Calendar of AMS Meetings and Conferences

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

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

Meetings

<table>
<thead>
<tr>
<th>Meeting #</th>
<th>Date</th>
<th>Place</th>
<th>Abstract Deadline</th>
<th>Program Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>850</td>
<td>August 7-10, 1989 (92nd Summer Meeting)</td>
<td>Boulder, Colorado†</td>
<td>May 16</td>
<td>July/August</td>
</tr>
<tr>
<td>851</td>
<td>October 21-22, 1989</td>
<td>Hoboken, New Jersey</td>
<td>August 16</td>
<td>October</td>
</tr>
<tr>
<td>852</td>
<td>October 27-28, 1989</td>
<td>Muncie, Indiana</td>
<td>August 16</td>
<td>October</td>
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<tr>
<td>853</td>
<td>November 16-19, 1989</td>
<td>Los Angeles, California</td>
<td>August 16</td>
<td>November</td>
</tr>
<tr>
<td>854</td>
<td>January 17-20, 1990 (96th Annual Meeting)</td>
<td>Louisville, Kentucky</td>
<td>October 11</td>
<td>December</td>
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<tr>
<td></td>
<td>March 16-17, 1990</td>
<td>Manhattan, Kansas</td>
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<tr>
<td></td>
<td>August 8-11, 1990</td>
<td>Columbus, Ohio</td>
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<tr>
<td></td>
<td>November 2-3, 1990</td>
<td>Denton, Texas</td>
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<tr>
<td></td>
<td>January 16-19, 1991 (97th Annual Meeting)</td>
<td>San Francisco, California</td>
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<td></td>
<td>August 8-11, 1991 (94th Summer Meeting)</td>
<td>Orono, Maine</td>
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<tr>
<td></td>
<td>January 8-11, 1992 (98th Annual Meeting)</td>
<td>Baltimore, Maryland</td>
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<td></td>
<td>June 29-July 1, 1992 (Joint Meeting with the London Mathematical Society)</td>
<td>Cambridge, England</td>
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<td></td>
<td>January 13-16, 1993 (99th Annual Meeting)</td>
<td>San Antonio, Texas</td>
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<tr>
<td></td>
<td>January 5-8, 1994 (100th Annual Meeting)</td>
<td>Cincinnati, Ohio</td>
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</table>

* Please refer to page 477 for listing of special sessions.
† Preregistration/Housing deadline is June 1

Conferences

May 26–May 30, 1989: AMS Pure Mathematics Symposium on Complex Geometry and Lie Theory, Sundance Resort, Sundance, Utah
June 3–August 5, 1989: Joint Summer Research Conferences in the Mathematical Sciences, Humboldt State University, Arcata, California
July 10–30, 1989: AMS Summer Research Institute on Several Complex Variables and Complex Geometry, University of California, Santa Cruz, California
August 6–7, 1989: AMS Short Course on Cryptology and Computational Number Theory, Boulder, Colorado

Deadlines

<table>
<thead>
<tr>
<th>Classified Ads*</th>
<th>May/June Issue</th>
<th>July/August Issue</th>
<th>September Issue</th>
<th>October Issue</th>
</tr>
</thead>
</table>

* 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

359 National Science Foundation Budget Request for Fiscal 1990
This article is the 17th in an annual series of reports outlining the President's request to Congress for the NSF budget.

376 Richard S. Nicholson Moves to AAAS
Richard S. Nicholson, who this month will become Executive Officer of the American Association for the Advancement of Science, is interviewed by Allyn Jackson.

380 NCTM School Mathematics Standards

A list of names and thesis titles for members of the 1987–1988 Ph.D. class is featured.

FEATURE COLUMNS

386 Computers and Mathematics Jon Barwise
This month's column includes three reviews of mathematical software, as well as a proof of Gödel's Incompleteness Theorem, which has played an important role in the relationship between computers and mathematics.

401 Inside the AMS Robert M. Fossum and Kenneth A. Ross
Robert M. Fossum, the Secretary of the AMS, and Kenneth A. Ross, the Secretary of the MAA, explain how the scientific portions of the Joint Mathematics Meetings are scheduled.

402 Washington Outlook Kenneth M. Hoffman
In this month's column, Hans J. Oser reports on the first hearings of the House Subcommittee on Science, Research, and Technology, which oversees the National Science Foundation and other technical agencies of the government.

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Mathematicians and Professional Service

The dialogue concerning mathematicians in public/professional service seems to be intensifying. The issue was a topic at the January Council Meeting in Phoenix. It is on the agenda of the Society's Committee on Science Policy and the Executive Committee of the Council and the Board of Trustees. In addition, it surfaced during the interview with Richard S. Nicholson that appears in this Notices.

What is at issue? Mathematicians need to serve the profession in administrative roles and in the various ad hoc assignments that call for the judgment of professional mathematicians. With increased emphasis on public representation, research funding, and education, the demands for mathematicians in such roles actually may be greater than in the past. Whether the demand is greater or not, there is no doubt that the community is more aware of this need and this awareness has generated a call for action.

The problems associated with this issue are not restricted to any one part of our community. Administration and service at the department level is as much at issue as administration and service at the national level. We are familiar with the department member who only reluctantly takes on the position of chair and with the constant struggle over what emphasis to give to service during merit evaluation. Relatively few upper level academic administrators are mathematicians, and most every mathematician does great soul searching before taking on a major committee responsibility. And, of course, there is the perennial effort to bring mathematicians into service at the federal funding agencies. All of this has special importance to the Society. Because the Society’s major role is to serve the mathematical community, an issue that impacts the broad mathematical community is an issue of the Society. Moreover, the Society functions as a collection of volunteer committees. The actions and successes of the Society are the culmination of services performed by these volunteer committees of members.

The dialogue on this issue has pinpointed several factors that may be responsible for the problems mentioned above. There is the factor of lack of recognition for service activity. This lack of recognition begins with our peers and may be most noticeably absent at the mathematics department chair level. Also, lack of remuneration has become a major concern for those considering moving to Washington for a rotating position with one of the federal agencies. These seem to be factors which we should be able to solve as a community. However, I believe the major factor, and perhaps the one that drives many of the others, is the disruption of research. We have all heard of the physicist whose lab solved a major problem while the physicist was serving in Washington. This just does not happen in mathematics. I know this from first-hand experience, and I wish I had a solution to this problem. The answer in some cases seems to be only a difficult change in career direction.

The entire mathematical community shares in the obligation to find solutions and will share in the rewards of those solutions. The dialogue will be continuing in the deliberations of the various bodies I mentioned above. I hope all of our community will join in this dialogue.

William H. Jaco
Executive Director
I have learned only recently that it has been an unwritten requirement that candidates for the presidency of the AMS be members of the National Academy of Sciences (NAS). Among other places, the fact is mentioned in an appendix to the Report of the AMS Committee on Election Scheduling, January 1989. It is also mentioned in the current instructions from the Secretary of the Society to Council where it states: “It is the tradition that the President is a research mathematician of distinction, as evidenced by such things as the quality of appointments held and books and papers published and by membership in the National Academy of Sciences.”

First, I think members of the AMS should know about this. Second, I wish to express my very strong objection. I have serious objections to the way the NAS functions; to its nominating and electoral procedures; to the overemphasis on NAS membership as a certification of wheels. There are as many, some would say a lot more, mathematicians outside the NAS deserving of equal or greater recognition as those who are in the NAS (this applies to other fields as well, as was forcefully written to me by David Mermin, Director of the Laboratory of Atomic and Solid State Physics at Cornell). There are also other factors which make the NAS often a problematic organization to deal with, or deal through.

I urge that the Nominating Committee recommend candidates to the Council and that the Council make nominations for the position of President of the Society independently of NAS membership.

Serge Lang  
Yale University  
(Received January 17, 1989)

AMS Referendum

In its centennial year of 1988 the American Mathematical Society passed a referendum which is likely to set us back one hundred years. As a mathematician and a member of the AMS, I am vitally interested in the health and well-being of the mathematics enterprise in this country. The 1988 referendum has had several adverse effects. It has deeply divided the mathematics community. It has given ample ammunition to our critics who claim that we don’t care about real applications of mathematics. It has hurt the credibility of our friends in Washington who claim that government support for research in mathematics serves the public interest. Worst of all it has caused many outside observers to question both the motives and the integrity of our membership.

I have been an active member of the American Mathematical Society since 1977. I have enjoyed attending and presenting at the annual meetings (especially the 1988 Atlanta meeting). I place a high value on the fine publications which the AMS supports, and I have been gratified to see some of my work appear there. As a graduate of the University of Michigan in Ann Arbor I have a strong sense of the tradition which the AMS represents.

The 1988 referendum marked a radical departure from that tradition. I believe it to have been a mistake of the first magnitude. I know of no more effective means of registering my disapproval than to tender my resignation from the AMS.

Mark M. Meerschaert  
Albion College  
(Received February 10, 1989)
AMS or pay an extra fee if we wished to have that information. I really do not understand the motivation behind this decision. I would hope that the Society would want information on assistantships and fellowships to reach all prospective graduate students, especially in view of the Society's concern about the decreasing number of students who choose to do graduate work in mathematics. This decision seems to work against encouraging students to go on in mathematics.

The decision to limit the dissemination of information on assistantships and graduate fellowships has certainly reduced the value of membership in the Society for faculty at liberal arts colleges. I encourage you to reverse this decision immediately and make this information available to all colleges and universities as before.

Roger B. Nelsen
Lewis & Clark College
(Received January 23, 1989)

EDITOR'S NOTE: See the letter to the editor from David G. Hartz and the accompanying editor's note in the March 1989 Notices, page 219.

Structural Changes in the Mathematical Community

The article "Mathematics for a New Century" by L. A. Steen in the February 1989 Notices, is but the latest in a sequence—going back at least as far as the David Report—of exhortations to the mathematical world to change ingrained habits and become more involved with what goes on in the rest of the scientific and engineering world. Although I have found each one individually admirable and reasonable, I would like to raise the point whether further, more concrete and difficult, structural changes are also necessary.

My own career has been involved with the development of pure and applied differential geometry and Lie group theory, particularly in physics, mechanics, and control. In view of the excellent report "Future Directions in Control Theory" recently published by SIAM, I will use Control Theory as the focus of my comments.

Control is a classic example of a field that lives in a no-man's-land between Pure and Applied Mathematics under the present system. As a consequence of this lack of an institutional base, its development has been stultified in recent years. (That is the unstated reason for the SIAM Report!) Fundamental mathematical and engineering breakthroughs were made in the period 1955–1965 through collaboration between a small group of engineers and mathematicians. This work was feasible because the mathematics needed to handle linear control theory—a mixture of algebra, differential equations, and probability—was available. Further progress at this high level of scientific attainment—for example, extension of the basic concepts into the nonlinear domain—has been inhibited by the fact that the mathematics intrinsically involved is much more difficult, beyond what is taught in even the best engineering graduate schools. In the analogous situation in Fundamental Physics, with the success in the 1970s of advanced ideas of differential geometry and Lie group theory, there was a push by leading mathematicians and physicists to make accessible and useful the needed mathematical tools. In Control, there has been no analogous movement, beyond a few isolated individuals. No major graduate mathematics department has hired a critical mass of first-rate people and started a major graduate educational program. Neither of the NSF Institutes has had a program in Control Theory: Minnesota has held one in signal processing, with some control theorists in attendance, but that is not the same thing.

Many of the new developments in Control since 1975—including many cited in the SIAM Report—have come from a program directed by control engineers at the Ames Research Center of NASA. Although it is very modest by national and international standards, a main reason that this program has been so successful is that it combines the best features of Big and Small Science. On the Big side, NASA is an agency with major responsibilities for the development of the sort of new technology that has the potential to highly motivate the development of new control mathematics. For example, control of helicopters involves mechanical systems which are composed of coupled rigid bodies, and the involvement of NASA-Ames with the development of such helicopter technology has led to the development of control methodologies which involves innovative aspects of pure and applied differential geometry, combining the linear control theory developed in 1955–1965 with new, differential-geometric techniques. However, since NASA is not an agency with the resources of the DOD, the Ames program has worked at basically a Small Science scale, supporting and collabrating with engineers and mathematicians scattered across the country and world, who come together at periodic Workshops. This Program has also influenced—through cooperation between individuals and participation in the Workshops—development of a thriving mathematical control theory culture in Western Europe, where the institutional base lacking here has much more successfully implanted.

For the past eight years, the DOD agencies have funded a succession of Big Science-oriented Centers to carry out research work between mathematics and engineering that is of potential interest to the bureaucracy that runs these agencies. I am not aware that, on the whole, these programs have had a major impact on the course of their disciplines.
at a national or international level. (This is in marked contrast to the 1960s, when the DOD supported many of the most innovative programs in mathematics, engineering, and physics, including several which won Fields and Nobel prizes.) NSF seems to be following this Big Science Model in the development of their Center programs. Might the Ames Model not be much more beneficial to the mathematical community as a whole, as well as to the national interests that seem to be motivating this diversion of funds from the traditional—and wildly successful—Small Science programs of NSF?

Recently my work for NASA has led me into a study of the more mathematical aspects of Computer Science, where I see more analogies with my Control and Physics experience. CS seems to be at the same point of potential for mathematical development that the physics and engineering disciplines were in the 1950s. Of course, there are various areas of traditional mathematics that are very useful and important in CS, but I believe that much of an Interdisciplinary nature needs to be done in closer intellectual collaboration. Unfortunately, great opportunities for such cooperation were lost in the 1960s when the negative attitude of many mathematicians led computer scientists to separate from their natural home in mathematics departments. As a result, the rising generation of researchers in CS does not seem to have the broad knowledge of contemporary mathematics that might be useful in their scientific lifetimes, and I doubt that graduate students in mathematics are learning very much of the fascinating mathematical background and challenging research opportunities in contemporary computer science. In view of the economic, scientific, and cultural importance of the development of CS, I would think that achieving such closer links might be a topic of great priority in the mathematical world! There is a need for new ways to do this, which combines the best features of big and small science.

Robert Hermann
Brookline, Massachusetts
(Received February 15, 1989)

Conference of Refusenik Scientists

During December 8–11, 1988, I took part in an international scientific conference in Moscow organized by refusenik scientists. (Refuseniks are primarily Jews whose requests to emigrate have been turned down—see AMS Notices, November 1988, Vol. 35, No. 9). “Frontiers of Science” took place in several private apartments; participating were 45 Soviet scientists and 18 scientists from the West including 9 from the U.S. and 6 Scandinavians. Bruce Solomon of Indiana University and I (as official representative of the AMS) were the two American mathematicians. There were also several American computer scientists including Boris Katz of MIT—himself a former refusenik.

Most of the refuseniks lost their jobs as scientists after applying to emigrate—a human and professional tragedy—and are often treated as pariahs. It is most important for them to maintain contact with each other and with their scientific peers in the West. Refusenik seminars began in 1972, and several international ones were held up to 1980. The conference planned for 1981 was blocked by Soviet authorities, and this was the first one since then; many people hope it will be the last one needed. Indeed, there was a sharp increase of Jewish emigration in 1988 to about 19,000 (the peak was 51,000 in 1979). This has led many people, even in Moscow, to believe that there are no more refuseniks. However, there are still hundreds of refusenik scientists—some 20 have been waiting at least 15 years. The reason that is usually given for refusal is that they once had security clearance, or access to classified work. But most of the refusenik scientists claim they never engaged in classified work. The rest hold that their exposure to secrets occurred so long ago that their knowledge is now either in the public domain or totally obsolete. One of the participants divorced his wife so that she and their son could leave. The son would otherwise have been drafted into the army and automatically branded a security risk.

About a year ago, after waiting for many years, the well-known mathematician Alexander Ioffe was allowed to leave. His sister and her husband, Inna and Igor Uspenskii, both entomologists, have been waiting since 1979. Their 19-year-old son Viacheslav, who never engaged in any scientific work, is prevented from leaving because of his parents’ and grandmother’s farfetched alleged access to secrets before then. He has been told that his refusal is effective until 1996.

Among the Soviet participants there were very few mathematicians, so I listened mainly to talks in computer science and the physical sciences. A number seemed very interesting. The visitors were all impressed by the courage of our Soviet colleagues and the good spirits and high morale of many.

Whereas in the past very few mathematicians could travel freely, I was told that I’d be unlikely to find any mathematicians in Moscow now: they are all travelling, or just back, briefly, “to change their laundry.” The mood of many people I spoke to was pessimistic. They all support Gorbachev’s efforts to change the situation, but the problems, especially economic ones, are enormous. People fear that he may be overthrown in a few years—resulting in chaos, or worse.

As for Moscow University, the situation seems unchanged; it is still very difficult for Jews to enter to study mathematics or physics.

Overall my visit to Moscow was exhilarating. My contacts with
refuseniks were especially rewarding. The scientists who hold meetings twice a month greatly welcome the participation of foreign colleagues. Should readers plan trips to the USSR, I recommend that they be in touch with the Committee of Concerned Scientists for up-to-date information: 330 Seventh Avenue, Suite 608, New York, New York 10001, 212-695-2560.

Louis Nirenberg Courant Institute of Mathematical Sciences New York University (Received February 16, 1989)

International Campaigns for Human Rights

I want to express my deep appreciation to mathematicians in the U.S.A. who have given generous support to the International Campaigns for Human Rights which I have been directing for the past 8 years. Previous Campaigns for Professor J. L. Massera in Uruguay and Drs. Orlov and Shcharansky in the USSR, were successful in helping to gain their freedom and are indebted to persons and groups in all walks of life and in many countries, but the mathematicians in many countries were the backbone of the Campaigns.

The present Campaign aims at an end to all abduction and torture in Chile. Its tremendous international community of supporters includes 125 Nobel Laureates. A message to the Human Rights Commission of the United Nations, now in session in Geneva, signed by these 125 Nobel Laureates, appears in the Geneva newspaper Journal de Genève, on Tuesday, February 7, 1989, published by the Campaign.

When the Chile Campaign ends successfully, but only then, the next International Campaign will begin, with the objective to eliminate apartheid in South Africa.

Individuals interested in helping the efforts of Campaigns for Human Rights should contact me at the Department of Mathematics, University of Toronto, Toronto, Ontario, Canada M5S 1A1.

Israel Halperin University of Toronto (Received February 8, 1989)

A Remembrance of Gordon Walker

We noted with deep sorrow the obituary of Dr. Gordon L. Walker by Professor William LeVeque in the February 1989 issue of Notices.

The Wilkes College Library suffered devastating loss in the great Agnes Flood of 1972. We fondly remember that Dr. Walker not only donated his considerable personal collection of mathematical books and journals to us, but also went out of his way to help us publicize our plight in Notices, enabling us to mount a highly successful national campaign to rebuild our library holdings in mathematics. As a result, hundreds of mathematicians all over the country contributed thousands of cartons of material for our mathematics collection.

It is such generosity, as exemplified by Dr. Walker, which added an extra measure of warmth and caring to our American mathematical community. On behalf of President Christopher N. Breiseth, we wish to convey our condolences to the family of Dr. Walker and to take this opportunity to express again our gratitude to our generous colleagues everywhere.

Bing K. Wong Wilkes College (Received February 10, 1989)
The fiscal year 1990 budget request for the National Science Foundation (NSF) contains few surprises, for it follows the same basic themes the Foundation has pursued for the last few years: disciplinary research, education and human resources, and groups and centers. Requesting a healthy 14% increase, the NSF is back on track with its goal of doubling its 1987 budget by 1992. Once again, mathematics received favored treatment, with a request of 15.5% over the 1989 budget for the Division of Mathematical Sciences (OMS).

Of course, Congress will rearrange the entire federal budget to its liking. President Bush made some changes in the Reagan request, but none of them applies to the NSF. Both the Executive and Legislative branches seem to agree the NSF is worthy of increases, but when it comes down to deciding among competing federal projects, Congress has repeatedly denied the President the large increases requested for the Foundation. As some at the NSF like to say, support for the Foundation in Congress is "a mile wide and an inch deep."

**Deficit Pressures**

Part of the difficulty has been the national debt, which now stands at a staggering $2 trillion. The interest alone on the debt—$150 billion last year—dwarfs the NSF's $1.9 billion budget. Gramm-Rudman-Hollings automatic spending cuts will go into effect if the projected deficit is more than $110 billion; this year, the deficit is expected to be $160 billion. In addition, the House and Senate committees overseeing the NSF also handle several social programs. In a time of tight budgets, comparing increases for the NSF against social spending makes for especially difficult choices.

In addition, changes in the leadership of these committees in both the House and the Senate bring a new uncertainty to the process. In the House, Representative Edward P. Boland (D-MA), a longtime supporter of NSF, has been replaced by Robert Traxler (D-MI). Traxler has in the past shown an interest in the NSF and other science programs, and is seen as supportive of science. In the Senate, Barbara Mikulski (D-MD) succeeds William Proxmire (D-WI), who retired last year. Mikulski has not been particularly active in science issues, but has recently spent time at NSF headquarters in order to learn more about the agency.

Last year's NSF budget provides a vivid example of how Congress can reorder the priorities set by the President. Though the Reagan Administration originally requested a 19.5% increase to $2.05 billion for the NSF in 1989, Congress pared it down to just 9.5%, and the DMS, though slated for a 6.8% increase, received just 3.3%. As usual in recent years, Congress gave more to education than requested, upping the request of $156 million to $171 million, a 22.5% increase over 1988. In addition, Congress shied away from the $150 million request to fully fund for five years the Science and Technology Centers (STC) program and gave the NSF $25 million to fund the first year of the program.

**Major Areas of Increase**

The 1990 requested budget designates a number of areas for major increases. The Directorate for Computer and Information Sciences and Engineering would jump by almost 26%, with a large increase for improvements in the NSFNET computer network. A requested increase of 22% for the Engineering Research Centers program would allow for the initiation of about three new centers. In the Directorate for Mathematical and Physical Sciences (MPS), the larger organizational structure housing the DMS, mathematics is set to receive a larger increase than most other divisions in the MPS (see Table II). The only exception is Materials Research, and most of that increase will fund construction of a new High Magnetic Field Laboratory. One question mark in next year's MPS budget centers on the choice for a new head of that directorate. Leaving his post as Assistant Director for
### Table I. National Science Foundation

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<tr>
<td>(1) Mathematical Sciences Research Support</td>
<td>$51.9</td>
<td>15.4%</td>
<td>$59.9</td>
<td>6.5%</td>
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<td>(2) Other Research Support (Note A)</td>
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<td>(3) Education, Foreign Currency Program (Note B)</td>
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<td>(4) Program Development and Management (&quot;Overhead&quot;) (Note C)</td>
<td>71.8</td>
<td>8.4%</td>
<td>77.8</td>
<td>8.6%</td>
<td>84.5</td>
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<td>(5) Science and Technology Centers</td>
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<tr>
<td>(6) Totals</td>
<td>$1493.2</td>
<td>9.0%</td>
<td>$1627.6</td>
<td>5.8%</td>
<td>$1722.6</td>
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</table>

Note A. Scientific research and facilities (excluding mathematics). National and special research programs, and national research centers. Support for mathematics has been excluded, cf. items (1) and (3).

Note B. The programs in this group are ones in which there is some support in every field, including mathematics. The foreign currency program was eliminated in FY 1989.

Note C. This heading covers the administrative expenses of operating the Foundation; the funds involved are not considered to constitute direct support for individual projects.

### Table II. Directorate of Mathematical and Physical Sciences

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<tr>
<td>Mathematical Sciences</td>
<td>$51.9 (11.9%)</td>
<td>$59.9 (12.9%)</td>
<td>$63.8 (13.5%)</td>
<td>$65.9 (13.1%)</td>
<td>$76.1 (13.8%)</td>
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<tr>
<td>Astronomical Sciences</td>
<td>80.2 (18.4%)</td>
<td>85.1 (18.3%)</td>
<td>85.8 (18.2%)</td>
<td>89.5 (17.8%)</td>
<td>94.0 (17.0%)</td>
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<tr>
<td>Physics</td>
<td>113.2 (26.0%)</td>
<td>117.0 (25.2%)</td>
<td>117.9 (25.0%)</td>
<td>122.6 (24.4%)</td>
<td>130.0 (23.5%)</td>
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<td>Chemistry</td>
<td>85.8 (19.7%)</td>
<td>93.8 (20.2%)</td>
<td>94.0 (19.9%)</td>
<td>96.6 (19.2%)</td>
<td>103.4 (18.7%)</td>
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<td>110.6 (23.4%)</td>
<td>115.0 (22.9%)</td>
<td>135.2 (24.4%)</td>
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<td>Science and Technology Centers</td>
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<td>13.7 (2.7%)</td>
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<td>$464.7</td>
<td>$472.0</td>
<td>$503.3</td>
<td>$553.5</td>
</tr>
</tbody>
</table>

### Table III. Compilation of the NSF Budget, 1985–1990

|----------|-------------|-------------|-------------|-------------|-----------|--------------|----------------|----------------|
MPS, Richard S. Nicholson, becomes executive officer of the American Association for the Advancement of Science this month (see the interview with Nicholson in this issue of Notices).

The requested increase may not mean more grants to individual investigators, for NSF Director Erich Bloch has made increasing grant size a top priority. Bloch believes the typical individual investigator grant, which now averages $75,000, should rise to $110,000 or $120,000 over time. Though it is tempting to spread grant money thinly to reach more investigators, “after a while, it catches up with you,” says Bloch. “Math is a particular area of concern, but the problem affects all fields.”

**Mathematics Gets a Boost**

The almost 16% requested increase for the DMS continues the pattern of a rising mathematics budget at the NSF, resulting from the 1984 David Report. In 1983, the budget of the DMS was $34.8 million, compared to the $63.8 in 1988, an increase of almost 74% in inflation-adjusted dollars; the analogous increase for the whole Foundation in that time was about 16%.(see also Table III). Over that time, most of the increases for the DMS have gone toward postdoctoral researchers and graduate students. The Division has also followed Bloch’s policy of increasing the size, rather than the number, of individual grants. In addition, the DMS launched the Computational Mathematics program in 1986.

For 1990, the DMS intends to increase the number of Mathematical Sciences Research Groups and to promote interactions between mathematics and other disciplines. In addition, the Division is requesting funds for a new set of activities in geometry. According to DMS Director Judith S. Sunley, the geometry activities are still in the planning stages, but she says the DMS is considering non-traditional activities such as regional institutes and other means of integrating research and educational activities and involving a broad segment of the mathematical sciences community. The Computational Mathematics program will also receive a sizeable increase, as it comes up to steady-state funding in its third year of existence.

**Centers in the NSF Budget**

In addition to increasing the number of engineering centers, the Foundation plans to run a second competition to establish eight to ten more STCs to add to the eleven funded this year. For this purpose, the STC budget is slated to rise by 90% to $47.5 million. The STCs are designed to support research in which the complexity of the problems or the resources needed to solve them require the facilities and collaboration best suited to a campus-based research center. Among the centers funded this year is one at Rutgers University, which focuses on discrete mathematics and theoretical computer science; two other STCs have a significant mathematical component (see “NSF Center Awards Announced,” Notices, February 1989, page 154).

There has been a great deal of controversy in the scientific community over the NSF’s increased emphasis on the center mode of funding research. Some believe the trend toward centers properly reflects the increasingly interdisciplinary nature of science as more and more complex problems are tackled. Others say that the centers are just a means of attracting more funds to the NSF and express concern that the centers may prove to be a drain on funds for individual investigators.

Whatever their merits and drawbacks, such large-scale activities are accounting for a bigger share of the NSF pie than in the past. The NSF typically lists four different activities under the center rubric: the STCs, the Engineering Research Centers, the Materials Research Laboratories, and the Industry/University Cooperative Research Centers. In 1983, before the STCs and the engineering centers were begun, the NSF spent about 2.5% of its research budget on centers’ activities. By 1985, when the engineering centers were under way, that share rose to 3.1%. With the establishment of the STCs, the figure is 6.4% under the current 1989 plan, and is set to rise to 7.5% in the requested 1990 budget.

**Educational Activities**

The NSF’s calculus reform effort, housed in the Course and Curriculum program of the Division of Undergraduate Science, Engineering, and Mathematics Education (USEME), has received wide attention in the mathematical community since its inception last year. The current budget for the program (which includes projects to revamp the undergraduate engineering curriculum) is $4 million, and no increase is requested for 1990. However, of the $1.8 million for undergraduate activities in the DMS, a portion will go to course and curriculum programs, either in calculus or other areas. In other areas—such as chemistry, biology, and computer science—undergraduate curriculum reform projects are being planned in the research divisions.

The DMS also handles two other programs coordinated through USEME: Research Experiences for Undergraduates and Instrumentation and Laboratory Improvement. The mathematics portion of the former program is handled entirely in the DMS, but for the latter program, the DMS handles only proposals coming from Ph.D-granting institutions. Increases for these two programs are not requested within USEME, but are scattered through the research divisions.

Allyn Jackson
Staff Writer
Mathematical Sciences Subactivity
$76,046,000

Summary of Request
The FY 1990 Request for the Mathematical Sciences Subactivity is $76.05 million, an increase of $10.18 million, or 15.5 percent, over the FY 1989 Current Plan of $65.87 million.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical Analysis</td>
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<td>$6.47</td>
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<tr>
<td>Modern Analysis</td>
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<tr>
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<td>5.85</td>
<td>5.92</td>
<td>7.16</td>
</tr>
<tr>
<td>Topology &amp; Foundations</td>
<td>6.87</td>
<td>7.10</td>
<td>7.87</td>
</tr>
<tr>
<td>Algebra &amp; Number Theory</td>
<td>9.63</td>
<td>9.88</td>
<td>11.15</td>
</tr>
<tr>
<td>Applied Mathematics</td>
<td>7.91</td>
<td>8.13</td>
<td>9.21</td>
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<tr>
<td>Statistics &amp; Probability</td>
<td>7.04</td>
<td>7.23</td>
<td>8.21</td>
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<tr>
<td>Computational Mathematics</td>
<td>4.15</td>
<td>4.86</td>
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<tr>
<td>Special Projects</td>
<td>10.92</td>
<td>11.07</td>
<td>13.67</td>
</tr>
<tr>
<td>Total, Subactivity</td>
<td>$63.76</td>
<td>$65.87</td>
<td>$76.05</td>
</tr>
</tbody>
</table>

Scientific Overview
The Mathematical Sciences Subactivity fosters the creation and development of mathematical ideas, methods, and techniques and promotes their use in improving our understanding of physical, biological, engineering, and social phenomena. Support for significant research and related infrastructure activities ensures the continuing vitality and long-range health of the discipline. All subdisciplines of the mathematical sciences, from those with the sharpest intrinsic focus to those that reach out to other areas of knowledge, are supported to encourage interaction and provide a healthy balance among them.

The core of the Foundation’s program of research support in the mathematical sciences has been the individual investigator award. Collaborative research efforts, inclusion of graduate students and postdoctoral researchers as participants in the research effort, and appropriate development and use of computational techniques are encouraged.

Much of the current excitement in mathematics stems from the interactions between various subdisciplines and between mathematics and other areas of science and engineering:

- Finite simple groups are the fundamental building blocks of all finite algebraic structures. Mathematicians at Rutgers and Yale Universities investigating the largest nonstandard finite simple group (nicknamed the “Monster”) have discovered fundamental connections with string theory, new physical theories developed to explain the structure of matter.
- The relationship between the shape and specific analytic properties of a geometric surface is one of the main concerns of contemporary mathematical research. The case of a region with “fractal” boundary, so irregular that its dimension is no longer an integer, has been the setting for some recent breakthroughs. It is now known that the dimension of the boundary can be recovered directly from analytic information. This work, carried out at the Georgia Institute of Technology, has involved both computer experimentation and sophisticated mathematical technique, and has applications to the study of porous media and the scattering of waves from fractal surfaces.

The above examples are typical of recent developments throughout mathematics and exhibit two related phenomena:

- Many of the most fundamental advances are being made by people with deep understanding of a wide range of mathematical and scientific topics.
- The lead time between theoretical development and application is decreasing so rapidly that they are often virtually simultaneous.

These observations have profound implications for the training of graduate students and for the continuing development of established researchers.

The Subactivity also supports, through its Special Projects Program, various efforts that cut across the mathematical sciences, including:

- research institutes and centers;
- postdoctoral research fellowships;
- research conferences, workshops and special years;
- shared scientific computing research equipment; and
- undergraduate programs managed in collaboration with the Science and Engineering Education Activity.

During the last few years, support in the mathematical sciences has been adjusted to address major infrastructure problems. Emphasis has been placed on improving the pool of talent entering the field. Significant gains have been made through added support for graduate students, postdoctoral researchers and undergraduate faculty and students. Support for undergraduate curriculum development in calculus was initiated in FY 1988 in cooperation with Science and Engineering Education.

Figure 1 illustrates the crucial role played by NSF in the federal support of academic research in the mathematical sciences. In all areas of the mathematical sciences, Foundation supported research involves a broader range of basic research topics than the more
project-oriented research sponsored by the mission agencies.

NSF coordinates its support of research in the mathematical sciences with its counterpart Federal agencies through the Interagency Committee for Extramural Mathematics Programs (ICEMAP). This group meets regularly to share information on policies of support and to discuss areas of emphasis and of unusual scientific opportunity.

### FEDERAL ACADEMIC MATHEMATICS FUNDING

(FY 1988 Total: $124.6 Million)

An increase in special projects reflects priority given to undergraduate activities. Other elements have been reduced to accommodate unspecified Congressional reductions.

#### FY 1990 Budget Request

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 1989 Current Plan</th>
<th>FY 1990 Request</th>
<th>Change Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical Analysis</td>
<td>$5.84</td>
<td>$6.47</td>
<td>10.8%</td>
</tr>
<tr>
<td>Modern Analysis</td>
<td>5.84</td>
<td>6.46</td>
<td>10.6%</td>
</tr>
<tr>
<td>Geometric Analysis</td>
<td>5.92</td>
<td>7.16</td>
<td>20.9%</td>
</tr>
<tr>
<td>Topology &amp; Foundations</td>
<td>7.10</td>
<td>7.87</td>
<td>10.8%</td>
</tr>
<tr>
<td>Algebra &amp; Number Theory</td>
<td>9.88</td>
<td>11.15</td>
<td>12.9%</td>
</tr>
<tr>
<td>Applied Mathematics</td>
<td>8.13</td>
<td>9.21</td>
<td>13.3%</td>
</tr>
<tr>
<td>Statistics &amp; Probability</td>
<td>7.23</td>
<td>8.21</td>
<td>13.6%</td>
</tr>
<tr>
<td>Computational Mathematics</td>
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<td>5.85</td>
<td>20.4%</td>
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<tr>
<td>Special Projects</td>
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<td>23.5%</td>
</tr>
<tr>
<td>Total, Subactivity</td>
<td>$65.87</td>
<td>$76.05</td>
<td>15.5%</td>
</tr>
</tbody>
</table>

The FY 1990 Budget Request of $76.05 million is $10.18 million (15.5 percent) above the FY 1989 Current Plan. Within the disciplines of the mathematical sciences, three areas will receive particular emphasis in FY 1990:

- Modern Geometric Mathematics. There has been a rapid expansion of the role of geometric ideas throughout mathematics and its applications. Within a planned increment of $1.25 million, particular attention will be paid to the critical need for increased training at all levels to support the integration of deep knowledge of geometry with that of other fields.

- Computational Mathematics presents researchers in the mathematical sciences with an experimental tool of unprecedented power. It also presents opportunities for bringing modern mathematics into contact with other disciplines. Timely areas for growth include computational geometry, computer visualization and image processing, and symbolic and algebraic computing. An increment of $1.00 million is requested.

- Interaction with other disciplines. Mathematics is becoming more involved with other areas of science and engineering, with promising opportunities for both mathematics and the partner field. Particularly exciting at this time are collaborative activities with the biosciences that envision combinations such as knot theory with the structure of DNA, probability and combinatorics with DNA sequence analysis, or statistics and dynamical systems with ecology. A requested increment of $1.40 million will allow for expansion of interactions with the biosciences, enhancement of joint activities with physics and astronomical sciences in the area of cosmology, and exploration and development of new partnerships.

The FY 1989 Current Plan is $65.87 million, a decrease of $1.72 million (2.5 percent) from the FY 1989 Budget Request, due to unspecified Congressional reductions. This represents an increase of $2.11 million (3.3 percent) above the FY 1988 level.

Figure 1

Changes Between FY 1989 Request and FY 1989 Current Plan

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 1989 Request</th>
<th>FY 1989 Current Plan</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical Analysis</td>
<td>$6.05</td>
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<tr>
<td>Modern Analysis</td>
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<td>Geometric Analysis</td>
<td>6.17</td>
<td>5.92</td>
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</tr>
<tr>
<td>Topology &amp; Foundations</td>
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<td>Algebra &amp; Number Theory</td>
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<td>Applied Mathematics</td>
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</tr>
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<td>Special Projects</td>
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<tr>
<td>Total, Subactivity</td>
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<td>$65.87</td>
<td>-2.5%</td>
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</table>
In all these areas, as with those being maintained in the base program, emphasis will be placed on providing opportunities for training and research activity that will be catalytic in developing the discipline.

- Many of the disciplinary priorities indicated above will be carried out through significant enhancement of Mathematical Sciences Research Groups, an activity initiated in FY 1989. Incremental funding of $2.6 million will more than double the size of the activity, which cuts across all programs. The groups will allow researchers to develop and sustain scientific collaborations with sufficient resources, in terms of personnel and equipment, to address the most pressing and complex questions.

- Education and human resource emphases are included in all programs of the subactivity. Support for undergraduate activities will increase by $1.8 million in FY 1990 with emphasis on Research Experiences for Undergraduates, Research at Undergraduate Institutions, Instrumentation and Laboratory Improvement, and Curriculum Development in Mathematics, including Calculus. Interaction with programs targeted at underrepresented groups will be enhanced, and proposals involving underrepresented groups will be encouraged. Increased funding of $0.5 million in this area will more than double current levels of activity.

The following text was prepared by the staff of the Division of Computer and Computation Research in the directorate of Computer and Information Science and Engineering at the NSF and was submitted to Congress as part of the Administration's Budget Request for the Fiscal Year 1990.

Scientific Overview

Computer and computation research discovers the laws which govern problem-solving procedures and develops computing systems which test and utilize them. Topics for study include strategies and algorithms for solving problems, methods of representing and transforming information, programs and software systems for carrying out computational procedures, and machines for executing programs.

Parallel computation is a basic theme for much of the research supported in the Subactivity. Promising new parallel computer architectures require new algorithms, languages, tools and software systems to be effective. To develop them, new research is required in theory, problem solving, design and implementation.

Both academic and industrial computer and computation research are supported by several agencies of the Federal government. However, with the exception of NSF, most Federal programs support mission-directed research. As with industry, most of these Federal programs concentrate their support at a few academic centers.

NSF provides support in all areas of computer and computation research, primarily to academic research institutions. This strengthens the Nation's long-term scientific and technology potential by directly involving teaching faculty, graduate and undergraduate student assistants in research, and by providing incentives for university-industry interaction. About 50 percent of academic research in software and 75 percent of research in computing theory is funded by this subactivity.

Changes Between FY 1989 Request and FY 1989 Current Plan

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 1989 Request</th>
<th>FY 1989 Current</th>
<th>Change Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer &amp; Computation Theory</td>
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<tr>
<td>Computer Systems Architecture</td>
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<tr>
<td>Software Systems</td>
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<tr>
<td>Software Engineering</td>
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<td>Total, Subactivity</td>
<td>$22.17</td>
<td>$21.15</td>
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The FY 1989 Current Plan is $21.15 million, a decrease of $1.02 million from the FY 1989 Budget Request due to unspecified Congressional reductions. This decrease is spread across all program elements except Computer Systems Architecture, which is kept at the Request level. The FY 1989 Current Plan represents an increase of $1.30 million, (6.5 percent) over the FY 1988 level, which is distributed across most program elements.
NSF Budget Request for 1990

FY 1990 Budget Request

(Millions of Dollars)

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 1989 Current Plan</th>
<th>FY 1990 Request</th>
<th>Change Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer &amp; Computation Theory</td>
<td>$6.42</td>
<td>$6.72</td>
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<tr>
<td>Numeric &amp; Symbolic Computation</td>
<td>2.83</td>
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<td>Computer Systems Architecture</td>
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<td>Software Systems</td>
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<td>Software Engineering</td>
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<tr>
<td>Total, Subactivity</td>
<td>$21.15</td>
<td>$23.67</td>
<td>11.9%</td>
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</tbody>
</table>

The Request for FY 1990 increases the emphasis on research on parallel computing systems and architecture. This research will focus on computation methods and on software for parallel systems. In the computation area, the increment for the Numeric and Symbolic Computation program element increases research on the utilization of new architectures, on the improvement of algorithms for scientific computing, and on the integration of numerical and symbolic techniques. Recent findings have demonstrated the high potential for significantly increased computational power delivered to scientists and engineers when problem solving software is improved (Figure 2).

Impact of Algorithm Research

Performance Increase Due to Improved Software On Three Supercomputers

Parallel processing software is another major area of emphasis. Despite considerable progress in software engineering technique and the underlying basic science of software systems, the major stumbling block in effectively using new parallel processing computer hardware is the lack of software. The requested increment for the Software Engineering and Software Systems program elements will expand basic research on new software systems and new approaches for their creation. Individual grants sizes will be increased to facilitate empirical work.

The following text was prepared by the staff of the directorate of Science and Engineering Education at the NSF and was submitted to Congress as part of the Administration's Budget Request for the Fiscal Year 1990.

Information, Robotics, and Intelligent Systems

$21,640,000

Summary of Request

The FY 1990 Request for the Information, Robotics, and Intelligent Systems Subactivity is $21.64 million, an increase of $2.52 million, or 13.2 percent, over the FY 1989 Current Plan of $19.12 million.

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<tbody>
<tr>
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<td>$21.64</td>
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</table>

Scientific Overview

This Subactivity supports research to improve basic understanding and design of information systems that enhance our ability to work and live in complex environments. Information in this context takes many forms: language, speech, images, various types of signals or sensory data, text, numbers and symbols. Research in this subactivity focuses on how to provide the best computational structures and physical devices to facilitate the use of these information forms. Research to improve understanding of economic and societal consequences of information technology, particularly on using information technology to increase organizational productivity, is also supported.

With the advent of efficient machinery to manipulate information, databases have become central elements of social and economic functioning, and key factors in scientific research. Similarly, as ways were discovered to automate the transformation of knowledge about processes into physical work, robots and other automated machines have proliferated. Both phenomena have had...
obvious effects on contemporary industrial development and growth, and appear to have major consequences for national economic competitiveness.

The current trajectory of technology improvement suggests that the past provides only a hint of the potential of electronic information processing in the future. Continued progress requires improvements in both theories and techniques for manipulating and using information as well as exploiting the power of new parallel devices and programs.

Major opportunities exist to improve the utilization of robots and databases, and to exploit computers as intelligent agents in performing complex tasks. To do so requires fundamental research and engineering experimentation on representing knowledge in machines, automating complex processes of sensing and understanding, inference, learning, reasoning and problem solving. Moreover, equal attention is needed to improve the interaction between people and computers by understanding the cognitive requirements of human information processing, and by improving the modes of interaction, such as graphic display, multi-media input, and high level mechanisms for human-machine dialogue.

This subactivity is a primary source of Federal support for interdisciplinary research in computing, neuropsychology, and the behavioral and social sciences dealing with both theory and experimental applications of information processing technology. It provides about 50 percent of the total Federal support for these areas. DOD agencies, particularly DARPA and ONR, provide the balance, concentrating on a relatively small and select number of institutions and on sharply defined military applications.

Industrial laboratories play an important role as consumers of basic university research, but they tend to focus on short term goals leading to marketable products rather than on fundamental knowledge improvement. Internationally, significant efforts in these areas are under way in Japan and in Europe.

Although research in this field is relatively new, significant progress has been made. Of particular importance are advances in the areas of computer vision, knowledge-based information processing, natural language interfaces, and sensor-based robotic systems. For example, research is supported that uses neural network software to mimic the way that children learn motor control, thus permitting a robot to expand control of its environment through sensing and repetitive training. This greatly reduces the complexity of calculations which must be used by the robot for real-time control, and may eventually lead to less expensive and more flexible robotic systems for manufacturing.

Changes Between FY 1989 Request and FY 1989 Current Plan

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 1989 Request</th>
<th>FY 1989 Current Plan</th>
<th>Change Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge and Database Systems</td>
<td>$8.30</td>
<td>$7.67</td>
<td>-8.2%</td>
</tr>
<tr>
<td>Robotics and Machine Intelligence</td>
<td>6.11</td>
<td>6.03</td>
<td>0.0%</td>
</tr>
<tr>
<td>Interactive Systems</td>
<td>2.73</td>
<td>2.66</td>
<td>-2.7%</td>
</tr>
<tr>
<td>Information Technology and Organizations</td>
<td>2.59</td>
<td>2.76</td>
<td>6.1%</td>
</tr>
<tr>
<td>Total, Subactivity</td>
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<td>$19.12</td>
<td>-3.1%</td>
</tr>
</tbody>
</table>

The FY 1989 Current Plan is $19.12 million, a decrease of $0.61 million (3.1 percent) from the FY 1989 Budget Request due to unspecified Congressional reductions. It represents an increase of $1.39 million (7.8 percent) over FY 1988, which is distributed across all program elements except Information Technology and Organizations, which increased slightly.

FY 1990 Budget Request

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 1989 Current Plan</th>
<th>FY 1990 Request</th>
<th>Change Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge and Database Systems</td>
<td>$7.67</td>
<td>$8.21</td>
<td>7.1%</td>
</tr>
<tr>
<td>Robotics and Machine Intelligence</td>
<td>6.03</td>
<td>6.77</td>
<td>12.3%</td>
</tr>
<tr>
<td>Interactive Systems</td>
<td>2.66</td>
<td>3.39</td>
<td>27.5%</td>
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<tr>
<td>Information Technology and Organizations</td>
<td>2.76</td>
<td>3.27</td>
<td>18.5%</td>
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<td>Total, Subactivity</td>
<td>$19.12</td>
<td>$21.64</td>
<td>13.2%</td>
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</table>

The Request will strengthen base support in all program elements to take advantage of new computing technologies such as sensors and high performance parallel computers. These technologies, unavailable just a few years ago, are rapidly changing how information from the physical environment is collected, stored, and retrieved as useful knowledge.

Resources of about $2.0 million from across the subactivity will be pooled to expand support for two initiatives begun in FY 1989. One deals with “coordination theory and technology”. This research, at the intersection of artificial intelligence, computer science, and economic theory, is aimed at understanding how work and problem solving can be made more productive in a distributed computer environment. It provides fundamental research with long term utility in high speed network applications. Scientific and engineering research enterprises will be used as the test area for experimentation.

The other initiative is a cooperative effort with DARPA for joint support of selected areas in artificial intelligence.
It emphasizes support of university research with industrial linkages to improve technology transfer.

The following text was prepared by the staff of the Division of Advanced Scientific Computing in the directorate of Computer and Information Science and Engineering at the NSF and was submitted to Congress as part of the Administration’s Budget Request for the Fiscal Year 1990.

**Advanced Scientific Computing**

$71,688,917

**Summary of Request**

The FY 1990 Request for the Advanced Scientific Computing Subactivity is $71.69 million, an increase of $15.86 million, or 28.4 percent, over the FY 1989 Current Plan of $55.83 million.

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Centers</td>
<td>$42.94</td>
<td>$54.03</td>
<td>$69.03</td>
</tr>
<tr>
<td>New Technologies</td>
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<tr>
<td>Total, Subactivity</td>
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<td>$55.83</td>
<td>$71.69</td>
</tr>
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</table>

**Scientific Overview**

The Advanced Scientific Computing Subactivity provides the science and engineering basic research community access to advanced computation facilities through support of five national Supercomputer Research Centers:

- the San Diego Supercomputer Center at the University of California at San Diego;
- the National Center for Supercomputing Applications at the University of Illinois;
- the John von Neumann Center for Scientific Computing near Princeton, New Jersey;
- the Pittsburgh Supercomputing Center; and
- the Cornell National Supercomputer Facility at Cornell University.

The Subactivity also supports basic research on methods and technologies for high performance scientific computing.

The Centers serve the U.S. academic research community, support software required to maximize productivity, and train new users. In addition, the Centers, working jointly with industry, are leaders in research on supercomputing systems including state-of-the-art supercomputers; peripherals for data storage, retrieval and display; network connections; and special purpose processors.

State-of-the-art high performance computers are essential to leadership in contemporary scientific and engineering research, as they permit researchers to explore otherwise unmanageable problems. Operating at hundreds of millions of instructions per second, supercomputers are used to analyze data and to stimulate processes at levels of complexity and detail that inform the most advanced notions of reality. The range and diversity of research addressed is vast, from modeling the surfaces of viruses to simulating the dynamics of thunderstorms, and from performing calculations for revealing new features of nucleon masses to building models of international economic activity. As a result, the Centers serve scientists and engineers from all the Foundation activities. Figure 3 shows the distribution of supercomputer use by discipline.

More than 11,000 university faculty, postdoctoral, graduate and undergraduate students, and industrial researchers have used Centers since the program began. They have come from institutions across the nation, and have been involved in more than 4,700 research projects. In addition to supplying computer cycles, the Centers provide a broad array of critical user services: specialized graphics and visualization systems, applications software libraries and consulting services, training workshops, and related activities.

The Subactivity also supports and coordinates cross-disciplinary research required for progress in computational science and engineering and advanced research computing. This includes: targeted research on computational strategies; distributed and parallel processing and vectorization; performance evaluation; new algorithms; visualization, graphics and image processing; and large scale scientific databases. The Subactivity actively
promotes interaction between the industrial and academic sectors in the use of advanced computing and related techniques. In doing so, it is a partner in the maintenance of industrial competitiveness in high performance computing systems.

NSF activities in this area are coordinated with the more mission-oriented activities of other federal agencies, most notably the Department of Energy, Department of Defense, the National Oceanic and Atmospheric Administration, and the National Aeronautics and Space Administration. This cooperation encourages the exchange of skills, applications, software operations and management experience, and optimizes facility utilization.

Changes Between FY 1989 Request and FY 1989 Current Plan

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 1989 Request</th>
<th>FY 1989 Current Plan</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centers</td>
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<td>0.0%</td>
</tr>
<tr>
<td>New Technologies</td>
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<tr>
<td>Total, Subactivity</td>
<td>$55.83</td>
<td>$55.83</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

The Subactivity is funded at the FY 1989 Request level of $55.83 million, consistent with Congressional directions, which is an $11.12 million (24.9 percent) increase over the FY 1988 level. This maintains basic operations at all centers, and allows improvements in services and equipment, software acquisition and selected upgrades at several Centers with non-NSF funds.

FY 1990 Budget Request

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 1989 Current Plan</th>
<th>FY 1990 Request</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centers</td>
<td>$54.03</td>
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<tr>
<td>New Technologies</td>
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<td>Total, Subactivity</td>
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<td>$71.69</td>
<td>28.4%</td>
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</table>

The requested increase allows for renewal of the cooperative agreements at the five Centers, and begins NSF support of major systems upgrading. Obtaining leading-edge supercomputing hardware is necessary to meet the increasing demand for computing resources and allows the Centers to continue their national leadership role in advanced scientific and engineering computing. However, hardware alone does not provide this capability. Consequently, major efforts will be initiated at the Centers to optimize systems, software, and services for maximum capacity utilization and research productivity. This will include: research on parallel computations and performance analysis; expansion and updating of software libraries; upgrading of data management systems; and improvement of communication and graphics capabilities. Efforts will be expanded in critical management areas: monitoring and evaluating resource utilization, characterizing workload, and assessing user needs.

Given the national leadership role of the Centers, two important features will be added. First, the Centers will be used, through joint projects with industry, as testing grounds to incorporate new high performance computer architectures and peripherals into advanced research. New systems will be integrated into the total research computing environment at the Centers. Second, the Centers program will expand training and outreach activities to promote the rapid transfer of knowledge to other advanced research computing centers.

In addition, undergraduate education in the use of advanced computational facilities will be continued, through the support of educational courses at participating universities, training institutes at supercomputer centers, augmentation of the user services function at the centers, and grants of access time for educational purposes and start-up projects.

The following text was prepared by the staff of the Division of Networking and Communications Research and Infrastructure in the directorate of Computer and Information Science and Engineering at the NSF and was submitted to Congress as part of the Administration's Budget Request for the Fiscal Year 1990.

Networking and Communications Research and Infrastructure

$27,130,000

Summary of Request

The FY 1990 Request for the Networking and Communications Research and Infrastructure Subactivity is $27.13 million, an increase of $9.45 million, or 53.5 percent over the FY 1989 Current Plan of $17.68 million.
NSF BACKBONE AND REGIONAL NETWORKS

REGIONAL NETWORKS
NorthwestNet, Boeing Computer Services
BARRNET, Stanford University
Westnet, University of Utah
MIDNET, University of Nebraska at Lincoln

SUPERCOMPUTING CENTER
NSCA (National Center for Supercomputing Applications),
University of Illinois at Urbana-Champaign

REGIONAL NETWORKS PLUS SUPERCOMPUTING CENTERS
SDSCNET, San Diego Supercomputing Center
USAN, National Center for Atmospheric Research
PSCNET, Pittsburgh Supercomputing Center
JVNCNET, Consortium Network,
John von Neumann National Supercomputing Center, Princeton University
NYSERNET, Center for Theory and Simulation in Science and Engineering,
Cornell, University

Figure 4
Scientific Overview

The Networking and Communications Research and Infrastructure Subactivity supports the development and operation of a general purpose computer network for supercomputer access, and fundamental scientific and engineering research on communications theory and network design. The research and network service functions are integrated, creating the mechanism for fast translation of research into practice and driving research toward new problems based on experience. This provides a vehicle for testing research results and a natural opportunity for university/industry collaboration. In addition to stimulating academic research in a highly leveraged way, this approach affords the use of new technology, such as high bandwidth fiber optic communications lines, at low marginal cost.

NSFNET, a network of computer networks, or "internet", was developed to provide access to the NSF Supercomputer Centers for the national computational science community. Its transcontinental "backbone" has been operational for more than two years, and rapid progress is being made to link most of the nation's research campuses. While fulfilling its primary role in supporting supercomputing, NSFNET has also begun to play a larger role, linking researchers to unique resources such as radio telescope arrays and biotechnology databases. Figure 4 shows the NSFNET, the regional networks, and the NSF Supercomputer Centers.

Collaborative development of national and international networking with other federal agencies which operate networks to support scientific research results in effective interaction within the nation's scientific and scholarly community. The NSFNET backbone is the centerpiece of the "internet" composed of connected Federal agency networks.

Although operational and pilot networks are the visible parts of the subactivity, progress depends on an aggressive program of research in communications sciences and engineering. Research, ranging from coding theory to experimentation with innovative electronic media, is closely coordinated with counterpart programs of other Federal agencies. The research often benefits from substantial industrial participation and is positioned to transfer directly into practice, thereby enhancing the Nation's industrial strength.

NSF is leading the interagency implementation of the FCCSET report recommendations on research networking. Cooperating closely with five other agencies to interconnect their cross-country research networks, it has achieved the report's initial goals. NSFNET recently became the first major research network to be upgraded to 1.5 megabit per second speeds. Small steps toward support of the aggressive research and development strategy for advance nets began in FY 1988 and expanded in FY 1989 through joint NSF-DARPA support.

Changes Between FY 1989 Request and FY 1989 Current Plan

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 1989 Request</th>
<th>FY 1989 Current Plan</th>
<th>Change Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSFNET</td>
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<td>$13.63</td>
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<tr>
<td>Networking and Communications Research</td>
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<td>4.05</td>
<td>0.00%</td>
</tr>
<tr>
<td>Total, Subactivity</td>
<td>$17.68</td>
<td>$17.68</td>
<td>0.00%</td>
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</tbody>
</table>

The Subactivity was funded at the FY 1989 Request level of $17.68 million, which is $6.21 million, or 54.1 percent over the FY 1988 level, consistent with Congressional direction. The backbone network and network operations are improved as planned, and interagency initiatives to coordinate research networks are developed as proposed in reports of the Office of Science and Technology Policy and the National Research Council of the National Academy of Sciences.

FY 1990 Budget Request

<table>
<thead>
<tr>
<th>Program Element</th>
<th>FY 1989 Current Plan</th>
<th>FY 1990 Request</th>
<th>Change Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSFNET</td>
<td>$13.63</td>
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<td>Networking and Communications Research</td>
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<td>$27.13</td>
<td>53.5%</td>
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</table>

The Request extends the NSFNET from about 240 to about 400 institutions. The NSFNET will be upgraded to 45 megabit per second speeds, fulfilling the original plan under which it was instituted in FY 1988. In addition, upgrades in equipment will be supported at midlevel networks to take advantage of the higher speeds; overall network operations and information services will be improved; additional nodes will be attached to the backbone; additional international links will be established; and improved library services and national network directory services will be added.

The requested increase for basic research will begin to strengthen the ability of U.S. research institutions and industry to meet the needs of this dynamic area. Initiatives in networking research include high speed networking and interconnection networks, network management, and advanced areas of application such as manufacturing. In the communication and information
theory area, funding for research on data compression and coding and on network security will be increased.

Finally, cooperative projects with NSF disciplines outside of the CISE Activity will be expanded to develop state-of-the-art applications aimed at improving the productivity of scientific and engineering research. Topics include software for computer mediated cooperative work, automated and "intelligent" database technology applications, and remote use of instruments and facilities.

The following text was prepared by the staff of the Division of Advanced Scientific Computing in the directorate of Computer and Information Science and Engineering at the NSF and was submitted to Congress as part of the Administration's Budget Request for the Fiscal Year 1990.

Science and Technology Centers

$20,000,000

Summary of Request
The FY 1990 Budget Request for Science and Technology Centers (STC) is $20.00 million.

<table>
<thead>
<tr>
<th></th>
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<td>Science and Technology Centers</td>
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<td>GEO</td>
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</tr>
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<td>CISE</td>
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</tr>
<tr>
<td>Total, Activity</td>
<td>$0.00</td>
<td>$0.33</td>
<td>$20.00</td>
</tr>
</tbody>
</table>

NSF Role

A primary objective of the Science and Technology Research Centers (STC) Program is to provide mechanisms to exploit opportunities in science and technology where the complexity of the research problems or the resources needed to solve them require the advantages of scale, duration, facilities, or collaborative relationships that can best be provided by campus-based research centers. STCs will also facilitate research projects involving individual investigators, students, and scientists from other sectors that cannot be supported by other mechanisms. In addition, by broadening educational training and opportunities for students, the STCs will increase and improve the Nation’s scientific and engineering human resources.

Centers developed in response to these objectives are expected to:

- Have a unifying intellectual theme, in any field, single or multidisciplinary;
- Have a size and structure that are determined by the science to be performed;
- Be based in academic institutions;
- Have strong educational components;
- Stimulate knowledge transfer;
- Establish linkages to other sectors (government, industry, states, etc.).

The Center model makes possible, in a comprehensive, cohesive manner, support for large equipment and major facilities; stimulates and enhances collaboration among and between science and engineering disciplines; and provides reliable and stable support.

In its solicitation for proposals, the Foundation did not select or target specific fields in advance. Rather, it was left to the scientific community to determine the most important areas which could be advanced through the Center concept. The 11 Centers funded in FY 1989 focus particularly on the physical sciences, biology, and computational science. Substantial investments will be made in superconductivity, parallel computing, and biotechnology. Fundamental cosmological questions will be investigated in one of the new Centers, with technological spinoffs expected to impact many fields where sophisticated detectors are required.

The Centers, many of which are multi-institutional, will carry out multidisciplinary research, conducted by scientists, mathematicians, and engineers. In addition to research, major investments will be made in the education of the next generation of scientists.

A cooperative agreement will be used to support each Center. If the Center maintains a high level of achievement, funding will continue for 11 years. The negotiated cooperative agreements, however, will be limited to five years. To receive funding for the full 11 years, the Center must demonstrate success and achievements at major reviews scheduled for years 3 and 6. If the Centers cannot demonstrate major achievement during these reviews, NSF support will be phased out.

The STCs in computer and computational science are described below:

- Rutgers University-Center for Discrete Mathematics and Theoretical Computer Science
- This Center will involve the participation of Princeton University, AT&T Bell Laboratories and Bell Communications Research. Mathematicians and theoretical computer scientists will not only have an environment where they can share findings to advance their own disciplines, but where they may ultimately contribute to progress in telecommunications, transportation, computer design and manufacture, and cryptography. Interrelated, focused "special year" topics will involve renowned visiting scientists and mathematicians in residence at the Center.
• Rice University-Center for Research on Parallel Computation

Researchers at Rice University, the California Institute of Technology, Argonne National Laboratory, and Los Alamos National Laboratory will use their expertise to attack the problem of parallel computation across a broad variety of fronts to make parallel computers easier to use. These areas range from computer architecture and operating/programming systems, through computational mathematics and the scientific applications which require high performance computing. While advanced supercomputing power is vital to long term economic welfare and security, higher performance now depends on the further development of parallel processing.

• University of Oklahoma-Center for Analysis and Prediction of Storms

University of Oklahoma and National Oceanic and Atmospheric Administration scientists will together create better mathematical models for predicting tornadoes, flash floods and severe thunderstorms. Although weather prediction has advanced rapidly, a gap remains in the scientific understanding of weather phenomena that arise on a regional scale too small to be accounted for by current techniques. Through use of new ground-based radar, advanced numerical methods, and supercomputers, modelers will develop and test new techniques to explain these “mesoscale” phenomena which give rise to damaging storms.

