


**Program:** The aim of the first part of this course is to provide a self-contained introduction to methods in the case of linear and nonlinear systems of PDE. The purpose of the second part of this course will be to give a brief introduction to differential algebra and the Galois theory for systems of algebraic PDE simply called "Differential Galois Theory". Finally, the course will provide for the first time the long-awaited group theoretical unification of finite element approach to elasticity, heat, and electromagnetism.


**Information:** ERCIM, Domaine de Volu­ceau, BP 105, F-78153 Le Chesnay Cedex, France; tel: +33-1-39635578; Fax: +33-1-39635330; email: ercim@inia.inria.fr or CWI, F. Sni­jders, Postbus 4079, 1009 AB Amsterdam, The Nether­lands.


**23–28. Workshop on Applications of Pattern Formation, The Fields Institute, Waterloo, Ontario.**

**Program:** This workshop will bring together scientists and mathematicians study-
ing pattern formation in a wide variety of specific applications modeled by partial differential equations. Significant progress has been achieved through interdisciplinary approaches of this type in the past decade. The emphasis in the workshop will be on realistic physical applications and on applying new mathematical theory in order to understand the underlying mechanisms.

INVITED SPEAKERS: S. Alama, McMaster; L. Bronsard, McMaster; S. Canic, Fields; K. Dierer, Fields; M. Golubitsky, Houston; J. Hale, Georgia Tech; P. Holmes, Cornell; R. Kapral, Toronto; J. Keener, Utah; B. Keyfitz, Houston; W. Langford, Guelph; A. Lawniczak, Guelph; J. Marsden, Fields; B. Matkowsky, Northwestern; R. Miura, British Columbia; L. Mysak, McGill; A. Peirce, McMaster; D. Pelletier, Toronto; D. Sattinger, Minnesota; J. Scheurle, Hamburg; L. Trainor, Toronto; B. Wetton, UBC; S. Wiggins, Caltech; and J. Wu, York.

INFORMATION: Workshop Information: J. Chadam, 519-725-0096, ext. 3012; email: chadam@fields.uwaterloo.ca. Registration Information: J. Motts, 519-725-0096, Fax: 519-725-0704; applic@fields.uwaterloo.ca.


29–April 2. Valuations, Topological Fields, and Geometries, Marseille, France.

CHAIRMAN: S. Priess-Crampe, München. INFORMATION: CIRM, Luminy Case 916, F-13288 Marseille Cedex 9.


30–April 1. IEEE Data Compression Conference (DCC ‘93), Snowbird, Utah. (Nov. 1992, p. 1116)

Spring 1993

Spring 1993. Valuations, Topological Fields, and Geometries, CIRM, Marseille, France. (Nov. 1992, p. 1116)

Spring 1993. IMACS Workshop on Inverse Problems, Berlin, Germany.

INFORMATION: K. Doppel, Inst. fur Math I, Fachbereich Mathematik FU Berlin, Arnimallee 3, D-1000 Berlin 33–Germany; email: doppel@math.fu-berlin.de or R. Gilbert, Dept. of Math. Sci., Univ. of Delaware, Newark, DE 19716; email: gilbert@math.udel.edu.

April 1993


4–9. Copper Mountain Conference on Multigrid Methods, Copper Mountain, Colorado. (Nov. 1992, p. 1116)


INFORMATION: J. Grasman, Dept. of Math., Dreijenlaan 4, NL-6703 HA Wageningen.


5–9. Théorie des Opérateurs, CIRM, Marseille, France.

ORGANIZER: M. Mbekhta (U. de Lille).

INFORMATION: Centre International de Rencontres Mathématiques, Case 916, 70, Route Léon-Lachamp, 13288 Marseille Cedex 9; tel: (91) 835000.


SESSION TOPICS: Circuit analysis, code validation against real devices and processes, computational techniques, device modelling, energy transport models, mathematical analysis, Monte Carlo simulations, physical aspects, process simulation, quantum effects.

CALL FOR PAPERS: Potential authors should submit a camera ready abstract (two pages, A4/297 x 210mm, 1000 words maximum) by January 31, 1993.

INFORMATION: P. McKeever, Chairperson-Organizing Committee, NASECODE IX Secretariat, 26 Temple Lane, Dublin 2, Ireland; telefax: (+353-1-) 679-2469; tel: (+353-1) 679-7655; jmiller@vax1.tcd.ie.


8–10. Clifford Algebras in Analysis, University of Arkansas, Fayetteville, AR. (Sep. 1992, p. 772)

9–10. Western Section, University of Utah, Salt Lake City, Utah.

INFORMATION: W. Drady, AMS, P.O. Box 6887, Providence, RI 02940.


12–17. Tenth Easter Conference on Model Theory, Wendisch-Rietz (near Berlin), Germany.

INFORMATION: H. Wolter and M. Weese, Fachbereich Mathematik, Humboldt Univ.,
Meetings and Conferences

Postfach 1297, D-O-1086 Berlin, Germany; logik@mathematik.hu-berlin.dhp.de; Fax: (030)2093 22 38.


* 14–17. Dynamics of Complex Systems in Biosciences, Marseille, France.


INFORMATION: CIRM, Luminy Case 916, F-13288 Marseille Cedex 9.


17–18. Eastern Section, Washington, DC.

INFORMATION: W. Drady, AMS, P.O. Box 6887, Providence, RI 02940.


19–20. IMA Minisymposium on Fuzzy Control, University of Minnesota, Minneapolis, MN. (Nov. 1992, p. 1117)


CHAIRMAN: L. Schnepf, Besancon.

INFORMATION: CIRM, Luminy Case 916, F-13288 Marseille Cedex 9.


INFORMATION: INRIA-Rocquencourt, Relations Extérieures, Bureau Cours/Colloques, F-78153 Le Chesnay Cedex.


INFORMATION: MAFELAP 1993, BICOM, Brunel Univ., Uxbridge, UB8 3PH, UK.

27–29. NSF/DoD’s National SBIR Conferences, Minneapolis, MN. (Sep. 1992, p. 772)


May 1993


CHAIRMEN: C.-S. Cheng, Berkeley; D. Rauch, Wageningen; F. Pukelsheim, Augsburg.


3–14. Workshop on Qualitative Aspects and Applications of Nonlinear Evolution Equations, Trieste, Italy.


INFORMATION: International Centre for Theoretical Physics, P.O. Box 586, I-34100 Trieste.

4–8. The Third International Colloquium on Cognitive Science (ICCS-93), Donostia-San Sebastian, Spain. (Nov. 1992, p. 1117)


10–12. IMACS Symposium on Signal Processing and Neural Networks—SPAN ’93, Université du Québec at Montréal, Canada. (Jan. 1992, p. 56)


10–14. Geometrie et Topologie des Sous­ Varietes, CIRM, Marseille, France. (Nov. 1992, p. 1117)


CONFERENCE TOPICS: Symplectic and contact geometry and topology; geometry of infinite-dimensional Lie algebras; dynamical systems and foliations; singularity theory and its applications to: mathematical physics, topology, and control; application of computer algebra and symbolic calculus to geometry.

INFORMATION: I. Yaroshevskaya, Sector of Visiting Programs, SOFTAPMAT, CNI-Project, Arch. Vlasova st., 51, Moscow 117393, Russia; Fax: (095)128 05 90, (095) 128 98 21; tel: (095) 128 05 92; email: jarosh@armix.exlink.msksu or yarosh@orgmath.msksu.


INFORMATION: INRIA-Rocquencourt, Relations Extérieures, Bureau Cours/Colloques, F-78153 Le Chesnay Cedex.


PROGRAM: The purpose of the conference is to provide a forum for the presentation of recent progress in the mathematical modeling and analysis of renewable resources. Particular emphasis will be given to the modeling of biological processes, population dynamics, and bioeconomics, especially as they relate to problems in fisheries, forestry, pest and wildlife management, as well as water resources, environmental and conservation issues.

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NOTICES OF THE AMERICAN MATHEMATICAL SOCIETY
**Meetings and Conferences**


**CALL FOR PAPERS:** Deadline for submission of abstracts and for early registration is February 1, 1993.

**INFORMATION:** J.M. Cushing, Math. Dept., B-89, Univ. of Arizona, Tucson, AZ 85721, 602-621-6863; Cushing@math.arizona.edu, Fax: 602-621-8322; or T.L. Vincent, AME Dept., Univ. of Arizona, Tucson, AZ 85721, 602-621-2325, vincent1t@ccit.arizona.edu.

13–16. ASL Spring Meeting in Conjunction with a Meeting of the Society for Exact Philosophy, York University, Toronto, Canada. (Nov. 1992, p. 1117)


*17–21. Algebre et Applications, Marseille, France.*

**CHAIRMAN:** P.-J. Cahen, Marseille.

**INFORMATION:** CIRM, Luminy Case 916, F-13288 Marseille Cedex 9.


21–22. Central Section, Northern Illinois University, Dekalb, IL.

**INFORMATION:** W.S. Drady, AMS, P.O. Box 6887, Providence, RI 02940.


*24–28. Théorie des Nombres et Automates, CIRM, Marseille, France.*

**ORGANIZERS:** J.-P. Allouche (U. de Bordeaux I), C. Frougny (U. de Paris 5), C. Mauduit (U. de Lyon I).

**INFORMATION:** Centre International de Rencontres Mathématiques, Case 916, 70, Route Léon-Lachamp, 13288 Marseille Cedex 9; tel: (91) 833000.


*27–28. Fifteenth Symposium on Mathematical Programming with Data Perturbations, George Washington University, Washington, DC.*

**PROGRAM:** This symposium is designed to bring together practitioners who use mathematical programming optimization models and deal with questions of sensitivity analysis, with researchers who are developing techniques applicable to these problems.

**CONFERENCE TOPICS:** Contributed papers in mathematical programming are solicited in the following areas: Sensitivity and stability analysis results and their applications; solution methods for problems involving implicitly defined problem functions; solution methods for problems involving deterministic or stochastic parameter changes; and solution approximation techniques and error analysis. Abstracts should be sent to the address below. Abstracts should provide a good technical summary of key results, avoid the use of mathematical symbols and references, not exceed 500 words, and include a title and the name and full mailing address of each author. Deadline is 15 March 1993. 30 minutes will be allocated for the presentation of each paper.


30–June 1. Canadian Society for the History and Philosophy of Mathematics, Carleton University, Ottawa, Ontario, Canada. (Sep. 1992, p. 772)

*30–June 2. Fourteenth Annual Meeting of the Canadian Applied Mathematics Society/Société Canadienne de Mathématiques Applique, York University, North York, Ontario.*

**PROGRAM:** Three symposia associated with the meeting are fluid dynamics, functional differential equations and mathematical biology, and numerical algorithms.

**PLENARY SPEAKERS:** R. Bartels, J. Gilbert, J. Hale, S. Leibovich, M. Mackey, L. Myjak, J. Nocedal, R. Nussbaum, and Y. Wu.

**CALL FOR PAPERS:** Deadline for submission of abstracts for contributed papers is April 2, 1993.

**INFORMATION:** J. Wu, Dept. of Math. and Stats., York Univ., North York, Toronto, Canada M3J 1P3; wuji@vmi.yorku.ca; tel: 416-736-5250; Fax: 416-736-5735.


30–June 13. First Caribbean Spring School of Mathematics and Theoretical Physics, Guadeloupe (French West Indies). (Nov. 1992, p. 1118)


June 1993


1–4. Rigidité et Déformation pour les Systemes Hyperboliques, CIRM, Marseille, France. (Nov. 1992, p. 1118)

*1–5. CBMS-NSF Conference on Applications of the Representation Theory of Quantum Affine Lie Algebras to Solvable Lattice Models, North Carolina State University, Raleigh, NC.*

**PRINCIPAL SPEAKER:** T. Miwa, RIMS, Kyoto University.

**INFORMATION:** K.C. Misra, Dept. of Math., North Carolina State Univ., Raleigh, NC 27695-8205; 919-515-3320; Fax: 919-515-3798; email: misra@math.ncsu.edu.


*3–9. Fifteenth Nevanlinna Colloquium, Ann Arbor, MI.*

**PROGRAM:** The program will consist of lectures on topics of current interest in complex function theory and related areas.
Each of the morning programs will be a special session of invited lectures on a single topic, as follows: circle packing; harmonic measure; quasiconformal and quasiregular mappings; hyperbolic geometry; Riemann surfaces; and discrete groups.

**INFORMATION:** E.M. Rathbun, Math. Dept., Univ. of Michigan, Ann Arbor, MI 48109; email: ethel.rathbun@um.cc.umn.edu; Fax: 313-763-0937.

*4–7. Sixth Meeting of European Women in Mathematics, Warsaw, Poland.*

**INFORMATION:** A. Romanowska, B. Roszkowska, Instytut Matematyki, Politechnika Warszawska, Plac Politechniki 1, 00 661 Warsaw, Poland.


7–11. IMA Tutorial: Mathematical Theory which Has become an Integral Part of Modern Financial Economics, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN. (Nov. 1991, p. 1172)

7–11. Colloque International en l’Honneur de G. Freiman. La Methode Additive Inverse et ses Applications, CIRM, Marseille, France. (Nov. 1992, p. 1119)


*7–12. Methodes Geometriques et Topologies en Physique Theorique, Lyon, France.*

**INFORMATION:** C. Roger, Lab. de Geometrie et Analyse, Batiment 101, Univ. Claude Bernard, 43 Bd du 11 Novembre 1918, F-69622 Villeurbanne Cedex; or P. Sorba, Lab. de Physique Theorique, Ecole Normal Superieure de Lyon, 46 Allee d’Italie, F-69364 Lyon Cedex 07.


14–17. The Fifth Asian Logic Conference, National University of Singapore, Singapore. (May/June, 1992, p. 496)

14–18. IMA Workshop on Mathematical Finance, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN. (Nov. 1991, p. 1172)

14–18. Linear Logic Workshop, Mathematical Sciences Institute, Cornell University, Ithaca, NY. (May/June, 1992, p. 496)


*14–19. Groups of Lie Type and Their Geometries, Como, Italy.*

**ORGANIZING COMMITTEE:** L. Di Martino (U. di Milano), W.M. Kantor (U. of Oregon), O.H. Kegel (U. of Freiburg), L. Rosati (U. di Firenze).


**INFORMATION:** L. Di Martino, Dipt. di Matematica "F.Enriques", Universita di Milano, via C. Saldini 50, 20133, Milano, Italy; email: dimartino@vsmima.unimi.it or dimartini@imucca.unimi.it.


**INFORMATION:** K. Marti, Univ. der Bundeswehr Muenchen Fak fur Luft-und Raumfahrttechnik, Werner-Heisenberg-Weg 39, W-8014 Neubiberg, Germany.


