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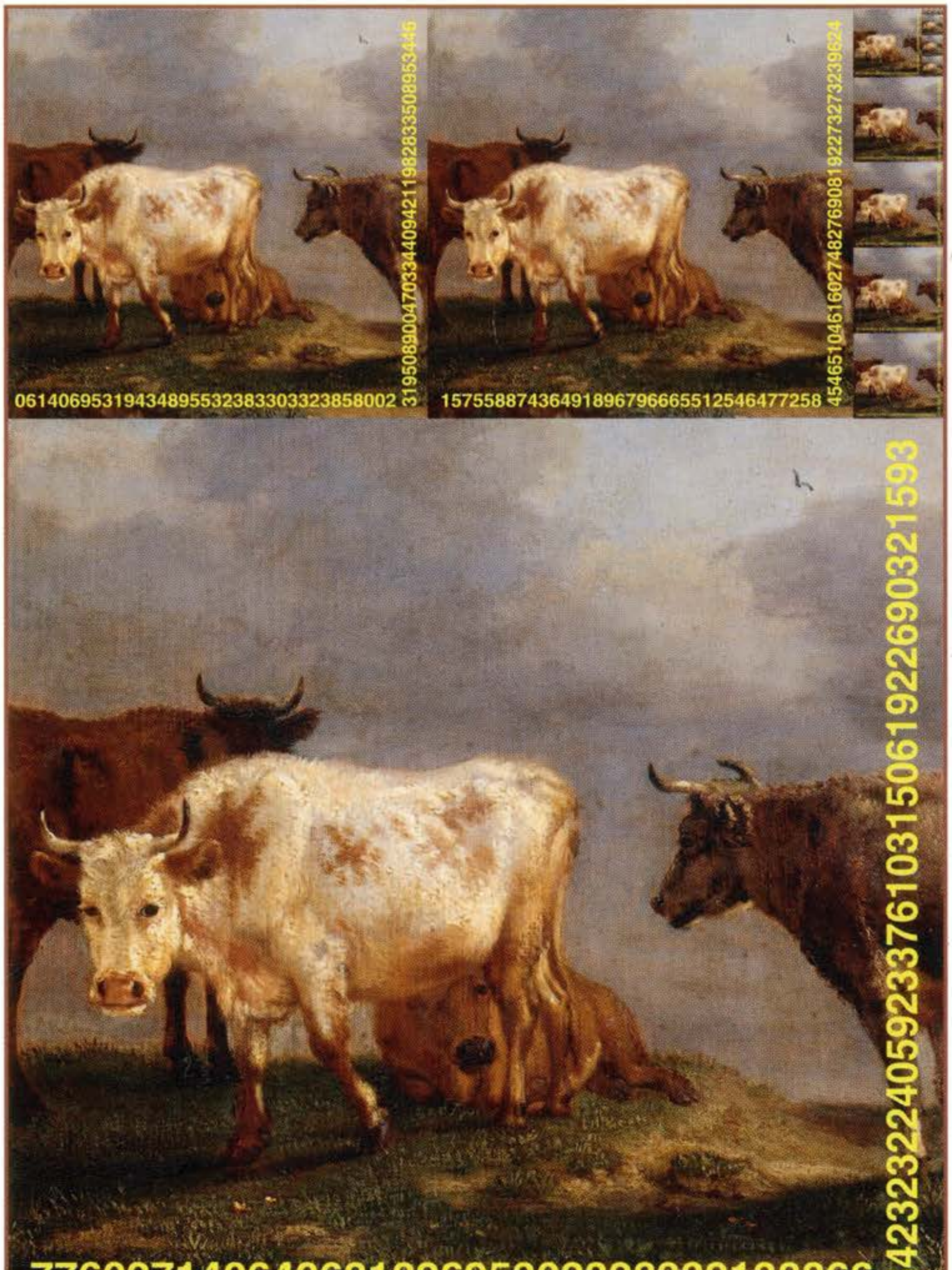
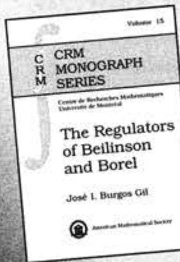
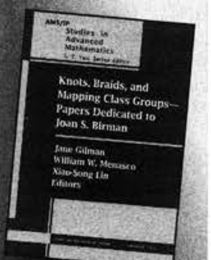


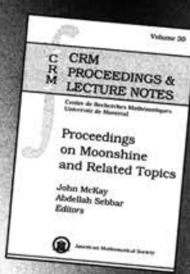
Archimedes' Cattle (see page 192)

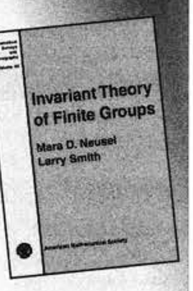
AMERICAN MATHEMATICAL SOCIETY

New Titles from the AMS









The Regulators of Beilinson and Borel

José I. Burgos Gil, *Universidad de Barcelona, Spain*

This book contains a complete proof of the fact that Borel's regulator map is twice Beilinson's regulator map. The strategy of the proof follows the argument sketched in Beilinson's original paper and relies on very similar descriptions of the Chern-Weil morphisms and the van Est isomorphism.

The book has two different parts. The first one reviews the material from algebraic topology and Lie group theory needed for the comparison theorem. Topics such as simplicial objects, Hopf algebras, characteristic classes, the Weil algebra, Bott's Periodicity theorem, Lie algebra cohomology, continuous group cohomology and the van Est Theorem are discussed.

The second part contains the comparison theorem and the specific material needed in its proof, such as explicit descriptions of the Chern-Weil morphism and the van Est isomorphisms, a discussion about small cosimplicial algebras, and a comparison of different definitions of Borel's regulator.

CRM Monograph Series, Volume 15; 2002; approximately 120 pages; Hardcover; ISBN 0-8218-2630-1; List $34; Individual member $20; Order code CRMM/15NT202

Knots, Braids, and Mapping Class Groups—Papers Dedicated to Joan S. Birman

Jane Gilman, *Rutgers University, Newark, NJ*, **William W. Menasco**, *State University of New York, Buffalo*, and **Xiao-Song Lin**, *University of California, Riverside*, Editors

There are a number of specialties in low-dimensional topology that can find in their "family tree" a common ancestry in the theory of surface mappings. These include knot theory as studied through the use of braid representations and 3-manifolds as studied through the use of Heegaard splittings. The study of the surface mapping class group (the modular group) is of course a rich subject in its own right, with relations to many different fields of mathematics and theoretical physics. But its most direct and remarkable manifestation is probably in the vast area of low-dimensional topology. Although the scene of this area has been changed dramatically and experienced significant expansion since the original publication of Professor Joan Birman's seminal work, *Braids, Links, and Mapping Class Groups* (Princeton University Press), she brought together mathematicians whose research span many specialties, all of common lineage.

The topics covered are quite diverse. Yet they reflect well the aim and spirit of the conference: to explore how these various specialties in low-dimensional topology have diverged in the past 20–25 years, as well as to explore common threads and potential future directions of development. This volume is dedicated to Joan Birman by her colleagues with deep admiration and appreciation of her contribution to low-dimensional topology.

AMS/IP Studies in Advanced Mathematics, Volume 24; 2002; 176 pages; Softcover; ISBN 0-8218-2966-1; List $35; All AMS members $28; Order code AMSIP/24NT202

Entire Functions in Modern Analysis

Boris Levin Memorial Conference

Yuri Lyubich, *Technion-Israel Institute of Technology, Haifa, Israel*, **Vitali Milman**, *Tel Aviv University, Israel*, **Iossif Ostrovskii**, *Bilkent University, Ankara, Turkey*, **Mikhail Sodin**, *Tel Aviv University, Ramat-Aviv, Israel*, **Vadim Tkachenko**, *Ben Gurion University of the Negev, Beer-Sheva, Israel*, and **Lawrence Zalcman**, *Bar Ilan University, Ramat Gan, Israel*, Editors

A publication of the Bar-Ilan University.

This volume presents the proceedings from the conference, "Entire Functions in Modern Analysis" held at Tel-Aviv University (Ramat-Aviv, Israel) in memory of Professor Boris Levin, an outstanding mathematician and a brilliant teacher whose mathematical activity spanned over 60 years. Levin's scientific interests lay principally in the theory of analytic functions and its applications to harmonic analysis, functional analysis, and operator theory. His ideas and results in this area, as expressed both through his personal influence and his papers and books, have influenced several generations of mathematicians.

Israel Mathematical Conference Proceedings, Volume 15; 2001; 392 pages; Softcover; List $130; Individual member $78; Order code IMCP/15NT202

Proceedings on Moonshine and Related Topics

John McKay, *Concordia University, Montreal, PQ, Canada*, and **Abdellah Sebbar**, *University of Ottawa, ON, Canada*, Editors

This volume contains the proceedings of the Moonshine workshop held at the Centre de Recherches Mathématiques (CRM) in Montréal. A glance at the contents will reveal that the connection of some papers to Moonshine is not immediate; however, Moonshine has proved to be a very fertile area, and it does not stretch the imagination to believe that many more threads will be drawn together before we understand what is really going on.

In this volume, all the classical Moonshine themes are presented, namely the Monster simple group and other finite groups, automorphic functions and forms and related congruence groups, and vertex algebras and their representations. These topics appear in either a pure form or in a blend of algebraic geometry dealing with algebraic surfaces, Picard-Fuchs equations, and hypergeometric functions.

CRM Proceedings & Lecture Notes, Volume 30; 2001; 268 pages; Softcover; ISBN 0-8218-2879-7; List $71; Individual member $43; Order code CRMP/30NT202

Invariant Theory of Finite Groups

Mara D. Neusel, *University of Notre Dame, IN*, and **Larry Smith**, *Mathemtatisches Institut, Göttingen, Germany*

The questions that have been at the center of invariant theory since the 19th century have revolved around the following themes: finiteness, computation, and special classes of invariants. This book begins with a survey of many concrete examples chosen from these themes in the algebraic, homological, and combinatorial context.

The book contains numerous examples to illustrate the theory, often of more than passing interest, and an appendix on commutative graded algebra, which provides some of the required basic background. There is an extensive reference list to provide the reader with orientation to the vast literature.

Mathematical Surveys and Monographs, Volume 94; 2002; 371 pages; Hardcover; ISBN 0-8218-2916-5; List $81; Individual member $49; Order code SURV/94NT202

Notices

of the American Mathematical Society

February 2002

Feature Articles

The sun god's cattle, friend, apply thy care to count their number, hast thou wisdom's share. They grazed of old on the Thrinacian floor of Sic'ly's island, herded into four, coulour by colour: one herd white as cream, the next in coats glowing with ebon gleam, brown-skinned the third, and stained with spots the last. Each herd saw bulls in power unsurpassed, in ratios these: count half the ebon-hued, add one third more, then all the brown include...

Communications

Commentary

Notices of the American Mathematical Society

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Departments

From the AMS Secretary

Educating for Numeracy: A Challenging Responsibility

Ordinary citizens must deal with numbers and data every day. Drawing from information amassed and analyzed by computers, news media are filled with graphs and charts explaining the economy, health risks, educational results, and consumer protection. Governments explain budgets, social programs, and defense strategies with elaborate analyses of averages and changes in averages. Most jobs use numerical tools. Investing, credit, insurance, and taxes are immersed in data and rates of change. Political debates, laws, and court decisions abound in probabilistic decision making. Polling has become an influential and continuous activity.

Quantitative literacy (QL) is the ability to understand and use quantitative measures and inferences that allow one to function as a responsible citizen, productive worker, and discerning consumer. There are strong indications, beyond litanies of anecdotes, that many U.S. high school and college graduates have not achieved QL. Even though the mathematics and statistics underlying everyday quantitative materials may be elementary, the contextual uses are sophisticated, surpassing the abilities of most adults.

Recent national and international surveys have reported very low levels of quantitative literacy among U.S. adults, both in absolute terms and in comparison with levels in other countries. Discussion of these surveys and other indicators is contained in a new book, *Mathematics and Democracy*, edited by Lynn Steen and available from the Mathematical Association of America.

Educating for QL has received little attention in either school or college curricula. Current efforts are scattered and results are uncertain, partly because the rapid escalation of quantification in society is a recent phenomenon. No doubt the necessary mathematics and some statistics have been in school and college courses. The difficulty in achieving QL is effecting transference of knowledge of mathematics and statistics to hundreds of everyday contexts, a well-known difficulty within college curricula. Achieving this transference will require considerably more contextual teaching of mathematics, as well as help from other disciplines.

Mathematics curricula in schools and colleges are ill designed to teach QL. Most colleges have put a low priority on the general education courses that are most suited to teaching QL. The sequence of mathematics courses from early high school through college calculus is linear and hurried, with no time to teach the mathematics in context, to help students develop the habits of mind necessary to interpret real-life situations in quantitative terms. Students are told that they will use the mathematics later, either in another mathematics course or in other disciplines. Mathematics courses become routes to somewhere else, not destinations themselves. Many, if not most, students end up stranded on the roadside, having mathematical skills that they are unable to use or to relate to their everyday lives.

Mathematics has a privileged place in the school curriculum, being the only subject other than English that is required and tested in every grade K–10. Statistics is now a part of this privileged place; the NCTM (National Council of Teachers of Mathematics) Standards include data analysis and probability at all grade levels. This privileged place entails responsibility to contribute significantly to QL. Other school disciplines will also need to help.

QL has no specific place in most college degree programs. When it does, it often is mistakenly equated with mathematics, statistics, or other quantitative disciplines. However, the power of mathematics is its abstractness and its generality; QL is anchored in real-world data. Likewise, other disciplines have their own bounds that constrain conveying QL.

Most colleges require some mathematics as part of general education. Very often these requirements are satisfied by service courses designed for specific majors; such courses may be part of the calculus-centered sequence. General education and service courses can contribute significantly to QL by connecting academic material to real-world contexts and by teaching skills students will need to be productive citizens. The responsibility to do this is shared with general education and service courses of the other disciplines—sciences, social sciences, arts, and humanities.

Educating for QL is difficult—transference is the acid test of understanding. Coordinated teaching across the curriculum, which has improved the teaching of writing, is evidently also needed to educate for QL. Creative new methods and additional research are needed to discover how to measure QL. Mathematics should lead the effort to meet these challenges because of its centrality in college education, the size of its faculty, its traditions of teaching students from all disciplines, and its kinship with QL.

Some colleges are making efforts to promote QL by adapting traditional courses, offering new courses, or teaching QL across the curriculum. The programs are sometimes controlled by mathematics departments, but sometimes not. A national forum on QL was recently convened at the National Academy of Sciences, and a National Numeracy Network (NNN) is being formed to promote QL education. Both of these had their impetus outside mathematics at the Woodrow Wilson Foundation. Many college and university mathematics faculty have joined the effort alongside collegiate faculty from other disciplines. These collaborations need to increase.

Although daunting in many respects, the QL challenge is an opportunity for mathematics both to meet an important and growing responsibility and to increase support for mathematics. Students will appreciate seeing immediately the relevance of the mathematics they are studying. As interdisciplinary and applied work has infused new energy into mathematics research, teaching for QL can create excitement and collaboration among different disciplines in general education. The need for QL among Americans will grow. As society becomes more quantitatively complex, citizens will need more skills to be informed participants and productive workers.

The U.S. mathematics community should apply its vast talent to the challenge of raising quantitative literacy.

—Bernard L. Madison
University of Arkansas

Solving the Pell Equation

H. W. Lenstra Jr.

Pell's Equation

The *Pell equation* is the equation

$$x^2 = dy^2 + 1,$$

to be solved in positive integers x, y for a given nonzero integer d. For example, for $d = 5$ one can take $x = 9$, $y = 4$. We shall always assume that d is positive but not a square, since otherwise there are clearly no solutions.

The English mathematician John Pell (1610–1685) has nothing to do with the equation. Euler (1707–1783) mistakenly attributed to Pell a solution method that had in fact been found by another English mathematician, William Brouncker (1620–1684), in response to a challenge by Fermat (1601–1665); but attempts to change the terminology introduced by Euler have always proved futile.

Pell's equation has an extraordinarily rich history, to which Weil's book [13] is the best guide; see also [3, Chap. XII]. Brouncker's method is in substance identical to a method that was known to Indian mathematicians at least six centuries earlier. As we shall see, the equation also occurred in Greek mathematics, but no convincing evidence that the Greeks could solve the equation has ever emerged.

A particularly lucid exposition of the "Indian" or "English" method of solving the Pell equation is found in Euler's *Algebra* [4, Abschn. 2, Cap. 7]. Modern textbooks usually give a formulation in terms of continued fractions, which is also due to Euler (see for example [9, Chap. 7]). Euler, as well as his Indian and English predecessors, appears to take it for granted that the method always produces a solution. That is true, but it is not obvious—all that is obvious is that *if* there is a solution, the method will find one. Fermat was probably in possession of a proof that there is a solution for every d (see [13, Chap. II, § XIII]), and the first to publish such a proof was Lagrange (1736–1813) in 1768 (see Figure 1).

One may rewrite Pell's equation as

$$(x + y\sqrt{d}) \cdot (x - y\sqrt{d}) = 1,$$

so that finding a solution comes down to finding a nontrivial unit of the ring $\mathbf{Z}[\sqrt{d}]$ of norm 1; here the norm $\mathbf{Z}[\sqrt{d}]^* \to \mathbf{Z}^* = \{\pm 1\}$ between unit groups multiplies each unit by its conjugate, and the units ± 1 of $\mathbf{Z}[\sqrt{d}]$ are considered trivial. This reformulation implies that once one knows a solution to Pell's equation, one can find infinitely many. More precisely, if the solutions are ordered by magnitude, then the nth solution x_n, y_n can be expressed in terms of the first one, x_1, y_1, by

$$x_n + y_n\sqrt{d} = (x_1 + y_1\sqrt{d})^n.$$

Accordingly, the first solution x_1, y_1 is called the *fundamental solution* to the Pell equation, and *solving* the Pell equation means finding x_1, y_1 for given d. By abuse of language, we shall also refer to $x + y\sqrt{d}$ instead of the pair x, y as a solution to

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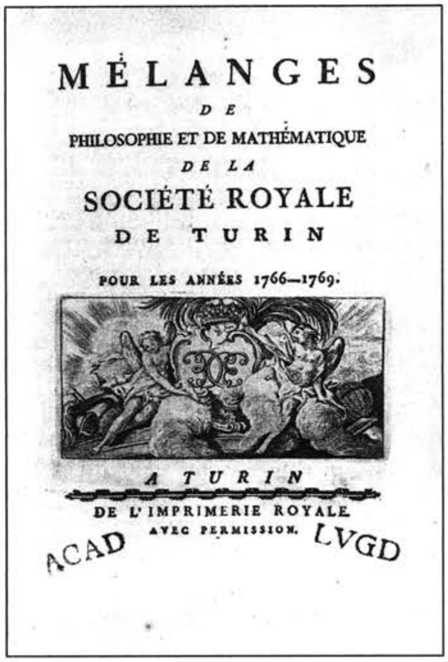
MÉLANGES
DE
PHILOSOPHIE ET DE MATHÉMATIQUE
DE LA
SOCIÉTÉ ROYALE
DE TURIN
POUR LES ANNÉES 1766–1769.
A TURIN
DE L'IMPRIMERIE ROYALE
AVEC PERMISSION.
ACAD LVGD


Zur
Geschichte
und
Litteratur
Aus den Schätzen
der
Herzoglichen Bibliothek
zu
Wolfenbüttel
Zweyter Beytrag
von
Gotthold Ephraim Lessing.
Braunschweig,
im Verlage der Fürstl. Waysenhaus-Buchhandlung.
1773.

Figures 1 and 2. Title pages of two publications from 1773. The first (far left) contains Lagrange's proof of the solvability of Pell's equation, already written and submitted in 1768. The second contains Lessing's discovery of the cattle problem of Archimedes.

Pell's equation and call $x_1 + y_1\sqrt{d}$ the fundamental solution.

One may view the solvability of Pell's equation as a special case of *Dirichlet's unit theorem* from algebraic number theory, which describes the structure of the group of units of a general ring of algebraic integers; for the ring $\mathbf{Z}[\sqrt{d}]$, it is the product of $\{\pm 1\}$ and an infinite cyclic group.