Changes Between FY 1989 Request and FY 1989 Current Plan

<table>
<thead>
<tr>
<th>(Millions of Dollars)</th>
<th>FY 1989 Request</th>
<th>FY 1989 Current Plan</th>
<th>Change Percent</th>
</tr>
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<tr>
<td>MPS</td>
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</tr>
<tr>
<td>BBS</td>
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</tr>
<tr>
<td>GEO</td>
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<td>N/A</td>
</tr>
<tr>
<td>CISE</td>
<td>N/A</td>
<td>(5.93)</td>
<td>N/A</td>
</tr>
</tbody>
</table>

*Annualized.

The FY 1989 Current Plan was established at $25 million. The FY 1989 Budget Request sought $150 million for up-front funding of the program for five years, or an annual rate of $30 million per year. The FY 1989 Current Plan, then, represents a decrease of $5 million, or 16.7 percent, from the annualized FY 1989 Budget Request, representing the Program’s share of an unspecified Congressional budget reduction. This $25 million will fund 11 new Science and Technology Centers and nine planning grants.

Because no areas of science were pre-selected to receive awards, it was not possible to attribute STC awards to the appropriate NSF Activity until awards were announced in December 1988. The STC award funds have been reprogrammed from the STC Activity to the Activities indicated. The remaining $0.33 million remains in the STC Activity and will be used for planning grants.

FY 1990 Budget Request

<table>
<thead>
<tr>
<th>FY 1989 Current Plan</th>
<th>FY 1990 Request</th>
<th>Change Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science and Technology Centers</td>
<td>$0.33</td>
<td>$20.00</td>
</tr>
</tbody>
</table>

The first STC competition clearly demonstrated that many more areas of excellent multidisciplinary, multi-institutional research would benefit from the center mode than could be funded. Over 300 proposals were submitted nationwide. Of these, the 48 most promising received on-site visits and reviews. While 11 centers were selected for funding, a significant number of highly meritorious proposals could not be funded.

Active support for the center concept is shown not only by the number of excellent proposals received, but by the significant private sector and state government contributions made to the centers selected for funding.

A second competition will enable the center mode of research to be expanded to, and thus have a major positive impact on, additional areas of science and engineering research and education. Therefore, $20 million is requested in FY 1990 to support eight to ten new Science and Technology Centers.

Changes in Budget Structure

FY 1989 and FY 1990 support for the 11 STCs awarded in FY 1989 was reprogrammed to the activity which has oversight for each STC. Support for eight to ten STCs to be awarded in FY 1990 remains in the STC Activity, and will be similarly reassigned to the appropriate activity(ies) at award time.
The following text was prepared by the staff of the directorate of Science and Engineering Education at the NSF and was submitted to Congress as part of the Administration's Budget Request for the Fiscal Year 1990.

Science and Engineering Education
$190,000,000

Summary of Request

The FY 1990 Request for the Science and Engineering Education (SEE) Activity is $190.00 million, an increase of $18.96 million, or 11.1 percent, over the FY 1989 Current Plan of $171.04 million.

(NSF Budget Request for 1990)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Teacher Preparation and Enhancement</td>
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<tr>
<td>Research Career Development</td>
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<tr>
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<td>$171.04</td>
<td>$190.00</td>
</tr>
</tbody>
</table>

NSF Role

The responsibility of the Science and Engineering Education (SEE) Activity is to define and fund programs and projects that support the educational aspects of the Foundation’s mission. SEE also plays a major role developing human resources for science and engineering. The magnitude of the educational effort in the United States and the long lead times needed for new programs, materials, and methods require a continuing and significant involvement in this area. Sustaining this level of commitment, visibility, and continuity is responsive to the national concern with science, mathematics, and engineering education and will draw the best, most creative people into the process.

SEE fulfills this responsibility by conducting leadership activities that inform and stimulate other sectors, and by supporting original work and other merit-based, high-leverage activities that serve as prototypes and models of excellence for the Nation. A major objective is to encourage appropriate cooperation among academic scientists, engineers, educators and the private sector for intellectual partnerships as well as for leveraging funds.

The National Science Foundation is active at all levels of education—precollege, undergraduate, graduate, and postgraduate; SEE serves as the focal point for education at NSF. In this role SEE manages the programs for which it has sole budgetary responsibility, and serves in a coordinating and facilitating capacity for other administrative units throughout the Foundation.

The role of SEE is to help insure that:

- a high-quality precollege education in science and mathematics is available to every child in the United States, sufficient to enable those who are interested and talented to pursue technical careers, especially in science and engineering, as well as to provide a base for understanding by all citizens. While other NSF programs provide apprenticeship training for the next generation of scientists and engineers through research support, SEE’s efforts (in addition to graduate and postdoctoral fellowships) concentrate on teachers, students, laboratories, and classroom resources;

- opportunities are available at the college level for interested nonspecialists to broaden their science, mathematics, and technical perspective and understanding to familiarize them with the principles, practices, techniques, and limits of science;

- informal science education programs are available to maintain public awareness of and interest in scientific and technological developments affecting their lives; and

- the educational pipelines leading to careers in science, engineering, and mathematics yield sufficient numbers of well-educated individuals to meet the needs of the U.S. technical workforce. Increasing the participation in such careers of minorities, women, and the disabled receives special attention at all educational levels.

Several SEE programs have specific requirements for cost sharing and other forms of funds leveraging. Data for FY 1988 demonstrate that precollege teacher enhancement and teacher preparation projects generate non-NSF funds equal to one-half of NSF funds invested, while projects in instructional materials development and informal science education generate external funding equal to twice the amount of the NSF awards. At the undergraduate level, there is a 1:1 matching requirement for equipment purchases.

SEE coordinates its activities closely with other relevant areas of NSF and with other agencies, e.g. NASA, the Department of Energy and the Department of Education (DoEd). Such coordination is intended to promote maximum use of expertise in the agencies, to minimize program overlap, and to optimize the use of limited Federal resources. Within the Foundation, the undergraduate instrumentation support is an example of an integrated management effort led by the SEE Activity and involving all of the Research Directorates. Externally, NSF and DoEd have collaborated in supporting a number of projects, including the International Study of Mathematics, and mathematics and science television series such as “3-2-1 Contact,” “The Voyage of the...
Mimi," and "Square One-TV." Other collaborative efforts have included support to the television series "Reading Rainbow" and to PBS's American Playhouse for the semi-documentary film "Stand and Deliver," based upon the outstanding successes of educator Jaime Escalante in teaching calculus at a minority high school in the Los Angeles area.

### Changes Between FY 1989 Request and FY 1989 Current Plan

<table>
<thead>
<tr>
<th>Subactivity</th>
<th>FY 1989 Request</th>
<th>FY 1989 Current Plan</th>
<th>Change Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Preparation and Enhancement</td>
<td>$53.50</td>
<td>$63.52</td>
<td>18.7%</td>
</tr>
<tr>
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<tr>
<td>Total, Activity</td>
<td>$156.00</td>
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</table>

The FY 1989 Current Plan is $15.04 million more than the FY 1989 Request of $156.00 million, and $31.41 million more than FY 1988, a 22.5 percent increase. The distribution of the increases, as specified by Congress, is: precollege --$10.52 million [Teacher Preparation and Enhancement $10.02 million; Materials Development, Research, and Informal Science Education $0.50 million]; undergraduate --$4.50 million [Undergraduate Science, Engineering, and Mathematics Education, College Science Instrumentation].

Across the Activity in FY 1989:

- precollege programs total $119.02 million ($28.81 million more than FY 1988, a 31.9 percent increase);
- undergraduate programs total $28.00 million ($8.97 million more than FY 1988, a 47.1 percent increase); and
- graduate programs total $24.02 million ($6.37 million less than FY 1988, a 21.0 percent decrease), reflecting the first transition year in the Fellowship Management Plan.

The increases will be used at the precollege level primarily for teacher enhancement projects and instructional materials development; and at the college level for the College Science Instrumentation program, the SEE component of the NSF-wide instrumentation and laboratory improvement program.

**FY 1990 Budget Request**

<table>
<thead>
<tr>
<th>Subactivity</th>
<th>FY 1989 Current Plan</th>
<th>FY 1990 Request</th>
<th>Change Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Preparation and Enhancement</td>
<td>$63.52</td>
<td>$68.50</td>
<td>7.8%</td>
</tr>
<tr>
<td>Materials Development, Research, and Informal Science Education</td>
<td>44.00</td>
<td>49.00</td>
<td>11.4</td>
</tr>
<tr>
<td>Undergraduate Science, Engineering, and Mathematics Education</td>
<td>28.00</td>
<td>30.00</td>
<td>7.1</td>
</tr>
<tr>
<td>Research Career Development</td>
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<td>38.00</td>
<td>22.5</td>
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<tr>
<td>Studies and Program Assessment</td>
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</tr>
<tr>
<td>Total, Activity</td>
<td>$171.04</td>
<td>$190.00</td>
<td>11.1%</td>
</tr>
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</table>

The Teacher Preparation and Enhancement Subactivity ($68.50 million) will continue to focus on improvement of precollege science and mathematics education through effective preservice and inservice teacher training. In FY 1990, emphasis will be placed on expansion of the projects to help teachers use technology more effectively in the classroom, and on the inservice teacher enhancement programs directed at inner-city school districts with large minority populations. In addition, the teacher recognition program, Presidential Awards for Excellence in Science and Mathematics Teaching, will be expanded to include elementary level teachers.

The Materials Development, Research, and Informal Science Education Subactivity ($49.00 million) will continue to focus on the need for a consistent pattern of elementary and secondary school science and mathematics instruction, fundamental knowledge about the learning and teaching process, and a rich and well-integrated informal learning environment. Special emphasis will be placed on efforts to develop and demonstrate the use of modern technologies to address these problems. A major effort will be initiated in FY 1990 to develop improved instructional materials for science in the secondary schools.

The Undergraduate Science, Engineering, and Mathematics Education Subactivity ($30.00 million) will continue to emphasize instrumentation-based strengthening of teaching laboratories at undergraduate institutions. Comprehensive regional centers for minorities and other model collegiate programs to stimulate the participation of women, minority, and disabled students in curricula leading to science careers will be increased substantially. Efforts to enhance the currency of undergraduate faculty and to improve the undergraduate curricula in calculus and engineering will continue.

The Research Career Development Subactivity ($38.00 million) will continue its current activities. The number of new three-year graduate fellowships will be increased to 960, continuing the expansion of this effort from its level of 560 new fellowships in FY 1987. Included
in this number will be a specially-focused "Women in Engineering" fellowship offering, which is intended to attract more women into the Nation's engineering faculty. The funding will also permit the continuation of the Young Scholars Program for talented high school and middle school students who may be candidates for careers in mathematics, engineering, and the sciences. The amount requested for this Subactivity in FY 1990 reflects the second step in an administrative adjustment in the funding schedule for the Graduate Fellowships and Minority Graduate Fellowships Programs. The Studies and Program Assessment Subactivity ($4.50 million) will continue its studies of national and international trends relevant to science education, the collection and analysis of data on science and engineering education issues, and the support of related policy studies. Efforts to assess the results of NSF education programming will be expanded.

### Summary by Educational Level

The allocations to programming at the various educational levels of FY 1989 appropriations and the funds requested for FY 1990 are shown in the following table.

<table>
<thead>
<tr>
<th>Education Level</th>
<th>FY 1989 Current Plan</th>
<th>FY 1990 Request</th>
<th>Change Percent</th>
</tr>
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<tr>
<td>Pre-college</td>
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<tr>
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<td>29.1%</td>
</tr>
<tr>
<td>Total, Activity</td>
<td>$171.04</td>
<td>$190.00</td>
<td>11.1%</td>
</tr>
</tbody>
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**NOMINATIONS FOR THE 1990 WIENER PRIZE**

This prize of $4000, in honor of Norbert Wiener, is normally awarded every five years by the American Mathematical Society and the Society for Industrial and Applied Mathematics for an outstanding contribution to applied mathematics in the highest and broadest sense. The recipient must be a member of one of these societies and a resident of the U.S., Canada, or Mexico.

Nominations and suggestions by members of the mathematics community are eagerly sought. Please send them (hopefully with supporting documentation) to each of the following three people: I. M. Singer, Mathematics Department, Massachusetts Institute of Technology; E. H. Lieb, Mathematics Department, Princeton University; S. Smale, Mathematics Department, University of California, Berkeley.

The letters should arrive by August 15, 1989.
Richard S. Nicholson has been Assistant Director for Mathematical and Physical Sciences (MPS) at the National Science Foundation (NSF) since 1985. This month, he will become Executive Officer of the American Association for the Advancement of Science (AAAS). Nicholson, who has been a strong supporter of mathematics throughout his tenure as Assistant Director, was interviewed by Notices Staff Writer Allyn Jackson.

Notices: At the NSF, mathematics has been favored in recent years—the current budget request asks for a 15% increase for mathematics. You have been very supportive of the increases, so obviously the mathematics community will watch very closely who will take your place. At the same time, some areas in your directorate have received only very small increases. Are the other areas getting jealous? How do you explain to them your strong support of mathematics?

Nicholson: I wouldn’t say I detect jealousy because I think, by and large, the physical scientists understand what an underpinning math is for the sciences. And it’s probably more true and more understood in the physical sciences than in any other sciences. Anybody who looks at the level of support in math can see it has been really out of balance with the level of support in other areas. I think all the areas are underfunded by a substantial amount in the physical sciences, but math is even worse off than the others. By and large, I’ve not detected what you call jealousy just because physical scientists understand the importance of mathematics and realize that when math grants are half the size of grants in other areas, that’s probably not right.

But I will say it’s not an easy decision to make when everything is underfunded and the whole budget hasn’t increased much. That’s certainly made it a lot harder to try to single out mathematics, no doubt about that. The NSF budget and the MPS budget hasn’t really grown much in about four years, so that’s made it harder to single out one area and give it more than cost-of-living increases at, you could say, the expense of the others.

But I think I and the NSF became really persuaded by the David Report.

Big Science vs. Little Science

Notices: Many people have been talking about “big science” and “little science” lately. Math is generally considered to be “little science.” How does somebody in your position make choices between a big $10 million piece of machinery and $10 million in individual grants? Obviously, a big piece of machinery is visible, it looks like an accomplishment, whereas individual grants are so much more dispersed that often they seem invisible.
Nicholson: It's not easy to do that, because it's a very complex thing. You're trading off different things. In my own case, I come from a background in chemistry, which is a “small" science that depends on fairly large numbers of relatively small grants. I was a chemist myself who had some of those grants before I came to NSF, so I think I appreciate and understand, as well as anybody who could occupy this job, the importance of that way of supporting research. On the other hand, when you're in this job, you find that there are fields of science that you simply cannot do if you don't have a large facility.

So it's a difficult thing to make that tradeoff, and I think it's especially important that they don't perceive that they need some big project to get attention and support. That's one of the things I work against because I don't want to see chemists or mathematicians—basically all small sciences—thinking the only way they can get more money or get more attention is to come up with some glitzy thing that they may not really need.

Facilities should not be seen as a way to add on to a budget. The policy at NSF right now is that, to the greatest extent possible, new facilities and new initiatives should be funded within the disciplinary divisions. The reason for that is they're trying to force some tradeoffs within a discipline. We've got a lot of examples of that. The big radio telescope we're building, called the Very Long Baseline Array, has 10 antennas spread across the whole continent. That's being funded out of astronomy, and astronomers will tell you that it's hurting them.

It wasn't an add-on to their budget. Their support for present facilities and individual investigator grants have been hurt as a result of that. I think that's a good policy, actually, because it's one where NSF's willing to do it when the justification is there, but I don't think it provides any incentive for people to just come up with ideas that cost a lot.

It's not a simple question. You've got to look at everything case-by-case and understand what the whole context is, what the whole national program is.

Update of David Report

Notices: You mentioned earlier the David Report, and I know you're familiar with the report's recommendations. Right now the Board on Mathematical Sciences at the National Research Council is planning to do an update of the David Report. As an NSF administrator, what kind of issues would you like to see the update address?

Nicholson: I think it should have some of the same things the David Report had, to provide a report card, so to speak, on what's happened. My expectation is that you'll find that we've made progress. I think that, of all the reports that have come out, that one clearly made a difference. And we surely get lots of reports all the time—opportunities in physics, opportunities in chemistry, and we've got one on materials research right now.

I think it should also have some discussion that's more traditional in such reports, about the intellectual opportunities in the field, and maybe on the international dimension. I think the David Report focused more on the infrastructure problems, which was correct, that was the right thing to focus on. But I think now it's fairly broadly understood what that problem is, and people are committed to trying to do something about it. I think we need to go to the next step and look at what the intellectual opportunities are, look at some of these ideas about connections to other disciplines, like biology and so on, and identify some of those kinds of opportunities.

We really need to keep the momentum alive on the David Report. You can only go so far by saying we don't support enough graduate students. Unfortunately, policymakers in this town have a short attention span. You start getting the reaction, “The David Report? I thought that was all taken care of.”

Prospects for Math Funding

Notices: What do you see as the prospects for math funding at the NSF? Do you see the increases as continuing?

Nicholson: It's hard to project because it depends on a lot of things I don't know. It depends on the person who sits here and what their values are and what they think is important. I think that by having math as part of the physical sciences at NSF, it's in a context where people understand the importance of mathematics. I think I'm optimistic. But I think it's going to take some diligence on the part of the community to continue to make their case. You've just got to keep doing that all the time. You can't relax. Sometimes people give you a report or something and then think, well, now that's all taken care of. But it's a constant battle.

The environment overall is going to be very difficult in the next four years, in my opinion. Interest on the national debt is huge now. It's the third largest thing in the federal budget after defense and social programs. We've spent $150 billion just paying the interest. The NSF is in the HUD [Housing and Urban Development]-Independent Agencies committees [in the House and Senate], and those committees have had a lot of budget pressure in the last 10 years. In fact, that budget has declined something like 23%, I think, in real dollars. Despite that, the NSF's grown by 100% over that same period. And the money has come from HUD, mostly. It's pretty hard for me to see that that's going to continue to be the pattern, that this Administration and the American people are going to be willing to reduce money for housing and urban development.
Richard S. Nicholson Moves to AAAS

[Edward P.] Boland [D-MA] in the House was chair­man of that committee basically since NSF was created. So we were dealing with a person who knew us very well, we knew very well. We didn’t always agree on everything, but there was an amazing level of understanding about what was going on. Now we’ve got a new person, [Robert Traxler, D-MI]. And in the Senate committee we’ve got a new person, Senator [Barbara] Mikulski [D-MD]. She clearly has a different way of looking at things [than Senator William Proxmire, D-WI, her predecessor].

So you put all that together, and I think it’s going to be tough. And I’m talking about the whole NSF, in which mathematics has a part of that total. Clearly, for a given discipline, it’s a lot easier if the total is growing. It’s sure easier to give one area an increase if it’s not “coming out of somebody else.” If it’s perceived as coming out of someplace else, that makes it very difficult, when a lot of those other places have a lot of their own excitement and opportunities and are underfunded.

We do have a good record of convincing the Executive Branch of increasing the NSF budget. You can go back to the time of President Ford, and NSF has always had good budgets going in, and very seldom has it ever gotten the President’s budget out of the Congress. It’s convincing Congress. One of the frustrations is that nobody’s opposed to increasing science. It’s when it gets down to deciding, now, where do we get the money to do this? We want to help veterans, to help the farmers. It’s at that level that support starts dissipating.

Serving in Washington

Notices: In the mathematical community, serving in Washington is seen as a drain on research time. People often think that when their colleagues go to Washington, they’re leaving research, their research ideas have dried up and they have to try to do something else. The Division of Mathematical Sciences has always been able to put together a very good staff, but it is always difficult for them to find good people. Is this attitude prevalent in other MPS disciplines?

Nicholson: It’s prevalent, and it’s true in all areas. It’s a built-in conflict: we want people who are active in research, and people who are active in research believe that coming here will harm their research. The people you want are not sitting out there, reading ads in magazines, saying, gee, I think I’d like to go to the NSF for a year. You’ve got to find them and somehow convince them that that’s what they should really do.

I’ll tell you, I have exit interviews with all the people who leave, and I’ve yet to meet someone who hasn’t said they were really glad they did it. It ranges from people who are anxious to get back to what they were doing, to some people who stay. Sometimes, as a result of being at the NSF for a year or two and being responsible for a broader range of subject matter than they are when they’re doing their own research, people get a different perspective on their field and sometimes change directions in their research as a result of ideas they got or things they saw and learned about while they were here.

I recruited 4 out of 5 division directors while I was here. It’s very hard to find people of the caliber you want who are even willing to consider it enough to come and have an interview. I think the scientific community in this country is really making a mistake when it has this attitude. Especially with the division directors, who oversee whole disciplines, we’ve got to have people with a fair amount of experience. But experience usually means they’re entrenched in something else, they make more than the government can pay, and they don’t want to do it.

Notices: Some have mentioned incentives to get people to come to the NSF—for example, if the universities would be willing to give the person a semester or a year off after service at the NSF, so that they can restart their research. Some would even go so far as to say that people who come back from the NSF should get an automatic one-year research grant to get them started again. What do you think of those kinds of incentives? Do you have other ideas?

Nicholson: We’ve been talking about the second possibility here. Eventually a lot of those things run into legal problems and problems of conflict of interest. And Washington is so sensitive to perceived conflict of interest problems and favoritism and things like that.

The universities, on the other hand, have a lot more flexibility in what they could do. But it’s not so clear to me that the top policy level people in the universities appreciate or accept the idea that it’s a very important thing for the faculty to do. They need to see the value to the country, if not to their own institution, to try to have good people at a place like NSF.

Notices: I think that’s particularly true in math, because mathematicians on campuses are seen as the teachers of hordes of calculus students.

Nicholson: Yeah, if that person’s gone it’s just a problem they have to solve, and to provide an incentive to encourage more people to do it is probably counterintuitive. It’s increasingly appreciated here that one of the keys to the future of this organization is to be able to attract people from the outside, and it’s getting harder and harder.

Math and AAAS

Notices: I’d like to ask you about AAAS too. AAAS, and especially Science magazine, seems very heavily focused
in the biomedical sciences. In the last few years, there have been efforts in the mathematical community to participate more in the AAAS meetings. Now Science has a very good freelance writer, Barry Cipra, who’s been writing about mathematics. But I was wondering what other ways you think mathematicians might be able to contribute to AAAS and how they can participate more in AAAS activities.

Nicholson: Well, I’m not going to have any clever answers to that, because I don’t know enough about it yet. But I will say that I think it’s important. I have gotten very informally a confirmation of what you say. One of the first congratulatory things I got was an email message from John Polking, who said what you said about the coverage of mathematics, and that he and other leaders in the community were eager to try to improve the participation of mathematics. As for Science magazine, there are just long, cultural traditions. To a biologist, you put your most important paper in Nature or Science. A chemist doesn’t. For a physicist, it’s Physics Review Letters, if it’s good. That’s a hard thing to change.

I’d like to see scientists and mathematicians view the AAAS as a forum for conveying to their colleagues in other areas some of the intellectual excitement in their area. There’s a great need for more cross-fertilization and for the sciences themselves to have a better appreciation of what’s going on in other areas. The AAAS, because it’s very interdisciplinary, should be perceived as a place where the sciences “display their wares,” so to speak. Not for themselves, because they have their own professional meetings, but as a way of communicating to the other sciences. And I think mathematicians need to do that. Even scientists who have a lot of faith in the importance of mathematics don’t really understand that it isn’t already all done. Let’s face it, other fields think that there’s nothing new in mathematics, it’s already done. I think that’s even true among physical sciences, actually.

Project 2061

Nicholson: I don’t know enough details yet to agree or disagree with that. I think the motivation and goals of the project are correct, to use a systems approach to it, and to get people to agree that it’s a long-term problem. I really think that one of the problems in the U.S. is that we are such a “quick-fix” country. We’re impatient, we live for today, and the education problem is not amenable to that approach. It’s going to take congressmen and policy leaders and superintendents and parents and everybody to accept it and approach it that way.

My understanding is the next phase, after this first report, is to go out into some individual school districts and, over a 4 or 5 year time period, to get teachers and administrators and local politicians to develop their own implementations of the stuff that comes out of this report. You’ve got to involve teachers. If the teachers don’t have some ownership of it, they won’t be committed. The whole point of the second phase is to involve people at a local level to do things that fit their own local environment and needs and not try to say there’s one approach that’s good for the country.

I’ve always felt that mathematics, because it’s hierarchical in the lower grades, is really more important than the other sciences. You could take no chemistry in high school and become a chemistry major in college if you’ve had the math. If you haven’t had the math, you can’t. So I’ve always felt that having people take math right up through high school is more important than taking other sciences. Probably a dangerous thing to say!

Nicholson: Well, I think other scientists would agree. Project 2061 is correct in that it’s long term. Training is not subject to a quick fix. You could spend the whole trillion dollars and you can’t make someone who’s not a physicist into a physicist in a year. It’s a long process, many, many years in becoming a scientist. And any kind of disruption, it’s gone forever. A person who gets frustrated and drops out, they’re gone forever.

Notices:

Notices: Soon AAAS’s Project 2061 will be coming out with a report that lays out what students should know about math and science when they leave high school. Some have criticized Project 2061, saying that they did not involve teachers from the start in the project. Also, in mathematics, people have said that Project 2061 has relegated mathematics to the role of a servant of science. Can you comment on this?
That mathematics education in this country is in a crisis is a view commonly held by a diverse group: teachers, school administrators, parents, the government, business and industry, and academic scientists and mathematicians. Consider the latest batch of dire statistics prepared by the Educational Testing Service. According to that report, American 13-year-olds ranked dead last on a standardized test of mathematics achievement given in 12 countries and Canadian provinces. An example: only 9% of American students could find the radius of a circle inscribed in a square with side of length 6, compared to 40% of the Korean students.

Unfortunately, a common reaction to such reports has been to impose greater doses of standardized testing and to require more from the same limited menu of mathematical fare. But now, the National Council of Teachers of Mathematics (NCTM) is seeking more fundamental changes. Last month, the NCTM released *Curriculum and Evaluation Standards for School Mathematics*, which lays out criteria for judging mathematics curricula and evaluation tools. The Standards were formulated over a three-year period by four grade-level panels and an oversight commission. These groups, totalling about 35 individuals, consisted of mathematicians and mathematics educators from academia, classroom teachers, state mathematics coordinators, and others having expertise in mathematics education. Last January, upon the recommendation of an AMS *ad hoc* committee formed to study this massive 300-page document, the AMS Council passed a motion stating the Society "supports and endorses the vision of school mathematics contained in the Standards." (See the report of the Council meeting, *Notices*, March 1989, page 323, for the text of the endorsement.)

While not a radical or groundbreaking departure from existing curricula, the Standards apply current views of mathematics teaching and learning to the entire K-12 curriculum. The Standards embody a more modern vision of how much and what kind of mathematics today's students will need to know in an increasingly mathematical and technological world. As the document puts it, "Businesses no longer seek workers with strong backs, clever hands, and 'shopkeeper' arithmetic skills."

**Not a Curriculum**

The Standards are not in themselves a mathematics curriculum, nor do they endorse any particular curriculum. Rather, they provide criteria for judging mathematics curricula and can be used as a curriculum framework. "The Standards provide people with a target for reasonable, achievable change over 5–10 years without wild changes in resources," says John Dossey, professor of mathematics education at Illinois State University and a member of the Standards commission. "The document establishes goals and points to various ways to achieve those goals." However, it is not merely a vague statement of an educational philosophy; the document is full of examples of problems and exercises illustrating the educational goals the Standards espouse.

The philosophical approach of the Standards emphasizes conceptual understanding over the traditional focus on execution of computational skills. Rote learning and paper-and-pencil drill should be downplayed and problem-solving should be stressed, the Standards advocate. "It would be hard for a basketball coach to get players to practice free throws if they never get to play a game," says Thomas A. Romberg, professor of mathematics education at the University of Wisconsin at Madison and chair of the Standards commission. "In mathematics, solving problems is what the game is all about."

**Use of Technology**

The Standards also call for the use of calculators and computers starting in the primary grades, taking the view that technology is not just a desirable teaching tool, but a necessity. Students should still learn to compute by hand, but should also be able to choose the most appropriate tool to solve a given problem and should develop greater estimation skills. A recent report by the congressional Office of Technology Assessment found
that virtually every school in the country now has at least one computer, but that technology is still far from becoming a standard classroom feature. In addition, Romberg says that many schools still have inadequate resources for computing. “But if science classes have labs, home ec classes have their facilities, and shop classes have theirs, why shouldn’t mathematics classes have computers?” he asks.

One important aspect of the Standards is that they examine the K-12 curriculum as a whole, so that important lines of mathematical development are systematically treated throughout the precollege years. Such broad topic areas as geometry, statistics, probability, and measurement appear in the curricular recommendations at each grade level. At the high school level, the Standards advocate introducing elements of discrete mathematics and calculus. This approach allows for curricula to break out of the traditional secondary mold of “algebra 1, algebra 2, geometry, precalculus.” “The emphasis on a broad range of mathematics is one of the Standards’ greatest strengths,” says Lynn Arthur Steen, professor of mathematics at St. Olaf College and a member of the Standards commission.

Communicating Mathematically

Being able to communicate mathematically and to work collaboratively on problems are goals advocated by the Standards. Though specific teaching strategies are not spelled out, the Standards do take the view that students should be more active learners, so that mathematics is seen as an activity people engage in rather than a set of rules to be absorbed. Students should also learn the value and utility of mathematics and understand its role in our culture and society. Another goal is promoting the growth of the students’ self-confidence in mathematics and of their capacity to judge their own mathematical knowledge and ability.

One section on Evaluation Standards outlines different methods of evaluation to correlate with the new goals the Curricular Standards set forth. The usual written examinations and standardized tests are inadequate for measuring the conceptual and reasoning abilities the Standards are pushing for. Rightly or wrongly, tests influence the curriculum, for, as the Standards put it, “tests are one way of communicating what is important for students to know. In this way, tests can be used to implement change.” For example, most standardized tests do not provide for the use of calculators, and until they do, many teachers will continue to prohibit the use of calculators in the classroom. “We’re not going to get rid of the tests,” says Romberg. “You can’t just decry the tests, you have to propose an alternative.” He says that “multidimensional” testing strategies—such as questions requiring written answers rather than filling in blanks, oral examinations, and the use of calculators and manipulatives—can provide better information about students’ abilities.

Broad Support for Standards

The Standards have garnered a positive response from many quarters. “One of the most striking things about the Standards is the enormous prestige they already have,” says Dick Stanley, a mathematician doing high school curricular work in U.C. Berkeley’s Professional Development Program. “Typically the Standards are viewed as a high quality product, a very impressive and useful output of a professional organization. There is a lot of hope and a lot of high expectations that the Standards will have a great beneficial effect on mathematics education.” “I think it’s a strong, forward-looking statement about mathematics education,” says Steen. “It articulates important areas of emphasis and it deals with assessment, which is a very important issue.”

The AMS ad hoc committee formed to review the Standards also had a generally positive response. “I endorse the broad, sweeping change the Standards emphasize, the use of technology, the emphasis on problem-solving and higher-order thinking,” says Harvey Keynes, professor of mathematics at the University of Minnesota. “The principles behind the Standards are excellent.” Keynes and some of the other committee members acknowledged that they had reservations about certain details in the Standards, but all felt that, overall, the document recommends changes that would help to improve mathematics curricula and instruction.

William P. Thurston, professor of mathematics at Princeton University, was also on the AMS committee. “The Standards emphasize ways of getting the students to think for themselves about the material and not just recite formulas,” he says. “They have a lot more mathematical content than current curricula and many good examples of problems.” However, Thurston wonders if the Standards are too ambitious. “The question is turning from some abstract list of ideas to reality. How can mathematics education really be changed in all the little, local school districts around the country?”

Edward A. Connors, professor of mathematics at the University of Massachusetts at Amherst and chairman of the AMS committee, says that while he supports the Standards as a whole, “I think they’re doing things backwards. Before they do curriculum reform, they need to strengthen the teaching corps.” He also questioned the Standards’ recommendation of requiring 3 years of high school mathematics for all students. “I’m skeptical of that,” he says. “It means high schools will need to teach more mathematics, but the principals and administrators, the powers-that-be, won’t necessarily be able to provide the additional staff to cover it. That means increased class
size and increased teaching loads." As a result, courses meant to serve the mathematically gifted may be cut to accommodate the greater numbers of students. "Overall, the quality of the courses and the enrichment courses, those that we depend on for prospective mathematics majors, may suffer." Still, he believes that the basic thrust of the Standards is positive. "If we continue to do things the way we’re doing them, we’re going down the tubes," he says. "I’m not convinced the Standards are the way to go, but it’s much better than what we’re doing now."

"It’s a fairly conservative document," says Paul J. Sally, professor of mathematics at the University of Chicago. "It’s not a document that’s going to change things radically," he says. "It’s least helpful at the K-3 level, where we need a lot of innovation." However, Sally believes that the national visibility of the Standards could influence publishers to make improvements in mathematics textbooks. Overall, he sees the Standards as positive. "This is the most prestigious document to come out of the NCTM in a long time," he notes. "They show that there is some sort of united front in school mathematics."

A Common Core Curriculum

Steen says that he believes that the aspect of the Standards that has been most controversial among mathematicians is the recommendation of a common core curriculum for all students at the secondary level. He says that many scientists and mathematicians believe that "tracking" students is the best way to identify and encourage talented students. But Steen says this practice cuts off a large number of students who may have talent that goes unnoticed in the traditional mathematics class. "The Standards are not saying that all students should be taught the same way at the same time," he notes, but there are many different ways and levels at which important core ideas can be taught. "We just don’t want to say that in the seventh grade, half the students won’t ever see anything more than ‘general math.’ All students should progress through a set of general goals for mathematics education."

The idea of equity in educational opportunity is laudable, but are all students capable of learning what the Standards recommend? "It is ambitious," says Romberg. "However, most of the ideas in the Standards are things that other countries are already doing. Also, research indicates that we don’t expect as much of our students as do other countries. We spend so much time on review and calculation." If the excessive emphasis on drill and repetition is decreased, says Romberg, teachers will have time to include the new topics the Standards recommend and to develop a more sophisticated understanding in the students.

It is clear that, even given their generally favorable reception, a great deal of work needs to be done before the Standards can be implemented. A section of the Standards entitled "Next Steps" outlines measures that need to be taken to insure implementation of the Standards: development of curricula, textbooks, and testing tools; teacher inservice retraining and education of future teachers; integration of technology into curricula; improvements in working conditions for teachers; the need for further educational research, etc. The steps are not described in detail, nor is any timetable provided; however, the NCTM is assembling various committees and task forces to investigate ways to implement the Standards.

One of Several Reports This Year

The NCTM Standards is just one of several important documents on mathematics education to come out this year. "Everybody Counts," the Report to the Nation from the Mathematical Sciences Education Board (MSEB) of the National Research Council, examines mathematics education from kindergarten through college and sets an agenda for reform over the next decade (see the summary of "Everybody Counts," Notices, March 1989, page 227). The American Association for the Advancement of Science released last month the first report, "Science for All Americans," in its Project 2061, which proposes fundamental changes in the content of school mathematics and science courses (see News and Announcements in this issue of Notices). And later this year the MSEB will release its report on the "strands" of mathematical thinking that should run through all levels of mathematics education. The MSEB has also designated 1990 as the "Year of National Dialogue" about mathematics education in the U.S.

The text of the Council's endorsement of the Standards calls for the "active involvement by AMS members in joining with local groups to work for the betterment of school mathematics." Many of the AMS committee members believe that mathematicians need to be more informed about and involved in education. "We've abdicated our responsibility in teacher training and mathematics education," says Connors. "But I'm an optimist. I believe we can improve things, and I'm glad research mathematicians are paying attention to the Standards."

Copies of the NCTM Standards are available for $25 prepaid for non-NCTM members. Write to: NCTM, Attention: Billing and Order, 1906 Association Drive, Reston, VA 22091; telephone 703-620-9840. Mastercard and Visa orders accepted. Virginia residents add 4.5% sales tax.

Allyn Jackson
Staff Writer
Annual AMS-MAA Survey


Doctoral Degrees Conferred 1987–1988
(Supplementary List)

The following list supplements the list of thesis titles published in the November 1988 issue of Notices. The numbers in parentheses following the names of universities have the following meanings: the first number is the number of degrees listed for that university; the next seven numbers are the number of degrees in the categories of 1. Pure mathematics (i.e., algebra, number theory, analysis, functional analysis, geometry, topology, logic or probability); 2. Statistics; 3. Computer science; 4. Operations research; 5. Applied mathematics; 6. Discrete mathematics; 7. Other.

ARIZONA

University of Arizona
(4;0,0,0,0,4,0,0)

APPLIED MATHEMATICS

Aceves, Alejandro, Snell's laws at the interface between nonlinear dielectrics.
Geng, Xiao, The hyperbolic system in the isotachophoresis model.
Gruszka, Thomas, Induced polarization and its interaction with electromagnetic coupling in low frequency geophysical exploration.
Kwok, Loog-Piu, Viscous cross-waves: Stability bifurcation.

COLORADO

Colorado School of Mines
(1;0,0,0,0,1,0,0)

Mathematics

Sumner, Brian L., Asymptotic solutions to forward and inverse problems in isotropic elastic media.

GEORGIA

Emory University
(2;0,0,0,0,0,0,2)

EPIDEMIOLOGY AND BIOSTATISTICS

Addy, Cheryl Lynn, The final size distribution for a generalized stochastic epidemic.
Williamson, Glen David, Models for multidimensional contingency tables with incomplete data.

ILLINOIS

University of Chicago
(3;0,3,0,0,0,0,0)

STATISTICS

Norton, Phillip N., Specifying inner structure in multiple time series analysis.
Skates, Steven James, Laplacian and uniform expansions with applications to multidimensional sampling.
Vos, Paul William, Dual geometries and their applications to generalized linear models.

LOUISIANA

University of Southwestern Louisiana
(4;3,1,0,0,0,0,0)

MATHEMATICS AND STATISTICS

Chen, Ching-Shyang, Theory and numerical methods for nonlinear singular parabolic quenching problems.
Hon, Yiu-Chung, Computational methods for generalized Thomas-Fermi models of atoms.
Meaux, Laurie, Multivariate Chebychev-type inequalities.
Navard, Sharon, Upper variance bounds for continuous and discrete distributions with an application to order statistics.

MARYLAND

University of Maryland, College Park
(1;0,0,0,0,1,0,0)

MEASUREMENT AND STATISTICS

Gugel, John, Evaluation of a normalized direct approach to estimation of the parameters of the normal ogive three-parameter model for ability tests.

NEW JERSEY

Rutgers University, New Brunswick
(2;0,2,0,0,0,0,0)

STATISTICS

Kushary, Debashis, Estimation of ordered parameters.
Tissafi-Idrissi, Mohamed, Asymptotic efficiencies of sequential two-sided tests.

NEW MEXICO

University of New Mexico
(1;1,0,0,0,0,0,0)

MATHEMATICS AND STATISTICS

Ryl, Paul, Some notes on probability and confidence.

NEW YORK

New York University
(1;0,0,0,1,0,0,0)

STATISTICS/OPERATIONS RESEARCH

Browne, Sidney, Optimal dynamic operating policies for cyclic-type queues.

SUNY at Albany
(3;3,0,0,0,0,0,0)

MATHEMATICS AND STATISTICS

Hibschweiler, Rita, Closure properties and convolutions of families of analytic functions.
Tennant, Raymond, Relation space groups and swap equivalence of presentations.
Teymouri, Jamal, Geometric methods in group theory.
The thesis title for Kamran Hajighasemi (Mathematics, Purdue University), was incorrect in the November 1988 Notices. The correct title is “On phase coordinate restrictions in differential games of fixed duration”.

**Erratum**

**The second section deals with some of the influential mathematics departments in the United States. Functioning as centers of research and training, these departments played a major role in shaping the mathematical life in this country. The section is organized around seven departments: Harvard, Yale, Chicago, Princeton, Stanford, Berkeley, and NYU. Several of the articles are primary accounts, and most of these are supplemented by other recent articles.

The second section deals with an extraordinary conference held at Princeton in 1946 to commemorate the university’s bicentennial. The war had just ended, mathematicians had returned to their university positions, and a large number of veterans were beginning or resuming graduate work. The conference brought together many of the leading mathematicians of that era to take stock of open problems and to try to chart the future course of research in nine broad areas. Reprinted here are written versions of the discussions in which von Neumann, Weyl, Whitehead, Hopf, Courant, Zariski, Gödel, and many others pondered the present and future of mathematical research. Providing a fascinating glimpse into the mathematical world of 1946, the discussions are put into a contemporary context with commentary by current leaders in these areas.

In the last section, various aspects of America’s mathematical past are explored on the political, social, and scientific levels. The influence of women in American mathematics, the burgeoning of differential geometry in the last 50 years, and discussions of the work of von Kármán and Wiener are among the topics covered.

Also included are the Joint AMS-MAA Invited Addresses presented at the AMS Centennial Celebration. Mathematicians, historians of science, and students alike will find this book illuminating and rewarding, and it would make an excellent addition to any library collection. That the lessons of the past can guide the resolution of future problems makes this book important reading for all who are concerned with the development of mathematics.

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THE FLOWERING OF APPLIED MATHEMATICS IN AMERICA
Peter D. Lax
This perceptive and wide-ranging videotaped lecture provides a perspective on the development of applied mathematics in America from one who has been at the forefront of research in this field for almost forty years. Asserting that mathematics doesn’t “trickle down” to the sciences but rather lives in partnership with them, Lax elucidates certain themes in applied mathematics by describing some of the field’s highlights in such areas as fluid dynamics, mathematical physics, and optimization. He indicates the ways in which other sciences have stimulated developments in mathematics and describes some of the decisive mathematical contributions made by scientists from other fields. In addition, he turns his experienced eye to issues of science policy, undergraduate education, and the role of computation in mathematical research.

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THE BASIC THEORY OF REAL CLOSED SPACE
Niels Schwartz
(Memoirs of the AMS, Number 397)
Through Grothendieck’s Elements de geometrie algebrique, classical algebraic geometry became part of the theory of schemes. Informally speaking, this book seeks to establish that a similar embedding of semialgebraic geometry into a more general theory should also be possible. The author generalizes locally semialgebraic spaces by real closed spaces, a class of locally ringed spaces. The underlying spaces of affine real closed spaces are real spectra of rings, and the structure sheaves are called real closed sheaves. The author shows that there is a natural functor from the category of semialgebraic spaces to the category of real closed spaces. In this way, functorial properties of semialgebraic spaces and their corresponding real closed spaces can be compared.

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Computers and Mathematics

Editorial notes

For Whom the Bell Rings and Cursor Blinks

On every front battles rage. In its bitterness and inviducive, if not in bloodshed, it might be the Spanish civil war. Schools, colleges, universities, research labs, companies of all kinds, government agencies both military and civilian, are confronted with the same problems: How to keep pace with the computer revolution? How to satisfy the demands of their employees and clients (e.g. students) for computational support? How to put limited computational resources to best use? For some of these institutions, finding the right answer is a matter of life and death. Poor decisions can mean the decline or end, either from investing in computational resources that it cannot afford, or from investing in inappropriate computational resources and so losing out to the competition in one way or another. For one example, an increasing number of defections are not over salaries, but over computational support.

What is it about computers that has so revolutionized the world about us? How should we think about them so as to make the best decisions about their acquisition and use?

There are many ways of conceptualizing computers and computation. For present purposes, I restrict myself to three, differing in what one takes computers to be trafficking in.

- **Numbers.** One view of computers is as super calculators. This view goes with the mathematical model of the computer as a register machine, a device with an infinite set of registers $R_0, R_1, \ldots$, each of which can be used to store an arbitrary natural number, with a few simple basic moves, like testing whether a given register holds 0, or incrementing or decrementing a register. This conception squares with many of the uses of computers in engineering and physical sciences. It is supported by programming languages like Fortran and Algol, languages that stress numerical procedures.

- **Formal strings of symbols.** Another view of computers is as devices which traffic is formal strings drawn from some alphabet $\Sigma = \{a, b, \ldots\}$ of meaningless symbols. This conception goes with Turing's original Turing machine model as a device that operates on an infinite tape marked off in squares, each of which can hold a single symbol from $\Sigma$. The conception also fits with many of the uses of computers in artificial intelligence. It is supported by programming languages like LISP and Prolog that stress string operations.

- **Information.** Finally, for our purposes, there is the view of computers as information processors, devices that receive, represent, process and store information. It is this conception which explains many of the uses of computers in the world around us. In spite of this, there is as yet no widely accepted mathematical model of computation which does justice to this conception. Similarly, as far as I know, there are no programming languages that use informational principles to structure the language and its constructs, though object-oriented and database languages can be seen as moving in this direction.

These different ways of thinking about computers color how we think about many, if not all, aspects of the computer revolution. How we conceptualize computers affects how we use them in research. It affects the ways we use them in our teaching, say in the kinds of courseware we create. It affects the design of computer languages and architectures. It affects the sorts of mathematics needed to understand computers and computation. It determines the kinds of hardware and software we need for our institutions. And last, but far from least, it affects the sort of people we need to have in charge of computer resources, and the sorts of people you want to maintain them on a day-to-day basis.

In my opinion, it is the third view of computers, as informational engines, that makes sense of the battle for computational resources that is going on around...
us. And it is only under a conception broad enough to include this view that the right decisions will be made by the right people.

The noun "computer" is part of the problem. For it clearly predisposes one toward the first view, that of computers as traffickers in numbers. We are probably stuck with the term, but we need not let its associations cloud our view of computers, or affect the decisions that need to be made, decisions about who will have access to them, who will pay for them, how they will be used, and how they should be studied. For these decisions, we need to see that computers serve as information engines.

Under the informational conception, the best analogy for understanding the importance of computers is not with calculators, but with books and printing. The invention of movable type in the fifteenth century was an essential ingredient of the revolution that brought about the age of enlightenment. Its importance cannot be overestimated. And it does not seem too risky to predict that, for better or worse, computers are going to have as large an impact, an impact that will make the next millennium as different from the present as the enlightenment was from the middle ages. For today's computers are not just super calculators. They make available a new informational medium, one that can be used for good or ill in countless ways, just as with printing.

If I am anywhere near right, the health of our colleges and universities depends on how we think about computers as we make the hard choices ahead. If our leaders view them exclusively as tools for use in engineering and the physical sciences, they will lead us to failure, just as did the Italian princes of the 15th century who failed to grasp the true significance of the invention of printing.

This is all very general, and might seem to have little to do with mathematics in particular. But I think the danger of misconstruing the nature of computers is greater for us as mathematicians than for others. Since today's mathematicians find ample uses for computers as number and symbol crunchers, there is a real danger that we may be blinded by these uses to the full range of their applications. We must guard against this narrow vision if we are to use computers to maximum advantage in mathematics. When we think about the kinds of equipment and programs we need, and how to use them in our teaching, research and writing, we should be inspired not just by their power to do computations, whether numerical or symbolic, but by their full potential for giving us a new medium in which to work, a medium in which calculation is part of the substrate. Only if we become masters of this medium will we be able to use it effectively.

Let me be a bit more concrete by giving one example. I had a message from a friend (who prefers to remain nameless here) who often teaches high school algebra to those college students who have serious trouble with mathematics. We all know the type. These are the sorts of students for whom the parentheses in "(x + 3)²" are pedantic fussiness, and who are as likely to evaluate this as \(x^2 + 9\) as anything else. Just getting them to understand what is going on in standard algebraic computations is very difficult. With these sorts of students in mind, my friend asserts that "American Mathematical Education needs computers like Zaire needs BMWs."

I think that my friend suffers from the narrow conception of the computer as a symbol cruncher. It is probably true that this sort of student is not going to benefit from being turned loose with one of the highpowered, mathematical application packages of the sort one finds in today's mathematics computer labs, say MATLAB or Mathematica. But if you think of the computer as a new medium for processing and conveying information, then a wide range of possibilities opens up.*

For example, imagine a program which creates a workspace for the student to perform algebraic computations, which the program checks on the fly. In a separate part of the screen, a graph of the expression in question is displayed. Then, if the student goes wrong, the program could indicate that a mistake has been made, and overlay the correct graph with the graph of the student's new expression. (And maybe such a program already exists.)

The problem is hard one that will take hard work and creativity to solve. But the example at least illustrates that under the informational conception of computers, it is as impossible to rule computers out of the solution, as my friend would do, as it would be to rule out textbooks, blackboards, or teachers. The problem is not with computers, but with the limited uses we have made of them.

To come back to the bigger picture, it seems to me that the right question is not for whom should the

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* A number of these are discussed in essays in Computers and Mathematics: The Use of Computers in Undergraduate Instruction, edited by D. A. Smith, G. J. Porter, L. C. Leinbach, and R. H. Wenger, MAA Notes Number 9, Mathematical Association of America.
bells ring and cursors blink. The questions are: How can we find the resources to make computers work for all who could profit from them? Failing that, how do we weigh conflicting demands for computational resources among different kinds of users? And how do we teach today’s users how to put the computers that are available to the best possible uses? These questions do not have easy answers, but until we answer them, many of us will be like teachers without books, or teachers who have books but are barely literate.*

This Month’s Column

This month’s column is an interesting potpourri of items variously related to computers and mathematics. It contains three reviews of mathematical software:

• a review by Raymond F. Smith of MathView Professional, a package of numerical routines for the Macintosh;
• a review by Gustaf Gripenberg of MINPAC-LIB, a collection of FORTRAN routines for solving nonlinear systems of equations and nonlinear least-squares problems on the IBM-PC; and
• a review by Mark Sand of ZG, a freeware program for data analysis, also for the IBM-PC.

The column also contains two freeware offerings, a couple of letters reacting to previous articles in the column, and a very lovely proof of Gödel’s Incompleteness Theorem, probably the deepest single result about the relationship between computers and mathematics, as well as having played an important (if slightly ironic) role in the development of computers, as I have discussed earlier. I am pleased to be able to include in this column the most straightforward proof of this result that I have ever seen.

If you have comments on or suggestions for this column, please get in touch. And if you have suggestions for software you would like to see reviewed, send me the name and address of the distributor.

Professor Jon Barwise Center for the Study of Language and Information Ventura Hall Stanford University Stanford, CA 94305

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A New Proof of the Gödel Incompleteness Theorem

George Boolos*
Massachusetts Institute of Technology

Many theorems have many proofs. After having given the fundamental theorem of algebra its first rigorous proof, Gauss gave it three more; a number of others have since been found. The Pythagorean theorem, older and easier than the FTA, has hundreds of proofs by now. Is there a great theorem with only one proof?

In this note we shall give an easy new proof** of the Gödel Incompleteness Theorem in the following form: There is no algorithm whose output contains all true statements of arithmetic and no false ones. Our proof is quite different in character from the usual ones and presupposes only a slight acquaintance with formal mathematical logic. It is perfectly complete, except for a certain technical fact whose demonstration we will outline.

Our proof exploits Berry’s paradox. In a number of writings Bertrand Russell attributed to G. G. Berry, a librarian at Oxford University, the paradox of the least integer not nameable in fewer than nineteen syllables. The paradox, of course, is that that integer has just been named in eighteen syllables. Of Berry’s paradox, Russell once said, “It has the merit of not going outside finite numbers”***

Before we begin, we must say a word about algorithms and “statements of arithmetic”, and about what “true” and “false” mean in the present context. Let’s begin with “statements of arithmetic”.

The language of arithmetic contains signs + and × for addition and multiplication, a name 0 for zero, and a sign s for successor (plus-one). It also contains the equals sign =, as well as the usual logical signs ¬ (not), ∧ (and), ∨ (or), → (if ... then ...), ↔ (if and only if ...), ∀ (for all), and ∃ (for some), and parentheses. The variables of the language of arithmetic are the expressions x, x', x", ..., built up from the symbols x and ‘: they are assumed to have

*George Boolos is Professor of Philosophy at MIT. His email address is Boolos@cogito.mit.edu.
** Saul Kripke has informed me that he noticed a proof somewhat similar to the present one in the early 1960s.
the natural numbers \((0,1,2,\ldots)\) as their values. We'll abbreviate variables by single letters: \(y, z, \) etc.

We now understand sufficiently well what truth and falsity mean in the language of arithmetic; for example, \(\forall x \exists y x = sy\) is a false statement, because it's not the case that every natural number \(x\) is the successor of a natural number \(y\). (Zero is a counterexample: it is not the successor of a natural number.) On the other hand, \(\forall x \exists y(x = (y + y) \lor x = s(y + y))\) is a true statement: for every natural number \(x\) there is a natural number \(y\) such that either \(x = 2y\) or \(x = 2y + 1\). We also see that many notions can be expressed in the language of arithmetic, e.g., less-than: \(x < y\) can be defined: \(\exists z(sz + x) = y\) (for some natural number \(z\), the successor of \(z\) plus \(x\) equals \(y\)). And, you now see that \(\forall x \forall y([ss0 \times (x + x]) = (y \times y) \rightarrow x = 0]\) is well, test yourself, is it true or false? (Big hint: \(\sqrt{2}\) is irrational.)

For our purposes, it's not really necessary to be more formal than we have been about the syntax and semantics of the language of arithmetic.

By an algorithm, we mean a computational (automatic, effective, mechanical) procedure or routine of the usual sort, e.g., a program in a computer language like C, Basic, Lisp, ..., a Turing machine, register machine, Markov algorithm, ... a formal system like Peano or Robinson Arithmetic, ..., or whatever. We assume that an algorithm has an output, the set of things it "prints out" in the course of computation. (Of course an algorithm might have a null output.) If the algorithm is a formal system, then its output is just the set of statements that are provable in the system.

Although the language of arithmetic contains only the operation symbols \(\times, +, \) and \(x\), it turns out that many statements of mathematics can be reformulated as statements in the language of arithmetic, including such famous unproved propositions as Fermat's last theorem, Goldbach's conjecture, the Riemann hypothesis, and the widely held belief that \(P \neq NP\). Thus if there were an algorithm that printed out all and only the true statements of arithmetic—as Gödel's theorem tells us there is not—we would have a way of finding out whether each of these as yet unproved propositions is true or not, and indeed a way of finding out whether or not any statement that can be formulated as a statement \(S\) of arithmetic is true: start the algorithm, and simply wait to see which of \(S\) and its negation \(\neg S\) the algorithm prints out. (It must eventually print out exactly one of \(S\) and \(\neg S\) if it prints out all truths and no falsehoods, for, certainly, exactly one of \(S\) and \(\neg S\) is true.) But alas, there is no worry that the algorithm might take too long to come up with an answer to a question that interests us, for there is, as we shall now show, no algorithm to do the job, not even an infeasibly slow one.

To show that there is no algorithm whose output contains all true statements of arithmetic and no false ones, we suppose that \(M\) is an algorithm whose output contains no false statements of arithmetic. We shall show how to find a true statement of arithmetic that is not in \(M\)'s output, which will prove the theorem.

For any natural number \(n\), we let \([n]\) be the expression consisting of \(0\) preceded by \(n\) successor symbols \(s\). For example, \([3]\) is \(ss0\). Notice that the expression \([n]\) stands for the number \(n\).

We need one further definition: we say that a formula \(F(x)\) names the (natural) number \(n\) if the following statement is in the output of \(M\): \(\forall(F(x) \leftrightarrow x = [n])\). (Observe that the definition of 'names' contains a reference to the algorithm \(M\). Thus, for example, if \(\forall(x + x = ss00 \leftrightarrow x = ss0)\) is in the output of \(M\), then the formula \(x + x = ss00\) names the number 2.

No formula can name two different numbers. For if both of \(\forall x(F(x) \leftrightarrow x = [n])\) and \(\forall x(F(x) \leftrightarrow x = [p])\) are true, then so are \(\forall x(x = [n] \leftrightarrow x = [p])\) and \([n] = [p]\), and the number \(n\) must equal the number \(p\). Moreover, for each number \(i\), there are only finitely many different formulas that contain \(i\) symbols. (Since there are 16 primitive symbols of the language of arithmetic, there are at most \(16^i\) formulas containing \(i\) symbols.) Thus for each \(i\), there are only finitely many numbers named by formulas containing \(i\) symbols. For every \(m\), then, only finitely many (indeed, \(\leq 16^{m-1} \cdots + 16^1 + 16^0\)) numbers are named by formulas containing fewer than \(m\) symbols; some number is not named by any formula containing fewer than \(m\) symbols; and therefore there is a least number not named by any formula containing fewer than \(m\) symbols.

Let \(C(x,z)\) be a formula of the language of arithmetic that says that \(x\) is a number that is named by some formula containing \(z\) symbols. The technical fact mentioned above that we need is that whatever sort of algorithm \(M\) may be, there is some such formula \(C(x, z)\). We sketch the construction of \(C(x, z)\) below, in 3).

Now let \(B(x, y)\) be the formula \(\exists z(z < y \land C(x, z))\). \(B(x, y)\) says that \(x\) is named by some formula containing fewer than \(y\) symbols.

Let \(A(x, y)\) be the formula \((\neg B(x, y) \land \forall a(a < x \rightarrow B(a, y)))\). \(A(x, y)\) says that \(x\) is the least number not named by any formula containing fewer than \(y\) symbols.
Let \( k \) be the number of symbols in \( A(x, y), k > 3 \).

Finally, let \( F(x) \) be the formula \( \exists y (y = ([10] \times [k]) \land A(x, y)) \). \( F(x) \) says \( x \) is the least number not named by any formula containing fewer than \( 10k \) symbols.

How many symbols does \( F \) contain? Well, \([10]\) contains 11 symbols, \([k]\) contains \( k + 1 \), \( A(x, y) \) contains \( k \), and there are 12 others (since \( y = x' \)) so \( 2k + 24 \) in all. Since \( k > 3 \), \( 2k + 24 < 10k \), and \( F(x) \) contains fewer than \( 10k \) symbols.

We saw above that for every \( m \), there is a least number not named by any formula containing fewer than \( m \) symbols. Let \( n \) be the least such number for \( m = 10k \). Then \( n \) is not named by \( F(x) \); in other words, \( \forall x (F(x) \iff x = [n]) \) is not in the output of \( M \).

But \( \forall x (F(x) \iff x = [n]) \) is a true statement, since \( n \) is the least number not named by any formula containing fewer than \( 10k \) symbols! Thus we have found a true statement that is not in the output of \( M \), namely, \( \forall x (F(x) \iff x = [n]) \). Q.E.D.

Some comments about the proof:
1. In our proof, symbols are the "syllables", and just as 'nineteen' contains 2 << 19 syllables, so the term \( ([10] \times [k]) \) contains \( k + 15 << 10k \) symbols.
2. In his memoir of Kurt Gödel,* Georg Kreisel reports that Gödel attributed his success not so much to mathematical invention as to attention to philosophical distinctions. Gregory Chaitin once commented that one of his own incompleteness proofs resembled Berry’s paradox rather than Epimenides’ paradox of the liar (“What I am now saying is not true”).** Chaitin's proofs make use of the notion of the complexity of a natural number, i.e., the minimum number of instructions in the machine table of any Turing machine that prints out that number, and of various information-theoretic notions. None of these notions are found in our proof, for which the remarks of Kreisel and Chaitin, which the author read at more or less the same time, provided the impetus.
3. Let us now sketch the construction of a formula \( C(x, z) \) that says that \( x \) is a number named by a formula containing \( z \) symbols. The main points are that algorithms like \( M \) can be regarded as operating on "expressions", i.e., finite sequences of symbols; that, in a manner reminiscent of ASCII codes, symbols can be assigned code numbers (logicians often call these code numbers Gödel numbers); that certain tricks of number theory enable one to code expressions as numbers and operations on expressions as operations on the numbers that code them; and that these numerical operations can all be defined in terms of addition, multiplication, and the notions of logic. Discussion of symbols, expressions (and finite sequences of expressions, etc.) can therefore be coded in the language of arithmetic as discussion of the natural numbers that code them. To construct a formula saying that \( n \) is named by some formula containing \( i \) symbols, one writes a formula saying that there is a sequence of operations of the algorithm \( M \) (which operates on expressions) that generates the expression consisting of \( \forall x, (\text{the } i \text{ symbols of some formula } F(x) \text{ of the language of arithmetic, } \iff x = n \text{ consecutive successor symbols } 0, 0, \text{ and } \text{for } M \text{ to be coded into formulas of arithmetic.}
4. Both our proof and the standard one make use of Gödel numbering. Moreover, the unprovable truths in our proof and in the standard one can both be seen as obtained by the substitution of a name for a number in a certain crucial formula. There is, however, an important distinction between the two proofs. In the usual proof, the number whose name is substituted is the code for the formula into which it is substituted; in ours it is the unique number of which the formula is true. In view of this distinction, it seems justified to say that our proof, unlike the usual one, does not involve diagonalization.


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**Correspondence**

A Letter from Bob Fisch and David Griffeth

As the authors of *Graphical Aids for Stochastic Processes (GASP)*, we were delighted to see our software product reviewed in your column (February 1989). However, there is one point the reviewer brought up which we would like to clarify.
The reviewer noted that GASP is "... nearly free of misprints except in the video on Poisson processes, for some reason." In fact, there is a reason. On text screen F3 of the Poisson process module, several real life examples which are modeled with the Poisson process are listed, and then the reader is told that a "... familiar example is hidden in the text screen of this module ...". We invite the reviewer to go back and try to find the misprints previously found in the Poisson process module, and to also find new misprints that did not appear before.

Of course, if any user finds true misprints (i.e., those which never go away, even after exiting the program and starting it again), other bugs with the software, or has any suggestions as to how GASP may be improved, we are always receptive to such correspondence.