**PROGRAM:** The purpose of this workshop is to bring together researchers in computer science to examine foundational issues in computer security, with emphasis on normal models that provide a framework for theories of security and techniques for verifying security as defined by such theories.

**CALL FOR PAPERS:** We are interested both in papers that describe new results in the theory of computer security and in papers, panels, and working group exercises that explore open questions and raise fundamental concerns about current theories of security. Possible topics include: access control, covert channels, information flow, database security, secure protocols, verification techniques, integrity and availability models, interactions of computer security requirements with other system requirements such as dependability and timing, and the role of formal methods in computer security. Four copies of a paper (750 word limit) should be sent by January 31, 1993 to the program chair at the address below.


*16–18. Fifth International Conference on Rewriting Techniques and Applications, Montreal, Canada.*

**CALL FOR PAPERS:** Papers in the following areas are solicited: term rewriting systems, constrained rewriting and theorem proving, graph rewriting and grammars, rewrite-based theory proving, lambda and combinatory calculus, parallel rewriting, solving and completion, symbolic and algebraic computation, equational program languages, completion procedures, unification and matching algorithms, constraint solving, and term-based architectures to Program Chair, C. Kirchner, INRIA Lorraine & CRIN, Campus Scientifique, 615, rue du Jardin Botanique, BP 101, 54602 Villers-les-Nancy cedex, France; claudie.kirchner@loria.fr by December 10, 1992.

**INFORMATION:** M. Okada, Dept. of Comp. Sci., Concordia Univ., H3G 1M8 Montreal (Quebec), Canada; email: rta93@concur.cs.concordia.ca.


20–23. Eighth Annual IEEE Symposium on Logic in Computer Science (LICS), Montreal, Canada. (Nov. 1992, p. 1119)


*20–July 2. NATO Advanced Study Institute: Real & Complex Dynamical Systems, Hillerod, Denmark.*

**PROGRAM:** The institute aims to bring to-


Meetings and Conferences

Together leading researchers involved in the mathematical analysis of both real and complex dynamics, to emphasize the recent exchange of ideas and tools between the two areas.

**Principal Speakers:** V. Baladi (Lyon), B. Branner (Lyngby), C. Budd (Bristol), A. Douady (Orsay), J.H. Hubbard (Cornell), P. Jones (Yale), B. Kitchens (IBM T.J. Watson Research Center), R. Perez-Marco (Orsay), J. Milnor (Stony Brook), M. Shishikura (Tokyo Institute of Technology), S. van Strien (Amsterdam), C.T. Sparrow (Cambridge), M. Viana (Porto/IMPA), J.-C. Yoccoz (Orsay), L.-S. Young (Arizona/UCLA).

**Information:** B. Branner, Math. Institute, Building 303, The Technical Univ. of Denmark, DK-2800 Lyngby, Denmark; email: dynsys@mat.dth.dk; Fax: (+45) 42 88 13 99. Requests for participation and financial assistance must be received before February 1, 1993.


**Information:** Janos Bolyai Math. Society, Fő utca 68, H-1027 Budapest.


1-25. Graphs on Surfaces, Johns Hopkins University, Baltimore, MD. (Sep. 1992, p. 773)


2-26. Czech Birthday Conference, Northeastern University, Boston, MA.

**Program:** This conference is in celebration of the centenary of Eduard Chech's birth. The focus will be on homotopy theory, stable and unstable, and its recent applications.

**Organizing Committee:** B. Cenkl, M.J. Hopkins, S. Jekel, H.R. Miller.

**Information:** Czech Homotopy Conference, Northeastern University, Boston, MA 02115; chtc@northeastern.edu.

23-27. Seventeenth Summer Symposium in Real Analysis, Macalester College, St. Paul, MN.

**Program:** The symposium will include hour-long lectures by five invited principal speakers, a limited number of supplemental twenty-minute presentations, and organized informal problem sessions.

**Principal Speakers:** Pending Funding: C. Goffman (Purdue), M. Laczkovicz (Eotvos Lorand U.), A. Olevskii (Moscow and Tel Aviv), D. Preiss (University College), D. Waterman (Syracuse).

**Call for Papers:** Abstracts for 20 minute presentations should be received in triplicate by April 1, 1993. For the problem sessions, a background and statement of the problem should be received in triplicate by April 1, 1993.

**Information:** K. Saxe, Dept. of Math. and CS, Macalester College, 1600 Grand Ave., St. Paul, MN 55105-1899; email: saxe@macalstr.edu.


**Conference Topics:** General topology and applications, special sessions on set-theoretic topological semi-groups, and uniform spaces.


**Call for Papers:** Deadlines for abstracts: May 1, 1993.

**Information:** Committee Chairman: E.M. Grabner, emg@srnu.bitnet; R. Buck, reb@srnu.bitnet; G.C. Grabner, ggg@srnu.bitnet; M. Ismail, msi@srnu.bitnet; W.F. Lindgill, wfl@srnu.bitnet; A. Szymanski, aas@srnu.bitnet.


**Call for Papers:** Papers are solicited on: verification and validation tools for hardware and software systems, including protocols, distributed systems, real-time control systems and digital circuits and systems; verification and validation methods based on model checking, theorem proving, automata based methods; verification theories and their applicability; and complexity and efficiency issues in automatic verification. Submissions in the form of a LaTeX or Postscript file to cav@csd.uch.gr and should be limited to 12 double-spaced pages. 5 hard copies should be sent to the program chair by January 15, 1993.

**Information:** Program Chair, C. Courcoubetis, Univ. of Crete, Dept. of Comp. Sci. and Inst. of Comp. Sci., FORTH, P.O. Box 1385, GR-71110, Heraklion, Crete, Greece; email: courcou@csi.forth.gr.

28-July 2. Geometrie Algebrique et Theorie des Codes, CIM, Marseille, France. (Nov. 1992, p. 1120)


**Information:** V. Statulevicius, Inst. of Math. and Informatics, Akademijos 4, 2600 Vilnius, Lithuania.


**July 1993**


4-10. Fifth International Congress on Algebraic Hyperstructures and Applications, Iasi, Romania. (Sep. 1992, p. 773)

**4-10. Methoden der Modul-und Ringtheorie, Oberwolfach, Federal Republic of Germany.**

**Information:** Mathematisches Forschungsinstut Oberwolfach Geschäftsstelle: Alberstrasse 24 D-7800 Freiburg im Breisgau.

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5-9. Communications et Reseaux d’Interconnexion, CIRM, Marseille, France. (Nov. 1992, p. 1120)

5-9. The Thirty-seventh Annual Meeting of the Australian Mathematical Society (AMS '93), University of Wollongong, Australia. (Nov. 1992, p. 1120)

5-9. CTAC93 Conference and Workshops, Australian National University, Canberra, A.C.T., Australia. (Dec. 1992, p. 1280)


5-31. The Thirty-seventh Annual Meeting of the IMA, University of Minnesota, Minneapolis, MN. (Nov. 1992, p. 1120)


7-10. The Second International Conference on Fluid Mechanics (ICFM-II), Beijing, China. (Sep. 1992, p. 773)

8-10. ATLAST 1993 Linear Algebra Workshops, University of Houston–Downtown, Houston, TX. (Dec. 1992, p. 1281)

9-11. 1993 Annual Meeting of the Australian Association for Logic, University of Adelaide, South Australia.


12-17. Colloque Takeuti: Theorie de la Demonstration et Applications en Informatique, CIRM, Marseille, France. (Nov. 1992, p. 1121)

12-17. Third International Conference on Nonassociative Algebra and its Applications, University of Oviedo, Spain. (Nov. 1992, p. 1121)


15-17. ATLAST 1993 Linear Algebra Workshops, Georgia State University, Atlanta, GA. (Dec. 1992, p. 1281)


19-23. Singularities, CIRM, Marseille, France. (Nov. 1992, p. 1121)


* 19-23. Seventh ACM International Conference on Supercomputing, Tokyo, Japan.

CONFERENCE TOPICS: Parallel and high-performance computer architectures; parallelizing compilers and programming environments; operating systems and performance evaluation; large-scale applications and algorithms; and new experimental and commercial systems.

INFORMATION: M. Sato, Secretary of ICS '93 Program Committee, Electrotechnical Laboratory, 1-1-4 Umezono, Tsukuba, Ibaraki 305, Japan; msat@etl.go.jp.


PROGRAM: The meeting will be addressed to both graduate students and researchers, with survey talks by experts in the field.

INFORMATION: J. Antoniadis or N. Tzanakis, University of Crete, P.O. Box 1470, Heraklio, Crete, Greece; email: eliptcurv@talos.cc.uch.gr.

* 19-August 13. CRM Summer School on Mathematical Biology, University of British Columbia.

ORGANIZER: R. Miura (UBC).


INFORMATION: M. Louis Pelletier, CRM, Univ. de Montréal, C.P. 6128, Succursale A, Montréal, Québec, H3C 3J7, Canada; or email: pellet@ere.umontreal.ca.

20-29. 1993 ASL European Summer Meeting (Logic Colloquium '93), University of Keele, United Kingdom. (Nov. 1992, p. 1121)


PROGRAM: This symposium is a forum for presenting the latest research findings that unify parallel and distributed computing fields.

CONFERENCE TOPICS: Parallel or distributed algorithms to solve computationally intensive problems across a LAN, MAN, or WAN; architectural support for high-speed communications or interconnection networks; gigabit network architectures; high performance distributed shared memory systems; distributed computing environments; HPDC Software Management Tools; High-speed communication transport protocols to achieve gigabit/sec application-to-application transfer rates; high performance I/O systems; performance evaluation of experimental systems to solve supercomputing applications across networks of computers.

CALL FOR PAPERS: Authors are requested to submit by January 15, 1993 five copies of their manuscript (not to exceed 25 double-spaced pages) to the address below.

INFORMATION: R. Mathsen, Dept. of Math., Washington State Univ., Pullman, WA 99164-2752; 509-335-8246; rgh@eecs.wsu.edu.


* 26-30. Groupes Ordonnés et Groupes de Permutations Infinis, Marseille, France.

INFORMATION: CIRM, Luminy Case 916, F-13288 Marseille Cedex 9.

* 26-30. Cryptography and Computational Number Theory, North Dakota State University, Fargo, ND.

PROGRAM: This is the 1993 Summer Seminar of the North Central Section of the Mathematical Association of America. C. Pomerance will deliver 10 lectures covering such topics as primality testing and Carmichael numbers, integer factoring, discrete logarithms, and cryptographic systems.

INFORMATION: R. Mathsen, Dept. of Math., North Dakota State University, Fargo, ND 58105-5075.

26-August 6. SMS-NATO ASI: Complex Potential Theory, Université de Montréal, Montréal, Canada. (Dec. 1992, p. 1282)

* 27-30. Seventh Workshop on Operator Theory and Boundary Eigenvalue Problems, Vienna Technical University, Vienna, Austria.

INFORMATION: H. Langer, Institut 114,
Meetings and Conferences

August 1993

August–December. A Semester at CRM: Spatial and Temporal Dynamics, Université de Montréal.

Organizers: J. Guckenheimer and P. Holmes (Cornell).


Information: M. Louis Pelletier, CRM, Univ. de Montréal, C.P. 6128, Succursale A, Montréal, Québec, H3C 3J7, Canada; or email: pellet@ere.umontreal.ca.


*6–19. Stochastic Analysis and Applications in Physics, NATO Advanced Study Institute at the Universidade de Madeira.

Program: The last decade saw enormous achievements in stochastic analysis and its applications in connection with analysis on infinite dimensional spaces. Quantum physics and dynamical systems were among the inspiring sources for these developments. The school will bring experts in these fields together for a comprehensive review in order to achieve coherence and to stimulate future research. A limited number of fellowships for partial support and a smaller one for full support are available.

Conference Topics: Markov and quantum fields, dirichlet forms, analysis on loop groups, Monte Carlo methods, stochastic methods in quantum field theory, quantum probability, stochastic (partial) differential equations, Feynman integration, stochastic dynamical systems, and white noise analysis.

Lecturers: S. Albeverio (Bochum), P. Collet (Paris), M. Fukushima (Osaka), L. Gross (Cornell), G. Jona-Lasinio (Rome), C.B. Lang* (Graz), R. Vilela Mendes (Lisbon), P.A. Meyers* (Strasbourg), P.K. Mitter (Paris), B. Øksendal (Oslo), E. Pardoux* (Marseille), J. Potthoff (Mannheim), R. Seneor (Paris), L. Streit (Funchal, Bielefeld). Speakers marked with a * are not yet fully confirmed.

Information: L. Streit, Universidade da Madeira, Edificio do Colegio, Praça do Municipio, P-9000 Funchal, Madeira; email: streit@telefonica.net.


15. Tutorial on Numerical Methods in Control, Signal, and Image Processing, University of Washington, Seattle, WA.

Organizer: B.N. Datta, Northern Illinois University.

Information: SIAM Conference Coordinator, Dept. CC1192, 3600 University City Science Center, Philadelphia, PA 19104-2688; tel: 215-382-9800; Fax: 215-386-7999; email: meetings@siam.org.


Information: International Centre for Theoretical Physics, P.O. Box 586, I-34100 Trieste.


Call for Papers: Original research papers and technical expository talks are solicited on all practical and theoretical aspects of cryptography. Authors are requested to send 12 copies of a detailed abstract (not a full paper) by April 26, 1993 to the address below. All submissions must be anonymous.

Program: The program will consist of 50-minute plenary lectures, delivered by invited speakers, and many 20-minute talks (probably in parallel sections) and a problem session.

Invited Speakers: G. McNulty (Columbia), I. Rival (Ottawa), R. Willard (Waterloo), and W. Geyer, N. Newry, and P. Vogt (Darmstadt).

Deadlines: April 30, 1993 for application and for booking accommodations; June 25, 1993 for abstracts; and August 1, 1993 for posters.

Information: G. Czele, JATE Bolyai Institute, Szeged, Aradi vertanuk tere 1, Hungary, H-6720; email: h1031ce@ella.hu; Fax: (+36) 62-326246.


24–27. Third Kurt Gödel Colloquium, Brno, Czech Republic.

Program: This colloquium is intended for logicians and computer scientists interested in the proof-theoretic and algorithmic aspects of logic.

Conference Topics: Proof theory, automated theorem proving, unification theory, complexity theory, logics of programs, nonstandard logics for theoretical computer science and AI, recursion theory, logic programming, and lambda-calculus.

Call for Papers: Persons interested in speaking should submit 3 copies of a full draft paper in English not to exceed 12 pages by January 31, 1993.