As an example, consider $d = 14$. One has

$$\sqrt{14} = 3 + \cfrac{1}{1 + \cfrac{1}{2 + \cfrac{1}{1 + \cfrac{1}{3 + \sqrt{14}}}}},$$

so the continued fraction expansion of $3 + \sqrt{14}$ is purely periodic with period length 4. Truncating the expansion at the end of the first period, one finds that the fraction

$$3 + \cfrac{1}{1 + \cfrac{1}{2 + \cfrac{1}{\frac{1}{1}}}} = \frac{15}{4}$$

is a fair approximation to $\sqrt{14}$. The numerator and denominator of this fraction yield the fundamental solution $x_1 = 15$, $y_1 = 4$; indeed one has $15^2 = 14 \cdot 4^2 + 1$. Furthermore, one computes $(15 + 4\sqrt{14})^2 = 449 + 120\sqrt{14}$, so $x_2 = 449$, $y_2 = 120$; and so on. One finds:

n	x_n	y_n
1	15	4
2	449	120
3	13455	3596
4	403201	107760
5	12082575	3229204
6	362074049	96768360

The shape of the table reflects the exponential growth of x_n and y_n with n.

For general d, the continued fraction expansion of $[\sqrt{d}] + \sqrt{d}$ is again purely periodic, and the period displays a symmetry similar to the one visible for $d = 14$. If the period length is even, one proceeds as above; if the period length is odd, one truncates at the end of the *second* period.

The cattle problem

An interesting example of the Pell equation, both from a computational and from a historical perspective, is furnished by the *cattle problem* of Archimedes (287–212 B.C.). A manuscript containing this problem was discovered by Lessing (1729–1781) in the Wolffenbüttel library, and published by him in 1773 (see Figure 2). It is now generally credited to Archimedes (see [5, 13]). In twenty-two Greek elegiac distichs, the problem asks for the number of white, black, dappled, and brown bulls and cows belonging to the Sun god, subject to several arithmetical restrictions. A version in English heroic couplets, taken from [1], is shown in Figure 3. In modern mathematical notation the problem is no less elegant. Writing x, y, z, t for the numbers of white, black, dappled, and brown bulls, respectively, one reads in lines 8–16 the restrictions

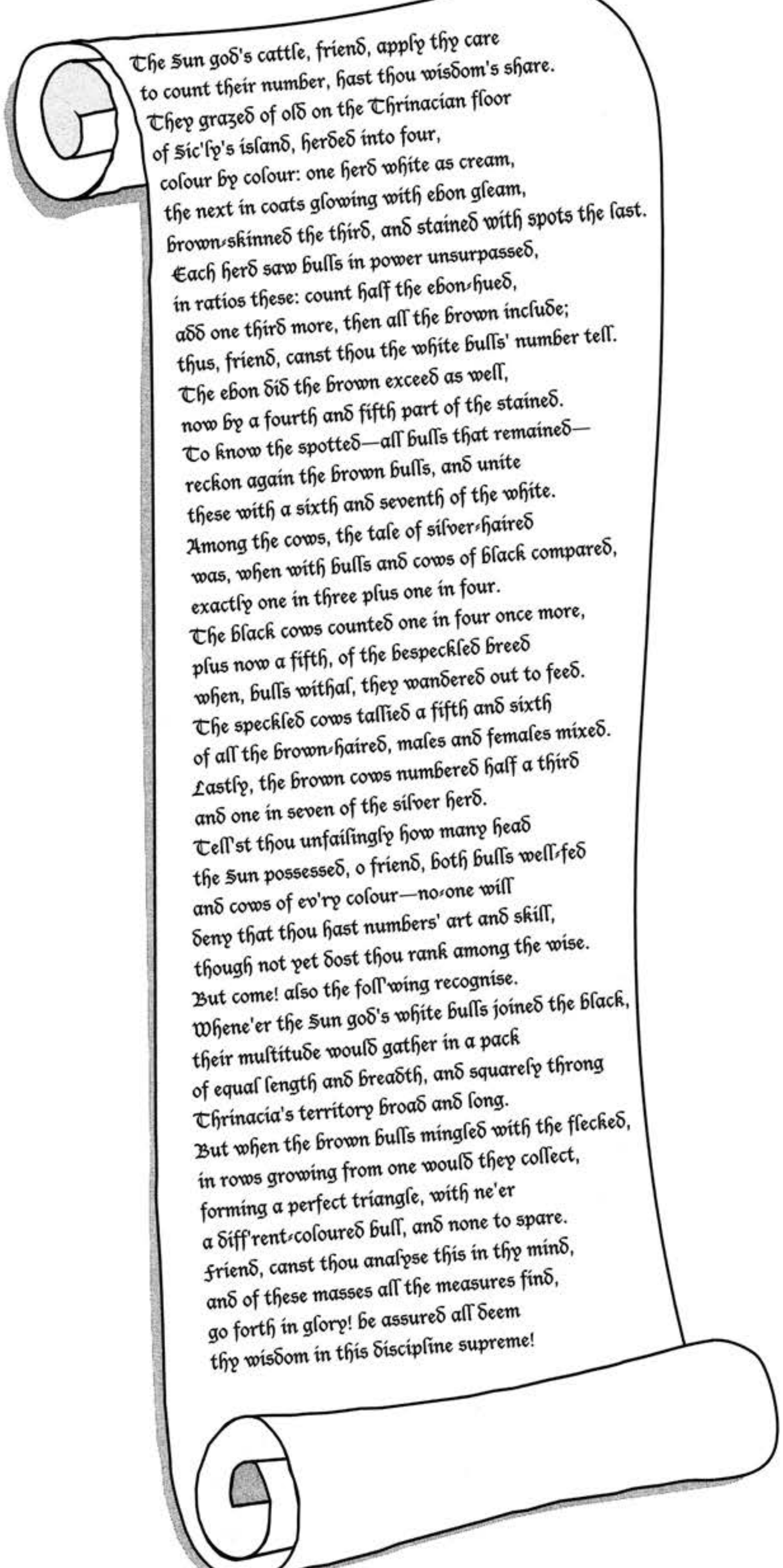

Figure 3. Problem that Archimedes conceived in verse and posed to the specialists at Alexandria in a letter to Eratosthenes of Cyrene.

$$x = (\tfrac{1}{2} + \tfrac{1}{3})y + t,$$
$$y = (\tfrac{1}{4} + \tfrac{1}{5})z + t,$$
$$z = (\tfrac{1}{6} + \tfrac{1}{7})x + t.$$

Next, for the numbers x', y', z', t' of cows of the same respective colors, the poet requires in lines 17–26

$$x' = (\tfrac{1}{3} + \tfrac{1}{4})(y + y'), \qquad z' = (\tfrac{1}{5} + \tfrac{1}{6})(t + t'),$$
$$y' = (\tfrac{1}{4} + \tfrac{1}{5})(z + z'), \qquad t' = (\tfrac{1}{6} + \tfrac{1}{7})(x + x').$$

Whoever can solve the problem thus far is called merely competent by Archimedes; to win the prize for supreme wisdom, one should also meet the conditions formulated in lines 33–40 that $x + y$ be a *square* and that $z + t$ be a *triangular number*.

The first part of the problem is just linear algebra, and there is indeed a solution in *positive* integers. The general solution to the first three equations is given by $(x, y, z, t) = m \cdot (2226, 1602, 1580, 891)$, where m is a positive integer. The next four equations turn out to be solvable if and only if m is divisible by 4657; with $m = 4657 \cdot k$ one has $(x', y', z', t') = k \cdot (7206360, 4893246, 3515820, 5439213)$.

The true challenge is now to choose k such that $x + y = 4657 \cdot 3828 \cdot k$ is a square and $z + t = 4657 \cdot 2471 \cdot k$ is a triangular number. From the prime factorization $4657 \cdot 3828 = 2^2 \cdot 3 \cdot 11 \cdot 29 \cdot 4657$ one sees that the first condition is equivalent to $k = al^2$, where $a = 3 \cdot 11 \cdot 29 \cdot 4657$ and l is an integer. Since $z + t$ is a triangular number if and only if $8(z + t) + 1$ is a square, we are led to the equation $h^2 = 8(z + t) + 1 = 8 \cdot 4657 \cdot 2471 \cdot al^2 + 1$, which is the Pell equation $h^2 = dl^2 + 1$ for

$$d = 2 \cdot 3 \cdot 7 \cdot 11 \cdot 29 \cdot 353 \cdot (2 \cdot 4657)^2$$
$$= 410\,286423\,278424.$$

Thus, by Lagrange's theorem, the cattle problem admits infinitely many solutions.

In 1867 the otherwise unknown German mathematician C. F. Meyer set out to solve the equation by the continued fraction method [3, p. 344]. After 240 steps in the continued fraction expansion for $\sqrt{d}$ he had still not detected the period, and he gave up. He may have been a little impatient; it was later discovered that the period length equals 203254. The first to solve the cattle problem in a satisfactory way was A. Amthor in 1880 (see [6]). Amthor did *not* directly apply the continued fraction method; what he did do we shall discuss below. Nor did he spell out the decimal digits of the fundamental solution to the Pell equation or the corresponding solution of the cattle problem. He did show that, in the smallest solution to the cattle problem, the total number of cattle is given by a number of 206545 digits; of the four leading digits 7766 that he gave, the fourth was wrong, due to the use of insufficiently precise logarithms.

The full number occupies forty-seven pages of computer printout, reproduced in reduced size on twelve pages of the *Journal of Recreational Mathematics* [8]. In abbreviated form, it reads

$$77602714\ldots 237983357\ldots 55081800,$$

each of the six dots representing 34420 omitted digits.

Several nineteenth century German scholars were worried that so many bulls and cows might not fit on the island of Sicily, contradicting lines 3 and 4 of the poem; but, as Lessing remarked, the Sun god, to whom the cattle belonged, will have coped with it.

The story of the cattle problem demonstrates that the continued fraction method is not the last word on the Pell equation.

Efficiency

We are interested in the *efficiency* of solution methods for the Pell equation. Thus, how much time does a given algorithm for solving the Pell equation take? Here *time* is to be measured in a realistic way, which reflects, for example, that large positive integers are more time-consuming to operate with than small ones; technically, one counts *bit operations.* The input to the algorithm is d, and the running time estimates are accordingly expressed as functions of d. If one supposes that d is specified in binary or in decimal, then the *length of the input* is approximately proportional to $\log d$. An algorithm is said to run in *polynomial time* if there is a positive real number c_0 such that for all d the running time is at most $(1+\log d)^{c_0}$, in other words, if the time that it takes the algorithm to *solve* the Pell equation is not much greater than the time required to *write down* the equation.

How fast is the continued fraction method? Can the Pell equation be solved in polynomial time? The central quantity that one needs to consider in order to answer such questions is the *regulator* R_d, which is defined by

$$R_d = \log(x_1 + y_1\sqrt{d}),$$

where $x_1 + y_1\sqrt{d}$ denotes, as before, the fundamental solution to Pell's equation. The regulator coincides with what in algebraic number theory would be called the regulator of the kernel of the norm map $\mathbf{Z}[\sqrt{d}]^* \to \mathbf{Z}^*$. From $x_1 - y_1\sqrt{d} = 1/(x_1 + y_1\sqrt{d})$ one deduces that $0 < x_1 - y_1\sqrt{d} < 1/(2\sqrt{d})$, and combining this with $x_1 + y_1\sqrt{d} = e^{R_d}$, one finds that

$$\frac{e^{R_d}}{2} < x_1 < \frac{e^{R_d}}{2} + \frac{1}{4\sqrt{d}},$$
$$\frac{e^{R_d}}{2\sqrt{d}} - \frac{1}{4d} < y_1 < \frac{e^{R_d}}{2\sqrt{d}}.$$

This shows that R_d is very close to $\log(2x_1)$ and to $\log(2y_1\sqrt{d})$. That is, if x_1 and y_1 are to be represented in binary or in decimal, then R_d is approximately proportional to the *length of the output* of any algorithm solving the Pell equation. Since the time required for spelling out the output is a lower bound for the total running time, we may conclude: *there exists* c_1 *such that any algorithm for solving the Pell equation takes time at least* $c_1 R_d$. Here c_1 denotes, just as do $c_2, c_3, \ldots$ below, a positive real number that does not depend on d.

The continued fraction method almost meets this lower bound. Let l be the period length of the continued fraction expansion of $[\sqrt{d}] + \sqrt{d}$ if that length is even and twice that length if it is odd. Then one has

$$\frac{\log 2}{2} \cdot l < R_d < \frac{\log(4d)}{2} \cdot l$$

(see [7, eq. (11.4)]); so R_d and l are approximately proportional. Using this, one estimates easily that the time taken by a straightforward implementation of the continued fraction method is at most $R_d^2 \cdot (1+\log d)^{c_2}$ for suitable c_2; and a more refined implementation, which depends on the fast Fourier transform, reduces this to $R_d \cdot (1+\log d)^{c_3}$ for suitable c_3. We conclude that the latter version of the continued fraction method is optimal, apart from a logarithmic factor.

In view of these results it is natural to ask how the regulator grows as a function of d. It turns out that it fluctuates wildly. One has

$$\log(2\sqrt{d}) < R_d < \sqrt{d} \cdot (\log(4d) + 2),$$

the lower bound because of the inequality $y_1 < e^{R_d}/(2\sqrt{d})$ above and the upper bound by a theorem of Hua. The gap between the two bounds is very large, but it cannot be helped: if d ranges over numbers of the form $k^2 - 1$, for which one has $x_1 = k$ and $y_1 = 1$, then $R_d - \log(2\sqrt{d})$ tends to 0; and one can show that there exist an infinite set D of d's and a constant c_4 such that all $d \in D$ have $R_d = c_4\sqrt{d}$. In fact, if d_0, d_1 are integers greater than 1 and d_0 is not a square, then there exists a positive integer $m = m(d_0, d_1)$ such that $D = \{d_0 d_1^{2n} : n \in \mathbf{Z}, n \geq m\}$ has this property for some $c_4 = c_4(d_0, d_1)$.

It is believed that for most d the upper bound is closer to the truth. More precisely, a folklore conjecture asserts that there is a set D of nonsquare positive integers that has density 1 in the sense that $\lim_{x\to\infty} \#\{d \in D : d \leq x\}/x = 1$, and that satisfies

$$\lim_{d\in D} \frac{\log R_d}{\log \sqrt{d}} = 1.$$

This conjecture, however, is wide open. The same is true for the much weaker conjecture that

$\limsup_d(\log R_d)/\log\sqrt{d}$, with d ranging over the *squarefree* integers > 1, is *positive.*

If the folklore conjecture is true, then for most d the factor R_d entering the running time is about $\sqrt{d}$, which is an exponential function of the length $\log d$ of the input.

Combining the results above, one concludes that the continued fraction method takes time at most $\sqrt{d}\cdot(1+\log d)^{c_5}$; that conjecturally it is exponentially slow for *most* values of d; and that *any* method for solving the Pell equation that spells out x_1 and y_1 in full is exponentially slow for *infinitely many* d, and will therefore fail to run in polynomial time.

If we want to improve upon the continued fraction method, then we need a way of representing x_1 and y_1 that is more compact than the decimal or binary notation.

Amthor's solution

Amthor's solution to the cattle problem depended on the observation that the number $d = 410\,286423\,278424$ can be written as $(2\cdot 4657)^2\cdot d'$, where $d' = 4\,729494$ is squarefree. Hence, if x, y solves the Pell equation for d, then $x, 2\cdot 4657\cdot y$ solves the Pell equation for d' and will therefore for some n be equal to the nth solution x'_n, y'_n (say) of that equation:

$$x + 2\cdot 4657\cdot y\cdot\sqrt{d'} = (x'_1 + y'_1\sqrt{d'})^n.$$

This reduces the cattle problem to two easier problems: first, solving the Pell equation for d'; and second, finding the least value of n for which y'_n is divisible by $2\cdot 4657$.

Since d' is much smaller than d, Amthor could use the continued fraction algorithm for d'. In a computation that could be summarized in three pages (see [6]), he found the period length to be 92 and $x'_1 + y'_1\sqrt{d'}$ to be given by

$$u = 109\,931986\,732829\,734979\,866232\,821433\,543901\,088049$$
$$+\ 50549\,485234\,315033\,074477\,819735\,540408\,986340\cdot\sqrt{d'}.$$

In order to save space, one can write

$$u = \big(300\,426607\,914281\,713365\cdot\sqrt{609} + 84\,129507\,677858\,393258\cdot\sqrt{7766}\big)^2.$$

This is derived from the identity $x + y\sqrt{d} = \left(\sqrt{(x-1)/2} + \sqrt{(x+1)/2}\right)^2$, which holds whenever $x^2 = dy^2 + 1$. The regulator is found to be $R_{d'} \doteq 102.101583$.

In order to determine the least feasible value for n, Amthor developed a little theory, which one would nowadays cast in the language of finite fields and rings. Using that $p = 4657$ is a prime number for which the Legendre symbol $\left(\frac{d'}{p}\right)$ equals -1, he deduced from his theory that the least value for n divides $p + 1 = 4658$; had he been a little more careful, he would have found that it must divide $(p+1)/2 = 2329 = 17\cdot 137$. In any case, trying a few divisors, one discovers that the least value for n is actually *equal* to 2329. One has $R_d = 2329\cdot R_{d'} \doteq 237794.586710$.

The conclusion is that the fundamental solution to the Pell equation for d itself is given by $x_1 + y_1\sqrt{d} = u^{2329}$, with u as just defined. Amthor failed to put everything together, but I did this for the convenience of the reader in Figure 4: for the first time in history, *all* infinitely many solutions to the cattle problem are displayed in a handy little table! It does, naturally, not contain the full decimal expansion of any of the numbers asked for, but what it does contain should be considered more enlightening. For example, it enables the reader not only to verify easily that the total number of cattle in the smallest solution has 206545 decimal digits and equals 77602714...55081800, but also to discover that the number of dappled bulls in the 1494 195300th solution equals 111111...000000, a number of 308 619694 367813 digits. (Finding the middle digits is probably much harder.) Archimedes had an interest in the representation of large numbers, and there is little doubt that the solution in Figure 4 would have pleased and satisfied him.

Power products

Suppose one wishes to solve the Pell equation $x^2 = dy^2 + 1$ for a given value of d. From Amthor's approach to the cattle problem we learn that for two reasons it may be wise to find the smallest divisor d' of d for which d/d' is a square: it saves time when performing the continued fraction algorithm, and it saves both time and space when expressing the final answer. There is no known algorithm for finding d' from d that is essentially faster than factoring d. In addition, if we want to determine *which* power of the fundamental solution for d' yields the fundamental solution for d—that is, the number n from the previous section—we also need to know the prime factorization of $\sqrt{d/d'}$, as well as the prime factorization of $p - \left(\frac{d'}{p}\right)$ for each prime p dividing $\sqrt{d/d'}$. Thus, if one wants to solve the Pell equation, one may as well start by factoring d. Known factoring algorithms may not be very fast for large d, but for most values of d they are still expected to be orders of magnitudes faster than any known method for solving the Pell equation.

Let it now be assumed that d is *squarefree*, and write $x_1 + y_1\sqrt{d}$ for the fundamental solution of the Pell equation, which is a unit of $\mathbf{Z}[\sqrt{d}]$. Then $x_1 + y_1\sqrt{d}$ may still be a proper power in the field $\mathbf{Q}(\sqrt{d})$ of fractions of $\mathbf{Z}[\sqrt{d}]$. For example, the least d with $y_1 > 6$ is $d = 13$, for which one has $x_1 = 649$, $y_1 = 180$, and

$$649 + 180\sqrt{13} = \left(\frac{3+\sqrt{13}}{2}\right)^6.$$

Also in the case $d = 109$, which Fermat posed as a challenge problem in 1657, the fundamental solution is a sixth power:

$$158\,070671\,986249 + 15\,140424\,455100\sqrt{109} = \left(\frac{261+25\sqrt{109}}{2}\right)^6.$$

However, this is as far as it goes: it is an elementary exercise in algebraic number theory to show that if n is a positive integer for which $x_1 + y_1\sqrt{d}$ has an nth root in $\mathbf{Q}(\sqrt{d})$, then $n = 1, 2, 3$, or 6, the case $n = 2$ being possible only for $d \equiv 1$, 2, or 5 mod 8, and the cases $n = 3$ and 6 only for $d \equiv 5$ mod 8. Thus, for large squarefree d one cannot expect to save much space by writing $x_1 + y_1\sqrt{d}$ as a power. This is also true when one allows the root to lie in a composite of quadratic fields, as we did for the cattle problem.