Bob Fisch  
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University of North Carolina at Charlotte

David Griffeath  
Department of Mathematics  
University of Wisconsin-Madison

Comments on Mathematical Courseware

The article John Etchemendy and I wrote on creating mathematical courseware (in the January 1989 issue) prompted quite a few responses. Most of them were expressions of gratitude, or asked various specific questions that were not answered in the article. However, there were three reactions that bear mentioning. One I have already referred to in the lead editorial. The following criticism, extracted from a longer letter by Professor Keith Stroyan, Mathematics Department, University of Iowa, is directed more at one specific of Etchemendy's and my article. Following that is a short piece by Charlie Gunn, of the Geometry Computer Group. Following is a short piece by Charlie Gunn, of the Geometry Computer Group.

Your January Notices article is very nice. ... My computer-teaching efforts have been in a different direction than yours—more elementary, but the projects you describe sound excellent. I believe that computers will eventually affect the way we teach in several important ways. I find myself feeling a little envious, having worked with all the problems you describe, but none of the support. I think your concept of "courseware" is too narrow. Courses like analytical geometry in high school and calculus in college can profit immensely from computer lab materials that do not fit anywhere in your "Three Levels of Courseware." In these courses, fairly simple programs that students work with more directly themselves can illustrate and cement ideas very effectively. I believe that this kind of computer use by students will eventually prove to be more important than individual stand-alone programs intended to illustrate one idea. (This does not mean that I see no role for the kinds of programs you describe.) This sort of computer use tends to be more active learning than your categories of courseware. Strange as this may sound, I would like to use Mathematica as calculus "courseware" next year. This is a pretty big "sandbox", but we have fairly well-developed experiments on which to focus students' attention (and will develop many more using its features.)

Your advice that, "Each hour spent learning the brute operation of your program is an hour not spent learning the subject you are trying to teach," and your comments on classroom mechanics and knowledge of other schools' computer use all hit the nail square on the thumb. But the questions raised don't have simple universal answers.

Etchemendy and I agree. While our exposition obviously did not make it clear, we intend the sort of material Stroyan describes to fall under our level three courseware. In fact, that is the way we often use our own programs.

Challenges of Using Computers in Mathematics

by Charlie Gunn*

This is primarily an appreciative response to the article "Creating Courseware" by Barwise and Etchemendy

*Gunn is on the staff of the Geometry Supercomputer Project (1200 Washington Ave. S., Rm. 2079, Minneapolis, MN 55415) described in Notices, February 1988, pp. 253-5. He says his comments "arise from my experience attempting to create computer environments for doing mathematics research that are easy to use, powerful, and will continue to operate past the end of next week." He can be reached at the above address or by Email at gunn@geom.umn.edu.
in the January issue of Notices. There the authors present a lively introduction to the issues involved in developing courseware for mathematics. As a point of departure, I begin by re-examining the meaning of this term.

What's in a Name?
I wish to emphasize the point made by Barwise and Etchemendy in their article: the educational and research uses of the computer are closely intertwined. Anyone who has had the satisfaction of developing a substantial piece of software designed to be used by naive users or students realizes that this effort pays large rewards for the mathematically expert also.

In fact, I believe that trying to consider courseware issues apart from the analogous issues for mathematical research is misguided. This important issue risks being obscured by thinking of it as a subset of mathematics education. For purposes of discussion I propose that the translation of mathematics into a computing environment is one of the leading challenges for mathematics (and not just mathematics teachers) as it heads into the next century.

In the discussion that follows, I make certain simplifying assumptions. That is: all computer hardware is the same; it can talk to all other computer hardware naturally and quickly; and it has the power to compute and display its results in near real-time for the types of tasks under consideration.

Translating Mathematics onto Computers
Mathematics is the science of abstract thought par excellence. Computers perfectly mirror logical thought. To the extent we can express abstract thought logically, we should be able to map mathematics onto computers. Yet we are barely beginning to approach the daunting task of exporting mathematics into a computer. This process is far more than writing specific programs to compute specific mathematical results. It is far more than archiving all mathematical writings into a computer. The task of translating requires the invention of new modes of access to this knowledge, modes which take advantage of the unique capabilities of the electronic computer. Our success in this endeavor will certainly revolutionize how we look upon the activity of doing mathematics, a transition already begun by the advent of hand-held calculators. It will at the same time, as a derivative follows the curve, revolutionize the activity of teaching mathematics.

How will the resulting edifice resemble what we consider today as the contents of mathematics? To begin with, it will create an electronic library which contains all published works of mathematics. In this sense it will contain the present. But it will go beyond the present in several ways. First, those perusing this knowledge will be able to use a complete set of cross-references to track down references and key-words in real time. Intelligent editors will allow the reader to read articles at varying levels of detail.

Beside this old road, a new one will have to be constructed, one that, to begin with, visits exactly the same towns. Think of it as a modern Encyclopedia of Mathematics. Like an encyclopedia, it is comprehensive, compact and precise. But instead of being written on paper and transferred to the computer this encyclopedia is written for the computer from the start. It has articles which can be read, just like the old encyclopedia, but it offers much more to the reader than static pages of words and diagrams. The diagrams it offers the reader are live diagrams, which can be brought to life by a standard set of interface gestures. It can equally well be thought of as a set of computer routines, tools, and data structures which allow the user of the encyclopedia to construct his own examples and experiments.

This is the DNA of mathematics, distilled into its clearest form. Like DNA, this nucleus is surrounded by a whirling dynamism, the metabolism of learning, which expresses this abstract content in a concrete, visualizable form. In our analogy, this is the software interface, infinitely plastic. This interface mediates between the contents of the encyclopedia and our human, be this researcher or student.

Realization of this vision admittedly will take the human race far into the next century with or without NFS funding. But it is I think the right one for mathematics of our time to aim for.

Meanwhile, Back on Planet Earth . . .
How can this vision of the possible influence our decisions today? I think there are several important themes in this vision which can influence our present sense of direction.

There are several frustrating aspects to the current situation which need to be addressed. First is the general sense that software takes too long to write, too little time to throw away, runs on too few machines, and is difficult to extend. All these problems are endemic to the software industry and vigorous efforts are under way to solve them.

One of the most important ingredients is the development of standard programming environments. There are several windowing environments currently under development which are designed to encourage portable code by providing a standard set of programming tools freely available on a variety of machines.
The aim is to provide the ease of use of the Macintosh environment across a broad range of machines. This is important as anyone who has tried to rewrite Macintosh code to run on another window system knows. The next few years should see a maturation in this field and the emergence of a genuine standard environment for window-based programming. Currently, the main contenders in this arena are the X-Windows system and the NeWS window system. It is too early to say who will emerge as the victor, if either. The question of portable standards for 3D graphics is not as far along but is only a matter of time before it too becomes a universal standard.

Solution of the windowing environment will do a lot to take the pain out of porting code. Other aids are on the way to take the pain out of generating the code. The key word here is object-oriented programming. This refers to a type of programming language which supports hierarchy and modularity through features of the language. For those who are faced with translating mathematics into the computer, such tools are particularly important, since mathematics is heavily hierarchical. For example, in an object-oriented environment, it is possible to define an abstract group and then to create various types of group which inherit all the properties of the generic one, in addition to specific new attributes. The procedure for multiplication might be defined by different methods for each sort of group, all referred to by the same name. The language provides the bookkeeping to know which sort of multiplication is required. If a particular group also exhibits the behavior of a dynamical system, such a group could also inherit the attributes and properties of the class dynamical system.

Finally, it is important to admit that creation of nice interfaces are critical to acceptance and enjoyment of the computer. Graphical interface techniques are being combined with object-oriented programming to provide tools for automatically generating the interface to programs. First impressions of the NeXT computer’s Interface Builder verify the promise of this approach. This paradigm makes available to the user commonly used interface widgets, such as menus, sliders, buttons, dialog boxes, and animation controls.

Other software advances which are paving the way for the mathematics of the future include navigational aids for accessing file systems and databases, and inquiry tools for examining and debugging programs and files.

Concrete Suggestions
The time is ripe, I believe, to begin to use the available tools to create some modules which integrate the themes discussed above. What sort of modules do I have in mind?

Current work with the Geometry Computing Group has provided some specific themes. One is a module to treat 3-dimensional manifolds. At the present time, work is focused on several topics within the large one. These include knots and links, a prime source of such manifolds; and the wide and rich area of discrete groups acting in 3 dimensions. Also envisioned is a tool for creating and analyzing minimal surfaces, and one for studying the iteration of complex maps. At a more basic level, differential geometry would be an appropriate domain, as would the rich realm of classical projective geometry, up and including the content of Klein’s Erlangen Program.

A brief listing of such topics raises more questions than it answers. Certainly all these areas overlap, and in this overlap it would of primary importance to provide uniform data structures, or at least, in the terminology of analysis, a coherent set of charts. At a higher level, the task will call on parallel disciplines of computer science, psychology, education, and art. There will be a long period of trial and error to discover how best to do this. But the time is certainly ripe for the effort.

Reviews of Mathematical Software

MathView Professional
Reviewed by Raymond F. Smith*

Introduction
As compared to many of the general purpose programs recently reviewed in Notices, MathView Professional is simply a package of numerical routines tied into a Macintosh interface rather than a symbolic manipulation program or a “supercalculator”. The routines available include: Algebraic systems problems, roots and zeros, ODE, integrals, “special problems” (complex powers and roots, FFT, evaluating special functions), optimization, series operations, function

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and data plotting, statistics, PDE, function evaluation and plotting.

MathView runs on Macintosh 512K Enhanced, Plus, SE and II computers, and requires an 800K internal drive as well as a second drive. Most of my testing has been on an SE with 20mb internal hard drive, though I did run the routines on a Macintosh II. A major bug that I found on the SE was that the computer routinely crashes when you quit MathView. This was not a problem on either the Plus or II. I should also note that I began this review as a skeptic, having first looked at MathView for possible use in a lab for first-year calculus students. It is not a program that will work well in that situation. In particular, its graphic capabilities are certainly not adequate to the sorts of things one might want to do in a lab. After working intensively with MathView for nearly two months, I have found that it is a good program for what it was designed to do—serve as an easy-to-use numerical package.

I will divide this review into three sections: an overview of the package, a discussion of performance on some of the now standard Notices benchmarks, and concluding comments on the high and low points of the package.

Overview
MathView was obviously written for the Macintosh rather than imported from some other machine. The entire interface is mouse-oriented. The user needs only to type in such things as function definitions, numbers, and file names. All other options are selected using standard Macintosh procedures.

When MathView is opened, the user is presented with a menu bar which contains the standard “File” and “Edit” menus as well as “Applications” and “Options” menus. The “Options” include such things as output options and listings of error codes and functions. The “Applications” menu allows the user to select general areas to work in (as described in the first paragraph of this review). After an area is selected, a particular routine is chosen from a list of options. All information that is needed by the program is requested through a series of dialogue boxes. The program is extremely easy to use, and takes little effort to learn.

MathView functions are created in standard computer style. There is a fairly large collection of built-in functions, including such things as Hermite polynomials, Bessel functions, and the Jacobi elliptic function. In addition, there are a number of special functions that can be evaluated through the “Special Problems” menu. These special functions cannot be used in other expressions or in the general routines.

Vectors and matrices are created and stored as one-dimensional lists. They may be entered through the program or created externally, stored as text files, and opened in routines that need them. For testing purposes, I created Hilbert matrices in Excel and saved them as text files. Once I read the discussion on file parameters in the MathView manual I was able to use these files with no difficulty. Data files may also be opened and edited from the “File” menu in MathView. Data created by MathView may also be saved for later use.

The documentation included with MathView is extremely easy to use, and is certainly adequate, given the ease of use of the Macintosh interface. In addition to the usual discussion of “how to use the package”, there is also a complete list of references to the sources of the algorithms. Thus even though the user has no access to the source code, one can at least have some feeling for what is going on in the routines.

Benchmarks
I will continue to use the benchmarks introduced in the review by Simon and Wilson (Notices, September, 1988, pp. 978-1001) and extended by Herman (Notices, November, 1988, pp. 1334-1344) to illustrate how the package works. The reader should continue to be aware that the purpose of these benchmarks is illustrative only. They are not designed to show the capabilities of the package in any precise manner. I have described the operation of the program in considerable detail in my discussion of the first benchmark to give a feeling for the way the program works. All of the other routines run in a similar manner.

Roots. Find the roots of \( x^3 - x^2 - x - 1 = 0 \). I selected “Roots and Zeros” from the Application menu, and then clicked the “Polynomial Roots” option and then “OK” in the box that was displayed. A dialogue box asked for the function, and I typed in

\[
x^3-x^2-x-1
\]

and clicked on OK. The next dialogue box asked for the real and imaginary parts of an estimate. I typed a “2” in the “Real” box and a “0” in the “Imaginary” box. I then clicked on “OK”, and in about five seconds the following lines were displayed in an output window

Zero number 1 is: -4.19643e-1 + -6.06291e-1*i
Zero number 2 is: -4.19643e-1 + 6.06291e-1*i
Zero number 3 is: 1.83929e+0 + -8.50221e-26*i

When I clicked to close the window, I was given the opportunity to pick another initial estimate or to
cancel the procedure. Choosing “Cancel” returned me to the main MathView window.

**System.** Solve the system of equations

\[
\begin{align*}
\sin(x) + y^2 + \log(z) &= 7 \\
3x + 2^y - z^3 &= -1 \\
x + y + z &= 5
\end{align*}
\]

I chose the “Roots and Zeros” application and then the “Nonlinear system solver” option. I typed the following lines into the equation entry window:

\[
\begin{align*}
\sin(x) + y^2 + \ln(z) &= 7 \\
3x + 2^y - z^3 &= -1 \\
x + y + z &= 5
\end{align*}
\]

Clicking the close box gave an “invalid operator” message and returned me to the equation entry window with the middle equation selected. After some experimentation, I discovered that it did not like the “-1”. I negated the entire second equation and continued. I chose 100 for the maximum number of iterations and used (1,1,1) as the initial vector. After a few seconds I was given the following output:

The solution is:

- at \( x = 5.9905376 \times 10^{-1} \)
- at \( y = 2.3959314 \times 10^0 \)
- at \( z = 2.0050148 \times 10^0 \)

I was given the opportunity to try another initial vector. I used (5,-2.5,2.5) (as suggested by Simon and Wilson), getting the solution

The solution is:

- at \( x = 5.1004127 \times 10^0 \)
- at \( y = -2.6442371 \times 10^0 \)
- at \( z = 2.5438244 \times 10^0 \)

in a few seconds. The routine seemed to work very well, and gave no problems once I figured out the syntax.

**Lissajou.** Graph \( x = \sin(2t + 0.6), \ y = \sin(5t) \) as \( t \) ranges over \([0, 2\pi]\). I selected “Function Plotting” from the applications menu, and then went on to the 2D section and parameterized plotting. I was asked for \( g(t) \) and \( h(t) \) and then for the interval of definition. I picked the “high resolution” mode, and waited for about 30 seconds before the graph started to appear. Although the graph itself is fine, the rest of what is produced is weak. Hash marks are hard to see and no values are printed, though values for \( x \) and \( y \) increments are given. I should note, though, that it is possible to add your own graph text. The low resolution option produces a graph within a few seconds, but with much lower quality.

**General Graphing.** I tried graphing the two functions introduced by Herman. Plotting

\[
\frac{\sqrt{4-x^2}}{x^2(1-x^2)}
\]

on \([-3, 3]\) gave errors when it tried to take the square root of a negative number. When I tried it on \([-2, 2]\), it began to work, but then stopped plotting and gave an error message when the \( y \)-value became too large.

After several minutes of calculation, the hidden lines plot of

\[
\frac{x^2 - y^2}{x^2 + y^2}
\]

on the rectangle \(-1 \leq x \leq 1, -1 \leq y \leq 1\) gave disappointing results.

**Hilbert.** What is the largest Hilbert matrix \( H_n = [1/(i+j-1)]_{i,j=1}^n \) which can be successfully inverted?

I used Excel to produce the matrices, saving them to a text file. The “Matrix Inversion” option is included in the “Algebraic and System Problems” menu. I chose the text file option and was given a standard Macintosh file menu. The inverse matrix was printed in an output window along with the value of the determinant. No message (other than a small determinant) is given in the case that the matrix is nearly singular. I used the “Matrix Multiplication” option to calculate \( H^{-1}H \) and \( HH^{-1} \) and the “Linear Combinations of Matrices” option to find \( I - H^{-1}H \) and \( I - HH^{-1} \). I determined the value of the ERR function as defined by Simon and Wilson by inspection. The time for the inversion includes file access time and printing the matrix to the screen. The results were
Although the results of the calculations are not particularly good, the routines were easy to use, and certainly seemed accurate in cases where singularity is not a problem.

DE. Solve numerically the following initial value-problem; also graph the solution.

\[ y' = 1 - 2xy, y(-1) = 0 \text{ on } [-1, 2] \]

I selected the "Ordinary Differential Equations" application and then chose the Runge-Kutta Method. I entered the function and the interval, initial value, error tolerance, etc. After 31 seconds the following data was printed in an output window:

I was given the option to save the data to a text file and then to draw the graph of the output. Another 30 seconds were required to produce this graph window:

The Macintosh II. I ran all of the benchmark routines on a Macintosh II. The results of the computations were identical with those on the SE, the only difference being in speed. For example, the roots problem was solved in 2 seconds, the 14 x 14 Hilbert matrix was "inverted" in 2 seconds, the differential equation solved in 5 seconds and its graph plotted in another 6 seconds, and the preparation for the hidden-lines graph was done in 30 seconds. I should emphasize that there was no improvement in the quality of the graphics, only in the speed.

Conclusion

My concerns with MathView center primarily on problems with its use of the Macintosh interface. Although it certainly takes complete advantage of the interface and is truly a Macintosh program, there are a number of inconsistencies and bugs that make it somewhat frustrating to use. I will illustrate this frustration with a few examples:

- Only one window created by MathView can be open at a time. It is impossible to open the scrapbook or a MathView file once a routine has begun, so that functions must be copied to the clipboard before a routine is begun. This makes it difficult to use pre-defined expressions in the routines that allow several functions.

- In general it is not possible to "back up". If you discover a mistake in entering a function or parameters after going to the next stage in a routine, you must start over. The experienced user learns to copy a function definition so that it may be pasted in when a routine must be redone.
There is a general inconsistency about what happens when a routine finishes. Sometimes closing a window simply takes the user back to the options menu (with an opportunity to save data if appropriate), while at other times there is an option to redo the routine with new parameters. There seems to be little consistency in these decisions.

- The “cancel” command (usually Command/ ) does not always work. For example, numerical integration by Simpson’s method is very slow, yet it is impossible to get out of it without shutting the machine off.

- There is also an inconsistency in the way similar routines operate. For example, the function evaluation routine allows the user to evaluate a function at several points, while the differentiation routine allows the evaluation of the derivative function at only one point. To evaluate the derivative at several points, the user must re-enter the function definition, the order of the derivative, and the value of \( h \) in the difference quotient as well as the point at which the derivative is to be evaluated.

- Although the plotting routine will plot a graph from raw data, the integration and differentiation routines do not work on such data.

On the positive side, once the user becomes accustomed to the inconsistencies and remembers such tricks as always copying functions, the routines are easy to use, and produce results very quickly. Given the wide variety of routines available and the relative speed of most of the algorithms, MathView would be useful to any mathematician who has occasional need of numerical routines.

Price and Publisher

MathView Professional is published by BrainPower, Inc., 24009 Ventura Boulevard, Calabasas, CA 91302, (818)884-6911. $249.95. (If ordered direct, a very large discount is available.)

MINPACK1-LIB

Reviewed by Gustaf Gripenberg*

The MINPACK1-LIB software package consists of a collection of FORTRAN library routines that can be used for solving nonlinear systems of equations and nonlinear least-squares problems. It is derived from the Argonne Minpack-1 software product and is therefore best suited for people who want to use the same FORTRAN programs on a mainframe and a microcomputer. A related library, FITLIB, for spline approximation is reviewed in the March, 1989 issue of Notices.

Systems of equations are solved with a modification of the Powell hybrid method and the least-squares problems are solved using a modification of the Levenberg-Marquardt algorithm.

The package requires an IBM-PC/PS compatible computer with at least 256K memory and a FORTRAN compiler. Different versions are supplied for the Microsoft 3.31, 4.01, IBM 2.0, IBM Professional 1.30, Ryan-McFarland 2.42, and Lahey 2.22 compilers. A math coprocessor is not needed unless required by the compiler (two different versions of the libraries are supplied), but I can hardly see why anyone using this kind of package would not have a math coprocessor unless it cannot be installed in the computer. The DOS requirement is dependent on the compiler.

There are two routines for solving nonlinear systems of equations, HYBRD and HYBRJ, the second one requiring that the user supplies the Jacobian. Furthermore there are two drivers HYBRD1 and HYBRJ1 for these core routines where default values for some of the parameters are chosen by the program. For the nonlinear least-squares problem there are altogether 6 routines: LMDER for which the Jacobian must be supplied, LMDSTR for which only one row of the Jacobian at a time must be supplied (in order to save memory), LMDIF where the function values are sufficient and the corresponding easy-to-use drivers LMDER1, LMDSTR1, and LMDIF1 for the core routines. Finally a routine CHKDER that checks gradients for consistency with function values, a subroutine LMPAR that calculates the Levenberg-Marquardt parameter, and a subroutine QRFAC that calculates QR-factorizations are supplied as well.

The strong points of this package are the strong points of good FORTRAN libraries in general (that have kept FORTRAN alive as a programming language) and the compatibility with the Minpack-1 library available on mainframe computers (which guarantees that the code is well tested and reliable). One noteworthy feature is that for every subroutine there is a “skeleton” file that contains the necessary declarations and subroutine calls that must be included in the main program. Thus it is quite easy to build a working program, including other calculations and the desired input and output, around such a

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skeleton file. This feature does not, however, make this package into an interactive program. One has to make a sizable investment in time and effort before one has a program running; one cannot just go over to the computer and see what the solution of a certain problem is.

Another weakness of the program is that one would probably want to solve other minimization problems than least-squares ones as well. It is, of course, possible to rewrite the functions one uses in such a way that instead of the $L^2$-norm one has a quadratic function close to zero and a linear one farther out. When I tested this approach on the standard problems included in the test programs supplied with the package, it worked reasonably well although the number of function evaluations increased considerably. A second restriction in the minimization programs is that the number of functions appearing in the least-squares formulation should be at least as large as the number of variables. Technically one can get around this requirement by defining sufficiently many additional functions to be zero. But if applied to the test problems in such a way that the sum of squares to be minimized is put into the first function and the remaining ones are taken equal to zero, then the results were far from satisfactory in the majority of cases.

The documentation is on the whole very good, including a booklet for quick reference and detailed discussions of how to interpret the output from the routines. One weakness is that the problem of passing parameters to the subroutine calculating function values is not explicitly discussed. (From the test programs one sees how this can be done using the COMMON clause but this is a problem in need of other solutions as well.) Another omission is that nothing is said about the possibility of calculating the Jacobians in a computer algebra system, in which case it is often possible to get the output directly in FORTRAN code.

This software package delivers the promised "mainframe FORTRAN power for your personal computer", but unfortunately, the price has not been adapted to personal computers.

Further information on the MINPACK1 package (or the technical support by phone which is available for an additional fee) can be obtained from:

Scientific, Inc.
6 Pine Tree Drive, Suite 250
St. Paul, Minn., 55112
Phone: (612) 490-0615

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**ZG: Quick Data Analysis**

*Reviewed by Mark Sand*

ZG is a new program for data analysis that is being distributed as freeware. It is available from the author, Professor Andrew Matchett of the University of Wisconsin - La Crosse, who announced the program and how to obtain it in the December 1988 issue of these Notices. It is a small program for IBM personal computers and compatibles, requiring only 140 Kbytes of memory.

ZG was created with small size and simplicity in mind, instead of being loaded with fancy features. A first indication of this is that the program doesn’t come with a written manual. Instead, the “ZG User’s Guide” is contained in a disk file named zg.doc. Listing this on a printer produces a 16-page document that is fairly complete. The user needs to keep this Guide nearby when using ZG, since there is no on-line help available and the commands are not always intuitively obvious.

There are two modes of operation in ZG, to accomplish the two objectives of the program. In base mode, the program functions as a calculator using reverse Polish notation and saving a list of all calculations. Although I like having this recorded list, I found calculating with this to be less convenient than using a hand-held calculator. Part of the reason is that I have not practiced using RPN recently. But the major reason is that some newer calculators (Casio fx-4000p and fx-7000g, for example) are so easy to use with ordinary algebraic entry that saving a few keystrokes with RPN is not necessary. These calculators can also replay a previous calculation. Thus I was not swayed by the extensive commentary in the User’s Guide about the superiority of RPN over algebraic notation.

ZG is clearly worth learning, however, because of its list mode. In this, up to four lists of numbers can be analyzed and manipulated, with two of the lists appearing on the screen at a time. Each list can contain up to 2000 values, and the list where the cursor lies is referred to as the “active” list.

In many other programs, a list or block of data can be analyzed to find one relevant statistic at a time. When in list mode of ZG, however, pressing ‘+’ gives an entire set of statistics for the active list. This set includes: population size, mean, standard deviation (sample), variance (sample and population),

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*Mark Sand is Assistant Professor of Mathematics at Augustana College.*
maximum value, minimum value, sum, and sum of squares. These can only be printed out using the PrtScrn key, since ZG doesn't have any printing options. The printed notation is slightly different from that used on the screen. For example, the sum of squares is denoted by \( \sum x^2 \) on the screen while the printed copy uses a different notation, the same as in the User's Guide.

ZG can also work on two lists at a time to compute regression statistics. This is very fast: for two short lists, the set of 19 statistics appeared virtually instantaneously, while for two lists of 2000 elements each, the set appeared in about 3 seconds (on a 12-Mhertz 80286 machine). This process can also be done on the numbers from the beginning of the list to the current cursor position, so that subsets can be considered. All calculations are rounded to a user-specified number of significant digits, up to a maximum of 11.

The list mode that I find so capable would be only a curiosity if long lists of numbers had to be entered each time. However, ZG supports input from and output to disk files, and doing this is very easy. Best of all, it will create a new file if the user desires to save changes, instead of having to overwrite an existing file. Another way to let the program do the work of entering numbers is to use the random number generator. A column of any length can be automatically filled with random numbers in the interval \([0, 1]\), or consecutive integers.

There are other manipulations that can be performed with these lists, including doing algebraic operations on all values simultaneously, and sorting. The neatest of them is the automatic graphing. Strangely, though, the graphing commands and several other list commands are issued while working in base mode. After selecting a list with the cursor, pressing 'G' produces a histogram of the frequencies with which the data values appear. When there are two lists present, they are always considered as x-values on the left and y-values on the right. Then pressing 'g' produces a scatterplot of the \((x, y)\) pairs. In both types of graphs, there are some options available to change the look of the graph. There is not a lot of flexibility available, however.

One caution needs to be observed in using the scatterplots. There is a "super hi resolution" mode created just for the AT&T 6300 computer, which the User's Guide says should not be used on most other computers. Ignoring this warning, I tried it on my Compaq computer, and got not only a blank screen but also a locked keyboard. Re-booting was the only way to continue.

So where do I envision ZG being used? ZG is much simpler and easier to use than a spreadsheet or large statistical package, though less powerful and flexible. It would help in an introductory statistics course since the students could learn to use most of the important features in just a few minutes. It is fast, uses very little memory, and gives whole lists of statistics at a time. Another advantage is the unlimited student access to ZG by virtue of being freeware. Also, the User's Guide gives an example of how the author has used the program in a classroom experiment to illustrate statistical principles.

For personal work, I find it to be most useful in its list mode. While a calculator is still a faster tool to use on a small group of numbers, ZG is much easier to use on large or changing data sets. A user can quickly call up an existing list, find its statistics, add or delete values, re-compute the statistics, and then store the modified list. I found myself frequently asking "What if I try ..." since it is so easy to do the above steps. One feature that I would like to see added is the ability to put titles on the lists shown, to avoid any confusion.

Mark Sand
Department of Mathematics
Augustana College
Sioux Falls, SD 57197

Mathematical Freeware and Shareware

A Desk Calculator for Recursive Reals
Hans-J. Boehm and Vernon Lee, of Rice University, are making available a desk calculator utility for Sun 3's that performs arithmetic on recursive reals. Real numbers are represented as functions capable of producing arbitrarily precise rational approximations. This allows the calculator to give the illusion that what you see on the screen is a finite window on an infinite real number. It is possible to, for example, display \( \pi \) on the screen, and then scroll arbitrarily far to the right to look at more and more digits of \( \pi \). (It takes about 3 hours to look at the 100,000th digit of
Computers and Mathematics

π.) Since answers are always accurate to the displayed accuracy, the expression \(\ln((\pi + e^{-500}) - \pi)\) actually evaluates to -500.

The ideas behind the underlying arithmetic package are described in a paper entitled "Constructive Real Interpretation of Numerical Programs", SIGPLAN '87 Proceedings, SIGPLAN Notices 22, 7 (July 87), pp. 214-221, and in some of the references given there. The current versions also include a few facilities especially tailored to the manipulation of large integers. A Solovay-Strassen primality tester is included.

The calculator and the underlying recursive reals package were written in the Russell programming language. Since most people would prefer not to install a new compiler for this purpose, the calculator is available in object form. The object code is available for anonymous ftp retrieval from titan.rice.edu:ftp/sun-source/calc.shar.0*, where * is one of the digits between 1 and 3. (The number of pieces may grow to 4 in a future version.) It may also be obtained by mailing a request to archive-server@rice.edu. The three files may be assembled into a Sun 3 executable by executing them as shell files in an otherwise empty directory, and then typing "make". Further instructions are included.

If you would prefer the compiler and source code, it is also available free of charge if you have ftp access to titan.rice.edu. For details, please write, or better send electronic mail, to:

Professor Hans-J. Boehm
Computer Science Department
Rice University
P.O. Box 1892
Houston, TX 77251-1892
Email: boehm@rice.edu

Lyons Cochlear Model

How do we hear? That is, what is the mathematics of the human ear? A Mathematica Notebook containing an implementation of Richard Lyon’s model of the cochlea has been written by Malcolm Slaney. It is intended for readers with some knowledge of signal processing since it uses filters described using Laplace and Z transforms. A written report is available, but to really use the Notebook version you need a Macintosh with 4MB of memory, and a hard disk, as well as Mathematica. The Notebook can be obtained by writing Malcolm Slaney, Apple Computer, 20525 Mariani Ave., Cupertino CA 95014, or preferably by electronic mail at malcolm@apple.com.

AMS Centennial Publications • Volume I

A History of the Second Fifty Years
American Mathematical Society • 1939-1988

Everett Pitcher

This is volume one of a two-volume set which is being published to commemorate the AMS Centennial. (Volume 2 will contain the Proceedings of the AMS Centennial and will be published at a later date.) Professor Everett Pitcher served as an AMS Associate Secretary for 8 years and as the Society Secretary for the past 22 years. His long association with the Society, his detailed knowledge of its workings, and his historical perspective on the American mathematical community make him the ideal author for such a work.

Professor Pitcher chronicles the Society’s activities over the past fifty years, as it grew in membership, in volume and diversity of its publications, in the number of meetings and conferences it organizes, and in the range of services it provides to the mathematical community. The book presents a picture of the AMS in 1938 and delineates the political and social influences that shaped its subsequent development. Some of the key personalities in the Society’s history, notably the Presidents, are also described. This book is the crowning achievement in Professor Pitcher’s years of dedication and service to the Society.

This book complements the history of the Society’s first fifty years, written in 1938, the Society’s semicentennial year, by Raymond Clare Archibald, who was the AMS librarian at that time. Archibald’s history is volume one of American Mathematical Society Semicentennial Publications.

1980 Mathematics Subject Classification: 01
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Let us briefly explain just how the scientific portions of Joint Mathematics Meetings are scheduled. The responsibility for scheduling lies with the AMS-MAA Joint Meetings Committee. The four voting members of this committee are the Executive Directors and Secretaries of the two organizations. Hope Daly, Director of Meetings, serves as a professional consultant to the committee. The sequencing of the scientific program is primarily the responsibility of the MAA Secretary and one of the four AMS Associate Secretaries in consultation with the AMS Meetings Department. Efforts are made to avoid concurrent scheduling of closely related program items, but some conflicts are nonetheless inevitable.

Over the decades various agreements concerning scheduling have been made. One rule is that there shall be no scientific program conflicting with business meetings. There are also agreements to avoid, as much as possible, conflicts with the major addresses that are designed for a broad audience: the MAA Hedrick Lectures, the first two AMS Colloquium Lectures, and the AMS-MAA Invited Addresses. In addition, each organization has separately required that none of its own regular programming conflict with its own invited addresses. We believe that these agreements have strengthened the meetings.

A problem developed in that some meeting attendees found too many different events of interest scheduled simultaneously during one time period of the meeting and too few events scheduled at another time period.

The remedy was easy: The AMS and MAA each agreed to relax the no-conflict rule for their separate schedules. Beginning with the summer meeting in Boulder, the combined program will be more evenly spread out. The total number of conflicting activities will remain about the same, but attendees will generally find more choices available to them and a more even schedule over all.

Robert M. Fossum
Secretary, American Mathematical Society

Kenneth A. Ross
Secretary, Mathematical Association of America
Washington Outlook

This month's column is written by Hans J. Oser, who is a consultant to the Office of Governmental and Public Affairs of the Joint Policy Board for Mathematics in Washington, D.C.

While the science policy gurus in Washington are waiting for the Bush administration to fulfill those promises of strong support for science and education, Capitol Hill went ahead with scheduling the first hearings of the 101st Congress assembled here in this town on the Potomac River. Beginning on the last day of February, the House Subcommittee on Science, Research, and Technology (which has oversight of the National Science Foundation (NSF), and other technical agencies of the government) opened its legislative agenda with hearings on how to decide between big science and little science, on finding ways to set priorities between different fields of science, and on the adequacy of funding for single investigators.

In his opening statement, chairman Doug Walgren, a Democrat from Pennsylvania, expressed his concern over the lack of support for the university infrastructure and whether the quality and number of students entering various fields of science is adequate to meet future needs of the country.

The first witness was Robert M. White, President of the National Academy of Engineering (NAE), who expanded on *Federal Science and Budget Priorities*, a paper the three academies (NAE, the National Academy of Sciences, and the Institute of Medicine) had submitted to Congress a month earlier. White expanded on the three points made in that paper.

One, to create a framework for the assessment of science and technology (S&T) budgets. This would entail the examination of proposed expenditures against a set of national purposes which, the academy paper suggests could be the following: S&T activities which support agency missions, maintenance of the nation's S&T base, S&T support for national priorities as decided by the President and the Congress, and major costly science and engineering initiatives that require large incremental expenditures.

Second, it is necessary, White said, to examine the present budget process where it fails to respond adequately, in particular where contributions from several agencies have to be judged together and multiple jurisdictions of Congress are involved. This requires presidential S&T budget guidance early in the annual budget cycle. The role of the science adviser to the president is crucial in this context, the academies say.

Third, the academies note the confusion that arises from lumping together civilian and defense research and development (R&D) statistics.

To illustrate White's point: Federal R&D support grew from $31.7 million in FY 1980 to $59.1 million in FY 1988. A closer inspection, found in a AAAS publication: *R&D in the 1980s: A Special Report* by Albert H. Teich and Kathleen M. Gramp:

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<td></td>
<td>Actual</td>
<td>Estimated</td>
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<td><strong>Defense R&amp;D</strong></td>
<td>$15.0</td>
<td>$40.3</td>
<td>169%</td>
<td>83%</td>
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<td>Basic Res.</td>
<td>0.6</td>
<td>0.9</td>
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<tr>
<td>Applied Res.</td>
<td>1.9</td>
<td>2.6</td>
<td>38%</td>
<td>-7%</td>
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<tr>
<td>Development</td>
<td>12.5</td>
<td>36.7</td>
<td>194%</td>
<td>99%</td>
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<tr>
<td><strong>Nondefense R&amp;D</strong></td>
<td>$16.7</td>
<td>$18.8</td>
<td>13%</td>
<td>-24%</td>
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<td>Basic Res.</td>
<td>4.2</td>
<td>8.6</td>
<td>107%</td>
<td>40%</td>
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<tr>
<td>Applied Res.</td>
<td>5.0</td>
<td>6.5</td>
<td>29%</td>
<td>-13%</td>
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<tr>
<td>Development</td>
<td>7.5</td>
<td>3.7</td>
<td>-50%</td>
<td>-66%</td>
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Source: AAAS Report VI and "OMB data for Special Analysis J, FY 1988 Budget." Notes: Includes conduct of R&D only. Columns may not add due to rounding. Percentages based on unrounded numbers.

The House committee sees the academies' report as a good start for applying meaningful criteria to budget decisions and for obtaining informed opinion before political judgment enters the appropriations process.
In other testimony, Lewis Branscomb, Harvard University, and Jay Keyworth III, Hudson Institute, and William Carey, a former Assistant Director of the Bureau of the Budget (now the Office of Management and Budget), suggested different models for how science advice at the presidential level should be given. Branscomb would prefer a science adviser with the rank of assistant to the president, supported by advisory committees. To abandon decentralized decision making which has served us so well for the past 40 years, should not be undertaken lightly, Branscomb feels. Keyworth still stands behind his proposal to create a department of science. Branscomb, on the other hand, does not believe it is possible to bring such diverse agencies as NSF, the National Aeronautics and Space Administration (NASA), and the National Institutes of Health (NIH) together into one department (and without these the department would not play any role at all). The powerful constituencies of these agencies and the congressional committees with jurisdiction over them would not permit such a reorganization. Carey's position is that the lack of a civilian counterpart to the Defense Advanced Research Projects Agency (DARPA) hurts the country and that it is wrong that funding for new technology can now only be obtained from the government when a defense interest is involved. All three witnesses agreed, however, that our present situation in mathematics and science education needs immediate attention if we want to stay competitive in world markets.

The committee also heard a panel of three active research scientists presenting their views on the current research climate. Charles Fefferman, Princeton University, for mathematics; Richard Muller, Lawrence Berkeley Laboratory, for physics; and Thomas Pollard, Johns Hopkins University, representing cell biology, spoke for about 10 minutes each. Rather different views emerged on the effectiveness of the peer review process used by the National Science Foundation. Fefferman saw the process as the preferred method for allocating resources within a scientific discipline, whereas Muller felt that the process assured nothing but mediocrity and that bold proposals had no chance to get funded at NSF.

It seems to this observer that the rather different perceptions of the NSF review process might be the result of using rotators differently in the mathematical sciences division than in the physics divisions. The high percentage of academic rotators in the mathematical sciences division at NSF certainly assures closeness to the cutting edge of current research and a sense of commitment "to have done the right thing" after returning to the academic world after a year or two. The dynamics are very different when the permanent staff outnumbers the rotators in a division. The frequent turnover in the mathematical sciences division also provides for a large number of alumni in the research community who have served as program officers at NSF and who can provide their professional colleagues with valuable insights on how the grants process works, thereby creating a better atmosphere for understanding how NSF operates.

Fefferman, in response to the committee's questions, put the responsibility for deciding on national priorities squarely in the hands of the political leadership. Scientists have the responsibility to provide input to the process for informed decision making. But there is a point when technical feasibility is not the deciding criterion alone, but when international competitiveness, national priorities, and national defense have to be weighed in, the political leadership in the executive branch and in the Congress must enter the picture. Fefferman warned the committee that the decline both in numbers and in quality of graduate students over the past decade is a serious problem for the future of mathematical research and that this will not change unless support for university research is brought up to the levels that were suggested by the David committee five years ago.

Pollard, whose support comes primarily from NIH, is deeply concerned over the large numbers of excellent proposals that have to be turned down every year. He was most eloquent in his assessment of the present state of science education and he called for vastly more ambitious programs for improving education than what the President proposed in his budget message this year. $250 million works out to just $5 for each student in our primary and secondary schools, he observed. To make a real impact, a more realistic figure would be $23 billion, in Pollard's opinion.

Regarding decisions on national priorities, Pollard showed his disdain for politicians. He feels quite sure that scientists can make decisions not only on the scientific merit of an idea but also whether it meets national priorities. The committee did not challenge Pollard's testimony during the questioning.

Strong testimony came from Mary Good, Allied Signal Inc., currently the chair of the National Science Board, the policy-making body of the NSF. She sees a serious threat to our industrial leadership position in the world because of our eroded science and technology base. Science and math scores of our children are alarmingly poor and fewer and fewer U.S. citizens are choosing scientific careers. Good raises four priority issues: (1) How do we effectively support the R&D
necessary for our competitiveness efforts?, (2) What is needed to provide the technology base for our continued military superiority?, (3) How do we provide the research and development necessary to continue our programs in health and environment improvement?, and (4) Can we strengthen the science and technology infrastructure in our schools, colleges and universities so that the science base for the next generation will be available as needed, including adequate [numbers of] scientists and engineers available to maintain our leadership positions? Good does not imply a priority ordering on that list because all four goals have to be met in some way. The question is how to meet these goals in the most cost effective manner.

To address these questions effectively, Good calls for a strong science adviser, with a rank of assistant to the president. Adding to that a high-quality president's advisory council for technology, she feels that the Office of Science and Technology Policy could actually manage a national strategic plan for science and technology. In her scheme, the science adviser would, early in the budget cycle, convene a planning group that includes the undersecretary for science and technology at Commerce, the undersecretary for research and development at Defense, the appropriate undersecretary at Energy, and the directors of NASA, NIH, and NSF. A group at that level would be expected to construct a framework for fundamental research focused on universities, assess the role of national laboratories in each of the agency missions, and coordinate major technology programs so that industry spinoffs are optimized to the extent compatible with the-mission objectives.

Good is quite aware that this language is provocative to some and she adds that one reason for our past strength has been our diversity. But she believes that such diversity can be maintained within the framework of a coordinated effort. With appropriate cross-cutting cooperation and the determination of the executive and congressional branches to "sunset" programs promptly, Good thinks we can afford the resources necessary to maintain our leadership in science and technology, including our share of so-called "big science" initiatives.

She concluded her testimony with a few specific ideas that suggest some first steps in the implementation of her plans. One, to promote international cooperation and sharing of large science projects. Candidates for joint activities with Europe and Japan would be "big science" facilities, global environment research, and human factors research. Immediate candidates are the NSF drill-ship program for global geology, the superconducting supercollider, global mapping for the greenhouse effect, and some astronomy centers.

Secondly, she feels that the annual cross-cutting strategic planning would lead to some joint agency funding—something that is rarely found today. Candidates for such funding would be certain materials research centers, science and technology centers, supercomputer centers, and some fellowship programs.

Her third observation is on science education and the fostering of public understanding of technology. The national need for improved science and mathematics education, and for the public to understand the technological environment, is so great that all agencies should contribute to the solutions. Every federal agency should have an educational component and a pre-planned public relations strategy, she suggests.

METHODS AND APPLICATIONS OF MATHEMATICAL LOGIC

Walter A. Carnielli and Luiz Paulo de Alcantara, Editors

(Contemporary Mathematics, Volume 69)

This volume constitutes the proceedings of the Seventh Latin American Symposium on Mathematical Logic, held July 29–August 2, 1985, at the University of Campinas in Brazil. Striking a balance between breadth of scope and depth of results, the papers in this collection range over a variety of topics in classical and non-classical logics. The book provides readers with an introduction to the active lines of research in mathematical logic and particularly emphasizes the connections to other fields, especially philosophy, computer science, and probability theory. The potential applicability of the mathematical methods studied in logic has become important because various areas—such as software engineering, mathematical biology, physics, and linguistics—now appear to need mathematical methods of the kind studied in logic.

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News and Announcements

Morton L. Curtis
1921–1989

Morton Landers Curtis, professor of mathematics at Rice University, died on February 4, 1989 at the age of 67. Throughout his professional career, Professor Curtis was active in many Society committees and held several AMS offices.

Professor Curtis received his B.S. in chemical engineering in 1943 from the Texas College of Arts and Industry and his Ph.D. in mathematics from the University of Michigan in 1951. Between 1950 and 1964, he held positions at Northwestern University, the Institute for Advanced Study, the University of Georgia, and Florida State University. He was also a National Science Foundation Postdoctoral Fellow at Causis College of Cambridge University in 1959–1960. From 1964 to 1969, he was chairman of the mathematics department at Rice University, and in 1967 he was appointed W. L. Moody, Jr. Professor of Mathematics at Rice, a post he held until his death.

In 1964-1965, Professor Curtis held the office of AMS Associate Secretary. During 1966–1969 he was a member of the Board of Trustees and, during 1971–1973, he served as a Member-at-Large of the Council. He served on numerous AMS committees, including the Committee on Graduate Instruction and Research (1962–1963), the Committee on Employment Opportunities (1962–1965), the Committee on Legal Aid (1975–1988), and the Committee on the Research Expository Journal (1977–1978). He also served on two committees of the Board of Trustees, the Building Committee (1968–1969) and the Committee on Staff and Services (1968–1971). He was Associate Editor for Research Expository Articles for the Bulletin of the AMS in 1979.

Professor Curtis presented an AMS Invited Address in 1970, and chaired a Special Session on nonassociative algebras and applications in 1979. His research area was topology.

Chorin and Kruskal to Share NAS Award

Alexandre J. Chorin of the University of California at Berkeley and Martin D. Kruskal of Princeton University will jointly receive the National Academy of Sciences Award in Applied Mathematics and Numerical Analysis. The $10,000 prize is among several Academy prizes to be awarded on April 24 at the Academy's 126th annual meeting in Washington, DC.

Chorin will be cited for “his numerous and deep investigations of scientific problems by means of computation and, in particular, for his development of the vorticity method for solving a wide variety of problems in fluid dynamics.”

Kruskal will be cited for “fundamental contributions to the understanding of plasma instabilities and the theory of general relativity, and for his discovery of solitons, the associated conservation laws, and the inverse scattering method.”

The Award in Applied Mathematics and Numerical Analysis was established in 1972 with funds provided by the International Business Machines Corporation. It is awarded every three years in recognition of outstanding work in applied mathematics and numerical analysis.

Sloan Research Fellowships Awarded

The Alfred P. Sloan Foundation announced that ninety-one outstanding young scientists and economists have been selected to receive Sloan Research Fellowships. The new fellows, doing research at the frontiers of physics, chemistry, mathematics, neuroscience and economics, are on the faculties of 55 universities and colleges.

The Sloan Research Fellowship Program is now 34 years old. With the current awards, the Foundation has spent more than $50 million to assist nearly 2500 young researchers. Fifteen of the former Sloan Fellows have received Nobel prizes, including two in 1988. Eleven have won the Fields Medal for mathematics, and hundreds have received other prestigious awards and honors.

The average age of the 1989 fellows is just under 32 years. They were selected from among hundreds of highly qualified young scientists in the early stages of their careers on
the basis of their exceptional promise to contribute to the advancement of knowledge. Candidates for the fellowships are nominated by senior scholars familiar with their talents.

Albert Rees, President of the Foundation, said in announcing the awards, “We were most pleased that there are twelve women among the new fellows, the largest number in more than a decade. We hope that this indicates a longer-run increase in the number of outstanding women attracted to academic careers in science.”

The Sloan Research Fellowships were established by the Alfred P. Sloan Foundation in 1955 as a means of stimulating fundamental research by young scholars at a time in their careers when government and other support is difficult to obtain. The grants of $25,000 each for a two-year period are administered by each fellow’s institution and are designed to permit the greatest possible freedom and flexibility for the researchers. Fellows need not pursue a specified research project and are free to shift the direction of their research at any time. The fellowship funds may be used for such purposes as equipment, technical assistance, professional travel, trainee support, or any other activity directly related to the fellow’s research.

Nominations for the 1989 awards were reviewed by a committee of distinguished senior scientists.

The following 21 mathematical scientists received awards:

David J. Anick, Massachusetts Institute of Technology; Keith Burns, Northwestern University; Jennifer Tour Chayes, University of California, Los Angeles; Lincoln Chayes, University of California, Los Angeles; Sidney I. Frankel, Columbia University; Andreas Floer, University of California, Berkeley; Solomon Friedberg, University of California, Santa Cruz; Amit Ghosh, Oklahoma State University; Matthew A. Grayson, University of California at San Diego, La Jolla; Joel Hass, University of California, Davis; Janos Kollar, University of Utah; Fang-Hua Lin, University of Chicago; John W. Lott, University of Michigan; Matei Macedon, Princeton University; Jill C. Pipher, University of Chicago; Leslie D. Saper, Duke University; Takahiro Shiota, Brandeis University; Panagiotis E. Souganidis, Brown University; Alain Sol Sznitman, New York University; Hans Wenzl, University of California at San Diego, La Jolla; Zhihong Xia, Harvard University.

News Release

CMS Gift for AMS Centennial

The Canadian Mathematical Society (CMS) has presented the AMS with a replica of the model for the original Fields medal, in honor of the AMS Centennial last year. The original medal was commissioned in 1933 and designed by Robert Tait McKenzie, the noted Canadian sculptor who died in 1938. The replica was produced with the permission of the University of Toronto.

The replica consists of two pieces, each about eight inches across, which show front and back of the medal. They are mounted on a blue background and set in a gilt frame. The front of the medal depicts the head of Archimedes, and the back contains a Latin inscription decorated with an olive branch. The gift will be displayed at the AMS headquarters office in Providence.

AAAS Report on Scientific Literacy Released

The American Association for the Advancement of Science (AAAS) has released a report outlining what all 18-year-olds should know about mathematics, science, and technology to function in our increasingly technological society. Without examining current ills in the educational system or recommending specific curricula or teaching strategies, the report seeks to characterize scientific literacy.

Entitled “Science for All Americans,” the report represents the first phase in Project 2061, which is intended to revamp precollege education in mathematics, science, and technology over the next 10 to 15 years. The AAAS assembled a National Council on Science and Technology Education, which drew on the reports of five independent scientific panels in the preparation of “Science for All Americans.” The mathematical scientists on the 26-member Council are Frederick Mosteller of Harvard University and Henry O. Pollak, an industrial mathematician retired from Bell Communications Research. The co-authors of the mathematics panel report are David Blackwell and Leon Henkin, both of the University of California at Berkeley.

A fundamental premise of Project 2061 is that the schools should not teach more, but rather less science and mathematics, so that students can learn the material more thoroughly. To this end, “Science for All Americans” focuses on identifying those ideas and skills that are most crucial for students to understand.

The report’s recommendations cover a broad array of topics, many of which are already treated in current science and mathematics curricula. However, the report’s perspective differs from the traditional in two major ways. First, Project 2061 seeks to reduce boundaries between disciplinary areas and emphasize connections between them. A second difference is the level and kind of detail students are expected to master. “Ideas and thinking skills are emphasized at the expense of specialized vocabulary and memorized procedures,” says a summary of the report. “Details are treated as a means of enhancing, not guaranteeing, students’ understanding of general ideas.”

Project 2061 initially met with some opposition from the mathematical sciences community, which
charged that the original conception of the project reduced the role
of mathematics to that of a “servant” of science. Because of the
project’s intention of blurring boundaries between disciplines, the idea
was to introduce mathematical concepts whenever they naturally surfaced in science. As a result of the controversy, the perspective of the project eventually was shifted to treat mathematics as a separate topic,
and the mathematics panel was appointed.

Henkin says that the biggest and most revolutionary part of the mathematics panel’s report is the way it treats the “processes” of mathematics, which the panel describes as abstraction; symbolic manipulation, including computation and deduction; and comparison and application. “Those are the things that happen when you do mathematics,” says Henkin. “The important part of mathematics is not this piece of trigonometry, or this piece of algebra, but these fundamental processes.”

Although the panel’s report does contain one section that focuses on certain topics that it recommends students should learn about—such as numbers, shapes and patterns, probability, and optimization—Henkin says the panel purposely did not want to simply list mathematical areas to be covered. “As they move from kindergarten through high school, kids should move through all of those processes in the context of activities that are appropriate to their lives,” he says. For example, a student who wants to build a birdhouse will go through those processes in a natural way. Traditionally, says Henkin, “We don’t encourage students to make their own abstractions. We just hand them multiplication tables and formulas.”

Two other important sections of the panel’s report focus on mathematical language, and mathematics and emotions. Henkin says the optimal age for learning languages is between 2 and 6, so “the earlier we get students talking mathematically about whatever they’re doing, the better.” In the area of emotions, Henkin notes that one characteristic that sets mathematics apart from other disciplines is fear. That mathematics is fearsome because it is inherently difficult is a pervasive notion in our society, and Henkin believes that bringing positive emotions to bear on mathematical activity from an early age will help to dispel this notion.

Henkin is unsure how much the mathematics panel’s report will end up influencing the direction of Project 2061, partly because “Science for All Americans” does not carry the full impact of the report. “I think ‘Science for All Americans’ is a useful and important document, but it doesn’t convey the spirit, and the main thrust of the panel’s report,” he says. “None of the authors on the various panels felt it captured the revolutionary flavor of their reports.” In addition, a great deal depends upon how those participating in Phase 2 of Project 2061—which involves the development of model curricula—use the panels’ reports. “I hope that people interested in mathematics education read both ‘Science for All Americans’ and the mathematics panel report,” says Henkin.

Mathematics Sweep

Top Prizes in Teenage Talent Search

Students submitting mathematics projects garnered the first and second prizes in the Westinghouse Science Talent Search, the prestigious national competition that annually awards scholarships and cash prizes to teenage students who conduct university-level research.

The top $20,000 scholarship went to Christopher McLean Skinner, age 16, of Little Rock, Arkansas, for a project investigating a certain form of Diophantine equation of two or more variables of the form \( ap^x + bq^y = c + dp^aq^w \). Generally, there are infinitely many solutions for each of the variables in such an equation. Skinner selected two specific equations with four unknowns of a form which had been considered by others to be insolvable by elementary methods. He demonstrated the existence of upper bounds on integral solutions for those equations.

The second place prize of a $15,000 scholarship went to Jordan S. Ellenberg, 17 years old, of Potomac, Maryland. Ellenberg’s project, “Investigation of \( k \)-ary \( n \)-tuples of Integers,” identified and characterized sets of positive integers satisfying certain simple symmetric systems of congruences. He proved the existence of upper bounds for the number of elements in these sets of numbers and identified all unitary 3-, 4-, and 5-tuples, as well as all 2-ary and 3-ary 3-tuples.

Mathematics winners are Christopher Skinner and Jordan Ellenberg, first row, third and fourth from left, respectively.

The third through tenth prizes, which range from $15,000 to $7500, went to students submitting projects in biology, social science, chemistry, microbiology, physics, toxicology, and bacteriology. Thirty other students were designated finalists and awarded $1000 each. Across the nation, 1,461 students competed for a total of $140,000 in prize money.

The forty semifinalists visited Washington in early March, where they went to the National Academy of Sciences to hear President Bush speak on the importance of science and education. The winners were selected by a panel of eight scientists following interviews designed to evaluate the students’ scientific creativity.
and potential. On March 6, the 10 top winners were announced at an awards ceremony and formal dinner in Washington. More than 500 leaders from science, government, education, and business attended the awards ceremony.

Among the 30 finalists, there were several submitting projects in mathematics: Wai Ling Ma of Brooklyn, New York and Vladimir Teichberg of Rego Park, New York, who both did projects in number theory, and Simon Robert Zuckerbraun of Esplanade, New York, who did a project on permutation groups. There were also several mathematically-based physics and computer science projects.

Of the 1,920 winners in the Westinghouse Science Talent Search since its inception in 1942, two have won Fields Medals, David Mumford of Harvard University, and Paul J. Cohen of Stanford University. In addition, five have gone on to win Nobel Prizes, eight have been awarded MacArthur Foundation Fellowships, and many have been elected as members of the National Academy of Sciences.

**BMS Sponsors Number Theory Symposium**

The Board on Mathematical Sciences (BMS) of the National Research Council will present a special symposium on number theory as part of National Science and Technology Week. John Tate of Harvard University will chair the symposium and will open the proceedings with a talk entitled "Number Theory: History and Future Directions."

The other speakers on the program are: Hendrik Lenstra of the University of California at Berkeley, who will speak on “Applied Number Theory”; Barry Mazur of Harvard University, who will speak on “Number Theory as Gadfly”; and Andrew Odlyzko of AT&T Bell Laboratories, who will speak on “Primes, Quantum Chaos, and Computers.”

**Mathematical Scientists Elected to National Academy of Engineering**

The National Academy of Engineering (NAE) recently announced the election of 90 new members and seven foreign associates. Academy membership honors those who have made “important contributions to engineering theory and practice, including significant contributions to the literature of engineering theory and practice,” or those who have demonstrated “unusual accomplishment in new and developing fields of technology.”

The following are the mathematical scientists who were elected to the NAE.

- **George A. Bekey**, University of Southern California
- **Joel S. Birnbaum**, Hewlett-Packard Company
- **Juris Hartmanis**, Cornell University
- **John E. Hopcroft**, Cornell University
- **Marvin L. Minsky**, Massachusetts Institute of Technology
- **Jeffrey D. Ullman**, Stanford University
- **Moshe Zakai**, Haifa, Israel

Alice T. Schafer Prize Established

At its meeting in Phoenix, the Executive Council of the Association for Women in Mathematics (AWM) established the Alice T. Schafer prize, in recognition of the many years of leadership and service that Alice Schafer has given to AWM. Schafer served as president of AWM from 1976-1978 and kept a watchful eye on the Wellesley office for nearly two decades. Beginning in 1990, the prize will be awarded annually to an undergraduate woman for excellence in mathematics. A committee has been established to determine an appropriate mechanism for awarding the prize.

**News from the Mathematical Sciences Research Institute Berkeley, California**

There has been a significant upgrading in the computing setup at Mathematical Sciences Research Institute (MSRI). A study grant being conducted jointly with IBM Corporation has brought to MSRI twenty RT workstations, along with auxiliary equipment and an in-house software engineer. On January 20, 1989, on the occasion of the annual meeting of the MSRI Board of Trustees, there was a ceremony initiating the RT’s. They are being named for outstanding mathematicians, and the first RT was named for Shing-Shen Chern, MSRI’s founding director.
yearlong programs in Combinatorial Group Theory and Symplectic Geometry there was a special month devoted to Completely Integrable Systems, conducted by Vaughan Jones. The opening lecture was delivered by Ludwig Faddeev of the Leningrad Steklov Institute; it lasted a full morning, as did nearly all the succeeding lectures. Some of the subsequent speakers were Atiyah, Bott, Freed, Goddard, Jimbo, Jones, Kauffman, Lepowsky, Miwa, Perk, Witten, and Ziman. From January 23 to January 27 MSRI hosted a workshop on Algorithms in Combinatorial Group Theory, chaired by Gilbert Baumslag. Six of the participants were from the Soviet Union: Adian, Apanasov, Greendlinger, Grigorchuk, Kharlamovich, and Repin.

Six more special events will round out the current academic year: a month of concentration on Quantization (April), a workshop on Arithmetic Groups (May 8–12), a visit by the Séminaire Sud-Rhodanien (May 22–June 2), a workshop on Vortex Methods (May 22–24), a workshop on Hamiltonian Systems (June 5–16), and a microprogram on Noncommutative Rings (July 10–21).

Future programs have been set as follows.


Applications are currently invited for 1990-1991. MSRI will offer postdoctoral fellowships and senior memberships; the deadline for applying is December 15, 1989. In addition, the program of Research Professorships will be repeated; this has the earlier deadline of October 1, 1989. Candidates are welcome in all areas of the mathematical sciences as well as in the three programs. Watch for detailed announcements in an advertisement in the AMS Notices and in a widely distributed poster.

Mathematical Sciences Institute Completes 1988-1989 Workshop Series
Cornell University

The Mathematical Sciences Institute (MSI) at Cornell University will conclude a series of workshops held during the 1988-1989 academic year, with a workshop on Markov Processes in Functional Spaces, organized by Eugene B. Dynkin, Cornell. The workshop will be held from May 14–16, 1989, in connection with MSI’s Statistics and Applied Probability Program.

MSI’s recent workshops covered a number of topics germane to two of the four primary areas of mathematical research pursued by MSI researchers: Applied Analysis and Physical Mathematics. In the area of Applied Analysis, MSI held workshops on: Kinetic Equations and Microlocal Analysis, both organized by Claude Bardos, ENS, and Mathematical Methods in Plasma Physics, organized by Jerrold E. Marsden and Philippe Similon, Cornell University.

Marsden, who will be MSI’s program director for Applied Analysis in the fall of 1989, will be overseeing three workshops on symmetry and Berry’s phase, symplectic integrators and transport, and mixing and reaction rates. He attributes the current high interest in mathematical methods in mechanics to the emergence and maturity of nonlinear science. Interest also is high because the mathematical structures explored in one area, such as plasma physics, are important in problems in others, such as spacecraft dynamics, dynamic motion of robots, and fluid mechanics.

In the area of Physical Mathematics, MSI held two workshops. Multiphase Flow, organized by D. Drew of Rensselaer Polytechnic Institute, and S. L. Passman of Sandia-Albuquerque, examined the partial differential equations that govern the motion of multiphase flows. Whither Turbulence? or Turbulence at the Crossroads, organized by John L. Lumley, Cornell University, explored a number of distinct research directions, including traditional ones, and was designed to allow proponents of various points of view to air opinions through position papers.

MSI also sponsored a Groebner Basis workshop, which presented recent theoretical developments in the area of Groebner Bases, an active branch of constructive algebra. It was organized by Moss Sweedler, Cornell University. MSI would like to follow up with related workshops in the areas of non-mathematical applications and implementation and is looking for potential organizers.