Information: Program Chair, A. Leitsch, Technische Univ. Wien, Inst. fur Computersprachen E185.2, rassgasse 3/1, A-1040 Vienna, Austria; kgs@csedc2.uwien.ac.at.


30–September 3. Inverse Problems: Principles and Applications in Geophysics, Technology, and Medicine, Potsdam (near Berlin), Germany. (Sep. 1992, p. 774)

30–September 3. Représentations des Groupes et Analyse Complex, CIRM, Marseille, France. (Nov. 1992, p. 1121)


Organizing Committee: P. Neittaanmäki (Chair), M. Krizek, Yu. Kuznetsov, J. Periaux, R. Stenberg.

Conference Topics: Historical developments; FE-grid generation, adaptive methods; A-priori and a-posteriori error estimates; superconvergence; irregular problems; implementation issues, parallelization; FEM in optimal control, free boundary problems; applications in elasticity, fluid dynamics, electromagnetism, etc.

Call for Papers: Abstracts (10–20 lines) of your papers should be sent to the Conference Secretariat in Jyväskylä by January 30, 1993.

Information: FEM 50 Secretariat, Dept. of Math., Univ. of Jyväskylä, PO. Box 35, SF-40351 Jyväskylä, Finland; Fax: 358 41 60 2731.

September 1993


Call for Papers: One abstract to be submitted by May 15, 1993.


Organizers: J.-M. Kantor and D. Zagier (Univ Paris 7).

Information: Centre International de Rencontres Mathématique, Case 916, 70, Route Léon-Lachamp, 13288 Marseille Cedex 9; tel: (91) 833000.

6–11. Eleventh International Conference on Topology, Trieste, Italy.

Program: The conference is part of the celebrations for the fiftieth anniversary of the Faculty of Engineering of the University of Trieste. A special session will be dedicated to Prof. Mario Dolcher and his work.

Information: G. Tironi, Dept. of Math. Sci., Univ. of Trieste, P/o Europa, 1–I–34127–Trieste (Italy); tel: (39) 40 676–3258, 3727; Fax: (39) 40 676–3256; email: tironi@univ.trieste.it or dsm@dsm@univ.trieste.it.

9–15. IMA Tutorial, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN.

Information: Institute for Mathematics and its Applications, University of Minnesota, 514 Vincent Hall, 206 Church St., S.E., Minneapolis, MN 55455.

12–16. Third Dublin Differential Equations Meeting, Dublin City University, Dublin, Ireland.

Program: The invited speakers will give 50 minute lectures. There will be sessions of contributed 25 minute talks, which can be on any aspect of the theory or applications of differential equations.


Information: D.W. Reynolds, School of Math. Sci., Dublin City Univ., Dublin 9, tel: 01 704 5290; email: math@dcu.ie.


13–18. Different Aspects of Differentiability, Warsaw, Poland. (May/June 1992, p. 497)
Meetings and Conferences


**Eastern Section**, Syracuse, NY.

Information: W. Drady, AMS, P.O. Box 6887, Providence, RI 02940.


22-23. **Central Section**, Texas A&M University, College Station, TX.

Information: W.S. Drady, AMS, P.O. Box 6887, Providence, RI 02940.


Organizers: Organized jointly by CERCA, CERFACS, and CRM.

Information: M. Louis Pelletier, CRM, Univ. de Montréal, C.P. 6128, Succursale A, Montréal, Québec, H3C 3J7, Canada; or email: pelletl@ere.umontreal.ca.

*27-October 1. **Orbites Périodiques des Systèmes Dynamiques**, CIRM, Marseille, France.

Organizer: J.-P. Francoise (U. de Paris 6) and R. Roussarie (U. de Dijon).

Information: Centre International de Rencontres Mathématiques, Case 916, 70, Route Léon-Lanchamp, 13288 Marseille Cedex 9; tel: (91) 833000.

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**October 1993**


*6-8. Games, Logic, and Process, CIRM, Marseille, France.*

Organizer: Y. Lafont (ENS, Paris).

Information: Centre International de Rencontres Mathématiques, Case 916, 70, Route Léon-Lanchamp, 13288 Marseille Cedex 9; tel: (91) 833000.

*11-14. Gestion de Projets Statistiques, CIRM, Marseille, France.*

Organizer: R. Teekens (TES, Luxembourg).

Information: Centre International de Rencontres Mathématiques, Case 916, 70, Route Léon-Lanchamp, 13288 Marseille Cedex 9; tel: (91) 833000.


18-22. **IMA Workshop on Finite Markov Chain Renaissance**, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN.

Information: Institute for Mathematics and its Applications, University of Minnesota, 514 Vincent Hall, 206 Church St., S.E., Minneapolis, MN 55455.

*19-22. 1993 International Conference on Network Protocols (ICNP-93), San Francisco, CA.*

Conference Topics: Network architectures, switching protocols, routing protocols, flow and congestion control, high-speed networks, real-time protocols, network security, name servers and directories, protocol conversion, broadcast systems, distributed operating systems, system support and interfaces, protocol design methodology, protocol verification, protocol testing and debugging, protocol implementation.

Call for Papers: Authors are requested to send six copies of their double-spaced typed manuscript (maximum of 25 pages) with an abstract by March 1, 1993 to: M.G. Gouda, Program Chair, Dept. of Comp. Sci., Univ. of Texas, Austin, TX 78712; tel: 512-471-9532; gouda@cs.utexas.edu.

*20-22. Stage de Bibliothécaires de Mathématiques, CIRM, Marseille, France.*

Organizer: Mr. Barbancon (U. de Strasbourg).

Information: Centre International de Rencontres Mathématiques, Case 916, 70, Route Léon-Lanchamp, 13288 Marseille Cedex 9; tel: (91) 833000.


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**November 1993**


6-7. **Western Section**, Claremont, CA.

Information: W. Drady, AMS, P.O. Box 6887, Providence, RI 02940.

*15-19. IMA Workshop on Random Discrete Structures**, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN.

Information: Institute for Mathematics and its Applications, University of Minnesota, 514 Vincent Hall, 206 Church St., S.E., Minneapolis, MN 55455.

*15-19. Systèmes d’Équations Algébriques, CIRM, Marseille, France.*


Information: Centre International de Rencontres Mathématiques, Case 916, 70, Route Léon-Lanchamp, 13288 Marseille Cedex 9; tel: (91) 833000.


*22-26. Géométrie Symplectique et Physique Mathématique, CIRM, Marseille, France.*


Information: Centre International de Rencontres Mathématiques, Case 916, 70, Route Léon-Lanchamp, 13288 Marseille Cedex 9; tel: (91) 833000.


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**January 1994**


Organizers: C. Rousseau and D. Schmillau (CRM).

Visitors: D. Cerveau, C. Christopher, F.
Meetings and Conferences


* INFORMATION: M. Louis Pelletier, CRM, Univ. de Montréal, C.P. 6128, Succursale A, Montréal, Québec, H3C 3J7, Canada; or email: pelletl@ere.umontreal.ca.


PROGRAM: The conference offers to researchers and mathematicians in harmonic analysis and operator theory a platform to discuss recent developments, to exchange new ideas, and to analyze trends for further research. There will be a session dedicated to discuss the social responsibility of the scientist.


CALL FOR PAPERS: Deadline for abstracts of invited and contributed papers is September 1, 1993.

INFORMATION: Comité Organizador Conferencia Cotlar, Apartado 47.898 Caracas, 1041-A, Venezuela; tel: (582)-662-9734-662-9734, UCV or (582)-501-1412-501-1412, IVIC; Fax: (582)-662-9734, (582)-662-7121 or (582)-501-1416, (582)-962-1695; Telex: 21657; email: wurbina@dino.conicet.ve.

5–8. Joint Mathematics Meetings, Cincinnati, OH. (Including the annual meetings of the AMS, AWM, MAA, and NAM)

INFORMATION: H. Daly, AMS, P.O. Box 6248, Providence, RI 02940.

* 24–28. IMA Workshop on Mathematical Population Genetics, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN.

INFORMATION: Institute for Mathematics and its Applications, University of Minnesota, 514 Vincent Hall, 206 Church St., S.E., Minneapolis, MN 55455.

February 1994

* February 1994. Workshop on Dynamical Disease, Laurentian Mountains north of Montréal.

ORGANIZERS: J. Bélair (CRM), L. Glass (McGill), U. an der Heiden (Witten/Herdecke), and J. Milton (Chicago).

INFORMATION: M. Louis Pelletier, CRM, Univ. de Montréal, C.P. 6128, Succursale A, Montréal, Québec, H3C 3J7, Canada; or email: pelletl@ere.umontreal.ca.

* 28–March 4. IMA Workshop on Stochastic Networks, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN.

INFORMATION: Institute for Mathematics and its Applications, University of Minnesota, 514 Vincent Hall, 206 Church St., S.E., Minneapolis, MN 55455.

The following new announcements will not be repeated until the criteria in the last paragraph in the box at the beginning of this section are met.

May 1994

* 2–6. IMA Workshop on Image Models (and Their Speech Model Cousins), Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN.

INFORMATION: Institute for Mathematics and its Applications, University of Minnesota, 514 Vincent Hall, 206 Church St., S.E., Minneapolis, MN 55455.

* 10–20. IMA Workshop on Stochastic Models in Geosystems, Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, MN.

INFORMATION: Institute for Mathematics and its Applications, University of Minnesota, 514 Vincent Hall, 206 Church St., S.E., Minneapolis, MN 55455.

July 1994

* 17–23. Conférence Internationale de Topologie, CIRM, Marseille, France.

ORGANIZER: Y. Mathieu (U. de Provence, Marseille).

INFORMATION: Centre International de Rencontres Mathématiques, Case 916, 70, Route Léon-Lachamp, 13288 Marseille Cedex 9; tel: (91) 833000.

August 1994

New Publications Offered by the AMS

COLLECTED WORKS

A. Adrian Albert Collected Mathematical Papers

Volume 3

This book contains the collected works of A. Adrian Albert, a leading algebraist of the twentieth century. Albert made many important contributions to the theory of the Brauer group and central simple algebras, Riemann matrices, nonassociative algebras, and other topics. Part 1 focuses on associative algebras and Riemann matrices, and Part 2 on nonassociative algebras and miscellaneous. Because much of Albert’s work remains of vital interest in contemporary research, this volume will interest mathematicians in a variety of areas.

Contents
Preface; Bibliography; Professional Biography of (Abraham) Adrian Albert; Ph.D. Students of A. Adrian Albert; A. A. Albert by Daniel Zelinsky; Abraham Adrian Albert, A biographical memoir by Irving Kaplansky; A. Adrian Albert by Israel N. Herstein, Collection of articles dedicated to the memory of Abraham Adrian Albert; Part 1: A determination of all normal division algebras in sixteen units; On the rank equation of any normal division algebra; The rank function of any simple algebra; On the structure of normal division algebras; Normal division algebras in 4 x units, p an odd prime; The structure of any algebra which is a direct product of rational generalized quaternion division algebras; The non-existence of pure Riemann matrices with normal multiplication algebras of order sixteen; A necessary and sufficient condition for the non-equivalence of any two rational generalized quaternion division algebras; Determination of all normal division algebras in thirty-six units of type B2; A note on an important theorem on normal division algebras; New results in the theory of normal division algebras; A construction of all non-commutative rational division algebras of order eight; The structure of pure Riemann matrices with non-commutative multiplication algebras; On direct products, cyclic division algebras, and pure Riemann matrices; On normal division algebras of type R in thirty-six units; On the Wedderburn norm condition for cyclic algebras; A note on cyclic algebras of order sixteen; On direct products; Division algebras over an algebraic field; The structure of matrices with any normal division algebra of multiplications; On the construction of cyclic algebras with a given exponent; Algebras of degree 2 and pure Riemann matrices; A construction of non-cyclic normal division algebras; Normal division algebras of degree four over an algebraic field; On normal simple algebras; A note on normal division algebras of order sixteen; (with H. Hasse), A determination of all normal division algebras over an algebraic number field; A note on the equivalence of algebras of degree two; On primary normal division algebras of degree eight; Non-cyclic algebras of degree and exponent four; Normal division algebras over algebraic number fields not of finite degree; Cyclic fields of degree eight; On the construction of Riemann matrices I; Normal division algebras of degree 4 over F of characteristic 2; On certain imprimitive fields of degree p over F of characteristic p; Normal division algebras over a modular field; A solution of the principal problem in the theory of Riemann matrices; Cyclic fields of degree p over F of characteristic p; On normal Kummer fields over a non-modular field; The principal matrices of a Riemann matrix; A note on the Poincaré theorem on pure Riemann matrices; On the construction of Riemann matrices; On cyclic fields; Involutional simple algebras and real Riemann matrices; Normal division algebras of degree p over F of characteristic p; Simple algebras of degree p over a centroid of characteristic p; p-algebras over a field generated by one indeterminate; Non-cyclic algebras with pure maximal subfields; On cyclic algebras; A note on normal division algebras of prime degree; On ordered algebras; On p-adic fields and rational division algebras; Division algebras over a function field; Two element generation of a separable algebra; Absolute valued real algebras; Absolute-valued algebraic algebras; Leonard Eugene Dickson (1874–1954); On involutorial algebras; A property of ordered rings; On involutorial associative division algebras; A normal form for Riemann matrices; New results on associative division algebras; On associative division algebras (Retiring Presidential Address); A note on certain cyclic algebras; Tensor products of quaternion algebras; Acknowledgments; Part 2: The integers of normal quartic fields; A determination of the integers of all cubic fields; The integers represented by sets of ternary quadratic forms; On universal sets of positive ternary quadratic forms; A note on the Dickson theorem on universal ternaries; On a certain algebra of quantum mechanics; Integral domains of rational generalized quaternion algebras; A note on matrices defining total real fields; Normalized integral bases of algebraic number fields 1; A quadratic form problem in the calculus of variations; Symmetric and alternate matrices in an arbitrary field, 1; Quadratic null forms over a function field; A rule for computing the inverse of a matrix; Quadratic forms permitting composition; Non-associative algebras. 1. Fundamental concepts and isometry; Non-associative algebras. 2. New simple algebras; The radical of a non-associative algebra; An inductive proof of Descartes' rule of signs; Quasigroups. 1. Algebras derived by non-associative matrix multiplication; The matrices of factor analysis; The minimum rank of a correlation matrix; Quasigroups. 2. Quasiquaternion algebras; On Jordan algebras of linear transformations; The Wedderburn principal theorem for Jordan algebras; A structure theory for Jordan algebras; On the power-associativity of rings; Power-associative rings; On right alternative algebras; A theory of trace-admissible algebras; Almost alternative algebras; A note on the exceptional Jordan algebra; A theory of power-associative commutative algebras; New simple power-associative algebras; Power-associative algebras; On nonassociative division algebras; On simple alternative rings; On commutative power-associative algebras of degree two; Rational normal matrices satisfying the incidence equation; The structure of right alternative algebras; (with M. S. Frank), Simple Lie algebras of characteristic p; On Hermitian operators over the Cayley algebra; A property...
of special Jordan algebras; On certain trinomial equations in finite fields; (with B. Muckenhoupt), On matrices of trace zero; On partially stable algebras; (with N. Jacobson), On reduced exceptional simple Jordan algebras; Addendum to the paper on partially stable algebras; A construction of exceptional Jordan division algebras; On the orthogonal equivalence of sets of real symmetric matrices; A solvable exceptional Jordan algebra; (with L. J. Paige), On a homomorphism property of certain Jordan algebras; (with John Thompson), Two-element generation of the projective unimodular group; Finite noncommutative division algebras; Finite division algebras and finite planes; On the collineation groups associated with twisted fields; On the collineation groups of certain non-Desarguesian planes; Generalized twisted fields; Isotopy for generalized twisted fields; On the nuclei of a simple Jordan algebra; On exceptional Jordan division algebras; On some properties of biabelian fields; On certain polynomial systems; Unpublished Articles: Some mathematical aspects of cryptography; (with L. J. Paige) Malcev algebras; Acknowledgments.