Let d again be an arbitrary positive integer that is not a square. Instead of powers, we consider *power products* in $\mathbf{Q}(\sqrt{d})$, that is, expressions of the form

$$\prod_{i=1}^{t}(a_i + b_i\sqrt{d})^{n_i}$$

where t is a nonnegative integer, a_i, b_i, n_i are integers, $n_i \neq 0$, and for each i at least one of a_i and b_i is nonzero. We define the *length* of such an expression to be

$$\sum_{i=1}^{t}\left(\log|n_i| + \log(|a_i| + |b_i|\sqrt{d})\right).$$

This is roughly proportional to the amount of bits needed to specify the numbers a_i, b_i, and n_i. Each power product represents a nonzero element of $\mathbf{Q}(\sqrt{d})$, and that element can be expressed uniquely as $(a + b\sqrt{d})/c$, with $a, b, c \in \mathbf{Z}$, $\gcd(a,b,c) = 1$, $c > 0$. However, the number of bits of a, b, c will typically grow linearly with the exponents $|n_i|$ themselves rather than with their logarithms. So one avoids using the latter representation and works directly with the power products instead.

Several fundamental issues are raised by the representation of elements as power products. For example, can we recognize whether two power products represent the same element of $\mathbf{Q}(\sqrt{d})$ by means of a polynomial time algorithm? Here "polynomial time" means, as before, that the run time is bounded by a polynomial function of the length of the input, which in this case equals the sum of the lengths of the two given power products. Similarly, can we decide in polynomial time whether a given power product represents an element of the form $a + b\sqrt{d}$ with $a, b \in \mathbf{Z}$, that is, an element of $\mathbf{Z}[\sqrt{d}]$? If it does, can we decide whether one has $a^2 - db^2 = 1$ and $a, b > 0$, so that we have a solution to Pell's equation, and can we compute the residue classes of a and b modulo a given positive integer m, all in polynomial time?

All questions just raised have affirmative answers, even in the context of general algebraic number fields. Algorithms proving this were exhibited recently by Guoqiang Ge. In particular, one can efficiently decide whether a given power product represents a solution to Pell's equation, and if it does, one can efficiently compute any desired number of "least significant" decimal digits of that solution; taking the logarithm of the power product, one can do the same for the *leading* digits, and for the *number* of decimal digits, except possibly in the probably very rare cases that a or b is excessively close to a power of 10. There is *no* known polynomial time algorithm for deciding whether a given power product represents the *fundamental* solution to Pell's equation.

All solutions to the cattle problem of Archimedes

$$w = 300\,426607\,914281\,713365 \cdot \sqrt{609} + 84\,129507\,677858\,393258 \cdot \sqrt{7766}$$

$$k_j = (w^{4658 \cdot j} - w^{-4658 \cdot j})^2/368\,238304 \qquad (j = 1,\ 2,\ 3,\ \ldots)$$

jth solution	*bulls*	*cows*	*all cattle*
white	$10\,366482 \cdot k_j$	$7\,206360 \cdot k_j$	$17\,572842 \cdot k_j$
black	$7\,460514 \cdot k_j$	$4\,893246 \cdot k_j$	$12\,353760 \cdot k_j$
dappled	$7\,358060 \cdot k_j$	$3\,515820 \cdot k_j$	$10\,873880 \cdot k_j$
brown	$4\,149387 \cdot k_j$	$5\,439213 \cdot k_j$	$9\,588600 \cdot k_j$
all colors	$29\,334443 \cdot k_j$	$21\,054639 \cdot k_j$	$50\,389082 \cdot k_j$

Figure 4.

Infrastructure

Suppose now that, given d, we are not asking for the fundamental solution $x_1 + y_1\sqrt{d}$ to Pell's equation, but for a power product in $\mathbf{Q}(\sqrt{d})$ that represents it. The following theorem summarizes essentially all that is rigorously known about the smallest length of such a power product and about algorithms for finding one.

Theorem. *There are positive real numbers c_6 and c_7 with the following properties.*

(a) For each positive integer d that is not a square there exists a power product that represents the fundamental solution to Pell's equation and that has length at most $c_6 \cdot (\log d)^2$.

(b) The problem of computing a power product representing the fundamental solution to Pell's equation is "polynomial time equivalent" to the problem of computing an integer $\tilde{R}_d$ with $|R_d - \tilde{R}_d| < 1$.

(c) There is an algorithm that given d computes a power product representing the fundamental solution to Pell's equation in time at most $R_d^{1/2} \cdot (1 + \log d)^{c_7}$.

Part (a) of the theorem, which is taken from [2], implies that the question we are asking does admit a brief answer, so that there is no obvious obstruction to the existence of a polynomial time algorithm for *finding* such an answer.

Part (b), which is not formulated too rigorously, asserts the existence of two polynomial time algorithms. The first takes as input a power product $\prod_i (a_i + b_i\sqrt{d})^{n_i}$ representing the fundamental solution to the Pell equation and gives as output an integer approximation to the regulator. There is no surprise here, one just uses the formula $R_d = \sum_i n_i \log|a_i + b_i\sqrt{d}|$ and applies a polynomial time algorithm for approximating logarithms. The second algorithm takes as input the number d as well as an integer approximation $\tilde{R}_d$ to R_d, and it computes a power product representing the fundamental solution to Pell's equation. Since the algorithm runs in polynomial time, the length of the output is polynomially bounded, and this is in fact the way part (a) of the theorem is proved.

The key notion underlying the second algorithm is that of "infrastructure", a word coined by Shanks (see [11]) to describe a certain multiplicative structure that he detected within the period of the continued fraction expansion of $\sqrt{d}$. It was subsequently shown (see [7]) that this period can be "embedded" in a circle group of "circumference" R_d, the embedding preserving the cyclical structure. In the modern terminology of Arakelov theory, one may describe that circle group as the kernel of the natural map $\mathrm{Pic}^0\overline{\mathbf{Z}[\sqrt{d}]} \to \mathrm{Pic}\,\mathbf{Z}[\sqrt{d}]$ from the group of "metrized line bundles of degree 0" on the "arithmetic curve" corresponding to $\mathbf{Z}[\sqrt{d}]$ to the usual class group of invertible ideals. By means of Gauss's reduced binary quadratic forms one can do explicit computations in $\mathrm{Pic}^0\overline{\mathbf{Z}[\sqrt{d}]}$ and in its "circle" subgroup. For a fuller explanation of these notions and their algorithmic use we refer to the literature [2, 7, 10, 11, 14].

The equivalence stated in part (b) of the theorem has an interesting feature that is not commonly encountered in the context of equivalences. Namely, one may achieve an improvement by going "back-and-forth". Thus, starting from a power product representing the fundamental solution, one can first use it to compute $\tilde{R}_d$ and next use $\tilde{R}_d$ to find a *second* power product, possibly of smaller length than the initial one. And conversely, starting from any rough approximation to R_d, one can compute a power product and use it to compute R_d to any desired accuracy.

The algorithm referred to in part (c) is the fastest rigorously proven algorithm for computing a power product as desired. Its run time is roughly the square root of the run time of the continued fraction algorithm. It again makes use of the infrastructure just discussed, combining it with a search technique that is known as the "baby step–giant step" method. The power product coming out of the algorithm may not have a very small length, but one can easily do something about this by using the algorithms of part (b). Our estimates for R_d show that the run time is at most $d^{1/4} \cdot (1 + \log d)^{c_8}$ for some c_8; here the exponent $1/4$ can be improved to $1/5$ if one is willing to assume certain generalized Riemann hypotheses (see [10]). Recent work of Buchmann and Vollmer shows that part (c) is valid with $c_7 = 1 + \epsilon$ for all $\epsilon > 0$ and all d exceeding a bound depending on ϵ.

Mathematically the infrastructure methods have great interest. Algorithmically one conjectures that something faster is available. But as we shall see, the final victory may belong to the infrastructure.

Smooth numbers

The algorithms for solving Pell's equation that we saw so far have an exponential run time as a function of $\log d$. One prefers to have an algorithm whose run time is polynomial in $\log d$. The method that we shall now discuss is believed to have a run time that is "halfway" between exponential and polynomial. Like many subexponential algorithms in number theory, it makes use of *smooth numbers*, that is, nonzero integers that up to sign are built up from small prime factors. Smooth numbers have been used with great success in the design of algorithms for factoring integers and for computing discrete logarithms in multiplicative groups of rings. Here we shall see how they can be used for the solution of Pell's equation as well.

Instead of giving a formal description, we illustrate the algorithm on the case $d = 4\,729\,494 =$

$2 \cdot 3 \cdot 7 \cdot 11 \cdot 29 \cdot 353$ derived from the cattle problem. The computation is less laborious and more entertaining than the expansion of $\sqrt{d}$ in a continued fraction performed by Amthor. We shall explain the method on an intuitive level only; readers desirous to see its formal justification should acquaint themselves with the basic theorems of algebraic number theory.

The smooth numbers that the algorithm operates with are not ordinary integers, but elements of the ring $\mathbf{Z}[\sqrt{d}]$, with d as just chosen. There is a natural way of extending the notion of smoothness to such numbers. Namely, for $\alpha = a + b\sqrt{d} \in \mathbf{Q}(\sqrt{d})$, with $a, b \in \mathbf{Q}$, write $\alpha' = a - b\sqrt{d}$. Then $\alpha \mapsto \alpha'$ yields an automorphism of the field $\mathbf{Q}(\alpha)$ and the ring $\mathbf{Z}[\alpha]$, and the *norm* map $N\colon \mathbf{Q}(\sqrt{d}) \to \mathbf{Q}$ defined by $N(\alpha) = \alpha\alpha' = a^2 - db^2$ respects multiplication. It is now natural to expect that an element α of $\mathbf{Z}[\sqrt{d}]$ is smooth if and only if α' is smooth; so one may as well pass to their product $N(\alpha)$, which is an ordinary integer, and *define* α to be smooth if $|N(\alpha)|$ is built up from prime numbers that lie below a certain bound. The size of this bound depends on the circumstances; in the present computation we choose it empirically.

The first step in the algorithm is to find a good supply of smooth numbers $a + b\sqrt{d}$ in $\mathbf{Z}[\sqrt{d}]$, or, equivalently, pairs of integers a, b for which $a^2 - db^2$ is smooth. One does this by trying $b = 1, 2, 3, \ldots$ in succession, and trying integers a in the neighborhood of $b\sqrt{d}$; then $|a^2 - db^2|$ is fairly small, which increases its chance to be smooth. For example, with $b = 1$ one finds for a near $b\sqrt{d} \doteq 2174.74$ the following smooth values of $a^2 - d$:

$$2156^2 - d = -2 \cdot 7 \cdot 11 \cdot 17 \cdot 31,$$
$$2162^2 - d = -2 \cdot 5^3 \cdot 13 \cdot 17,$$
$$2175^2 - d = 3 \cdot 13 \cdot 29,$$
$$2178^2 - d = 2 \cdot 3 \cdot 5 \cdot 11 \cdot 43,$$
$$2184^2 - d = 2 \cdot 3 \cdot 7 \cdot 31^2,$$
$$2187^2 - d = 3 \cdot 5^2 \cdot 23 \cdot 31.$$

For $b = 2, 3, 4$, one finds, restricting to values of a that are coprime to b:

$$4329^2 - 2^2 d = -3 \cdot 5 \cdot 17^2 \cdot 41,$$
$$4341^2 - 2^2 d = -3 \cdot 5 \cdot 17^3,$$
$$4351^2 - 2^2 d = 5^2 \cdot 23^2,$$
$$4363^2 - 2^2 d = 13^2 \cdot 17 \cdot 41,$$
$$4389^2 - 2^2 d = 3 \cdot 5 \cdot 7 \cdot 11 \cdot 13 \cdot 23,$$
$$4399^2 - 2^2 d = 5^2 \cdot 13 \cdot 31 \cdot 43,$$
$$6514^2 - 3^2 d = -2 \cdot 5^3 \cdot 13 \cdot 41,$$
$$6524^2 - 3^2 d = -2 \cdot 5 \cdot 7 \cdot 41,$$
$$6538^2 - 3^2 d = 2 \cdot 7 \cdot 13 \cdot 23 \cdot 43,$$
$$8699^2 - 4^2 d = 17 \cdot 41.$$

The prime numbers occurring in these sixteen factorizations are the small prime factors 2, 3, 7, 11, 29 of d, as well as the prime numbers $p \le 43$ with $\left(\frac{d}{p}\right) = 1$. It is only the latter primes that matter, and there are seven of them: 5, 13, 17, 23, 31, 41, and 43. It is important that the number of smooth expressions $a^2 - db^2$ exceeds the number of those primes, which is indeed the case: $16 > 7$. If one uses only the prime numbers up to 31 and the eight factorizations that do not contain 41 or 43, there is still a good margin: $8 > 5$. Thus, one decides to work with the "smoothness bound" 31.

The next step is to write down the prime *ideal* factorizations of the eight numbers $(a + b\sqrt{d})/(a - b\sqrt{d})$. Consider, for example, the case $a = 2162$, $b = 1$. Since $2162^2 - d$ contains a factor 13, the element $2162 + \sqrt{d}$ has a prime ideal factor of norm 13, and from $2162 \equiv 4 \bmod 13$ one sees that this is the prime ideal $\mathbf{p}_{13} = (13, 4 + \sqrt{d})$; it is the kernel of the ring homomorphism $\mathbf{Z}[\sqrt{d}] \to \mathbf{Z}/13\mathbf{Z}$ sending $\sqrt{d}$ to -4 (mod 13). The conjugate prime ideal $\mathbf{q}_{13} = (13, 4 - \sqrt{d})$ then occurs in $2162 - \sqrt{d}$. Likewise, $2162 + \sqrt{d}$ is divisible by the cube of the prime ideal $\mathbf{p}_5 = (5, 2 + \sqrt{d})$ and by $\mathbf{p}_{17} = (17, 3 + \sqrt{d})$, and $2162 - \sqrt{d}$ by $\mathbf{q}_5^3\mathbf{q}_{17}$, where $\mathbf{q}_5 = (5, 2 - \sqrt{d})$ and $\mathbf{q}_{17} = (17, 3 - \sqrt{d})$. Finally, $2162 + \sqrt{d}$ has the prime ideal factor $(2, \sqrt{d})$, but since 2 divides d, this prime ideal equals its own conjugate, so it cancels when one divides $2162 + \sqrt{d}$ by its conjugate. Altogether one finds the prime ideal factorization

$$\left((2162 + \sqrt{d})/(2162 - \sqrt{d})\right) = (\mathbf{p}_5/\mathbf{q}_5)^3 \cdot (\mathbf{p}_{13}/\mathbf{q}_{13}) \cdot (\mathbf{p}_{17}/\mathbf{q}_{17}).$$

As a second example, consider $a = 4351$, $b = 2$. We have $4351^2 - 2^2 d = 5^2 \cdot 23^2$, and from $4351/2 \equiv -2 \bmod 5$ one sees that $4351 + 2\sqrt{d}$ belongs to $\mathbf{q}_5$ rather than $\mathbf{p}_5$. Similarly, $4351/2 \equiv 2 \bmod 23$ implies that it belongs to $\mathbf{p}_{23} = (23, 2 + \sqrt{d})$. Writing $\mathbf{q}_{23} = (23, 2 - \sqrt{d})$, one obtains

$$\left((4351 + 2\sqrt{d})/(4351 - 2\sqrt{d})\right) = (\mathbf{p}_5/\mathbf{q}_5)^{-2} \cdot (\mathbf{p}_{23}/\mathbf{q}_{23})^2.$$

Doing this for all eight pairs a, b, one arrives at the table in Figure 5. The first row lists the prime numbers p we are using. The first column lists the eight expressions $\alpha = a + b\sqrt{d}$. In the αth row and the pth column, one finds the exponent of

$\mathbf{p}_p/\mathbf{q}_p$ in the prime ideal factorization of α/α'; here $\mathbf{p}_p$, $\mathbf{q}_p$ are as above, with $\mathbf{p}_{31} = (31, 14 + \sqrt{d})$ and $\mathbf{q}_{31} = (31, 14 - \sqrt{d})$. Thus, each α gives rise to an "exponent vector" that belongs to $\mathbf{Z}^5$.

The third step in the algorithm is finding linear relations with integer coefficients between the eight exponent vectors. The set of such relations forms a free abelian group of rank 3, which is 8 minus the rank of the 8×5 matrix formed by the eight vectors. A set of three independent generators for the relation group is given by the last three columns of Figure 5; in general, one can find such a set by applying techniques of linear algebra over $\mathbf{Z}$.

In the final step of the algorithm one inspects the relations one by one. Consider for example the first relation. It expresses that the sum of the exponent vectors corresponding to $2156 + \sqrt{d}$ and $2162 + \sqrt{d}$ equals the sum of the exponent vectors for $2187 + \sqrt{d}$ and $4389 + 2\sqrt{d}$. In other words, if we put

$$\alpha = \frac{(2156 + \sqrt{d}) \cdot (2162 + \sqrt{d})}{(2187 + \sqrt{d}) \cdot (4389 + 2\sqrt{d})},$$

then the element $\epsilon = \alpha/\alpha'$ has all exponents in its prime ideal factorization equal to 0. This is the same as saying that ϵ is a unit $x + y\sqrt{d}$ of the ring $\mathbf{Z}[\sqrt{d}]$; also, the norm $\epsilon\epsilon' = x^2 - dy^2$ of this unit equals $N(\alpha)/N(\alpha') = 1$, so we obtain an integral solution to Pell's equation $x^2 - dy^2 = 1$, except that it is uncertain whether x and y are positive. We can write $\epsilon = \alpha/\alpha' = \alpha^2/N(\alpha)$, where the prime factorization of $N(\alpha)$ is available from the factorizations of $a^2 - db^2$ that we started with; one finds in this manner the following two power product representations of ϵ:

$$\epsilon = \frac{(2156 + \sqrt{d}) \cdot (2162 + \sqrt{d})}{(2156 - \sqrt{d}) \cdot (2162 - \sqrt{d})} \times \frac{(2187 - \sqrt{d}) \cdot (4389 - 2\sqrt{d})}{(2187 + \sqrt{d}) \cdot (4389 + 2\sqrt{d})} = \frac{3^2 \cdot 23^2 \cdot (2156 + \sqrt{d})^2 \cdot (2162 + \sqrt{d})^2}{2^2 \cdot 17^2 \cdot (2187 + \sqrt{d})^2 \cdot (4389 + 2\sqrt{d})^2}.$$

In the second representation, ϵ is "visibly" a square, or, equivalently, $N(\alpha)$ is a square; this is a bad sign, since it is certain to happen when $\epsilon = 1$, in which case one has $\alpha \in \mathbf{Q}$, $N(\alpha) = \alpha^2$, $x = 1$, and $y = 0$. That is indeed what occurs here. (Likewise, it would have been a bad sign if ϵ were visibly $-d$ times a square; this is certain to happen if $\epsilon = -1$.) In the present case, the numbers are small enough that one can directly verify that $\epsilon = 1$. For larger power products, one can decide whether ϵ equals ± 1 by computing $\log|\epsilon|$ to a suitable precision and proving that the logarithm of a positive unit of $\mathbf{Z}[\sqrt{d}]$ cannot be close to 0 without being equal to 0.

Thus, the first relation disappointingly gives rise to a trivial solution to the Pell equation. The reader may check that the unit

$$\frac{29^2 \cdot (4351 + 2\sqrt{d})^2 \cdot (4389 + 2\sqrt{d})^4}{5^4 \cdot 7^2 \cdot 11^2 \cdot 23^4 \cdot (2175 + \sqrt{d})^4}$$

obtained from the second relation is also equal to 1. The third relation yields the unit

$$\eta = \frac{2^4 \cdot 5^{14} \cdot (2175 + \sqrt{d})^{18} \cdot (2184 + \sqrt{d})^{10}}{3^{27} \cdot 7^5 \cdot 29^9 \cdot 31^{20}} \times \frac{(2187 + \sqrt{d})^{20} \cdot (4341 + 2\sqrt{d})^6}{(2162 + \sqrt{d})^{18} \cdot (4351 + 2\sqrt{d})^{10}}.$$

Since this is not visibly a square, we can be certain that it is not 1. Since it is positive, it is not -1 either. So η is of the form $x + y\sqrt{d}$, where $x, y \in \mathbf{Z}$ satisfy $x^2 - dy^2 = 1$ and $y \neq 0$; thus, $|x|$, $|y|$ solve Pell's equation. From the power product, one computes the logarithm of the unit to be about 102.101583. This implies that $\eta > 1$, so that η is the largest of the four numbers $\eta, \eta' = 1/\eta, -\eta$, and $-\eta'$; in other words, $x + y\sqrt{d}$ is the largest of the four numbers $\pm x \pm y\sqrt{d}$, which is equivalent to x and y being *positive*. In general one can achieve this by first replacing η by $-\eta$ if η is negative and next by η' if $\eta < 1$.