Four MSI workshops are planned for the summer of 1989 on the topics of The Packing and Mechanics of Aggregates of Spheres (June 15–19), organized by Robert Connelly and James Jenkins, Cornell University; Feasible Mathematics (June 26–28), organized by Samuel Buss, University of California at San Diego, and Philip Scott, University of Ottawa; Hardware Specification, Verification, and Synthesis, Mathematical Aspects (July 5–7), organized by Goefrey Brown and Miriam Leeser, Cornell University; and Mathematical Theory of Modern Financial Markets (July 19–22), organized by D. Heath, R. Jarrow, and K. Shell, Cornell University, and P. Artzner, Strasbourg.

For more information, contact Teresa M. Craighead, MSI Media Coordinator, 607-255-8911, ter@cornellc.bitnet.

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

The Institute for Mathematics and its Applications (IMA) preparations for the 1989 summer in Statistics are nearly complete. The first two weeks July 10–21 are organized by
Werner Stahel and will concentrate on issues in Robustness. This will be followed by a two week focus on Diagnostics (July 24–August 4) with Sanford Weisberg as coordinator. Finally there will be a three week period August 14–September 1 on Computational Statistics and Statistical Graphics with Andreas Buja, Luke Tierney, Paul Tukey, and Werner Stuetze as organizers. The IMA will dedicate August 1 to the work of John Tukey; he will be joined by his colleagues and former students who will celebrate his 70th birthday. During the week of August 7–10 there will be a break for the American Statistical Association annual meeting in Washington, D.C., and the IMA will host at that time a conference on “New Trends and Applications of Distributed Parameter Control.” This conference is organized by G. Chen, E. Bruce Lee, W. Littman, and L. Markus. For details contact E. B. Lee, University of Minnesota, Department of Electrical Engineering, Minneapolis, Minnesota 55455.

As the present year on Nonlinear Waves is unfolding the IMA will be running in April a three week workshop on Multidimensional Hyperbolic Problems and Computations. The Tuesday April 4 program will be devoted to forward-looking lectures based on the work of Ron DiPerna and delivered by his friends. The third week of the workshop, April 17–21, will concentrate on Computational Issues; there will be emphasis on working sessions and numerical illustrations on the Cray 2 with a minimum of formal lectures. Part of the April workshop will be sponsored jointly with the Minnesota Supercomputer Institute.

The IMA has just concluded a series of activities on Hyperbolicity and Change of Type in Multiphase Flows. Many of the discussions made it clear that, aside from the significant mathematical difficulties, some of the basic models are still in need of fundamental developments. This is particularly so for the existing models of fluidized beds (suspension fluids), composite materials, plastic materials, and heat waves.

The final workshop in the Nonlinear Waves program in the coming spring will be on “Microlocal Analysis in Nonlinear Waves” and is organized by Michael Beals, Richard Melrose, and Jeffrey Rauch. It will take place May 15–19. During the preceding week Michael Beals will give a tutorial on the subject. Finally during June 26–30 B. F. Caviness and Michael Singer will organize a workshop on “Symbolic Computation Methods in Differential Equations.” The workshop will feature research talks as well as tutorial lectures on the use of computer algebra systems in solving ODE and PDE problems. Each participant will be given a computer account for hands on use of one or more of the systems. Featured systems are expected to be MACSYMA, REDUCE, and SCRATCHPAD II.

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**FACTORIZATIONS OF** $$b^n \pm 1, \ b = 2, 3, 5, 6, 7, 10, 11, 12 \text{ UP TO HIGH POWERS}, $$
**SECOND EDITION**

(Contemporary Mathematics, Volume 22, Second Edition)

This book is a revised and updated edition of a work that originally appeared in 1983. It gives a historical account of the various methods and machines that have been used to factor, and prove prime, the numbers $$b^n \pm 1.$$ It is a revised version of an extension of a rare 1925 work by Cunningham and brings together results going back to the seventeenth century. The factorizations and the very large primes of special form are useful in group theory, number theory, discrete Fourier transforms, random number generators, and cryptography. The present edition contains more than 2000 large primes which have never been published before.

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

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NSF-NATO Postdoctoral Fellowships Awarded

The National Science Foundation has announced the award of fifty-four National Science Foundation-North Atlantic Treaty Organization (NATO) Postdoctoral Fellowships in Science. These fellowships are awarded to young U.S. scientists and engineers for full-time postgraduate study abroad at institutions and laboratories in other NATO countries.

The two recipients in the mathematical sciences for 1989 are ALAN S. EDELMAN of the Massachusetts Institute of Technology who will visit the University of Madrid, Spain, and MARK SPIVAKOVSKY of Harvard University who will visit the Institute des Hautes Etudes Scientifiques, Bures-sur-Yvette, France.

The application deadline for the 1990 Fellowship program is November 5, 1989. For information and application material for the 1990 program write to NATO Program, Division of Research Career Development, Room 630, National Science Foundation, Washington, DC 20550.

Faculty Enhancement Awards Announced

The National Science Foundation (NSF) has announced 45 new awards in its Faculty Enhancement program, which sponsors workshops and seminars for undergraduate teaching faculty to keep abreast of developments in their fields. The program is part of an NSF initiative in undergraduate science, engineering, and mathematics education.

In all disciplines, approximately 3000 undergraduate faculty members will participate in the program. The grants cover the cost of instruction, facilities, and, in many cases, room and board and a modest stipend for participants. In addition to the workshops and seminars, activities sponsored by the program include computer network development, site visits by project leaders to participants' home institutions, and reunions at national meetings.

The following lists the names of principal investigators for the new awards in mathematics and computer science, together with their institutions, the title of the projects, and the amount of the grant.

- DAVID W. KAMMLER, Southern Illinois University, Carbondale, Short courses in discrete and continuous Fourier analysis, $39,731;
- DONALD B. SMALL, Colby College, Computer algebra systems workshops, $192,024;
- BERNARD A. FUSARO, Salisbury State College, Mathematics and the microcomputer workshops: I. Chaos, II. Decisionmaking, $16,885;
- CHRISTOPHER H. NEVISON, Colgate University, Parallel computing for undergraduate faculty, $50,464;
- ALBERTO GUZMAN, City University of New York City College, Comprehensive regional center for minorities at City College, $9,000;
- PETER B. HENDERSON, State University of New York at Stony Brook, Modern foundations of computer science, $52,207;
- VIVIAN KRAINES, Meredith College, Computers in the classroom for mathematics education, $38,236;
- JERRY A. JOHNSON, Oklahoma State University, Uses of electronic technology in undergraduate mathematics: A workshop and forum for college faculty, $88,044;
- MARVIN L. BRUBAKER, Messiah College, Using ISETL and CAL to teach mathematics, $24,025;

Although the deadline for the next round of proposals will be available by the time this issue of Notices reaches its readers, it had not been set at the time of this writing. Readers interested in learning the deadlines and obtaining more information may write to Undergraduate Faculty Enhancement Program, Division of Undergraduate Science, Engineering, and Mathematics Education, Directorate for Science and Engineering Education, National Science Foundation, 1800 G Street, NW, Washington, DC 20550.

DoEd Graduate Education Program

Last year the Department of Education initiated the Graduate Assistants in Areas of National Need program to address pending shortages of doctoral-level personnel. The program is designed to encourage U.S. citizens to pursue Ph.D.s in areas of need crucial to academia, business, and industry.

The program provides funds to educational institutions to establish graduate fellowship programs. Last
year, awards ranging between $100,000 and $500,000 (per year for each of 3 years) were made to institutions across the country. The particular fields are chosen in consultations between the Secretary of Education and the National Academy of Sciences, the National Science Foundation, and the National Endowments for the Arts and for the Humanities. Last year, the designated areas were mathematics, chemistry, physics, and engineering.

Although the areas have not been determined for this year's competition, they are likely to be the same as last year. Mathematics departments had a good showing in the program last year, garnering 11 of the 42 awards made, for a total of $1.8 million. The total program budget last year was $7.6 million. This year the figure has risen to $13 million, about $5 million of which will go toward new awards. For the last batch of awards, the fellowships will begin this fall. In the upcoming competition, the fellowships will begin in fall of 1990.

The awards may be used only for tuition and stipends for students. Institutions receiving awards in the program must match 25% of the award, and this contribution may be met by tuition waivers or stipends. A minimum of 60% of the federal funds must go toward stipends, and no overhead is permitted. There is also a cap of $10,000 on that portion of an individual stipend drawn from the federal funds. To be eligible, students must be U.S. citizens or permanent residents. Apart from these rules, the institutions are permitted to decide how to administer the fellowships.

At the time of this writing, the program announcement had not yet been published, and the deadline was not set. However, the announcement and application forms are slated to appear in April in the Federal Register. Current plans call for a deadline sometime during the month of June, 1989.

It should be noted that the forms are available only in the Federal Register, not from the Department of Education. However, more information about the program may be obtained from Alan Cissell at the Department of Education, 202-732-4415. Though Cissell prefers phone calls over written inquiries, individuals may write to him at Graduate Assistants in Areas of National Need, U.S. Department of Education, 400 Maryland Ave., SW, Washington, DC 20202-5251.

Cissell also says that he is seeking qualified proposal reviewers for the program's panel review. Interested individuals should send their curriculum vitae and social security number to Cissell at the address given above.

1990-1991 Competition Opens for Fulbright Scholar Awards

The Council for International Exchange of Scholars has announced the opening of competition for 1990-1991 Fulbright grants in research and university lecturing abroad.

The awards for 1990-1991 include about 1,000 grants in research and university lecturing for periods ranging from three months to a full academic year. There are openings in over 100 countries and, in many regions, the opportunity exists for multicountry research. Fulbright awards are granted in virtually all disciplines, and scholars in all academic ranks are eligible to apply. Applications are especially encouraged from professionals, retired faculty, and independent scholars.

Grant benefits, which vary by country, generally include round-trip travel for the grantee and, for most full academic-year awards, one dependent; stipend in U.S. dollars and/or local currency; in many countries, tuition allowance for school-age children; and book and baggage allowances.

The basic eligibility requirements for a Fulbright award are U.S. citizenship; Ph.D. or comparable professional qualifications; university or college teaching experience; and, for selected assignments, proficiency in a foreign language. It should be noted that there is no limit on the number of Fulbright grants a single scholar can hold, but there must be a three-year interval between awards.

Application deadlines for the awards are:

- June 15, 1989: Australasia, Asia, and Latin America, except lecturing awards to Mexico, Venezuela, and the Caribbean;
- September 15, 1989: Africa, Asia, Europe, the Middle East, and lecturing awards to Mexico, Venezuela, and the Caribbean; Travel-only awards to France, Italy, and Federal Republic of Germany (travel awards have new deadline);
- November 1, 1989: institutional proposals for Scholar-in-Residence Program;
- November 1, 1989: International Education Administrators Program in Federal Republic of Germany, United Kingdom, and Japan; Seminar in German Civilization (all these programs have new deadline);
- January 1, 1990: NATO Research Fellowships and Spain Research Fellowships.


--CIES News Release

1990-1991 Fulbright Teacher Exchange Program

The United States Information Agency has announced details of the 1990-1991 Fulbright Exchange Program. The Teacher Exchange Program involves a one-on-one exchange for teachers at the elementary, secondary
and postsecondary levels with suitable teachers overseas. The 1990-1991 overseas exchange programs will likely involve Argentina, Belgium/Luxembourg, Brazil, Canada, Chile, Colombia, Cyprus, Denmark, Federal Republic of Germany, France, Hungary, Iceland, Italy, Mexico, The Netherlands, Norway, Philippines, Senegal, South Africa, Switzerland, and the United Kingdom. The number of exchanges available and the eligibility requirements vary by country. All programs are announced on a tentative basis and are subject to the availability of funds.

The program also provides opportunities for teachers to participate in summer seminars from three to eight weeks in length. During the summer of 1990, seminars will be held in Italy and The Netherlands.

Applications will be available in the summer of 1989. The deadline for receipt of completed applications is October 15, 1989. For further information, write: Fulbright Teacher Exchange Program, E/ASX, United States Information Agency, 301 Fourth Street, S.W., Washington, DC 20547; telephone 202-485-2555.

– United States Information Agency News Release

NIST Engineering Research Fellowships

The National Institute of Science and Technology (NIST, formerly the National Bureau of Standards) and the American Society for Engineering Education have announced a new program of Postdoctoral Engineering Research Fellowships, with tenures beginning in the fall of 1989. Although primarily focused on engineering, the program does sponsor fellowships in several mathematical and computer science areas:

• Applied mathematics and scientific computing: mathematical modeling, scientific software, and statistical analysis.

• Computer and telecommunications systems: open systems interconnection, integrated service digital network, distributed processing, database technology, and information integrity and security.

• Fire safety research: computer modeling and applied mathematics.

• Manufacturing engineering: Data modeling and data interfaces.

The fellowships are for research, normally over a two-year period, at the NIST Laboratories in Gaithersburg, Maryland, and Boulder, Colorado. Stipends will range from $36,000 to $42,000, depending on experience and field of study. Travel and transportation of goods to NIST will be paid. To be eligible, participants must be citizens or permanent residents of the U.S. with a Ph.D., Sc.D., or other equivalent doctoral degree.

Application deadline dates are January 1, April 1, July 1, and October 1. Awards will be made about 2 months after each deadline date, and the fellowships are tenable any time after the awards are made. Application materials may be obtained from: NIST/ASEE Postdoctoral Fellowship Program, American Society for Engineering Education, Eleven Dupont Circle, NW, Suite 200, Washington, DC 20036; telephone 202-745-3616 or 202-293-7080.

Questions concerning research opportunities should be directed to: Dr. George Sinnott, Associate Director for Technical Evaluation, National Engineering Laboratory, National Institute of Science and Technology, Building 225, Room B119, Gaithersburg, MD 20899; telephone 301-975-2304.

Research Experiences for Undergraduates Awards Announced

The Division of Mathematical Sciences of the National Science Foundation (NSF) has announced the 1989 awards in the Research Experiences for Undergraduates (REU) program. The program gives students hands-on experience in research in science, mathematics, and engineering. Designed to encourage talented students to pursue careers in research, REU gives the students a chance to experience the excitement of research while they are still in the process of making career choices.

The REU program makes two different kinds of awards: Sites and Supplements. REU Sites bring together groups of students during the summer for an organized program of research activities. The programs vary in size from 4 to 12 students and generally last 4 to 6 weeks. REU Supplements permit a principal investigator to add an undergraduate student to his or her research grant.

This year, out of 27 proposals for REU Sites, there were 9 new awards and 7 continuing awards, for a total of just over $0.5 million. What follows is a list of REU Sites planned for the summer of 1989, giving the names of the principal investigators, their institutions, and the mathematical emphasis of each program.

STEVEN L. BLUMSACK, Florida State University, Applied mathematics; WILLIAM J. COLES, University of Utah, Mathematical modeling in population biology; JAMES H. CURRY, University of Colorado, Discrete mathematics (continuing award); CHARLES CURTIS, University of Washington, Numerical solutions of inverse problems (continuing award); JOSEPH GALIAN, University of Minnesota-Duluth, Graph theory and combinatorics (continuing award); DAVID L. HOUSMAN, Worcester Polytechnic Institute, Discrete mathematics (continuing award); LAWRENCE S. HUSCH, University of Tennessee, Selected topics (continuing award); STEVEN G. KRANZ, Washington University, Harmonic analysis algorithms; ROBERT H. LEWIS, Fordham University, Nilpotent spaces; FRANK MORGAN, Williams College, Small geometry project; ROBERT ROBSON, Oregon State University, Experimentation using computers (continuing award); CECIL C. ROUSSEAU, Memphis State University, Graph theory
In addition to REU Sites and Supplements, the DMS is contributing funds to the Third Conference on Undergraduate Research, to be held at Trinity University in San Antonio, April 27-29 (for more information on this conference, see Notices, October 1988, page 1155).

The NSF-wide budget for the REU program for this fiscal year is $12 million. The program is handled by the research divisions and coordinated through the Division of Undergraduate Science, Engineering and Mathematics Education in the NSF's education directorate. NSF-wide, the funds are split approximately evenly between REU Sites and Supplements. For fiscal year 1990, the Foundation has requested a 75% increase to $21 million for the REU program.

Requests for REU Supplements may be submitted at any time. For more information, interested individuals should contact the program director handling his or her research grant.

The deadline to submit proposals for the 1990 REU Sites will be in early October, 1989. For more information, contact John V. Ryff, Program Director, Research Experiences for Undergraduates, Division of Mathematical Sciences, Room 339, National Science Foundation, 1800 G Street, NW, Washington, DC 20550; telephone 202-357-3455; email jryff@note.nsf.gov (Internet) or jryff@nsf (Bitnet). More information can also be found in the article “Research Experiences for Undergraduates,” Notices, May/June 1988, page 686.

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1990-1991 Advanced Research Fellowships in India

The Indo-U.S. Subcommission on Education and Culture is offering twelve long-term (6-10 months) and nine short-term (2-3 months) awards for 1990-1991 research in India. These grants will be available in all academic disciplines, except clinical medicine. Applicants must be U.S. citizens at the postdoctoral or equivalent professional level. The fellowship program seeks to open new channels of communication between academic and professional groups in the United States and India and to encourage a wider range of research activity between the two countries than now exists. Therefore, scholars and professionals with limited or no prior experience in India are especially encouraged to apply.

Fellowship terms include $1,500 per month, of which $350 per month is payable in dollars and the balance in rupees; an allowance for books and study/travel in India; and international travel for the grantee. In addition, long-term fellows receive international travel for dependents; a dependent allowance of $100-$250 per month in rupees; and a supplementary research allowance up to 34,000 rupees. This program is sponsored by the Indo-U.S. Subcommission on Education and Culture and is funded by the United States Information Agency, the National Science Foundation, the Smithsonian Institution, and the Government of India.


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Funding Information

The National Science Foundation (NSF) has announced 69 new awards in its Young Scholar program, which funds science, mathematics, and engineering enrichment projects for high-ability and high-potential secondary school students.

The new awards are in addition to the 68 projects initiated last year and bring the total number of students participating in the program to 4800 this year. The budget for the program is $7 million for this fiscal year, and the new awards have received cost-sharing commitments from their sponsoring institutions for a total of $2.3 million.

The Young Scholars program is designed to excite students about science careers by offering them the opportunity to work side by side with research scientists in ongoing research projects or in projects of their own design. The program strongly emphasizes student participation in the process of scientific discovery. Role modeling is an important component of project activities, and project directors will foster lasting mentor relationships between faculty and students.

The projects are aimed at students entering grades 8-12, in order to capture their interest before they opt out of science careers. The program consists of residential and commuter projects conducted during the summer or on weekends on the campuses of colleges, universities, and research organizations. The projects emphasize areas of science and mathematics not ordinarily encountered in school curricula.

Awards are for one year with a second year of support contingent on NSF review of project activities and the availability of funds. The ten principal investigators for the new awards in mathematics, together with the amount of the grants, the duration of the projects, and the number of students, are as:
follows: DAVID FRIED, GLENN STEVENS, Boston University, $64,998, a 6-week program for 30 students; BODEPTI V. R. GANDHI, University of Puerto Rico, Mayaguez, $102,018, a 3-week program for 30 students; ELMER HAYASHI, Wake Forest University, $34,000, a 4-week program for 24 students; HARVEY KEYNES, the University of Minnesota, $29,670, a 2-week program for 35 students; WILLIAM J. MARETH, JR., Del Mar College, $60,533, a 9-week program for 30 students; MARY G. O’DONNELL, University of Pittsburgh-Greensburg, $82,321, a 6-week program for 30 students; ARNOLD ROSS, Ohio State University, $99,998, an 8-week residential program for 61 students; ROBERT A. ROSENBAUM, Wesleyan University, $91,085, a 6-week program for 60 students; IRWIN E. VANCE, Michigan State University, $232,368, a 6-week program for 74 students.

The deadline for the next round of proposals (for awards to be made in 1990) will be in mid-summer of 1989, and a new program announcement will be available from the NSF in mid-spring. Florence Fasanelli, a mathematician and associate program director, says that proposals in the mathematical sciences are strongly encouraged. She can be contacted for more information at Young Scholars Program, Division of Research Career Development, Directorate for Science and Engineering Education, National Science Foundation, 1800 G Street, NW, Washington, DC 20550; telephone 202-357-7538; electronic mail ffasanel@note.nsf.gov (Internet) or ffasanel@nsf (Bitnet).

Small Business Innovation Research Awards

The National Science Foundation (NSF) made $8.2 million in grants in its Small Business Innovation Research (SBIR) program. This year’s grantees, 149 small high technology firms, are located in 28 states, and range in size from one to 400 employees. Under Phase I of the three-phase SBIR program, NSF awarded up to $50,000 to these 149 companies, selected from 1,513 proposals submitted.

Upon completion of Phase I research, projects which appear the most likely to result in economically and socially beneficial products will receive Phase II NSF grants of up to $250,000 for two years of continuing research. Private investors fund Phase III product development, manufacturing, and marketing efforts. Cumulative private investment and subsequent sales resulting from NSF SBIR projects now exceed $500 million.

Abstracts of the 1988 SBIR Phase I awards, and copies of the 1989 solicitation, will be available about April 15, and can be obtained from: National Science Foundation, Forms and Publications Office, 1800 G Street, N.W., Room 232, Washington, DC 20550.

Listed below are those firms receiving Phase I awards in the mathematical sciences; advanced scientific computing; computer and computation research; and information, robotics, and intelligent systems.


—NSF News Release
Support for the mathematical sciences continues a modest upward trend in 1990. Leading the advances is the National Science Foundation, carried forward by the momentum created by the NSF five-year plan to double the agency's budget in that period. Should the proposed increases hold in fiscal year 1990, then the Mathematical Sciences budget in NSF will have almost exactly doubled (in constant dollars) in the 1980–1990 period. NSF continues to furnish well over half of all federal support for the mathematical sciences.

Since the David Report was published in 1984, support for graduate students and postdoctoral associates has risen substantially in NSF, although the number of supported senior investigators has remained flat. Additional funds that went to senior investigators merely compensate for the increased salaries.

New in NSF for FY 1989 is a $25 million appropriation for the start-up of eleven Science and Technology Centers, two of them with major components in mathematics: Rice University obtained $4.1 million for a Center for Research on Parallel Computation, and Rutgers University received a grant in the amount of $1.825 million for a Center for Discrete Mathematics and Theoretical Computer Science. In the area of weather modeling the University of Oklahoma received a grant for $900,000 for a Center for Analysis and Prediction of Storms, whose emphasis is clearly on the meteorological aspects, not on the mathematical ones.

The NSF strategy to obtain a separate line item in the budget for a five-year appropriation from Congress was not accepted for FY 1989. But the principle of a separate budget line item is nevertheless a laudable one, since it can allay the fears voiced by single investigators that this "new" money is merely a transfer of traditional grants money into a new initiative with popular appeal.

After failing in FY 1989 to get approval for the first installment in a five-year budget doubling plan, the NSF director once again convinced the OMB (Office of Management and Budget) and the President to go forward in FY 1990 with a request for doubling the NSF budget by 1994.

The budget of the Division of Mathematical Sciences (DMS) has been treated rather well, certainly a consequence of the publication of the David Report in 1984 ("Renewing U.S. Mathematics: Critical Resource for the Future," National Research Council). In constant dollars, the DMS budget will have just doubled in ten years. This is substantially better than the growth of the total R&D budget of the NSF which, science and engineering education excluded, grew less than 40% (in constant dollars) over the same period.

Just as a year ago, the observation still holds that increases in the DMS budget went primarily to support more graduate students and postdoctoral associates. The number of senior investigators supported is still around 1500. This low number is a major concern and it now requires priority attention to meet the target of 2600 set in the David Report five years ago.

Distribution of Federal Support
Support of the mathematical sciences has come mostly from NSF, the Department of Energy, and the three services in the Department of Defense. Since 1985, DARPA (Defense Advanced Research Projects Agency), and, since 1984, the National Security Agency, have begun to support mathematical research in selected areas.

Over eighty percent of core mathematics is supported by NSF, while the mission agencies are primarily supporting fields in applied mathematics, such as optimization and control, statistics and probability, computational mathematics, and dynamical systems, for example. The overall ratio of support for the mathematical sciences between NSF and the other government agencies is about 7:5, up from 6:5 just a few years ago.
As in prior years, the funding decisions for the University Research Initiatives (URI) in DOD are affected by some uncertainty since some awards still have not been made.

The table on the next page shows the budgets for the various agencies between 1983 and 1990. Some of these figures show corrections from the tables published in prior years.

**Agency Programs**

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

Personnel changes in the agencies are, unfortunately, rather frequent. The new director of the Applied and Computational Mathematics Program in DARPA is now Dr. Louis Auslander; the first Director of the Mathematical Sciences Program at the National Security Agency was replaced by Dr. Marvin Wunderlich; the U. S. Air Force Director of Mathematical Sciences is now Dr. Charles Holland, who left the top position in the ONR (Office of Naval Research) computer science program. ONR's director of the Mathematical Sciences Division left after 17 months in that position. That division also has currently three vacancies among its program directors. Leadership in the Army Research Office and at the Department of Energy's mathematics programs has been stable.

**A. National Science Foundation (NSF).** The decision by Congress last October to deny the NSF the doubling of its budget by 1993 forced the mathematical sciences division to scale back some of its plans. Instead of a 16% increase, DMS was able to hold more or less even with inflation. Substantial increases for mathematics in FY 1989 came only through the new Science and Technology Centers.

In fiscal year 1990, plans are to reach full funding for the computational mathematics program, begun in FY 87. The program covers computational geometry, visualization, image processing, and symbolic and algebraic computation. For another program, modern geometric mathematics, initial funding of $1.25 million is being requested from Congress. Special program emphasis is on training at the undergraduate and graduate levels.

A third initiative proposed in the FY 90 budget is targeted on interactions with other disciplines. Collaborations with the biosciences are expected as work in knot theory relates to DNA structure; probability theory and combinatorics are relevant to DNA sequence analysis; and statistics and dynamical systems can be expected to apply to problems in ecology. Other interactions are expected with bioscience and cosmology.

**B. Air Force Office of Scientific Research (AFOSR).** Major program areas supported by the AFOSR are nonlinear dynamics and control theory, nonlinear wave mechanics, optimization, finite mathematics, signal processing and communication, and statistics and probability. In addition, the AFOSR supports the URI program with about $4 million. Counted in the budget figures are the DURIP equipment replacement program, the small business incentive research, and support for [historically] Black colleges, which together add up to about $1 million. Mathematics has been able to hold its historical share of the AFOSR budget.

**C. Army Research Office (ARO).** The ARO mathematics budget has remained flat into FY 1990. ARO's mathematical sciences program is divided into four areas: applied analysis and physical mathematics, computational mathematics (including numerical analysis, scientific computing and optimization), probability and statistics, and systems and control. ARO also supports two centers: The Mathematical Sciences Institute at Cornell University and the Center for Intelligent Systems at Brown and Harvard Universities.

A new initiative is planned for FY 1990: to establish a High-Performance Computing Research Center that is expected to cost $8–9 million over a five-year period. $25 million is budgeted for hardware acquisitions (which may include a supercomputer or a number of massively parallel architectures, workstations, and the like.) Hardware will be purchased for the new center during the summer of 1989. The center will conduct basic research in high-performance computing, algorithm development, multiprocessing, and visualization.

**D. Office of Naval Research (ONR).** The Mathematical Sciences Division’s program is divided into six areas: applied analysis, discrete mathematics, numerical mathematics, operations research, probability and statistics, and signal analysis. The core program in FY 1989 is $6.6 million and is expected to increase to $6.8 million in 1990. The Accelerated Research
Initiatives (ARI) are short-term programs with typically five-year lifetimes. Their share of the mathematics budget is $3.9 million. These ARI funds shift as the result of annual competitions within ONR. There is a small young investigators program which is funded at $100,000. The mathematical sciences division of ONR administers $1.4 million of URI funds.

E. Defense Advanced Research Programs Agency (DARPA). The change of leadership had the consequence that a reevaluation of current program direction is now taking place. DARPA’s Applied and Computational Mathematics Program supports research in nonlinear dynamical systems, turbulent flow dynamics, harmonic analysis, computational algorithms, and image/data compression. $5 million are in the core program, $4.0 million derive from the URI program. This total of $9.0 million represents a substantial reduction from the projected level of $12 million for FY 1989. The program supports computer science and desk-top physics programs; thus, the total available for mathematical sciences may be closer to $6 million. Projections for FY 1990 are difficult to ascertain at this time, pending the on-going review of that program.

F. National Security Agency (NSA). NSA supports unclassified research in algebra, number theory, discrete mathematics, statistics and probability. Since NSA’s mathematical science programs emerged from classified obscurity in 1984, their support of mathematical research in universities has nearly tripled, showing an annual growth rate of 20%. The agency is naturally concerned about finding enough qualified professionals for its ongoing mission. Due to the nature of NSA’s work, the decline in the number of U.S. citizens entering graduate studies in mathematics is a special concern of the agency.

G. Department of Energy (DOE). The Applied Mathematical Sciences program in the DOE Office of Energy Research has two distinct roles. Mathematical sciences research is aimed at understanding models arising in DOE research and development programs and to provide supercomputing resources to DOE’s researchers. Growth of these programs continued in 1989 and 1990. The applied mathematical sciences research program funds basic research in the national laboratories, universities, and private research institutions, in these categories: analytic and numerical methods, computational statistics, information analysis techniques, and advanced computing concepts for parallel architectures and languages. Topical areas of mathematics that are supported include: applied analysis, discrete mathematics, statistics and probability, linear algebra, optimization and control, geometry, dynamical systems, and nonlinear analysis. These programs are designed to support energy research. Approximately one-half of the university-based funding goes to mathematics departments and half to computer science departments. Support for both computer science and the mathematical sciences is roughly split evenly between intramural research and university research.

H. Other Agencies. Several agencies such as the National Aeronautics and Space Administration (NASA), and the National Institutes of Health (NIH), support mathematical sciences programs, mostly in-house. NASA also supports the Institute for Computer Applications in Science and Engineering in Langley, Virginia, with approximately $1 million annually. The National Institute of Standards and Technology (NIST), as well as numerous national laboratories attached to other agencies, conduct substantial in-house mathematics, statistics, and computer science research programs.

### Federal Agency Support in the Mathematical Sciences

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<th>Department of Defense</th>
<th>FY 83</th>
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1Estimated. (In DOD they include URI Grants.) 2Projected budgets. (Includes estimates for URI Grants.) 3Includes estimates for Science and Technology Centers. 4Includes projects in computer science and computational physics.
# Meetings and Conferences of the AMS

## FUTURE MEETINGS

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<td>Boulder, Colorado</td>
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<td>439</td>
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## Invited Speakers and Special Sessions

## FUTURE CONFERENCES

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<th>Conference</th>
<th>Location</th>
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<td>Pure Mathematics Symposium</td>
<td>Sundance Resort, Sundance, Utah</td>
<td>May 26–30</td>
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<tr>
<td>Symposium on Some Mathematical Questions in Biology</td>
<td>University of Toronto, August 7</td>
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<td>Call for Topics</td>
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- **Hartshorne conjecture and extremal ray** by S. Mori
- **Solvable lattice models of dim. 2 and modular functions** by M. Okado, M. Jimbo, and T. Miwa
- **Theory of computable quantities and proof theory** by G. Takeuti
- **Irreducibility of Painlevé transcendental functions** by J. Umemura
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Note: Subscriptions to AMS journals are sold only on a calendar year basis (January-December). Split year and multiple year subscription orders will not be accepted.
The eight-hundred-and-forty-ninth meeting of the American Mathematical Society will be held on the Lake Shore Campus of Loyola University of Chicago on Friday, May 19, and Saturday, May 20, 1989. All special sessions and sessions for contributed papers will be held in Damen Hall and all invited addresses in the auditorium of Flanner Hall.

Invited Addresses
By invitation of the Committee to Select Hour Speakers for Central Sectional Meetings, there will be four invited one-hour addresses. The speakers, their affiliations, the titles of their talks, and the scheduled times of presentation are:

HENRI GILLET, University of Illinois at Chicago, Analogies between number fields and function fields, 3:00 p.m. Friday.

NICHOLAS LERNER, Purdue University, Microlocal analysis and applications to tomographic problems, 3:00 p.m. Saturday.

RICHARD ROCHBERG, Washington University, Estimates for singular numbers of integral operators, 11:00 a.m. Saturday.

SHMUEL WEINBERGER, University of Chicago, Flexibility and rigidity of stratified spaces, 11:00 a.m. Friday.


Numerical methods in harmonic analysis, JONATHAN COHEN, DePaul University. Speakers include G. Beylkin, R. Coifman, James E. Daly, Ronald A. DeVore, Leslie Greengard, Bjorn Jawerth, Jeff E. Lewis, Stephane Mallat, Keith Phillips, Grant V. Welland.


Algebraic groups and related topics, STEPHEN DOTY, Loyola University of Chicago. Speakers include Michael Barry, Steve M. Cohen, Romuald Dabrowski, Richard Dipper, Eric M. Friedlander, Frank D. Grosshans, J. E. Humphreys, Leonid Krop, Jyrki Lahtonen, Zongzhu Lin, Gary M. Seitz, Stephen D. Smith, Bhama Srinivasan, Lin
Tan, Hemant Kumar Tiwari, Jian Pan Wang, Donald L. White.

**Arithmetic geometry and intersection theory, Henri Gillet.** Speakers include Ted Chinburg, David Harbater, Ernst Kani, William G. McCallum, Robert Rumely, Christophe Soulé, Paul Vojta.

**Recursion theory, Christine Haughton.** University of Chicago. Speakers include Seema Ahmad, William C. Calhoun, Marcia J. Groszek, Carl Jockusch, Alexander S. Kechris, Julia F. Knight, Antonin Kucera, Masahiro Kumabe, Manuel Lerman, Terrence Millar, Anil Nerode, Gerald E. Sacks, Richard A. Shore, Theodore A. Slaman, Michael Stob, Hong Ye.


**Contributed Papers**

There will also be sessions for contributed ten-minute papers. Late papers will not be accommodated.

**Registration**

The meeting registration desk will be located in room 147 of Damen Hall and will be open from 8:00 a.m. to 5:00 p.m. on Friday, May 19, and 8:00 a.m. to noon on Saturday, May 20. The registration fees are $30 for members of the AMS, $45 for nonmembers, and $10 for students or unemployed mathematicians.

**Petition Table**

A petition table will be set up in the registration area. Additional information about petition tables can be found in a box in the Phoenix meeting announcement on page 1502 of the December 1988 issue of Notices.

**Accommodations**

Blocks of rooms are being held in Mertz Hall on the Lake Shore Campus. This air conditioned facility is adjacent to a campus parking lot, cafeteria, and athletic facilities. It is a three-minute walk to Damen and Flanders Halls. Participants should make reservations by calling 312-508-3300, and should indicate that they are attending the AMS meeting. After May 1, 1989, reservations will be accepted on a space available basis. Families are welcome in Mertz Hall, and arrangements can be made to stay longer than the time of the conference. The rates are $32 for single occupancy and $22 per person double occupancy.

For participants staying on campus, housing registration and check-in will be in the Front Desk Lobby on the second floor of Mertz Hall. The Front Desk is open daily from 7:00 a.m. until midnight. If the Front Desk is not open, please refer to the Conference Staff Duty Roster that is posted at the Front Desk for the extension of the staff member on duty. Dial the four digit extension on the beige house phone located around the corner from the Front Desk and the person on duty will come to the Front Desk.

Although rooms have not been blocked at either of the following locations, they are included for information. Rates are subject to change. Both are approximately 20 minutes by car and 30 minutes by public transportation from Loyola.
Meetings

Loyola University of Chicago

Lake Shore Campus

1 DAMEN HALL
2 FLANNER HALL
3 MERTZ HALL (DORM)
4 HALAS SPORTS CENTER
5 PARKING FOR CONFERENCE
Holiday Inn, Evanston
1501 Sherman Avenue, Evanston, IL 60201
Telephone: (312) 491-6400
Single $70    Double $78

Orrington Hotel
1710 Orrington Avenue, Evanston, IL 60202
Telephone: (312) 866-8700
Single $90    Double $100

Food Service
The campus food service is located on the second floor of Centennial Forum, across the patio from Mertz Hall. A daily meal pass costing $10 can be purchased at the housing registration desk (second floor, Mertz Hall). Present this pass or pay the appropriate price to gain entry into any meal. Among the features offered by the food service are a variety of cereals, a salad bar with a multitude of fresh fixings, a daily soup bar, menu variety of both meat eaters and vegetarians, a selection of ice cream, a large array of beverages, and unlimited seconds.

There are several restaurants and fast food establishments within walking distance or a short drive. A list of these will be available at the meeting registration desk in Damen Hall 147.

Travel
To reach Loyola University’s Lake Shore Campus at 6525 North Sheridan Road, corner of Sheridan Road on Loyola Avenue:

FROM MIDWAY AIRPORT: Take the Continental Airport bus to the Park Hyatt Hotel on Chicago Avenue. Walk two blocks west on Chicago Avenue to the State Street subway and take the Howard line north to Loyola Avenue. Or, take the Outer Drive Express bus (CTA #147), or the Sheridan Howard Terminal bus (CTA #151), north to Sheridan and Devon (catch this bus on the north-east corner of Water Tower Place). By taxi it is fifty-six blocks north.

FROM O’HARE FIELD: Take the Continental Airport bus to the Park Hyatt Hotel on Chicago Avenue. Walk two blocks west on Chicago Avenue to the State Street subway and take the Howard line north to Loyola Avenue. Or, take the Outer Drive Express bus (CTA #147), or the Sheridan Howard Terminal bus (CTA #151), north to Sheridan and Devon (catch this bus on the north-east corner of Water Tower Place). By taxi it is fifty-six blocks north.

Alternatively, take the airport bus to the Holiday Inn in Evanston and a taxi to Loyola. This would be a shorter ride. Or, take the O’Hare/Congress or O’Hare/Douglas subway (located under the O’Hare Hilton) downtown to Washington Street. Get off at Washington and take the stairs down to the tunnel and walk across to the State Street subway and take the Howard Line north (A or B train) to Loyola Avenue.

FROM THE GREYHOUND OR TRAILWAYS BUS STATION: From the Greyhound Station walk east on Randolph to State Street (two blocks) and take the Howard Line subway north to Loyola Avenue Station.

From the Trailways Station walk west on Randolph to State Street and take the Howard Line subway north to Loyola Avenue Station.

FROM UNION STATION (AMTRAK): Take the Sheridan/Devon (CTA #151) to State Street, then take the Howard Line subway north to Loyola Avenue Station.

FROM THE ILLINOIS CENTRAL STATION (SOUTH SHORE): Take the Outer Drive Express bus (CTA #147) at Michigan Avenue north to Loyola Avenue, or walk west to State Street and take the Howard Line subway north to Loyola Avenue Station.

BY AUTOMOBILE: If arriving from the south, east, or west by Interstates 55, 57, 90, or 94, take an exit to Lake Shore Drive north to its limit. Turn north on Sheridan Road and take it to Loyola.

If arriving on Interstate 94 from the north, take Touhy Avenue eastbound to its limit at Sheridan Road South. Take a right on to Sheridan Road. Loyola is on the left approximately 8 or 9 blocks south.

If arriving on Interstate 194 or 294 from the north or northwest, take Foster Avenue east to Broadway or Sheridan, then north to Loyola.

Parking
Parking is available in the parking lot south of Mertz Hall. The fee is 50 cents. To park in the lot overnight, please obtain a parking sticker at the housing desk.

Athletic Facilities
All meeting participants will be given complimentary access to the new George Halas Jr., Sports Center on Loyola’s campus. This facility has an olympic-size swimming pool, six racketball/handball courts, weight rooms with free-weight and Nautilus equipment, two aerobic dance rooms, three full length basketball courts, and an indoor track (an outdoor track is also available).

Weather
The average high temperature in Chicago in May is 70°F and the average low is 48°F. Because the university is located on the shore of Lake Michigan, it may be slightly cooler during the daytime. The average rainfall for the month is 3.15 inches.
## Program of the Sessions

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

Abstracts of papers presented in the sessions at this meeting will be found in the April 1989 issue of Abstracts of papers presented to the American Mathematical Society, ordered according to the numbers in parentheses following the listings below.

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

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### Friday, May 19

#### AMS Special Session on Sequence Spaces and Summability, I

<table>
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<tr>
<th>Time</th>
<th>Title</th>
<th>Authors</th>
<th>Institution</th>
<th>Phone</th>
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<tbody>
<tr>
<td>7:30 a.m.</td>
<td>BH envelopes and BH completions of NH spaces.</td>
<td>Jeff Connor* and W. E. Kaufman, Ohio University, Athens (849-46-75)</td>
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<tr>
<td>8:00 a.m.</td>
<td>The role of the sequence space $\psi$ in the theory of barrelled spaces.</td>
<td>P. P. Narayanaswami, Memorial University of Newfoundland (849-46-165)</td>
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<tr>
<td>8:30 a.m.</td>
<td>Some properties of absolute summability domains.</td>
<td>M. S. Macphail*, Carleton University, and C. Orhan, University of Ankara, Turkey (849-40-18)</td>
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<tr>
<td>9:00 a.m.</td>
<td>Sequences of regular summability methods.</td>
<td>Preliminary report.</td>
<td>Casper Goffman, Purdue University, West Lafayette (849-40-02)</td>
<td></td>
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<tr>
<td>9:30 a.m.</td>
<td>FK-products, $E^P$ and uniformly convergent Fourier series.</td>
<td>Gunther W. Goes, University of Stuttgart, Federal Republic of Germany (849-40-104)</td>
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<tr>
<td>10:00 a.m.</td>
<td>A question concerning self-dual Hilbert $K$-spaces.</td>
<td>A. K. Snyder, Lehigh University (849-40-37)</td>
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<tr>
<td>10:30 a.m.</td>
<td>Absolute Norlund matrix summability of Fourier series based on inclusion theorems.</td>
<td>Brian Kuttner, University of Birmingham, England, and Billy E. Rhoades*, Indiana University (849-40-129)</td>
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#### AMS Special Session on Geometric Topology, I

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<tr>
<td>8:00 a.m.</td>
<td>Eta invariants of hyperbolic 3-manifolds.</td>
<td>Walter D. Neumann*, Ohio State University, Columbus, and Robert Meyerhoff, Boston University (849-57-21)</td>
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<tr>
<td>8:30 a.m.</td>
<td>Some new 4-manifolds.</td>
<td>Selman Akbulut, Michigan State University (849-57-234)</td>
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<tr>
<td>9:00 a.m.</td>
<td>Some simple fake 4-manifolds.</td>
<td>Robert E. Gompf, University of Texas, Austin (849-57-81)</td>
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<tr>
<td>9:30 a.m.</td>
<td>Representation spaces of Seifert fibered homology spheres.</td>
<td>Preliminary report.</td>
<td>Paul Kirk* and Eric Klassen, California Institute of Technology (849-57-72)</td>
<td></td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Instanton polynomials for homology three spheres.</td>
<td>Ronald J. Stern*, University of Utah, and Ronald Fintushel, Michigan State University (849-57-127)</td>
<td></td>
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<tr>
<td>10:30 a.m.</td>
<td>Realization of group actions on 4-manifolds.</td>
<td>Preliminary report.</td>
<td>Allan L. Edmonds* and John H. Ewing, Indiana University, Bloomington (849-57-99)</td>
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#### AMS Special Session on Quadratic Forms and Real Algebraic Geometry, I

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<tr>
<th>Time</th>
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<tbody>
<tr>
<td>8:00 a.m.</td>
<td>Sums of squares in Witt rings.</td>
<td>D. W. Lewis, University College of Dublin, Republic of Ireland (849-11-168)</td>
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<tr>
<td>8:30 a.m.</td>
<td>Witt kernels of algebraic extensions.</td>
<td>Preliminary report.</td>
<td>David B. Leep, University of Kentucky (849-12-142)</td>
<td></td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>On the structure of the Clifford algebra over a commutative ring.</td>
<td>Alexander J. Hahn, University of Notre Dame (849-15-13)</td>
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<tr>
<td>9:30 a.m.</td>
<td>Galois groups over C-fields.</td>
<td>Tara L. Smith*, Ohio State University, Columbus, and Jan Minac, University of Western Ontario (849-12-32)</td>
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<tr>
<td>10:00 a.m.</td>
<td>Informal Discussion</td>
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<tr>
<td>10:30 a.m.</td>
<td>Picard groups of Witt rings.</td>
<td>Robert W. Fitzgerald, Southern Illinois University, Carbondale (849-11-110)</td>
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</tbody>
</table>
AMS Special Session on Codes and Designs, I

8:30 a.m.–10:50 a.m.  Room 149, Damen Hall

8:30 a.m.  On smallest Latin square graphs with given automorphism group. Preliminary report.  
William C. Arlinghaus, Lawrence Institute of Technology (849-05-57)
9:00 a.m.  Isomorphisms of objects over a finite field.  
Hong Goo Park, University of North Texas (849-05-132)
9:30 a.m.  Partition lattices and experimental design. Preliminary report.  
Jay H. Beder, University of Wisconsin, Milwaukee (849-06-89)
10:00 a.m.  Designs admitting affine linear maps as automorphisms.  
Neal Brand*, University of North Texas, and Somporn Sutinuntopas, Ramkamhaeng University, Thailand (849-05-158)
10:30 a.m.  Character tables of commutative association schemes and the study of their subschemes.  
Eiichi Bannai, Ohio State University, Columbus (849-05-252)

AMS Special Session on Noncommutative Ring Theory, I

9:00 a.m.–10:50 a.m.  Room 730, Damen Hall

9:00 a.m.  Inner gradings and Galois extensions with normal basis.  
Margaret Beattie, Mount Allison University (849-16-50)
9:30 a.m.  Some 3-dimensional skew polynomial rings.  
Allen D. Bell*, University of Wisconsin, Milwaukee, and S. Paul Smith, University of Washington (849-16-125)
10:00 a.m.  Verbally prime P.I. algebras.  
Allan Berele, DePaul University (849-16-123)  
(Sponsored by Jeffrey M. Bergen)
10:30 a.m.  Reflection representations of Hecke algebras of certain Weyl groups.  
Hemant Kumar Tiwari, University of Chicago (849-20-209)  
(Sponsored by Stephen R. Doty)

AMS Special Session on Numerical Methods in Harmonic Analysis, I

9:00 a.m.–10:50 a.m.  Room 238, Damen Hall

9:00 a.m.  Fast wavelet transforms in numerical analysis and potential theory, I.  
G. Beyikin*, R. Coifman and V. Rokhlin, Yale University (849-65-196)
9:30 a.m.  Informal Discussion
10:30 a.m.  Fast wavelet transforms in numerical analysis and potential theory, II.  
G. Beyikin, R. Coifman* and V. Rokhlin, Yale University (849-65-197)

AMS Special Session on Kazhdan-Lusztig Theory and Related Topics, I

9:00 a.m.–10:50 a.m.  Room 441, Damen Hall

9:00 a.m.  The proof of the Kazhdan-Lusztig conjecture revisited. Preliminary report.  
Leonard Scott*, University of Virginia, and S. Roan, Clark University (849-20-180)
9:30 a.m.  An approach to the Kazhdan-Lusztig conjecture for Kac-Moody algebras.  
Luis Casian, Ohio State University, Columbus (849-22-146)
10:00 a.m. Multiplicity free categories of highest weight representations, I.  
Brian D. Boe*, University of Georgia, and David H. Collingwood, University of Washington (849-17-215)
10:30 a.m.  Systems of differential operators and unitary highest weight modules.  
Thomas J. Enright, University of California at San Diego, La Jolla (849-17-150)  
(Sponsored by Vinay V. Deodhar)

AMS Special Session on Algebraic Groups and Related Topics, I

9:00 a.m.–10:50 a.m.  Room 440, Damen Hall

9:00 a.m.  Reflection representations of Hecke algebras of certain Chevalley groups.  
Rommald Dabrowski, Indiana University, Bloomington (849-20-92)
9:30 a.m.  Algebraic properties of Kloosterman sums for Rings of invariants for maximal unipotent subgroups. Preliminary report.  
Frank D. Grosshans, West Chester University of Pennsylvania (849-20-38)
### AMS Special Session on Arithmetic Geometry and Intersection Theory, I

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<tr>
<th>Time</th>
<th>Speaker</th>
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<tbody>
<tr>
<td>9:00 a.m.</td>
<td>The arithmetic Riemann-Roch theorem.</td>
<td>Christophe Soulé, Institut des Hautes Études Scientifiques, and Centre National de la Recherche Scientifique, France (849-11-66) (Sponsored by Henri Gillet)</td>
<td>Room 530, Damen Hall</td>
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<tr>
<td>9:30 a.m.</td>
<td>Discussion</td>
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<tr>
<td>10:00 a.m.</td>
<td>Green's functions on non-archimedean Riemann surfaces.</td>
<td>Ernst Kani, Queen's University (849-11-255)</td>
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<td>10:30 a.m.</td>
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### AMS Special Session on Recursion Theory, I

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<tr>
<th>Time</th>
<th>Speaker</th>
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<tbody>
<tr>
<td>9:00 a.m.</td>
<td>Separating jump classes in the r.e. degrees I: Working below a low, r.e. degree. Preliminary report.</td>
<td>Richard A. Shore*, Cornell University, and Theodore A. Slaman, University of Illinois, Chicago (849-03-88)</td>
<td>Room 529, Damen Hall</td>
</tr>
<tr>
<td>9:30 a.m.</td>
<td>Working below a high recursively enumerable degree. Preliminary report.</td>
<td>Richard A. Shore, Cornell University, and Theodore A. Slaman*, University of Chicago (849-03-108)</td>
<td></td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Some results on the structure of the $\Sigma_1$ enumeration degrees. Preliminary report.</td>
<td>Seema Ahmad, Simon Fraser University (849-03-97)</td>
<td></td>
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<tr>
<td>10:30 a.m.</td>
<td>Homogeneous countable models of tame theories.</td>
<td>Terrence Millar, University of Wisconsin, Madison (849-03-85)</td>
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### AMS Special Session on Partial Differential Equations, I

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<tr>
<th>Time</th>
<th>Speaker</th>
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<tr>
<td>9:40 a.m.</td>
<td>On certain partial differential operators of odd finite type.</td>
<td>Alexandrou A. Himonas, Princeton University (849-35-43)</td>
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### AMS General Session, I

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<th>Time</th>
<th>Speaker</th>
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<th>Location</th>
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<tr>
<td>9:00 a.m.</td>
<td>Representation of invariant nonstandard hulls in internal set theory.</td>
<td>Nader Vakil, Western Illinois University (849-03-190)</td>
<td>Room 148, Damen Hall</td>
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### AMS Invited Address

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<tr>
<th>Time</th>
<th>Speaker</th>
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<th>Location</th>
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<tr>
<td>11:00 a.m.</td>
<td>Flexibility and rigidity of stratified spaces.</td>
<td>Shmuel Weinberger, Courant Institute of Mathematical Sciences, New York University (849-99-270)</td>
<td>Auditorium, Flanner Hall</td>
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<th>Time</th>
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<tr>
<td>1:30 p.m.</td>
<td>Analogies between function fields and number fields.</td>
<td>Henri Gillet, University of Illinois, Chicago (849-14-161)</td>
<td>Auditorium, Flanner Hall</td>
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### AMS Special Session on Sequence Spaces and summability, II

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<tr>
<th>Time</th>
<th>Speaker</th>
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<tr>
<td>2:30 p.m.</td>
<td>Sequence transformations that guarantee a given rate of convergence.</td>
<td>G. H. Fricke, Wright State University, Dayton, and J. A. Fridy*, Kent State University, Kent (849-40-56)</td>
<td>Room 339, Damen Hall</td>
</tr>
<tr>
<td>3:00 p.m.</td>
<td>Coin tossing and moment sequences.</td>
<td>Graeme Bennett, Indiana University, Bloomington (849-40-10) (Sponsored by Billy E. Rhoades)</td>
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<tr>
<td>3:30 p.m.</td>
<td>Asymptotic relationships between Dirichlet series.</td>
<td>David Borwein, University of Western Ontario (849-40-84)</td>
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### Friday, May 19 (cont'd)

<table>
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<tr>
<th>Time</th>
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<tr>
<td>4:00 p.m.</td>
<td><strong>Some distinguished subsets of FK-spaces containing $\phi$.</strong> Preliminary report.</td>
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<td><strong>Wolfgang Beekmann</strong>, Fern Universitat Hagen, Federal Republic of Germany, and <strong>Shao-Chien Chang</strong>*, Brock University (849-40-106)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td><strong>The gliding humps property of the factor sequences and the weakly sequential completeness of the $\beta$ dual of a sequence space.</strong> Preliminary report.</td>
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<td><strong>Johann Boos</strong>, Fern Universitat, Hagen, Federal Republic of Germany (849-46-175) (Sponsored by Martin G. Bunneis)</td>
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<tr>
<td>5:00 p.m.</td>
<td><strong>Bounded consistency on strong summability fields.</strong> Preliminary report.</td>
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<td><strong>C. S. Chun</strong> and <strong>Allen R. Freedman</strong>*, Simon Fraser University (849-40-202)</td>
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<tr>
<td>5:30 p.m.</td>
<td><strong>Full families and sequential completeness.</strong> Preliminary report.</td>
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<td><strong>John J. Sember</strong>, Simon Fraser University (849-40-141)</td>
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<tr>
<td>6:00 p.m.</td>
<td><strong>Sequence spaces and summability.</strong> Preliminary report.</td>
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<td><strong>George U. Brauer</strong>, University of Minnesota, Minneapolis (849-40-07)</td>
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### AMS Special Session on Noncommutative Ring Theory, II

**Room 730, Damen Hall**

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<th>Time</th>
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<tbody>
<tr>
<td>3:00 p.m.</td>
<td><strong>Rings all of whose Pierce stalks are weakly local.</strong> Preliminary report.</td>
</tr>
<tr>
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<td><strong>Douglas G. Burkholder</strong>, Wichita State University (849-16-242)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td><strong>Semiprime crossed products.</strong> Preliminary report.</td>
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<td><strong>William Chin</strong>, DePaul University (849-16-118)</td>
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<tr>
<td>4:00 p.m.</td>
<td><strong>When is the Clifford algebra of a binary cubic form split?</strong> Preliminary report.</td>
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<td><strong>Darrell Haile</strong>, Indiana University, Bloomington (849-16-120)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td><strong>Quantum Kleinian singularities.</strong> Preliminary report.</td>
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<td><strong>Timothy J. Hodges</strong>, University of Cincinnati (849-16-121)</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td><strong>A characterization of uniserial rings via continuous modules.</strong> Preliminary report.</td>
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<td><strong>S. K. Jain</strong>*, <strong>S. R. Lopez-Permuth</strong>, Ohio University, Athens, and <strong>S. Tariq Rizvi</strong>, Ohio State University, Lima (849-16-69)</td>
</tr>
<tr>
<td>5:30 p.m.</td>
<td><strong>Informal Discussion</strong></td>
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<tr>
<td>6:00 p.m.</td>
<td><strong>Splitters and relative homological algebra.</strong> Preliminary report.</td>
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<td><strong>Mark Kleiner</strong>*, Syracuse University, and <strong>Aboubakr Lbekkouri</strong>, Universite de Mohammed V, Morocco (849-16-49)</td>
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### AMS Special Session on Geometric Topology, II

**Room 641, Damen Hall**

<table>
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<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>3:00 p.m.</td>
<td><strong>Cutting and pasting and the $\eta$ invariant.</strong> Preliminary report.</td>
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<td><strong>Daniel Ruberman</strong>*, Brandeis University, and <strong>Robert Meyerhoff</strong>, Boston University (849-57-67)</td>
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<tr>
<td>3:30 p.m.</td>
<td><strong>On Milnor's invariants and the concordance classification of links.</strong> Preliminary report.</td>
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<td><strong>Nathan Habegger</strong>*, University of Georgia, and <strong>Xiao-Song Lin</strong>, Columbia University (849-57-247)</td>
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<tr>
<td>4:00 p.m.</td>
<td><strong>Homology boundary links, Andrews-Curtis conjecture and the Hawaiian earrings space.</strong> Preliminary report.</td>
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<td><strong>Tim D. Cochran</strong>, Northwestern University (849-57-237)</td>
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<tr>
<td>4:30 p.m.</td>
<td><strong>Cochran's link invariants and Massey products.</strong> Preliminary report.</td>
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<td><strong>Kent Orr</strong>, University of Chicago (849-57-240)</td>
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<tr>
<td>5:00 p.m.</td>
<td><strong>Surgery invariants of link cobordism.</strong> Preliminary report.</td>
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<td><strong>Lawrence J. Smolinsky</strong>, Louisiana State University, Baton Rouge (849-57-100)</td>
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<tr>
<td>5:30 p.m.</td>
<td><strong>Studying links via closed braids. II.</strong> Preliminary report.</td>
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<td><strong>William W. Menasco</strong>*, State University of New York, Buffalo, and <strong>Joan S. Birman</strong>, Columbia University (849-57-236)</td>
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<tr>
<td>6:00 p.m.</td>
<td><strong>Spherical space forms and Dehn surgery.</strong> Preliminary report.</td>
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<td><strong>Steven A. Bleiler</strong>, Portland State University (849-57-235)</td>
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### AMS Special Session on Numerical Methods in Harmonic Analysis, II

**Room 238, Damen Hall**

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<th>Time</th>
<th>Session</th>
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<tr>
<td>3:00 p.m.</td>
<td><strong>The $\phi$-transform and applications to computer graphics.</strong> Preliminary report.</td>
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<td><strong>Anca Deliu</strong>, University of Georgia, and <strong>Björn Jawerth</strong>*, University of South Carolina, Columbia (849-42-212)</td>
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<tr>
<td>3:30 p.m.</td>
<td><strong>Local extrema of a wavelet transform.</strong> Preliminary report.</td>
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<td><strong>Stephanie Mallat</strong>, Courant Institute of Mathematical Sciences, New York University (849-42-195) (Sponsored by Jonathan Cohen)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td><strong>Atomic decompositions and non-linear approximation.</strong> Preliminary report.</td>
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<tr>
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<td><strong>Ronald A. DeVore</strong>*, <strong>Björn Jawerth</strong>, University of South Carolina, Columbia, and <strong>Vasil Popov</strong>, Bulgarian Academy of Science, Sofia, Bulgaria (849-65-107)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td><strong>Generalized sampling and Triebel-Lizorkin spaces.</strong> Preliminary report.</td>
</tr>
<tr>
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<td><strong>Björn Jawerth</strong>, University of South Carolina, Columbia, and <strong>Grant V. Welland</strong>*, University of Missouri, St. Louis (849-42-220)</td>
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## Program of the Sessions

### AMS Special Session on Kazhdan-Lusztig Theory and Related Topics, II

**3:00 p.m. – 5:50 p.m.**  Room 441, Damen Hall

<table>
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<th>Time</th>
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<tr>
<td>3:00 p.m.</td>
<td><strong>Geometry and combinatorics of Schubert varieties.</strong> Preliminary report.</td>
<td>V. Lakshmibai, Northwestern University</td>
<td>(849-14-153)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td><strong>A connection of equivariant K-theory with the singularity of Schubert varieties.</strong></td>
<td>Shrawan Kumar, Institute for Advanced Study and Tata Institute of Fundamental Research, Bombay, India</td>
<td>(849-20-152)</td>
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<td>4:00 p.m.</td>
<td><strong>Loop groups, the Schubert calculus and the principal nilpotent.</strong></td>
<td>Dale H. Peterson, University of British Columbia</td>
<td>(849-22-157)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td><strong>Frobenius action on the B-cohomology.</strong> Preliminary report.</td>
<td>Olivier Mathieu, Université de Paris 7, France</td>
<td>(849-20-154)</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td><strong>Schubert varieties in Hermitian symmetric spaces.</strong> Preliminary report.</td>
<td>Erhard Neher, University of Ottawa</td>
<td>(849-20-155)</td>
</tr>
<tr>
<td>5:30 p.m.</td>
<td><strong>Hyperalgebras, highest weight categories and finite dimensional algebras.</strong></td>
<td>Brian Parshall, University of Virginia</td>
<td>(849-20-156)</td>
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</tbody>
</table>

### AMS Special Session on Algebraic Groups and Related Topics, II

**3:00 p.m. – 5:20 p.m.**  Room 440, Damen Hall

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Institution</th>
<th>Phone Number</th>
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</thead>
<tbody>
<tr>
<td>3:00 p.m.</td>
<td><strong>On the structure of parabolic subgroups.</strong></td>
<td>Hassan Azad, Quaid-i-Azam University, Islamabad, Pakistan</td>
<td>(849-20-53)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td><strong>Decomposition numbers of SP(4,q) for primes dividing q + 1.</strong></td>
<td>Donald L. White, University of Illinois, Chicago</td>
<td>(849-20-52)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td><strong>Some connections between M-G- and S-representations.</strong></td>
<td>Leonid Krop, DePaul University</td>
<td>(849-20-05)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td><strong>Invariant theory of regular subgroups.</strong></td>
<td>Lin Tan, Indiana University, Bloomington</td>
<td>(849-20-248)</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td><strong>On the symmetric powers of the natural representation of groups of classical types.</strong> Preliminary report.</td>
<td>Jyrki Lahtonen, University of Notre Dame</td>
<td>(849-22-178)</td>
</tr>
</tbody>
</table>