1991 Mathematics Subject Classifications: 11-xx, 12-xx, 14-xx, 16-xx, 17-xx

Contents

**G-Categories**

Robert Gordon

Volume 101, Number 482

A G-category is a category on which a group G acts. This work studies the 2-category G-Cat of G-categories, G-functors (functors which commute with the action of G) and G-natural transformations (natural transformations which commute with the G-action).

There is particular emphasis on the relationship between a G-category and its stable subcategory, the largest sub-G-category on which G operates trivially. Also contained here are some very general applications of the theory to various additive G-categories and to G-topoi.

Contents

G-Categories: The stable subcategory, G-limits and stable limits; Systems of isomorphisms and stably closed G-categories; Partial G-sets: G-adjoints and G-equivalence; Par(G-set) and G-representability; Transversals; Transverse limits and representations of transversal functors; Reflections and stable reflections; G-Cotripleability; The standard factorization of insertion; Cotripleability of stable reflectors; The case of $\mathcal{D}_G^G$; Induced stable reflections and their signatures; The $\mathcal{D}_G^G$-targeted case.

1991 Mathematics Subject Classification: 18A35, 18A40, 18B25, 18C15, 18D05, 18E05

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**MEMOIRS OF THE AMS**

**G-Categories**

Robert Gordon

Volume 101, Number 482

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**Orientation and the Leray-Schauder Theory for Fully Nonlinear Elliptic Boundary Value Problems**

Patrick Fitzpatrick and Jacobo Pejsachowicz

Volume 101, Number 483

The aim of this work is to develop an additive, integer-valued degree theory for the class of quasilinear Fredholm mappings. This class is sufficiently large that, within its framework, one can study general fully nonlinear elliptic boundary value problems. A degree for the whole class of quasilinear Fredholm mappings must necessarily accommodate sign-switching of the degree along admissible homotopies. The authors introduce "parity", a homotopy invariant of paths of linear Fredholm operators having invertible endpoints. The parity provides a complete description of the possible changes in sign of the degree and thereby permits use of the degree to prove multiplicity and bifurcation theorems for quasilinear Fredholm mappings. Applications are given to the study of fully nonlinear elliptic boundary value problems.

Contents

Quasilinear Fredholm mappings; Orientation and the degree; General properties of the degree; Mapping theorems; The parity of a path of linear Fredholm operators; The regular value formula and homotopy dependence; Bifurcation and continuation; Strong orientability; Fully nonlinear elliptic boundary value problems.

1991 Mathematics Subject Classification: 35J65, 47H15, 58G10

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**Duality for Actions and Coactions of Measured Groupoids on von Neumann Algebras**

Takehiko Yamanouchi

Volume 101, Number 484

Through classification of compact abelian group actions on semifinite injective factors, Jones and Takesaki introduced the notion of an action of a measured groupoid on a von Neumann algebra, which has proven to be an important tool for this kind of analysis. Elaborating on this notion, this work introduces a new concept of a measured groupoid action that may fit more perfectly into the groupoid setting. Yamanouchi also shows the existence of a canonical coproduct on every groupoid von Neumann algebra, which leads to a concept of a coaction of a measured groupoid. Yamanouchi then proves duality between these objects, extending Nakagami-Takesaki duality for (co)actions of locally compact groups on von Neumann algebras.

Contents

Relative tensor products of Hilbert spaces over abelian von Neumann algebras; Coproducts of groupoid von Neumann algebras; Actions and coactions of measured groupoids on von Neumann algebras; Crossed products by groupoid actions and their dual coactions; Crossed products by groupoid coactions and their dual actions; Duality for actions on von Neumann algebras; Duality
for integrable coactions on von Neumann algebras; Examples of actions and coactions of measured groupoids on von Neumann algebras.

1991 Mathematics Subject Classification: 46L10, 46L55; 22D25, 22D35
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Axiomization of Passage from 'Local' Structure to 'Global' Object
Paul Feit
Volume 101, Number 485

Requiring only familiarity with the terminology of categories, this book will interest algebraic geometers and students studying schemes for the first time. Feit translates the geometric intuition of local structure into a purely categorical format, filling a gap at the foundations of algebraic geometry. The main result is that, given an initial category C of "local" objects and morphisms, there is a canonical enlargement of C to a category Cfl which contains all "global" objects whose local structure derives from C and which is functorially equivalent to the traditional notion of "global objects". Using this approach, Feit unifies definitions for numerous technical objects of algebraic geometry, including schemes, Tate's rigid analytic spaces, and algebraic spaces.

Contents
Terminology; Canopies; Canopies and colimits; Smoothing; Local and global structures.

1991 Mathematics Subject Classification: 14A, 14K, 18A, 18B, 18D, 18F
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107 pages (softcover), January 1993
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A New Look at Knot Polynomials
Joan Birman

This videotape combines a lecture with an informal interview to bring out the fascination of the subject of knot polynomials as well as a personal view of the field from one of its leaders. In the interview portion of the tape, Birman discusses her role in the discovery of the celebrated Jones polynomial, how she got started in knot theory, and some of the changes she has seen in the field. Birman's lecture, widely praised at the 1992 Joint Mathematics Meetings in Baltimore as one of the best introductions to the subject, balances the intuition of pictures with the rigor of technical details. Because she starts with the basic definition of a knot and moves up to the latest developments involving Vassiliev invariants, this lecture will interest undergraduates and researchers alike.

SOCIÉTÉ MATHEMATIQUE DE FRANCE,
ASTÉRISQUE

An Extension of a Theorem by Cheeger and Müller
Jean-Michel Bismut and Weiping Zhang
Number 205

This work grew out of the theorem of Cheeger and Müller on the equality of the Reidemeister metric and the Ray-Singer metric on the determinant of the cohomology of a flat vector bundle equipped with a flat or unimodular metric. The authors extend this theorem to the case of flat vector bundles equipped with arbitrary metrics. The ratio of these two metrics is expressed in terms of the integral of a Chern-Simons current on M. In addition, the authors establish anomaly formulas for Ray-Singer metrics. The book closes with an appendix on the Thom-Smale complex by F. Laudenbach.

Titles in this series are published by the Société Mathématique de France and distributed by the AMS in the United States, Canada, and Mexico. Orders from other countries should be sent to the SMF, Maison de la SMF, Case 916-Luminy, F-13 288 Marseille Cedex 9, France, or to OFFLIB, 46 rue Gay-Lussac, 75240 Paris Cedex 05, France.

Contents
Reidemeister metrics and Milnor metrics; Ray-Singer metrics and the de Rham map; Berezin integrals and Morse functions; Anomaly formulas for Ray-Singer metrics; A closed 1-form on $\mathbb{R}^\times \times \mathbb{R}^\times$; Some properties of the integral $\int_M (\delta g, g^p)(\nabla f)^p\psi(TM, \nabla^2 M)$; An extension of a theorem of Cheeger and Müller; The asymptotic structure of the matrix of the $d^2$ operator on the Helffer-Sjöstrand orthogonal base; Proof of Theorem 7.6: The asymptotics as $T \to +\infty$ of certain traces associated to the operator $D_2^2$; The asymptotics of $\text{Tr}_4[N \exp(-iD)]$ as $T \to 0$; An asymptotic expansion for $\text{Tr}_4[f \exp(-itD)]$ as $T \to +\infty$; An estimate for $\text{Tr}_4[f \exp(-(tD + T)(\nabla f)^2)]$ in the range $0 < t \leq 1$, $0 \leq T < 1$; The asymptotics as $t \to 0$ of $\text{Tr}_4[f \exp(-(tD + T)(\nabla f)^2)]$; The asymptotics of $\text{Tr}_4[f \exp(-(tD + T/2)(\nabla f)^2)]$ for $0 < t \leq 1$, $T \geq 1$; A direct proof of a formula comparing two Milnor metrics.

1991 Mathematics Subject Classification: 58G
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Electoral Results of 1992
In the Election of 1992, 4579 valid ballots were returned. Anil Nerode was elected to a three-year term as Vice-President and Roy L. Adler to a five-year term as Trustee.

There are five newly-elected Members-at-Large of the Council: Susan Gayle Williams, Steven G. Krantz, James I. Lepowsky, Svetlana R. Katok, and Peter Li. Each serves a three-year term.

Elected to three-year terms on the Editorial Boards Committee are Bryan J. Birch and Fan R. K. Chung.

Candidates elected to three-year terms on the Nominating Committee are Vaughan F. R. Jones, Nancy K. Stanton, and Jerome A. Goldstein.

All terms begin on February 1, 1993, except those for the Nominating Committee, which commence January 1, 1993. The report of the tellers may be obtained by contacting the Secretary of the Society. The full list of the Council, the Trustees, and the Members of the Executive Committee will appear in the February 1993 issue of the Notices.

Robert M. Fossum
Secretary
Urbana, Illinois

The March Meeting in Springfield
The 873rd meeting of the Society was held in Springfield, Missouri at Southwest Missouri State University on March 20 and 21, 1992. There were 348 registrants, including 236 members of the Society.

Invited Addresses. By invitation of the Central Section Program Committee, there were four invited addresses. The speakers, their affiliations, and their titles were as follows: Alexander Eremenko, Purdue University, Recent progress in value distribution theory; Julia Knight, University of Notre Dame, Algorithms based on guessing: infinitely nested priority arguments; Peter J. Olver, University of Minnesota, Quantization of Lie algebra cohomology and quasi-exactly solvable Schrödinger operators; and Ernst A. Ruh, Ohio State University, Nilpotent structures on principal bundles. The speakers were introduced by David Drasin, Clayton Sherman, Niky Kamran, and Luis Hernandez, respectively.

Special Sessions. By invitation of the same Committee, there were twelve Special Sessions of selected 20-minute papers. The topics and the names and affiliations of the organizers were as follows:

Harmonic Analysis, Nakhle Habib Asmar and Stephen John Montgomery-Smith, University of Missouri-Columbia.

Combinatorics and Discrete Geometry, Margaret M. Bayer, University of Kansas, Lawrence.

Partial Differential Equations, Wengxiang Chen and Shou Chuan Hu, Southwest Missouri State University.

Commutative Algebra, William J. Heinzer and Craig Huneke, Purdue University, and Kishor M. Shah, Southwest Missouri State University.

The Geometry of Connections, Luis Hernandez, University of Chicago, and Ernst Ruh, Ohio State University.

Lie Algebras, Cohomology, and New Applications to Quantum Mechanics, Niky Kamran, McGill University, and Peter J. Olver, University of Minnesota.

C*-algebras and Algebraic Topology, Ellen Maycock Parker, DePauw University.

Semigroups, Boris M. Schein, University of Arkansas.

Fourier Analysis, Vera B. Stanojevic, Southwest Missouri State University.

Approximation Theory, Xingping Sun and Xiang Min Yu, Southwest Missouri State University.

Geometry of Affine Space, David Wright, Washington University.

Classical Complex Analysis and Related Areas, Jang-Mei Wu, University of Illinois, Urbana, and David Drasin, Purdue University.

Contributed Papers. There were four sessions of contributed papers. The session on Algebra was chaired by Liang-Cheng Zhang of Southwest Missouri State University. The sessions on Combinatorics and Analysis were chaired by George Matthew of Southwest Missouri State University.

Committee. Clayton Sherman of Southwest Missouri State University supervised local arrangements.

Andy R. Magid
Associate Secretary
Norman, Oklahoma

The October-November Meeting in Dayton
The 876th meeting of the Society was held in Dayton, Ohio at Wright State University on October 30 and 31 and November 1, 1992. There were 362 registrants, including 266 members of the Society.

Invited Addresses. By invitation of the Central Section Program Committee, there were four invited addresses. The speakers, their affiliations, and their titles were as follows: Martin Golubitsky, University of Houston, Symmetry and Chaos; Jonathon I. Hall, Michigan State University, Finite methods in infinite groups and discrete geometries; Louis H. Kauffman, University of Illinois at Chicago, From knots to quantum field theory and back; J. Toby Stafford, University of Michigan, Ann Arbor, Noncommutative graded algebras and projective geometry. The speakers were
introduced by Lawrence Turyn, Daniel Frohardt, Josef Przyticky, and Timothy Hodges, respectively.

Special Sessions. By invitation of the same Committee, there were twelve Special Sessions of selected 20-minute papers. The topics and the names and affiliations of the organizers were as follows:

Hyperbolic Manifolds, COLIN C. ADAMS, Williams College, and ARA S. BASMAJIAN, University of Cincinnati. 
Quantum Groups and Regular Algebras, CAROLYN A. DEAN and J. TOBY STAFFORD, University of Michigan, Ann Arbor, and TIMOTHY J. HODGES, University of Cincinnati. 
Operator Theory and Operator Algebras, JOANNE M. DOMBROWSKI and RICHARD MERCER, Wright State University. 
Groups and Geometries, DANIEL E. FROHARDT, Wayne State University. 
Control Theory and Partial Differential Equations, LOP FAT HO and THOMAS SVOBODY, Wright State University, and SRDJAN D. STOJANOVIC, University of Cincinnati. 
Combinatorics and Graph Theory, ANTHONY B. EVANS and TERRY A. McKEE, Wright State University. 
Differential and Integral Equations, MUHAMMAD N. ISLAM, University of Dayton, and LAWRENCE TURYN, Wright State University. 
Knots and Topological Field Theory, LOUIS H. KAUFFMAN, University of Illinois at Chicago. 
Riccati Equations and Transport Theory, HENDRIK J. KUIPER, Arizona State University, and TAPAS MAZUMDAR, Wright State University. 
Topology of Affine Hypersurfaces and Related Number Theory, ANATOLY S. LIGOBER, University of Illinois at Chicago, and STEVEN SPERBER, University of Minnesota, Minneapolis. 
Set-Theoretic Topology, JOE D. MASHBURN, University of Dayton. 
Function Theory, C. DAVID MINDA, University of Cincinnati.