We conclude that the power product defining η does represent a solution to Pell's equation. The next question is whether it is the *fundamental* solution. In the present case we can easily confirm this, since from Amthor's computation we know that $R_d \doteq 102.101583$,

	5	13	17	23	31			
$2156 + \sqrt{d}$	0	0	−1	0	−1	1	0	0
$2162 + \sqrt{d}$	3	1	1	0	0	1	0	−9
$2175 + \sqrt{d}$	0	1	0	0	0	0	−2	9
$2184 + \sqrt{d}$	0	0	0	0	2	0	0	5
$2187 + \sqrt{d}$	2	0	0	1	−1	−1	0	10
$4341 + 2\sqrt{d}$	−1	0	3	0	0	0	0	3
$4351 + 2\sqrt{d}$	−2	0	0	2	0	0	1	−5
$4389 + 2\sqrt{d}$	1	1	0	−1	0	−1	2	0

Figure 5.

and the logarithm of any *non*fundamental solution would be at least $2 \cdot R_d$. Therefore, η is equal to the solution u found by Amthor, and it is indeed fundamental. In particular, the numbers $\log \eta \doteq 102.101583$ and $\log u \doteq 102.101583$ are exactly equal, not just to a precision of six decimals.

The power product representation we found for η is a little more compact than the standard representation we gave for u. Indeed, its length, as defined earlier, is about 93.099810, as compared to $R_d \doteq 102.101583$ for u. The power product

$$\frac{(2175+\sqrt{d})^{18}(2184+\sqrt{d})^{10}(2187+\sqrt{d})^{20}}{(2175-\sqrt{d})^{18}(2184-\sqrt{d})^{10}(2187-\sqrt{d})^{20}} \times \frac{(4341+2\sqrt{d})^{6}(2162-\sqrt{d})^{18}(4351-2\sqrt{d})^{10}}{(4341-2\sqrt{d})^{6}(2162+\sqrt{d})^{18}(4351+2\sqrt{d})^{10}},$$

which also represents u, has length about 125.337907.

Performance

The smooth numbers method for solving Pell's equation exemplified in the previous section can be extended to any value of d. There is unfortunately not much one can currently prove either about the run time or about the correctness of the method. Regarding the run time, however, one can make a reasonable conjecture.

For $x > e$, write

$$L(x) = \exp\left(\sqrt{(\log x)\log\log x}\right).$$

The conjecture is that, for some positive real number c_9 and all $d > 2$, the smooth numbers method runs in time at most $L(d)^{c_9}$. This is, at a doubly logarithmic level, the exact average of $x^{c_9} = \exp(c_9 \log x)$ and $(\log x)^{c_9} = \exp(c_9 \log\log x)$; so conjecturally, the run time of the smooth numbers method is in a sense halfway between exponential time and polynomial time.

The main ingredient of the heuristic reasoning leading to the conjecture is the following proven theorem: for fixed positive real numbers c, c', and $x \to \infty$, the probability for a random positive integer $\le x^{c'}$ (drawn from a uniform distribution) to have all its prime factors $\le L(x)^c$ equals $1/L(x)^{c'/(2c)+o(1)}$. This theorem explains the importance of the function L in the analysis of algorithms depending on smooth numbers. Other ingredients of the heuristic run time analysis are the belief that the expressions $a^2 - db^2$ that one hopes to be smooth are so with the same probability as if they were random numbers, and the belief that the units produced by the algorithm have a substantial probability of being different from ± 1. These beliefs appear to be borne out in practice.

Probably one can take $c_9 = 3/\sqrt{8} + \epsilon$ in the conjecture just formulated, for any $\epsilon > 0$ and all d exceeding a bound depending on ϵ; one has $3/\sqrt{8} \doteq 1.06066$. One of the bottlenecks is the time spent on solving a large sparse linear system over **Z**. If one is very optimistic about developing a better algorithm for doing this, it may be possible to achieve 1 instead of $3/\sqrt{8}$.

The smooth numbers method needs to be supplemented with an additional technique if one wishes to be reasonably confident that the unit it produces is the fundamental solution to Pell's equation. We forgo a discussion of this technique, since there is no satisfactory method for testing whether it achieves its purpose. More precisely, there is currently no known way of verifying in subexponential time that a solution to the Pell equation that is given by means of a power product is the fundamental one. The most promising technique for doing this employs the *analytic class number formula*, but its effectiveness depends on the truth of the *generalized Riemann hypothesis*. The latter hypothesis, abbreviated "GRH", asserts that there does not exist an algebraic number field whose associated zeta function has a complex zero with real part greater than $\frac{1}{2}$. The GRH can also be used to corroborate the heuristic run time analysis, albeit in a probabilistic setting. This leads to the following theorem.

Theorem. *There is a probabilistic algorithm that for some positive real number c_{10} has the following properties.*

(a) Given any positive integer d that is not a square, the algorithm computes a positive integer R that differs by less than 1 from some positive integer multiple $m \cdot R_d$ of R_d.

(b) If the GRH is true, then (a) is valid with $m = 1$.

(c) If the GRH is true, then for each $d > 2$ the expected run time of the algorithm is at most $L(d)^{c_{10}}$.

The algorithm referred to in the theorem is *probabilistic* in the sense that it employs a random number generator; every time the random number generator is called, it draws, in unit time, a random bit from the uniform distribution, independently of previously drawn bits. The run time and the output of a probabilistic algorithm depend not only on the input, but also on the random bits that are drawn; so given the input, they may be viewed as random variables. In the current case, the expectation of the run time for fixed d is considered in part (c) of the theorem, and (a) and (b) describe what we know about the output. In particular, the algorithm always terminates, and if GRH is true, then it is guaranteed to compute an integer approximation to the regulator.

The theorem just stated represents the efforts of several people, an up-to-date list of references being given by Ulrich Vollmer [12]. According to a recent unpublished result of Ulrich Vollmer, one may take $c_{10} = 3/\sqrt{8} + \epsilon$ for any $\epsilon > 0$ and all d exceeding a bound depending on ϵ; this improves the value $\sqrt{2} + \epsilon$ found in [12].

The last word on algorithms for solving Pell's equation has not been spoken yet. Very recently, Sean Hallgren exhibited a *quantum algorithm* that computes, in polynomial time, a power product representing the fundamental solution. His algorithm depends on infrastructure, but not on smooth numbers. For practical purposes, the smooth numbers method will remain preferable until quantum computers become available.

Acknowledgements

This paper was written while I held the 2000–2001 HP-MSRI Visiting Research Professorship. I thank Sean Hallgren, Mike Jacobson Jr., and Ulrich Vollmer for answering my questions, John Voight for writing a first draft, Bart de Smit for numerical assistance, and the Universiteitsbibliotheek Leiden for providing Figure 1. A special word of thanks is due to Hugh Williams, whose version [14] of the same story contains many details omitted in mine.

Bibliographic note

The present paper will, with additional references, also appear in *Algorithmic number theory*, the proceedings of an introductory workshop held at MSRI (Berkeley) in August 2000, to be published by Cambridge University Press. Readers interested in acquainting themselves with number theoretic algorithms are encouraged to consult those proceedings. An extensive and up-to-date bibliography on the Pell equation and on methods for solving it can be found in Hugh Williams's paper [14].

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About the Cover

This month's cover is what the graphics expert Edward Tufte would likely call a confection. It tries very hard to portray all of the cattle and all of the digits involved in the minimal solution to Archimedes' cattle problem described in Hendrik Lenstra's article. It also illustrates a well known geometrical version of the algorithm for constructing a continued fraction expansion (in this case, of the ratio of dimensions of the image itself).

The picture of the animals has been extracted from a famous painting by the seventeenth century artist Paulus Potter entitled (in translation from the original Dutch) "Four cows in a meadow," even though the "cows" seem to be steers. It is reproduced here by permission of the Rijksmuseum in Amsterdam, where the original is located.

The 206,545 digits to be displayed down to subatomic level were supplied by Lenstra and Bart de Smit.

—*Bill Casselman* (`covers@ams.org`)

John Wilder Tukey (1915–2000)

David R. Brillinger

I believe that the whole country—scientifically, industrially, financially—is better off because of him and bears evidence of his influence.

—*John A. Wheeler, Princeton emeritus professor of physics*

We have watched at least four Presidents of the United States listen to him and heed his counsel.

—*William O. Baker, retired chairman of the board, Bell Labs*

John Wilder Tukey (JWT): chemist, topologist, advisor, information scientist, researcher, statistician, educator, data analyst, executive, died of a heart attack on July 26, 2000, in New Brunswick, New Jersey. The death followed a short illness. He was eighty-five years old.

John Tukey's whole life was one of public service, and as the preceding quotes make clear, he had profound influence. He was a member of the President's Scientific Advisory Committee for each of Presidents Eisenhower, Kennedy, and Johnson. He was special in many ways. He merged the scientific, governmental, technological, and industrial worlds more seamlessly than, perhaps, anyone else in the 1900s. His scientific knowledge, creativity, experience, calculating skills, and energy were prodigious. He was renowned for creating statistical concepts and words.

JWT's graduate work was in mathematics, but driven by World War II, he left that field to go on to revolutionize the world of the analysis of data. At the end of the war he began a joint industrial-academic career at Bell Telephone Laboratories and at Princeton University. Science and the analysis of data were ubiquitous. This split career continued until he retired in 1985. Even after retirement his technical and scientific work continued at a very high level.

David R. Brillinger is professor of statistics at the University of California, Berkeley. He obtained his Ph.D. under John Tukey's supervision in 1961, and he edited the Time Series *volumes of* The Collected Works of John W. Tukey. *His e-mail address is* brill@stat.berkeley.edu.

In memorializing John Tukey's life, one has to review his contributions to both science and society. It is further interesting to follow his evolution from mathematician to statistician. The sections of this article are: Narrative of the Professional Life, The Scientific Legacy, Concluding Remarks, and Epilogue. Sidebars list his Ph.D. students and his books.

Narrative of the Professional Life

Chronology

John Tukey was born in New Bedford, Massachusetts on June 16, 1915. After being schooled precollege at home, he earned bachelor's and master's degrees in chemistry. For a Ph.D. he went to Princeton, where he quickly switched to mathematics.

Graduate School. He arrived at Princeton in September 1937. One has the strong impression that John and his friends had a wonderful time during their graduate studies. The Graduate College and Fine Hall, where the mathematics department was located, were very special places. Meals in the Graduate College were taken in academic gowns, and eating groups formed. In the first year JWT was drafted into the "Fuhrocracy" whose members included L. Spitzer, F. Smithies, R. P. Boas, G. W. King, M. Kanner, H. Wallman, and A. Stone. In later years his group included G. W. Brown, Richard Feynman, and O. Morgenstern. His other friends included N. Steenrod, B. MacMillan, and Bill Baker.

Fine Hall, besides housing the mathematics faculty, was renowned for its library and for tea time in the lounge. The Princeton mathematics faculty at that time included: C. Eisenhart, S. Lefschetz, S. S. Wilks, and A. W. Tucker. The members of the Institute for Advanced Studies (IAS), such as John von Neumann, were also housed in Fine Hall then.

JWT attended many (all?) mathematics lectures. Of those by Marston Morse on symbolic dynamics, he said that Steenrod and he did their best to keep "Morse honest". Keeping people honest remained a key part of his scientific life. Of a course A. W. Tucker gave in 1938, Tucker once said that every time he gave a definition of a combinatorial manifold, JWT would come up with a counterexample. Tucker further remarked, "It ended in a draw."

At the party celebrating the completion of their graduate studies, JWT and Robert Eddy became famous for serving milk rather than the traditional beer. In a story whose authenticity was not denied by JWT, John von Neumann is reputed to have remarked, "There is this very bright graduate student, and the remarkable thing is that he does it all on milk."

While living in the Graduate College, John came to know the physicist Richard Feynman, and he appears in various of the books by and about Feynman. One special story relates to keeping time. Feynman knew that he could keep track of time while reading, but not while speaking. He presented this as a challenge. Rising to it, JWT showed that he could speak and keep track of time simultaneously. Of this Feynman remarks: "Tukey and I discovered that what goes on in different people's heads when they *think* they're doing the same thing—something as simple as *counting*—is different for different people." This may also be the source of JWT's remark, "People are different."

In 1939 Feynman and Tukey, together with Bryant Tuckerman and Arthur Stone, were members of the Flexagon Committee. This group formed directly following the discovery of certain origami-like objects by Stone. Flexagons are folded from strips of paper and reveal different faces as they are flexed. A theory of flexagons was worked out by Tukey and Feynman, the theory being a hybrid of topology and network theory. Feynman created a diagram that showed all the possible paths through a hexaflexagon. The Feynman-Tukey theory was never published, but parts were later rediscovered.

World War II. In 1941 Tukey was appointed assistant professor of mathematics at Princeton. That year he listed his interests in *American Men of Science* as point set topology and analysis. With America's entry into World War II, things changed dramatically. John joined the Fire Control Research Office at 20 Nassau Street, Princeton. This organization was concerned with armored vehicle fire control, ballistic behavior of rocket powder, gunfire control, and the accuracy of anti-aircraft stereoscopic height and bomber range finders.

While working there, JWT had countless interactions with Charles P. Winsor (1895–1951), a Harvard engineer with a Ph.D. in physiology. He was referred to as an "engineer-turned-physiologist-turned-statistician." To quote John: "It was Charlie and the experience of working on the analysis of real data that converted me to statistics." JWT encountered many others at 20 Nassau Street who went on to renowned careers in statistics. It is hard to know just what the research consisted of, but one finds the following "example" in the Mosteller and Tukey regression book:

> During World War II, in investigating aiming errors made during bomber flights over Europe, one of the research organizations developed a regression equation with several carriers (explanatories). Among its nine or so carriers were altitude, type of aircraft, speed of the bombing group, size of group, and the amount of fighter opposition. On physical grounds, one might expect higher altitudes and higher speeds to produce larger aiming errors. It would not be surprising if different aircraft differed in performance. What the effect of size of group might be can be argued either way. But few people will believe that additional fighter opposition would help a pilot and bombardier do a better job. Nevertheless, amount of fighter opposition appeared as a strong term in the regression equation—the more opposition, the smaller the aiming error. The effect is generally regarded as a proxy phenomenon, arising because the equation had no variable for amount of cloud cover. If clouds obscured the target, the fighters usually did not come up and the aiming errors were ordinarily very large.

Bell Telephone Laboratories and Princeton. In early 1945 "Mr. Tukey" began his long association with Bell Labs, Murray Hill, perhaps the foremost industrial research organization the world has known. He never left. He was full time at the Labs for a very brief period, taking leave from Princeton, but quickly switched to half time at Princeton and half time at the Labs. At the Labs he was in succession member of technical staff, subdepartment head of statistics research, associate executive director communication principles research, and associate executive director information sciences.

In his parallel career at Princeton, John rose through the ranks to become full professor of mathematics, a position he held 1950–1966. He was first chair of the new statistics department 1966–1970, and professor of statistics from 1966 until his retirement in 1985.

At the Labs JWT was involved in a myriad of projects. One such project was the Nike missile system, in whose research and development the Bell System played a very substantial role. B. D. Holdbrook and JWT did the aerodynamics, the trajectory, and the warhead design. A collaboration with Ralph Blackman led to two highly influential papers that introduced the engineering and scientific worlds to the computational practice of spectrum analysis. The Labs supported much of his more academic research, as he has acknowledged.

In 1956, Tukey set up the Statistical Techniques Research Group (STRG) at Princeton. The first computer on the Princeton campus was very possibly the IBM 650 at STRG's Gauss House on Nassau Street. Calculation and computers were ever present in JWT's life. The Fire Control Office had one of the first IBM multiplying punches and used it creatively. The classic work by Burks, Goldstine, and von Neumann (1946) states in the preface: "The authors also wish to express their thanks to Dr. John Tukey, of Princeton, for many valuable discussions and suggestions." Of just what JWT did Arthur Burks writes:

> John Tukey designed the electronic adding circuit we actually used in the IAS Computer. In this circuit, each binary adder fed its carry output directly into the next stage without delay. … And this was the circuit actually used because it was reliable and much simpler than the alternative.

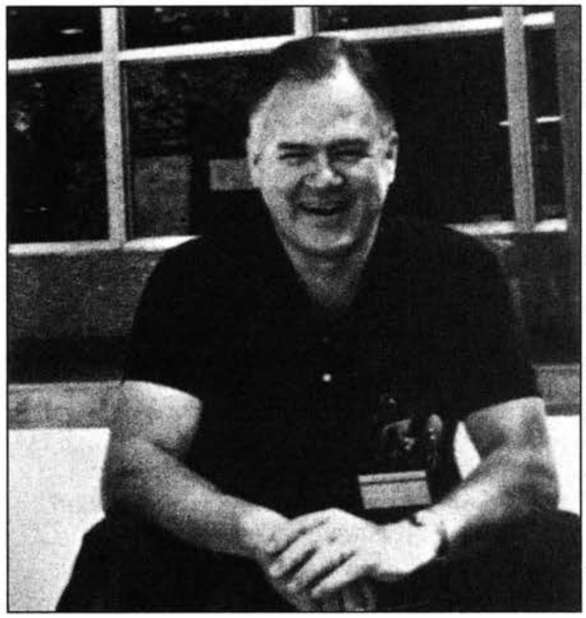
Retirement. JWT retired from both the Labs and Princeton in 1985 at age seventy. At the retirement event W. O. Baker, retired chair of the board, remarked:

> John has had an incisive role in each major frontier of telecommunications science and technology: uses of transistors and solid state; digital coding and computers; …; evolution of software and operations support systems; earth satellite and other microwave techniques; electronic switching; laser-based photonics; topology of integrated circuits; ….

At Princeton JWT became Emeritus Donner Professor of Science and Senior Research Statistician. He further worked as a consultant at places including: Xerox PARC, Bellcore, Merck, the Health Effects Institute, and the Educational Testing Service (ETS).

Contributions to Society

Through the Bell Labs, Princeton, and Washington connections Tukey's skills became well known to



Photograph by Paul R. Halmos, from I have a Photographic Memory,

John Tukey

many, and there were countless calls on his time. Throughout the years, he chaired or was a member of countless national panels, particularly ones concerned with protecting the environment. Here I mention some of his most notable activities.

The Kinsey Report. In 1950, following a request, the American Statistical Association assembled a committee to review the statistical problems in Alfred C. Kinsey's work on sex research, work described in his controversial 1948 book, *Sexual Behavior in the Human Male.* The members of the committee were W. G. Cochran, F. Mosteller, and JWT. They were concerned particularly with the sampling methods and the absence of controlled randomness.

Things did not go well in the committee's interaction with Kinsey. For example, following a dinner at the Kinsey home, Kinsey's wife, Clara, said, "I never fed a group of men that I would have so liked to have poisoned. … Tukey was the worst." This and other anecdotes may be found in the J. H. Jones biography *Alfred C. Kinsey.*

The U-2 Airplane. The "Cold War" was in full flight in the middle 1950s. One concern was the existence of a "bomber gap" that might enable the USSR to launch a surprise attack. Spurred by such concerns, President Eisenhower created the Killian Committee in 1954. Its Project 3 concerned technical intelligence collection. It was chaired by E. H. Land of Polaroid camera fame and included the astronomer J. G. Baker, the chemist J. W. Kennedy, the engineer A. Latham Jr., the Nobel laureate physicist E. M. Purcell, and JWT. Project 3 recommended the adoption of "a vigorous program for the extensive use … of the most advanced knowledge in science and technology." The end proposal was to create a high-flying spy plane, and the development

Ph.D. Students of John W. Tukey	
Fredrick Mosteller (1946)	Charles Lewis (1970)
John Walsh (1947)	Stanislaus D'Souza (1971)
Donald Fraser (1948)	Jon Knudsen (1971)
Melvin Peisakoff (1950)	James Schlesselmen (1971)
Leo Goodman (1950)	David Hoaglin (1971)
Bernard Sherman (1950)	Alan Gross (1973)
Ray Murphy (1951)	Anita Nowlin (1973)
Paul Meier (1951)	Edward Binkowski (1974)
Alan James (1953)	Steven Finch (1974)
David Wallace (1953)	Lincoln Polissar (1974)
Marvin Minsky (1954)	Paul Velleman (1976)
Richard Link (1954)	Tony Quon (1976)
Ralph Wormleighton (1955)	Susan Arthur (1979)
Arthur Dempster (1956)	Michael Schwarzchild (1979)
Thomas E. Kurtz (1956)	Karen Kafadar (1979)
N. Roy Goodman (1957)	Roberta Guarino (1981)
Bradley Bucher (1957)	Katherine Krystinik (1981)
James Templeton (1957)	Paul Horn (1981)
Harvey Arnold (1958)	Stephan Morgenthaler (1983)
David Brillinger (1961)	Fanny O'Brien (1984)
Donald Burdick (1961)	Dhammika Amaratunga (1984)
John Hartigan (1962)	Clifford Hurvich (1985)
Peter Nemenyi (1963)	George Easton (1985)
Thomas Wonnacott (1963)	Ha Nguyen (1986)
James Thompson (1965)	David Brown (1987)
Morton Brown (1965)	Katherine Hansen (1988)
W. Morven Gentleman (1966)	Eugene Johnson (1988)
James Filliben (1969)	

of the U-2 followed very quickly. Photos obtained by overflights of the USSR refuted the claims of a bomber gap, but at the same time they gave evidence of efforts to build long-range missiles. I heard it said that it was JWT who suggested the use of titanium in the construction of the bodies of such airplanes.