### AMS Special Session on Arithmetic Geometry and Intersection Theory, II

**3:00 p.m. – 5:50 p.m.**  Room 530, Damen Hall

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Institution</th>
<th>Phone Number</th>
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<tbody>
<tr>
<td>3:00 p.m.</td>
<td><strong>Algebraic points on curves of genus greater than one.</strong> Preliminary report.</td>
<td>William G. McCallum, University of Arizona</td>
<td>(849-14-230)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td><strong>Faltings’s metrics on cohomology.</strong></td>
<td>Hong Ye, University of California, Santa Barbara</td>
<td>(849-03-47)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td><strong>Potential theory on arithmetic curves.</strong> Preliminary report.</td>
<td>Marcia J. Groszek, Dartmouth</td>
<td>(849-03-171)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td><strong>Polytime mathematics and logic.</strong></td>
<td>Anil Nerode, Cornell University</td>
<td>(849-03-94)</td>
</tr>
</tbody>
</table>

### AMS Special Session on Recursion Theory, II

**3:00 p.m. – 4:50 p.m.**  Room 529, Damen Hall

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<tr>
<th>Time</th>
<th>Speaker</th>
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<th>Phone Number</th>
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<tbody>
<tr>
<td>3:00 p.m.</td>
<td><strong>Universes for 3-E.</strong> Preliminary report.</td>
<td>Gerald E. Sacks, Harvard University and Massachusetts Institute of Technology</td>
<td>(849-03-109)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td><strong>The structure of degrees uniform under different equivalence relations.</strong></td>
<td>Hong Ye, University of California, Santa Barbara</td>
<td>(849-03-47)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td><strong>Priority arguments and ( \Sigma_2 )-induction.</strong></td>
<td>pastoral</td>
<td>(849-03-94)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td><strong>Polymathematics and logic.</strong></td>
<td>pastural</td>
<td>(849-03-94)</td>
</tr>
</tbody>
</table>

### AMS Special Session on Codes and Designs, II

**3:00 p.m. – 5:50 p.m.**  Room 149, Damen Hall

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Institution</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>3:00 p.m.</td>
<td><strong>On the problem of constructing binary constant weight codes.</strong></td>
<td>N. J. A. Sloane, AT&amp;T Bell Laboratories, Murray Hill, New Jersey</td>
<td>(849-94-229)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td><strong>Designs characterized by codes.</strong></td>
<td>J. D. Key, Clemson University</td>
<td>(849-51-161)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td><strong>Affine planes from codes.</strong></td>
<td>Ted Slaman</td>
<td>(849-05-193)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td><strong>Decompositions of designs and codes.</strong> Preliminary report.</td>
<td>K. T. Phelps, Auburn University, Auburn</td>
<td>(849-05-193)</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td><strong>Code automorphism group algorithms.</strong> Preliminary report.</td>
<td>Jeffrey S. Leon, University of Illinois, Chicago</td>
<td>(849-05-262)</td>
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### Program of the Sessions

#### Friday, May 19 (cont'd)

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<th>Time</th>
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<tbody>
<tr>
<td>5:30 p.m.-5:20 p.m.</td>
<td>Room 531, Damen Hall</td>
<td>AMS Special Session on Algebraic Topology of Varieties, I</td>
<td></td>
</tr>
<tr>
<td>3:00 p.m.</td>
<td></td>
<td>Topological types of isolated two-dimensional hypersurface singularities and Zariski multiplicity problem.</td>
<td><a href="849-55-96">Stephen S-T. Yau, University of Illinois, Chicago</a></td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td></td>
<td>Applications of mixed Hodge theory to the topology of complex varieties.</td>
<td><a href="849-14-93">Alan H. Durfee, Mount Holyoke College</a></td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td></td>
<td>Casson invariant of links of surface singularities.</td>
<td><a href="849-57-23">Walter D. Neumann*, Ohio State University, Columbus, and Jonathan Wahl, University of North Carolina, Chapel Hill</a></td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td></td>
<td>Complex structure on Kähler manifolds.</td>
<td><a href="849-57-87">Anatoly S. Libgober and John W. Wood*, University of Illinois, Chicago</a></td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td></td>
<td>The Riccati flow and singularities of Schubert varieties.</td>
<td><a href="849-14-68">James S. Wolper, Hamilton College</a></td>
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#### AMS Special Session on Partial Differential Equations, II

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<tbody>
<tr>
<td>3:00 p.m.-5:20 p.m.</td>
<td>Room 239, Damen Hall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3:00 p.m.</td>
<td></td>
<td>Singular solutions of the equation $-\Delta u = \lambda e^u$.</td>
<td><a href="849-35-45">Hamid Bellout, Northern Illinois University</a></td>
</tr>
<tr>
<td>3:40 p.m.</td>
<td></td>
<td>Uniqueness in the Cauchy problem and weakly pseudo-convex initial surfaces.</td>
<td><a href="849-35-111">Xavier Saint-Raymond, Purdue University, West Lafayette</a></td>
</tr>
<tr>
<td>4:20 p.m.</td>
<td></td>
<td>A global attractor for a reaction-diffusion system arising from climate modeling.</td>
<td><a href="849-35-60">Georg Hetzer* and Paul Guenter Schmidt, Auburn University</a></td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td></td>
<td>A parametrix for the $\bar{\partial}$-Neumann problem.</td>
<td><a href="849-35-42">Kyoko Kimura, University of South Carolina, Columbia</a></td>
</tr>
</tbody>
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#### AMS Special Session on Quadratic Forms and Real Algebraic Geometry, II

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<tbody>
<tr>
<td>3:00 p.m.-5:50 p.m.</td>
<td>Room 342, Damen Hall</td>
<td></td>
<td></td>
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<tr>
<td>3:00 p.m.</td>
<td></td>
<td>A sup-inf-polynomially varying solution to Hilbert's 17th problem.</td>
<td><a href="849-14-160">Charles N. Delzell, Louisiana State University, Baton Rouge</a></td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td></td>
<td>Places on $\ast$-fields and the real holomorphy ring.</td>
<td><a href="849-12-26">Thomas C. Craven, University of Hawaii, Honolulu</a></td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td></td>
<td>Orders and order closures for not necessarily formally real fields. Preliminary report.</td>
<td><a href="849-12-113">Ron Brown, University of Hawaii, Honolulu</a></td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td></td>
<td>Witt rings and spaces of orderings of projective planes.</td>
<td><a href="849-11-203">Franz Kalhoff, University of Dortmund, Federal Republic of Germany</a></td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td></td>
<td>Signatures of higher level on rings with many units.</td>
<td><a href="849-13-19">M. Marshall and L. Walter*, University of Saskatchewan</a></td>
</tr>
<tr>
<td>5:30 p.m.</td>
<td></td>
<td>Higher level orders on noncommutative rings.</td>
<td><a href="849-06-177">Victoria A. Powers, Emory University</a></td>
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#### AMS Special Session on Nonlinear Analysis and its Applications, I

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<tr>
<th>Time</th>
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<th>Speaker(s)</th>
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<tbody>
<tr>
<td>3:00 p.m.-5:50 p.m.</td>
<td>Room 340, Damen Hall</td>
<td></td>
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<tr>
<td>3:00 p.m.</td>
<td></td>
<td>A common fixed point theorem in metric spaces with normal structure.</td>
<td><a href="849-46-243">M. A. Khamsi, University of Rhode Island</a></td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td></td>
<td>Eigenvectors and fixed points for superlinear maps.</td>
<td><a href="849-46-105">Mario Martelli, California State University, Fullerton</a></td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td></td>
<td>Degree theory for some semilinear equations and applications to wave equations.</td>
<td><a href="849-35-98">Juha Berkovits and Vesa Mustonen*, University of Oulu, Finland</a></td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td></td>
<td>Bivariational and singular variational derivatives.</td>
<td><a href="849-49-227">M. Zuhair Nashed, University of Delaware</a></td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td></td>
<td>Generalized Brouwer-Kakutani type fixed point theorems.</td>
<td><a href="849-46-33">Sehie Park, Seoul National University, Korea and MSRI, Korea</a></td>
</tr>
<tr>
<td>5:30 p.m.</td>
<td></td>
<td>Some generalizations of the Meir-Keller type contraction maps.</td>
<td><a href="849-47-55">Billy E. Rhoades*, Indiana University, Bloomington, Sehie Park, Seoul National University, Korea, and Kwon Bae Moon, San Myung Women's University, Korea</a></td>
</tr>
</tbody>
</table>
Program of the Sessions

AMS General Session, II

3:00 p.m.—5:40 p.m. Room 148, Damen Hall

3:00 p.m. Fake generic splitting fields. Preliminary report.
James K. Deveney* and Joe Yanik, Virginia Commonwealth University (849-12-103)

Hürşit Öniper, Middle East Technical University, Ankara, Turkey (849-14-187) (Sponsored by George C. Bush)

3:30 p.m. On gluing affine varieties.
Khomo T. S. Mohapeloa, Pennsylvania State University, McKeesport (849-14-219)

3:45 p.m. The spherical spectrum of a graded ring. Preliminary report.
Hasan Yousef* and Gilbert Stengle, Lehigh University (849-14-221)

4:00 p.m. A characterization of spaces of closest fit.
Seymour Kass, University of Massachusetts, Boston (849-15-226)

4:15 p.m. Correspondence theorems for endomorphism rings of modules.
Khuri Soumaya, East Carolina University (849-16-96)

4:30 p.m. Some properties of higher order derivatives.
P. S. Bullen*, University of British Columbia, and S. N. Mukhopadhyay, Burdwan University, West Bengal, India (849-26-211)

4:45 p.m. On an extension of the Lebesgue measure. Preliminary report.
Jerzy Filiu, Illinois Institute of Technology (849-28-182) (Sponsored by Maurice J. Frank, Jr.)

5:00 p.m. Constructing a pair of pants.
Ara Basmajian, University of Oklahoma (849-30-138)

5:15 p.m. A Picard theorem for projective varieties.
Peter Hall, Washington University (849-32-30)

5:30 p.m. A two point connection problem for a certain ordinary linear homogeneous differential equation.
T. K. Puttaswamy, Ball State University (849-34-12)

Saturday, May 20

AMS Special Session on Sequence Spaces and Summability, III

7:30 a.m.—10:50 a.m. Room 339, Damen Hall

7:30 a.m. Types P and P* sequence spaces. Preliminary report.
Lee Baric, Dickinson College (849-40-58)

8:00 a.m. Positive matrix operators between Koethe sequence spaces.
William H. Ruckle, Clemson University (849-40-04)

8:30 a.m. The β-dual of FK-spaces, II.
J. C. Magee, State University of New York, College at Potsdam (849-40-184)

9:00 a.m. Matrix methods of Bohr-Hardy type.
J. V. DeFranza, St Lawrence University (849-40-185) (Sponsored by Daniel J. Fleming)

9:30 a.m. Summability factors on a class of methods of Bohr-Hardy type.
D. J. Fleming*, St Lawrence University, and A. Peyerimhoff, Universität Ulm, Federal Republic of Germany (849-40-183)

10:00 a.m. Limited sets and c0 and some other stuff. Preliminary report.
Joseph Diestel, Kent State University, Kent (849-46-01)

10:30 a.m. Toeplitz bases in matrix fields.
Amnon Jakimovski, Tel-Aviv University, Israel (849-40-253) (Sponsored by Ambikeshwar Sharma)

AMS Special Session on Noncommutative Ring Theory, III

8:00 a.m.—10:50 a.m. Room 730, Damen Hall

8:00 a.m. Minimal differential identities in prime rings with involution.
Charles Lanski, University of Southern California (849-16-122)

8:30 a.m. Rings of differential operators over rational affine curves. Preliminary report.
Gail Letzter* and Leonid Makar-Limanov, Wayne State University (849-16-205)

9:00 a.m. Reiter's and Drozd's theorems in dimension 1. Preliminary report.
Robert M. Guralnick*, University of Southern California, and Lawrence S. Levy, University of Wisconsin, Madison (849-16-144)

9:30 a.m. Trace functions in the rings of fractions of polycyclic group rings.
A. I. Lichtman, University of Wisconsin, Parkside (849-16-208)

10:00 a.m. On the global dimension of fixed rings. Preliminary report.
Martin Lorenz, Northern Illinois University (849-16-119)

10:30 a.m. Automorphism groups of the universal enveloping algebras of general-position finite dimensional Lie algebras.
Leonard G. Makar-Limanov, Wayne State University (849-16-206)

AMS Special Session on Geometric Topology, III

8:00 a.m.—10:50 a.m. Room 641, Damen Hall

8:00 a.m. Studying links via closed braids, I.
Joan S. Birman*, Columbia University, and William W. Menasco, State University of New York, College at Buffalo (849-57-231)
Saturday, May 20  (cont’d)

<table>
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<tr>
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<tr>
<td>8:30 a.m.</td>
<td>Cutting and pasting and the Chern-Simons invariant.</td>
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<td>Robert Meyerhoff*, Boston University, and Daniel Ruberman, Brandeis University (849-53-82)</td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>On links as obstructions to free reduction. Preliminary report.</td>
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<td>R. Craggs, University of Illinois, Urbana-Champaign (849-57-80)</td>
</tr>
<tr>
<td>9:30 a.m.</td>
<td>Masses of moduli spaces of punctured surfaces.</td>
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<td>R. C. Penner, University of Southern California (849-51-51)</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>One fixed point actions on low-dimensional spheres.</td>
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<td>N. P. Buchdahl, Slawomir Kasik*, Tulane University, and Reinhard Schultz, Purdue University, West Lafayette (849-57-102)</td>
</tr>
<tr>
<td>10:30 a.m.</td>
<td>Pin structures on manifolds. Preliminary report.</td>
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<td>Laurence R. Taylor, University of Notre Dame (849-57-137)</td>
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AMS Special Session on Codes and Designs, III

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<tr>
<td>8:00 a.m.</td>
<td>AMS Special Session on Codes and Designs, III</td>
</tr>
<tr>
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<td>Room 149, Damen Hall</td>
</tr>
<tr>
<td>8:00 a.m.</td>
<td>Informal Discussion</td>
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<tr>
<td>8:30 a.m.</td>
<td>PG(2,4) and connected 2-regular graphs on six vertices. Preliminary report.</td>
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<tr>
<td></td>
<td>Chester J. Salwach, Lafayette College (849-05-173)</td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>Support sizes of triple systems.</td>
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<tr>
<td></td>
<td>Charles J. Colbourn, University of Waterloo (849-05-15)</td>
</tr>
<tr>
<td>9:30 a.m.</td>
<td>Large sets of designs.</td>
</tr>
<tr>
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<td>Yeow Meng Chee*, Charles J. Colbourn, University of Waterloo, and Donald L. Kreher, Rochester Institute of Technology (849-05-17)</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Halving Steiner triple systems.</td>
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<td>Alexander Rosa, McMaster University (849-05-134)</td>
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<tr>
<td>10:30 a.m.</td>
<td>Some structures related to 1-designs. Preliminary report.</td>
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<td>Luc Teirlinck, Auburn University (849-05-191)</td>
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AMS Special Session on Quadratic Forms and Real Algebraic Geometry, III

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<tr>
<td>8:00 a.m.</td>
<td>AMS Special Session on Quadratic Forms and Real Algebraic Geometry, III</td>
</tr>
<tr>
<td></td>
<td>Room 342, Damen Hall</td>
</tr>
<tr>
<td>8:00 a.m.</td>
<td>The real spectrum of higher level of a commutative ring.</td>
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<td>Susan Barton, Pennsylvania State University, Delaware County Campus (849-13-140) (Sponsored by Victoria A. Powers)</td>
</tr>
<tr>
<td>8:30 a.m.</td>
<td>Nonarchimedean real analysis.</td>
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<td>Robby Robson, Oregon State University (849-14-24)</td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>Nash groups. Preliminary report.</td>
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<td>J. Madden* and C. Stanton, Indiana University, South Bend (849-22-143)</td>
</tr>
<tr>
<td>9:30 a.m.</td>
<td>Some new Vapnik-Chervonenkis classes.</td>
</tr>
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<td>Gilbert Stengle* and Joseph Yukich, Lehigh University (849-14-27)</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Spinor norms of similarities. Preliminary report.</td>
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<td>D. B. Shapiro* and I. Alarcion, Ohio State University, Columbus (849-15-78)</td>
</tr>
<tr>
<td>10:30 a.m.</td>
<td>Round quadratic forms under algebraic extensions.</td>
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<td>Burkhard Alpers, University of Saskatchewan (849-11-44) (Sponsored by Murray A. Marshall)</td>
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AMS General Session, III

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<tr>
<td>8:00 a.m.</td>
<td>AMS General Session, III</td>
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<tr>
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<td>Room 148, Damen Hall</td>
</tr>
<tr>
<td>8:00 a.m.</td>
<td>L^∞-bounds for a quasilinear reaction-diffusion system arising from climate modeling. Preliminary report.</td>
</tr>
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<td>Georg Hetzer and Paul Guenter Schmidt*, Auburn University, Auburn (849-35-188)</td>
</tr>
<tr>
<td>8:15 a.m.</td>
<td>Strictly equicontinuous subsets of the space of Bochner integrable functions.</td>
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<td>Mark Gruenwald, Northern Illinois University (849-46-189)</td>
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**Program of the Sessions**

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<tr>
<td>8:30 a.m.-10:50 a.m.</td>
<td>The topological degree for locally strongly L₁-accretors operators. Yi-Chun Zhao*, Appalachian State University and Northeast Normal University, People's Republic of China, and Tao Sun, Northeast Normal University, People's Republic of China (849-47-77) (Sponsored by Ernest P. Lane)</td>
<td>Room 238, Damen Hall</td>
</tr>
<tr>
<td>8:45 a.m.</td>
<td>The group and some finite surgery manifold groups of the Whitehead link. Preliminary report. F. D. Lonergan*, Webster, Massachusetts, and J. Hosack, University of the South Pacific, Fiji Islands (849-55-29)</td>
<td>Room 238, Damen Hall</td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>Moments of quadratic mappings. Joann S. Turisco, United States Naval Academy (849-55-268)</td>
<td>Room 238, Damen Hall</td>
</tr>
<tr>
<td>9:30 a.m.</td>
<td>Fixed point minimization. Michael R. Kelly, Tulane University (849-57-115)</td>
<td>Room 238, Damen Hall</td>
</tr>
<tr>
<td>9:45 a.m.</td>
<td>On a constrained variational problem and the space of horizontal path. Zhong Ge, Mathematical Sciences Research Institute, Berkeley (849-58-170) (Sponsored by Alan D. Weinstein)</td>
<td>Room 238, Damen Hall</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Degenerate and Poisson convergence criteria for success runs. Preliminary report. Anant Godbole, Michigan Technological University (849-60-228)</td>
<td>Room 238, Damen Hall</td>
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</tbody>
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**AMS Special Session on Numerical Methods in Harmonic Analysis, III**

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<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td>9:00 a.m.-10:50 a.m.</td>
<td>Room 238, Damen Hall</td>
<td>Room 238, Damen Hall</td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>Layer potentials for elastostatics in curvilinear polygonal domains. Jeff E. Lewis, University of Illinois, Chicago (849-35-194)</td>
<td>Room 238, Damen Hall</td>
</tr>
<tr>
<td>9:30 a.m.</td>
<td>The optimal number of terms of Fourier and Walsh series for applications in population biology, image processing, and data presentation. Preliminary report. James E. Daly, University of Colorado, Colorado Springs (849-42-172)</td>
<td>Room 238, Damen Hall</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Potential flow in channels. Leslie Greengard, Yale University (849-31-159)</td>
<td>Room 238, Damen Hall</td>
</tr>
<tr>
<td>10:30 a.m.</td>
<td>Pattern recognition by Fourier series. Keith Phillips, New Mexico State University, Las Cruces (849-42-199)</td>
<td>Room 238, Damen Hall</td>
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</tbody>
</table>

**AMS Special Session on Kazhdan-Lusztig Theory and Related Topics, III**

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<thead>
<tr>
<th>Time</th>
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<tbody>
<tr>
<td>9:00 a.m.-10:50 a.m.</td>
<td>Room 441, Damen Hall</td>
<td>Room 441, Damen Hall</td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>A decomposition theorem for self-dual modules in the category 0. David Collingwood and Ronald Irving*, University of Washington (849-22-151)</td>
<td>Room 441, Damen Hall</td>
</tr>
<tr>
<td>9:30 a.m.</td>
<td>On the image of the Jacquet functor. David H. Collingwood, University of Washington (849-22-204)</td>
<td>Room 441, Damen Hall</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Almost rigid nilpotent orbits. Preliminary report. David Vogan, Massachusetts Institute of Technology (849-22-08)</td>
<td>Room 441, Damen Hall</td>
</tr>
<tr>
<td>10:30 a.m.</td>
<td>Bruhat cells in the nilcone and the intersection rings of Schubert varieties. James B. Carrell, University of British Columbia (849-20-145) (Sponsored by Vinay V. Deodhar)</td>
<td>Room 441, Damen Hall</td>
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**AMS Special Session on Algebraic Groups and Related Topics, III**

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<tr>
<th>Time</th>
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<th>Location</th>
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<tbody>
<tr>
<td>8:30 a.m.-10:50 a.m.</td>
<td>Room 440, Damen Hall</td>
<td>Room 440, Damen Hall</td>
</tr>
<tr>
<td>8:30 a.m.</td>
<td>The research of the modular representations of algebraic groups in China. Xi-Hua Cao, East China Normal University, People's Republic of China, and Jian Pan Wang*, East China Normal University, People's Republic of China and University of Virginia (849-20-198) (Sponsored by Brian J. Parshall)</td>
<td>Room 440, Damen Hall</td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>Nonstandard vanishing of sheaf cohomology for reductive groups. Preliminary report. J. E. Humphreys, University of Massachusetts, Amherst (849-20-90)</td>
<td>Room 440, Damen Hall</td>
</tr>
<tr>
<td>9:30 a.m.</td>
<td>On decomposition of modular homology representations for group geometries. Preliminary report. Stephen D. Smith, University of Illinois, Chicago (849-20-34)</td>
<td>Room 440, Damen Hall</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Induction, deformation, and specialization of Lie algebra representations. Preliminary report. Eric M. Friedlander*, Northwestern University, and Brian J. Parshall, University of Virginia (849-17-213)</td>
<td>Room 440, Damen Hall</td>
</tr>
<tr>
<td>10:30 a.m.</td>
<td>Informal Discussion</td>
<td>Room 440, Damen Hall</td>
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**AMS Special Session on Arithmetic Geometry and Intersection Theory, III**

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<tr>
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<tbody>
<tr>
<td>9:00 a.m.-10:50 a.m.</td>
<td>Room 530, Damen Hall</td>
<td>Room 530, Damen Hall</td>
</tr>
<tr>
<td>9:00 a.m.</td>
<td>Riemann-Roch formulas and capacity theory. Preliminary report. Ted Chinburg, Columbia University (849-14-174)</td>
<td>Room 530, Damen Hall</td>
</tr>
<tr>
<td>9:30 a.m.</td>
<td>Discussion</td>
<td>Room 530, Damen Hall</td>
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<tr>
<td>10:00 a.m.</td>
<td>Capacity theory and intersection theory. Preliminary report. Robert Rumely, University of Georgia (849-11-214)</td>
<td>Room 530, Damen Hall</td>
</tr>
<tr>
<td>10:30 a.m.</td>
<td>Discussion</td>
<td>Room 530, Damen Hall</td>
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</table>
### Saturday, May 20 (cont’d)

#### AMS Special Session on Recursion Theory, III

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<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>9:00 a.m.</td>
<td>Diagonally nonrecursive functions and their generalizations. Preliminary report.</td>
</tr>
<tr>
<td>(196)</td>
<td>Antonin Kucera, Cornell University and Charles University, Prague, Czechoslovakia (849-03-71) (Sponsored by Richard A. Shore)</td>
</tr>
<tr>
<td>9:30 a.m.</td>
<td>( n )-generic degrees in ( n )-quantifier arithmetic.</td>
</tr>
<tr>
<td>(197)</td>
<td>Masahiro Kumabe, University of Chicago (849-03-116)</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Array nonrecursive sets, I.</td>
</tr>
<tr>
<td>(198)</td>
<td>Rod Downey, Victoria University of Wellington, New Zealand, Carl Jockusch*, University of Illinois, Urbana-Champaign, and Michael Stob*, Massachusetts Institute of Technology (849-03-167)</td>
</tr>
<tr>
<td>10:30 a.m.</td>
<td>Array nonrecursive sets, II.</td>
</tr>
<tr>
<td>(199)</td>
<td>Rod Downey, Victoria University of Wellington, New Zealand, Carl Jockusch*, University of Illinois, Urbana-Champaign, and Michael Stob, Massachusetts Institute of Technology (849-03-169)</td>
</tr>
</tbody>
</table>

#### AMS Special Session on Algebraic Topology of Varieties, II

<table>
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<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>9:00 a.m.</td>
<td>A generalization of the braid group. Preliminary report.</td>
</tr>
<tr>
<td>(200)</td>
<td>Igor Dolgachev, University of Michigan, Ann Arbor (849-55-128)</td>
</tr>
<tr>
<td>9:30 a.m.</td>
<td>Mapping class groups, function spaces and their cohomology.</td>
</tr>
<tr>
<td>(201)</td>
<td>F. R. Cohen, University of Kentucky (849-55-86)</td>
</tr>
<tr>
<td>10:00 a.m.</td>
<td>Homotopy invariants of nonorientable 4-manifolds.</td>
</tr>
<tr>
<td>(202)</td>
<td>Myung Ho Kim*, University of Wisconsin, Parkside, Sadayoshi Kojima, Tokyo Institute of Technology, Japan, and Frank Raymond, University of Michigan, Ann Arbor (849-57-163)</td>
</tr>
<tr>
<td>10:30 a.m.</td>
<td>Informal Discussion</td>
</tr>
</tbody>
</table>

#### AMS Special Session on Partial Differential Equations, III

<table>
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<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>9:00 a.m.</td>
<td>Remarks on the Szegő kernel.</td>
</tr>
<tr>
<td>(203)</td>
<td>Nicholas Hanges, Herbert H. Lehman College, City University of New York (849-32-112)</td>
</tr>
<tr>
<td>9:40 a.m.</td>
<td>Long range scattering and the Stark effect. Preliminary report.</td>
</tr>
<tr>
<td>(204)</td>
<td>Denis A. W. White, University of Toledo (849-35-79)</td>
</tr>
</tbody>
</table>

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### AMS Invited Address

**11:00 a.m.–11:50 a.m.**

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<thead>
<tr>
<th>Location</th>
<th>Speaker and Affiliation</th>
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</thead>
<tbody>
<tr>
<td>Auditorium, Flanner Hall</td>
<td>(205) Richard H. Rochberg, Washington University (849-46-225)</td>
</tr>
</tbody>
</table>

### AMS Invited Address

**1:30 p.m.–2:20 p.m.**

<table>
<thead>
<tr>
<th>Location</th>
<th>Speaker and Affiliation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditorium, Flanner Hall</td>
<td>(206) Nicholas Lerner, Purdue University, West Lafayette (849-35-130)</td>
</tr>
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### AMS Special Session on Noncommutative Ring Theory, IV

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tbody>
<tr>
<td>3:00 p.m.</td>
<td>Computational techniques in enveloping algebras and fields. Preliminary report.</td>
</tr>
<tr>
<td>(207)</td>
<td>Peter Malcolmson, Wayne State University (849-16-207)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>The symmetric ring of quotients of the coproduct of rings. Preliminary report.</td>
</tr>
<tr>
<td>(208)</td>
<td>Wallace S. Martindale, III, University of Massachusetts, Amherst (849-16-117)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>Primitive factor rings of enveloping algebras of nilpotent Lie superalgebras.</td>
</tr>
<tr>
<td>(209)</td>
<td>Allen D. Bell and Ian M. Musson*, University of Wisconsin, Milwaukee (849-16-126)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td>An unusual free module. Preliminary report.</td>
</tr>
<tr>
<td>(210)</td>
<td>John D. O'Neill, University of Detroit (849-16-41)</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td>X-Inner automorphisms of enveloping rings.</td>
</tr>
<tr>
<td>(211)</td>
<td>James Osterburg*, University of Cincinnati, and D. S. Passman, University of Wisconsin, Madison (849-16-06)</td>
</tr>
<tr>
<td>5:30 p.m.</td>
<td>A quantum deformation of the shape-algebra for ( GL(n) ).</td>
</tr>
<tr>
<td>(212)</td>
<td>Earl J. Taft*, Rutgers University, New Brunswick, and Jacob Towber, Yale University (849-16-36)</td>
</tr>
<tr>
<td>6:00 p.m.</td>
<td>Uniform modules over serial rings with Krull dimension.</td>
</tr>
<tr>
<td>(213)</td>
<td>Mary H. Wright, Southern Illinois University, Carbondale (849-16-31)</td>
</tr>
</tbody>
</table>
### AMS Special Session on Sequence Spaces and Summability, IV

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker and Topic</th>
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</thead>
<tbody>
<tr>
<td>3:00 p.m.</td>
<td>Hardy’s inequality for the discrete Hausdorff transformation.</td>
</tr>
<tr>
<td></td>
<td>Constantine Georgakis, DePaul University (849-40-176)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>Hardy’s inequality for higher order derivatives.</td>
</tr>
<tr>
<td></td>
<td>Hans P. Heinig*, McMaster University, and Alois Kufner, Mathematical Institute,</td>
</tr>
<tr>
<td></td>
<td>Prague, Czechoslovakia (849-44-74)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>Summability methods associated with Carleman classes and the representation of</td>
</tr>
<tr>
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<td>quasianalytic functions.</td>
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<td></td>
<td>Jamil A. Siddiqi, Universite Laval (849-40-264)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td>Banach algebra of sequences and orthogonal polynomials.</td>
</tr>
<tr>
<td></td>
<td>William C. Connett and Alan L. Schwartz*, University of Missouri, St. Louis</td>
</tr>
<tr>
<td></td>
<td>(849-40-238)</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td>Hilb type estimates for homomorphisms of $\ell^2$ algebras.</td>
</tr>
<tr>
<td></td>
<td>William C. Connett* and Alan L. Schwartz, University of Missouri, St. Louis</td>
</tr>
<tr>
<td></td>
<td>(849-40-239)</td>
</tr>
<tr>
<td>5:30 p.m.</td>
<td>“Nice” restriction of functions between certain sequence spaces.</td>
</tr>
<tr>
<td></td>
<td>Jong P. Lee, State University of New York, College at Old Westbury (849-40-241)</td>
</tr>
<tr>
<td>6:00 p.m.</td>
<td>On an analogue of Hardy’s inequality.</td>
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<tr>
<td></td>
<td>P. D. Johnson, Jr., Auburn University, and R. N. Mohapatra*, University of Central</td>
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<td>Florida (849-40-250)</td>
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### AMS Special Session on Geometric Topology, IV

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<tr>
<th>Time</th>
<th>Speaker and Topic</th>
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<tbody>
<tr>
<td>3:00 p.m.</td>
<td>Some homeomorphic, but not diffeomorphic homogeneous 7-manifolds with strictly</td>
</tr>
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<td></td>
<td>positive sectional curvature.</td>
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<tr>
<td></td>
<td>Matthias Kreck, Universitat Mainz, Federal Republic of Germany, and Stephan</td>
</tr>
<tr>
<td></td>
<td>Stolz*, University of Notre Dame (849-57-201)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>Volumes of hyperbolic 3-manifolds.</td>
</tr>
<tr>
<td></td>
<td>Peter B. Shalen* and Marc Culler, University of Illinois, Chicago (849-57-232)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>Alexander polynomials of periodic knots.</td>
</tr>
<tr>
<td></td>
<td>James F. Davis* and Charles Livingston, Indiana University, Bloomington (849-57-</td>
</tr>
<tr>
<td></td>
<td>101)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td>Knots and links in 3-manifolds.</td>
</tr>
<tr>
<td></td>
<td>Richard K. Skora, State University of New York, Stony Brook (849-57-139)</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td>Skein modules of 3-manifolds.</td>
</tr>
<tr>
<td></td>
<td>Jim Hoste*, Pomona College, and Jozef Przytycki, University of British Columbia</td>
</tr>
<tr>
<td></td>
<td>and Warsaw University, Poland (849-57-218)</td>
</tr>
</tbody>
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### AMS Special Session on Kazhdan-Lusztig Theory and Related Topics, IV

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker and Topic</th>
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</thead>
<tbody>
<tr>
<td>3:00 p.m.</td>
<td>Hecke algebras and shelling of Bruhat intervals.</td>
</tr>
<tr>
<td></td>
<td>Matthew J. Dyer, Massachusetts Institute of Technology (849-20-149) (Sponsored</td>
</tr>
<tr>
<td></td>
<td>by Vinay V. Deodhar)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>Cells in the affine Weyl group of type $D_n$.</td>
</tr>
<tr>
<td></td>
<td>Jie Du, University of Virginia and East China Normal University, Shanghai, People’s</td>
</tr>
<tr>
<td></td>
<td>Republic of China (849-20-148) (Sponsored by Leonard L. Scott)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>A combinatorial set-up for questions in Kazhdan-Lusztig theory</td>
</tr>
<tr>
<td></td>
<td>Vinay Deodhar, Indiana University, Bloomington (849-17-147)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td>Informal Discussion</td>
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### AMS Special Session on Algebraic Groups and Related Topics, IV

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<tr>
<th>Time</th>
<th>Speaker and Topic</th>
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<tbody>
<tr>
<td>3:00 p.m.</td>
<td>Extending morphisms from finite to algebraic groups.</td>
</tr>
<tr>
<td></td>
<td>Gary M. Seitz*, University of Oregon, and Donna Testerman, Institute for Advanced</td>
</tr>
<tr>
<td></td>
<td>Study (849-20-54)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>Some remarks on Green functions of classical groups.</td>
</tr>
<tr>
<td></td>
<td>Preliminary report.</td>
</tr>
<tr>
<td></td>
<td>Bhamma Srinivasan, University of Illinois, Chicago (849-20-222)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>Quantum GL sub n.</td>
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<tr>
<td></td>
<td>Richard Dipper, University of Oklahoma (849-20-179)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td>Structure of cohomology of line bundles on $G/B$ for semisimple groups.</td>
</tr>
<tr>
<td></td>
<td>Zongzhu Lin, University of Massachusetts, Amherst (849-20-51)</td>
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### AMS Special Session on Recursion Theory, IV

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<tr>
<th>Time</th>
<th>Speaker and Topic</th>
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<tbody>
<tr>
<td>3:00 p.m.</td>
<td>Constructions by transfinitely many workers.</td>
</tr>
<tr>
<td></td>
<td>Preliminary report.</td>
</tr>
<tr>
<td></td>
<td>Julia F. Knight, University of Notre Dame (849-03-166)</td>
</tr>
<tr>
<td>Time</td>
<td>Event Description</td>
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<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>The lattice of ideals of R.E. degrees. Preliminary report.</td>
</tr>
<tr>
<td>(237)</td>
<td>William C. Calhoun, University of California, Berkeley (849-03-131)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>Minimal degrees and recursively inseparable sets.</td>
</tr>
<tr>
<td>(238)</td>
<td>Preliminary report.</td>
</tr>
<tr>
<td></td>
<td>Manuel Lerman, University of Connecticut, Storrs (849-03-59)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td>Amenable equivalence relations and Turing degrees.</td>
</tr>
<tr>
<td>(239)</td>
<td>Preliminary report.</td>
</tr>
<tr>
<td></td>
<td>Alexander S. Kechris, California Institute of Technology (849-03-76)</td>
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**AMS Special Session on Codes and Designs, IV**

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<tr>
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<tbody>
<tr>
<td>3:00 p.m.</td>
<td>Redundancy of Goppa codes. Preliminary report.</td>
</tr>
<tr>
<td>(240)</td>
<td>Jonathan I. Hall* and Albert M. Roseiro, State University (849-94-260)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>On minimum weight codewords in QR codes.</td>
</tr>
<tr>
<td>(241)</td>
<td>Donald W. Newhart, Department of Defense, Ft. Meade, Maryland (849-94-133) (Sponsored by John F. Dillon)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>Quadratic residue codes in their prime.</td>
</tr>
<tr>
<td>(242)</td>
<td>Harold Ward, University of Virginia (849-94-192)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td>Simplifications to &quot;A new approach to the covering radius...&quot;</td>
</tr>
<tr>
<td>(243)</td>
<td>H. F. Mattson, Jr., Syracuse University (849-94-251)</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td>On extremal self-dual quaternary codes of lengths 18 to 28.</td>
</tr>
<tr>
<td>(244)</td>
<td>W. Cary Huffman, Loyola University of Chicago (849-94-223)</td>
</tr>
<tr>
<td>5:30 p.m.</td>
<td>The interplay of coding theory and algebraic topology.</td>
</tr>
<tr>
<td>(245)</td>
<td>Preliminary report.</td>
</tr>
<tr>
<td></td>
<td>Jay A. Wood, Bowdoin College (849-94-249)</td>
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**AMS Special Session on Quadratic Forms and Real Algebraic Geometry, IV**

<table>
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<tr>
<th>Time</th>
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<tbody>
<tr>
<td>3:00 p.m.</td>
<td>An introduction to blenders.</td>
</tr>
<tr>
<td>(253)</td>
<td>Bruce Reznick, University of Illinois, Urbana-Champaign (849-15-114)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>Quadratic forms over function-fields of elliptic and hyperelliptic curves.</td>
</tr>
<tr>
<td>(254)</td>
<td>Preliminary report.</td>
</tr>
<tr>
<td></td>
<td>Jonathan E. Shick, University of California at San Diego, La Jolla (849-12-64)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>Automorphism groups of positive definite integral quadratic forms.</td>
</tr>
<tr>
<td>(255)</td>
<td>John S. Hsia, Ohio State University, Columbus (849-11-62)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td>Integral quadratic forms whose class and spinor genus coincide.</td>
</tr>
<tr>
<td>(256)</td>
<td>Andrew G. Earnest, Southern Illinois University, Carbondale (849-11-73)</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td>Even unimodular positive definite quadratic forms over real quadratic fields.</td>
</tr>
<tr>
<td>(257)</td>
<td>David C. Hung, State University of New York, Binghamton (849-11-63)</td>
</tr>
<tr>
<td>5:30 p.m.</td>
<td>Trace forms over Hilbertian and Henselian fields.</td>
</tr>
<tr>
<td>(258)</td>
<td>Martin Kruskemper, University of Saskatchewan (849-12-28) (Sponsored by Murray A. Marshall)</td>
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**AMS Special Session on Nonlinear Analysis and its Applications, III**

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<tr>
<td>3:00 p.m.</td>
<td>Equivariant rational homotopy of G Kahler manifolds.</td>
</tr>
<tr>
<td>(246)</td>
<td>Preliminary report.</td>
</tr>
<tr>
<td></td>
<td>Melvin G. Rothenberg, University of Chicago (849-57-267)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>Pseudofree group actions on four-manifolds.</td>
</tr>
<tr>
<td>(247)</td>
<td>Sławomir Kwaśnik, Tulane University, and Reinhard Schultz*, Purdue University, West Lafayette (849-57-61)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>Homotopy K3 surfaces containing Σ(2, 3, 7).</td>
</tr>
<tr>
<td>(248)</td>
<td>Ronald Fintushel*, Michigan State University, and Ronald J. Stern, University of Utah (849-57-186)</td>
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<td>3:30 p.m.</td>
<td>Fixed points for nonexpansive type multi-valued mappings.</td>
</tr>
<tr>
<td>(260)</td>
<td>Duane E. Anderson, University of Minnesota, Duluth, and K. L. Singh*</td>
</tr>
<tr>
<td></td>
<td>Fayetteville State University (849-47-83)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>Fixed point theorems and nonlinear ergodic theorems for nonlinear semigroups.</td>
</tr>
<tr>
<td>(261)</td>
<td>Wataru Takahashi, Tokyo Institute of Technology, Japan (849-47-224)</td>
</tr>
<tr>
<td>4:30 p.m.</td>
<td>Polynomials and analytic functions on Banach spaces.</td>
</tr>
<tr>
<td>(262)</td>
<td>J. H. M. Whitfield, Lakehead University (849-46-261)</td>
</tr>
<tr>
<td>5:00 p.m.</td>
<td>An alternative principle and some of its applications.</td>
</tr>
<tr>
<td>(263)</td>
<td>Biagio Ricceri, University of Messina, Saint'Agata-Messina, Italy</td>
</tr>
<tr>
<td></td>
<td>(849-47-271)</td>
</tr>
<tr>
<td>5:30 p.m.</td>
<td>Non monotonicity of Fejer means in L superior p spaces. Preliminary report.</td>
</tr>
<tr>
<td>(264)</td>
<td>Leonede De Michele* and Delfina Roux, University of Milan, Italy</td>
</tr>
<tr>
<td></td>
<td>(849-42-274) (Sponsored by S. P. Singh)</td>
</tr>
<tr>
<td>6:00 p.m.</td>
<td>Informal Discussion</td>
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### AMS General Session, IV

#### 3:00 p.m.-4:10 p.m.

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<td>3:00 p.m.</td>
<td>Regularities in the computer orbits of Čebyšev pseudo-random number generators.</td>
</tr>
<tr>
<td>(265)</td>
<td>T. Erber* and D. Gavelek, Illinois Institute of Technology (849-68-14)</td>
</tr>
<tr>
<td>3:15 p.m.</td>
<td>Computer precision and algorithmic complexity of pseudo-random number generators.</td>
</tr>
<tr>
<td>(266)</td>
<td>D. Gavelek* and T. Erber, Illinois Institute of Technology (849-68-11)</td>
</tr>
<tr>
<td>3:30 p.m.</td>
<td>Generalized Kustaanheimo-Stiefel transformation.</td>
</tr>
<tr>
<td>(267)</td>
<td>J. S. Rno, University of Cincinnati (849-81-246)</td>
</tr>
<tr>
<td>3:45 p.m.</td>
<td>Central place fractals: Theoretical geography in an urban setting.</td>
</tr>
<tr>
<td>(268)</td>
<td>Sandra Lach Arlinghaus, Institute of Mathematical Geography, 2790 Briarcliff, Ann Arbor, Michigan (849-92-265)</td>
</tr>
<tr>
<td>4:00 p.m.</td>
<td>Riemannian superlogic. Preliminary report.</td>
</tr>
<tr>
<td>(269)</td>
<td>Stephen L. Weinberg, Berkeley Academy of Artscience, Berkeley, California (849-83-09)</td>
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### Presenters of Papers

Numbers following the names indicate the speakers' positions on the program.

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- **AMS Special Session Speaker**

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Boulder Meetings
August 7–10, 1989

Preliminary Announcement

The August 1989 Joint Mathematics Meetings, including the 92nd Summer Meeting of the AMS, the 68th Summer Meeting of the Mathematical Association of America, and the 1989 summer meetings of the Association for Women in Mathematics and Pi Mu Epsilon will be held August 7–10 (Monday–Thursday), 1989, at the University of Colorado, Boulder. Sessions will take place on the campus of the university.

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The members of the Local Arrangements Committee are Larry W. Baggett, William L. Briggs, Frieda K. Holley, Richard A. Holley, William H. Jaco (ex-officio), Andy Roy Magid (ex-officio), Arlan Ramsay (chairman), William N. Reinhardt, Kenneth A. Ross (ex-officio), and Richard L. Roth.

AMS-MAA-PME Invited Address

Pi Mu Epsilon, Inc., the national honorary mathematical society founded in 1914 at Syracuse University, will celebrate its 75th anniversary at the Boulder meetings.

In honor of the occasion, AMS and MAA will cosponsor with Pi Mu Epsilon an invited address on The mathematics of identification numbers by Joseph A. Gallian, University of Minnesota, Duluth. This talk is scheduled for Wednesday, August 9, at 2:30 p.m.

AMS-MAA Invited Addresses

By invitation of the AMS-MAA Joint Program Committee (Sheldon Axler, chairman; Alexandra Bellow; Hugh Montgomery; and Mary Ellen Rudin), four speakers will address the AMS and MAA on the history and development of mathematics. The names of the speakers,
their affiliations, the titles, dates, and times of their talks follow:

**John H. Conway**, Princeton University, \(ax^2 + hxy + cy^2 = n\), 10:10 a.m. Thursday.

**Shizuo Kakutani**, Yale University, *The principle of duality in mathematical analysis*, 10:10 a.m. Wednesday.

**Serge Lang**, Yale University, *Case studies of political opinions passed off as science and mathematics*, 10:10 a.m. Tuesday.

**Jean E. Taylor**, Rutgers University, *Crystals, in equilibrium and otherwise*, 11:00 a.m. Monday.

---

**92nd Summer Meeting of the AMS**

**August 7 – 10, 1989**

**Progress in Mathematics Lectures**

Beginning with the Boulder meetings, the Society will inaugurate a new kind of lecture series titled *Progress in Mathematics*. This series will provide a forum for the exposition of mathematical topics that have come into prominence in the past five years. The members of the Selection Committee for these lectures are Armand Borel, Paul H. Rabinowitz, Hugo Rossi, John T. Tate, and Alan Weinstein.

The names and affiliations of the speakers, their titles, and the days and times they will talk are as follows:

**Haim Brezis**, Rutgers University and Université de Paris VI, *Liquid crystals*, 1:15 p.m. Thursday.

**Dusa McDuff**, SUNY at Stony Brook, *Applications of PDE methods by Gromov, Floer, and others to symplectic geometry of manifolds*, 2:30 p.m. Tuesday.

---

**Colloquium Lectures**

A series of four Colloquium Lectures will be given by **William P. Thurston** of Princeton University. The title of this lecture series is *Geometry, groups, and self-similar tilings*. The lectures will be given at 1:15 p.m. daily, Monday through Wednesday, August 7–9, and at 3:00 p.m. on Thursday, August 10.

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**Prizes**

The 1989 Leroy P. Steele Prizes will be awarded at 4:35 p.m. on Tuesday, August 8.

---

**Invited Addresses**

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


**Howard A. Masur**, University of Illinois at Chicago, *The dynamics of billiards in polygons*, 8:30 a.m. Monday.

---

**Special Sessions**

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

**History of orthogonal polynomials**, **Richard A. Askey**, University of Wisconsin, Madison, Thursday 8:00 a.m. and 3:00 p.m.

**Mathematical questions in computational geometry**, **George J. Fix** and **Rangabahary Kannan**, University of Texas at Arlington, Wednesday 8:00 a.m. and 1:15 p.m., Thursday 8:00 a.m. and 3:00 p.m.

**Free boundary problems and partial differential equations**, **Kirk E. Lancaster**, Wichita State University, and **Edward W. Stredulinsky**, Lawrence University, Tuesday 8:00 a.m., Wednesday 1:15 p.m., Thursday 8:00 a.m. and 3:00 p.m. A. Acker, F. Brulois, A. Elcrat, R. Finn, R. Guenther, N. Korevaar, K. Lancaster H. Parks, D. Siegel, J. Spruck, E. Stredulinsky, D. Tepper, T. Vogel, V. Isakov.

**Dynamics and moduli space**, **Howard A. Masur** and **John Smillie**, Cornell University, Monday 2:30 p.m., Tuesday 8:00 a.m., Wednesday 8:00 a.m. and 1:15 p.m. H. Masur, J. Smillie, J. Harer, S. Kerckhoff, W. Thurston, V. Vesel, M. Boshernitzan, M. Wolf, A. Fathi, W. Goldman.

**Computational number theory and applications**, **Kevin S. McCurley**, I.B.M. Almaden, Monday 2:30 p.m., Tuesday 8:00 a.m., Wednesday 8:00 a.m. and 1:15 p.m. Eric Bach, Joan Boyar, Johannes Buchmann, Paul Dombich, Daniel Gordon, Ming-Deh Huang, Kireeti Kompella, Jeffrey C. Lagarias, Susan Landau, A. K. Lenstra, Andrew Odlyzko, Carl Pomerance, Rene Schoof, Jeffrey Shallit, Victor Shoup, Hug C. Williams.

Most of the papers to be presented at these special sessions will be by invitation; however, anyone contributing an abstract for the meeting who feels that his or her paper would be particularly appropriate for one of these sessions should indicate this clearly on the abstract, and should submit it by May 16, 1989, three weeks earlier than the normal deadline for contributed papers, in order that it be considered for inclusion.

Abstracts should be prepared on the standard AMS form available from the AMS office in Providence or in departments of mathematics, and should be sent to Abstracts, Editorial Department, American Mathematical Society.
Society, Post Office Box 6248, Providence, Rhode Island 02940. A charge of $16 is imposed for retyping abstracts that are not in camera-ready form.

Contributed Papers

There will be sessions for contributed papers Monday morning and afternoon, Tuesday morning, Wednesday morning and afternoon, and Thursday morning and afternoon.

Abstracts should be prepared on the standard AMS form available from the AMS office in Providence or in departments of mathematics, and should be sent to Abstracts, Editorial Department, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940, so as to arrive by the abstract deadline of June 6, 1989. A charge of $16 is imposed for retyping abstracts that are not in camera-ready form.

Late papers will not be accepted.

Council Meeting

The Council of the Society will meet at 2:00 p.m. on Sunday, August 6.

Business Meeting

The Business Meeting of the Society will take place immediately following the award of the Steele Prizes at 4:35 p.m. on Tuesday, August 8. The secretary notes the following resolution of the Council: Each person who attends a Business Meeting of the Society shall be willing and able to identify himself as a member of the Society. In further explanation, it is noted that each person who is to vote at a meeting is thereby identifying himself as and claiming to be a member of the American Mathematical Society. For additional information on the Business Meeting, please refer to the box titled Committee on the Agenda for Business Meetings.

Other AMS–MAA Joint Sessions

Everybody Counts Panel Discussion

The AMS and MAA are cosponsoring a panel discussion of the recent report Everybody Counts. This report, which was prepared by the Mathematical Sciences Education Board of the National Research Council, describes weaknesses in our mathematics education enterprise and issues a call for action. The panel will outline the findings of the report and discuss how the mathematical community can help. JOHN A. THORPE, SUNY at Buffalo and Chair of the MAA Science Policy Committee, is the organizer and moderator. This session is scheduled from 2:30 p.m. to 4:00 p.m. on Monday, August 7.

68th Summer Meeting of the MAA

August 7–10, 1989

Hedrick Lectures

The 37th Earle Raymond Hedrick Lectures will be given by PERSI DIACONIS of Harvard University. These lectures are scheduled at 11:15 a.m. on Tuesday, Wednesday and Thursday, August 8–10. The titles of the lectures are as follows: Lecture I–The mathematics of mixing things up: From card shuffling to counting and back; Lecture II–The mathematics of mixing things up: Reversible chains and eigenvalues of the Laplacian; Lecture III–The mathematics of mixing things up: Modern Markov chain theory.

Invited Addresses

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

JOHN W. ADDISON, JR., University of California, Berkeley, Selfdual quantifiers: a unifying theme in mathematics and logic, 8:40 a.m., Tuesday;
LINDA KEEN, Herbert H. Lehman College, CUNY, Iteration of rational maps and symbolic dynamics, 2:30 p.m., Monday;
MARY ELLEN RUDIN, University of Wisconsin, Madison, Metrizability in manifolds, 3:35 p.m., Monday;
WOLFGANG M. SCHMIDT, University of Colorado, Boulder, The number of solutions of Diophantine equations, 8:40 a.m., Thursday; and
NANCY K. STANTON, University of Notre Dame, The Riemann mapping non-theorem, 3:35 p.m., Wednesday.
Minicourses

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

Minicourse #1: The use of personal computers in an introductory linear algebra course is being organized by Homer Bechtell, University of New Hampshire. Part A is scheduled from 8:45 a.m. to 10:45 a.m. on Monday, August 7, and Part B from 4:00 p.m. to 6:00 p.m. on Monday, August 7. Enrollment is limited to 80.

The effective use of personal computers in an undergraduate linear algebra course is the focus of this course. In Part A, goals and strategies for their implementation are established through the use of the less sophisticated software. This is followed by a review of the mathematical literacy required for a student to be proficient with the software. By removing the constraints imposed by computation, attention is directed toward the design of problem sets that reinforce the fundamentals in the underlying theory. Among the areas in an introductory course in which challenging exercises are needed are the sum and intersection of vector spaces, the LU-decomposition, least squares, projections, quadratic forms, and orthogonal transformations. In Part B, a format will be suggested through examples for each area. Participant involvement will be encouraged. Experience in teaching undergraduate linear algebra is the only prerequisite. Computer anxiety is permitted.

Minicourse #2: Combinatorics via functional equations is being organized by Donald R. Snow, Brigham Young University. Part A is scheduled from 8:45 a.m. to 10:45 a.m. on Monday, August 7, and Part B from 4:00 p.m. to 6:00 p.m. on Monday, August 7. Enrollment is limited to 80.

Many combinatorial functions can be described, studied, and unified by using a simple functional equations approach. These functions include combinations and permutations with various allowable repetitions or no repetitions, sums of the powers of the integers formulas, and many generalizations of these. This gives a method of describing the functions based on its combinatorial interpretation, studying its properties, obtaining its generating function in a direct manner, showing how all these functions are related, and giving several new results. Some of these combinatorial functions yield generalizations of Pascal's Triangle and their properties yield generalizations of the Pascal triangle properties of binomial coefficients. Some of these more interesting properties will be illustrated using computer printouts. The needed background in functional equations will be developed in the Minicourse so only a knowledge of calculus will be assumed.

Minicourse #3: Chaotic dynamical systems is being organized by Robert L. Devaney, Boston University. Part A is scheduled from 4:00 p.m. to 6:00 p.m. on Monday, August 7, Part B from 8:00 a.m. to 10:00 a.m. on Tuesday, August 8, and Part C from 2:25 p.m. to 4:25 p.m. on Tuesday, August 8. Enrollment is limited to 80.

The goal of this Minicourse is to introduce some of the main ideas of dynamical systems theory in as simple a setting as possible, namely, iteration of functions of a single real or complex variable. Lectures will be devoted to such topics as chaos, Julia sets, the Mandelbrot set, and bifurcations. Computer graphics experiments which yield the fascinating images from dynamics will be described. Most of the lectures will be aimed at describing the mathematics behind the concept of "chaos," but some time will be devoted to ways to incorporate ideas from dynamics into the undergraduate curriculum, ranging from precalculus and calculus courses to advanced student research projects.

Minicourse #4: Faculty-managed programs that produce minority mathematics majors is being organized by Ray Shiflett, California State Polytechnic University, Pomona, and Uri Treisman, University of California, Berkeley. Part A is scheduled from 8:00 a.m. to 10:00 a.m. on Tuesday, August 8, and Part B from 2:25 p.m. to 4:25 p.m. on Tuesday, August 8. Enrollment is limited to 40.

Freshman Calculus and Pre-calculus have been burial grounds for the aspirations of the great majority of Black and Hispanic students who enter college to prepare for careers in mathematics- or science-based professions.

Persi Diaconis, Hedrick Lecturer
These courses have been insuperable barriers, even for minority students who are well prepared mathematically and who want to become mathematics majors. This Minicourse is an exploration of a faculty-managed and departmentally-based approach to helping students excel in first-year college mathematics. It is an alternative to remedial or developmental programs—the standard responses to minority student failure. The approach has led to dramatic improvements in Black and Hispanic students' performance at Berkeley, where it was developed in the mid-1970's. It has now been adapted successfully at Cal Poly Pomona and at more than 30 other colleges and universities nationwide.

Minicourse #5: Starting, funding and sustaining mathematics laboratories is being organized by Stavros N. Busenberg, Harvey Mudd College. Part A is scheduled from 8:00 a.m. to 10:00 a.m. on Tuesday, August 8, and Part B from 2:25 p.m. to 4:25 p.m. on Tuesday, August 8. Enrollment is limited to 75.

This course will familiarize participants with successful examples of the use of computer laboratories in the undergraduate mathematics curriculum. The course will feature descriptions of ongoing examples of such laboratories by three or four faculty who have been involved in them at a variety of settings: a small college, a private university, a large state university, and a two-year college. The presentations will describe the curricular innovations that have been made possible by the availability of a mathematics computer laboratory, the software that has been found to be useful, and the means by which the laboratories obtained their initial fund and continuing support.

Part of the Minicourse will outline sources of funding and methods for increasing the probability of success for proposals for such funding. A representative (current or recent past) of the National Science Foundation will be available to give first-hand information about funding possibilities there.

Minicourse #6: Group theory through art is being organized by Thomas Brylawski, University of North Carolina, Chapel Hill. Part A is scheduled from 8:00 a.m. to 10:00 a.m. on Wednesday, August 9, and Part B from 2:30 p.m. to 4:30 p.m. on Wednesday, August 9. Enrollment is limited to 80.

This Minicourse will explore how most of the theory introduced in a first course in group theory can be illustrated (and better understood) using discrete groups of isometries (frieze and wallpaper patterns). Using only synthetic plane geometry as a basis, the two-dimensional groups will be classified. In classification concepts such a isomorphism (of both groups and short exact sequences), examples of subgroup, index, centralizer, conjugate, quotient group, free abelian groups, homomorphism, commutator, etc. occur naturally and are illustrated by patterns from many cultures (e.g., many colored patterns each give examples of non-isomorphic groups, each isomorphic to a subgroup of the other). Hand-in-hand with this analytic theory, going from the pattern to its symmetry group, goes the synthetic theory of creating patterns from the group and a fundamental region. Here, kaleidoscopes illustrate generators and relations, word problems, and Dirichlet tessellations.

Minicourse #7: HP-28S short course for nearly inexperienced users is being organized by Jerold Mathews, Iowa State University. Part A is scheduled from 8:00 a.m. to 10:00 a.m. on Wednesday, August 9, and Part B from 8:00 a.m. to 10:00 a.m. on Thursday, August 10. Enrollment is limited to 80.

This Minicourse will provide a jump-start for nearly inexperienced users toward using the power of the HP-28S. Each participant is expected to bring along an HP-28S (those with an HP-28C will be able to participate fully, excepting one or two topics). The course will include an introduction to reverse Polish and algebraic entry modes, use of some of the built-in functions, and writing, entering, editing, and running user-written functions and programs. A handout will be distributed, including course notes, programs, and a bibliography of HP-28S literature and program sources. Participants will work through (i.e., discuss, enter, edit, and run) built-ins including (as time permits) SOLV, DRAW, CROSS, DOT, MOD, FACT, LR, IFTE, and d/dx., as well as several programs. These may include a program for the game in which the player chooses a positive integer n, replaces it by n/2 or 3n+1, depending on whether n is even or odd, and then repeats until 1 is obtained (if ever), a Pythagorean triples generator, recursive and a non-recursive Fibonacci sequence programs, a polar plotting program, and a Newtons method program. We will try to arrange a program exchange for those who are interested.

Minicourse #8: Applications of the HP-28S for experienced users is being organized by Thomas W. Tucker, Colgate University. Part A is scheduled from 2:30 p.m. to 4:30 p.m. on Wednesday, August 9, and Part B from 1:15 p.m. to 3:15 p.m. on Thursday, August 10. Enrollment is limited to 80.

This Minicourse will illustrate uses of the HP-28S supercalculator in various undergraduate mathematics courses. Particular emphasis will be given to the creation of environments customized for experimenting or problem-solving in a given part of a course: curve sketching for calculus with various features (automatic range finding, single-button computation of extrema and inflection points), comparison of numerical integration techniques also for calculus, numerical solution of differential equations and trajectory plotting, pivoting and matrix editing, and viewing for linear algebra, curve fitting for data analysis, routines for number theory.
(factoring, prime testing, linear congruence solving, powering). Although there will be some playing around with fractals or music, attention will generally be restricted to things the HP-28S can do quickly and easily; things best left to a computer (e.g. 3-dimensional graphics) are left to a computer.

Participants will be expected to bring their own HP-28S calculators and be comfortable with the main features of the HP-28S. In particular, it is assumed that participants have done some programming on the calculator.

Minicourse #9: A seminar on women in mathematics is being organized by Miriam P. Cooney CSC, Saint Mary's College, Notre Dame, Indiana. Part A is scheduled from 8:00 a.m. to 10:00 a.m. on Thursday, August 10, and Part B from 1:15 p.m. to 3:15 p.m. on Thursday, August 10. Enrollment is limited to 30.

The goal of this Minicourse is to prepare participants to conduct a seminar that identifies women mathematicians (past and present), studies their lives and the mathematical times as a context for their work, and reveals mathematics as a human pursuit. Applying the assumption that social-emotional aspects of learning are important to students of mathematics, the Minicourse will provide strategies for creating a seminar that provides a support group to encourage potential mathematics majors, both women and men.

The content of the Minicourse, like the seminar, will include history and stories of women mathematicians, gender bias and its historic causes, research on gender differences, alternate teaching/learning styles, and research on "women's ways of knowing." The format will follow seminar-style discussions, including consideration of the difficulties in learning the discussion process as a mode of teaching. Readings and a syllabus will be sent to participants prior to the meeting.

Participants interested in attending any of the MAA Minicourses should complete the MAA Minicourse Pre-registration Form found at the back of this issue and send it directly to the MAA office at the address on the form so as to arrive prior to the June 1 deadline. DO NOT SEND THIS FORM TO PROVIDENCE. Please note that these MAA Minicourses are NOT the AMS Short Course. After the deadline, potential participants are encouraged to call the MAA headquarters at 800-331-1622.

Please note that prepayment is required. Payment can be made by check payable to MAA (Canadian checks must be marked "in U.S. funds") or Visa or MasterCard credit cards.