Contributed Papers. There were four sessions of contributed papers. The first session on Graph Theory was chaired by Ann Farrell of Wright State University. The second session on Graph Theory and the session on Algebra were chaired by David Miller of Wright State University. The session on Analysis was jointly chaired by Steve Hoffman and Carl Maneri, both of Wright State University.

Committee. James T. Vance, Jr., of Wright State University supervised local arrangements. Among the amenities he arranged were special guest accounts on the Wright State University computer to allow meeting participants to remotely log on via the Internet to their home machines.

Andy R. Magid
Associate Secretary
Norman, Oklahoma
Personal

Cornelius O. Horgan, of the University of Virginia, Charlottesville, was named a Fellow of the American Society of Mechanical Engineers (ASME).

Deaths

Ilya Bakelman, of Texas A&M University, died on August 30, 1992, at the age of 63. He was a member of the Society for 12 years.

Peter A. Ruymgaart, of Leiderdorp, The Netherlands, died on June 11, 1992, at the age of 66. He was a member of the Society for 26 years.

Gail A. Schweiter, of Daniel H. Wagner Associates, died on April 23, 1992, at the age of 34. She was a member of the Society for 12 years.

Michael J. Seymour, of the University of New Hampshire, died on April 16, 1992, at the age of 39. He was a member of the Society for 2 years.

Earl W. Swokowski, of West Allis, Wisconsin, died on June 2, 1992, at the age of 66. He was a member of the Society for 40 years.

Janet D. Thomas, of Rydal, Pennsylvania, died on October 21, 1992, at the age of 87. She was a member of the Society for 59 years.

Visiting Mathematicians

Supplementary List


Karl Barth (U.S.A.), University College, England, Complex Analysis, 1/93-8/93.

R. Miron (Romania), University of Tsukuba, Lagrange Geometry and Applications, 4/92-5/92; and University of Haifa, Differential Geometry, 5/92-6/92.

CONTEMPORARY MATHEMATICS

Volume 138

Hypergeometric Functions on Domains of Positivity, Jack Polynomials, and Applications

Donald St. P. Richards, Editor

This volume is based largely on lectures presented at a Special Session at the AMS meeting in Tampa, Florida, in March 1991, which was devoted to hypergeometric functions of matrix argument and to fostering communication among representatives of the diverse scientific areas in which these functions are utilized. Accessible to graduate students and others seeking an introduction to the state of the art in this area, this book is a suitable text for advanced graduate seminar courses, as it contains many open problems.

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In particular, readers should note that the Equal Employment Opportunity Act (42 U.S.C., §§2000e et seq.), which prohibits discrimination in employment on the basis of race, religion, sex, or national origin, contains (in §2000e-1) an exception from the provisions of the Act for any religious corporation, association, educational institution, or society with respect to employment of individuals of a particular religion to perform work connected with the carrying on by such corporation, association, educational institution, or society of its activities.

The Age Discrimination Act of 1967 (29 U.S.C., §§621 et seq., as amended), makes it unlawful for an employer to discriminate against any individual between the ages of 40 and 70 because of age. Thus it is legal to seek as an employee someone who is "over 30," but not one "over 50"; neither is it legal to express a preference for someone who is "young," or is a "recent graduate," since the latter tend (on statistical grounds) to be young.
AUBURN UNIVERSITY

College of Sciences and Mathematics

The Auburn University College of Sciences and Mathematics invites applications and nominations for the position of Dean. Auburn University is the 1862 land-grant institution located in east central Alabama. It enrolls approximately 21,500 students on the Auburn campus. The College of Sciences and Mathematics consists of the departments of Botany and Microbiology; Chemistry; Discrete and Statistical Sciences; Geology; Mathematics; Physics; and Zoology and Wildlife Sciences.

The Dean is the chief executive officer of the college and reports directly to the Provost. General responsibilities include:

1) provide creative leadership for teaching, research, and extension programs;
2) promote the academic unit, through activities including fundraising, with alumni and external groups;
3) effectively represent the position of the College faculty to the central administration;
4) continue to lead the College toward national prominence.

Qualifications include: earned doctorate in a field appropriate for full professor and tenure in one of the departments in the College; excellence in research and teaching; strong administrative and leadership capability, including effective personnel management and communication skills; commitment to Affirmative Action/Equal Employment Opportunity.

Twelve-month salary is competitive and commensurate with qualifications. Employment date is negotiable, preferably beginning by 7/1/93.

A review of applications and materials will begin on March 1, 1993 and will continue until the position is filled. Applicants should submit a vita and the names of five references to:

Dr. June Henton, Chair
Search Committee
210 Spidle Hall
Auburn University, AL 36849

Auburn University is an Affirmative Action, Equal Opportunity Employer. Women and minorities are encouraged to apply.

CALIFORNIA

CALIFORNIA STATE UNIVERSITY SAN MARCOS

California State University San Marcos, the newest campus in the CSU, seeks a Ph.D. mathematician in algebraic geometry, analytic geometry, computational geometry, differential geometry, finite geometry, geometric analysis, or a related field of geometry. This entry-level, tenure-track Assistant Professor position will begin in August 1993. This position is subject to final administrative authorization. CSUSM seeks an individual with strong academic preparation who has an interest in teaching undergraduates. An application consists of a statement of interest, a complete resume, and at least three letters of reference which should comment on the applicant's credentials in teaching, research, and service. Applications should be sent to: Mathematics Search Committee, California State University San Marcos, San Marcos, California 92096-0001. Review of applications will begin January 25 and will continue until the position is filled. CSU San Marcos is an Affirmative Action/Equal Opportunity Employer. The University has a strong commitment to the principle of diversity and, in that spirit, seeks a broad spectrum of candidates including women, members of minority groups and people with disabilities.

HUMBOLDT STATE UNIVERSITY (HSU)

Applications are invited for a temporary (one or more expected) one-year, full- or part-time, assistant professor position for Fall 1993. Candidates must possess an earned doctorate in a mathematical science at the time of appointment, and must present experience or training in either mathematical modeling, statistics, or mathematics education (elementary school teacher training preferred) with a commitment to teaching excellence. HSU, located on the California north coast, has an active mathematics faculty, a strong undergraduate major, and a masters program in mathematical modeling of environmental systems. Direct inquiries to Search Committee, Department of Mathematics, Humboldt State University, Arcata, CA 95521-4957. Application deadline 15 February 1993. HSU is an EO/AA employer.

Occidental College

Los Angeles, California

Applications are invited to a tenure-track position in the Department of Mathematics at the assistant or associate professor level. Excellence in teaching and substantial professional achievement are the major expectations. The department is involved in curricular reform and encourages innovative teaching. The normal teaching schedule is 5-6 courses per year. New faculty members are currently released for one course during the initial year. Some institutional support for extended leaves is available.

Occidental College is a selective private college of the liberal arts and sciences with 1650 undergraduate students, a college faculty of 133, and a mathematics faculty of nine. Occidental is located in northeast Los Angeles, easily accessible to USC, UCLA, and Caltech.

Salary is competitive. An excellent benefits package includes a choice of health care plans, tuition grants for children of faculty, and a mortgage subsidy program.

Completed applications must include a current resume and three letters of reference (at least one evaluating teaching performance and potential). Please include a clear statement of commitment to teaching in a liberal arts college environment as well as indicating professional goals. All materials should be received by February 16, 1993. Address all materials of Faculty Search Committee, Department of Mathematics, Occidental College, 1600 Campus Drive, Los Angeles, CA 90041.

Occidental College is an Equal Opportunity/Affirmative Action Employer and encour...
UNIVERSITY OF CALIFORNIA, BERKELEY
Fellowships in Mathematics
and Molecular Biology

The Program in Mathematics and Molecular Biology has graduate and postdoctoral fellowship support available. Current topics in the Program include geometry, topology, and sequence analysis of DNA, molecular dynamics, and mapping functions and algorithms for DNA and protein structure prediction. Other areas will be considered. Fellowships can be held at any university or college in the United States. Awards made assuming continuation of funding. Deadline for Applications: March 1, 1993. Women and minorities are encouraged to apply. Apply to: PMMB, 103 Doherty Cb, University of California, Berkeley, CA 94720. Email: sylviaj@violet.berkeley.edu.

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92717

Applications are invited for three regular faculty positions in the following four areas of research: 1) applied and computational mathematics; 2) geometry and topology (includes geometrical analysis); 3) analysis and PDE (including mathematical physics); 4) algebra and number theory (includes algebraic and arithmetic geometry); 5) logic and set theory; 6) probability. Strong promise in research and teaching is required. Positions are budgeted at the assistant professor level. Applicants should send a resume, reprints and preprints, and for assistant professor positions a dissertation abstract and ask three people to send letters of recommendation to: Chair of the Recruitment Committee, at the above address. We should receive the material no later than February 15, 1993. The University of California is an Equal Opportunity/Affirmative Action employer committed to excellence through diversity.

Chair of the Recruitment Committee at the above address. We should receive the material no later than February 15, 1993. The University of California is an Equal Opportunity/Affirmative Action employer committed to excellence through diversity.

CONNECTICUT
UNIVERSITY OF CONNECTICUT
AT AVERY POINT
Assistant Professor of Mathematics

Applications are invited for an anticipated full-time position at the Assistant Professor level for the Avery Point campus. The Avery Point campus is located in the Groton-New London area. A Ph.D. in Mathematics, experience in teaching at the college level, demonstrated talent in teaching undergraduates, and evidence of ability to contribute to the research mission of the department are required. Salary will be competitive, commensurate with qualifications. Screening will begin February 1, 1993, and continue until the position is filled. Send curriculum vitae and have at least three letters of reference sent to: Professor Jerome Neuwirth, Department of Mathematics, University of Connecticut, U-9, 196 Auditorium Rd., Storrs, CT 06269-3009. We encourage applications from minorities, women, and people with disabilities. (Search #3A111)

FLORIDA
FLORIDA INTERNATIONAL UNIVERSITY

The Department of Mathematics announces tenure track positions beginning August 1993. These positions are usually at the beginning Assistant Professor level. Candidates must have a Ph.D. in Mathematics and a commitment to research and quality teaching. Qualified candidates in all areas of Mathematics will be considered.

Teaching load consists of no more than five 3-credit courses per academic year. Send resume and arrange for 3 letters of recommendation to: Recruitment Committee, Department of Mathematics, Florida International University, Miami, FL 33199.

Florida International University is an equal opportunity/affirmative action employer. It is a member of the State University system of Florida, with approximately 23,000 students. The department offers bachelor's and master's degrees.

FLORIDA STATE UNIVERSITY
Department of Mathematics

The department invites applications for a tenure-track position of assistant professor. Requirements include a Ph.D. and demonstrated excellence in research and teaching. Appointment would begin August 1993.

Applicants should submit curriculum vitae, list of publications, statement of research interests, and arrange for three letters of recommendation to: H.F. Kreimer, Chairman, Department of Mathematics B-154, Florida State University, Tallahassee, Florida 32306-3027. The deadline for applications is February 1, 1993. Florida State University is an affirmative action/equal opportunity employer. Women and minorities are encouraged to apply.

UNIVERSITY OF NORTH FLORIDA
Instructor in Mathematics

The Department of Mathematics and Statistics invites applications for a nontenure-track position at the Instructor rank beginning August 1993. Candidates must have a Masters degree in Mathematics or the Mathematical Sciences and a history of excellent teaching at the undergraduate level. Additional consideration may be given to experience working with student organizations. The Department offers the B.A. and B.S. degrees in Mathematics and Statistics. The University of North Florida is a growing state university with approximately 9,000 students. Degree programs are offered in the traditional areas. Send applications with vita and three letters of recommendation by March 5, 1993 to: Dr. Jingcheng Tong, Search Committee Chairperson, Department of Mathematics and Statistics, University of North Florida, 4567 St. Johns Bluff Road, South Jacksonville, FL 32224-2645. THE UNIVERSITY OF NORTH FLORIDA IS AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER. MINORITY AND WOMEN CANDIDATES ARE ENCOURAGED TO APPLY.

THE UNIVERSITY OF SOUTH FLORIDA
Department of Mathematics

We invite applications for two tenure-track positions at the Assistant Professor level effective August 1993, contingent on availability of funds. Applicants must have or expect to have a Ph.D. in mathematics upon assuming the position, and must show evidence of strong research potential. Candidates demonstrating research experience beyond the Ph.D. are particularly encouraged to apply. The duties include research activity and both graduate and undergraduate teaching. We encourage applications from the following fields: Analysis, Discrete Mathematics/Foundations of Computing, Numerical Analysis, and Probability. Applicants must indicate in which of these four fields they wish to be considered, although outstanding candidates in other areas may apply.

The University of South Florida is the second largest state university in the Southeast, with more than 34,000 students enrolled. The Mathematics Department offers B.A., M.A., and Ph.D. degrees. To apply, send a letter of application, with a curriculum vitae, and arrange to have at least three letters of recommendation sent to: Search Committee, Department of Mathemat-
icics. University of South Florida, 4202 Fowler Avenue, PHY 114, Tampa, Florida 33620-5700 (email: mathdept@math.usf.edu, FAX: (813) 974-2700).

Applications, which may be submitted by email or FAX, must be submitted by February 1, 1993. USF is an Equal Opportunity/Affirmative Action Employer and follows ADA guidelines.

GEORGIA
UNIVERSITY OF GEORGIA
Department of Mathematics
Athens, GA 30602

The department has one or more tenure-track positions available for the 1993–94 academic year at the assistant professor level. The salary will be commensurate with the applicant’s abilities and experience. The principle requirement is excellence in teaching and research. Some preference will be given to areas in which the department is already represented. Send curriculum vitae and four letters of recommendation to John G. Hollingsworth, Head (address above). Applications will be accepted until March 15, 1993. UGA is an Equal Opportunity/Affirmative Action Employer.