In 1957 Eisenhower formed the President's Scientific Advisory Panel partly in response to the effective way that the scientists had dealt with the bomber gap.

Nuclear Disarmament. In 1959 JWT spent a month in Geneva, Switzerland, as a U.S. delegate to Technical Working Group 2 of the Conference on the Discontinuance of Nuclear Weapon Tests. His expertise, in part, concerned the time series problem of distinguishing earthquakes from nuclear explosions. John's wife, Elizabeth, said once that JWT was the one who suggested that tests might be able to be masked to a degree. This possibility very much startled the Russians.

JWT has spoken about the difficulties of that period, describing it as a "time of stress ... like a utilities rate case." In 1967 he wrote:

> ... resembles my experiences with Geneva ... where the political conference set up technical working groups in the hope that the scientists would settle some of the questions that the politicians could not. ... The politicians' attempt to evade responsibility failed, as was inevitable.

Psephology—Election Forecasting. In 1960 RCA/NBC hired a statistical consulting firm to develop a procedure for projecting election results on the basis of partial counts. They involved John Mauchly and JWT amongst others. John Tukey became renowned that year for preventing an early call of victory for Richard Nixon.

Starting with the 1962 congressional election, John assembled a statistical team to develop required methodology and to analyze the results as they flowed in. In the development of methods, the uncertainty was just as important as the point estimates. It turned out that the problem of projecting turnout was more difficult than that of projecting candidate percentage. The procedures developed might be described as an early example of empirical Bayes, or "borrowing strength", to use JWT's term.

NBC stopped involving John in 1980. One reason was that exit polls, where people are interviewed after they leave a polling station, had gotten refined. One can speculate on what might have happened had JWT been involved with one of the networks in making the Florida projections in the fall of 2000.

Education. JWT was very interested in the effectiveness of education. From 1965 on he was a consultant to ETS in Princeton. He had a long involvement with the National Assessment of Educational Progress (NAEP), which is a long-term program of assessing what the inhabitants of the U.S. can do as measured by their performance on exercises at various ages. JWT, Lee Cronbach, Ralph Tyler, Bob Abelson, and Lyle Jones met often in the late 1960s to guide its formation. JWT brought robust procedures, novel ways to measure change, uncertainty estimation, and careful interpretation of the results into the work.

Information Retrieval. Starting in the mid-1960s, John Tukey sought to bring order to the literature of statistics and probability by constructing indexes of the papers of those fields. He had done extensive work for *Mathematical Reviews* and prepared bibliographies before, e.g., for time series, and perhaps this is what spurred him on. In particular he constructed a citation index. Regarding that effort, it is impressive to see the roll call of eminent statisticians that JWT recruited to compile the papers and the reference lists. The citation index that was constructed then was one of the earliest outside of the legal profession. JWT constructed other indices as well. These were taken over later by the American Mathematical Society and are part of MathSciNet.

After retirement JWT consulted at Xerox PARC. His name, with a variety of co-inventors from that company, appears on quite a number of patents, some of the key words of which are: *information access, ordering document clusters, identifying drop words, generating thematic summaries, automatic document summarization, phase query formation.*

Census Adjustment. JWT advised the Census Bureau for many years. In 1980 the Census Bureau's step of adjusting the raw values to obtain "improved" estimates became a political issue. Probably to the great surprise of the Bureau, it found itself tangled up in the adversarial setup of the U.S. legal and political systems. This happened because congressional apportionment and the allocation of funds are both based on census counts. The Constitution states, regarding the House of Representatives, "The actual Enumeration shall be made ... in such Manner as they shall by Law direct." This leaves lots of room for argument.

JWT felt that adjustment should be made because errors would be smaller and their direction unpredictable. Regarding the idea that the errors would be smaller, he was perhaps spurred by the success of the borrowing strength procedure in election forecasting.

Teaching. JWT's teaching style was on the oblique side. Indeed, sometimes people wondered if he was being deliberately obscure. It has been suggested that his home schooling background led to some of the difficulties. My personal impression was that he wanted the people with whom he interacted to figure things out on their own, to the degree possible.

The courses he presented at Princeton were state of the art, indeed introducing the art in many cases. The topics included: Monte Carlo, fractional replication, time series,.... Major investigators, such as Cuthbert Daniel, came along to class.

John's interactions with students often took place at the house on Arreton Road, particularly on Saturdays. In particular he believed that gardening was a social activity.

John was always very busy. In one period of his life, to deal with obligations in Washington and elsewhere, he scheduled four classes each week. Then he picked the three times that were the most convenient for the week at hand. Another method was to schedule classes for, say, 2:00–4:00 p.m. Tuesday/Thursday instead of the usual 2:00–3:15 p.m., and to skip a class sometimes and at other times to run it for two hours.

The Scientific Legacy

Mathematics

JWT's contributions to mathematics proper were pre-World War II. They evidenced the mathematical ability that stood him in such good stead in his statistical and scientific work.

His thesis, "On denumerability in topology", was submitted in 1939, nominally under the supervision of Lefschetz. Part of it later appeared in 1942 in the *Annals of Mathematics Studies* series under the title *Convergence and Uniformity in Topology.* Chapter 3 was never published because of overlap with work of M. M. Day.

The principal part of the thesis was a formulation of uniformity in topology. JWT was seeking to extend convergence techniques to general spaces. The structures have three distinct, but equivalent, definitions via: Weil's pseudometrics, Bourbaki's entourages, and Tukey's families of covers. Appearing in the thesis is the so-called Teichmüller-Tukey Lemma: "Every nonempty collection of finite character has a maximal set with respect to inclusion." This lemma is equivalent to the Axiom of Choice. Also in his book JWT christens Zorn's Lemma.

Tukey's approach was used extensively by J. R. Isbell and N. R. Howse in their books. Howse recently wrote me:

> ... But Tukey's contribution in this area went beyond showing us how we should think about uniform spaces. His insight was almost prophetic. He sensed that the most interesting uniform spaces were the ones that were fully normal. ... Tukey predicted that the fully normal uniform spaces would play a major role in mathematics, and indeed they have.

D. H. Fremlin wrote:

> Of course Tukey's ideas on partial orders did have great influence on me. This was really through J. R. Isbell. Steve Todorovic took the same ideas much further ... I still believe that Tukey's notion of cofinal equivalence gives fundamental insight into some important questions in set-theoretic analysis.

There are papers with R. P. Boas and with A. Stone as well as solo-authored articles. The one with Stone, titled "Generalized sandwich theorems", showed that the volumes of any n solids in $\mathbf{R}^n$ can be simultaneously bisected by an $(n-1)$ sphere, with a plane able to be regarded as a sphere of infinite radius. The Ham Sandwich Theorem is the case of $n = 3$.

Statistics

> Statistics is a science, not a branch of mathematics, but uses mathematical models as an essential tool.
>
> —*JWT*

The Mosteller-Tukey bombing example mentioned above gives an indication of the difficulties of interpretation of results that statisticians deal with regularly in the world of experiments and data. JWT's statistical contributions reflect his struggles with that often messy world. Some highlights follow.

Robustness. Robustness refers to the property of a procedure remaining effective even in the absence of usual assumptions such as normality and no incorrect data values. In simplest terms the idea is to improve upon the use of the simple arithmetic average in estimating the center of a distribution. As a simple case one can ask: Is it ever better to use the sample median than the sample mean, and if so, when?

Tukey had gotten interested in the problem of robustness in the last stages of his work at 20 Nassau Street. He remarked that C. P. Winsor taught him to beware of extreme deviates. The two learned, for example, that if you add 0.1 percent of a Gaussian three times as spread out as a basic Gaussian, then the mean deviation does better than the classic standard deviation as a way of measuring scale.

An important part of JWT's contribution was developing particular forms of problem distributions, those displaying the difficulties that occurred in practice. The ones employed included the mixture of Gaussians, the slash, and the $g - h$.

For the smoothing case he recommended running medians. This tool has proved exceedingly useful in image processing.

Time Series. During World War II, JWT had become acquainted with Norbert Wiener's seminal work, later published in book form.

JWT has told the story of how he got interested in the spectral analysis of time series. Just after the war, a Bell Laboratories engineer working on tracking radars was heading to a conference and wished to show a slide of an estimated power spectrum. He met with Tukey and Richard Hamming. Those two knew the Fourier relation between the autocovariance function and the spectrum and took the Fourier transform of the sample autocovariance function. The estimate was seen to ripple. This led Hamming to make the suggestion that the engineer's estimate would look better were it smoothed, for example via the weights 0.25, 0.50, 0.25. The result was a striking success and led to JWT's major involvement in the field of time series analysis.

Tukey often argued the advantages in favor of the power spectrum over the autocorrelation. Such an argument is needed because the two are mathematically equivalent. He claimed that the analyst could learn more from a spectral analysis, particularly in discovering unexpected phenomena.

Bogert, Healey, and Tukey introduced cepstral analysis as a way to address the problem of distinguishing an earthquake from an explosion [1]. This was based on the observation that a signal laid on top of itself with a delay leads to a rippling spectrum. The delay may be estimated as the frequency of the ripple and from that the depth of the seismic event. A lot of colorful language, like "saphe cracking", "quefrency", and "alanysis" was also introduced in that paper. Of the language Dick Hamming remarked to John that "from now on you will be known as J. W. Cutie." The cepstrum was quite unlike any time series quantity that had been proposed previously.

Nearly all of the time series papers may be found in Volumes I and II of the *Collected Works.*

Data Analysis. JWT had a philosophy for studying experimental results from early on. He called it data analysis. One of his descriptions was the following:

> ... data analysis which I take to include, among other things: procedures for analyzing data, techniques for interpreting the results of such procedures, ways of planning the gathering of data to make its analysis easier, more precise or more accurate, and all the machinery and results of (mathematical) statistics which apply to analyzing data.

His 1962 paper on the subject changed the paradigm and language of statistics. His 1977 book made the techniques available to a very broad audience. JWT recognized two types of data analysis: exploratory data analysis (EDA) and confirmatory data analysis (CDA). In the former the data are sacred while in the latter the model is sacred. In EDA the principal aim is to see what the data are "saying". It is used to look for unexpected patterns in data. In CDA one is trying to disconfirm a previously identified indication, hopefully doing this on fresh data. It is used to decide whether data confirm hypotheses the study was designed to test.

Some parts of EDA are ugly, but the real world is ugly, particularly when errors and other aberrant material enters a data set.

Statistical Graphics.

> The best single device for suggesting, and at times answering, questions beyond those originally posed is the graphical display.
>
> —*JWT*

E. Tufte has remarked of Tukey's work on graphics that "he made the field respectable." In particular one can mention JWT's paper at the Vancouver International Congress of Mathematicians.

Statistical graphics are a critical part of EDA. Tukey's boxplots and stem-and-leaf diagrams now appear throughout scientific presentations and high-school texts.

A field that he popularized is dynamic graphics. Following Tukey's direction a display program, PRIM-9, was developed at SLAC (Stanford Linear Accelerator Center) for looking at multidimensional data. It was based on point cloud rotation and associated dynamic operations. Nowadays point cloud rotation is basic to statistical packages. One difficulty was which direction to rotate to. JWT proposed the procedure of projection pursuit to handle this. It seeks 1 and 2 dimensional projections of multivariate data, looking for data points that concentrate near intermediate-dimensional manifolds.

JWT's last book, written together with Basford, was titled *The Graphical Analysis of Multivariate Data*. It contained novel graphical procedures and his current views on the problem of multiple comparisons.

Analysis of Variance (ANOVA). ANOVA and regression are the workhorses of statistics, and JWT made many important contributions to each of them. An assumption of additivity is basic, and JWT was concerned with how to examine that assumption in practice. He remarked, "I carried the problem about how to do something about removable non-additivity 'in my pocket' for at least two years before the right idea dawned." The idea was to work with a bilinear expansion in the additive parts. The resulting paper was titled "One degree of freedom for additivity".

Another novel idea of his was dyadic ANOVA, an analysis of variance for vectors. To develop a multivariate analysis of variance he worked with the inner product of the data vector with an abstract-valued vector of the same length.

Multiple Comparisons. In many statistical situations there is a concern to control the error rate of statements being made. Difficulties arise if one gives in to temptations associated with the application of a number of tests to the same data set, as in asking several questions at the same time, or in carrying out several analyses of the same data set.

This is another problem that JWT acknowledged working on for a number of years before developing a solution. He actually commented once on how few papers he had written during that period. His solution was developed in a famous 1953 unpublished manuscript, "The problem of multiple comparisons". It now appears in the *Collected Works*.

The Tukey technique is often seen under the rubric of the "honestly significantly difference" (HSD) test, another term that is JWT's. In later years JWT moved on to using the false discovery rate (FDR) of Benjamini and Hochsted when many things were being compared.

The Jackknife. This is a tool that Tukey proposed and used for CDA over many years. In naive terms it provides an indication of the uncertainty of an estimate by judiciously combining estimates based on subsets of the full data set.

He called the procedure the jackknife because

> The procedure ... shares two characteristics with a Boy Scout Jackknife: (1) wide applicability to very many different problems, and (2) inferiority to special tools for those problems for which special tools have been designed and built.

It provides uncertainty analyses when exact estimates are unavailable.

J. W. Tukey's Collected Works

Volumes I–II, *Time Series*, 1984–1985, edited by D. R. Brillinger
Volumes III–IV, *Philosophy and Principles of Data Analysis*, 1984–1986, edited by L. V. Jones
Volume V, *Graphics*, 1988, edited by W. S. Cleveland
Volume VI, *More Mathematical*, 1990, edited by C. M. Mallows
Volume VII, *Factorial and ANOVA*, 1992, edited by D. R. Cox
Volume VIII, *Multiple Comparisons*, 1994, edited by H. I. Braun

J. W. Tukey's Index to Statistics and Probability

Volume 1, *The Citation Index*, 1973
Volumes 2–3, *Permuted Titles*, 1975, with I. C. Ross
Volumes 4, *Locations and Authors*, 1973, with I. C. Ross
These indexes appeared as Volumes 2–5 of the Information Access Series; Volume 1 of that series is *Statistics CumIndex*, 1973, with J. L. Dolby.

Other Books of J. W. Tukey

Convergence and Uniformity in Topology, 1940
Data Analysis and Regression, 1977, with F. Mosteller
Exploratory Data Analysis, 1977
Graphical Analysis of Multiresponse Data, 1998, with K. E. Basford
The Management of Weather Resources, Volume 2, The Role of Statistics, 1978, with D. R. Brillinger and L. V. Jones
The Measurement of Power Spectra from the Point of View of Communications Engineering, 1959, with R. B. Blackman
Robust Estimates of Location, 1972, with D. F. Andrews, P. J. Bickel, F. R. Hampel, P. J. Huber, and W. H. Rogers
Statistical Problems of the Kinsey Report on Sexual Behavior in the Human Male, 1954, with W. G. Cochran and F. Mosteller

Books Edited by J. W. Tukey

Configural Polysampling: A Route to Practical Robustness, 1991, with Stephan Morgenthaler
Exploring Data Tables, Trends, and Shapes, 1985, with David C. Hoaglin and Frederick Mosteller
Fundamentals of Exploratory Analysis of Variance, 1991, with David C. Hoaglin and Frederick Mosteller
Understanding Robust and Exploratory Data Analysis, 1983, with David C. Hoaglin and Frederick Mosteller

Other Contributions. JWT successfully pushed for applications of statistical methods to a wide variety of fields. To mention a few: economics, aeronautics, geophysics, oceanography, meteorology, space science, and astrophysics.

Brief mention may also be made of JWT's novel contributions to: mathematical statistics, quality assurance, theory of games, and medical statistics. There is much that remains unpublished, including various Princeton course notes, working papers, and technical reports. It is a shame that work ended on his *Collected Works*, which brought various unpublished items into public view.

Computation

Head/hand Methods. The arithmetic skills of Feynman and von Neumann are legendary, and Tukey had these too. In particular he developed a variety of quick methods for carrying out statistical analyses in real time. These were basic to his consulting work. He spoke of "using pen, paper, and slide rule." There are a variety of his numerical short cuts presented in the EDA book.

JWT was a member of the Supervising Scientific Committee of the highly influential handbook of mathematical functions edited by Abramowitz and Stegun. The story was the suggestions were all generated spontaneously during a single lunch meeting.

Monte Carlo/Simulation. JWT made contributions to the techniques of Monte Carlo. In 1956 Trotter and Tukey introduced the technique of conditional Monte Carlo wherein one estimates an integral of a weighted function by simple Monte Carlo, instead of the integral of the function itself. This is a means of variance reduction. In it one imbeds the sample space in a larger one.

He also introduced polysampling wherein a single set of samples is able to produce estimates of means and standard errors under two, three, ... different distributions at the same time by combining the sample with two, three, ... sets of weights.

Fourier Analysis. JWT had picked up on the Gibbs phenomenon and the practical need for convergence factors early on. He also wrote concerning the difficulties of interpretation such as those caused by aliasing.

In lectures at Princeton in 1963 he showed that if one wished the discrete Fourier transform of a sequence of N numbers, then when $N = GH$, the computation of the empirical Fourier transform required only $(H + 2 + G)GH$ multiplications. He further remarked that for $N = 4^k$ one needed fewer than $2N + N \log_2 N$. The resulting Cooley-Tukey paper, [3], has become a citation classic. When it popularized the FFT, signal processing very quickly switched from analog to digital.

There is one sad aspect to the FFT story. On numerous occasions JWT made remarks of the type, "Gordon Sande ... had purely independently found an algorithm to reach the same effect." He clearly felt bad about Sande's not receiving some share of the credit.

Another side of Tukey's FFT work was his and his collaborators' finding novel applications of the algorithm(s).

Concluding Remarks

Support and Recognition

Throughout his career JWT served in various capacities as an officer in professional societies: AMS Council, vice-president ASA (American Statistical Association), vice-president SIAM (Society for Industrial and Applied Mathematics), president Institute of Mathematical Statistics. He received many prominent honors: member National Academy, recipient National Medal of Science, foreign member Royal Society of London, and some seven honorary doctorates. He received his first from Case Institute of Technology in 1962. The citation of the award from the University of Waterloo in 1999 included the words: "He has pioneered developments in fields that intersect with every development in mathematics facilities."

Tukey Neologisms

John Tukey was famous for creating new words and new uses for old ones. He said that he did this to avoid confusions.

He is said to have introduced the terms: "bit", "linear programming", "ANOVA", "Colonel Blotto", and was first into print with "software". Of these efforts L. Hogben and M. Cartwright wrote, "The introduction by Tukey of bits for binary digits has nothing but irresponsible vulgarity to commend it." Tukey's word "polykay" was described as "linguistic miscegenation" by Kendall and Stuart because of its combining a Greek prefix with a Latin suffix. JWT did it again later with "polyspectrum".

His own name led to some amusing confusions. In 1980 NASA sponsored a symposium on using robotics to explore space using self-replicating systems. (Feynman and JWT were among the attendees.) Coming out of the discussion was "Tukey's ratio"—the fraction of total necessary resources that must be supplied by some external agency. It was also referred to in that report as the "Turkey Ratio".

The Collected Works

Many of the Tukey papers, as well as a number of previously unpublished works, may be found in *The Collected Works of John W. Tukey* published by Wadsworth, Belmont. These volumes were Bill Cleveland's wonderful prescient idea. There are JWT's and editors' forewords discussing various of the individual papers.

There are a partially complete curriculum vitae, a list of coauthors, and a bibliography of his works in [2]. Papers are still appearing. JWT has more than 105 coauthors, the most joint works being with Fred Mosteller. There is a Bell Labs website containing a variety of materials related to John, including personal reminiscences [4]. There is an oral history with JWT and others mentioning him [5].

Epilogue

John Tukey was a giant of a scientist and public servant. He was an academic who liked to argue and expected to win. But at the same time he was the most generous, patient, caring soul.

When my elder son died after a twenty-year struggle with a brain tumor and JWT heard of his death, he telephoned. He was weeping away.

JWT dealt with his own personal grief when his wife Elizabeth died; he wrote some very special words:

One is so much less than two.