The MAA Minicourses are open only to persons who register for the Joint Mathematics Meetings and pay the Joint Meetings registration fee. If the only reason for registering for the Joint Meetings is to gain admission to a MAA Minicourse, this should be indicated by checking the appropriate box on the MAA Minicourse Preregistration Form. Then, if the Minicourse is fully subscribed, full refund can be made of the Joint Meetings preregistration fee. Otherwise, the Joint Meetings preregistration will be processed, and then be subject to the 50% refund rule. Participants should take care when cancelling Minicourse preregistration to make clear their intention as to their Joint Meetings preregistration, since if no instruction is given, the Joint Meetings registration will also be cancelled. PREREGRISTRATION FORMS FOR THE JOINT MEETINGS SHOULD BE MAILED TO PROVIDENCE PRIOR TO THE DEADLINE OF JUNE 1.

The registration fee for each MAA Minicourse is $30.

Contributed Papers

Contributed papers are being accepted on three topics in collegiate mathematics. The topics, the names and affiliations of the organizers, and days they will meet are:

- Pedagogical uses of symbolic computer systems, Arnold M. Ostobe, St. Olaf College, Tuesday morning and afternoon; Monday afternoon if needed.

Symbolic computer systems (also known as computer algebra systems) make machine-based graphical, numerical, and symbolic computing accessible to students. Examples of such systems are muMATH, Derive, Macsyma, Maple, Mathematica, Reduce, SMP, and the HP-28S calculator. Papers are invited that describe experiences using symbolic computer systems in instructional settings at all levels, from pre-calculus to graduate-level courses.

- Calculus revision, Thomas W. Tucker, Colgate University, for the CUPM Subcommittee on Calculus Reform and the First Two Years, Tuesday afternoon and Wednesday morning; Wednesday afternoon if needed.

The session will feature papers describing recent developments in revising the content and pedagogy of calculus. This is a continuation of the session What is happening with calculus revision presented at Phoenix, January 1989.

- Students as consultants, Hedley C. Morris, San Jose State University, Thursday afternoon; Thursday morning if needed.

Papers are solicited on special programs or mathematics clinics for advanced undergraduates who have served as part of a consulting team to nearby industry. Talks by students who have participated are particularly encouraged.

Presentations are normally limited to ten minutes, although selected contributors may be given up to twenty minutes. Individuals wishing to submit papers for any
of these sessions should send the following information to the MAA Washington office at 1529 Eighteenth Street, NW, Washington, DC 20036 by May 17:
1. Title
2. Intended session
3. A one-paragraph abstract (for distribution at the meeting)
4. A one-page outline of the presentation
   Please see information about audio-visual equipment for these sessions which follows.

**Undergraduate Student Paper Session**
The Second Undergraduate Student Paper Session is sponsored by MAA in conjunction with Pi Mu Epsilon, the undergraduate mathematics honorary society, and the MAA Student Sections. The talks are scheduled for Tuesday afternoon, August 8, and Wednesday morning, August 9. Nominations for papers from sections of MAA, mathematics departments, and other interested parties, with a brief abstract, should be sent to Ron Barnes, Department of Applied Mathematical Sciences, University of Houston-Downtown, 1 Main Street, Houston, TX 77002. Deadline for nominations is May 15, 1989.

**Other MAA Sessions**

**Public Hearing on Accreditation**
The ad hoc Committee on Accreditation (John D. Fulton, chair) is sponsoring a “public hearing” while in the process of drafting an accreditation document for undergraduate mathematics. It will propose accreditation for mathematics among U.S. colleges (including two-year) and universities and will include guidelines for accreditation. Alternatively, the completed document could be used as a model to delineate guidelines for undergraduate programs in the mathematical sciences. JOHN D. FULTON, University of West Florida, will moderate the panel. Participants are CALVIN T. LONG, Washington State University and LYNN A. STEEN, St. Olaf College. This session is scheduled from 8:30 a.m. to 9:55 a.m. on Tuesday, August 8.

**A Forum on Mathematics Majors**
A forum on *Are we teaching majors the right mathematics? Are we teaching it the right way?* is scheduled from 8:30 a.m. to 9:55 a.m. on Wednesday, August 9. The participants include BETTYE ANNE CASE, Florida State University, who is chair of the CUPM Subcommittee on the Major in the Mathematical Sciences; JAMES R.C. LEITZEL, Ohio State University, who is chair of the Committee on the Mathematical Education of Teachers (COMET); and LYNN A. STEEN, St. Olaf College, who is chair of the Committee on the Undergraduate Program in Mathematics (CUPM).

**Computers in Calculus Reform**
The Committee on Computers in Mathematics Education (CCIME) is sponsoring a panel discussion on *The role of the computer in calculus reform*. The moderator for this panel is EUGENE A. HERMAN, Grinnell College. Participants include ROBERT L. DEVANEY, Boston University; KENNETH R. HOFFMAN, Hampshire College; DAVID A. SMITH, Duke University and chair of CCIME; and PAUL ZORN, St. Olaf College. This session is scheduled from 8:00 a.m. to 9:55 a.m. on Thursday, August 10.

**Audio-Visual Equipment**
Rooms where MAA sessions will be held are equipped with one overhead projector and screen. (Invited 50-minute speakers are automatically provided with two overhead projectors.) Blackboards will be available only in some rooms.

Persons having other equipment needs should contact the secretary (Kenneth A. Ross, Department of Mathematics, University of Oregon, Eugene, OR 97403) as soon as possible, but in any case prior to June 1.

Upon written request, the following projection equipment will be made available: one additional overhead projector/screen, 35mm carousel slide projector, 16mm film projector, or VHS video cassette recorder with one color monitor.

Speakers requiring special equipment are required to submit their needs in writing prior to June 1.

**Prize Session and Business Meeting**
The MAA Prize Session and Business Meeting is scheduled from 4:40 p.m. to 5:40 p.m. on Wednesday, August 9. The 1989 Beckenbach Book Prize and Merten M. Hasse Prize will be awarded. In addition, the 1989 Carl B. Allendoerfer, Lester R. Ford, and George Polya Awards will be presented. A bylaw change that would add the chair of the Committee on Sections to the Executive Committee will be voted on by the membership. This meeting is open to all members of the Association.

**Board of Governors**
The MAA Board of Governors will meet at 8:30 a.m. on Sunday, August 6. This meeting is open to all members of the Association.

**Section Officers**
There will be a Section Officers’ meeting at 4:40 p.m. on Monday, August 7.

**MAA Banquet for 25-year Members**
The MAA is planning its fourteenth annual banquet for those individuals who have been members of the Association for twenty-five years or more. The banquet will be held on Wednesday, August 9, in the University Club dining room. A reception with cash bar will take
place from 5:45 p.m. to 6:30 p.m. Dinner will be served at 6:30 p.m.

The menu includes tossed salad, filet mignon, baked potato, broccoli with cheese, rolls and butter, French silk pie, and coffee. Please note that all tickets for this banquet must be purchased through preregistration, since a guarantee must be given to the caterer. Tickets are $21 each; the price includes the gratuity. Interested participants should complete the appropriate section of the Preregistration/Housing Form and include appropriate payment. In the event of cancellations, a 50% refund of the amount paid for the ticket will be made if notification is received in Providence by July 14. After that date, no refund can be given.

**Activities of Other Organizations**

The Association for Women in Mathematics (AWM) is sponsoring a panel discussion on *Women in operations research: Their work and experiences*, on Tuesday, August 8, at 9:00 a.m. The moderator is Jill P. Mesirow, Thinking Machines Corporation. Panelists are Margaret Brandeau, Stanford University; Janice Hammond, Harvard Business School; and Margaret Wright, AT&T Bell Laboratories.

The AWM Membership Meeting will be held at 8:30 a.m. on Tuesday, August 8.

An open reception is planned for Tuesday evening, August 8, at 9:30 p.m.

The Joint Policy Board for Mathematics (JPBM) Committee for Mathematics Department Heads has organized a National Meeting of Department Heads at 7:00 p.m. on Monday, August 7, organized by Tom Trotter, Arizona State University.

As previously mentioned, Pi Mu Epsilon is celebrating its 75th anniversary in Boulder. PI ME encourages institutions to send student speakers and delegates to its Diamond Jubilee. Travel grants will be available for student participants. For further information, please contact Eileen Poiani, Saint Peter's College, 2641 Kennedy Boulevard, Jersey City, NJ 07306 or Robert Woodside, Department of Mathematics, East Carolina University, Greenville, NC 27858.

The PI ME Reception will be held on Monday, August 7, at 7:00 p.m. There will be sessions for contributed papers Tuesday morning and afternoon and Wednesday morning. The PI ME Council will meet from noon to 1:00 p.m. on Tuesday, August 8.

PI ME invites all participants to help celebrate its 75th anniversary at the Western Hoe Down on Tuesday evening, August 8, at 6:30 p.m. A special program of entertainment will be presented by PI ME members.

The PI ME Dutch Treat Breakfast will take place on Wednesday, August 9, at 8:00 a.m.

The PI ME Banquet will take place on Wednesday, August 9, at 6:30 p.m. followed by the Frame Lecture. The banquet will be held in the Aspen Room, located in the University Memorial Center on campus.

Please note that all tickets for this banquet must be purchased through preregistration, since a guarantee must be given to the caterer. Tickets are $9 each; the price includes gratuity. The menu includes tossed salad, chicken crepes in lemon sauce, vegetable, rice, rolls with butter, fresh fruit tort, coffee and nonalcoholic punch. Interested participants should complete the appropriate section of the Preregistration/Housing Form and include appropriate payment. In the event of cancellations, a 50% refund of the amount paid for the ticket will be made if notification is received in Providence by July 14. After that date, no refund can be given.

The J. Sutherland Frame Lecture will be delivered on Wednesday, August 9, at 8:30 p.m. by Jane Cronin Scanlon, Rutgers University, on *Entrainment of frequency: A recurring theme*.

PI ME will cosponsor undergraduate student paper sessions with MAA. Further information can be found in the MAA section of this announcement.

There will be an exhibit of PI ME memorabilia on campus at a location to be announced. Materials for this exhibit are on loan from Syracuse University where PI ME was founded in 1914.

**Other Events of Interest**

**Book Sales**

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

**AMS Members’ Information Booth**

Please visit the AMS members’ booth in the exhibit area during the meeting. Complimentary coffee and tea will be served for participants. Carol-Ann Blackwood, Member Services Manager of the Society, will be at the members’ booth to meet members personally. Bring Mrs. Blackwood your comments and compliments about member services.

**Exhibits**

The book and educational media exhibits are open Monday through Thursday, August 7–10. The hours
they are open are 1:00 p.m. to 5:00 p.m. on Monday, 9:00 a.m. to 5:00 p.m. Tuesday and Wednesday, and 9:00 a.m. to noon on Thursday. All participants are encouraged to visit the exhibits during the meeting.

Summer List of Applicants
At the direction of the AMS-MAA-SIAM Committee on Employment Opportunities, which is charged with operation of the Employment Register and with the publication of Employment Information in the Mathematical Sciences, the Society will publish a Summer List of mathematical scientists seeking employment for distribution at the Boulder meeting.

Copies of the 1989 summer list of applicants will be available at the Transparencies section of the registration desk for $5. Following the meeting, they may be purchased from the AMS office in Providence for $7. This list should prove useful to employers who have last-minute openings in the latter part of the summer or in the fall.

The deadline for receipt of applicant forms to appear in this summer list is June 1.

The applicant preregistration résumé and instructions on its completion can be found in this issue.

Instead of an Employment Register at the Summer Meeting in Boulder, there will be an opportunity for posting of both applicant résumé forms and employers' announcements of open positions in or near the main meeting registration area. There will be no special room set aside for interviews. No provisions will be made by the Society for interviews; arrangements will be the responsibility of each employer and applicant. Messages may be left in the message box located in the registration area.

Special applicant and employer forms will be available at the Transparencies section of the registration desk both for applicants to post résumés and for employers to post forms announcing positions.

Applicants who submit an applicant form, but do not plan to attend the meeting, will appear on the printed list only. There is no provision made for posting résumés for participants who do not attend the meeting. No printed lists of employers or applicants who register at the meeting will be available after the meeting.

How to Preregister
The importance of early preregistration cannot be overemphasized. Some of the benefits of early preregistration are a guaranteed room at the university, inclusion in the alphabetical list of preregistrants displayed in the registration area, reduced waiting time at the Joint Meetings Registration Desk, and registration at fees considerably lower than the fees that will be charged for registration at the meeting.

Preregistration for these meetings must be completed by June 1, 1989.

It is essential that the Preregistration/Housing Form (found at the back of this issue) be completed fully and clearly. In the case of several preregistrations from the same family, each family member who is preregistering should complete a separate copy of the Preregistration/Housing Form, but all preregistrations from one family may be covered by one payment. Please print or type the information requested, and be sure to complete all sections. Absence of information (missing credit card numbers, incomplete addresses, etc.) causes a delay in the processing of preregistration for that person.

Please provide your nickname if you wish this information to be printed on your badge. Also, it is planned to make available at the meeting a list of preregistrants by area of interest. If you wish to be included in this list, please provide the Mathematical Reviews classification number of your major area of interest on the Preregistration/Housing Form. The master copy of this list will be available for review by participants at the Message Center section of the registration desk.

Modes of payment which are acceptable, provided they are payable in U.S. dollars to the order of the American Mathematical Society, are U.S. Postal Money Orders, certified U.S. bank checks, U.S. bank money orders, personal checks drawn on a U.S. bank, or credit card (Visa or MasterCard only).

Receipt of the Preregistration/Housing Form and payment will be acknowledged by the Mathematics Meetings Housing Bureau. Participants are advised to bring a copy of this acknowledgement with them to Boulder.

The Joint Meetings registration fees at the meeting will be 30% higher than the preregistration fees listed below.

Joint Mathematics Meetings
Member of AMS, Canadian Mathematical Society, MAA, PiME $63
Emeritus Member of AMS, MAA $18
Nonmember $98
Student/Unemployed $18

AMS Short Course
Student/Unemployed $15
All Other Participants $40

MAA Minicourses
(if openings available)
Minicourses # 1 – 9 $30

A $5 charge will be imposed for all invoices prepared when preregistration forms are submitted without accompanying check(s) for the preregistration fee(s) or are accompanied by an amount insufficient to cover the
There are exceptions to these rules. Therefore, one should contact one's tax advisor to determine the applicability of these provisions.

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

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

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

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

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

How to Obtain Residence Hall Accommodations

The use of the services offered by the Mathematics Meetings Housing Bureau requires preregistration for the Joint Mathematics Meetings. All reservation requests for university accommodations must be received in writing and be processed through the Housing Bureau. Telephone requests cannot be accepted. Please do not contact the university directly, since they will only refer callers back to the Housing Bureau. Preregistrants will receive an acknowledgement of their room requests. However, the university is responsible for making room assignments in the residence halls.

Participants desiring confirmed reservations in the University of Colorado, Boulder, residence halls should read carefully the section on University Housing and then choose preferred accommodations. This information should be indicated clearly in the Housing Section of the Preregistration/Housing Form, and the form submitted with the appropriate payment in full so as to arrive no later than June 1, 1989.

Participants who are able to do so are urged to share a room whenever possible. This procedure can be economically beneficial. The housing form should be fully completed to ensure proper assignment of rooms. Participants planning to share accommodations should provide the name of the person with whom they plan to occupy a room. Each participant should, however, complete a separate Preregistration/Housing Form. Parties planning to share rooms should send their forms together in the same envelope, if possible. If two participants arriving on different days plan to share a double room, each participant must submit the per person amount due applicable to his or her particular choice.

Housing payments for residence hall accommodations will be forwarded to the University of Colorado, Boulder, on your behalf.

Accommodations

University Housing

Participants desiring confirmed reservations for on-campus housing must preregister and send payment in full for housing to the Mathematics Meetings Housing Bureau prior to the June 1, 1989 deadline. Participants in the Joint Mathematics Meetings may occupy residence hall rooms at the University of Colorado during the period August 4 to August 11 only. All must check out by 10:00 am on August 11. (Check-in time is 10:00 a.m.)

All rooms on campus are offered through a room/board package ONLY. A very limited number of rooms on campus will be available for those participants who do not preregister but plan on attending the meetings and registering on site. Such rooms are based on space availability ONLY. (See section on Room and Board Rates for more information.) All check-ins and room assignments will be done in the Kittredge Commons Office, located in the Commons Building on the Upper level of the North Wing. (See section on Check-In Locations and Times for more information.) The Kittredge Commons Office
will not, however, accept any payments for housing assigned through preregistration. ALL advance payments for housing must be sent to the Housing Bureau, located in Providence. (See Preregistration/Housing form.) ALL balances due on preregistration and/or housing must be paid at the Meetings Registration Desk during the hours registration is open. Payments at the Meetings Registration Desk can be made with cash, personal checks, traveler's checks, Visa, and MasterCard. No other credit cards will be accepted. The Meetings Registration Desk will not, however, accept payments for university housing that was not assigned through preregistration (walk-in room assignments). Payments for rooms assigned after preregistration are due at check-in time and must be made at the university check-in desk. Payments at the university check-in desk can be made with cash, traveler's checks, personal checks, Visa and MasterCard. No other credit cards will be accepted.

Participants requesting housing on the University of Colorado campus will be assigned to a hall in the Kittredge Complex. The Housing Bureau will forward their request for housing to the university, who will assign all rooms. The Housing Bureau is not responsible for any room assignments in the residence halls.

Families with children will be allowed to stay in the dormitories. Children over 13 years of age will be charged the full adult room and board rate. Children six to 13 years of age occupying a room separate from that of their parent(s) will be charged the child room and board rate. Children six to 13 years of age staying in the same room as their parent(s) but not occupying a bed will not be charged a room rate; however, there will be a rollaway charge plus a child board rate. Sleeping bags are not permitted in the rooms. Children six to 13 years of age staying in the same room as their parent(s) and occupying a bed will be charged the child room and board rate. There is no charge for board for children under six years old; however, they will be charged for the use of a rollaway, crib, or bed. The maximum number of occupants allowed in one room is two adults and one child. (See section on Hotel Accommodations below for alternate housing for families.)

Residence halls at the University of Colorado have three floors, no elevators, and limited ramps. (Only a few residence halls are accessible to the handicapped.) All single rooms contain a single bed, chest of drawers, one closet, one chair, one desk, a telephone and a desk light. At check-in, participants receive bed linen, a pillow, a blanket, towels, soap, and a drinking glass. Participants are advised to bring their own washcloths, alarm clock, clothes hangers, and fans. Rooms will be prepared for occupancy in advance and housekeeping service will be provided Monday through Friday. There is a daily linen change, including towels.

Each building in the Kittredge Complex has three wings. Each wing has a crossover lounge and one or two laundry rooms. Ironing boards and coin operated washers and dryers are provided in the laundry rooms; however, participants will have to provide their own laundry detergent. A limited supply of clothes irons are available at the Commons Office, which can be checked out with an ID or meal card. Buildings are not air conditioned; however, the weather is usually quite cool at night. There is a bathroom for each gender on each floor of the residence halls. These will be clearly identified. There are vending machines in each residence hall. Firearms, fireworks, pets, or open containers of alcohol are not permitted in or around the residence halls; however alcoholic beverages are permitted inside sleeping rooms for those of legal age. Smoking and nonsmoking rooms are available. Participants can request smoking or nonsmoking rooms on the Preregistration/Housing Form. There is an adequate fire alarm system in the residence halls; however, there are no smoke alarms in the rooms.

Check-In Locations and Times

All check-ins and room assignments will be done in the Kittredge Commons Office, located in the Commons Building on the upper level of the North Wing. The office is open Sunday through Friday from 7:00 a.m. to 11:00 p.m. and Saturday from 7:00 a.m. to 9:00 p.m. Should assistance be needed when the office is closed, a Conference Aide will be on duty, whose name and telephone extension will be posted in front of the desk of the Commons Office. Participants planning to arrive later than the hours stated above should notify the Housing Bureau well in advance so that special arrangements can be made.

Directions to the Kittredge Complex are as follows: Take the Baseline Exit off of Highway 36. Turn west on Baseline to Broadway. Turn right on Broadway (off of Baseline). Follow Broadway to Regent Drive. Turn right on Regent Drive (off of Broadway). Continue on Regent Drive to Kittredge Loop Drive, which is immediately before the Planetarium. Turn right on Kittredge Loop Drive. Take the first left. The Kittredge Commons parking lot is next to the Planetarium. Directions to specific residence halls will be provided.

At the time of check-in, participants who requested rooms through the Mathematics Meetings Housing Bureau will be checked against a master list (Housing Bureau receipts may prove useful) and asked to sign a bill to be used solely for the purpose of verifying the
Meetings

1 STUDENT RECREATION CENTER
2 UNIVERSITY MEMORIAL CENTER
3 UNIVERSITY CLUB
4 ENGINEERING CENTER
5 FISKE PLANETARIUM
6 KITTREDGE COMMONS (check in)
7 KITTREDGE COMPLEX (residence halls)
8 VISITORS' PARKING vvvvv
9 PERMIT PARKING ppppp

MAP IS CONTINUED ON NEXT PAGE
Meetings

university’s billing figures. Each person will also receive
one room key, an information sheet, and meal cards.
Those participants being assigned a room onsite by the
check-in desk will be required to fill out a housing form
and pay for their room, thus enabling them to receive
a room key. Spouses desiring a room key must follow
this procedure also. Please note that, although there is no
deposit required for keys, a penalty of $10 will be imposed
for each key lost or not returned. It is the responsibility of
the Mathematics Meetings Housing Bureau to collect this
penalty. Therefore, it is requested that proper caution
be exercised to avoid this charge. At checkout, all keys
must be returned to the check-in desk. Should the clerk
not be present, please ensure that your name is left at
the check-in desk with the key. Participants can park
temporarily in the Visitor’s Parking Lot, located just
outside of the Commons Office, while checking in. There
will be students available to help carry bags.

Room and Board Rates

The following rates apply for residence hall accommo-
dations at the University of Colorado. There is a 2.53% 
city tax applied to the board portion and a 5.5% city tax
applied to the room portion.

The university allows a maximum of two adults and
one child in each room. Should a family with two children
request accommodations, two rooms would be required
and the double rate (with appropriate adjustments for
children six to 13 years of age) applies in each case. Room and board rates can be found in a box in this
announcement. Meals for children under six years of age
are free.

Please note that a minimum room-and-board package
would be one night’s lodging, one dinner and one
breakfast. The university will accept changes in packages

<table>
<thead>
<tr>
<th>University of Colorado, Boulder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room/Board Rates (per person)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adults</th>
<th>Children 6-13 years in bed</th>
<th>Children 6-13 years in rollaway</th>
<th>Children under 6 years *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>8/4</td>
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<td>$14 single</td>
<td>$3</td>
</tr>
<tr>
<td></td>
<td>$19 double</td>
<td>$9 double</td>
<td></td>
</tr>
<tr>
<td>8/5</td>
<td>$41 single</td>
<td>$23 single</td>
<td>$12</td>
</tr>
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<td></td>
<td>$31 double</td>
<td>$18 double</td>
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<td>8/6</td>
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<td>$31 double</td>
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<td>8/7</td>
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<td>$31 double</td>
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<td></td>
<td>$31 double</td>
<td>$18 double</td>
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</tr>
</tbody>
</table>

* There will be a $3 rollaway or crib charge for all children under 6 years of age, for whom meals are free. Smoking and nonsmoking rooms are available upon request.
reserved up until two weeks prior to check-in. After that, no changes may be made. Any requested exceptions to this policy should be addressed to Elise Graninger, Conference Manager, (303) 492-6777. With the exception of August 4 and August 8, all daily room and board packages include dinner on the night of arrival and breakfast the next day. The last meal of a package will be breakfast. There will not be any refunds issued for meals missed. On August 4, there are no meals included in the package and on August 8, there is no dinner included in the package. Any participant not attending the social event on August 8 but planning to dine on campus should indicate this on the preregistration form AND purchase a meal card at the Meetings Registration Desk for that meal. The cost for this meal card is $7.75 per person. Meal tickets are nonrefundable.

**Food Services**

Residence hall guests may dine either in the East or West dining rooms of the Commons Building, which may be approached from both sides of the serving area using either of the stone stairways from the ground floor of the Commons. There are no ramps for handicapped; however, service elevators can be used if sufficient notice is given ahead of time to Elise Graninger, Conference Manager, (303) 492-6777. Serving hours for breakfast are 6:30 a.m. to 8:00 a.m. Serving hours for dinner are 5:00 p.m. to 6:30 p.m. (As long as someone is inside the dining hall by 6:30 p.m., he/she will be served.) Meal tickets must be presented at each meal for admission to the dining area. Children must be accompanied by parents in the dining area. A typical breakfast is eggs, ham, bacon, sausage, cereal, toast, muffins, assorted fresh fruit, juices, etc. A typical dinner offers one or two entrees, vegetables, rolls, salad bar, desserts, fresh fruit, ice cream, and beverages. Servings are generous; unlimited seconds are allowed. There are no Kosher meals available.

A very limited number of meals is available on a cash basis for guests in the dining rooms.

Within the University Memorial Center on campus there are several eating establishments located in the Grill, which is a food court. Serving hours are from 7:00 a.m. to 5:00 p.m. There is also a sit-down dining area, The Tabor Inn. Lunch is served there from 11:00 a.m. to 1:00 p.m.

There are also several restaurants within the immediate vicinity of the university, on Arapahoe Avenue. They range from fast food (burgers, pizza, tacos, etc.) to ethnic.

**Hotel Accommodations**

As an alternative to university housing, the Housing Bureau lists the following hotels/motels with group rates. All are located within walking distance of the university. Rates are subject to a 9.4% state room tax and are firm.

Participants should make their own reservations early, directly with the hotels/motels, and should identify themselves as participants in the Joint Mathematics Meetings. Participants making reservations should be prepared to remit a one night’s deposit to the hotel or motel or give a major credit card number in order to guarantee their room reservation.

In all cases “single” refers to one person in one bed; “double” refers to two persons in one bed; and “twin double” refers to two persons in two beds. A rollaway cot for an extra person can be added to a room; however, not all hotels are able to do so and for those that do, the number of cots available is limited and given on a first-come, first-served basis.

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

If you hold a guaranteed reservation at a hotel, but are informed upon arrival that there is no room for you, there are certain things you can request the hotel do. First, they should provide for a room at another hotel in town for that evening, at no charge. (You have already paid for the first night when you made your deposit.) They should pay for taxi fares to the other hotel that evening, and back to the meetings the following morning. They should also pay for one telephone toll call so that you can let people know you are not at the hotel you expected. They should make every effort to find a room for you in their hotel the following day, and if successful, pay your taxi fares to and from the second hotel so that you can pick up your baggage and bring it to the first hotel. Not all hotels in all cities follow this practice, so your request for these services may bring mixed results, or none at all.
Clarion Harvest House (Headquarters) Across the street from the Northeast end of the University campus
1345 28th Street
Boulder, CO 80302
Telephone: 303-443-3850
Single $60
Double $60
Suites Upon request
Full service hotel, restaurant, lounge, free parking, indoor/outdoor pools, tennis courts, volleyball courts, workout room, jacuzzi, and jogging trail. Children 12 years and younger are free in same room as parents. Visa, MasterCard, American Express, and Diner’s Club credit cards accepted. The Clarion is the headquarters hotel, and so there is a very LIMITED number of rooms available. Participants are strongly advised to make their reservations with this hotel VERY EARLY.

Holiday Inn Across the street from the East side of campus (near Events Center)
800 28th Street
Boulder, CO 80303
Telephone: 303-443-3322
Single $52
Double $52
Triple $52
Triple w/cot $60
Quadruple $52
Quadruple w/cot $60
Suites Upon request
* Cots are very limited, based on availability.

Broker Inn Two blocks from the Southeast corner of campus
555 30th Street
Boulder, CO 80303
Telephone: 303-444-3330
Single $49 (on weekends only)
Single (1 bed) $53 (on weekdays)
Double (1 bed) $49 (on weekends only)
Double (1 bed) $63 (on weekdays)
Double (2 beds) $49 (on weekends only)
Double (2 beds) $63 (on weekdays)
Triple (2 beds) $63
King size beds are $10 additional

Full service hotel. Outdoor swimming pool, fitness club, free continental breakfast, and lounge. Children 16 years and younger are free in same room as parents. Visa, MasterCard, American Express, and Diner’s Club credit cards accepted. Personal checks are accepted with one form of identification and a major credit card. Upon check-in, all guests will be asked to fill out a registration card and must have some official form of identification.

*The Best Western Boulder Inn offers a Room and Car package that includes sleeping room (1 or 2 beds), rental car with free unlimited mileage, complimentary continental breakfast, car pickup and return at Denver Stapleton Airport or hotel lobby, complimentary nearby health club privileges, free morning newspapers, and free local telephone calls. ROOM AND CAR ARE SUBJECT TO AVAILABILITY and 48 hour advance reservation is requested. Participants are advised to call early for this special deal! For further information and reservations, call 303-449-3800 or 1-800-233-8469.

454 NOTICES OF THE AMERICAN MATHEMATICAL SOCIETY
Meetings

DOWNTOWN BOULDER

1. BOULDER INN
2. BROKER INN
3. HOLIDAY INN
4. UNIVERSITY OF COLORADO
5. THE CLARION HARVEST HOUSE
6. HIGHLANDER INN
7. MARRIOTT RESIDENCE INN
Meetings

Single rooms have queen size beds, while double rooms contain one queen size bed and one double bed. King size beds and waterbeds (very limited) are available upon request and at a higher rate. There are no rollaways available. There is also no restaurant on the property. The nearest restaurant, Perkins, is one-and-one-half blocks away. Outdoor solar-heated swimming pool, free parking.

Marriott Residence Inn Two miles Northeast of campus
All suites hotel
3030 Center Green Drive
Boulder, CO 80301
Telephone: 303-449-5545 or 800-331-3131

Studio (1 Bedroom - 1 to 6 nights) $ 99
Studio (1 Bedroom - 7 to 29 nights) $ 89
Penthouse (2 Bedroom - 1 to 6 nights) $119
Penthouse (2 Bedroom - 7 to 29 nights) $109

Rollaways are $10 extra.

Studio suites accommodate up to three people; penthouse suites accommodate up to four people. There is no restaurant on the property. The nearest restaurant is the Boulder Court, on 28th Street. The Residence Inn offers many other amenities including fully-equipped kitchens, grocery shopping service, private entrances, private patios or balconies, living rooms with fireplaces, free continental breakfast, free parking, outdoor pool, and jacuzzi and sport court. Visa, MasterCard, American Express, and Diner’s Club credit cards accepted.

Participants should be aware that when major conventions occur in any city, additional safety problems are created, especially at night. Those who are attending the meetings alone, or who are concerned about walking to and from the meetings after dark, are encouraged to choose a hotel in close proximity to the campus. Participants are also urged to read the “Words to the Wise” in the local information insert in the program they receive at the meetings.

Registration at the Meetings

Meeting preregistration and registration fees only partially cover expenses of holding meetings. All mathematicians who wish to attend sessions are expected to register, and should be prepared to show their meeting badge, if so requested. Badges are required to obtain discounts at the AMS and MAA Book Sales and to cash a check with the meeting cashier. If a preregistrant should arrive too late in the day to pick up his/her badge, he/she may show the acknowledgement received from the Mathematics Meetings Housing Bureau as proof of registration.

The fees for Joint Meetings registration at the meeting listed below are 30% more than the preregistration fees.

Joint Mathematics Meetings

Member of AMS, Canadian Mathematical Society, MAA, PIHE $ 82
Emeritus Member of AMS, MAA $ 23
Nonmember $127
Student/Unemployed $ 23

AMS Short Course

Student/Unemployed $ 20
All Other Participants $ 50

MAA Minicourses
(if openings available)
Minicourses # 1 - 9 $ 30

Modes of payment which are acceptable, provided they are payable in U.S. dollars to the order of the American Mathematical Society, are U.S. Postal Money Orders, certified U.S. Bank checks, U.S. bank money orders, personal checks drawn on a U.S. bank, or credit card (Visa or MasterCard only).

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

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

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

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

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

Registration Dates and Times

AMS Short Course

Sunday, August 6 8:30 a.m. to 2:30 p.m.
Joint Mathematics Meetings  
[and MAA Minicourses (until filled)] 

Sunday, August 6  3:00 p.m. to 7:00 p.m.  
Monday, August 7 through  
Wednesday, August 9  7:30 a.m. to 4:00 p.m.  
Thursday, August 10  7:30 a.m. to 1:00 p.m.  

Registration Desk Services 

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

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

Audio-Visual Assistance  
A member of the AMS/MAA staff will be available to advise or consult with speakers on audio-visual usage. 

Rooms where special sessions and contributed paper sessions will be held are equipped with an overhead projector and screen. Blackboards will be available only in some rooms. 

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

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

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

Baggage and coats may be left in the Joint Meetings registration area only during the hours that registration is open. The staff cannot, however, take responsibility for lost or stolen articles. 

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

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

Lost and Found  
See the Joint Meetings cashier. Also, participants can check at the Administrative Wing in the Engineering Center. 

Mail  
All mail and telegrams for persons attending the meetings should be addressed as follows: Name of Participant, Joint Mathematics Meetings, c/o Office of Conference Services, 500 30th Street, University of Colorado Campus Box 454, Boulder, Colorado 80309-0454. Mail and telegrams so addressed may be picked up at the mailbox in the registration area during the hours the registration desk is open. U.S. mail not picked up will be forwarded after the meeting to the mailing address given on the participant's registration record. 

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

A telephone message center is located in the registration area to receive incoming calls for participants. The center is open from August 6 through 10, during the hours that the Joint Mathematics Meetings registration desk is open. Messages will be taken and the name of any individual for whom a message has been received will be posted until the message has been picked up at the message center. Once the registration desk has closed for the day there is no mechanism for contacting participants other than calling them directly at their
hotel. The telephone number of the message center is 303-492-4186.

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

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

Miscellaneous Information
Athletic Facilities
Indoor facilities are in the Recreation Center, located near the north edge of the campus, just west of the stadium. This building contains a swimming pool, a diving pool, an ice rink, a weight room, a fitness systems room with stationary bicycles and other equipment, courts for handball, racquetball and squash, and a room

<table>
<thead>
<tr>
<th>Handout Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>The handout table at Joint Meetings of the AMS and MAA is set up in the registration area for the dissemination of information of a nonmathematical nature of possible interest to the members. The administration of the table is in the hands of the AMS-MAA Joint Meetings Committee, as are all arrangements for joint meetings. The following rules and procedures apply.</td>
</tr>
<tr>
<td>1. Announcements submitted by participants should ordinarily be limited to a single sheet no more than $8^{1/2}\times14\text{&quot;}$.</td>
</tr>
<tr>
<td>2. A copy of any announcement proposed for the table is to be sent to the Director of Meetings, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940 to arrive at least one week before the first day of the scientific sessions.</td>
</tr>
<tr>
<td>3. The judgment on the suitability of an announcement for display rests with the Joint Meetings Committee. It will make its judgments on a case by case basis to establish precedents.</td>
</tr>
<tr>
<td>4. Announcements of events competing in time or place with the scheduled scientific program will not be accepted.</td>
</tr>
<tr>
<td>5. Copies of an accepted announcement for the table are to be provided by the proponent. Announcements are not to be distributed in any other way at the meeting (for example, not by posting or personal distribution of handbills).</td>
</tr>
<tr>
<td>6. It may be necessary to limit the number of events or the quantity of announcements distributed at a meeting.</td>
</tr>
<tr>
<td>7. At the close of registration, the table will be swept clean. A proponent who wishes the return of extra copies should remove them.</td>
</tr>
</tbody>
</table>

for volleyball and basketball. Tickets for use of this facility can be purchased on a daily basis for $2.50, or on a weekly basis for $7, at the main entrance to the building. Additional family members under the age of five are free. Over age five the cost is the same as for the first member, up to a maximum cost for a family of $21 for a week. Participants should bring their meeting badges when purchasing the tickets. The building is open as follows: Monday and Wednesday 7:30 a.m. to midnight, Tuesday and Thursday 6:30 a.m. to midnight, Friday 7:30 a.m. to 11:00 p.m., Saturday 9:00 a.m. to 11:00 p.m., and Sunday from 10:00 a.m. to 10:00 p.m. Tennis courts can be found just south of the Kittredge Complex of dormitories. Sign-up sheets are available for reserving courts of all kinds, one day in advance. Reservations can be made by calling 303-492-6561

Camping and RV Facilities
August is the highest month of the season, as possibly everyone knows.

Several campgrounds are managed by the National Forest Service in Roosevelt National Forest, west of Boulder. Most are not more than an hour's drive from town. All but one will have a water supply and trash pickup, and those will cost $6 per night. Olive Ridge, 1.5 miles north of Allenspark, may be on a reservation basis in August; call 303-444-6001 for information. The others are on a first-come-first-camper basis.

Boulder Mountain Lodge, on Four Mile Canyon Road, is a private camping facility, costing $14 per night. Electricity and a hot tub are provided. They do not take reservations, but are willing to tell how crowded it is one or two days ahead: 1-800-458-0882.

Boulder County Fairgrounds Campground is at 9595 Nelson Road, Longmont. The nightly base rate is $10, electricity is $2, and water is $1. Anyone staying seven nights pays for just six nights. Reservations can be made by calling 303-678-1525 starting in May.

Car Rental
It has been arranged for participants to rent cars for the Boulder meetings from Thrifty Rent A Car. To book a reservation, participants should call 1-800-367-2277, extension 314 between 8:00 a.m. and 4:30 p.m. Central Time and tell the operator that they will be attending the Joint Mathematics Meetings in Boulder, Colorado, August 7–10. Normal renter and credit requirements apply, including a valid driver's license, major credit card, and minimum rental age. Taxes, refueling, and optional insurance (the property damage waiver is $8.95 per day) are not included in the rental costs.

[Note, as long as one has collision coverage on one's car at home, and it is not driven while one is on vacation, most insurance companies will cover collision (PDW, formerly CDW) on the rental car; so there is no need to
purchase it from the rental company. However, coverage will not extend if the rental car is for business purposes. Participants should check with their insurance agent for clarification of their specific policy. The following rates include unlimited mileage:

<table>
<thead>
<tr>
<th>Car Type</th>
<th>Day</th>
<th>Week</th>
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</thead>
<tbody>
<tr>
<td>Sub-compact</td>
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<td>$99.99</td>
</tr>
<tr>
<td>Compact</td>
<td>26.99</td>
<td>109.99</td>
</tr>
<tr>
<td>Mid Size</td>
<td>27.99</td>
<td>129.99</td>
</tr>
<tr>
<td>Full Size (four doors)</td>
<td>29.99</td>
<td>149.99</td>
</tr>
<tr>
<td>Luxury (3 day notice)</td>
<td>34.95</td>
<td>244.65</td>
</tr>
</tbody>
</table>

**Child Care**

Boulder has more than a few child care facilities that accept drop-in clients. A booklet listing more will be available at the local information desk, but some are listed here. It is advisable to call a week or two in advance to verify availability.

Jack and Jill Preschool and Kindergarten, 303-442-1571, 1301 North Street, Boulder, CO 80302. Director: Ruth Jones. Ages: 2 1/2 to 8. Hours: 6:30 a.m. to 6:00 p.m. Rates: $17/day, $72/week, $2/hour.

Kinder Learning Center, 303-440-0749, 3600 Hazelwood Court, Boulder, CO 80302. Director: Amy L. Austin. Ages: 12 months to 12 years. Hours: 6:30 a.m. to 6:00 p.m. Rates: $22/day, $73/week for over 2 1/2.

Sacred Heart Childcare Program, 303-443-0684, 1317 Mapleton Avenue, Boulder, CO 80302. Director: Louis Coenon. Ages: 3 to 12. Hours: 7:00 a.m. to 6:00 p.m. Rates: $2/hour.


In addition, a Parent-Child Lounge will be located near the Joint Meetings registration area. It will be furnished with casual furniture, a crib, a changing area, some assorted toys and a television set. Any child using this lounge MUST be accompanied by a parent (not simply an adult) who must be responsible for supervision of the child. This lounge will be unattended and parents assume all responsibility for their children. This lounge will only be open during the hours of registration and all persons must leave the lounge at the close of registration each day.

**Handicapped**

Most session rooms on campus are accessible by wheelchair. The university will provide alternate accommodations if necessary. Please contact Arlan Ramsay, Department of Mathematics, Campus Box 426, University of Colorado, Boulder, CO 80309-0426, if there are any questions.

Participants with special needs should be sure to indicate this on the Preregistration/Housing Form.

**Libraries**

Norlin Library is the main library on the campus. Most mathematics books and journals are in the Math-Physics Library in the east end of Duane Physics Building on level one.

The main branch of the Boulder Public Library is at 1000 Canyon Boulevard.

**Local Information**

For following directions, remember that the mountains are to the west of Boulder. There are many things to do in the mountains near Boulder, including trails that start in the city. Please visit the Local Information section of the Meetings Registration Desk to get more information about the hiking trails. Some start at the west end of Baseline Road (Gregory Canyon, or Chautauqua Park), or at the National Center for Atmospheric Research (NCAR) at the west end of Table Mesa Drive, or at the west end of Mapleton Avenue.

Flagstaff Mountain is a city park. There is a bicycle and jogging/walking trail that runs along Boulder Creek starting near the mouth of the canyon and going out to 55th Street.

NCAR and NIST (National Institute of Standards and Technology) are places to visit, as are museums on campus and in Denver. Central City, Leadville, and Georgetown are historical small cities. Rocky Mountain National Park is an hour's drive north of Boulder on US36. Mesa Verde is in the Southwest Corner of the state, and all the roads that can be taken to arrive there go past beautiful scenery. Visit the Local Information section for more hints on where to go after the meeting.

Be aware that it is easier to sunburn at higher altitudes and easier to get dehydrated. Sunblock and water bottles are essentials of hiking.

**Medical Services**

Boulder Community Hospital is at Broadway and Balsam; follow Broadway north from downtown, or go west from 28th Street on Valmont (which connects to Balsam).

Boulder Memorial Hospital is at 311 Mapleton; go north on Broadway and turn left on Mapleton.

Boulder Medical Center has an Urgent Care Center for walk-in patients and is also located at Broadway and Balsam. Hours are 8:00 a.m. to 7:00 p.m.

For all emergencies, on or off campus, dial 911.

**Parking**

Participants staying on campus can purchase permits for the Kittredge Permit Parking Lots for $1 per day at the check-in desk, located in the Kittredge Commons.
Office. These lots are only available for those residing at Kittredge.

Participants driving in but not staying on campus can purchase stickers at a cost of $3 per day for the Visitors' Parking Lot, located across the street from the University Memorial Center. These stickers do not include in and out privileges. A new sticker will have to be presented to the attendant every time one leaves the lot. These stickers can be purchased at the Transparencies section of the Meetings Registration Desk, located in the University Memorial Center.

The Permit Parking Lot located next to the Engineering building is free on weekends.

Smoking
Please note that smoking is not allowed in any of the buildings on the university campus, except for specially designated areas. Smoking is not allowed in any of the sessions.

Social Events
PIME invites all participants to help celebrate its 75th anniversary at the Western Hoe Down on Tuesday evening, August 8, at 6:30 p.m. A special program of entertainment will be presented by PIME members, and a local square dance caller will show you how to swing your partner and do-si-do.

The Hoe Down will take place in the Gardens at the Clarion Harvest House. The hotel is located across the street from the Northeast corner of campus. The menu includes barbecue chicken, ribs, and beef brisket, baked beans, creamed corn, tossed salad, Southern slaw, apple cobbler, corn muffins, coffee, and tea. The children's menu includes soft drinks. For vegetarians, a vegetarian lasagne will replace the three meats on the menu. Participants may indicate their meal preference on the Preregistration/Housing Form.

Tickets are $19 for adults' regular meal, $16 for vegetarian meal, and $9 for children five through 12 years of age. There is no charge for children under five years of age; however, if bringing a child under five years of age, please indicate on the Preregistration/Housing Form. Participants may indicate their meal preference on the Preregistration/Housing Form. Tickets may be purchased through preregistration by completing the appropriate section of the Preregistration/Housing Form, and enclosing the proper payment. Please note that 50% refund can be made on Western Hoe Down tickets until July 14. After July 14, no refunds are possible.

Rocky Mountain National Park Tour
Most airlines offer specially reduced fares requiring that one stay over on Saturday night. Because the Boulder meetings end on Thursday, August 10, it is not feasible for most participants to plan to stay over on Saturday, August 12, but it might be possible for a large number of participants to plan to arrive in Boulder on Saturday, August 4. Since there is no scientific program planned over that weekend, special arrangements have been made for early arrivals to participate in an unguided bus trip to Rocky Mountain National Park on Sunday, August 6.

Buses will leave from the University Memorial Center on campus at 9:00 a.m. on Sunday, August 6, and travel to the park via rugged North St. Vrain Canyon. The buses will arrive at Estes Park at 10:00 a.m. and proceed to Bear Lake. From 10:30 a.m. until 12:30 p.m. participants will be on their own for hiking, etc. There is a series of hiking trails from the Bear Lake Trail Head linking Bear Lake, Dream Lake, and Emerald Lake. These are not difficult trails, and the scenery is breathtaking. Participants are urged to bring their cameras.

At 12:30 p.m., the buses will depart Bear Lake for Estes Park for lunch (the cost of which is not included in the ticket price). At 2:00 p.m., the buses will depart Estes Park for the return to campus, arriving about 3:00 p.m., in plenty of time to register for the meeting, and have a leisurely dinner with friends.

The price of the bus ticket is $12 per person, with no price differential for children. In addition, participants will be required to pay a $2 admission fee to the park upon arrival. (Children 16 years of age or under are admitted to the park free.) The deadline for purchase of tickets is June 1. Interested participants should request their tickets on the Preregistration/Housing Form and remit the total amount due. 50% will be refunded for tickets canceled in writing prior to July 14. After July 14, no refunds will be possible.

Travel
In August, Colorado is on Mountain Daylight Time. Airline passengers will arrive at Stapleton International Airport in Denver. From there regular bus service to Boulder via downtown Denver costs $2 and takes 1.25 hours. The Boulder Airporter runs a shuttle service, leaving every hour, costing $8 and taking about 40 minutes. Call 303-499-1559 for reservations.

For some years now, the AMS-MAA Joint Meetings Committee has engaged a travel agent for the January and August Joint Meetings in an effort to ensure that everyone attending these meetings is able to obtain the best possible airfare. This service is presently being performed by Meetings, Incentives, Conventions of America, Inc. (MICA); their advertisement can be found elsewhere in this meeting announcement. Although any travel agent can obtain Supersaver or other such published promotional fares, only MICA can obtain the special additional 5% discount over and above these fares, and the 40% off regular coach fare. The latter, of course, is financially beneficial only when one does not qualify for one of the promotional fares. Participants should pay
particular attention to the cancellation policies stated in the ad.

Weather

Boulder is mainly on the plain, but next to (small) mountains. The humidity tends to be very low (20% to 30%). High temperatures at the time of the meeting average 84°F and the temperature drops rapidly in the evening with overnight lows averaging 58°F. Of course, in the mountains it will be cooler. Afternoon and evening thundershowers are fairly common but usually brief. Keep an eye out for rainbows, if you like them.

Andy Roy Magid
Associate Secretary
Norman, Oklahoma
MICA, Inc., the official travel management firm for the Joint Mathematics Meetings to be held in Boulder, Colorado, August 7-10, 1989, has arranged for special discounts aboard United Airlines!*

Save 5% off published promotional fares, meeting all restrictions, or 40% off regular roundtrip coach fares, with a 7 day advance purchase. The lowest fares require a Saturday night stay, are subject to an airline change/cancellation penalty, and may be purchased at least 30 days prior to departure.

Every Joint Mathematics Meetings participant will also receive $100,000.00 flight insurance with each ticket purchased through MICA aboard any airline.

* United Airlines has been designated as the official airline for the Boulder meetings because it provides the best service for the majority of participants around the country. For some participants, United may not provide optimal service, but since the airlines permit only one carrier to be designated as the official airline, other airlines will not offer the discount convention airfares. However, if United does not provide convenient service to and from your location, MICA will inform you of the best available service and fare on another airline.

Call Today Toll-Free and Save:
1-800-888-6422
Monday - Friday, 8:30 am - 6:00 pm EST

Meetings, Incentives, Conventions of America, Inc. (MICA, Inc.)
Suite 303, 195 Farmington Avenue, Farmington, CT 06032
The purpose of this timetable is to provide assistance to preregistrants in the selection of arrival and departure dates. The program, as outlined below, is based on information available at press time.

UMC=University Memorial Center

### Sunday, August 6

<table>
<thead>
<tr>
<th>Time</th>
<th>American Mathematical Society</th>
<th>Mathematical Association of America</th>
<th>Other Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MORNNG</strong></td>
<td>SHORT COURSE REGISTRATION</td>
<td>BOARD OF GOVERNORS' MEETING</td>
<td></td>
</tr>
<tr>
<td>8:30 a.m. - 2:30 p.m.</td>
<td>SHORT COURSE SERIES CRYPTOLOGY AND COMPUTATIONAL NUMBER THEORY</td>
<td></td>
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</tr>
<tr>
<td>8:30 a.m. - 4:00 p.m.</td>
<td>SHORT COURSE LECTURE #1 Introduction</td>
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<tr>
<td></td>
<td>Carl Pomerance</td>
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<tr>
<td>9:15 a.m. - 10:30 a.m.</td>
<td>SHORT COURSE LECTURE #2 The search for provably secure cryptosystems</td>
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<td></td>
<td>Shafi Goldwasser</td>
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<tr>
<td>10:45 a.m. - noon</td>
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<tr>
<td><strong>AFTERNOON</strong></td>
<td>SHORT COURSE LECTURE #3 Primality testing</td>
<td></td>
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<tr>
<td>1:30 p.m. - 2:45 p.m.</td>
<td>Arjen K. Lenstra</td>
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<tr>
<td>2:00 p.m. - 7:00 p.m.</td>
<td>COUNCIL MEETING</td>
<td></td>
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<tr>
<td>3:00 p.m. - 4:15 p.m.</td>
<td>SHORT COURSE LECTURE #4 Factoring</td>
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<td></td>
<td>Carl Pomerance</td>
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<tr>
<td>3:00 p.m. - 7:00 p.m.</td>
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</tbody>
</table>

REGISTRATION FOR JOINT MATHEMATICS MEETINGS
Glenn Miller Ballroom, UMC
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Presenter/Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:30 a.m. - 4:00 p.m.</td>
<td></td>
<td>Registration: Glenn Miller Ballroom, UMC</td>
</tr>
<tr>
<td>8:00 a.m. - 8:15 a.m.</td>
<td></td>
<td>Welcome Address</td>
</tr>
<tr>
<td>8:00 a.m. - 8:15 a.m.</td>
<td>Short Course Lecture #5: The rise and fall of knapsack cryptosystems</td>
<td>Kevin S. McCurley</td>
</tr>
<tr>
<td>8:30 a.m. - 9:20 a.m.</td>
<td>Invited Address: The dynamics of billiards in polygons</td>
<td>Howard A. Masur</td>
</tr>
<tr>
<td>8:30 a.m. - 10:45 a.m.</td>
<td>Sessions for Contributed Papers</td>
<td></td>
</tr>
<tr>
<td>8:45 a.m. - 10:45 a.m.</td>
<td></td>
<td>MINICOURSE #1 (Part A): The use of personal computers in an introductory linear algebra course</td>
</tr>
<tr>
<td>8:45 a.m. - 10:45 a.m.</td>
<td></td>
<td>MINICOURSE #2 (Part A): Combinatorics via functional equations</td>
</tr>
<tr>
<td>9:35 a.m. - 10:25 a.m.</td>
<td>Invited Address: Asymptotic densities for diffusing particles in certain basic chemical reactions</td>
<td>Maury D. Bramson</td>
</tr>
<tr>
<td>11:00 a.m. - 11:50 a.m.</td>
<td></td>
<td>AMS-MAA Invited Address: Crystals, in equilibrium and otherwise</td>
</tr>
<tr>
<td>1:00 p.m. - 5:00 p.m.</td>
<td></td>
<td>Exhibit and Book Sale</td>
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<tr>
<td>1:00 p.m. - 5:00 p.m.</td>
<td></td>
<td>Book Sale</td>
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<tr>
<td>1:00 p.m. - 5:00 p.m.</td>
<td></td>
<td>Exhibits</td>
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</tbody>
</table>
### Monday, August 7 (cont'd)

#### AFTERNOON (cont'd)

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Organizer/Editor</th>
</tr>
</thead>
</table>
| 1:15 p.m. - 2:15 p.m. | COLLOQUIUM LECTURE I  
Geometry, groups, and self-similar tilings  
William P. Thurston |                                                                                   |
| 2:30 p.m. - 3:20 p.m. | SHORT COURSE LECTURE #6  
Pseudorandom number generators in cryptography and number theory  
Jeffrey C. Lagarias |                                                                                   |
| 2:30 p.m. - 4:00 p.m. | AMS-MAA PANEL DISCUSSION  
Everybody Counts  
John A. Thorpe (moderator) |                                                                                   |
| 2:30 p.m. - 6:00 p.m. | SPECIAL SESSIONS  
Dynamics and moduli space I  
Computational number theory and applications I |                                                                                   |
| 2:30 p.m. - 6:00 p.m. | SESSIONS FOR CONTRIBUTED PAPERS |                                                                                   |
| 3:35 p.m. - 4:25 p.m. | INVITED ADDRESS  
Metrizability in manifolds  
Mary Ellen Rudin |                                                                                   |
| 4:00 p.m. - 6:00 p.m. | MINICOURSE #1 (Part B)  
The use of personal computers in an introductory linear algebra course  
Homer Bechtel |                                                                                   |
| 4:00 p.m. - 6:00 p.m. | MINICOURSE #2 (Part B)  
Combinatorics via functional equations  
Donald R. Snow |                                                                                   |
| 4:00 p.m. - 6:00 p.m. | MINICOURSE #3 (Part A)  
Chaotic dynamical systems  
Robert L. Devaney |                                                                                   |
| 4:40 p.m. - 6:40 p.m. | SECTION OFFICERS' MEETING |                                                                                   |

#### EVENING

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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</thead>
</table>
| 7:00 p.m. - 9:00 p.m. | NATIONAL MEETING OF DEPARTMENT HEADS |}

**Other Organizations**
## TIMETABLE

### Tuesday
**August 8**

#### MORNING
7:30 a.m. - 4:00 p.m.

**REGISTRATION**
Glenn Miller Ballroom, UMC

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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</thead>
<tbody>
<tr>
<td>8:00 a.m.</td>
<td>SPECIAL SESSIONS&lt;br&gt;Free boundary problems and partial differential equations I&lt;br&gt;Dynamics and moduli space II&lt;br&gt;Computational number theory and applications II</td>
</tr>
<tr>
<td>8:00 a.m.</td>
<td>SESSIONS FOR CONTRIBUTED PAPERS</td>
</tr>
<tr>
<td>8:00 a.m.</td>
<td>CONTRIBUTED PAPER SESSION&lt;br&gt;Pedagogical uses of symbolic computer systems, Part A&lt;br&gt;A. M. Ostebee</td>
</tr>
<tr>
<td>8:00 a.m.</td>
<td>MINICOURSE #3 (Part B)&lt;br&gt;Chaotic dynamical systems&lt;br&gt;R. L. Devaney</td>
</tr>
<tr>
<td>8:00 a.m.</td>
<td>MINICOURSE #4 (Part A)&lt;br&gt;Faculty-managed programs that produce minority mathematics majors&lt;br&gt;R. Shiflet&lt;br&gt;U. Treisman</td>
</tr>
<tr>
<td>8:00 a.m.</td>
<td>MINICOURSE #5 (Part A)&lt;br&gt;Starting, funding and sustaining mathematics laboratories&lt;br&gt;S. N. Busenberg</td>
</tr>
<tr>
<td>8:30 a.m.</td>
<td>PUBLIC HEARING ON ACCREDITATION&lt;br&gt;John D. Fulton (moderator)&lt;br&gt;C. T. Long&lt;br&gt;L. A. Steen</td>
</tr>
<tr>
<td>8:40 a.m.</td>
<td>INVITED ADDRESS&lt;br&gt;Selfdual quantifiers: a unifying theme in mathematics and logic&lt;br&gt;J. W. Addison, Jr.</td>
</tr>
<tr>
<td>Time</td>
<td>American Mathematical Society</td>
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<td><strong>Tuesday, August 8 (cont'd)</strong></td>
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<td><strong>MORNING (cont'd)</strong></td>
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<td>9:00 a.m. - 10:00 a.m.</td>
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<tr>
<td>9:00 a.m. - 5:00 p.m.</td>
<td>EXHIBIT AND BOOK SALE</td>
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<td>9:00 a.m. - 5:00 p.m.</td>
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<td>10:10 a.m. - 11:00 a.m.</td>
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<td>11:15 a.m. - 12:15 a.m.</td>
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<tr>
<td><strong>AFTERNOON</strong></td>
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<tr>
<td>noon - 1:00 p.m.</td>
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<tr>
<td>1:15 p.m. - 2:15 p.m.</td>
<td>COLLOQUIUM LECTURE II</td>
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<tr>
<td></td>
<td>Geometry, groups, and self-similar tilings</td>
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<td></td>
<td>William P. Thurston</td>
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<tr>
<td>2:25 p.m. - 4:25 p.m.</td>
<td>MINICOURSE #3 (Part C)</td>
</tr>
<tr>
<td></td>
<td>Chaotic dynamical systems</td>
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<td></td>
<td>Robert L. Devaney</td>
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<tr>
<td>2:25 p.m. - 4:25 p.m.</td>
<td>MINICOURSE #4 (Part B)</td>
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<tr>
<td></td>
<td>Faculty-managed programs that produce minority mathematics majors</td>
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<td></td>
<td>Ray Shiflett</td>
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<tr>
<td></td>
<td>Uri Treisman</td>
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<tr>
<td>2:25 p.m. - 4:25 p.m.</td>
<td>MINICOURSE #5 (Part B)</td>
</tr>
<tr>
<td></td>
<td>Starting, funding and sustaining mathematics laboratories</td>
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<td>Stavros N. Busenberg</td>
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</tbody>
</table>
**Tuesday, August 8 (cont'd)**

**AFTERNOON (cont'd)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
</table>
| 2:30 p.m. - 4:00 p.m. | PROGRESS IN MATHEMATICS LECTURE  
Applications of PDE methods by Gromov, Floer, and others to symplectic geometry of manifolds  
Dusa McDuff |
| 2:30 p.m. - 4:20 p.m. | CONTRIBUTED PAPER SESSION  
Pedagogical uses of symbolic computer systems, Part B  
Arnold M. Ostebee |
| 2:30 p.m. - 4:20 p.m. | CONTRIBUTED PAPER SESSION  
Calculus revision, Part A  
Thomas W. Tucker |
| 2:30 p.m. - 4:20 p.m. | PME CONTRIBUTED PAPER SESSIONS |
| 4:35 p.m. - 6:00 p.m. | STEELE PRIZE SESSION AND BUSINESS MEETING |

**EVENING**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:30 p.m. - 9:30 p.m.</td>
<td>WESTERN HOE DOWN</td>
</tr>
<tr>
<td>9:30 p.m. - 11:00 p.m.</td>
<td>AWM RECEPTION</td>
</tr>
</tbody>
</table>

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**Wednesday, August 9**

**MORNING**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event Description</th>
</tr>
</thead>
</table>
| 7:30 a.m. - 4:00 p.m. | REGISTRATION  
Glenn Miller Ballroom, UMC |
| 8:00 a.m. - 9:55 a.m. | SPECIAL SESSIONS  
Mathematical questions in computational geometry I  
Dynamics and moduli space III  
Computational number theory and applications III |
<table>
<thead>
<tr>
<th>Time</th>
<th>American Mathematical Society</th>
<th>Mathematical Association of America</th>
<th>Other Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:00 a.m. - 9:55 a.m.</td>
<td>SESSIONS FOR CONTRIBUTED PAPERS</td>
<td>CONTRIBUTED PAPER SESSION Calculus revision, Part B Thomas W. Tucker</td>
<td></td>
</tr>
<tr>
<td>8:00 a.m. - 9:55 a.m.</td>
<td>MINICOURSE #6 (Part A) Group theory through art Thomas Brylawski</td>
<td>MAA-PME UNDERGRADUATE STUDENT PAPER SESSION</td>
<td></td>
</tr>
<tr>
<td>8:00 a.m. - 9:55 a.m.</td>
<td>MINICOURSE #7 (Part A) HP-28S short course for nearly inexperienced users Jerold Mathews</td>
<td>PME CONTRIBUTED PAPER SESSIONS</td>
<td></td>
</tr>
<tr>
<td>8:00 a.m. - 9:00 a.m.</td>
<td>MINICOURSE #6 (Part A) Group theory through art Thomas Brylawski</td>
<td>PME DUTCH-TREAT BREAKFAST</td>
<td></td>
</tr>
<tr>
<td>8:30 a.m. - 9:55 a.m.</td>
<td>FORUM ON MATHEMATICS MAJORS Are we teaching majors the right mathematics? Are we teaching it the right way? Bettye Anne Case James R.C. Leitzel Lynn A. Steen</td>
<td></td>
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</tr>
<tr>
<td>9:00 a.m. - 5:00 p.m.</td>
<td>EXHIBIT AND BOOK SALE</td>
<td>BOOK SALE</td>
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<tr>
<td>9:00 a.m. - 5:00 p.m.</td>
<td>EXHIBITS</td>
<td></td>
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<tr>
<td>10:10 a.m. - 11:00 a.m.</td>
<td>AMS-MAA INVITED ADDRESS The principle of duality in mathematical analysis Shizuo Kakutani</td>
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<tr>
<td>11:15 a.m. - 12:15 p.m.</td>
<td>EARLE RAYMOND HEDRICK LECTURE II The mathematics of mixing things up: Reversible chains and eigenvalues of the Laplacian Persi Diaconis</td>
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### TIMETABLE

**Wednesday, August 9 (cont'd)**

<table>
<thead>
<tr>
<th>Time</th>
<th>American Mathematical Society</th>
<th>Mathematical Association of America</th>
<th>Other Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AFTERNOON</strong></td>
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</table>
| 1:15 p.m. - 2:15 p.m. | **COLLOQUIUM LECTURE III**  
*Geometry, groups, and self-similar tilings*  
*William P. Thurston* |                                     |                     |
| 1:15 p.m. - 4:15 p.m. | **SPECIAL SESSIONS**  
*Mathematical questions in computational geometry II*  
*Free boundary problems and partial differential equations II*  
*Dynamics and moduli space IV*  
*Computational number theory and applications IV* |                                     |                     |
| 1:15 p.m. - 4:15 p.m. | **SESSIONS FOR CONTRIBUTED PAPERS** |                                     |                     |
| 2:30 p.m. - 3:20 p.m. | **AMS-MAA-PME INVITED ADDRESS**  
*The mathematics of identification numbers*  
*Joseph A. Gallian* |                                     |                     |
| 2:30 p.m. - 4:30 p.m. | **MINICOURSE #6 (Part B)**  
*Group theory through art*  
*Thomas Brylawski* |                                     |                     |
| 2:30 p.m. - 4:30 p.m. | **MINICOURSE #8 (Part A)**  
*Applications of the HP-28S for experienced users*  
*Thomas W. Tucker* |                                     |                     |
| 3:35 p.m. - 4:25 p.m. | **INVITED ADDRESS**  
*The Riemann mapping non-theorem*  
*Nancy K. Stanton* |                                     |                     |
| 4:40 p.m. - 5:40 p.m. | **PRIZE SESSION AND BUSINESS MEETING** |                                     |                     |
| 5:45 p.m. - 10:00 p.m. | **BANQUET FOR 25-YEAR MEMBERS** |                                     |                     |
| **EVENING** |                               |                                     |                     |
| 6:30 p.m. - 8:15 p.m. | **PME BANQUET** |                                     |                     |
| 8:30 p.m. - 9:30 p.m. | **PME J. SUTHERLAND FRAME LECTURE**  
*Entrainment of frequency: A recurring theme*  
*Jane Cronin Scanlon* |                                     |                     |
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<tr>
<th>Time</th>
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<th>Location</th>
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<tr>
<td>7:30 a.m. - 1:00 p.m.</td>
<td><strong>REGISTRATION</strong></td>
<td>Glenn Miller Ballroom, UMC</td>
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<tr>
<td>8:00 a.m. - 9:55 a.m.</td>
<td><strong>SPECIAL SESSIONS</strong></td>
<td>History of orthogonal polynomials I</td>
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<td>Mathematical questions in computational geometry III</td>
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<tr>
<td></td>
<td></td>
<td>Free boundary problems and partial differential equations III</td>
</tr>
<tr>
<td>8:00 a.m. - 9:55 a.m.</td>
<td><strong>SESSIONS FOR CONTRIBUTED PAPERS</strong></td>
<td></td>
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<tr>
<td>8:00 a.m. - 9:55 a.m.</td>
<td><strong>COMMITTEE ON COMPUTERS IN MATHEMATICS EDUCATION (CCIME) PANEL DISCUSSION</strong></td>
<td>The role of the computer in calculus reform</td>
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<td></td>
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<td>Robert L. Devaney</td>
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<td></td>
<td>Eugene A. Herman (moderator)</td>
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<td>Kenneth R. Hoffman</td>
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<td>Paul Zorn</td>
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<td>8:00 a.m. - 10:00 a.m.</td>
<td><strong>MINICOURSE #7 (Part B)</strong></td>
<td>HP-28S short course for nearly inexperienced users</td>
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<td>Jerold Mathews</td>
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<td>8:00 a.m. - 10:00 a.m.</td>
<td><strong>MINICOURSE #9 (Part A)</strong></td>
<td>A seminar on women in mathematics</td>
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<td>Miriam P. Cooney</td>
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<tr>
<td>8:40 a.m. - 9:30 a.m.</td>
<td><strong>INVITED ADDRESS</strong></td>
<td>The number of solutions of Diophantine equations</td>
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<td>Wolfgang M. Schmidt</td>
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<tr>
<td>9:00 a.m. - noon</td>
<td><strong>EXHIBIT AND BOOK SALE</strong></td>
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<tr>
<td>9:00 a.m. - noon</td>
<td><strong>BOOK SALE</strong></td>
<td></td>
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<tr>
<td>10:10 a.m. - 11:00 a.m.</td>
<td><strong>AMS-MAA INVITED ADDRESS</strong></td>
<td>$ax^2 + hxy + cy^2 = n$</td>
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<td>John H. Conway</td>
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<tr>
<td>11:15 a.m. - 12:15 p.m.</td>
<td><strong>EARLE RAYMOND HEDRICK LECTURE III</strong></td>
<td>The mathematics of mixing things up: Modern Markov chain theory</td>
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<td></td>
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<td>Persi Diaconis</td>
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**Thursday, August 10 (cont'd)**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
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<tr>
<td><strong>AFTERNOON</strong></td>
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<tr>
<td>1:15 p.m. - 2:45 p.m.</td>
<td><strong>PROGRESS IN MATHEMATICS</strong>&lt;br&gt;LECTURE&lt;br&gt;<strong>Liquid crystals</strong>&lt;br&gt;Haim Brezis</td>
</tr>
<tr>
<td>1:15 p.m. - 6:00 p.m.</td>
<td><strong>CONTRIBUTED PAPER SESSION</strong>&lt;br&gt;<em>Students as consultants, Part A</em>&lt;br&gt;Hedley C. Morris</td>
</tr>
<tr>
<td>1:15 p.m. - 3:15 p.m.</td>
<td><strong>COLLOQUIUM LECTURE IV</strong>&lt;br&gt;<strong>Geometry, groups, and self-similar tilings</strong>&lt;br&gt;William P. Thurston</td>
</tr>
<tr>
<td>1:15 p.m. - 3:15 p.m.</td>
<td><strong>SPECIAL SESSIONS</strong>&lt;br&gt;<em>History of orthogonal polynomials II</em>&lt;br&gt;<em>Mathematical questions in computational geometry IV</em>&lt;br&gt;<em>Free boundary problems and partial differential equations IV</em></td>
</tr>
<tr>
<td>3:00 p.m. - 6:00 p.m.</td>
<td><strong>SESSIONS FOR CONTRIBUTED PAPERS</strong></td>
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</table>
American Mathematical Society Short Course Series

Introductory Survey Lectures on
Cryptography and Computational Number Theory
Boulder, Colorado, August 6–7, 1989

The American Mathematical Society, in conjunction with its ninety-second Summer Meeting, will present a two day Short Course entitled “Cryptography and Computational Number Theory” on Sunday and Monday, August 6–7, 1989, at the University of Colorado, Boulder. The program is under the direction of Carl Pomerance, University of Georgia. Seven lectures are planned, and it is anticipated that proceedings will be published in the series Proceedings of Symposia in Applied Mathematics.