NORTHERN ILLINOIS UNIVERSITY
Department of Mathematical Sciences

Anticipated assistant professorship with a specialization in Functional Analysis, preferably with an interest in optimization theory. Ph.D. or equivalent and strong potential in research and teaching required. Application (vita) plus three letters of reference and description of research program should be sent to: Functional Analysis Position, c/o Professor William D. Blair, Chair, Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115 by February 15, 1993. EO/AAE

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We are looking for more top-quality mathematicians to join the Mathematica research and development team. We anticipate openings in several areas. At present, a position is available in our algebraic computation group. Applicants should be able to work in a fast-paced environment and be capable of interacting well with mathematicians and others. Applicants should have a broad knowledge of mathematics. Research experience in algebraic geometry, complex analysis, or a related field is desirable. Applicants should have considerable programming experience: knowledge of Mathematica is required; experience with C is preferred. A Ph.D. in mathematics (or equivalent experience) is required.

Send resumes to: Attn: Personnel Department, Wolfram Research, Inc., 100 Trade Center Drive, Champaign, IL 61820 or send email to resumes@wri.com. Wolfram Research, Inc. is an affirmative action, equal opportunity employer.

IOWA
IOWA STATE UNIVERSITY
Department of Mathematics

Subject to budgetary approval, there will be two tenure-track positions starting in August 1993. The positions will be full time during the 9-month academic year; they require a Ph.D. or equivalent.

One position will be in numerical analysis, and will be at the assistant professor or associate professor level. The successful candidate should have a strong interest in teaching at both the graduate and undergraduate level. He or she should maintain an active research program in some branch of numerical analysis. The candidate will be expected to apply for externally funded grants. Senior candidates should have a strong record of publications and grants. Startup funds for a workstation will be available. The salary will be commensurate with qualifications.

The second position will be in mathematics education, at the assistant professor level. Candidates should have strong interest and qualifications in teaching both mathematics and mathematics education, the latter at both the graduate and undergraduate level. They should maintain an active research program in mathematics education. The duties will include teaching, advising, supervision of student teachers, and participation in regional and national math education activities.

Iowa State University is an Affirmative Action/Equal Opportunity Employer. Women and minority candidates are encouraged to apply.

The department will begin screening applications January 15, 1993; applications will be accepted, however, until the positions are filled. Applications (vita, description of research plans, and three letters of recommendation) should be sent to Stephen J. Willson, Chair, Department of Mathematics, Iowa State University, Ames, Iowa 50011.

Classified Advertisements

NORTHERN ILLINOIS UNIVERSITY
Department of Mathematical Sciences

Anticipated assistant professorship with a specialization in Numerical Differential Equations. Ph.D. or equivalent and strong potential in research and teaching required. Application (vita) plus three letters of reference and description of research program should be sent to: Numerical Differential Equations Position, c/o Professor William D. Blair, Chair, Department of Mathematical Sciences, Northern Illinois University, DeKalb, IL 60115 by February 15, 1993. EO/AAE

INDIANA
INDIANA UNIVERSITY-PURDUE UNIVERSITY
AT INDIANAPOLIS (IUPUI)
Department of Mathematical Sciences

The Department of Mathematical Sciences at IUPUI is seeking applicants for two tenure-track positions to begin in August 1993. Rank is open depending on qualifications. Applicants must have an earned doctorate by the starting date, either a strong research record or excellent research potential, and a commitment to quality graduate and undergraduate teaching. Some preference may be given to applicants in algebra, scientific computing and applied statistics. However, strong applicants from all areas of mathematical sciences are encouraged to apply.

IUPUI is a comprehensive urban university with over 26,000 students. The department offers programs of study leading to Purdue University B.S., M.S. and Ph.D. degrees and we anticipate significant growth in our faculty during the next few years. The university offers competitive salaries and provides excellent fringe benefits. Send resume and three letters of recommendation to Prof. Bart S. Ng, Chair, Department of Mathematical Sciences, IUPUI, 1125 E. 38th St., Indianapolis, IN 46205-2820. Closing date: February 1, 1993. Late applications will be considered until positions are filled.

IUPUI is an Affirmative Action/Equal Opportunity Employer. Women and minority candidates are encouraged to apply.
KANSAS STATE UNIVERSITY
Department of Mathematics

Subject to budgetary approval, applications are invited for several tenure track and visiting positions commencing August 18, 1993; rank and salary commensurate with qualifications. All fields will be considered, but for some of the tenure-track positions, preference will be given to candidates in Differential Equations, Geometry/Topology, Algebra, and Functional Analysis. Applicants must have strong research credentials and a commitment to excellence in teaching. A Ph.D. in mathematics or a Ph.D. dissertation accepted with only formalities to be completed is required. Letter of application, current vita, description of research and three letters of recommendation should be sent to:

Louis Pigno
Department of Mathematics
Cardwell Hall 137
Kansas State University
Manhattan, KS 66506

It is expected that offers will begin on December 15, 1992, but applications for all positions will be accepted until February 1, 1993, or until positions are closed. AA/EOE

WASHBURN UNIVERSITY
Chair

Applications are invited for the position of Chair, Department of Mathematics and Statistics. Tenure track, 12-month position to lead an 11 member undergraduate department. Starts July 1, 1993. 6 credit-hours per semester teaching load. Current programs include mathematics, applied mathematics, mathematics education, and actuarial science. QUALIFICATIONS: Earned doctorate in Mathematics, Statistics, or Mathematics Education with significant college teaching experience. A strong commitment to excellence in teaching and a significant record of continued scholarly activity. Strong communication, leadership, and interpersonal skills. Desirable attributes include administrative experience and experience with applications of technology in the classroom.

Send letter of application, resume, transcripts, and names, addresses, and telephone numbers of 3 references to Ann Ukena, Washburn University, Topeka, KS 66621. APPLICATION DEADLINE: March 1, 1993. Consideration will continue until a suitable candidate is identified. AA/EOE Employer.

MARYLAND

THE JOHNS HOPKINS UNIVERSITY
Department of Mathematical Sciences

Applications are invited for 3 anticipated faculty positions within the areas of
1) numerical linear algebra (Senior applicants preferred), 2) statistics, 3) operations research, 4) applied discrete mathematics.

Selection is based on demonstration and promise of excellence in research, teaching and innovative applications. Minority and women candidates 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 21218-2899

Applications are requested by January 15, 1993. Applicants whose primary research is in algebra, analysis, geometry, logic, number theory, or topology will not be considered.

UNIVERSITY OF MARYLAND UNIVERSITY COLLEGE
Teach in Asia or Europe

University of Maryland University College seeks excellent teachers for openings on U.S. military bases overseas. Appointments begin August 1993. Requirements include M.A. or Ph.D., recent college teaching experience, and U.S. citizenship. Competence to teach in another discipline desirable. Benefits include transportation and military base privileges (PX, commissary, etc.). Frequent travel and the cost of schooling make these positions difficult for those with children. Send resume to: Dr. Ralph E. Millis, Assistant to the President, Overseas Programs, University of Maryland University College, College Park, MD 20742-1642. AA/EOE.

WASHINGTON COLLEGE
Department of Mathematics and Computer Science
300 Washington Avenue
Chesterstown, Maryland 21620

Washington College announces a tenure track position at the assistant professor level. The position begins in late August 1993.

Applications are invited from persons trained in mathematics or computer science, especially those with some training in both. A Ph.D. is required. Applicants should send a letter of application including a statement on teaching and learning mathematics in a liberal arts setting, a resume, transcripts, at least three letters of recommendation to Dr. Albert W. Briggs, Jr. at the address above.

Evaluation of candidates will begin in January and continue until the position is filled. We will be at the San Antonio meeting.

Washington College is an equal opportunity employer.

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Tulane University
The Department of Mathematics invites applications for the following positions:

Assistant Professorships, two or three positions, to begin Sept. 1, 1993. Initial one-year contract, renewable to a maximum of three years. Ph.D., promise of strong research and evidence of strong teaching ability required. Relation of research interests to those of members of the department will be a consideration. Research interests preferred: For Position No. 1, probability and statistics; Position No. 2, Lie group representation; Position No. 3, combinatorial group theory including braid theory. Send application with Position No. and three letters of recommendation by March 1, 1993, to R. Weiss, Search Committee Chair.

As an EO/AA employee, Tulane encourages applications from minority and women candidates.

Tufts University
Math Department
Medford, MA 02155

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 November 15, 1992, and continue until the positions are filled. AA/EOE.

MICHIGAN
GMI ENGINEERING & MANAGEMENT INSTITUTE
Faculty Position in Mathematics and Computer Science

GMI Engineering & Management Institute invites applications for a tenure-track position in Mathematics and Computer Science. This position is at the Assistant Professor level, and it is intended that it be filled by July 1, 1993.

GMI operates on a five-year fully cooperative plan of education. The Science and Mathematics Department offers a Bachelor of Science degree in Applied Mathematics with areas of concentration in Applied Analysis, Computer Science, and Statistics. The department also offers courses at all levels in support of the various Engineering and Management bachelor's and master's degree programs. Department faculty typically teach 3 courses per term and are expected to participate in curriculum development, research, and professional development, student advising and service activities.

The minimum qualifications for this position include an earned Ph.D. in either Mathematics or Computer Science with a strong background in the other field and evidence of effective communication skills in the English language. The successful candidate will be expected to show evidence of strong research abilities and a strong interest in undergraduate teaching. Experience in undergraduate education, in industry, or in computer-aided classroom instruction is desirable.

Please send resume, statement of research interests, and three letters of reference to: Professor John W. Dulin, Search Committee Chair: Science and Mathematics Department, GMI Engineering & Management Institute, 1700 West Third Avenue, Flint, Michigan 48504-4898. Review of applicants will commence immediately and continue until the position is filled.

GMI is an affirmative action/equal opportunity employer and actively seeks the candidacy of women and minorities. Preference will be given to citizens and permanent residents of the U.S.

MICHIGAN TECHNOLOGICAL UNIVERSITY
Department of Mathematical Sciences
Houghton, MI 49931

Applications are invited for four tenure track positions as well as visiting and temporary positions starting August 1993.

Subject to funding, the department anticipates tenure track openings in the areas of algebra (1 position), applied mathematics (2 positions) and mathematics education (1 position). Candidates for the positions in algebra and applied mathematics must have a Ph.D. in mathematics while candidates in mathematics education are expected to have a Ph.D. or Ed.D. degree and be able to teach undergraduate mathematics courses.

The successful candidates are expected to have strong teaching credentials and outstanding research potential. Appointment at the senior level will require a strong research record. Duties include teaching, service and research with a normal teaching load of courses (6 to 8 hours) per quarter. Preference will be given to candidates who can complement existing research interests in the department.

Send curriculum vitae, transcript and three letters of recommendation to:
Alphonse Baartmans, Head
Department of Mathematical Sciences
Michigan Technological University
1400 Townsend Drive
Houghton, MI 49931-1295

Review of applications will begin on December 1, 1992. Applications will be accepted until the positions are filled. MTU is an equal opportunity educational institution/equal opportunity employer.

NEBRASKA
UNIVERSITY OF NEBRASKA-LINCOLN

We invite applications for two Assistant Professor tenure-track positions beginning in fall 1993. Candidates must have a Ph.D. in mathematics by August 1993, and have excellent teaching ability and outstanding research potential in an area that complements existing expertise in the department. Strong preference given to candidates in the areas of: (1) combinatorics and graph theory; or (2) nonlinear partial differential equations with emphasis on applications, dynamical systems, or numerics. Send vita and three letters of recommendation to Search Committee Chair, Department of Mathematics and Statistics, University of Nebraska-Lincoln, Lincoln, NE 68588-0323. Women and minority candidates are particularly encouraged to apply. The University of Nebraska is committed to a pluralistic campus community through Affirmative Action and Equal Opportunity, and is responsive to the needs of dual career couples. We assure reasonable accommodation under the Americans with Disabilities Act. Contact AA/EO at (402) 472-3417. The review of applications will begin February 1, 1993, and continue until suitable candidates are selected.

NEW HAMPSHIRE
DARTMOUTH COLLEGE
John Wesley Young Research Instructorship in Mathematics

The John Wesley Young Research Instructorship is a two year post-doctoral appointment for promising new or recent Ph.D.'s whose research interests overlap a department member's Current departmental interests include areas in algebra, analysis, algebraic geometry, combinatorics, computer science, differential geometry, logic and set theory, number theory, probability and topology. Teaching duties of four...
ten-week courses spread over two or three quarters. In at least one course in the instructor's specialty and include elementary, advanced and (at instructor's option) graduate courses. Nine-month salary of $34,000 supplemented by summer (resident) research stipend of $7,556 (two-ninths). Send letter of application, résumé, graduate transcript, thesis abstract, description of other research activities and interests if appropriate, and 3 or preferably 4 letters of recommendation (at least one should discuss teaching) to Phyllis A. Bellmore, Mathematics and Computer Science, 6188 Bradley Hall, Hanover, NH, 03755-3551. Applications received by Jan. 15 receive first consideration; applications will be accepted until position is filled. Dartmouth College is committed to affirmative action and strongly encourages applications from minorities and women.

NORTH CAROLINA

NORTH CAROLINA STATE UNIVERSITY Department of Mathematics

Applications are invited for an anticipated tenure-track junior level position in algebra. Of particular interest are candidates with an expertise in representation theory. Applicants must have a strong commitment to research and teaching. Please send a curriculum vitae, an outline of current research program, and arrange to have three letters of recommendation to the Algebra Search Committee, Department of Mathematics, Box 8205, North Carolina State University, Raleigh, NC 27695-8205. Women and minorities are encouraged to apply. AA/EOE

OHIO

BOWLING GREEN STATE UNIVERSITY Department of Mathematics and Statistics

The department anticipates a position in (Applied Analysis/Computational Mathematics) and/or (Group Theory or Combinatorics). We have 33 faculty, 65 full-time graduate students, and a growing doctoral program (15 Ph.D.'s awarded in the last three years). The selected candidate, who must have a Ph.D. in Mathematics, will be expected to pursue research, teach two courses per semester, work with graduate students, and eventually direct Ph.D. dissertations. Those with postdoctoral experience are encouraged to apply. Candidates are expected to have a strong research record (or potential) in an area compatible with current faculty. Salary competitive. Please provide a vita, publication list, official transcript, and have three letters of recommendation (one concerning teaching) sent by 2/1/93 to:

Andrew Glass, Chair
Mathematics & Statistics Dept.
Bowling Green State University
Bowling Green, OH 43403-0221
EOE Employer. Female & minorities encouraged to apply.