Acknowledgments

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I apologize for not referring more specifically to JWT's collaborators on occasion. JWT himself was totally generous in acknowledging them.

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Mathematics Education Positions in Higher Education and Their Applicants: A Many-to-One Correspondence

Robert E. Reys

The National Research Council reported that during the 1990s, there were between 80 and 115 new doctoral graduates per year in mathematics education [6]. During the same decade, job openings for people with doctorates in mathematics education increased significantly and currently exceed the supply [5]. In a survey of institutions of higher education conducting national searches to fill mathematics education positions during the 2000–01 academic year, I found 134 announced positions in mathematics education. This article presents some information from the survey and documents the shortage of doctorates in mathematics education.

Introduction

One reviewer of this paper asked, "Why should a research mathematician care about a shortage of doctorates in mathematics education?" This question came as a complete surprise to me, as I naively assumed that this shortage would be of keen interest to the entire mathematics community. As I pondered the question, I thought about presidents of the AMS (from E. H. Moore to Hyman Bass) who have expressed both interest in and strong support for teaching and learning mathematics, which is the heart and soul of mathematics education. Such mathematicians have often served as ambassadors for mathematics education within the mathematics community, and have bridged the chasm that seems to separate mathematicians from mathematics educators. This encouraged me to think of reasons why mathematicians (research or otherwise) should care about the shortage of doctorates in mathematics education. Here are a few:

1) Because doctoral programs in mathematics education typically require numerous courses in advanced mathematics, doctoral students in mathematics education generate many credit hours (and revenue) for mathematics departments.
2) Doctoral students in mathematics education often teach entry-level and service courses in mathematics departments. Thus, a shortage of doctoral students means heavier teaching loads for regular professorial-level faculty.
3) Search committees and department chairs need to be aware of the supply of and demand for doctorates in mathematics education. Informed with this information, search committees will likely be more aggressive in their searches, extend the outreach of their job announcements, and make their salary offers competitive.
4) Knowing about the shortage of doctorates in mathematics education, research mathematicians can alert their students to career options in mathematics education.
5) A significant number of doctorates in mathematics do not continue to do research in mathematics after their doctoral program. However, they do teach mathematics at the collegiate level and frequently have opportunities to work with prospective K–12 teachers. In order to prepare these students

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adequately for the work they will be doing, doctoral programs in mathematics should consider including opportunities for doctorates in mathematics to become aware of the issues, research, and opportunities in mathematics education.

6) Doctorates in mathematics education represent a group with many of the same interests and goals as mathematicians. Faculty in both areas have much to gain by working together. They should seek each other out and explore opportunities for collaboration, including joint efforts to seek external funds to support their efforts.

The mismatch between the number of available positions and the number of new doctorates in mathematics education is exacerbated because many new graduates of doctoral programs in mathematics education never apply for positions in mathematics education. About 30 percent of new mathematics education doctoral graduates were on leave from or were already employed by an institution when they completed their degree [1]. These people returned to previous jobs or never left their institution while working on their doctorate and therefore never entered the job market. Another 20 percent of new graduates (including international students) take positions outside the United States or assume a range of other jobs, including working for publishing companies, test developers, government agencies, and K–12 school districts. Thus, of the new doctorates each year in mathematics education, only about half of them vie for announced mathematics education positions in higher education [1].

It is surprising that the discipline of mathematics education maintains no annual survey of openings or placements, yet information regarding doctorates in mathematics is reported annually. In fact, since 1957 the *Notices* has provided annual updates about mathematics doctorates, including number of degrees awarded, specialty areas in mathematics, job opportunities, and salaries for new graduates with Ph.D.'s in mathematics. This information is compiled by an Annual Survey Data Committee, and includes representation from the AMS, the American Statistical Association, the Institute of Mathematical Statistics, and the Mathematical Association of America (MAA). The information collected is so detailed and comprehensive that the annual report [4] in the *Notices* is split over several issues.

During the last two years, I chaired committees at the University of Missouri searching for tenure-track faculty in mathematics education. Although we had three positions and sought applicants aggressively, we received fewer than 20 applications for the three positions. During this same period, the Department of Mathematics received over 400 applications for six positions in mathematics. The application-to-position ratios in mathematics and in mathematics education are significantly different. The few applicants together with the large number of positions in mathematics education suggest that competition for applicants holding doctorates in mathematics education is keen. Although personal testimonies describing the challenges of recruiting faculty with doctorates in mathematics education are abundant, there has been no systematic effort to report the extent of the success or failure of the searches.

The Survey

In an effort to document the job market for doctorates in mathematics education, I surveyed higher education job searches announced and conducted during the 2000–01 academic year in the United States for doctorates in mathematics education. From October 2000 to April 2001, I compiled a list from several sources[1] of higher education institutions that nationally advertised positions for doctorates in mathematics education.

I sent a survey to 133 institutions that announced a faculty position for a doctorate in mathematics education or a position that called for a doctorate in "mathematics or mathematics education" (see `http://showmecenter.missouri.edu/position/survey.html` for a copy of the survey). Nearly 90 percent (119/133) of the institutions responded. The 119 institutions represented small colleges and large universities, including both public and private schools. I used the 2000 Carnegie Classifications (see `http://www.carnegiefoundation.org/Classification/index.htm` for details of the classification) to categorize the responding institutions. In Table 1 the Carnegie classifications are accompanied by the roughly equivalent groupings (defined in [2]) that are familiar to *Notices* readers from the annual survey of mathematics doctorates [4].

The 119 institutions announced searches for a total of 134 positions, all but one being tenure-track. Over half (51 percent) of the positions were in mathematics departments, 44 percent were in schools of education, and the remaining positions were joint appointments. Table 1 summarizes the rate of return by type of institution.

The majority of positions in mathematics departments were in institutions from Group M and Group III, whereas the majority of positions in education were in research universities (Groups I and II).

[1] *Specific sources used to locate job openings are available upon request from the author.*

Institution type	Mathematics Departments Number Sent	Returned	Percent Returned	Schools of Education Number Sent	Returned	Percent Returned
Baccalaureate & Associate Colleges (Group B)	4	3	75	3	2	67
Master's Colleges & Universities I (Group M)	40	38	95	17	15	88
Doctoral/Research Universities–Intensive (Group III)	18	16	89	8	6	75
Doctoral/Research Universities–Extensive (Groups I & II)	11	10	91	32	29	91
Total	73	67	92	60	52	87

Table 1: Rate of return job search surveys in mathematics departments and schools of education by institutions according to the Carnegie Classification.

Nature of Positions

The survey included questions designed to provide insight into the nature of the announced positions. In response to the question, "What best describes the research and publication expectation for this position?", 80 percent of respondents marked "Essential for tenure and promotion", 16 percent marked "Encouraged but not essential for tenure and promotion", and 4 percent marked "Excellent teaching is the number one priority, research and publication not important for tenure and promotion". The responses were uniform across institution type, but research and publication were "essential for tenure and promotion" at all institutions offering doctoral degrees.

The survey asked about the major teaching responsibilities of the positions and the grade-level focus of the courses. At schools of education, the overwhelming majority (89 percent) of the required teaching involved mathematics education courses. At mathematics departments, over three-fourths of the teaching involved both mathematics and mathematics education courses. The grade-level focus of the courses was distributed across the K–12 areas, which demonstrates the need for mathematics educators' expertise to span a wide range of levels—from elementary grades to senior high school.

Salary Ranges

Figures 1 and 2 show the reported salary ranges for the positions. For both mathematics departments and schools of education, the most frequent salary ranges were $40,001 to $45,000 at the assistant professor level and $50,001 to $55,000 at the associate professor level. Over 80 percent of the positions at the associate professor level in either mathematics departments or schools of education had salaries above $50,000. Many of the respondents requested salary information. One mathematics department chair said: "We have not been successful in hiring mathematics educators, but we don't know if our salaries are competitive with other institutions. We are anxious to learn from your survey what salary level is required."

Applicants and Hires

The number of applicants for the advertised positions varied greatly, ranging from 0 to 60. The position that attracted 60 applicants was for a mathematics education position in a mathematics department, and the majority of the applicants had Ph.D.'s in mathematics. Overall, the number of applicants for the announced positions typically ranged from 2 to 10. The number of applicants interviewed for a position was as high as 7, with a mode of 2 interviews on-site. Of the 134 positions available, 66, or 49 percent, were not filled. Table 2 reports the number of hires by mathematics departments and by schools of education according to institutional type.

About one-third of the hires (24/68) were in Group M mathematics departments, and nearly another one-third (20/68) were in education schools at Doctoral/Research Universities–Extensive. Mathematics departments in groups I, II, and III made about one-sixth (11/68) of the hires.

Tables 3 and 4 provide two different perspectives of the distributions of hires and no hires. Table 3 shows the frequencies of hires with respect to institutions, and Table 4 reports the distribution by academic unit.

Discussion

About 20 percent of the respondents not only completed the survey but also sent personal notes with a range of comments. For example, some respondents (most often ones from mathematics departments) indicated that they were unaware of the job announcement services provided by the National Council of Teachers of Mathematics, the Association of Mathematics Teacher Educators, and the Special Interest Group for Research in Mathematics Education. Respondents from mathematics departments typically reported using the job listings of the AMS, the MAA, and the Association for Women in Mathematics, as well as Employment Information in the Mathematical Sciences (EIMS) to reach potential candidates. They also sent announcements to mathematics department chairs, so their efforts to recruit doctorates in mathematics education were directed toward the mathematics community. Respondents in departments of mathematics and in schools of education frequently reported being unaware of ways to reach qualified minority candidates in mathematics education.

Chairs of search committees also expressed surprise at the range of academic backgrounds of doctoral students in mathematics education. While diversity of experience is a strength, the lack of a common core of course work stimulated a frequently recurring question: What does it mean to complete a doctorate in mathematics education? Defining mathematics education as a discipline has long challenged mathematics educators, and addressing the issue of a "common core of knowledge" generated a spirited discussion at the National Conference on Doctoral Programs in Mathematics Education [6]. This issue prompted a call for seriously discussing the need for and value of guidelines for doctoral programs in mathematics education that would further define the discipline [3].

Several respondents reported that the majority of their applicants had a doctorate in mathematics, with no record of knowledge or experience in the field of mathematics education. Four institutions reported hiring a Ph.D. in mathematics to fill their mathematics education positions. This is likely an underestimate of the number of institutions that hired mathematicians to fill mathematics

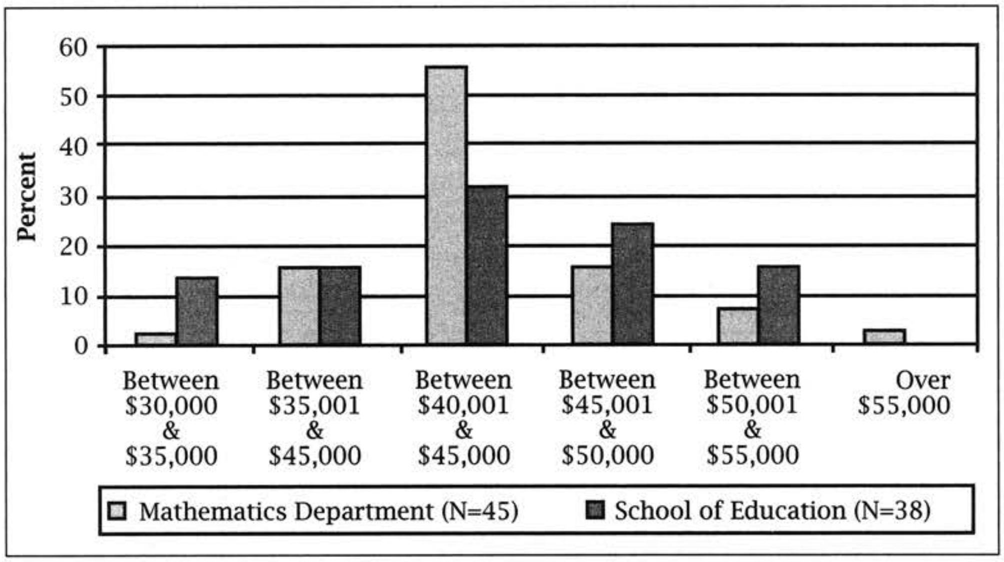

Figure 1. Salary range for assistant professors in mathematics departments and schools of education.

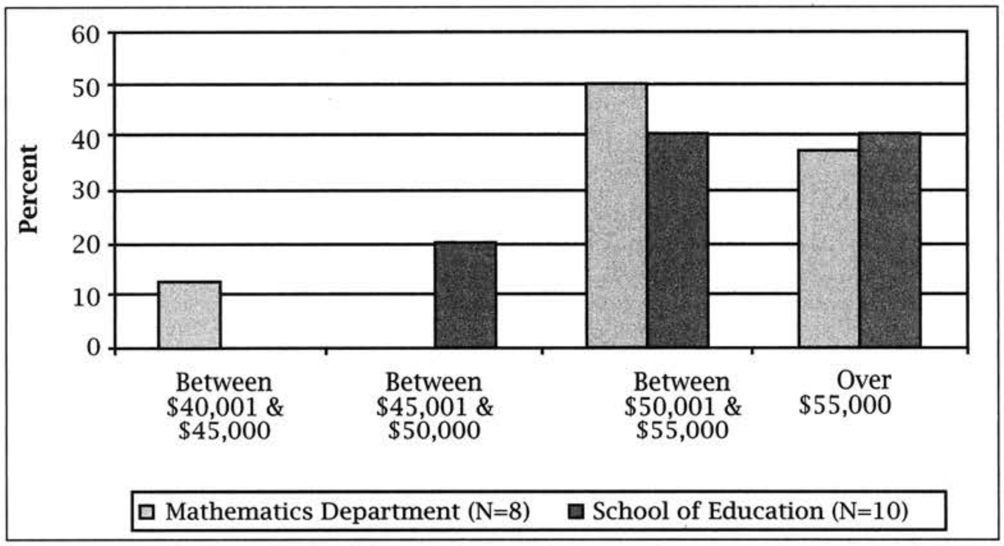

Figure 2. Salary range for associate professors in mathematics departments and schools of education.

Institution	Mathematics Department	School of Education	Joint appointment
Baccalaureate & Associate Colleges (Group B)	0	1	0
Master's Colleges & Universities I (Group M)	24	5	0
Doctoral/Research Universities-Intensive (Group III)	8	3	2
Doctoral/Research Universities-Extensive (Groups I & II)	3	20	2
Total	35	29	4

Table 2: Distribution of the 68 hires by institution type.

Institution type	Number of Hires	Number of No Hires
Baccalaureate & Associate Colleges (Group B)	1	4
Master's Colleges & Universities I (Group M)	29	32
Doctoral/Research Universities-Intensive (Group III)	13	9
Doctoral/Research Universities-Extensive (Groups I & II)	25	21
Total	68	66

Table 3: Frequency of hires (68) verses no hires (66) by institutional type.

Academic unit	Number of Hires	Number of No Hires
Education	29	29
Mathematics	35	33
Joint appointment in mathematics & education	4	4
Total	68	66

Table 4: Frequency of hires (68) versus no hires (66) by academic unit.

education positions, because the survey was not designed to collect this information.

Many respondents reflected frustrations with their searches, and the greatest frustrations centered on the small pool of qualified applicants. The inability to recruit successfully was experienced by all types of institutions and by departments of mathematics as well as by schools of education. The main reason positions went unfilled was an inability to attract a candidate whose qualifications matched the job description. Often the same candidates were interviewing for positions at several institutions, and the competition for these new doctorates was keen. One respondent from a major institution reported:

> "Our top candidate had seven offers within a month and accepted a position within one week of interviewing at one place...before we could interview him!"

The frustration of unsuccessful searches is reflected in remarks from a search chair at a four-year college:

> "This is the second consecutive year that we have searched unsuccessfully for a mathematics educator, and I must say that I am not particularly optimistic that we will be successful next year...I hope work is being done on creating multiple solutions to the problem that we face in recruiting mathematics educators."

Positions calling for interest and expertise in working on improving K-8 teacher preparation and doing research related to elementary mathematics education were particularly difficult to fill. Several respondents indicated a desire to find someone with elementary teaching experience AND a *strong* mathematics background. Such candidates are rare, for elementary teachers are required to take very few mathematics courses in their undergraduate programs. Lacking foundational courses necessary to study advanced mathematics, the elementary teacher who completes a doctorate in mathematics education with a *strong* mathematics background is exceptional.

The survey also asked if respondents "anticipated openings" for mathematics educators for 2002-03. More than 80 openings were projected (58 institutions anticipating one opening, 23 anticipating two openings, and 2 institutions anticipating three openings) that were independent of the "no hire." This finding, coupled with the "no hire" for 2000-01 and the current production level of new doctorates in mathematics education (typically less than 100), suggests that the current shortage of doctorates in mathematics education will become even more acute.

Conclusion

This article provides baseline information regarding job searches in higher education for doctorates in mathematics education. The review of applicants rekindled the questions: What characterizes a doctorate in mathematics education? Is there a core or canon of knowledge? These are important questions in need of answers.

It should be noted that the data presented here underestimate the number of jobs available for doctorates in mathematics education, for the list of positions included only national searches announced by institutions of higher education. Omitted are job announcements from publishers, test development companies, governmental (state/federal) agencies, and school districts, where shortages also exist. Furthermore, many institutions—particularly junior colleges and four-year colleges—advertise position openings only on a local or regional basis. Indeed, a recent study [1] determined that about two-thirds of the recent graduates in mathematics education were employed at institutions without doctoral programs, yet only about one-third of the 134 job listings in my survey were from these kinds of institutions.

More than half of the announced jobs for doctorates in mathematics education were in mathematics departments. Only about half of the announced mathematics education positions were filled either in mathematics departments or in schools of education. This fact, coupled with anticipated future openings and projected retirements [5], suggests that future demands for doctorates in mathematics education will be great. This many-to-one correspondence between jobs and applicants in mathematics education underscores the need for the mathematics and mathematics education communities to work together to explore ways of increasing the production of doctorates in mathematics education. I hope that this article will help to stimulate increased collaboration.

Acknowledgments

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Reflections of Departing DMS Rotators

The Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) now accounts for about two-thirds of all federal funding for academic research in the mathematical sciences. Ensuring that this money is well spent depends on having a highly qualified staff of program officers in the DMS. Visiting scientists—or, in common parlance, "rotators"—are a critical element of the DMS staff. Most rotators have permanent positions in academia and work in the DMS for one, two, or sometimes three years and then return to their home institutions. More than half of DMS program officers are rotators, and they complement the experience and institutional memory of the permanent DMS staff by bringing in fresh viewpoints and first-hand knowledge of current research. And when rotators return to their regular positions, they bring back insights and understanding about how the NSF operates and about policy issues affecting mathematics.

Every year, the DMS needs to fill rotator positions—and every year it is a challenge to find qualified people willing to come to Washington. Jong-Shi Pang of The Johns Hopkins University, who served as a rotator in the DMS full-time during 1998–2000 and part-time during 2000–2001, is enthusiastic about his stint at the NSF. "I had a very good experience and enjoyed my stay there," he remarks. "I would encourage more people from the community to respond to the call for help to serve the discipline."

Shepherding Proposals

The main responsibility of DMS program officers is shepherding through the reviewing process the approximately 2,000 proposals the DMS receives each year. Proposals come in response to solicitations to programs like VIGRE (Grants for Vertical Integration of Research and Education in the Mathematical Sciences) or Focused Research Groups, or are submitted to one of the division's six disciplinary programs: Algebra, Number Theory, and Combinatorics; Analysis; Applied Mathematics; Computational Mathematics; Statistics and Probability; and Geometric Analysis, Topology, and Foundations. In the past, the reviewing process was conducted almost exclusively by mail (meaning postal mail or e-mail). Increasingly, the DMS uses a combination of panel reviews and mail reviews. The mix varies from program to program and depends partly on the judgment of the program officers about which method works best for their particular areas. A proposal under serious consideration for funding needs at least three outside reviews, and those reviews may be written by mail reviewers who each see only that one proposal, or by panel members who can compare the proposal to others submitted in the same area.

Dmitry Khavinson of the University of Arkansas in Fayetteville recalls that in years past, when he was a mail reviewer for the DMS, he would occasionally get "goofy" proposals. But when he served as a rotator in the Analysis program during 1999–2001, he says, "I did not see any proposals that I could easily dismiss," and nearly all mail reviews came back with "very good" ratings. The Analysis program relies primarily on panel reviews, which Khavinson believes is the fairest system. "When the panel meets, they see the whole picture," he notes. "They see the 'very goods' in comparison with the other 'very goods'." During his time in the DMS, Khavinson assembled and oversaw several panels, each of which had 12 to 16 members who met at the NSF for three days to review from 60 to 80 proposals. Sometimes he supplemented the panels' recommendations with mail reviews, and some proposals that were hard to categorize he handled by mail review only.