Both cryptography and computational number theory have been with us for centuries as independent branches of mathematical thought. In the past decade, however, we have witnessed an explosion in both fields that has not only brought revolutionary changes in each, but has brought them closer together. The catalyst for this development was the introduction of the RSA public-key cryptosystem in 1978. This system is based on the relative ease of some number-theoretic computations, such as primality testing and exponentiation in modular arithmetic, versus the great difficulty in factoring a large number composed of two roughly equal primes. Since then, the web of ties between cryptography and computational number theory has drawn more complex with the introduction of schemes based on the supposed intractability of other number-theoretic problems, such as the computation of discrete logarithms and the subset-sum problem.

Sunday, August 6:
CARL POMERANCE, University of Georgia, Introduction. A few of the basic cryptographic systems based on number theory and the underlying number-theoretic themes.
SHAFI GOLDWASSER, Massachusetts Institute of Technology, The Search for Provably Secure Cryptosystems. More advanced issues in cryptography, including zero knowledge proofs.
ARJEN K. LENSTRA, University of Chicago, Primality Testing. How to distinguish between primes and composites - theoretically and practically.
CARL POMERANCE, University of Georgia, Factoring. How to factor 100 digit numbers - emphasis on the quadratic sieve and the elliptic curve method.

Monday, August 7:
KEVIN MCCURLEY, IBM Research and Sandia National Laboratories, Discrete Logarithms. Some algorithms with emphasis on the multiplicative group of a finite field.
ANDREW M. ODLZYKO, AT&T Bell Laboratories, The Rise and Fall of Knapsack Cryptosystems. The use of lattice reduction algorithms in geometric number theory to break cryptosystems based on the subset-sum problem.
JEFFREY C. LAGARIAS, AT&T Bell Laboratories, Pseudorandom Number Generators in Cryptography and Number Theory. The relation of pseudorandom numbers to cryptography.

Synopses of the talks and accompanying reading lists appear in this issue of Notices. Complete lecture notes will be mailed to those who preregister for the course and will be available at the Short Course registration desk for those registering on site.

The lectures will require no advanced background in number theory or cryptography and should be accessible to participants with conventional graduate training in mathematics. However, some familiarity with elementary number theory would be desirable. In addition to specific reference materials suggested by the speakers, the following book contains much of the spirit of the course: N. Koblitz, A Course in Number Theory and Cryptography, Springer-Verlag, 1987.

Advance registration fee: $40 ($15 student/unemployed). Onsite registration fee: $50 ($20 student/unemployed). For registration and housing information, please refer to the sections in this issue of Notices titled Preregistration, Housing and Registration at the Meetings.

Those who also plan to attend the Summer Meeting should take note of a Special Session entitled “Computational Number Theory and Applications,” organized by Kevin S. McCurley, of IBM Research and Sandia National Laboratories. For more information, see the Special Session section of the Boulder meeting announcement in this issue of Notices.

The Short Course was recommended by the AMS-MAA Committee on Employment and Educational Policy (CEEP), whose members are Morton Brown, Stefan A. Burr, Edward A. Connors (chair), Philip C. Curtis, Jr., David J. Lutzer, and James J. Tattersall. The Short Course series is under the direction of the Short Course Subcommittee, whose members are Stefan A. Burr (chair), R. Peter DeLong, Lisl Novak Gaal, Robert P. Kurshan, Barbara L. Osofsky, Marjorie L. Stein, and James J. Tattersall.
The following synopses are arranged in the order of presentation as currently scheduled. The final schedule will be available at the Short Course registration desk.

**Introduction** (Carl Pomerance). In this introductory lecture, three public-key cryptosystems and the underlying number-theoretic problems will be described. The first of these is the RSA system, which is based on the comparative ease of finding large random primes and the great difficulty in factoring the product of two such primes. The knapsack cryptosystem is based on the difficulty of solving the “subset-sum” problem; namely, given a number \( n \) and a set of numbers \( W = \{ w_1, \ldots, w_k \} \), find a subset of \( W \) whose sum is \( n \), if such a subset exists. Finally, we discuss systems based on the discrete logarithm problem. This problem, in a general setting, is that of computing an integer \( x \) such that \( g^x = h \) given a generator \( g \) of a finite cyclic group \( G \) and given an element \( h \in G \).


**Primality Testing** (Arjen K. Lenstra). It is usually easy to prove the compositeness of a composite number. If several attempts to prove the compositeness of a certain number have failed, then the number in question is believed to be prime, and it remains to prove that the number is indeed prime. Providing such a proof is the object of ‘primality testing’. We will discuss some of the classical methods like the Rabin-Miller probabilistic compositeness test, Pépin’s test, the Lucas-Lehmer test, and Pocklington’s theorem. More recent methods make use of elliptic curves, or of Jacobi sums. These methods will be touched upon as well.


Factoring (Carl Pomerance). Although not all factoring algorithms known can be so neatly categorized, most fit into one of two broad classes. The first class is distinguished by a search for a moderate number of special congruences which are to be somehow found in a huge set; the desired factorization is then produced via a combination of these special congruences. The fastest known algorithm for “hard” numbers comes from this class, namely the quadratic sieve method. The other class of algorithms involves searching over a large set of finite abelian groups for just one special group; that you have found this group is marked by the factorization of your number. The elliptic curve method is such an algorithm and its performance surpasses the quadratic sieve for all but the very hardest numbers.


Discrete Logarithms (Kevin S. McCurley). Let $G$ be a group, and let $g \in G$. One formulation of the discrete logarithm problem is: given $g$ and $a \in G$, find an integer $x$ with $g^x = a$, provided one exists. The discrete logarithm problem occupies a central role in applications of computational number theory to cryptography, because it provided one of the earliest examples of a function that is believed to be one way. In the seminal paper of Diffie and Hellman [1], they proposed a protocol for two parties to agree on a secret key using a public communication channel and exponentiation in the multiplicative group of a finite field. The argument for the security of their scheme was based on the presumed difficulty of solving the discrete logarithm problem in a finite field $GF(p)$ for a large prime $p$. Variations of the original Diffie-Hellman scheme have found widespread use in actual systems. Since their initial proposal, some progress has been made on algorithms for solving the discrete logarithm problem, but it remains an excellent candidate for a one way function. In addition to these algorithmic developments, several new cryptosystems have been proposed whose security is based on the difficulty of the discrete logarithm problem.

In this lecture we shall concentrate on three themes:
(1) A general discussion of the discrete logarithm problem and its relation to other computational problems.
(2) A survey of some notable cryptosystems based on the difficulty of solving the discrete logarithm problem.
(3) The state of the art in algorithms for solving the discrete logarithm problem.

2. Whitfield Diffie and Martin E. Hellman, New Directions in Cryptography, IEEE Transactions on Information Theory 22 (1976), 472–492. The paper that started the revolution in applications of number theory to cryptography. See particularly section III.

The Rise and Fall of Knapsack Cryptosystems (A. M. Odlyzko). The knapsack (or subset-sum) problem is to determine, given positive integers $a_1, \ldots, a_n$, whether $x$ is a sum of a subset of the $a[i]$. This problem was shown to be $NP$-complete very early, and so is thought to be hard. It was used to construct a large family of public-key cryptosystems, of which the Merkle-Hellman ones were the first and most famous. However, over the last half a dozen years, practically all of these cryptosystems have been broken, starting with Shamir’s attack on the basic Merkle-Hellman system, and culminating in Brickell’s attack on the multiply-iterated scheme. Furthermore, there are some very general algorithms, one due to Brickell and the other to Lagarias and the speaker, which enable one to solve most instances of the low-density knapsack problem (i.e., one in which the weights $a[i]$ are large). All of these attacks rely on methods of diophantine approximation, especially the Lovasz lattice basis reduction algorithm.


Pseudorandom Number Generators in Cryptography and Number Theory (J. C. Lagarias). Pseudorandom number generators produce by a deterministic process from a seed (or key) a sequence of apparently random numbers \((s_1, s_2, s_3, \ldots)\). Sequences of such “random” numbers have many applications including Monte Carlo simulation, statistical sampling, and numerical analysis. In such applications the \(\{s_i\}\) are required to behave like independent draws from some given probability distribution, by passing certain statistical tests of “randomness.” In the past 10 years it has been realized that pseudorandom number generators are also intimately connected with cryptography. They provide a theoretical foundation for conventional (private-key) cryptosystems. Starting from the work of Yao, this has recently culminated in a proof that, roughly speaking, the following concepts are equivalent: (1) Existence of a one-way function. (2) Existence of a secure pseudorandom number generator. (3) Existence of a secure private-key cryptosystem.

Many of the best known pseudorandom number generators used for simulation use number-theoretic ideas, e.g., the linear congruential generator \(x_{n+1} \equiv ax_n + b \pmod{M}\). The question of cryptographic security of this and other generators leads to interesting problems in number theory and algebra.

This talk has two parts. The first describes the abstract theory of secure pseudorandom number generators and their relation to cryptography. The second describes number-theoretic pseudorandom number generators, and results arising from studying their cryptographic security.

The noncryptographic side of pseudorandom numbers is discussed thoroughly in:


The subsequent development of the relations between pseudorandom number generators and cryptography has appeared in rather technical articles, of which the following are only a sample.


Some articles on cryptanalysis of simple pseudorandom number generators include:


Invited Speakers and Special Sessions

Invited Speakers at AMS Meetings

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

Boulder, August 1989
Maury D. Bramson
Haim Brezis
(Progress in Mathematics Lecture)
John H. Conway
(AMS-MAA)
Persi Diaconis
(Hedrick Lecture)
Joseph A. Gallian
(AMS-MAA-PME)
Shizuo Kakutani
(AMS-MAA)
Serge Lang (AMS-MAA)
Howard A. Masur
Dusa McDuff
(Progress in Mathematics Lecture)
Jean E. Taylor
(AMS-MAA)
William P. Thurston
(Colloquium Lectures)

Hoboken, October 1989
Russel Caflisch
Fang Hua Lin
Bruce Kitchens
(Special Session on Algebraic geometry, p-adic aspects)

Muncie, October 1989
Laszlo Lempert
Kenneth Meyer
Paul S. Muhly
(AMS-MAA-PME)
Sheldon E. Newhouse
(AMS-MAA)

Los Angeles, November 1989
Stephen M. Gersten
Nicolas Spaltenstein
Thomas H. Wolff

Louisville, January 1990
Sun-Yung Alice Chang
George B. Dantzig
(Gibbs Lecture)
Israel C. Gohberg
Mike Hopkins
Henryk Iwaniec
Israel M. Sigal
Shlomo Sternberg
(Colloquium Lectures)

Organizers and Topics of Special Sessions

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

August 1989 Meeting in Boulder
Associate Secretary: Andy Roy Magid
Deadline for organizers: Expired
Deadline for consideration: April 25, 1989
Richard A. Askey, History of orthogonal polynomials
George J. Fix and Rangabhary Kannan, Mathematical questions in computational geometry
Kirk E. Lancaster and Edward W. Stredulinsky, Free boundary problems and partial differential equations
Howard A. Masur and John Smillie, Dynamics and moduli space
Kevin S. McCurley, Computational number theory and applications

October 1989 Meeting in Hoboken
Eastern Section
Associate Secretary: W. Wistar Comfort
Deadline for organizers: Expired
Deadline for consideration: July 26, 1989
Prabir Bhattacharya and Robert A. Melter, Geometry related to computer vision
Stephen Bloom, Algebraic semantics
Russel Caflisch, Mathematical fluid dynamics
Mark Feighn, Lee Mosher and Ulrich Oertel, Low-dimensional topology
Bruce P. Kitchens and Sheldon Newhouse, Smooth dynamical systems
Richard Lyons and Richard O'Nan, Finite groups
Charles Sims, Computational algebra
Marvin D. Tretkoff, Algebraic geometry, p-adic aspects
Invited Speakers and Special Sessions

October 1989 Meeting in Muncie
Central Section
Associate Secretary: Andy Roy Magid
Deadline for organizers: Expired
Deadline for consideration: July 26, 1989
Alan Adolphson and Steven Sperber, Number theory and algebraic geometry
David Bennett and Laszlo Lempert, Complex analysis
Ananda Gubbi, Extremally disconnected spaces and their applications
Darrell E. Haile, Noncommutative algebra in geometry and arithmetic
David Larson, Triangular operator algebras
Ali Masoom and Arunava Mukherjea, Statistics and probability
Kathryn Porter, Functions spaces and topology
T. K. Puttaswamy, Differential equations

November 1989 Meeting in Los Angeles
Far Western Section
Associate Secretary: Lance W. Small
Deadline for organizers: Expired
Deadline for consideration: July 26, 1989
James P. Lin, Algebraic topology
Nicolas Spaltenstein, To be announced
Thomas H. Wolff, Harmonic analysis

January 1990 Meeting in Louisville
Associate Secretary: Joseph A. Cima
Deadline for organizers: Expired
Deadline for consideration: September 28, 1989

March 1990 Meeting in Manhattan, Kansas
Central Section
Associate Secretary: Andy Roy Magid
Deadline for organizers: June 15, 1989
Deadline for consideration: To be announced

August 1990 Meeting in Columbus
Associate Secretary: W. Wistar Comfort
Deadline for organizers: November 15, 1989
Deadline for consideration: To be announced

November 1990 Meeting in Denton
Central Section
Associate Secretary: Andy Roy Magid
Deadline for organizers: February 15, 1990
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. They are administered by the Associate Secretary in charge of that meeting with staff assistance from the Meetings and Editorial Departments in the Society office in Providence.

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

Each Invited Speaker is invited to generate a Special Session, either by personally organizing one or by having a Special Session organized by others. Proposals to organize a Special Session are sometimes requested either by the Program Committee or by the Associate Secretary. Other proposals to organize a Special Session may be submitted to the Associate Secretary in charge of that meeting (who is an ex-officio member of the committee and whose address may be found below). These proposals must be in the hands of the Program Committee well in advance of the meeting and, in any case, at least nine (9) months prior to the meeting at which the Special Session is to be held in order that the committee may consider all the proposals for Special Sessions simultaneously. Proposals that are sent to the Providence office of the Society, to 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 Notices in such a timely fashion that any member of the Society who so wishes may submit an abstract for consideration for presentation in the Special Session before the deadline for such consideration. This deadline is usually three (3) weeks before the Deadline for Abstracts for the meeting in question.

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

past the deadline, after which members can no longer send abstracts for consideration for presentation in that Special Session.

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

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

Send Proposals for Special Sessions to the Associate Secretaries

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

Far Western Section (Pacific and Mountain)
Lance W. Small, Associate Secretary
Department of Mathematics
University of California, San Diego
La Jolla, CA 92093
(Telephone 619 – 534 – 3590)

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

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

Southeastern Section
Joseph A. Cima, Associate Secretary
Department of Mathematics
University of North Carolina, Chapel Hill
Chapel Hill, NC 27599 – 3902
(Telephone 919 – 962 – 1050)

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

Information for Speakers

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

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

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.
Symposium on Complex Geometry and Lie Theory
Sundance, Utah
May 26–May 29, 1989

With the support from the National Science Foundation, Duke University, and the University of Utah, a symposium on Complex Geometry and Lie Theory will take place Friday through Monday, May 26-29, 1989 at the Sundance Center, Sundance, Utah.

The topic was selected by the AMS Committee on Summer Institutes and Special Symposia whose members at the time of selection were: Eric M. Friedlander, Steven L. Kleiman, Paul H. Rabinowitz, Thomas C. Spencer, Robert B. Warfield, Jr., and John Wermer.

Proceedings will be published by the American Mathematical Society.

The Organizing Committee for the symposium includes James A. Carlson, University of Utah (co-chair); C. Herbert Clemens, University of Utah (co-chair); and David Morrison, Duke University.

This symposium will review the interaction of the two fields of complex geometry and Lie theory, with concentration on the interaction related to Hodge theory. Speakers will also present current work and discuss possible future directions.

The list of invited speakers includes Enrico Arbarello, University of Rome, Italy; Robert Bryant, Duke University; James Carlson, University of Utah; Eduardo Cattani, University of Massachusetts, Amherst; C. Herbert Clemens, University of Utah; Maurizio Cornalba, University di Pavia, Italy; Robert Friedman, Columbia University; Phillip Griffiths, Duke University; Mark Green, University of California, Los Angeles; Richard Hain, University of Washington; Joseph Harris, Harvard University; Aroldo Kaplan, University of Massachusetts, Amherst; Janos Kollar, University of Utah; Robert MacPherson, Massachusetts Institute of Technology; John Morgan, Columbia University; David Morrison, Duke University; Chris Peters, University of Leiden, The Netherlands; Morihiko Saito, RIMS Kyoto; Wilfried Schmid, Harvard University; Carlos Simpson, Princeton University; Andrew Sommese, Notre Dame University; Joseph Steenbrink, University of Nijmeigen, The Netherlands; and Steven Zucker, Johns Hopkins University.

<table>
<thead>
<tr>
<th>Registration</th>
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<tr>
<td>The symposium registration desk will be located in the Cottage Reception Center. The desk will be staffed from 2:00 p.m. until 7:00 p.m. on Thursday, from 7:00 a.m. until 4:30 p.m. Friday through Sunday, and from 7:00 a.m until 11:00 a.m. on Monday. Participants opting for the meal plan should check in at the symposium desk in order to obtain a meal card. There is a restaurant to serve participants not on the meal plan.</td>
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<tr>
<th>Registration Fees</th>
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<tr>
<td>All participants including speakers and committee members are required to pay a $25 social fee and a $15 registration fee. The social fee will cover the cost of refreshments served at breaks and evening refreshments. These fees cannot be prorated for those participants choosing not to attend the full period of the symposium. Cash, travelers' checks, and personal checks will be accepted; credit cards cannot be accepted.</td>
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<th>Accommodations</th>
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| The accommodations are a collection of privately owned homes scattered among the aspen and pine. They range from the rustic charm of log homes to contemporary architecture. Individual needs can be met with single accommodations to large Inns holding up to twelve people. All units are equipped with kitchen and bathroom units. Many units also have fireplaces and jacuzzi spas. Two types of accommodations are available. The first, referred to as cottages, are units consisting of two-bedroom and three-bedroom complexes, all with kitchenettes, living rooms, and private bathrooms. The bedding configuration varies greatly from one twin bed to two queen-sized beds per room. The second type of accommodations are private homes, referred to as cabins, along the mountainside of Mt. Timpanagos. These cabins range in size from two-bedroom to seven-bedroom homes. All cabins have at least two full baths, several parlors, full kitchens, and many have at least one jacuzzi spa. The
Meetings

bedding configuration in these cabins is more varied than the cottages, with one king or queen-sized bed to four assorted sized beds per room.

Participants with special dietary needs are encouraged to bring any special foods required and are free to make use of the kitchen facilities in any of the accommodations. Utensils are supplied in kitchen areas.

Participants desiring accommodations at the resort cannot be guaranteed the preferred type of housing due to the unique configurations of the bedroom areas offered. Final housing assignments are the responsibility of the Organizing Committee.

Check-In Locations and Times
The residence check-in desk will be located at the Cottage Reception Center. The desk is open on a 24-hour basis. Participants opting for the meal plan should refer to the schedule listed in the Registration section of this announcement.

Room and Board Rates
Due to the limited nature of dining facilities and the isolated location of the Sundance Resort a complete meal plan is being offered to participants beginning with dinner on Thursday evening, May 25 from 7:00-9:00 p.m., and ending with a continental breakfast on Tuesday morning, May 30. The cost for the meal plan is $225.00.

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<tr>
<td>Single</td>
<td>$60.00</td>
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<tr>
<td>Double</td>
<td>$30.00</td>
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Travel

The Salt Lake City International Airport has service from all parts of the country, and the major carrier is Delta Airlines. The distance to the Sundance Resort is 50 miles and approximately a one-hour drive by car.

Limousine service directly to the resort is provided by Key Limo Transportation at a cost of approximately $40 round trip. A shuttle service will also be available to participants for travel to and from the Salt Lake City area and the resort.

Social Event
A professionally organized two-day river trip on the Colorado River is planned following the symposium. The trip does not require river skills, and the total cost including all food, and transportation to and from Sundance and the Salt Lake City airport is $235. Individuals who do not have the necessary camping gear such as sleeping bags and parkas will be charged an additional $30 rental fee.

The bus taking participants to the embarkation point on the Colorado River will leave Sundance at 6:00 a.m. on Tuesday morning, May 30, arriving at the starting point by 2:00 p.m. that afternoon. Return service is on Wednesday afternoon at approximately 2:00 p.m., at which time participants will be bussed back to Salt Lake City by early evening. At present there are only 35 openings and reservations can be made by contacting Herb Clemens, Mathematics Department, University of Utah, Salt Lake City, UT 84112. The telephone number is 801-581-5275. Reservations can also be made by contacting Barbara Smoot at 801-581-7710. The deadline for making reservations was April 7, 1989.
The twenty-third annual Symposium on Some Mathematical Questions in Biology on Sex allocation and sex change: Experiments and models will be held on August 7, 1989, during the annual meeting of the American Institute of Biological Sciences (AIBS), August 6–10, 1989. The symposium is sponsored by the American Mathematical Society, the Society for Industrial and Applied Mathematics, and the Society for Mathematical Biology.

The AMS-SIAM Committee on Mathematics in the Life Sciences serves as the Organizing Committee for the symposium. The committee consisted of Kenneth L. Lange, Michael C. Mackey, Marc Mangel (Organizer), Hans G. Othmer, Alan S. Perelson, Richard E. Plant (Chairman), and John Rinzel.

The theme of the symposium is Sex allocation and sex change: Experiments and models. There will be two half-day sessions, each including three one-hour lectures.

Program
Chairman: Marc Mangel
9:00 a.m. – Presiding: MARC MANGEL, University of California, Davis

The adaptive advantage of sexual reproduction in plants. PAULLETTE BIERZYCHUDEK, Pomona College

Male based size competition in plants. MAUREEN STANTON, University of California, Davis

Population genetics of sex allocation. SABIN LESSARD, University of Montreal

2:00 p.m. – Presiding: MARC MANGEL, University of California, Davis

Sex change in sequential hermaphrodites. DONNA FERNANDES, University of Liverpool

Dynamics of sex change in Capitellid polychaetes. PETER PETRAITIS, University of Pennsylvania

Sex allocation in simultaneous hermaphrodites. CHRIS PETERSEN, Friday Harbor Laboratories and University of Toronto

Male allocation and the cost of sex under local family competition. CURT LIVELY, Rutgers University

ASYMPTOTIC BEHAVIOR OF DISSIPATIVE SYSTEMS
Jack K. Hale
(Mathematical Surveys and Monographs, Volume 25)

This book is directed at researchers in nonlinear ordinary and partial differential equations and at those who apply these topics to other fields of science. About one third of the book focuses on the existence and properties of the flow on the global attractor for a discrete or continuous dynamical system. The author presents a detailed discussion of abstract properties and examples of asymptotically smooth maps and semigroups. He also covers some of the continuity properties of the global attractor under perturbation, its capacity and Hausdorff dimension, and the stability of the flow on the global attractor under perturbation. The remainder of the book deals with particular equations occurring in applications and especially emphasizes delay equations, reaction-diffusion equations, and the damped wave equations. In each of the examples presented, the author shows how to verify the existence of a global attractor, and, for several examples, he discusses some properties of the flow on the global attractor.

1980 Mathematics Subject Classifications: 34, 35, 58
ISSN 0076-5376
200 pages (hardcover), March 1988
Individual member $32, List price $54,
Institutional member $43
To order, please specify SURV/25NA

Shipping/Handling: 1st book $2, each additional $1, maximum $25, by air, 1st book $5, each additional $3, maximum $100
Prepayment required. Order from American Mathematical Society, P.O. Box 1571, Annex Station Providence, RI 02901-9930, or call toll free 800-556-7774 to charge with Visa or MasterCard
Call For Topics
For 1991 Conferences

Suggestions are invited from mathematicians, either singly or in groups, for topics of the various conferences that will be organized by the Society in 1991. The deadlines for receipt of these suggestions, as well as some relevant information about each of the conferences, are given below. An application form to be used when submitting suggested topic(s) for any of these conferences (except the Short Course Series) may be obtained by writing to the Meetings Department, American Mathematical Society, P.O. Box 6248, Providence, RI 02940, or telephoning 401-272-9500, E-mail MEET@MATH.AMS.COM.

Individuals willing to serve as organizers should be aware that the professional meeting staff in the Society's Providence office will provide full support and assistance before, during, and after each of these conferences. Organizers should also note that for all conferences except Summer Research Conferences, it is required that the proceedings be published by the Society, and that proceedings of Summer Research Conferences are frequently published. A member of the Organizing Committee must be willing to serve as editor of the proceedings.

All suggestions must include (1) the names and affiliations of proposed members and the chairman of the Organizing Committee; (2) a two- or three-page detailed outline of the subject(s) to be covered, including the importance, timeliness of the topic, and estimated attendance; (3) a list of the recent conferences in the same or closely related areas; (4) a tentative list of names and affiliations of the proposed principal speakers; (5) a list of likely candidates who would be invited to participate and their current affiliations; and (6) any other observations which may affect the size of the conference and the amount of support required. Any suggestions as to sites and dates should be made as early as possible in order to allow adequate time for planning. By action of the AMS Board of Trustees, the Meetings Department of the Society is responsible for the final selection of the site for each conference and for all negotiations with the host institution. Individuals submitting suggestions for the conferences listed below are requested to recommend sites or geographic areas which would assist the Meetings Department in their search for an appropriate site. In the case of Joint Summer Research Conferences in the Mathematical Sciences, a one-, two-, or three-week conference may be proposed.

1991 AMS Summer Institute
Summer institutes are intended to provide an understandable presentation of the state of the art in an active field of research in pure mathematics and usually extend over a three-week period. Dates for a summer institute must not overlap those of the Society's summer meeting, which at the time of this printing have not yet been determined. There should be a period of at least one week between them. Proceedings are published by the Society as volumes in the series Proceedings of Symposia in Pure Mathematics.

Current and recent topics:
1989 – Several complex variables and geometry, organized by Steven G. Krantz of Washington University.
1990 – Differential geometry, organized by Robert E. Greene of University of California, Los Angeles, and Shing-Tung Yau of Harvard University.

Deadline For Suggestions: September 1, 1989

1991 AMS-SIAM-SMB Symposium
Some Mathematical Questions in Biology
This one-day symposium, now under joint sponsorship with the Society for Mathematical Biology, is usually held in conjunction with the annual meeting of a biological society closely associated with the topic. Papers from the symposia are published by the Society as volumes in the series Lectures on Mathematics in the Life Sciences.
Call for Topics

Current and recent topics:
1987—Models in population biology, organized by Alan Hastings of the University of California, Davis.
1988—Dynamics of excitable media, organized by Hans G. Othmer of the University of Utah.
1989—Sex allocation and sex change: Experiments and models, organized by Marc Mangel of the University of California, Davis.
1990—Neural Nets, organized by Jack D. Cowan of the University of Chicago.

Deadline For Suggestions: September 1, 1989

1991 AMS-SIAM Summer Seminar
The goal of the summer seminar is to provide an environment and program in applied mathematics in which experts can exchange the latest ideas and newcomers can learn about the field. Proceedings are published by the Society as volumes in the series Lectures in Applied Mathematics.

Current and recent topics:
1987—Computational Aspects of VLSI Design with an Emphasis on Semiconductor Device Simulation, organized by Randolph Bank of the University of California, San Diego.
1988—Computational solution of nonlinear systems of equations, organized by Eugene Allgower of Colorado State University.
1989—The mathematics of random media, organized by Werner Kohler of Virginia Polytechnic Institute and Benjamin White of Exxon Research & Engineering Company.
1990—Vortex dynamics and vortex methods, organized by Claude Greengard of IBM T. J. Watson Research Center and Christopher R. Anderson of University of California, Los Angeles.

Deadline For Suggestions: September 1, 1989

1991 AMS-IMS-SIAM Joint Summer Research Conferences in the Mathematical Sciences
These conferences are similar in structure to those held at Oberwolfach and represent diverse areas of mathematical activity, with emphasis on areas currently especially active. Careful attention is paid to subjects in which there is important interdisciplinary activity at present. Topics for the seventh series of one-week conferences, being held in 1989, are Probabilistic and analytic methods in discrete mathematics; Statistical analysis of measurement error models and applications; Relationships between continuum theory and the theory of dynamical systems; Statistical multiple integration; Integral geometry; Finite and algebraic groups: Modular representations and cohomology; The geometry of Riemann surfaces and discrete groups; and Inverse problems in partial differential equations.

If proceedings are published by the Society, they will appear as volumes in the series Contemporary Mathematics.

Deadline For Suggestions: February 1, 1990

Call for Topics for 1991 AMS Short Course Series
The AMS Short Courses consist of a series of introductory survey lectures and discussions ordinarily extending over a period of one-and-one-half days starting immediately prior to the Joint Mathematics Meetings held in January and August each year. Each theme is a specific area of applied mathematics or mathematics used in the study of a specific subject or collection of problems in one of the physical, biological, or social sciences, technology, or business.

Current and recent topics:

Deadline for Suggestions: Suggestions for the January 1991 course should be submitted by July 1, 1989; suggestions for the August 1991 course should be submitted by December 1, 1989.
Submit suggestions to: Stefan A. Burr, Chairman, Short Course Subcommittee, Department of Computer Science, CUNY, City College, New York, NY 10031.
1989 AMS Elections

Nominations by Petition

Vice-President or Member-at-Large
Two positions of vice-president and member of the Council ex officio for a term of two years are to be filled in the election of 1989. The Council intends to nominate four candidates, whose names may be expected to appear in the June issue of Notices, which is scheduled to be mailed by the printer on 25 May. Nominations by petition as described in the rules and procedures are acceptable.

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 seven candidates, whose names may be expected to appear in the June Notices. Nominations by petition in the manner described in the rules and procedures are acceptable. The Council has stated its intent to have at least ten candidates and will bring the number up to ten if the nominations by petition do not do so.

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

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

Editorial Boards Committee
Two places on the Editorial Boards Committee will be filled by election. The new members will be elected in a preferential ballot. The President will name three candidates for these two places. The names may be expected to appear in the June issue of Notices. Nominations by petition, in the manner described in the rules and procedures, will be accepted. Should the final number of candidates be less than six, the President will bring it up to six.

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

The Nominating Committee for 1990
Three places on the Nominating Committee will be filled by election. There will be six continuing members of the Nominating Committee, namely:

<table>
<thead>
<tr>
<th>Joan S. Birman</th>
<th>Victor Klee</th>
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<tr>
<td>James E. Humphreys</td>
<td>Alan D. Weinstein</td>
</tr>
</tbody>
</table>

The new members will be elected in a preferential ballot. The President will name five candidates for these three places. The names may be expected to appear in the June issue of Notices. Nominations by petition, in the manner described in the rules and procedures, will be accepted. Should the final number of candidates be less than six, the President will bring it up to six.

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

Rules and Procedures
Use separate copies of the form for each candidate for vice-president, member-at-large, or member of the Nominating 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 6 July 1989.

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

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

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

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

6. The signature may be in the style chosen by the signer. However, the printed name and address will be checked against the Combined Membership List and the mailing lists. No attempt will be made to match variants of names with the form of name in the CML. A name neither in the CML nor on the mailing lists is not that of a member. (Example: The name Robert M. Fossum is that of a member. The name R. Fossum appears not to be. Note that the mailing label of the Notices can be peeled off and affixed to the petition as a convenient way of presenting the printed name correctly.)

7. When a petition meeting these various requirements appears, the Secretary will ask the candidate whether he is willing to have his name on the ballot. Petitioners can facilitate the procedure by accompanying the petitions with a signed statement from the candidate giving his consent.
NOMINATION PETITION FOR 1989 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

of the American Mathematical Society for a term beginning 1 January, 1990; or 1 September, 1990, in the case of member of the Nominating Committee.

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

______________________________

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
Mathematical Sciences
Meetings and Conferences

April 1989

27–29. Third Annual Conference on Undergraduate Research, Trinity University, San Antonio, Texas. (October 1988, p. 1243)


Invited Speakers: A. Chang, University of California, Berkeley and University of California, Los Angeles; M. Crandall, University of California, Santa Barbara; G. David, École Polytechnique and University of California, Los Angeles; C. Kenig, University of Chicago; L. Lempert, Purdue University; L. Simon, Stanford University.

Information: S. Baouendi or L. Rothschild, Department of Mathematics, University of California, San Diego, La Jolla, California 92093.

May 1989


Invited Speakers: J. Tate, Number Theory; History and Future Directions; H. Lenstra, Factorization and Applied Number Theory; B. Mazur, Number Theory as Gadfly; A. Odlyzko, Primes, Quantum Chaos and Computers.

Information: L. H. Cox, National Academy of Sciences, Board of Mathematical Sciences, 2101 Constitution

* This section contains announcements of meetings and conferences of interest to some segment of the mathematical public, including ad hoc, local, or regional meetings, and meetings or symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. (Information on meetings of the Society, and on meetings sponsored by the Society, will be found inside the front cover.)

An announcement will be published in Notices if it contains a call for papers, and specifies the place, date, subject (when applicable), and the speakers; a second full announcement will be published only if there are changes or necessary additional information. Once an announcement has appeared, the event will be briefly noted in each issue until it has been held and a reference will be given in parentheses to the month, year, and page of the issue in which the complete information appeared. Asterisks (*) mark those announcements containing new or revised information.

In general, announcements of meetings and conferences held in North America carry only date, title of meeting, place of meeting, names of speakers (or sometimes a general statement on the program), deadlines for abstracts or contributed papers, and source of further information. Meetings held outside the North American area may carry more detailed information. In any case, if there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on meetings and conferences in the mathematical sciences should be sent to the Editor of Notices, care of the American Mathematical Society in Providence.

Deadlines for entries in this section are listed on the inside front cover of each issue. In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of Notices prior to the meeting in question. To achieve this, listings should be received in Providence six months prior to the scheduled date of the meeting.
Meetings and Conferences


4–7. Mathematicians and Education Reform Network, University of California, Berkeley, Berkeley, California. (January 1989, p. 66)


ORGANIZING COMMITTEE: G. S. Bloom; F. Buckley; S. Burr; J. W. Kennedy; E. Lutwak; and L. V. Quintas.


8–12. Algorithme Et Programmation Pascal, Marseille, France. (February 1989, p. 176)

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


15–19. Moments de Geometrie Symplectique, Marseille, France. (February 1989, p. 176)


17–19. SIAM Conference on Control and Systems Theory, San Francisco, California. (December 1988, p. 1586)

19–20. Central Section Meeting of the AMS, Loyola University, Chicago, Illinois.

INFORMATION: W. Drady, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

22–24. International Conference on Algebraic Methodology and Software Technology, AMAST, Iowa City, Iowa. (December 1988, p. 1587)


22–24. Workshop on Vortex Methods, Mathematical Sciences Research Institute, Berkeley, California. (September 1988, p. 1059)


22–26. Meeting on Rational Mechanics and Analysis in Honor of Clifford Truesdell on His 70th Birthday, Pisa, Italy. (December 1988, p. 1587)

22–June 3. NATO Advanced Study Institute on Orthogonal Polynomials and Their Applications, The Ohio State University, Columbus, Ohio. (September 1988, p. 1059)


26–30. AMS Pure Mathematics Symposium on Complex Geometry and Lie Theory, Sundance, Utah.

INFORMATION: W. Drady, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.


29–June 1. Third International Conference in Mathematics: Fractional Calculus and Its Applications, Nihon University, Tokyo, Japan. (May/June 1988, p. 731)

29–June 2. NSF-CBMS Regional Conference on Discrete Groups, Expanding Graphs, and Invariant Measures, University of Oklahoma, Norman, Oklahoma. (February 1989, p. 177)


29–June 2. Ondelettes, Marseille, France. (February 1989, p. 177)


29–June 3. Meeting on Computer and Commutative Algebra (COCOA II), Dipartimento di Matematica, Universita, Genova, Italy. (February 1989, p. 177)


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

31–June 2. Workshop on Blow-up and Extinction for Parabolic and Other Systems, Heriot-Watt University, Edinburgh. (January 1989, p. 66)

June 1989

* IMACS International School on Lyapunov Functions, Irkutsk, Union of Soviet Socialist Republics.


* NSF-CBMS Conference on Function Estimation in the Context of Independent and Dependent Observations, University of California, Davis, California.

LECTURER: M. Rosenblatt.

INFORMATION: G. Roussas, Department of Statistics, University of California, Davis, California 95616, 916-752-8142.

1–3. Annual Summer Meeting of the Canadian Mathematical Society, University of Windsor, Windsor, Ontario. (March 1989, p. 306)
2–5. Seminar on Fractional Calculus, Nihon University, Koriyama, Japan. (February 1989, p. 177)
3–August 5. Joint AMS-IMS-SIAM Summer Research Conferences in the Mathematical Sciences, Humboldt State University, Arcata, California.

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

4–9. Geometrical and Algebraical Aspects in Several Complex Variables, Cetraro (CS), Italy. (November 1988, p. 1385)
4–30. 1989 Complex Systems Summer School, Santa Fe, New Mexico. (January 1989, p. 67)
5–8. International Colloquium on Complex Analysis and Sixth Romanian-Finnish Seminar, University of Bucharest, Romania. (December 1988, p. 1588)
5–8. Fourth Annual Symposium on Logic in Computer Science (LICS), Asilomar, California. (October 1988, p. 1244)
5–9. Chaos and the Microcomputer, Salisbury State University, Salisbury, Maryland. (January 1989, p. 67)
5–9. Conference in Mathematical Analysis in Honor of the Memory of Jose Luis Rubio de Francia, El Escorial, Spain. (February 1989, p. 178)


CONFERENCE TOPICS: The topics will include nonexpansive mappings, set-valued mappings, minimax, topological methods, applications to economics analysis, optimization, and game theory.

PROGRAM: The conference will consist of invited talks (50 minutes) and contributed lectures (30 minutes).

ORGANIZERS: J. Baillon, Université Lyon I; M. Thera, Université de Limoges.

INFORMATION: A. Meier, Luminy Case 916, 13288 Marseille Cedex 9.

5–10. Analytic Number Theory, Centre de recherches mathématiques, Université de Montréal. (Please note date change from September 1988, p. 1059)
5–10. Théorie du Point Fixe et Applications, Marseille, France. (February 1989, p. 178)

* 8–10. 1989 NCGA Arts Conference, San Jose University, San Jose, California.

PROGRAM: This conference, hosted by the Computers in Art and Design, Research and Education Institute (CADRE) will features symposia, workshops, and other events focusing on the integration of art and media technology.


12–16. NSF-CBMS Conference on Harmonic Analysis, Real Function Spaces and Related Areas, Auburn University-Auburn, Auburn University, Alabama. (March 1989, p. 307)
12–16. Greco Calcul Formel, Marseille, France. (February 1989, p. 178)
Meetings and Conferences


12-17. Conference on the Geometry of Banach Spaces, Strobi on Wolfgangsee, Austria. (October 1988, p. 1244)

12-July 8. Summer Conference on Complex Analysis, Bordeaux, France. (February 1989, p. 178)

13-15. Third Chico State Western States Topology Conference, California State University, Chico, Chico, California. (March 1989, p. 307)


14-17. International Conference on Dynamical Systems, Control Theory, and Applications, Wright State University, Dayton, Ohio. (October 1988, p. 1244)


15-23. CIME Course on Methods of Nonconvex Analysis, Villa Monastero, Varenna Lake (Lake of Como), Italy. (January 1989, p. 67)


CHAIRMAN: S. H. Moolgavkar, University of Washington and Fred Hutchinson Cancer Research Center.
CONFERENCE DIRECTOR: D. L. Thomasen, Junior, SIMS.
PROGRAM: The conference will focus on the problems posed by quantitative cancer risk assessment with particular emphasis on the use of biologically-based models for species to species and low dose extrapolation.


19-24. Harmonizable Fields and Related Topics, Marseille, France. (February 1989, p. 179)


21-23. Thirty-second Meeting of the Society for Natural Philosophy on Geometrical and Topological Methods in Mechanics, Calgary, Canada. (December 1988, p. 1588)

25-28. Western Regional Meeting of the Biometric Society (WNAR) and the Institute of Mathematical Statistics, Davis, California. (January 1989, p. 68)


PRINCIPAL SPEAKER: J. Goldfeather, Carleton College.

PROGRAM: This conference is intended to acquaint mathematicians with the mathematical techniques used in the field of computer graphics. The main focus of the conference will be a short course on computer graphics taught by J. Goldfeather. The program will also include special lectures by experts on applications of graphics to mathematical teaching and research, and contributed papers by conference participants. (Note: Registration forms must be received by May 26, 1989. Registration is limited to 120.)

INFORMATION: For further information about the conference, as well as a registration form, contact S. Galovich, Department of Mathematics and Computer Science, Carleton College, Northfield, Minnesota 55057, 507-663-4362.


25-July 1. 18th Conference on Stochastic Processes and Their Applications, University of Wisconsin-Madison, Madison, Wisconsin. (January 1989, p. 68)


26-29. IFAC/IMACS/IFIP Symposium on Control of Distributed Parameter Systems, Perpignan, France. (March 1989, p. 308)

26-29. ICOSAHOM '89: International Conference on Spectral and High Order Methods for Partial Differential Equations, Como, Italy. (February 1989, p. 179)


26-30. AAEC-7 International Conference, P. Sabatier University, Toulouse. (March 1989, p. 308)

26-30. Centenaire Halpen, Marseille, France. (February 1989, p. 179)

26-30. Workshop on Symbol Manipulation, Institute for Mathematics and its Applications, Minneapolis, Minnesota. (February 1989, p. 179)

July 1989


INFORMATION: Logic at Botik '89, Post Office Box 11, Program Systems Institute of the Union of Soviet Socialist Republics Academy of Sciences, 152140 Pereslavl-Zalessky, Union of Soviet Socialist Republics.

2-7. Fourth Gregynog Symposium on Differential Equations, Gregynog Conference Center, University of Wales, United Kingdom. (December 1988, p. 1388)


2-7. NSF-CBMS Regional Research Conference in the Mathematical Sciences: Harmonic Analysis and Real Function Spaces, Auburn University, Auburn University, Alabama. (February 1989, p. 179)

2-7. Annual General Meeting of the Australian Mathematical Society, Macquarie University, Sydney, New South Wales, Australia. (December 1988, p. 1589)


3-7. Fourteenth IFIP Conference on System Modelling and Optimization, Leipzig, German Democratic Republic. (November 1988, p. 1386)


3-11. CIME Course on Microlocal Analysis and Applications, Villa "La Querceta," Montecatini Terme (Pistoia), Italy. (January 1989, p. 68)

3-13. Surfaces Minimales, Marseille, France. (March 1989, p. 309)

3-21. SMS-NATO ASI: Fractal Geometry and Analysis, Université de Montréal, Montréal, Canada. (January 1989, p. 68)


6-9. Third Mathematicians and Education Reform Network Workshop, University of Minnesota, Minneapolis. (March 1989, p. 309)

10. Tutorial Short Courses, Trinity College, Dublin, Ireland. (November 1988, p. 1386)


10-21. NATO Advanced Study Institute: Computation of Curves and Surfaces, Puerto de la Cruz, Canary Islands, Spain. (February 1989, p. 180)


10-30. AMS Summer Research Institute on Several Complex Variables and Complex Geometry, University of California, Santa Cruz, California.

INFORMATION: W. Drady, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.


ORGANIZERS: J. R. Bunch and R. E. Bank, University of California, San Diego.

CONFERENCE TOPICS: Signal processing; parallel computation; numerical analysis; linear algebra; computer science; discrete mathematics; nonlinear fluid dynamics; numerical PDE's and ODE's, scientific computing; inverse problems; optimization; control; dynamical systems.

INVITED SPEAKERS: J. L. Bona, Pennsylvania State University; T. F. Chan, University of California, Los Angeles; J. W. Curran, Center for Disease Control, Atlanta; J. W. Demmel, Courant Institute of Mathematical Sciences; J. P. Keener, University of Utah; H. Lev-Ari, Stanford University; T. A. Manteuffel, University of Colorado, Denver; R. L. Parker, University of California, San Diego; P. G. Saffman, California Institute of Technology; D. C. Sorensen, Argonne National Laboratory; J. M. Speiser, Naval Oceans Systems Center, San Diego.


Meetings and Conferences


24–27. Gauss Symposium on Mathematics and Theoretical Physics, Guarujá, SP, Brazil. (November 1988, p. 1387)


24–August 5. 1989 European Summer Meeting of the Association for Symbolic Logic, West Berlin. (March 1989, p. 310)


SPONSOR: The Summer School is organized under the auspices of the Munich University of Technology and is sponsored by the NATO Science Committee under the Advanced Study Institutes Program. Partial support for this conference is expected from the National Science Foundation and from various industrial companies.

LECTURERS: W. Brauer; R. L. Constable; G. Huet; Z. Manna; A. Nerode; J. A. Robinson; H. Schwichtenberg; D. S. Scott; E. Y. Shapiro; J. V. Tucker; S. S. Wainer.

TOPICS: Automated deduction; proving techniques; types; concurrency and logic; concurrent processes; semantics; constructive methods; non-traditional logics.

INFORMATION: Institut für Informatik, Technische Universität München, Sommer School, Arcisstr. 21, 8000 München 2, Germany. Telephone: +49/2105-8113.

*27–29. Sixth Annual Western Geometric Topology Workshop, Brigham Young University, Provo, Utah.

SPONSOR: National Science Foundation and Brigham Young University.

PRINCIPAL SPEAKER: J. Luecke, University of Texas.

CALL FOR PAPERS: Time will be allotted for participants to give 30-minute talks.

ORGANIZING COMMITTEE: F. Tinsley and J. Henderson, Colorado College; D. Garity, Oregon State University; D. Wright, Brigham Young University.

INFORMATION: D. Wright, Department of Mathematics, Brigham Young University, Provo, Utah 84602.


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

INVITED SPEAKERS: J. Arthur, University of Toronto; J. Bernstein, Harvard University; L. Corwin, Rutgers University; W. Schmid, Harvard University; D. Vogan, Massachusetts Institute of Technology.

ORGANIZING COMMITTEE: W. H. Barker, Bowdoin College; J. N. Bernstein, Harvard University; R. Herb, University of Maryland; P. J. Sally, Jr. University of Chicago; J. A. Wolf, University of California, Berkeley.

INFORMATION: W. H. Barker, Department of Mathematics, Bowdoin College, Brunswick, Maine 04011. Telephone: 207-725-3571.


August 1989


6–7. AMS Short Course on Cryptology and Computational Number Theory, Boulder, Colorado.

INFORMATION: M. Foulkes, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.


7. AMS-SIAM-SMB Symposium on Some Mathematical Questions in Biology: Sex Allocation and Sex Change, Experiments and Models, University of Toronto, Toronto, Ontario, Canada. (February 1989, p. 181)

*7–10. 92nd Summer Meeting of the AMS, Boulder, Colorado.

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


TOPICS: Interactions of combinatorics and geometry.

INVITED SPEAKERS: N. Alon; L. Billera; H. Crapo; A. Dress; J. E. Goodman; G. Kalai; V. Klee; A. Lascoux; M. Las Vergnas; L. Lovasz; N. E. Mnev; R. Pollack; V. Sernova; R. Stanley; B. Sturmfels; H. Tverberg; A. Vershik; N. White; A. Zelevinskii.

INFORMATION: A. Björner, Department of Mathematics, KTH, S-10044 Stockholm, Sweden.

7–11. Thirteenth Johns Hopkins Mathematical Sciences Summer Lecture Series, Johns Hopkins University, Baltimore, Maryland. (March 1989, p. 310)


10–12. International Conference on Computational Techniques and Applications, Brisbane, Australia. (February 1989, p. 181)

13–18. Fifth International Conference on Stochastic Programming, University of Michigan, Ann Arbor, Michigan. (March 1989, p. 311)


16–September 2. Nineteenth Summer School of Algebra and Analysis, Saint-Flour, France. (June 1989, p. 69)

21–24. Ninth Annual Crypto Conference, University of California at Santa Barbara, Santa Barbara, California. (February 1989, p. 181)


21–25. EQUADIFF 7, Prague, Czechoslovakia. (February 1989, p. 181)

21–25. First Canadian Conference on Computational Geometry, McGill University, Montreal, Quebec, Canada. (February 1989, p. 181)

24–26. Twenty-fourth Actuarial Research Conference, Concordia University, Montréal, Canada. (March 1989, p. 311)


28–September 1. International Conference on Symplectic Geometry and Computational Hamiltonian Dynamics, Beijing, China. (January 1989, p. 69)


* Principal Speaker: F. M. Christ, University of California, Los Angeles, California.

** Purpose: The conference is intended to provide an introduction and a summary of the developments of the last ten years in singular integral operators with a discussion of applications for nonexperts.

** Program: F. M. Christ will deliver two one-hour lectures each day on the recent advances and applications of singular integral operators. In addition to the ten one-hour lectures that he will give, there will be several other talks each day. There will be sessions for short papers, research announcements, and discussions of open problems.

** Call for Papers: Applicants wishing to present papers are invited to submit titles and abstracts before April 30, 1989.

** Information: W. R. Derrick, Mathematics Department, University of Montana, Missoula, Montana 59802, 406-243-4171.


28–September 2. Second International Conference on Function Spaces, Poznan, Poland. (November 1988, p. 1387)

28–September 8. Topical Meeting on Variational Problems in Analysis, Trieste, Italy. (October 1988, p. 1245)


September 1989

1–10. Summer School of Algebra and Ordered Sets, The Jeseniky Mountains, Czechoslovakia. (January 1989, p. 69)

4–8. Twelfth CNMAC Brazilian Congress on Computational and Applied Mathematics, São José Do Rio Preto, São Paulo State, Brazil. (March 1989, p. 312)


5–8. Third European Simulation Congress, Edinburgh, Scotland. (March 1989, p. 312)


8–14. COSMEX '89: International Conference on Stochastic Methods in Experimental Sciences, Technical University of Wroclaw, Poland. (November 1988, p. 1388)


11–15. Journées de Probabilités, Marseille, France. (March 1989, p. 312)

11–15. Fifth International Conference on Numerical Methods in Engineering, Lausanne, Switzerland. (November 1988, p. 1388)

11–16. Trends in Functional Analysis and Approximation Theory, Acqua Fredda di Maratea (Potenza), Italy. (February 1989, p. 182)

Meetings and Conferences

CAE/CIM Aerospace and Electronics, Santa Clara, California.

Program: This conference and exposition (September 13-15) will focus on CAD/CAM/CAE/CIM applications in aerospace, electronics and related industries.


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


18-22. Bifurcations et Orbites Periodiques des Champs de Vecteurs du Plan, Marseille, France. (February 1989, p. 182)


Information: L. Boi, Centre d’Analyse et de Mathématiques Sociales, Ecole des Hautes Etudes en Science Sociales, 54 Boulevard Raspail, 75270 Paris, Cedex 06. Telephone: 33/1/45.44.03.49. (March 1989, p. 312)


24-October 6. Extrapolation et Approximation Rationelle, Marseille, France. (March 1989, p. 312)


29-October 1. Sixth IFAC/IFIP/IFORS/IMACS Symposium on Information Control Problems in Manufacturing Technology, Madrid, Spain. (March 1989, p. 313)

October 1989


2-6. Third Workshop on Computer Science Logic, Kaiserslautern, West Germany.

Purpose: This is the third of a series of workshops on concepts and methods of logic which are relevant to computer science. Both computer scientists whose research activities involve logic and logicians working on algorithmic aspects of logical problems are invited to attend.

Program: The scientific program will consist of invited lectures and of short contributions which will be selected from the submitted papers. All contributions will be refereed for a proceedings volume.

Call for Papers: An extended abstract (1-2 pages) of submitted papers should be sent to the program committee chairman (M. M. Richter) no later than June 1, 1989 at the address given below. The authors will be notified of acceptance for presentation to the workshop by July 15, 1989. The preliminary version of the complete paper should be ready for the workshop. The final camera-ready versions of the paper for inclusion in the workshop proceedings will be due December 1, 1989.

Information: M. M. Richter, Fachbereich Informatik, Universität Kaiserslautern, Postfach 30 49, 6750 Kaiserslautern, West Germany.

Purpose: This conference is designed to show the state-of-the-art in modern applied mathematics, through topics of current interest, and to enhance the interaction between mathematics and industry.

Invited Speakers: C. Cercignani; A. Chorin; C. W. Gear; J. B. Keller; P. D. Lax; J. L. Lions; A. Majda; S. Mitter; H. Neunzert; J. Ockendon; M. Primicerio; M. Pulvirenti; A. Quarteroni; S. Rionero.

Information: R. Spigler, Chairman, The Organizing Committee of Symposium Venice-I, Università di Padova, Dipartimento di Metodi e Modeli Matematici per le Scienze Applicate Via Belzoni, 7-35131 Padova-Italy. Telephone: 39 49 831914.


Principal Speakers: L. K. Barrett, Mississippi State University; T. W. Tucker, Colgate University; J. J. Uhl, Junior, University of Illinois.

Call for Papers: Abstracts for contributed papers should be sent by May 15, 1989 to F. Gass or T. Farmer at the address given below.

Information: F. Gass or T. Farmer, Department of Mathematics and Statistics, Miami University, Oxford, Ohio 45056. (Note: The conference programs with information concerning preregistration and housing will be available after July 17, 1989.)
Meetings and Conferences

D. S. Simberloff, Florida State University; P. Waltman, Emory University. INFORMATION: M. Mesterton-Gibbons, Department of Mathematics, Florida State University, Tallahassee, Florida 32306-1027, 904-644-2580 or 2202.


*16-18. Second International Conference on Data and Knowledge Systems for Manufacturing and Engineering, National Institute of Standards and Technology, Gaithersburg, Maryland.

PURPOSE: The conference will bring together leading researchers and engineers who are working on software and hardware systems to improve engineering design and manufacturing. TOPICS: General topics of interest include computer-aided design (CAD), computer-assisted manufacturing (CAM), and computer-integrated manufacturing (CIM).

PROGRAM: Tutorials, practitioner presentations, and research presentations will be featured. Tutorial topics will include heterogeneous distributed databases, object-oriented databases, expert systems for manufacturing, and CIM systems.

INFORMATION: L. A. Rowe, University of California, Berkeley, California 94720.