OHIO UNIVERSITY

Department of Mathematics

The Department of Mathematics anticipates the appointment of two tenure-track assistant professors beginning September 1, 1993. One position is in operator theory or functional analysis and the other in general topology or set theory with possible applications to topology. Salary is competitive dependent on the candidate's qualifications and experience, with a minimum of $29,000. Applicants must have a Ph.D. in mathematics before September 1, 1993. Send resume and have three letters of recommendation sent to Shih-liang Wen, Chairman, Department of Mathematics, Ohio University, Athens, Ohio 45701. The deadline for applications is January 31, 1993.

Ohio University is an Equal Opportunity/ Affirmative Action Employer.

THE OHIO STATE UNIVERSITY

AT NEWARK

Lecturer, Mathematics

The Ohio State University at Newark is seeking a Lecturer for a full-time, nine-month, temporary, non-tenure track, one year position, with the possibility of renewal up to two additional years.

DUTIES INCLUDE: Ability to teach courses from remedial levels through the calculus level. QUALIFICATIONS INCLUDE: Master's degree in mathematics or equivalent required; documented excellence in college teaching required. Doctoral degree desired. SALARY: $25,080–$28,200 with comprehensive co-pay benefits package. STARTING DATE: Autumn Quarter, 1993. To assure consideration, send vita and three letters of reference by 4/16/93 to Chairperson, Lecturer, Mathematics Search, c/o Coordinator, Human Resources, The Ohio State University at Newark, 1179 University Drive, Newark, OH 43055-1797. The Ohio State University is an Equal Opportunity/Affirmative Action Employer. Qualified women, minorities, Vietnam-era Veterans, disabled veterans, and individuals with disabilities are encouraged to apply.

OREGON

UNIVERSITY OF OREGON

Department of Mathematics

Eugene, Oregon 97403
Frank W. Anderson, Head

Assistant or Associate Professor tenure track position in pure mathematics beginning September 1, 1993. Preference given to person with research interests that complement those currently represented. Competitive salary with excellent fringe benefits. Send complete resume and three letters. Closing date is January 18, 1993. Women and minorities are encouraged to apply. An EO/AA Institution committed to cultural diversity.

PENNSYLVANIA

UNIVERSITY OF PITTSBURGH

Department of Mathematics and Statistics

The department invites applications for the following position, Professor of Mathematics, with specialty in Ring Theory.

This would be a tenured senior position. It is dependent on funding. We anticipate that it will be available in either Fall 1993 or Fall 1994.

Requirements include outstanding research accomplishment commensurate with experience, and ability and interest in excellent teaching.

Applicants should send a resume to S. Hastings, Chairman, Department of Mathematics and Statistics, University of Pittsburgh, Pittsburgh, PA 15260. Do not have letters of...
YORK COLLEGE OF PA

Tenure track position, assistant or associate professor level. Applicants should be able to teach in our course in numerical analysis and have completed Ph.D. mathematics by Fall 1993. Facility with computer languages or experience in computer-aided instruction is a plus.

York College of PA is an excellent, private mainly undergraduate institution with about 3,000 full-time and 1900 part-time students. We offer competitive salary and fringe benefits and a friendly working environment. Our department is mostly a service department but we have about 50 mathematics education majors and a new mathematics major. All full-time faculty teach two or three freshman level courses. As our major grows, there will be opportunity to teach one or two jr/sr level courses per year. Professional/research activities and college service are also required. Send curriculum vita, three letters of recommendation, and a cover letter expressing interest to: Mathematics Search Committee, Department of Physical Sciences, York College of PA, York, PA 17405-7199. First consideration to applications received by Feb. 15, 1993. York College of PA is an equal opportunity employer. Women and minorities are encouraged to apply.

SOUTHERN CALIFORNIA

COKER COLLEGE

Coker College invites applications for a tenure-track position in mathematics/computer science. Candidates must have a Ph.D. and demonstrate the potential for high quality teaching and continuing scholarly activity. Duties begin August 1993 and include teaching introductory level as well as major courses in mathematics and courses necessary to support a computer science minor. Total teaching load is 12 semester hours per semester with some teaching responsibilities in evening and off-campus programs. Rank and salary commensurate with experience. Coker College is a private, four-year liberal arts college in Hartsville, South Carolina. Deadline for applications is February 1, 1993. Send a letter of application, curriculum vitae, and three references to: Professor Kaye Crock, Chair, Mathematics Search Committee, Coker College, Hartsville, South Carolina 29550. Affirmative Action, Equal Opportunity Employer.

UNIVERSITY OF SOUTHERN CALIFORNIA

Department of Mathematics

The Department of Mathematics invites applications for expected tenure-track faculty positions for Fall 1993, at all ranks. Applications in all areas of mathematics will be considered. Research is supported by excellent inhouse library and computing facilities. The Ph.D. degree or its equivalent is required. Appointments will be consistent with the Department's commitment to excellence in research and in teaching at the undergraduate and graduate levels. A detailed resume, containing a summary of research accomplishments and goals, and four letters of recommendation should be sent to:

Dr. George F. McNulty
Chairman, Mathematics Search Committee
Department of Mathematics
University of Southern California
Columbia, SC 29208

The University of South Carolina is an Affirmative Action/Equal Opportunity Employer.

UNIVERSITY OF TENNESSEE AT CHATTANOOGA

Department Head

The University of Tennessee at Chattanooga invites applications for Head of the Department of Mathematics. A Ph.D. in a mathematical science and at least five years of college mathematics teaching experience are required. Applicants should provide evidence of leadership in curriculum development, teaching, public service and research/scholarly activities. In this primarily undergraduate institution, the faculty is expected to exhibit excellence in teaching while maintaining a strong commitment to research and public service. The mathematics department has 22 faculty members including a Chair of Excellence in Applied Mathematics. Located in a very scenic metropolitan area of 400,000, UTC has a student enrollment of 8100. Send applications with current vita to: Dr. Irene Loonis; Chair of the Search Committee, Dept. of Mathematics, UTC, Chattanooga, TN 37403-2598. Consideration of applications will begin November 1, 1992, and will continue until the position is filled. Women and minorities are encouraged to apply. UTC is an Equal Opportunity Employment/Affirmative Action/Title IX Section 504 Institution.

UNIVERSITY OF TENNESSEE

Knoxville, Tennessee

The Mathematics Department of the University of Tennessee, in an effort to significantly improve its research position, seeks to fill 3 or 4 tenure-track assistant or beginning associate professorships in several areas. A Ph.D. is required. Some postdoctoral experience is preferred. There will be one and possibly two positions available in Numerical Mathematics; candidates should be well versed in the core areas of Numerical Analysis with research interests in the numerical solution of differential equations. Preference will be shown those candidates working in numerical fluid dynamics. Another position will be offered in differential equations, with preference given to those having expertise in the nonlinear qualitative theory of differential equations. Another position will be offered in Stochastic Differential Equations and related fields of Stochastic Analysis. Employment begins August 1993. Substantial research opportunity/affirmative action employer. Women and minorities are encouraged to apply.

Send curriculum vitae, research statements, and names of three or more references to:

Professor J. W. C. Yu
Chairperson, Search Committee
Department of Mathematics
University of Tennessee
Knoxville, TN 37996-1300.

VANDERBILT UNIVERSITY

Department of Mathematics

136 Stevenson Center
Nashville, TN 37240

DISTINGUISHED OR NAMED PROFESSOR.

We are seeking someone with outstanding research credentials in algebra. The interests of our algebra group include universal algebra, set-theoretic algebra, abelian groups, semigroups, ring theory, ordered algebraic structures, lattice theory, and logic with applications to computer science. Evidence of effective teaching is required. Have vita and 5 letters of recommendation sent at this time. Applications will begin December 1 and will continue until the positions are filled.

UTK is an EEO/AA/Title IX/Section 504/ADA Employer.

LAMAR UNIVERSITY

Beaumont, Texas

The Department of Mathematics seeks applications for a tenure-track Assistant/Associate Professor position beginning Fall 1993. Applicants must hold an earned Ph.D., should be active researchers in Analysis and/or Applied Mathematics, and have a strong commitment to teaching.

Lamar is a state supported educational and research institution of approximately 12,000 students. The Department, which is located within the College of Engineering, offers the B.A., B.S., and M.S. degrees in Mathematics and has 16 full-time faculty.

For the approximately 250,000 people in the Beaumont area, there are eight museums, a symphony orchestra, ballet, opera, and other theatrical productions. Other facilities and events are found in Houston 85 miles west. Nearby outdoor recreational opportunities include two of the largest freshwater lakes in Texas, the Big Thicket National Preserve, four national forests, the Gulf of Mexico, and a large inland saltwater lake.

Salary and rank are commensurate with qualifications and experience. Send a resume.
and three letters of recommendation to: Dr. John R. Cannon, Chair, Department of Mathematics, Lamar University, P. O. Box 10047, Beaumont, TX 77710. Full consideration will be given to completed applications received before March 15, 1993. Lamar is an EEO/AA employer.

TEXAS A&M UNIVERSITY
Department of Mathematics

Subject to availability of resources and administrative approval, at least one tenure-track position at the Assistant Professor level or higher will be available beginning with the Fall Semester 1993. Candidates must have a Ph.D. in Mathematics, tangible evidence of scholarly publications, and a strong commitment to superior teaching. Salary is commensurate with experience. Send resume and three letters of recommendation to:

Faculty Search Committee
Department of Mathematics
Campus Box 172
Texas A&M University
Kingsville, TX 78363-2021

Applications completed by February 1, 1993 will receive first consideration. Texas A&M is a part of the Texas A&M University System and is an equal opportunity/affirmative action employer.

TEXAS A&M UNIVERSITY
Research Instructorships in Mathematics

The department expects to have several Research Instructorships available for the 1993-1994 academic year. These are two year positions, and candidates should have recently received their Ph.D., show promise of research excellence in an area of pure or applied mathematics, and have a commitment to teaching. Preference will be given to applicants whose expertise augments our existing research strengths.

Application material consisting of a vita which should include a statement of research goals, and 3 letters of recommendation should be sent to:

William Rundell, Interim Head
Department of Mathematics
Texas A&M University
College Station, Texas 77843-3368

Texas A&M University is an Equal Opportunity/Affirmative Action employer. Women and minority applicants are especially encouraged.

TEXAS A&M UNIVERSITY
Department of Mathematics

Applications are invited for one or more tenure-track or tenured faculty positions beginning in the 1993-1994 academic year. Outstanding candidates in all fields of mathematics are encouraged to apply. Significant research accomplishments, or, in the case of a junior appointment, exceptional promise plus an earned Ph.D., together with evidence of good teaching ability, will be expected of successful applicants. Salary will be commensurate with qualifications.

Candidates should send a letter of application, full vita, and arrange to have at least 3 letters of recommendation sent to:

William Rundell, Interim Head
Department of Mathematics
Texas A&M University
College Station, Texas 77843-3368

TEXAS A&M University is an Equal Opportunity/Affirmative Action employer. Women and minority applicants are especially encouraged.

UTAH

UNIVERSITY OF UTAH
Department of Mathematics

The University of Utah, Department of Mathematics, invites applications for the following positions:

1. At least two full time tenure track appointments on the professional levels. The Department is primarily interested in applicants who work in the research areas represented in the Department and who received their Ph.D. degrees prior to 1992. Selection will be based on research and teaching ability.

2. Two or more nonrenewable three-year Instructorships. Persons of any age receiving Ph.D. degrees in 1992 or 1993 are eligible. Applicants will be selected on the basis of ability and potential in teaching and research. Starting salary will be $33,000; future cost of living increases are contingent on action by the State Legislature. Duties consist of teaching five courses during the three quarter academic year.

3. One C. R. Wylie Instructorship. The term of this instructorship is one year, but it may be renewed for up to three years. It will be awarded either to an incoming instructor or to one of the instructors already in residence on the basis of ability and potential in teaching and research. The stipend is $37,000. Duties consist of teaching four courses during the three quarter academic year.

4. One or more visiting faculty positions of one year or less in any of the professorial ranks. Selection will be based on potential contributions to the department's research program, and on teaching ability.

It is expected that offers of Instructorships will begin on January 1, 1993, but applications...
for all positions will be accepted until January 31, 1993, or until all positions are filled. Applications for any of these positions should include curriculum vitae, bibliography and three letters of reference. (Instructorship applications should also include an abstract of the thesis and either a list of graduate courses completed or a transcript of graduate work.) Visiting faculty applications should indicate the portion of the three-quarter academic year during which the applicant wishes to visit. Please send your application to Committee on Staffing, Department of Mathematics, 400 State University, Logan, UT 84322-3900 or email: ibeasley@usu.edu. The selection process will begin February 1, 1993 and will continue until the position is filled.

Women and minorities are particularly encouraged to apply. EO/AAE.

UTAH STATE UNIVERSITY
Department of Mathematics and Statistics

Applications are invited for one or more tenure-track positions in mathematics at the assistant professor level, to begin September 1993. Requirements include a Ph.D. (by September 1993) in mathematics or mathematical sciences, potential for excellence in research, and demonstrated commitment to both undergraduate and graduate teaching. Candidates with research interests in algebra or related areas, integrable or dynamical systems, or computational optimization are especially encouraged to apply.

Utah State University, located in the Wasatch Range of the Rocky Mountains, offers competitive salaries and excellent medical, retirement, and professional benefits. Applications, including resume and three letters of reference, should be sent to LeRoy Beasley, Search Committee, Department of Mathematics & Statistics, Utah State University, Logan, UT 84322-3900 or email: ibeasley@usu.edu. The selection process will begin February 1, 1993 and will continue until the position is filled.

Women and minorities are particularly encouraged to apply. EO/AAE.

WASHINGTON STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics actively seeks applications for a tenure-track assistant professor position in the area of discrete mathematics, combinatorics, and graph theory beginning with the 1993-94 academic year. A Ph.D. in mathematics, strong research potential, and good teaching credentials are required. Preference will be given to candidates with postdoctoral experience. Applications will be accepted for as long as there is a possibility of making an appointment or until March 15, 1993. Those completed by January 1, 1993 will be included in the first round of evaluations. Applicants should send a curriculum vitae and arrange to have three letters of reference sent to Professor Charles Parry, Chair, Discrete Math Search Committee, Department of Mathematics, VPI & SU, Blacksburg, VA 24061-0123. At least one letter should address the applicant’s qualifications as a teacher. Applications will be accepted until March 15, 1993, or until position is filled. Applications completed by January 1, 1993 will be included in the first round of evaluations. Virginia Tech is an Equal Opportunity/Affirmative Action Employer. The University takes its affirmative action mission seriously and is especially interested in receiving applications from women and people of color.