Joseph Brennan of North Dakota State University in Fargo was a rotator in the Algebra, Number Theory, and Combinatorics program from 1999 to 2001. This program used to be called Algebra and Number Theory and had a tradition of using only mail reviews. However, proposals in combinatorics have been reviewed by panels ever since that area was added to this program a few years ago. The proposals Brennan handled were mostly in algebra and algebraic geometry, and he used mostly mail reviews in his first year at the NSF and some panel reviews in his second. "There are positive and negative aspects to panel and mail reviews," he notes. He found that mail reviews allow for a greater diversity of opinion than do panels and increase the chances of getting proposals to reviewers who have exactly the right expertise. On the other hand, he notes, panels have a better perspective on all the issues facing the DMS as it tries to compare proposals.

William Smith, who is now the executive director of the American Statistical Association, was on the faculty at Texas A&M University before going to the DMS in 1999 for a two-year stint as a rotator. He worked in the Statistics and Probability program, which is the only DMS program that uses a "screening panel." The screening panel reviews a batch of a couple of hundred proposals and groups them into three categories. In the first category are a very small number of proposals, perhaps half a dozen, that are so outstanding they must be funded. The second category contains proposals deemed to be not competitive—typically about 40 percent of all the proposals. The third category contains all the remaining proposals, and for these Smith used mail review, often drawing on recommendations from the panel about who could review which proposals. The statistics program funded about 25 percent of the proposals it received, which is less than the NSF's general target of funding about one-third of all proposals.

Rotators get an inside view of the state of research in the mathematical sciences today. "I hadn't realized how high the quality of proposals is," remarks Andrew Pollington. "There were hardly any that I could not have funded with a clear conscience." Pollington, who is at Brigham Young University, was in the Algebra, Number Theory, and Combinatorics program during 1999–2000, and he may serve a second year during 2002–2003. During his time at the NSF, he got to see first hand the impact of two developments in number theory: the work of Andrew Wiles in *L*-functions and arithmetic, which led to the proof of Fermat's Last Theorem, and work on the zeroes of the Riemann zeta function, which has been enriched by connections with physics. Going to the DMS, says Pollington, "is a great opportunity to learn about what's going on in your subject."

Other Program Officer Duties

DMS program officers also spend time seeking joint funding from other NSF divisions. A proposal with connections to, for example, biology, could be of interest to the program officers in one of the NSF's biology divisions. "The program officer has the responsibility and the difficulty of taking the proposals around, pitching them, and trying to sell them" to other divisions, Smith remarks. In the same way, program officers outside the DMS pitch their mathematically-oriented proposals to DMS program officers. "So it's a quid pro quo," Smith says, noting that usually the tradeoff ends up even. Grantees are not always aware of the efforts a program officer makes to find ways to fund their proposals. "It's not always a matter of recognizing great work," remarks Brennan. "It's finding the money to make it happen." Finding funding for a good proposal that might otherwise go unfunded is satisfying, he says. "These are things you can point to and say, 'Here's an accomplishment.'"

In addition to overseeing the disciplinary programs of the DMS, program officers work on a variety of projects within the division and across the foundation. For example, Smith was on the management team for VIGRE, a DMS program that supports efforts by mathematics departments to integrate research and education from the undergraduate through the postdoctoral and senior researcher levels. Because he had served on a panel to review VIGRE proposals before he came to the NSF, and because he has extensive administrative experience, Smith was a natural for involvement in VIGRE. During his tenure at the NSF, Smith worked on the VIGRE selection panels and led several site visits. "VIGRE is a long-range program that will train a lot of mathematicians—it will train the next generation of leaders," Smith remarks. "It's exciting to be involved with something like that."

A rotator in the Analysis program during 1999–2001, Peter Polyakov of the University of Wyoming became deeply involved in work on an NSF-wide initiative in nanotechnology. With Joe Jenkins, lead program officer in Analysis, Polyakov organized a workshop that brought together mathematicians and people from other sciences and engineering to discuss how to pool their expertise to attack problems in nanotechnology. Polyakov also began work on a document describing how mathematics can make contributions to solving these problems. Prior to coming to the NSF, Polyakov was not involved in interdisciplinary research, but he enjoyed working on the initiative and getting to know researchers in other areas. "To me, this looked like the direction the NSF is moving in, which is toward more interdisciplinary research," he says.

A Time of Optimism

The last couple of years have been a time of optimism and high hopes for the DMS, as the NSF director, Rita Colwell, has promoted an NSF-wide "Mathematical Sciences Initiative" (technically the initiative has been relabeled a "priority area" because the Bush administration mandated that there would be no new initiatives by the government). The initiative is built around three linked themes: "interdisciplinary mathematics", which addresses problems in science and engineering; "fundamental mathematics", which represents the core of the field and which must be strong if mathematics is to come to the service of other disciplines; and education and mathematical literacy. In the spring of 2000, Colwell appointed James Rosenberger to chair an internal working group, with representatives from across the NSF, to formulate the

Information about applying to be a rotator in the DMS may be found in "DMS Employment Opportunities" in the January 2002 issue of the *Notices*, page 45. Or contact: Bernard R. McDonald, Executive Officer, Division of Mathematical Sciences, National Science Foundation, 4201 Wilson Boulevard, Suite 1025, Arlington, Virginia 22230; telephone 703-292-4851; fax 703-292-9032; e-mail: bmcdonal@nsf.gov. The DMS website is at http://www.nsf.gov/mps/divisions/dms/.

In addition, the Opinion piece "A Time of Opportunity" by Phillip Griffiths (*Notices*, November 2001, page 1149) discusses being a rotator in the DMS.

—*A. J.*

initiative. Rosenberger was a rotator in the Statistics and Probability program during 1998–2000. After returning to his home institution of Pennsylvania State University, he stayed on part-time for another six months to finish work on the initiative.

"One focus of the initiative is to forge links with other disciplines where collaborative work would both benefit the other disciplines and provide a mechanism to bring mathematical challenges back to the mathematics community," Rosenberger explains. He says the initiative enjoys strong support across the NSF, especially from the biological, geological, earth, and atmospheric sciences, all of which face enormous computational, mathematical, and statistical problems. Inspiring more mathematicians to communicate with nonmathematicians is only part of what is needed, Rosenberger remarks. "A mix of people who do that and those who bear down on theoretical work is what makes a rich community," he notes.

If the most optimistic scenario materializes, the initiative could mean a four- or five-fold increase in the DMS budget over the next few years. The initiative will start during the 2003 fiscal year, which begins October 1, 2002. In the aftermath of the September 11, 2001, attacks, all nonmilitary aspects of the government have received lower priority. As a result, the DMS budget will probably rise more slowly than originally hoped. DMS program officers were gratified by and optimistic about the initiative, says Polyakov. But, he notes, the DMS still faces the hard work of developing serious collaborations with other divisions, and, because this is an NSF-wide initiative, the new money will not go only to mathematicians. "This is money mathematicians will have to fight for," Polyakov states.

Some in the mathematical sciences community are concerned that, despite the initiative's emphasis on linking fundamental and interdisciplinary mathematics, core areas of the field might nevertheless lose out. DMS rotators have to confront such concerns all the time. Pang says that, before one can really understand all aspects of the problem of increasing funding for the mathematical sciences, one has to "come and understand [the problem] from the inside" of the NSF. "The program officers, the division director and the community have the same voice, the same goal: to try to grow the budget for mathematics," says Pang. The challenge is how to accomplish that goal. "The DMS is taking a strategy that sees interdisciplinary work as a way to help the mathematical sciences as a whole."

"It's a Lot of Work!"

With all they have to do, DMS program officers are very busy. "On balance, I largely enjoyed the time" at NSF, Rosenberger says. "But it's a lot of work!" Like most rotators, he had to put his own research on hold while he was at the NSF. Pollington reports that he was able to continue his research by working in the evenings, but he was hampered by the lack of a mathematics library close at hand. Rotators can apply for up to fifty days off for research per year; many use this time to go back to their home institutions to advise graduate students and work with colleagues, or to attend conferences. Nevertheless, the reality is that a great deal of energy and discipline are needed to keep up one's research alongside the demands of being a program officer.

Rotators have two options for salary arrangements. The first comes under the "Intergovernmental Personnel Act", or IPA, and stipulates that the NSF pays for a 12-month appointment based on the 9-month base pay of the home institution; the home institution contributes 15 percent of the total cost. IPA rotators remain employees of their home institutions and therefore have no interruption in things like pension fund contributions. The other option is to become a "Visiting Scientist", and then the NSF pays the entire cost at a negotiated rate depending on government pay scales. Because visiting scientists are government employees, they are subject to some pesky regulations, such as clocking in and accounting for hours worked. Both salary options are possible for rotators, and most prefer to be visiting scientists. In any case, rotators never take a pay cut to go to the NSF.

"There is a lot of help for any fresh rotator" in DMS, Pang remarks. "The permanent people are very helpful. You can walk into any office and ask anything...Rotators are very, very welcome." The NSF has its impersonal, bureaucratic side, which is just as immersed in regulations and paper-shuffling as any other government agency. But, says Khavinson, "I didn't see a bureaucratic approach" among the DMS staff, who were all working hard to advance the mathematical sciences. "Mathematics is healthy and well, all areas of it, and a lot of people are doing very exciting things," he says. "And when you see it from the NSF, you see it much more clearly."

—*Allyn Jackson*

The Universal History of Numbers and *The Universal History of Computing*

Reviewed by Joseph Dauben

> The main aim of this two-volume work is to provide in simple and accessible terms the full and complete answer to all and any questions that anyone might want to ask about the history of numbers and of counting, from prehistory to the age of computers.
>
> —*Georges Ifrah,* The Universal History of Numbers *(Foreword)*

> The final step in this technological advance was made when the microprocessor was introduced in 1971...
>
> —*Georges Ifrah,* The Universal History of Computing *(p. 298)*

This is the second installment of a two-part book review. The first part appeared in the January 2002 issue of the *Notices*, pp. 32–38. In the review *Numbers* refers to Volume I and *Computing* to Volume II.

The Universal History of Numbers. From Prehistory to the Invention of the Computer (Volume I)
Georges Ifrah
Translated from the French by David Bellos, E. F. Harding, Sophie Wood, and Ian Monk
John Wiley & Sons, New York, 1999
xxii + 633 pages

The Universal History of Computing. From the Abacus to the Quantum Computer (Volume II)
Georges Ifrah
Translated from the French and with notes by E. F. Harding, Sophie Wood, Ian Monk, Elizabeth Clegg, and Guido Waldman
John Wiley & Sons, New York, 2000
410 pages

The Universal History of Numbers is full of detail, with charts and diagrams and the author's own hand-drawn illustrations. Its sequel, *The Universal History of Computing* (the volume under review here), seems something of an afterthought by comparison. There are no illustrations, no photographs, nothing to enliven the prose, which at times is plodding. For example, the translators surely could have found a more felicitous way to express Ifrah's characterization of writing systems than as providing "a visual medium to embalm human thought" (*Computing*, p. 3)! Indeed one of the points Ifrah makes repeatedly about the modern number system is that it led to great things—hardly the implication of "embalm".

The British edition of Ifrah's books appeared as a two-volume set, while the American edition is designed to look like two separate books. The title of the American edition of Volume II, *The Universal History of Computing. From the Abacus to the Quantum Computer*, also differs from the British title, which was *The Universal History of Numbers. The Computer and the Information Revolution.* This change, designed perhaps to appeal to American readers, makes it seem as if Ifrah's book were on the cutting edge of scholarship in the history of computing. But there is nothing to be found here at all on quantum computers—in fact Ifrah offers little in detail beyond introduction of the pocket calculator and thermal printers (*Computing*, p. 299).

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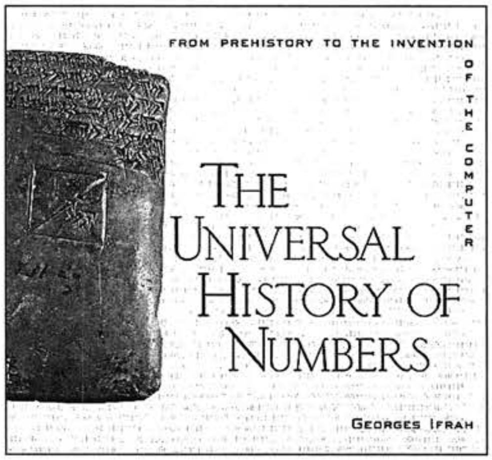
Although the American edition of *The Universal History of Computing* bears a publication date of 2000, Ifrah's account for the most part stops some thirty years ago, with the introduction of microprocessors in the mid-1970s. Thus many of the major advances of the past few decades are missing from this "universal" history. In describing different kinds of computers, Ifrah does mention briefly—in addition to electronic computers—mechanical, electromagnetic, pneumatic, and opto-optical computers, and also discusses the possibility of biochemical computers (*Computing*, pp. 302–3). But there is no hint here of quantum computers, and other omissions are just as surprising: There is no mention of Japanese efforts related to supercomputers, almost nothing on the importance of software in the computer revolution, and no discussion of the ways in which desktop and laptop computers have affected virtually every aspect of daily life. And for a book that purports to cover the information age, in which the Internet is synonymous with information, it is amazing that the Internet receives not a word of mention (the translators do add notes with references to information available on the World Wide Web (*Computing*, p. 344)).



The translators of Volume II seem to have sensed its problems, for not just occasionally, but time and again they step in to offer their own comments. They rightly point out difficulties of translation, such as the distinction between *computer* and *ordinateur* that is relevant in French but lost in English. More surprising is the need the translators often feel to explain, expand, or correct what Ifrah has written. Why didn't Ifrah's editors ask that he revise the English edition if such extensive editorial tinkering was found to be necessary?

The first example of the translators adding material occurs as early as page 2, but becomes increasingly intrusive in Chapter 3 ("From Calculation to Calculus"), where Ifrah is not entirely clear about the meaning of "calculation" and where the translators add more than half a page of further explanation. A paragraph later, Ifrah mentions the word "calculus" and then jumps to discussion of "tensor calculus". The translators again feel it necessary to intersperse a page outlining the basics of the differential and integral calculus and then to go on to explain what the tensor calculus is, because Ifrah does not (*Computing*, pp. 70–1). When Ifrah mentions Luca Pacioli, who wrote "an important book on arithmetic and algebra", it is the translators who indicate that this was the *Summa de Arithmetica* published in 1494 (*Computing*, p. 76).[1] When Ifrah says that René Descartes invented analytical geometry in 1637, it is the translators who explain what this was. And when Ifrah mentions that Nicolai Lobachevski and Wolfgang Bolyai invented non-Euclidean geometry (mistaking Wolfgang the father with János the son, who was the one to advance the idea of a geometry based on rejection of the parallel axiom (*Computing*, p. 82)), it is the translators who again provide the explanatory footnote (but without noting the mistake). Mathematicians of course will not need such explanations, but general readers for whom this book is intended will.

Sometimes the translators find it necessary to correct the author. For example, Ifrah states that in 1837 the American Samuel F. Morse used binary code to transmit messages by electrical impulse. As the translators point out, strictly speaking, Morse did not use a binary code, but a ternary system, in base 3, since the Morse code depends upon three signs, the dot, the dash, and the silence separating the sequences of dots and dashes encoding a given character.

Ifrah leaves many substantial concepts unexplained, and the translators often feel obliged to offer more information. For example, at the beginning of Ifrah's account of analog computation devices, the translators add a helpful definition of what analog computation is. One of the earliest devices mentioned is the Antikythera mechanism (which Ifrah mistakenly refers to as the Antikythera (*Computing*, p. 155), as if the place where the orrery-like device was found in an ancient shipwreck off the island of Antikythera in Greece were indeed the object itself). With no evidence or explanation whatsoever, Ifrah suggests that this device of gears to replicate the motions of the planets "may possibly have been used in navigation" (*Computing*, p. 155).

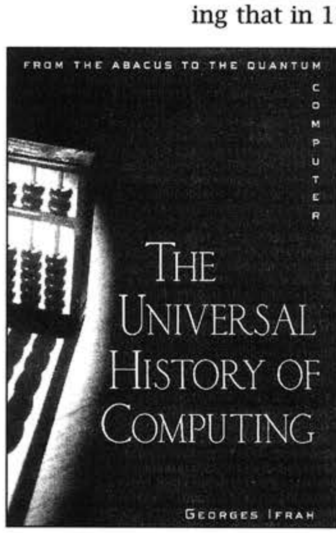
Ifrah soon gets to more recent analog devices—like the slide rule—but again offers little in the

[1] *The translators also add that this was the first printed work on mathematics, but actually, the first was the Latin edition of* Euclid's Elements *by Campanus, printed by Ratdolt in 1482. Commercial arithmetics were printed as early as 1478, and the* Bamberger Blockbuch *was block printed sometime between 1471 and 1482, with the* Bamberger Rechenbuch *published in 1483. I am grateful to C. J. Scriba for bringing these details to my attention.*

way of helpful information. The following is typical of the presentation:

> The slide rule was invented in 1620 by the Englishman Edmund Gunter and enhanced around 1623 by William Oughtred. It was further improved by Robert Bissaker in 1654 and by Seth Partridge in 1671, finally receiving its modern form in 1750 at the hands of Leadbetter. As a matter of interest, while the slide rule had been introduced in France in 1815 by Jomard, it was judged too revolutionary at the time; only in 1851, when the mathematician Amédée Mannheim added further useful enhancements to it, did it take on [sic] with the French...." (*Computing*, p. 156)

This is also a very good example of how frustrating at times this book is to read, with its strings of dates and last names (assuming readers will be familiar with the likes of Leadbetter and Jomard), and without indications of what is at issue. Apart from problems with the translation (either the slide rule "caught on" or "took off", but it did not "take on"), surely most readers would like to know what made the slide rule seem so revolutionary in France, and what additions Mannheim made that were particularly useful. This same frustration was apparently felt by the translators, because several pages later, they provide an addendum of nearly four pages offering "principles and examples of analog computational devices" (*Computing*, pp. 163–7), including a brief but clear explanation of how the slide rule works. However, the various "improvements" to which Ifrah alludes are not described, nor is anything said about the French Revolution.



The Universal History of Computing is divided into two parts. Part One is a summary of the major results of Volume I, including a chronological summary recapitulating in a mere eighteen pages what Volume I covered in over 600! This is followed by more than forty tables classifying the world's many different number systems into three basic types (additive, hybrid, and positional), with various subcategories distinguishing minor variants. Unfortunately, the same mistakes or misinterpretations are repeated here as in Volume I, and more blatantly in some cases, as for example when Ifrah writes that between 2700 and 2300 BCE, the people of Sumer "invent their abacus", or when he says that the Zapotecs and other pre-Columbian cultures "make use of calculating instruments" because their base-twenty system is "ill-adapted" for calculation.

Two examples of how unreliable Ifrah's "chronology" can be are the entries for Dedekind and Cantor. Ifrah quotes Dedekind to the effect that "[t]he straight line is infinitely richer in points than the set of algebraic numbers is" (*Computing*, p. 84). This is a misquotation—Dedekind does not refer to algebraic numbers, but rather to the set of rational numbers (which were the elements of Dedekind's famous "cuts"—the means by which he rigorously defined the real numbers, something Ifrah does not mention). What is significant here is that Dedekind had no idea how much "richer" the set of real numbers really was. That understanding had to wait for Georg Cantor's proof that the real numbers are nondenumerably infinite.

Ifrah then gets the dating out of sequence, saying that in 1883 Cantor proved that the set of algebraic numbers is countable. This time Ifrah is right about algebraic numbers but wrong about the year—which was in fact a decade earlier, in 1873. In addition to proving that the algebraic numbers are denumerably infinite, Cantor ended his paper (published in 1874) with his truly revolutionary proof that the *real* numbers are *nondenumerably* infinite—something Ifrah never mentions! It is surprising that there is also no mention of Cantor's later use of the diagonalization method to again establish the nondenumerability of the real numbers (and the existence of even higher powers of transfinite sets) in 1891, or the continuum hypothesis (though Ifrah does include an entry in his chronology for 1931 mentioning Gödel and his Incompleteness Theorem).

In what is called a "tailpiece" to this section, apparently added by the translators, a short paragraph calls attention to the fact that "we have now met the five fundamental numbers of mathematics, 0, 1, e, π and i" and notes these five numbers have a startling relationship: $e^{i\pi} + 1 = 0$. But this is offered with absolutely no explanation of why such a relationship should exist or of what its truly remarkable features are (p. 85). And this time the translators do not attempt to make up for the omission.