16-20. Sixth World Congress on Medical Informatics, Beijing, China. (February 1989, p. 182)

16-20. Workshop: Patterns and Dynamics in Reactive Media, Institute for Mathematics and its Applications, Minneapolis, Minnesota. (February 1989, p. 182)

20-24. Hamiltonian Systems, Transformation Groups and Special Transform Methods, Centre de Recherches Mathématiques (CRM) Université de Montréal. (January 1989, p. 70)

21-22. Eastern Section Meeting of the AMS, Stevens Institute of Technology, Hoboken, New Jersey.

INFORMATION: W. Drady, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.


26-28. The Riccati Equation In Control, Systems and Signals, Villa Gallia, Como, Italy. (January 1989, p. 70)

27-28. Central Section Meeting of the AMS, Ball State University, Muncie, Indiana. (May/June 1988, p. 732)

INFORMATION: W. Drady, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.


30-November 2. Workshop on Homotopy Theory, Mathematical Sciences Research Institute, Berkeley, California. (March 1989, p. 313)

30-December 1. College on Differential Geometry, Trieste, Italy. (March 1989, p. 313)

November 1989

2-4. Second Annual Conference on Technology in Collegiate Mathematics, Ohio State University, Columbus, Ohio. (March 1989, p. 313)


PURPOSE: The conference is designed for electrical engineering computer-aided design professionals, concentrating on computer-aided design for electronic circuit design.

CALL FOR PAPERS: Authors should submit 12 copies of a one-page abstract, as well as a more detailed description not to exceed 18 double-spaced pages, figures and tables included, to the address given below. The deadline for submissions is April 28, 1989.


December 1989


INVITED SPEAKERS: C. Ahlbrandt; L. Berkovitz; J. Haddock; L. Hall; M. K. Kwong; G. Meisters; R. Miller; J. Nohel; A. Peterson; M. Pinsky; G. Seifert; T. W. Ting; L. White.

CALL FOR PAPERS: Abstracts for contributed papers should be sent to the address given below by August 15, 1989. Late abstracts will be considered, if there is space available.


PROGRAM: This conference and exposition (November 13-15) is for users and vendors of products and services for energy mapping, urban and regional mapping, defense mapping, public utilities mapping, automated mapping, and geographic information systems.


18-19. Far Western Section Meeting of the AMS, University of California, Los Angeles.

INFORMATION: W. Drady, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.
January 1990


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


February 1990


March 1990

16–17. Central Section Meeting of the AMS, Kansas State University, Manhattan, Kansas.

Information: W. Drady, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.


May 1990


Program: This is the twentieth annual symposium of its kind with sessions in algebra, logic, computer science and engineering, including approximation reasoning, automated reasoning, high speed computation, and diagnosis of faults.

Invited Speakers: The prospective list of speakers includes M. Fitting, City University of New York, Herbert H. Lehman College; L. Illuzio, Université Claude Bernard; M. Kameyama, Tohoku University; E. J. McCluskey, Stanford University; R. Michalski, George Mason University.

Information: G. Epstein, Computer Science Department, University of North Carolina at Charlotte, Charlotte, North Carolina 28223.

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

June 1990


Organizers: Rolf Nevanlinna Institute; University of Helsinki, Lahti Research and Training Center; Finnish Mathematical Society.


6–12. 1990 Barcelona Conference on Algebraic Topology, Centre de Recerca Matematica, Barcelona, Spain. (September 1988, p. 1060)

11–14. Fourteenth Rolf Nevanlinna Colloquium, University of Helsinki, Helsinki, Finland.

Program: This is the twentieth annual symposium of its kind with sessions in algebra, logic, computer science and engineering, including approximation reasoning, automated reasoning, high speed computation, and diagnosis of faults.

Invited Speakers: The prospective list of speakers includes M. Fitting, City University of New York, Herbert H. Lehman College; L. Illuzio, Université Claude-Bernard; M. Kameyama, Tohoku University; E. J. McCluskey, Stanford University; R. Michalski, George Mason University.

Information: G. Epstein, Computer Science Department, University of North Carolina at Charlotte, Charlotte, North Carolina 28223.

Topics: Semihypergroups; hypergroups; hyperrings; hyperspaces; ordered hyperstructures; join spaces cogradors; polygroups.

Invited Speakers: P. Corsini; J. Mitas.

Program: There will be two one-hour invited lectures which will introduce the topics. There will also be twenty-minute contributed talks. The congress will be conducted in French and English.

Call for Papers: Abstracts should be typewritten, ready for reproduction, and should not exceed one page. They should be sent to the address given below by May 1, 1990. Camera-ready copies of the final papers (each
Meetings and Conferences

not exceeding 10 pages) should be
The organizers would like to publish
the proceedings of the congress.

**July 1990**

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**August 1990**

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<td>8-11. 93rd Summer Meeting of the AMS, Ohio State University, Columbus, Ohio.</td>
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<td>3-6</td>
<td>Fourth Asian Logic Conference, Tokyo, Japan. (March 1989, p. 316)</td>
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Meetings and Conferences

**October 1990**


**Chairmen:** A. Bak, Bielefeld; T. T. Dieck, Göttingen; A. Ranick, Edinburgh.

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


**Chairmen:** H. Bühlmann, Zürich; H.-U. Gerber, Lausanne; W. S. Jewell, Berkeley; J. Teugels, Heverlee.

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


**Chairmen:** A. D. Barbour, Zürich; B. Bollwoss, Cambridge.

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


**Chairmen:** P. Bundschuh, Köln; R. Tijdeman, Leiden.

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

**November 1990**

2–3. Central Section Meeting of the AMS, University of North Texas, Denton, Texas.

**Information:** W. Drady, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

*18–24. Komplexitätstheorie,* Oberwolfach, Federal Republic of Germany.

**Chairmen:** C. P. Schnorr, Frankfurt; A. Schönhage, Tübingen; V. Strassen, Konstanz.

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


**Chairmen:** G. Pflug, Gießen; H. Walk, Stuttgart.

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

**December 1990**


**Chairmen:** D. Braess, Bochum; W. Hackbusch, Kiel; U. Trottenberg, Köln/Bonn.

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


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


**Chairmen:** W. Felscher, Tübingen; H. Schwichtenberg, München; A. S. Troelstra, Amsterdam.

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


**Chairmen:** H. Drygas, Kassel; O. Krafft, Aachen; E. Sonnemann, Trier.

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

January 1991


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

July 1991


Meetings and Conferences

August 1991
8-11. 94th Summer Meeting of the AMS, University of Maine, Orono, Maine.

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

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

January 1992
8-11. 98th Annual Meeting of the AMS, Baltimore, Maryland.

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

June 1992

January 1993

Information: W. Drady, American Mathematical Society, Post Office Box 6248, Providence, Rhode Island 02940.

January 1994
5-8. 100th Annual Meeting of the AMS, Cincinnati, Ohio.

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

Zeros of Bernoulli, Generalized Bernoulli, and Euler Polynomials
Karl Dilcher
(Memoirs of the AMS, Number 386)

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

Shipping/Handling: 1st book $2, each add’l $1. $25 max. By air, 1st book $5, each add’l $3. $100 max. Prepayment required. Order from AMS, P.O. Box 1571, Annex Station, Providence, RI 02901-9930, or call 800-556-7774 to use VISA or MasterCard.

1980 Mathematics Subject Classifications: 11, 30
ISSN 0065-9266
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New AMS Publications

**INVARIANT THEORY**
R. Fossum, W. Haboush, M. Hochster, and V. Lakshmibai, Editors
(Contemporary Mathematics, Volume 88)

This volume contains the proceedings of the AMS Special Session on Invariant Theory, held in Denton, Texas in the fall of 1986; also included are several invited papers in this area. The purpose of the conference was to exchange ideas on recent developments in algebraic group actions on algebraic varieties.

The papers fall into three main categories: actions of linear algebraic groups; flag manifolds and invariant theory; and representation theory and invariant theory. This book is likely to find a wide audience, for invariant theory is connected to a range of mathematical fields, such as algebraic groups, algebraic geometry, commutative algebra, and representation theory.

Contents
A. Magid, Equivariant completions of affine varieties with group action
A. Neeman, GAGA for quotient schemes
R. Joshua, Equivalent intersection cohomology
J. P. Brennan, Invariants of affine group schemes
G. Kempf, The number of invariants
M. Hochster, The canonical module of a ring of invariants
B. Ulrich, Linkage and ring of invariants
C. Huneke, A. Simis, and W. Vasconcelos, Reduced normal cones are domains
S. Montgomery, Prime ideals and group actions in non-commutative algebras
R. Gustafson, Invariant theory and special functions
R. Proctor, Interconnections between orthogonal and symplectic characters
J. Stembridge, A combinatorial theory for rational actions of GL_n
J. Weyman, Littlewood-Richardson rule for classical groups
S. Doty, Submodules of symmetric powers of the natural module for GL_n
H. H. Anderson, A new proof of old character formulas
K. Akin, Resolutions of representations
D. Buchsbaum, Jacobi-Trudi and Giambelli identities in characteristic-free form

R. Fossum, Properties of kernels of nilpotent derivation in characteristic p
A. Fauntleroy, Quasi-projective orbit spaces for linear algebraic group actions
R. W. Richardson, Irreducible components of the null cone
A. Helminck, On the orbits of symmetric spaces under the action of parabolic subgroups
V. Lakshmibai and K. N. Rajheswari, Standard monomial theory for exceptional groups
V. V. Deodhar, An extension of Kazhdan-Lusztig theory
A. Lascoux and M. P. Schützenberger, Fonctorialité des polynomes de Schubert

1980 Mathematics Subject Classifications: 14M05, 14M15, 17B10; 20G05, 20G15
ISBN 0-8218-5094-6, LC 89-311
ISSN 0271-4132
608 pages (softcover), April 1989
Individual member $31, List price $52,
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**GRAPHS AND ALGORITHMS**
R. Bruce Richter, Editor
(Contemporary Mathematics, Volume 89)

This volume contains the proceedings of the AMS-IMS-SIAM Joint Summer Research Conference on Graphs and Algorithms, held in 1987 at the University of Colorado in Boulder. The purpose of the conference was to foster communication between computer scientists and mathematicians, for recent work in graph theory and related algorithms has relied on increasingly sophisticated mathematics. Wagner's Conjecture, self-adjusting data structures, graph isomorphism, and various embedding and labelling problems in VLSI are examples of the kinds of questions now facing the field. With around 65 participants, the conference brought out the depth and diversity of current research in this area. The wide range of topics covered in this volume demonstrates the vitality of the activity in both mathematics and computer science and captures the diversity and excitement of the conference.

Contents
Michael R. Fellows, The Robertson-Seymour theorems: A survey of applications

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SOME TOPICS IN PROBABILITY AND ANALYSIS
Richard F. Gundy
(CBMS Regional Conference Series, Number 70
Supported by the National Science Foundation)

This book is based on lectures presented by the author at DePaul University in July 1986. The lectures cover three main topics. The first is local time theory for Brownian motion and some geometrical inequalities for harmonic functions in the upper half-plane $R^{n+1}$. The author sketches a proof of the inequalities obtained by Barlow and Yor for the maximal local time functional. The second topic concerns a probabilistic treatment of Riesz transforms in $R^{n+1}$, and semimartingale inequalities. The author proves semimartingale inequalities of the type usually obtained for martingales. The final topic centers on a discussion of the Ornstein-Uhlenbeck semigroup and P. A. Meyer’s extension of the Riesz inequalities for the infinite-dimensional version of this semigroup. One of the major results of the book is the establishment of inequalities for the density of the area integral.

Contents

The Barlow-Yor inequalities

The density of the area integral
Norm inequalities for $D$
Local estimates
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(American Mathematical Society Translations, Series 2, Volume 142)

This volume contains papers ranging over a variety of topics, including computational geometry and tiling, nonclassical logic, approximation by polynomials, entire functions, operator algebras, equations involving nonlinear operators, and the theory of programming.

Contents

V. Yu. Sazonov, The collection principle and the existential quantifier
L. V. Nosov, E. G. Nosova, E. B. Rabinovich, and
V. Z. Feĭnberg, Optimal algorithms for solving problems of arrangement and covering of plane polygonal figures
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M. G. Kreĭn, B. Ya. Levin, and A. A. Nudel’man, On a special representation of polynomials that are positive on a system of closed intervals
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SÉMINAIRE N. BOURBAKI 1987–88
(Astérisque, Number 161–162)

Comme les précédents volumes de ce Séminaire, celui-ci contient des exposés de synthèse sur des sujets d’actualité: deux de Théorie des systèmes dynamiques, deux de Théorie des nombres, un de Théorie des Groupes, deux sur les avatars de la transformation de Fourier, quatre de Mathématiques appliquées, un de Mathématiques inspirées par la physique théorique, un de Géométrie algébrique et un de Topologie.

On y fait, entre autres, le point sur l’état actuel du problème de Fermat, celui de la représentation des groupes finis comme groupe de Galois d’extensions de Q, sur le problème de Dulac, sur les points critiques dans les systèmes variationnels sans hypothèse de compacte, sur l’équation de Boltzmann et sur les méthodes de recuit simulé.

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The following listing is being repeated with corrections from the January 1989 issue.

ORDERED SETS AND LATTICES
(American Mathematical Society Translations, Series 2, Volume 141)

This book is another publication in the recent surveys of ordered sets and lattices. The papers, which might be characterized as “reviews of reviews,” are based on articles reviewed in the Referativnyi Zhurnal: Matematika from 1978 to 1982. For the sake of completeness, the authors also attempted to integrate information from other relevant articles from that period. The bibliography of each paper provides references to the reviews in RZhMat and Mathematical Reviews where one can seek more detailed information. Specifically excluded from consideration in this volume were such topics as algebras of logic, Boolean functions, vector lattices, ordered algebraic systems (including ordered topological spaces), and semigroup properties of semilattices, as well as papers in which such topics as nonlattice-theoretical
properties of congruence lattices and subalgebra lattices were considered.

Contents

H. Draškovičevá, T. Katriňák, and M. Kolibiar, *Boolean algebras and similar lattices*

T. S. Fofanova, *General theory of lattices*

V. I. Igoshin, *Varieties and other classes of lattices. Categorical questions*

A. V. Mikhalëv, V. N. Saliǐ, and L. A. Skornyakov, *Concrete lattices*

V. N. Saliǐ, *Partially ordered sets. Semilattices. Generalizations of lattices*

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reviews in

GLOBAL ANALYSIS

1980-86

Introduction by Anthony J. Tromba

The term "global analysis" refers to the general area of analysis on manifolds, in which the methods of modern algebra, analysis, geometry, and topology are blended. Although the beginnings of these ideas can be traced to the 17th century, major contributions in this direction were made by Lie, Riemann, and Poincaré toward the end of the last century, followed by the work of G. D. Birkhoff, E. Cartan, and Morse in the early part of this century. However, it is only in recent years that the subject has attained its present central position in mathematics. The subject has many rich applications to fields outside mathematics—such as mechanics, quantum physics, and general relativity—as well as within mathematics itself.

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Contents:

Volume 1: Global analysis, analysis on manifolds; General theory of differentiable manifolds; Infinite-dimensional manifolds; Calculus on manifolds; nonlinear operators; Spaces and manifolds of mappings;

Volume 2: Variational problems in infinite-dimensional spaces; Ordinary differential equations on manifolds; dynamical systems;

Volume 3: Ordinary differential equations on manifolds; dynamical systems;

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Recent Appointments

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

Jill P. Mesirov (1991) has been reappointed to the Visiting Committee on Computer Operations and Facilities by Chairman of the Board of Trustees, M. Susan Montgomery. Continuing members of the committee are S. Tucker Taft (1989), chairman and Peter J. Weinberger (1990).

Julius L. Shaneson has been appointed chairman of the Committee on Committees by President William Browder. Continuing members of the committee are M. Salah Baouendi (1990), William Browder (ex officio), Robert M. Fossum (ex officio), Morris W. Hirsch (1990), Rhonda J. Hughes (1990), Irwin Kra (1990), and Philip Kutzko (1990).

Ronald F. Gariepy (1989) has been appointed by President William Browder to the Committee to Select Hour Speakers for Southeastern Sectional Meetings. Continuing members of the committee are Joseph A. Cima (ex officio), Patrick B. Eberlein (1989), chairman, Ray A. Kunze (1990), and William Pardon (1990).

John Oppelt has been appointed by Presidents Lida Barrett (MAA) and William Browder (AMS) to the AMS-MAA Arrangements Committee for the Louisville Meeting January 17–20, 1990 as its chairman. Other members of the committee are Joseph A. Cima (ex officio), William H. Jaco (ex officio), and Kenneth A. Ross (ex officio).

Officers of the Society 1988 and 1989

Except for the Members-at-Large of the Council, the month and year of the first term and the end of the present term are given. For Members-at-large of the Council, the last year of the present term is listed.

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Miscellaneous

**Personal Items**

Lynn Batten, of the University of Winnipeg, has been appointed head of the Department of Mathematics and Astronomy at the University of Manitoba, effective July 1, 1989.

Nobuo Shimada has retired from Kyoto University, effective March 31, 1989, and will move to the Okayama University of Science, effective April 1, 1989.

**Deaths**

Morton L. Curtis, W. L. Moody Professor of Mathematics (Emeritus) died on February 4, 1989, at the age of 67. He was a member of the Society for 40 years. (See the News and Announcements section of this issue of Notices.)

Otto Endler, of the Institute for Pure and Applied Mathematics, Rio de Janeiro, died on May 12, 1988, at the age of 58. He was a member of the Society for 17 years.

John Finch, of Beloit, Wisconsin, died on November 11, 1988, at the age of 70. He was a member of the Society for 46 years.

Wilfried H. Nobauer, of Vienna Technical University, died on February 12, 1988, at the age of 60. He was a member of the Society for 19 years.

Alvin C. Sugar, of Los Angeles, California, died on January 15, 1989, at the age of 80. He was a member of the Society for 54 years.
The Joy of \TeX is the user-friendly user's guide for \texttt{AMS-\TeX}, an extension of \TeX, which was especially designed to simplify the input of mathematical material and to format the output according to any of various preset style specifications.

There are two primary features of the \TeX system: it is a computer system for typesetting technical text, especially text containing a great deal of mathematics; and it is a system for producing beautiful text, plain or technical, which is comparable to the work of the finest printers.

One of the strengths of \TeX is its ability to use macros—aggregates of several commands into one—and Spivak has created a collection of macros that makes the preparation of mathematical text for printing a true Joy.

Chapters cover: ordinary text and control sequences, changing fonts, running a file through \TeX, spacing and line breaking, symbols and accents, formatting a paper, formulas in text, displayed formulas, fractions and binomial coefficients, $\sum$ and other large operators, braces and other variable size symbols, aligning equations in a display, and matrices. More special topics include exact sequences and continued fractions.

Exercises sprinkled generously through each chapter encourage the reader to sit down at a terminal and learn through experimentation. Appendixes list summaries of frequently used and more esoteric symbols as well as answers to the exercises.
SUGGESTED USES for classified advertising are positions available, books or lecture notes for sale, books being sought, exchange or rental of houses, and typing services. THE 1989 RATE IS $42.50 per inch on a single column (one-inch minimum), calculated from the top of the type; $18 for each additional 1/2 inch or fraction thereof. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Advertisements in other sections of the classified pages will be set according to the advertisement insertion. Headlines will be centered in boldface at no extra charge. Classified rates are calculated from top of type in headline to bottom of type in body copy, including lines and spaces within. Any fractional text will be charged at the next 1/2 inch rate. Ads will appear in the language in which they are submitted.

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SITUATIONS WANTED ADVERTISEMENTS from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-556-7774 and speak to Paula Montella for further information.

SEND AD AND CHECK TO: Advertising Department, Attn: Paula Montella, AMS, P.O. Box 6248, Providence, Rhode Island 02940. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Individuals are requested to pay in advance, institutions are not required to do so. AMS FAX 401-331-3842.

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UNIVERSITY OF ALBERTA

Department of Mathematics

Applications are invited for a tenure-track position, in Approximation Theory (File AP-2) at the Assistant or Associate Professor level, beginning July 1, 1989. Requirements are a Ph.D. and proven ability or demonstrated potential for research and teaching. Current salary range is from $33,144 (Canadian) per annum depending upon qualifications. Send vitae and arrange for three letters of reference to be sent to: Professor L. H. Erbe, Chairman, Department of Mathematics, University of Alberta, Edmonton, 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 April 30, 1989. Please quote file number when responding to this advertisement. The University of Alberta is committed to the principle of equity in employment.

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Classified Advertisements

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Applications are invited for one or more anticipated tenure or tenure-track positions in Mathematics beginning Fall 1989. Candidates must have a Ph.D. degree, demonstrated excellence in research, and potential for high-quality teaching. Strong candidates in all areas will be considered with preference given to research interests compatible with those of our current faculty. Duties include research, normally teaching six hours per semester, and Departmental and University service appropriate to rank. Salary and rank will be commensurate with qualifications and experience. There may also be visiting positions. Applicants should send their vita and have at least three letters of reference sent to Dr. Darryl McCullough, Search Committee Chair, Department of Mathematics, University of Oklahoma, 601 Elm Avenue, Norman, Oklahoma 73019. Closing dates are December 15, 1988 and every two weeks thereafter, until the final closing on April 20, 1989. The University of Oklahoma is an Affirmative Action/Equal Opportunity Employer.

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Department of Mathematics
Carbondale, IL 62901
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Dept. of Mathematics
Chapel Hill, NC 27599
Applications are invited for a senior level tenured appointment in the general area of applied and computational mathematics, effective Fall 1989. Rank and salary depend on qualifications. A Ph.D. and demonstrated excellence in research and teaching are required. Applications will be accepted until the position is filled. Contact Jon Tolle, Mathematics Department, Box 3250 Phillips Hall, UNC at Chapel Hill, Chapel Hill, NC 27599. EO-AA Employer. Women and minorities are encouraged to identify themselves voluntarily.

UNIVERSITY OF THE WEST INDIES
Cave Hill Campus–Barbados
Applications are invited for two posts of Lecturer/Assistant Lecturer in Computer Science in the Department of Mathematics, University of the West Indies, Cave Hill Campus, Barbados. Applicants should possess a postgraduate degree in Computer Science; have a strong record of achievement or potential in research; and evidence of effective teaching. Applicants should also be competent in two or more of the following areas: -Information Structures; Assembly Language and Systems Programming; Operating Systems; Distributed and Parallel Programming; Software Engineering; Communications Networks; VLSI. Applicants with competence in other areas of Computer Science will also be considered. The successful applicants will be expected to assume duties by September 1, 1989 or as soon as possible thereafter. SALARY SCALES: LECTURER: BDS$38,208 x 1644–48,072 (B) x 1644–57,936 p.a. ASSISTANT LECTURER: BDS$31,548 x 1548–34,644 p.a. Detailed applications (three copies) giving full particulars of qualifications and experience, date of birth, marital status and the names and addresses of three referees should be sent as soon as possible to the CAMPUS REGISTRAR, UNIVERSITY OF THE WEST INDIES, P.O. BOX 64, BRIDGETOWN, BARBADOS.

UNIVERSITY OF OKLAHOMA
CHAIRPERSON
DEPARTMENT OF MATHEMATICS
Nominations and applications are invited for the position of Chairperson in the Department of Mathematics effective Fall, 1989. Candidates must possess an earned doctorate, a substantial record of research achievement, a commitment to excellence in teaching, and leadership and administrative abilities appropriate to a growing department that is dedicated to a balanced program of quality research and teaching. The Mathematics Department has over thirty faculty members, most of whom are actively involved in research, and offers programs for the bachelors, masters, and Ph.D. degrees. There is also an extensive program of scientific activity supplemented by a substantial endowment for discretionary funds. Candidates should send a cover letter, vita, selected reprints, and arrange to have four letters of reference (including at least one concerning administrative abilities) sent to: Dr. Kevin Grasse, Chair Search Committee, Department of Mathematics, 601 Elm-Phsc 423, Norman, Oklahoma 73019. Phone 405-325-2903.
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NOTICES OF THE AMERICAN MATHEMATICAL SOCIETY
APPLICATIONS are invited for a tenure track position at the assistant or associate level. Qualifications include a Ph.D. in a mathematical or a strong dedication to undergraduate teaching and a continuing interest in research. Preference will be given to individuals in applied or computational areas of mathematics. Salary negotiable.

The Citadel is a state-supported liberal arts, military college offering undergraduate degrees in the Arts, Sciences, Engineering, Education, and Business Administration. The Department of Mathematics and Computer Science offers the B.S. and B.A. degrees in mathematics and a B.S. degree in computer science. Please send resume and three letters of reference to Charles E. Cleaver, Head Department of Mathematics/Computer Science, The Citadel, Charleston, S.C. 29409. Review of applications will begin April 15 and continue until position is filled.

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THE UNIVERSITY OF ALABAMA

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O. Pironneau (Univ. Paris VI and INRIA)
P. E. Dabaghi (INRIA)
Finite Element Methods for Fluid Mechanics Problems

2nd SESSION (1 June - 25 August 1989)
V. Thomée (Chalmers Univ. of Techn. & Univ. of Goteborg)
Galorik Methods for Parabolic Partial Differential Equations

Limited financial support in the form of free housing may be available for graduate students. Apply with brief vita to:

The Institute of Applied and Computational Mathematics
P.O.Box 1527, Heraklion, Crete, Greece.
Deadline for applications will be May 15, 1989.
UNIVERSITY OF LONDON

CHAIR OF STATISTICS TENABLE AT IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

THE SENATE INVITE APPLICATIONS FOR THE ABOVE CHAIR OF STATISTICS TENABLE IN THE DEPARTMENT OF MATHEMATICS AT IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE. THE ESTABLISHED CHAIR WAS PREVIOUSLY HELD BY PROFESSOR SIR DAVID COX WHO LEFT IN OCTOBER 1988 TO BECOME WARDEN OF NUFFIELD COLLEGE, OXFORD.

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THE CLOSING DATE FOR RECEIPT OF APPLICATIONS IS 30 APRIL 1989

The University of Sydney, Australia

SENIOR LECTURESHP/LECTURESHPs

Reference No. 08/01

Department of Pure Mathematics

Applications are invited from mathematicians with a PhD degree or equivalent qualification with strong research interests in any branch of Pure Mathematics. It is expected that three appointments will be made. Appointment may be at Senior Lecturer or Lecturer level, tenurable or fixed-term (for three years). Tenurable appointments have the potential to lead to tenure and are usually probationary for three years.

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The University reserves the right not to proceed with any appointment for financial or other reasons.

Applications close: May 12, 1989

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vac.nr. 141.081 professor in applied mathematics

The candidate will be an expert in both research into and the applications of numerical methods, for instance numerical analysis or algebra, but specialists in other areas of numerical methods are also invited to consider applying.

He or she will be expected to build up active research relationships with those working in other areas in the faculty. He or she will base the teaching of numerical methods on modern developments in this field and will stimulate their use in mathematical research and education. Furthermore he or she will contribute to the general teaching programme of the Department of Mathematics and to the organizational tasks in the faculty.

The salary will be according to Dutch civil service regulations, in the professor's scales A or B (to a maximum of hfl. 9621, — of hfl. 11.383, — bruto per month, respectively).

Further information can be obtained from E.M.J. Bertin, Chairman of the Search Committee, Department of Mathematics, tel. 31-30531529 (secr.: 31-30531421).

Applications should be sent in writing, and accompanied by a curriculum vitae and a list of publications, within four weeks of the appearance of this advertisement to T.A. Springer, the Dean of the Faculty of Mathematics and Computer Science, P.O. Box 80.010, 3508 TA Utrecht, Netherlands, mentioning the above reference number.

Anyone who would like to draw the attention of the search committee to suitable candidates is also urged to communicate this to the dean.

With equally qualified applicants preference will be given to a woman.
The Institute solicits applications for membership in the Institute for the 1990-91 year, which begins in September 1990. In 1990-91 three programs will be featured.

PARTIAL DIFFERENTIAL EQUATIONS AND CONTINUUM MECHANICS

The topics of this program include:

2. Hyperbolic waves, oscillations, and integrable systems.

The program committee consists of L.C. Evans, A.J. Majda (Chairman), G. Papanicolaou, and T. Spencer.

REPRESENTATIONS OF FINITE GROUPS (FIRST HALF OF YEAR)

The following topics will be emphasized:

1. Representations of groups of Lie type and Coxeter groups.
   A. Characteristic zero theory: character sheaves, the geometry of orbits, and the generalized Springer correspondence.
   B. Natural characteristic theory: Lusztig's proposed formula for the composition factors of Weyl modules.
   C. Representations of Chevalley groups for a prime other than the natural characteristic.
2. General theory: local representation theory and Alperin's conjecture, homological methods, Clifford theory, and the structure of block algebras.
3. Related areas: realizations of finite groups as Galois groups, connections with singularity theory, geometry and number theory.

The program committee consists of J.L. Alperin, C.W. Curtis (Chairman), W. Feit, and P. Fong.

STRINGS IN MATHEMATICS AND PHYSICS (SECOND HALF OF YEAR)

Seminars will review progress and open problems in areas of interest. At present they are:

1. Quantum groups and integrable models.
2. Topological quantum field theory.
3. Two-dimensional conformal field theory.
5. String field theory.

The program committee consists of O. Alvarez, D. Friedan, G. Moore, G. Segal, I.M. Singer (Chairman), and C. Taubes.

POSTDOCTORAL FELLOWSHIPS

We anticipate making approximately 20 awards of postdoctoral fellowships. The stipend for 1989-90 is $30,000 and it will be at least that for 1990-91. In addition there is an award for round trip travel. The candidate's Ph.D. should be 1985 or later. Candidates are asked to solicit three letters of recommendation. Most awards are for a year, but a shorter period is possible. The deadline for applications is December 15, 1989.
RESEARCH INSTITUTE
BERKELEY, CALIFORNIA, 94720

SENIOR MEMBERSHIPS
For mathematicians whose Ph.D. is 1984 or earlier, applications are invited for part or all of 1990-91. Letters of recommendation are encouraged but not required. It is generally expected that members at this level will come with partial or full support from other sources. For visits of less than three months, Institute support is generally limited to awards to help offset living expenses. The deadline for applications is December 15, 1989.

RESEARCH PROFESSORSHIPS
These awards are intended for midcareer mathematicians; an applicant should be six years or more beyond the doctorate. An award for a full academic year will be limited to a ceiling of $30,000 and normally will not exceed half the applicant’s salary. Appointments can be made for a portion of the year; the $30,000 ceiling and half salary limit would then be prorated. It is anticipated that between six and ten awards will be made.

In addition to the basic stipend, there will be an award for round trip travel to MSRI.

Letters of recommendation are encouraged but not required.

Because applicants for an award of this kind need additional time to make their plans the deadline for these applications is October 1, 1989, earlier than the general deadline of December 15, 1989.

SOVIET-AMERICAN SUMMER WORKSHOPS
There are tentative plans for a pair of Soviet-American Summer Workshops, jointly sponsored by the Academies of Sciences of the two countries, under the title “Mathematical physics with emphasis on strings.” In these plans ten American scientists with age at most 35 on June 1, 1990 will meet with a similar group of Soviet scientists at MSRI from June 10 to June 28, 1991 as a climax to the Strings program at MSRI. The same 10 will travel to the Soviet Union in the summer of 1992 and join their Soviet colleagues. Funding is being sought to cover the participants’ expenses.

Applications are invited from candidates who wish to join the group of American participants. The normal application materials for a postdoctoral fellowship are requested, including three letters of reference. Date of birth should be included. The usual deadline of December 15, 1989 applies.

Applicants may, if they wish, submit their materials so as to apply both to the Soviet-American workshops and to the MSRI Strings program which will run for the period January - June, 1991.

FURTHER REMARKS
Each application should include an up-to-date vita and bibliography and a statement of research plans.

The Institute does not use formal application forms. However, an information sheet giving additional suggestions to prospective applicants is available upon request. Write to the Mathematical Sciences Research Institute, 1000 Centennial Drive, Berkeley CA 94720.

Applications received after the deadline (October 1, 1989 for the Research Professorships and December 15, 1989 for all others) cannot be assured a complete consideration.

For 1991-92 the Institute plans a full year program in Statistics and a program on Symbolic Dynamics in the second half. This will be rounded out with another program for the first half, to be announced at a later date. Suggestions for future programs are welcome.

The Institute is committed to the principles of Equal Opportunity and Affirmative Action.
Applications are invited for teaching appointments from candidates who are able to teach in one or more of the following areas:

- Pure Mathematics
- Applied Mathematics
- Operational Research
- Statistics

Candidates should possess a PhD degree in Mathematics or its equivalent.

Gross annual emoluments range as follows:

- Lecturer ................... S$43,850 - 57,350
- Senior Lecturer ......... S$51,950 - 91,070
- Associate Professor .... S$79,780 - 109,880

(US$1 = S$2.03 approximately)

The commencing salary will depend on the candidate's qualifications, experience and the level of appointment offered. Leave and medical benefits will be provided. Depending on the type of contract offered, other benefits may include: provident fund benefits or an end-of-contract gratuity, a settling-in allowance of S$1,000 or S$2,000, subsidised housing at nominal rentals ranging from S$100 to S$216 p.m., education allowance for up to three children subject to a maximum of S$10,000 per annum per child, passage assistance and baggage allowance for the transportation of personal effects to Singapore. Staff members may undertake consultation work, subject to the approval of the University, and retain consultation fees up to a maximum of 60% of their gross annual emoluments in a calendar year.

The Department of Mathematics is a department in the Faculty of Science. There are eight faculties in the National University of Singapore with a current student enrolment of some 14,000. All departments are well-equipped with a wide range of facilities to enhance the teaching and research activities of staff members. The University is linked to BITNET, an international network that interconnects almost 500 mainframe computers at 200 institutions of higher learning and research centres around the world.

Application forms and further information on terms and conditions of service may be obtained from:

- The Director
- Personnel Department
- National University of Singapore
- 10 Kent Ridge Crescent
- Singapore 0511

Enquiries may also be sent through BITNET to: PERSDEPT@NUSVM
The Geometry of Jet Bundles
D.J. Saunders
London Mathematical Society Lecture Notes Series
This text is an introduction to the theory of jet bundles for mathematicians and physicists who wish to study, in a modern geometric way, differential equations. A major theme proposes that jets may be considered as a natural generalization of vector fields for studying problems in field theory.
1989/300 pp./36948-7/Paper $29.95

Heat Kernels and Spectral Theory
E.B. Davies
Cambridge Tracts in Mathematics
This book investigates the theory of second order of elliptic operators. It sets the precedent as the first account of dramatic improvements made in recent years in our quantitative understanding of the subject area.
1989/197 pp./36136-2/Hardcover $49.50

Groups Acting on Graphs
Warren Dicks and M.J. Dunwoody
Cambridge Studies in Advanced Mathematics
This is an advanced text and research monograph on groups acting on low-dimensional topological spaces, and the viewpoint is primarily algebraic.
1989/203 pp./23033-0/Hardcover about $49.50

Analysis at Urbana I
Proceedings of the Special Year in Modern Analysis at the University of Illinois, 1986–87
Edited by Earl R. Berkson, N.T. Peck and J. Uhl
London Mathematical Society Lecture Note Series
This book arose as a result of the yearlong symposium held at the University of Illinois and lays emphasis on the synthesis of modern and classical analysis at the current frontiers of knowledge.
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Undergraduate Algebraic Geometry
M. Reid
London Mathematical Society Students Texts
Reid introduces the reader to the basic concepts of algebraic geometry, including: plane conics, cubics and the group law, affine and projective varieties, and nonsingularity and dimension.
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From Cardinals to Chaos
Reflections on the Life and Legacy of Stanislaw Ulam
Necia Grant Cooper
This highly illustrated exploration into the life and legacy of one of the most fascinating men of modern science will be essential reading for professional scientists and students.
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36734-4/Paper $24.95

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P.G. Drazin and R.S. Johnson
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Discusses the theory of solitons and its diverse applications to nonlinear systems that arise in the physical sciences. The authors explain the generation and properties of solitons, introducing the mathematical technique known as the Inverse Scattering Transform.
1989/230 pp./33389-X/Hardcover $59.50
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The Design of Experiments
Statistical Principles for Practical Application
Roger Mead
Mead describes the statistical principles of good experimental design while employing a minimum of mathematics. He assumes that the large-scale analysis of data will be performed by computers and thus he discusses how all of the available information can be used to extract the clearest answers to many questions.
1988/620 pp./24512-5/Hardcover $130.00

Conley Memorial Volume
Special Issue of Ergodic Theory and Dynamical Systems
Edited by M. Herman, R. McGehee, J. Moser, and E. Zehnder
This is a special issue of the journal Ergodic Theory and Dynamical Systems, consisting of papers dedicated to the memory of Charles Conley. He wrote a number of penetrating and profound papers in ergodic theory, and the breadth and significance of his work is reflected here.
1989/409 pp./36929-0/Hardcover $69.50

An Introduction to Mathematical Physiology and Biology
J. Mazumdar
Australian Mathematical Society Lecture Series
The author provides important mathematical techniques needed to appreciate mathematical modelling in biology and medicine. He discusses a range of phenomena, including diffusion, population dynamics, autonomous differential equations and the stability of ecosystems as well as the spectral analysis of heart sounds using FFT techniques.
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Gregory L. Naber
London Mathematical Society Student Texts
Provides an elementary introduction to geometrical methods and notions used in special and general relativity. Emphasizes the ideas concerned with the structure of space-time which play a role in the Penrose-Hawking singularity theorems.
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33612-0/Paper $16.95

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Alfredo M. Ozorio de Almeida
Cambridge Monographs on Mathematical Physics
The book introduces the theory of Hamiltonian chaos by outlining the main results in the field and considering implications for quantum mechanics.
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The Lefschetz Centennial Conference, Part I: Proceedings on Algebraic Geometry
D. Sundararaman, Editor

This volume contains many of the papers in the area of algebraic geometry presented at the Conference. The proceedings begin with two interesting articles: A Page of Mathematical Autobiography, that has been reprinted from an early edition of the Bulletin of the AMS, and “Solomon Lefschetz, a biography” by William Hodge. that is reprinted from the Bulletin of the London Mathematical Society.

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- Calcutta Mathematical Society
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- Deutsche Mathematiker-Vereinigung e.V.
- Edinburgh Mathematical Society
- Gesellschaft für Angewandte Mathematik und Mechanik
- Glasgow Mathematical Association
- Indian Mathematical Society
- Iranian Mathematical Society
- Irish Mathematical Society
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- Israel Mathematical Union
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**Shipping and Handling**

<table>
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<th>First Book</th>
<th>Each Additional</th>
<th>Maximum</th>
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<tr>
<td>Surface</td>
<td>$2</td>
<td>$1</td>
<td>$25</td>
</tr>
<tr>
<td>Air</td>
<td>$5</td>
<td>$3</td>
<td>$100</td>
</tr>
</tbody>
</table>

Prices are subject to change without notice.

**Books** are sent via surface mail (UPS to U.S. addresses and printed matter elsewhere) unless air delivery is requested. The shipping and handling charges for book orders are shown in the table. Journal back numbers, Mathematical Reviews indexes and review volumes are sent via surface mail to any destination unless air delivery is requested. Postage for surface mail is paid by the AMS. Air delivery rates, which will be quoted upon request, must be paid by the purchaser. Software: Nonindividual customers need not prepay provided a Purchase Order number is given with the order. Software/books are sent via UPS to U.S. addresses, first class mail to Canada, and air delivery elsewhere. Add shipping and handling for Software/Books: $6 per order in the U.S. and Canada; $25 per order air delivery outside the U.S. and Canada.

Customers in these areas should request price information from and direct their orders to the following distributors:

**Europe/Middle East/Africa**: Barry Emms, Clarke Assoc. - Europe Ltd., 13a Small Street, Bristol BS1 1DE, England. Tel. 01-0272-268864, Telex 445991 CALORB G; exclusive distributor of AMS books.

**Japan**: Maruzen Co. Ltd., P.O. Box 5050, Tokyo International 100-31, Japan. Tel. Tokyo 272-7211, Telex J26516

Change of Address

Members of the Society who move or who change positions are urged to notify the Providence Office as soon as possible.

Journal mailing lists must be printed four to six weeks before the issue date. Therefore, in order to avoid disruption of service, members are requested to provide the required notice well in advance.

Besides mailing addresses for members, the Society’s records contain information about members’ positions and their employers (for publication in the Combined Membership List). In addition, the AMS maintains records of members’ honors, awards, and information on Society service. Information of the latter kind appears regularly in Notices.

When changing their addresses, members are urged to cooperate by supplying the information requested below. The Society’s records are of value only to the extent that they are current and accurate.

If your address has changed or will change within the next two or three months, please fill out this form, supply any other information appropriate for the AMS records, and mail to the address given below.

Name: __________________________________________ Customer code: __________________________________________

Change effective as of: ________________________________

New mailing address: ______________________________________________________

New position: ____________________________________________________________

If mailing address is not that of your employer, please supply the following information:

New employer: ____________________________________________________________

Location of employer:

<table>
<thead>
<tr>
<th>City</th>
<th>State/Province</th>
<th>Country</th>
<th>Zip Code</th>
</tr>
</thead>
</table>

Telephone number(s): ________________________________

Electronic address(es): __________________________________

Recent honors and awards: __________________________________

Personal items for publication in Notices: ________________________________

Mail completed form to:

Member Services, AMS, P.O. Box 6248, Providence, RI 02940
MAA Minicourse Preregistration Form, Boulder, Colorado
August 7-10, 1989

NOTE: This is not an AMS Short Course Form. Please use the Boulder, Colorado Preregistration/Housing Form to preregister for the AMS Short Course.

To preregister for MAA Minicourse(s), please complete THIS form and return it with your payment to:

Susan Wilderson
Mathematical Association of America
1529 Eighteenth Street, N.W.
Washington, DC 20036
Telephone: 202-387-5200

(Please print) Surname First Middle Telephone: __________________________

Street address City State Zip

- Deadline for MAA Minicourse preregistration: June 1, 1989 (After this date, potential participants are encouraged to call the MAA headquarters at 800-331-1622.)
- Deadline for cancellation in order to receive a 50% refund: July 31, 1989
- Each participant must fill out a separate Minicourse Preregistration form.
- Enrollment is limited to two Minicourses, subject to availability.
- Please complete the following and send both form and payment to Susan Wilderson at the above address:
  I would like to attend [ ] 1 Minicourse [ ] 2 Minicourses
  Please enroll me in MAA Minicourse(s): #__________ and #__________
  In order of preference, my alternatives are: #__________ and #__________

- PAYMENT
  Check enclosed: $__________
  Credit card type: [ ] MasterCard [ ] Visa
  Credit card #__________________________ Expiration date: _______________________

Your Employing Institution __________________________ Signature (as it appears on credit card) __________________________

Minicourse Number and Name

1. The use of personal computers in an introductory linear algebra course
   Homer Bechtell $30
2. Combinatorics via functional equations
   Donald R. Snow $30
3. Chaotic dynamical system
   Robert L. Devaney $30
4. Faculty-managed programs that produce minority mathematics majors
   Uri Treisman & Ray Shiflett $30
5. Starting, funding and sustaining mathematics laboratories
   Stavros N. Busenberg $30
6. Group theory through art
   Thomas Brylawski $30
7. HP-28S short course for nearly inexperienced users
   Jerold Mathews $30
8. Applications of the HP-28S for experienced users
   Thomas W. Tucker $30
9. A seminar on women in mathematics
   Miriam P. Cooney $30

☐ I plan on preregistering for the Boulder, Colorado meetings ONLY in order to attend the MAA Minicourse(s) indicated above. It is my understanding that, should the course(s) of my choice be filled, full refund of the Boulder meetings preregistration fee will be made.
NINETEEN PAPERS
ON ALGEBRAIC SEMIGROUPS

A. Ya. Aizenshtat, A. E. Evseev, N. E. Podran,
I. S. Ponizovskii, B. M. Shain (Boris M. Schein),
E. G. Shutov, and Yu. M. Vazhenin
(AMERICAN MATHEMATICAL SOCIETY TRANSLATIONS, SERIES 2, VOLUME 139)

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

1980 MATHMATICS SUBJECT CLASSIFICATIONS: 20; 94, 04, 05, 06, 08 and others
ISBN 0-8218-3115-1, LC 88-10352
ISSN 0065-9290
224 pages (hardcover), June 1988
Individual member $41, List price $69,
Institutional member $55
To order, please specify TRANS2/139 NA

Shipping/Handling: 1st book $2, each addl $1, $25 max. By air, 1st book $5, each addl $3, $100 max. Prepayment required. Order from AMS, P.O. Box 1571, Annex Station, Providence, RI 02901-9930, or call 800-556-7774 to use VISA or MasterCard.

INTRODUCTION TO
ANALYTIC NUMBER THEORY
A. G. Postnikov
(TRANSLATIONS OF MATHEMATICAL MONOGRAPHS, VOLUME 68)

AIMED AT A LEVEL BETWEEN TEXTBOOKS AND THE LATEST RESEARCH MONOGRAPHS, THIS BOOK IS DIRECTED AT RESEARCHERS, TEACHERS, AND GRADUATE STUDENTS INTERESTED IN NUMBER THEORY AND ITS CONNECTIONS WITH OTHER BRANCHES OF SCIENCE. THE AUTHOR HAS ATTEMPTED TO GIVE AS BROAD A PICTURE AS POSSIBLE OF THE PROBLEMS OF ANALYTIC NUMBER THEORY WHILE AVOIDING SPECIALIZATION AND THOSE TOPICS ALREADY SUFFICIENTLY COVERED IN THE LITERATURE. IN PARTICULAR, THIS BOOK FOCUSES ON GENERAL ADDITIVE NUMBER THEORY AND THE CONCEPT OF A NUMERICAL SEMIGROUP—AND GIVES A SYSTEMATIC DISCUSSION OF THESE TOPICS.

1980 MATHMATICS SUBJECT CLASSIFICATIONS: 11
ISBN 0-8218-4521-7
ISSN 0065-9282
336 pages (hardcover), March 1988
Individual member $68, List price $114,
Institutional member $91
To order, please specify MMONO/68 NA

Shipping/Handling: 1st book $2, each addl $1, $25 max. By air, 1st book $5, each addl $3, $100 max. Prepayment required. Order from AMS, P.O. Box 1571, Annex Station, Providence, RI 02901-9930, or call 800-556-7774 to use VISA or MasterCard.

SUMMER LIST OF APPLICANTS

INSTRUCTIONS FOR APPLICANT FORM ON FACING PAGE

THE FORM. Forms submitted by job applicants who attend the August meetings in Boulder will be posted. The first impression a prospective employer has of an applicant may be based on the appearance of this form.

The forms should be carefully typed using a fresh black ribbon. The best results are obtained with a carbon-coated polyethylene film ribbon, but satisfactory results may be obtained using a ribbon made of nylon or other woven fabric if suitable care is exercised. It is important that the keys be clean and make a sharp, clear impression. Use a correcting typewriter or correction tape or fluid if necessary. Submit the original typed version only. Hand lettered forms are acceptable if prepared carefully.

THE SUMMARY STRIP. Information provided here will be used to prepare a printed list of applicants for distribution to employers. Please supply all information requested, and confine your characters to the boxes provided. Use the codes below. Circled letters identify corresponding items on the form and the strip.

ADDRESS FORMS TO THE MATHEMATICS MEETINGS HOUSING BUREAU, P. O. BOX 6887, PROVIDENCE, RI 02940.

The deadline for receipt is JUNE 1, 1989.

A Specialties

AL = Algebra
BI = Biomathematics
CB = Combinatorics
CN = Control
CT = Circuits
EC = Economics
FA = Functional Analysis
FL = Fluid Mechanics
HM = History of Math
MB = Mathematical Biology
MO = Modelling
MS = Management Science
NT = Number Theory
PR = Probability
ST = Statistics

B Career Objectives

AR = Academic Research
NR = Nonacademic R&D
NS = Nonacademic Supervision
AT = Academic Teaching
NC = Nonacad. Consulting

H Duties

T = Teaching
G = Graduate
C = Consulting
S = Supervision
GOV = Government
U = Undergraduate
R = Research
A = Administration
IND = Industry
DP = Data Processing

Location

E = East
C = Central
W = West
S = South
M = Mountain
O = Outside U.S.
I = Indifferent

L U.S. Citizenship Status

C = U.S. Citizen
T = Temporary Resident
P = Permanent Resident
N = Non-U.S. Citizen
Preregistration/Housing Form, Boulder, Colorado
August 7–10, 1989

Must Be Received in Providence No Later Than June 1, 1989

Please complete this form and return it with your payment to

Mathematics Meetings Housing Bureau
P.O. Box 6887, Providence, Rhode Island 02940 – Telephone: (401) 272-9500, Ext. 290–Telex: 797192

DEADLINES:
- Preregistration/Dormitory Reservations: June 1, 1989
- Housing Changes/Cancellations: July 17, 1989
- Preregistration Changes: July 31, 1989
- 50% Refund on Preregistration: July 31, 1989 (no refunds after this date)
- 90% Refund on Residence Hall Package: July 17, 1989 (no refunds after this date)
- 50% Refund on Banquets/Tour/Hoe Down: July 14, 1989 (no refunds after this date)

REGISTRATION FEES
- Joint Mathematics Meetings
  - Member of AMS, CMS, MAA, PME: $63
  - Nonmember: $98
  - Student, Unemployed, or Emeritus: $18
- AMS Short Course
  - Member/Nonmember: $40
  - Student or Unemployed: $15
- MAA Banquet Ticket: $21 each
- PME Banquet Ticket: $9 each
- Rocky Mtn. Nat’l. Park Tour Ticket: $12 each
- Western Hoe Down Adult Ticket: $19 each
- Western Hoe Down Child (5-12 yrs.) Ticket: $9 each
- Western Hoe Down Vegetarian Ticket: $16 each

JOINT MATHEMATICS MEETINGS
- Member of AMS, CMS, MAA, PME: $63
- Nonmember: $98
- Student, Unemployed, or Emeritus: $18

AMS SHORT COURSE
- Member/Nonmember: $40
- Student or Unemployed: $15

NOTES
- All full-time students currently working toward a degree or diploma qualify for the student registration fees, regardless of income. The unemployed status refers to any person currently unemployed, actively seeking employment, and who is not a student; it is not intended to include persons who have voluntarily resigned from their last position. The emeritus status refers to any person who has been a member of the AMS or MAA for twenty years or more and is retired on account of age or on account of long term disability from his or her last position.

PREREGISTRATION SECTION: Please check the function(s) for which you are preregistering:

Joint Meetings ☐ AMS Short Course (August 6–7) ☐ (A separate form for MAA Minicourses appears in this issue)

1) __________________________ Phone: ________________
   (Please print) Surname          First          Middle

2) __________________________ (Mailing address)

3) Badge information: a) Nickname (optional): __________________________
   b) Affiliation __________________________
   c) City & State __________________________

4) I am a student at __________________________ City & State __________________________
   5) Emeritus member ☐ Unemployed ☐

6) Accomp[anied] by spouse __________________________ Number of children __________________________ (Enumerate only if accompanying to meeting)
   (name)

7) Member of AMS ☐ CMS ☐ MAA ☐ PME ☐ Nonmember ☐ (Member discount applies only to members of AMS, CMS, MAA, and PME)
   Member of other organizations: AWM ☐ NAM ☐

MR Classification #: __________________________

8) Joint Meetings fee $ ____________
9) AMS Short Course fee $ ____________
10) Dormitory payment $ ____________
11) ______ MAA 25-Year Banquet ticket(s) @ $21 each = $ ______
12) ______ PME Banquet ticket(s) @ $9 each = $ ______
13) ______ Rocky Mtn. Nat’l. Park Tour ticket(s) @ $12 each = $ ______
14) ______ Western Hoe Down Adult ticket(s) @ $19 each = $ ______
15) ______ Western Hoe Down Vegetarian ticket(s) @ $16 each = $ ______
     ______ Western Hoe Down Child (5-12 yrs.) ticket(s) @ $9 each = $ ______
     I will bring ______ children under 5 years of age to the Western Hoe Down.

15) TOTAL AMOUNT ENCLOSED FOR 8 through 14 $ ____________

   NOTE: May be paid by check payable to AMS (Canadian checks must be marked “U.S. Funds”) or VISA or MasterCard credit cards.

   Credit card type: __________________________
   Card number: __________________________
   Expiration date: __________________________
   If this is your credit card, please print your name as it appears on the credit card on the line below as well as sign your name.
   If this is not your credit card, please print card holder’s name as it appears on the credit card on the line below, and have the card holder sign:

   __________________________ (Printed name)
   __________________________ (Signature)

   Please complete the Housing Section on the reverse if you will require dormitory accommodations.
   If housing is not needed, please indicate arrival/departure dates in Travel Section on the reverse.

For office use only:

<table>
<thead>
<tr>
<th>Codes:</th>
<th>Options:</th>
<th>Hotel:</th>
<th>Dorm:</th>
<th>Room type:</th>
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<tr>
<th>Dates:</th>
<th>Hotel Deposit</th>
<th>Room/Board Pmt</th>
<th>Total Amt. Paid:</th>
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</tbody>
</table>

Special Remarks:

$ __________________________ room/board paid; $ __________________________ room/board due
HOUSING SECTION:

☐ PLEASE CHECK HERE IF YOU WILL NOT BE STAYING IN ANY HOTEL, MOTEL, OR DORMITORY

☐ PLEASE CHECK HERE IF YOU WILL BE STAYING IN ONE OF THE HOTELS/MOTELS LISTED IN THE TEXT

UNIVERSITY HOUSING

NOTE: Full prepayment for room and board is required. Please make checks payable to AMS. Canadian checks must be marked 'In U.S. Funds'. VISA and MasterCard credit cards will also be accepted. Acknowledgements of your residence hall reservations will be sent to address indicated on reverse. The University's Kittredge Commons Office will assign ALL rooms. Purchase of meal tickets is mandatory, and the price is included in the rates below.

Please circle applicable rates listed below for each day and enter totals in column at far right. Rates listed below are PER PERSON.

<table>
<thead>
<tr>
<th>Date</th>
<th>Adults</th>
<th>Children 6-13 yrs. in bed</th>
<th>Children 6-13 yrs. in rollaway</th>
<th>Children under 6 yrs.*</th>
<th>Enter total rate per day</th>
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<tr>
<td>8/4</td>
<td>$29.00</td>
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<td>8/5</td>
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<td>$31.00</td>
<td>$18.00</td>
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</table>

Total for Residence Hall Package =
(Please insert this amount in #10 on the reverse.) $  

*There will be a $3.00 rollaway or crib charge for all children under 6 years of age. Meals are free. Smoking and nonsmoking rooms are available upon request.

Please list other room occupants; indicating ages of children.

<table>
<thead>
<tr>
<th>FULL NAME</th>
<th>ARRIVAL DATE</th>
<th>DEPARTURE DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

☐ I am not going to the Western Hoe Down, but plan to eat dinner on campus on Tuesday, August 8. I will purchase a ticket at the Meetings Registration Desk for this meal.

TRAVEL SECTION: (Arrival/Departure dates are mandatory.)

I plan to arrive by on __________________ am/pm and depart on __________________ am/pm
(date) (date)

☐ I plan to drive to the meeting. ☐ I will need a parking sticker for the University of Colorado campus.
Harmonic Analysis in Phase Space
Gerald B. Folland
This book provides the first coherent account of the area of analysis that involves the Heisenberg group, quantization, the Weyl calculus, the metaplectic representation, wave packets, and related concepts. This circle of ideas comes principally from mathematical physics, partial differential equations, and Fourier analysis, and it illuminates all these subjects.
Annals of Mathematics Studies, 122
Cloth: $55.00 ISBN 0-691-08527-7

Cosmology in (2 + 1)-Dimensions, Cyclic Models, and Deformations of M_{2,1}
Victor Guillemin
The subject matter of this work is an area of Lorentzian geometry which has not been heretofore much investigated: Do there exist Lorentzian manifolds all of whose light-like geodesics are periodic? A surprising fact is that such manifolds exist in abundance in (2 + 1)-dimensions. This book is concerned with the deformation theory of M_{2,1}.
Annals of Mathematics Studies, 121
Cloth: $55.00 ISBN 0-691-08513-7

Simple Algebras, Base Change, and the Advanced Theory of the Trace Formula
James Arthur and Laurent Clozel
A general principle, discovered by Langlands and named by him "functoriality principle," predicts relations between automorphic forms on arithmetic subgroups of different reductive groups. This book studies one of the simplest general problems in the theory, that of relating automorphic forms on arithmetic subgroups of GL(n,E) and GL(n,F) when E/F is a cyclic extension of number fields.
Annals of Mathematics Studies, 120
Cloth: $60.00 ISBN 0-691-08517-X

Plateau’s Problem and the Calculus of Variations
Michael Struwe
This book is meant to give an account of recent developments in the theory of Plateau’s problem for parametric minimal surfaces and surfaces of prescribed constant mean curvature ("H-surfaces") and its analytical framework. A comprehensive overview of the classical existence and regularity theory for disc-type minimal and H-surfaces is given and recent advances toward general structure theorems concerning the existence of multiple solutions are explored in full detail.
Mathematical Notes, 35
Significant New Titles for Mathematicians and Students

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By E.J. Barbeau, Univ. of Toronto, Ontario, Canada
- Extends the high school curriculum and provides a backdrop for later study in calculus, modern algebra, numerical analysis and complex variable theory;
- Introduces many techniques and topics in the theory of equations, such as evaluation and factorization of polynomials, solution of equations, interpolation, approximation and congruences;
- Illustrates the theory of equations through examples;
- Tests understanding, ingenuity and skill with over 300 problems drawn from journals, contests, and examinations;
- Includes answers to many of the exercises and solutions to all of the problems.
This is a wonderful introduction to the fascinating study of polynomials!
1989/441 pp., 36 illus./Hardcover $59.00
Problem Books in Mathematics

Classical Fourier Transforms
By K. Chandrasekharan, Eidgenössische Technische Hochschule Zürich, Switzerland
- Gives a thorough introduction to classical Fourier transforms in a clear and compact form.
  Chapter I: Devoted to the L-Theorem, basic properties are proved as well as the Poisson summation formula, the central limit theorem and Wiener’s general tauberian theorem. As an illustration of a Fourier transformation of a function not belonging to L, (−∞,∞) an integral due to Ramanujan is given.
  Chapter II: Devoted to the L2-theory, including Plancherel’s theorem, Heisenberg’s inequality, the Paley-Wiener theorem, Hardy’s interpolation formula and two inequalities due to Bernstein.
  Chapter III: Deals with Fourier-Stieltjes transforms. After the basic properties are explained, distribution functions, positive-definite functions and the uniqueness theorem of Offord are treated.
- Intended for undergraduate students with basic knowledge in real and complex analysis.
Universitext

Continua with Microstructure
By G. Capriz, Universita Pisa, Italy
Proposes a new general setting for theories of bodies with microstructure when they are described within the scheme of the continuum: then, besides the usual fields of classical thermomechanics (displacement, stress, temperature, etc.) some new fields enter the picture (order parameters, microstress, etc.).
Continua with Microstructure can be used in a semester course for students who have some background on the classical theory of continua as an introduction to special topics (for example: materials with voids, liquid crystals, meromorphic continua).
Research students studying continuum theories of new materials will find helpful the book’s appropriate framework for new developments and a link between apparently disparate themes such as the topological theory of defects, phase transitions and boundaries.
Springer Tracts in Natural Philosophy, Vol. 35

Percolation
By G. Grimmett, Univ. of Bristol, England
- Presents a fresh new look at the mathematical theory of percolation;
- Contains a definitive and coherent account of the subject in an orderly manner unrestricted to the non-specialist;
- Includes the shortest and neatest proofs currently known;
- Describes the subcritical and supercritical phases in considerable detail;
- Uses the recent proofs of the uniqueness of critical points and the infinite open cluster extensively.
1989/approx. 320 pp., 77 Illus./Hardcover $49.80
ISBN 0-387-96843-1

Continuity, Integration and Fourier Theory
By A.C. Zaanen, Univ. of Leiden, The Netherlands
The first part of this thorough textbook is devoted to continuity properties, culminating in the theorems of Korovkin and Stone-Weierstrass. The last part consists of extensions and applications of the Fourier theory, for example, the Wilbraham-Gibbs phenomenon, the Hausdorff-Young theorem, the Poisson sum formula and the heat and wave equations.
Since the Lebesque integral is indispensable for obtaining familiarity with Fourier series and Fourier transforms on a somewhat higher level, the book also contains a brief survey with complete proofs of abstract integration theory.
Universitext

Modular Forms
T. Miyake, Hokkaido University, Sapporo, Japan
Translated from the Japanese by Y. Maeda
- Provides the reader with the basic knowledge of elliptic modular forms necessary to understand the recent developments in number theory;
- Gives the general theory of modular groups, modular forms and Hecke operators, with emphasis on the Hecke-Weil theory of the relationship between modular forms and Dirichlet series;
- Contains a section on the unit groups of quaternion algebras, which are seldom dealt with in books;
- Includes the so-called Eichler-Selberg trace formula of Hecke operators and gives the explicit computable formula;
- Discusses the Eisenstein series with parameter following the recent work of Shimura.
1989/336 pp., 11 illus./Hardcover $73.00
ISBN 0-387-50268-8

Ordering Information:
Call Toll-Free: 1-800-SPRINGER (In NJ call 201-348-4033).
Or send FAX: 201-348-4055. For mail orders, send payment plus $2.50 for postage and handling to: Springer-Verlag New York, Inc., Attn.: S. Klainkin, 175 Fifth Avenue, New York, NY 10010. We accept Visa, MC, and Amex charges (with signature and exp. date noted) as well as personal checks and money orders.

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New York Berlin Heidelberg Vienna
London Paris Tokyo Hong Kong