WISCONSIN UNIVERSITY OF WISCONSIN-MADISON
Department of Mathematics

Applications are invited for an anticipated tenure-track appointment in Geometry (differential or algebraic, or related areas) beginning Fall 1993. Because we seek applicants who will be able to develop a strong case for eventual promotion and tenure, preference will be given to those with postdoctoral or instructorship experience and established research programs. Please send vita and brief description of research and three letters of reference sent to Prof. William Floyd, Chair, Geometry Search Committee, Department of Mathematics, Virginia Tech, Blacksburg, VA 24061-0123. At least one letter should address the applicant’s qualifications as a teacher. Applications will be accepted until March 15, 1993, or until position is filled. Applications completed by January 1, 1993 will be included in the first round of evaluations. Virginia Tech is an Equal Opportunity/Affirmative Action Employer. The University takes its affirmative action mission seriously and is especially interested in receiving applications from women and people of color.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics is actively seeking applications for an anticipated tenure-track position at the Assistant Professor level in the area of discrete mathematics, combinatorics, and graph theory beginning with the 1993-94 academic year. A Ph.D. in mathematics, strong research potential, and good teaching credentials are required. Preference will be given to candidates with postdoctoral experience. Applications will be accepted for as long as there is a possibility of making an appointment or until March 15, 1993. Those completed by January 1, 1993 will be included in the first round of evaluations. Applicants should send a curriculum vitae and arrange to have three letters of reference sent to Professor Charles Parry, Chair, Discrete Math Search Committee, Department of Mathematics, VPI & SU, Blacksburg, VA 24061-0123. At least one letter should address the applicants teaching credentials. VPI & SU is an Equal Opportunity/Affirmative Action Employer. The University takes its affirmative action mission seriously and is especially interested in receiving applications from women and people of color.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Department of Mathematics

Applications are invited for an anticipated tenure-track position at the Assistant Professor level in the general area of Dynamical Systems beginning with the 1993-94 academic year. A Ph.D. and strong research potential are required. The likelihood of productive interaction with current faculty members, such as the group in partial differential equations and continuum mechanics, will be a consideration. Position involves teaching duties of approximately six hours per week. Evidence that candidate is or will become an effective teacher should be included in application materials; in particular, at least one reference letter should address this issue. Send a vita and arrange to have three letters of reference submitted to Kenneth Hanssens, Chair, Dynamical Systems Search Committee, Department of Mathematics, Virginia Tech, Blacksburg, VA 24061-0123. Applications will be accepted for as long as there is a possibility of making an appointment or until 3/15/93. Those completed by 1/1/93 will be included in the first round of evaluations. Equal Opportunity/Affirmative Action Employer. The University takes its affirmative action mission seriously and is especially interested in receiving applications from women and people of color.

VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY
Department of Mathematics

Applications are invited for an anticipated tenure-track appointment in Geometry (differential or algebraic, or related areas) beginning Fall 1993. Because we seek applicants who will be able to develop a strong case for eventual promotion and tenure, preference will be given to those with postdoctoral or instructorship experience and established research programs. Please send vita and brief description of research and three letters of reference sent to Prof. William Floyd, Chair, Geometry Search Committee, Department of Mathematics, Virginia Tech, Blacksburg, VA 24061-0123. At least one letter should address the applicant’s qualifications as a teacher. Applications will be accepted until March 15, 1993, or until position is filled. Applications completed by January 1, 1993 will be included in the first round of evaluations. Virginia Tech is an Equal Opportunity/Affirmative Action Employer. The University takes its affirmative action mission seriously and is especially interested in receiving applications from women and people of color.
The Mathematics Department solicits applications for a tenure-track Assistant Professor position in the area of applied mathematics with an emphasis on large-scale scientific computation. The position would be available in the fall of 1993. All candidates should exhibit evidence of outstanding research and a strong commitment to good teaching. Application forms are available from the above address. The deadline for submission of applications is February 1, 1993. The University of Wisconsin is an Affirmative Action, Equal Opportunity Employer, and encourages women and minorities to apply. Unless confidentiality is requested in writing, information regarding the applicants must be released upon request. Finalists cannot be guaranteed confidentiality.

**WYOMING**

**UNIVERSITY OF WYOMING**

Department of Mathematics

Tenure-Track Position in Analysis

The University of Wyoming Mathematics Department invites applications for a tenure-track position in Analysis starting August 1993. Applicants must demonstrate strong ability in research, breadth of mathematical knowledge, interest in collaboration with mathematicians in other areas, strong commitment to high quality undergraduate and graduate teaching, and willingness to supervise masters and doctoral students. Preference will be given to researchers with strength in the areas of functional, complex and harmonic analysis. The Mathematics Department has 25 full-time faculty in applied mathematics, algebra/combinatorics, analysis and mathematics education.

Complete applications consist of a vita, a list of publications, a summary of research interests, and three letters of recommendation sent directly to Professor Myron B. Allen, Chair, Department of Mathematics, University of Wyoming, Laramie, WY 82071. Applications completed by January 1, 1993 will receive first consideration. The University of Wyoming is an equal-opportunity employer and encourages applicants from women and minorities.

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**AUSTRALIA**

**THE UNIVERSITY OF MELBOURNE**

Department of Mathematics

Research Fellow Grade 1 (Temporary)

Geometry and Topology Group

Applications are invited for the above position funded by the Australian Research Council (ARC). The grant held by Dr. K. Ecker and Prof. J.H. Rubinstein is for a project entitled Minimal Surfaces and Engels.

Candidates should be familiar with nonlinear elliptic and parabolic PDE theory as well as differential geometry. Additional knowledge of geometric measure theory and/or low dimensional topology would be of advantage.

The position will commence on 1 April 1993 or as soon as possible thereafter. The duration will be for one year initially with a possible extension for a further year subject to continued funding. Candidates must have a Ph.D. or equivalent qualifications.

Salary: $28,700–38,950 (Research Fellow Grade 1)

Further information

Dr. K. Ecker (03) 344 5535 or Prof. J.H. Rubinstein (03) 344 5550.


Reference number: y/618/185.

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**UNIVERSITY OF ALBERTA**

Department of Mathematics

Applications are invited for a tenure-track position at the assistant professor level, beginning July 1, 1993, subject to confirmation of funding. Requirements are a Ph.D. and proven ability or demonstrated potential for research and teaching. Salary for assistant professor is currently $40,035–$57,003. Send vita and arrange for three letters of reference to be sent to:

Professor R. Bercov, Chairman

Department of Mathematics

University of Alberta

Edmonton, Alberta, Canada T6G 2G1

In accordance with Canadian Immigration requirements priority will be given to Canadian citizens and permanent residents of Canada. Closing date for applications is February 15, 1993. The University of Alberta is committed to the principle of equity in employment. The University encourages applications from aboriginal persons, disabled persons, members of visible minorities, and women.

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**UNIVERSITÉ LAVAL**

Poste en Algèbre et Théorie des Nombres

Le Département de mathématiques et de statistique sollicite des candidatures pour un poste de carrière en algèbre et théorie des nombres qui sera disponible le 1er juin 1993.

**FONCTIONS**

- Enseignement des mathématiques aux trois cycles, y compris dans des cours autres que ceux des programmes de mathématiques.
- Direction d'étudiants de deuxième et de troisième cycle.
- Recherche fondamentale en algèbre et théorie des nombres.
- Participation aux autres tâches universitaires.

**QUALIFICATIONS**

- Être titulaire d'un doctorat en mathématiques ou d'un diplôme jugé équivalent.
- Être actif en recherche fondamentale et oeuvrer en algèbre et théorie des nombres ou dans un domaine relé à la théorie des nombres. Manifester la volonté de développer l'équipe d'algèbre et de théorie des nombres du Département et la composante à l'Université Laval du Centre interuniversitaire en calcul mathématique algébrique.
- Posséder des aptitudes pour l'enseignement, y compris à de grands groupes.
- Pouvoir enseigner en français.

**INFORMATION**

L'Université Laval applique un programme d'accès à l'égalité qui consacre la moitié des postes vacants à l'engagement de femmes. Conformément aux exigences en matière d'immigration, cet avis de concours s'adresse en premier lieu aux personnes qui ont la citoyenneté...
The Department of Pure Mathematics at the University of Waterloo encourages applications from qualified women and men, members of visible minorities, native peoples and persons with disabilities. All appointments are subject to the availability of funds. Please send applications to: Dr. J.W. Lawrence, Chair, Department of Pure Mathematics, University of Waterloo, Waterloo, Ontario, Canada, N2L 3G1.

**UNIVERSITY OF GUAM**

The University of Guam solicits applications to establish a list of eligibles for the following non-tenure track or tenure track, full-time positions (one-, two-, or three-year appointment subject to availability of funds):

**ASSISTANT PROFESSOR TO ASSOCIATE PROFESSOR**

**STATISTICS:** 1 VACANCY; APPLIED MATHEMATICS: 1 VACANCY; PURE MATHEMATICS: 2 VACANCIES

**General Description:** The Division of Mathematical Sciences offers a baccalaureate degree in mathematics. The Division also has a large developmental program. Faculty are expected to participate in the developmental program. The normal faculty load is twelve (12) credit hours per semester, of which at least three (3) credit hours would be normally devoted to the developmental program.

**Educational and Professional Background:** A Ph.D. in the appropriate mathematical science is required. An ability to teach a variety of undergraduate courses is required. At least two years of teaching experience is preferred.

**ASSISTANT PROFESSOR $34,307.00-$50,765.00 per Academic Year; ASSOCIATE PROFESSOR $39,300.00-$59,307.00 per Academic Year.** (Salary will be commensurate with qualifications and experience relevant to the position applied for by the applicant.)

**Application Process:** Submit current vita, an official transcript sent directly from the institution awarding the highest degree and unofficial transcripts of other degrees earned, three current letters of reference sent directly from persons knowledgeable about the applicant's academic and professional performances and request for official application to: Prof. Martin De Beer, Chairperson, Mathematical Sciences Division, c/o Personnel Services Division, UOG Station, Mangilao, Guam 96923. **Deadline:** March 1, 1993.

For more information, call UOG Personnel Services Division at (671) 734-9535, 734-9109 or call Dr. John Rider, our representative on the U.S. Mainland West Coast, Toll Free at 1-800-821-9233. EEO/AAD

**UNIVERSITY OF WATERLOO**

Department of Pure Mathematics

The Department of Pure Mathematics invites applications for one or more tenure track positions at the Assistant Professor level starting July 1, 1993. For its first appointment the Department is particularly interested in candidates whose research interests are related to Algebraic Geometry, Algebraic Topology or Differential Geometry. A second appointment (tenure track or definite term) may also be made in the above areas or in some area of Analysis. In order to be considered for the position, a Ph.D. is required. An appointment will be offered only to someone with very strong research and teaching qualifications. The University of Waterloo is committed to increasing the number of its female faculty, and therefore applications from women mathematicians are particularly welcome. Duties will include research, and teaching at all levels. Salary will depend on the candidate’s qualifications.

The deadline for applications is January 15, 1993. An application should contain the curriculum vitae of the candidate plus three letters of reference sent directly from the referees. In accordance with Canadian immigration regulations this advertisement is directed at Canadian citizens and permanent residents of Canada. The University of Waterloo encourages applications from qualified women and men, members of visible minorities, native peoples and persons with disabilities. All appointments are subject to the availability of funds. Please send applications to: Claude LEMAIRE, Département de mathématiques et de statistique, Université Laval, Sainte-Foy (Québec), Canada G1K 7P4.

**UNIVERSITY OF TORONTO**

Department of Mathematics

The Department solicits applications for a limited term Assistant Professorship at the Erindale campus, for the three-year period from July 1, 1993 to June 30, 1996. This position is subject to budgetary approval. Duties consist of teaching and research, and candidates must demonstrate clear ability in both. Applicants should send their complete C.V. including a list of publications and any appropriate material about their teaching, and arrange to have at least four letters of reference sent directly to Professor K. Murty, Associate Chair, Department of Mathematics, University of Toronto, Toronto, Canada M5S 1A1. At least one letter should deal with the candidate's teaching. To insure full consideration, this information should be received by February 28, 1993.

The University of Toronto encourages both women and men to apply. In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents.

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The Chinese University of Hong Kong (founded 1963) offers comprehensive programmes up to the Ph.D. level in the Humanities, Business Administration, Education, Engineering, Medicine, Science, Social Science, and Architecture. Student enrollment is planned to expand to over 11,000 full-time equivalent by 1994-95. The University is very active in promoting research and consultancies and in liaising with industry and the business sector worldwide. English and/or Chinese are used in teaching and administration.

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**The Department of Mathematics**

The Department is seeking an outstanding candidate for a teaching position. Subject to qualifications and funding from the University, this position may be filled at the rank of Lecturer or Senior Lecturer, or a higher rank. Candidates in applied and pure mathematics are encouraged to apply. Duties include teaching, research, and candidates are expected to demonstrate excellence at each. Salary: Lecturer: HK$28,640 - 47,845 per month (US$44,062 - 73,608 per year); Senior Lecturer: HK$44,500 - 59,780 per month (US$68,462 - 91,969 per year); Reader: HK$46,425 - 61,675 per month (US$71,423 - 94,885 per year); Professor: HK$83,520 per month minimum (US$119,723 per year minimum). (approx. exchange rate: US$1=HK$7.8)

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American University of Beirut

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Interested persons may send their curricula vitae and three letters of recommendation before April 15, 1993 to the Dean of Arts and Sciences, c/o New York Office of the American University of Beirut, 850 Third Avenue, New York, New York 10022, USA.

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The Hong Kong University of Science and Technology

Department of Mathematics

The Hong Kong University of Science and Technology is a new publicly-funded research University. Students have been admitted for October 1991 at both undergraduate and postgraduate levels, including the doctorate. Enrollment is expected to grow to 7,000 FTE (on full-time equivalent basis) by 1995–1996. The medium of instruction is English. Applications are invited for the following positions:

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The Department will place major emphasis on applications with an appropriate component of pure mathematics to preserve the integrity of the discipline. Research areas will be highly interdisciplinary and will include discrete mathematics, scientific computation, statistics, fluid and solid mechanics, mathematical physics, analysis, algebra, geometry, etc.

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THE RATIONALE
Mesh generation is one of the most time-consuming aspects of the numerical solution of scientific and engineering problems that involve partial differential equations. An iterative process of alternate mesh and solution generation evolves in an adaptive manner with the end result that the solution is computed to prescribed specifications in an optimal, or at least efficient, manner. Mesh generation and adaptivity are major challenges for computational problems involving moving boundaries and interfaces, such as free-surface flows and fluid-structure interactions. This program will assemble researchers in geometric modeling, mesh generation, adaptive strategies, and a posteriori error estimation with the goals of (i) exchanging information, (ii) stimulating interdisciplinary research, and (iii), ultimately, unifying these endeavors.

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