As if acknowledging the hopelessness of his chronology of the major steps "from calculation to calculus" when it comes to the first half of the twentieth century, this is—*verbatim*—what Ifrah writes:

> This period saw fundamental contributions from Western mathematicians

> and logicians to the development of contemporary mathematics and logic, especially in the areas of algorithmic logic and symbolic calculus. Notable figures in this history are G. Frege, G. Peano, B. Russell, A. N. Whitehead, D. Hilbert, E. Zermelo, E. Steinitz, R. Carnap, E. Artin, K. Gödel, E. Post, S. C. Kleene, A. Turing, A. Church, J. von Neumann, A. A. Markov, P. S. Novikov, H. Cartan, C. Chevalley, J. Delsarte, J. Dieudonné, A. Weil; and of course many others. (*Computing*, p. 85)

And that is all Ifrah has to say. If these are among the most prominent mathematicians and logicians who made "fundamental contributions" in areas relevant to Ifrah's project, it would be reasonable to expect more details to come up, if not now, then surely later. But the hopeful reader turning to the index will be disappointed to find that *nothing* is listed there for Frege, Zermelo, Steinitz, Carnap, Artin, Post, Kleene, Markov, Novikov, Cartan, Chevalley, Delsarte, Dieudonné, or Weil. Why parade all these names if nothing more about them is to be said? Without some explanation of the accomplishments of these "notable figures", this is an otherwise meaningless succession of names.

Later in the book, Ifrah again uses this same approach in an impossible attempt to cover the course of mathematics from classical algebra to set theory in a very brief two pages. After describing developments from Cantor and the origins of set theory to lattice theory, general topology, and the theory of categories, Ifrah presents a list of mathematical areas, about which he comments:

> This list quite simply gives the names of some of the countless areas which modern mathematics has explored with new and fascinating techniques for whoever takes the trouble of mastering them. It is nevertheless amply sufficient to provide an understanding of how much these new concepts, marked by the growing importance attributed to set theory, have radically altered the very spirit of the science of mathematics. (*Computing*, p. 260)

But this verges on parody. Ifrah provides nothing more than the names of these mathematical areas; he alludes to "techniques" but does not describe what they are or why they are so significant. This provides no insight about how such concepts altered mathematics, nor does it provide anything to interest or enlighten the reader.

Moreover, Ifrah clearly does not have a good understanding of set theory or its history. Without citing his sources, Ifrah explains that "[t]hus axiomatics was created by Cantor for sets, and by Hilbert for geometry" (*Computing*, p. 263). Not only did neither of these great figures create axiomatics, but Cantor never treated his theory axiomatically—in his hands it always remained a naive theory. And surely Ifrah knows that it was Euclid and his Greek progenitors who created axiomatics for geometry; what Hilbert did was to axiomatize geometry in a way that he hoped would make it possible to prove its consistency. Ifrah never gets to such levels of detail or significance.

Calculators and Computers

Part Two of *The Universal History of Computing* consists of three chapters: "From Clockwork Calculator to Computer: The History of Automatic Calculation", "What is a Computer?", and "Information, the New Universal Dimension". These chapters address the volume's main subject, but it is territory on which Ifrah is not very sure of himself.

Unexpectedly, Ifrah himself admits to some misgivings: "I have, over many years, hesitated long and often before publishing the account which follows. I have held back for so long as the ideas which I expressed were still no better structured than the accounts in sundry 'static' histories, mere accumulations of fact but not co-ordinated on the historical scale" (*Computing*, p. 109). But in fact, what appears here is still largely unstructured, a mix of material snipped and quoted from various sources, more secondary than primary, and mostly lacking either technical or historical perspective. A couple of brief examples will give a sense of the truly "universal" problems with the presentation Ifrah offers.

Despite Ifrah's wish to go beyond the "static histories", his account of the evolution of the computer is basically a prosaic one, starting from the earliest calculating machine designed by the German astronomer Wilhelm Schickard in 1623, and continuing to the first machines to survive to the present, those of Pascal and Leibniz. Charles Babbage receives considerable space, but the development of true computers is a twentieth-century story. As Ifrah says, Babbage's dream became reality with the Mark I at Harvard, built by Howard Aiken. Typically, much of Ifrah's treatment is unsatisfyingly vague. Ifrah says that Aiken "was faced with a set of complex mathematical problems whose solutions would have required an inordinate amount of time by human hand alone." What problems Aiken faced, and how they may have influenced development of the Mark I, Ifrah never says. He does point out the limitations of the slowness of the Mark I as an electro-mechanical calculator, a limitation overcome in the Mark II and successive generations that moved entirely to electronic computing. The first completely electronic, multipurpose, analytical calculator was the American ENIAC (Electronic Numerical Integrator and Computer).

Ifrah covers many of the basic computers that were coming onto the scene in the 1940s and 1950s—BINAC, EDVAC, SEAC, UNIVAC, MADM, EDSAC, LEO, etc.—but does not mention my personal favorite, von Neumann's Mathematical Analyzer, Numerical Integrator and Computer (MANIAC). In a book replete with acronyms throughout, a glossary would have been helpful. American readers can be assumed perhaps to know what IBM and UNIVAC represent, but what about the machines from France that Ifrah naturally introduces? For example, he discusses the development in the 1950s of the SEA analog computers, including the ANALAC built by CSF. None of the acronyms are defined or explained, and none appear in the index.

Incompleteness

One problem with Ifrah's presentation is that facts are often listed as if he were assembling a mass of information collected on note cards. Usually there is no interpretation or analysis of the significance of the items strewn about one after the other. To give but one example, in a very condensed summary of advances made in computing in the U.S. in the 1950s, Ifrah mentions the Whirlwind I at the Massachusetts Institute of Technology, "another computer based on the plans of von Neumann" (*Computing*, p. 294). It was conceived under the direction of Jay W. Forrester and had "a magnetic-core memory, a graphics printer, remote user interaction system,..., etc." What the "etc." means is unclear, and most of this will be meaningless to anyone not already conversant with the basics of computer engineering and the Whirlwind I. It should at least have been pointed out that what was truly innovative about Forrester's Whirlwind was the invention of the coincident-current magnetic core memory (developed with Jan Rajchman of RCA), which for the first time allowed computers to be built with very large storage capacities.

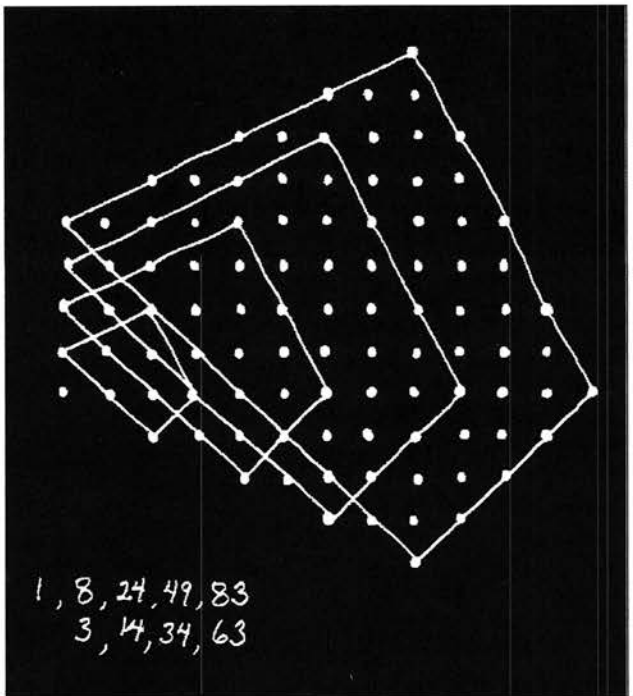
Ifrah also misses one of the most interesting points about the first public application of UNIVAC, when "it was used on CBS television for opinion polls during the presidential elections of 1952, accurately predicting Eisenhower's victory" (*Computing*, p. 294). That it did, but there is more to the story. Nationwide polls had forecast a nose-to-nose race between Dwight D. Eisenhower and Adlai Stevenson. The UNIVAC programmers were so aghast at the landslide the computer initially predicted (forty-three states and 438 electoral votes for Eisenhower) that they pulled the plug on UNIVAC and repeatedly reprogrammed the computer until it predicted twenty-four states for each candidate, with an electoral vote difference of 270 for Eisenhower, 261 for Stevenson. This was an outcome too close to call, as CBS news then reported. Only later, after the official precinct-by-precinct counts had been reported, was the truth admitted and the original UNIVAC prediction allowed to stand, with some difficult explaining to do. As the Jacksonville, Florida *Journal* headlined the next morning: "Machine Makes a Monkey out of Man," (Wulforst, p. 170).

Quantum Computing, Information, and Human Intelligence

As *The Universal History of Computing* comes to an end, Ifrah seems to have run out of energy or lost interest. The last chapter, prior to Ifrah's conclusion, is called "Information, the New Universal Dimension" and offers little more than a pastiche of the views of others. One would expect that, as Ifrah reaches his conclusion, "Intelligence, Science, and the Future of Mankind", he would make an attempt to tie everything together. But rather than speak for himself, he again leaves the writing to others. "To unravel this story of human intelligence our best option in this concluding chapter has been to have a number of significant authors speak in their own words, which we have collated into a sort of mosaic" (*Computing*, p. 348). He then presents a rag-tag collection of such authors as Molière, d'Alembert, Gonseth, Bergson, Piaget, Ellul, Brunschvicg, Comte, Hadamard, Poincaré, Bachelard, Blondel, Lévi-Strauss, and Rabelais (to list only a few of the French authors cited). More satisfying would have been a critical analysis and discussion of the most recent work of the past decade on the subject of information.

Responsibility

In reflecting on the course of this review, I want to end with some personal observations about the obligations of writers, publishers, editors, and reviewers to their respective audiences. As George Sarton once advised in a notice about how to write a book review, no one who has ever written a book should be taken lightly (Sarton, pp. 155-156). It is a tremendous amount of work to get anything into print. A book is the result of a collaborative effort among authors, publishers, editors, printers, and ultimately, the public that purchases the final product. But authors, editors, and publishers share an important responsibility in this process—to be sure that the subject matter is treated accurately and that the book does not create false impressions about what it achieves. On both counts it seems clear that neither Ifrah nor his editors and publishers have served their readers well. Despite Ifrah's obvious enthusiasm for his subject, what he has written cannot be regarded as reliable or "universal".



A nonspecialist who writes for a popular audience about very technical matters needs more than enthusiasm for his subject to earn the confidence of his readers. Here too, editors and publishers bear responsibility. Did the original French publisher, Editions Robert Laffont, or subsequently the Harvill Press in Britain or John Wiley & Sons in the U.S., actually refer Ifrah's manuscripts to any serious experts in the history of mathematics? This hardly seems possible. The lack of expert evaluation no doubt helps to explain why a group of French academics felt it was necessary, and indeed was their obligation, to collaborate in making clear Ifrah's dangerous disregard for the most recent research and scholarship (see the references in the first part of this review). Furthermore, the numerous additions, explanations, and corrections offered by the translators in Volume II should have alerted Ifrah's editors to problems that the author could have addressed as the books were being translated, especially in light of the strong criticism Volume I received in France.

Potential readers should in turn be wary of reviews of such books by nonexperts. The newspaper critics quoted on the books' dust jackets may have been impressed, but those critics were clearly not aware of the scholarship of experts—scholarship Ifrah has exaggerated, misinterpreted, ignored, or failed to consult. Insuring the integrity of the finished work is especially important with books like Ifrah's, because the background necessary to judge them is well beyond the capacity of ordinary readers, who are unlikely to be able to spot his inaccuracies and inflated claims.

For its part, John Wiley & Sons has made clear it accepts no responsibility for the contents of Ifrah's books: Tucked away on the back of each title page is a disclaimer I have never seen in a book before (though the publisher says it appears in all Wiley books as a matter of course). The disclaimer reads:

> This publication is designed to provide accurate and authoritative information in regard to the subject matter covered. It is sold with the understanding that the publisher is not engaged in rendering professional services. If professional advice or other expert assistance is required, the services of a competent professional person should be sought.

In other words, *Caveat lector.*

References

[1] George Sarton, Notes on the reviewing of learned books, *Isis*, **41** (1950), 149–158.

[2] Harry Wulforst, *Breakthrough to the Computer Age*, Charles Scribner's Sons, New York, 1982.

2001 Annual Survey of the Mathematical Sciences

(First Report)

Report on the 2001 New Doctoral Recipients
Faculty Salary Survey

Don O. Loftsgaarden, James W. Maxwell, and Kinda Remick Priestley

The First Report of the 2001 Annual Survey gives information about the employment status of 2000–01 new doctoral recipients from U.S. departments in the mathematical sciences and salary data on faculty members in U.S. departments of mathematical sciences in four-year colleges and universities. This report is based on information collected from two questionnaires distributed to departments in May 2001. A follow-up questionnaire was distributed to the individual new doctoral recipients in October 2001. This questionnaire will be used to update and revise results in this report, which are based on information from the departments that produced the new doctorates. Those results will be published in the Second Report of the 2001 Annual Survey in the August 2002 issue of the *Notices*. Another questionnaire concerned with data on fall 2001 course enrollments, majors, graduate students, and departmental faculty was distributed to departments in September 2001. Results from this questionnaire will appear in the Third Report of the 2001 Annual Survey in the September 2002 issue of the *Notices*.

The 2001 Annual Survey represents the forty-fifth in an annual series begun in 1957 by the American Mathematical Society. The 2001 Survey is under the direction of the Annual Survey Data Committee, a joint committee of the American Mathematical Society, the American Statistical Association, the Institute of Mathematical Statistics, and the Mathematical Association of America. The current members of this committee are Lorraine Denby, J. Douglas Faires, Mary W. Gray, Peter E. Haskell, G. Samuel Jordan, Ellen E. Kirkman, James M. Kister, James Lewis, Don O. Loftsgaarden (chair), James W. Maxwell (ex officio), and Yashiswini Mittal. The committee is assisted by AMS survey analyst Kinda Remick Priestley and survey coordinator Colleen Rose. Comments or suggestions regarding this Survey Report may be directed to the Committee.

Report on the 2001 New Doctoral Recipients

This report presents a statistical profile of recipients of doctoral degrees awarded by departments in the mathematical sciences at universities in the United States during the period July 1, 2000, through June 30, 2001. It includes a preliminary analysis of the employment of 2000–01 doctoral recipients and a demographic profile summarizing characteristics of citizenship status, sex, and racial/ethnic group. All information came from the departments that gave the degrees. Table 1 provides the departmental response rates for the 2001 Survey of New Doctoral Recipients. See page 231 for a description of the groups. No adjustments were made in this report for nonresponding departments.

Table 1: Doctorates Granted Response Rates

Group I (Pu)	24 of 25 including 0 with 0 degrees
Group I (Pr)	22 of 23 including 0 with 0 degrees
Group II	51 of 56 including 4 with 0 degrees
Group III	70 of 74 including 20 with 0 degrees
Group IV	70 of 86 including 8 with 0 degrees
Group Va	18 of 20 including 1 with 0 degrees
Group Vb	No longer surveyed

Recent Changes in Procedures for the Annual Survey

The following three changes need to be considered when comparing results in this report to those in prior years. More details on these changes can be found in the First Report for the 2000 Annual Survey.

Highlights

There were 1,008 new doctoral recipients in 2000-01, down from 1,119 in 1999-00. Approximately 40% of this decrease is due to a lower response rate from departments in 2000-01.

The number of new doctoral recipients from Groups I (Pu), I (Pr), and II combined has dropped from 744 in 1997-98 to 565 in 2000-01, a drop of 24.1% in three years.

Based on responses from departments alone, the fall 2001 unemployment rate for the 876 new doctoral recipients from 2000-01 whose employment status is known is 5.6%. This figure will be revised later using information collected from the new doctoral recipients themselves. The fall 2000 unemployment rate was 4.6%.

Of the new doctoral recipients who have jobs, 58 (7.1%) have positions in the institution from which they received their degrees, though not necessarily in the same department, and 14 have part-time jobs. The 58 represents 11.4% of the U.S. academic positions filled by new doctoral recipients.

Of the 717 new doctoral recipients employed in the U.S., 168 (23.4%) have jobs in business or industry. In fall 2000 this number was 206 (25.9%).

The number of new doctoral recipients taking U.S. academic positions was 510 in fall 2001 down from 551 in fall 2000.

Of the 1,008 new doctoral recipients in 2000-01, 494 (49.0%) are U.S. citizens.

Females account for 292 (29.0%) of the 1,008 new doctoral recipients in 2000-01 down slightly from 302 (27.0%) in 1999-2000. Of the 494 U.S. citizen new doctoral recipients, 151 (30.6%) are females, down from the record 187 (33.8%) in 1998-99, but still the second largest percentage ever recorded.

Among the U.S. citizen new doctoral recipients, there were 14 Black or African Americans and 11 Hispanic or Latinos. The largest minority group was Asians with 30. Whites accounted for 431 (87.2%) of U.S. citizen new doctoral recipients.

Among new doctoral recipients hired in U.S. doctoral granting departments, 46.4% are U.S. citizens. For other U.S. academic positions, 65.9% of the new doctoral recipients hired were U.S. citizens.

Group IV produced 237 new doctorates of which 98 (41.4%) are females, compared to all other doctoral groups combined where 194 of 771 (25.2%) are females.

For field of thesis, 289 of the 1,008 new doctoral recipients were in probability (34) or statistics (255). The next highest number was in algebra and number theory with 137.

1. Data used for the First Report is gathered from doctoral-granting departments beginning in May each year. These results are updated in the Second Report using data gathered from the new doctoral recipients in the following October. Prior to 1997 these latter data were gathered earlier and early returns were used in the First Reports.

2. Group Vb containing Operations Research/Management Science doctoral-granting departments has not been surveyed since 1998. Doctorates granted in Group Vb have been removed from any tables in this report that give data from past years, unless noted otherwise.

3. For the past five years Group IV, doctoral-granting statistics and biostatistics departments, has been under revision. It included 80 departments in 1995-96 and for 2000-01 it has 86 departments. Several drops and additions were involved in going from 80 to 86.

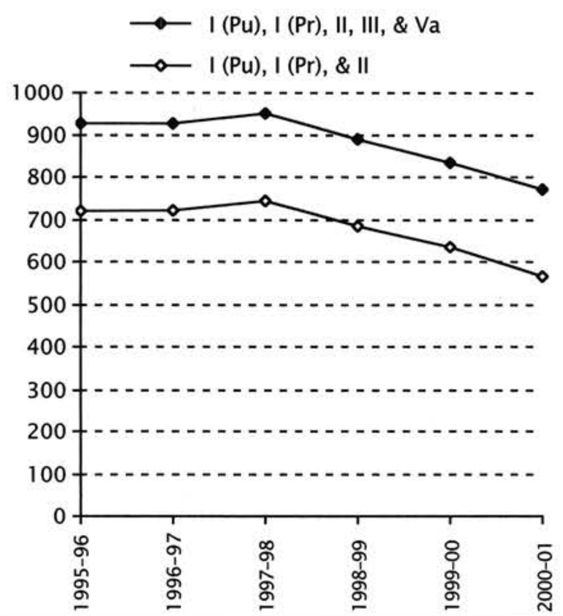
Doctoral Degrees Granted

Table 2 shows the number of new doctoral degrees granted by the different doctoral groups surveyed in the Annual Survey for the past six years. The 1,008 new doctorates granted by these departments in 2000-01 is a decrease of 111 from 1999-2000. While every group except Group Va showed a decrease this year, the drops in Groups

Table/Figure 2: New Doctoral Degrees Awarded by Group, Fall Count

Group	I (Pu)	I (Pr)	II	III	IV	Va	Total*
1995-96	325	174	222	124	172	81	1098
1996-97	297	187	238	132	197	72	1123
1997-98	306	174	264	129	213	77	1163
1998-99	292	152	241	136	243	69	1133
1999-00	256	157	223	132	284	67	1119
2000-01	233	129	203	125	237	81	1008

*Does not include Vb. See "Recent Changes in Procedures" on page 217.



Don O. Loftsgaarden is professor emeritus of mathematics at the University of Montana. James W. Maxwell is AMS associate executive director for Professional Programs and Services. Kinda Remick Priestley is AMS survey analyst.

Table 3A: Employment Status of 2000–01 U.S. New Doctoral Recipients in the Mathematical Sciences by Field of Thesis

TYPE OF EMPLOYER		FIELD OF THESIS: Algebra Number Theory	Real, Comp., Funct., & Harmonic Analysis	Geometry/ Topology	Discr. Math./ Combin./ Logic/ Comp. Sci.	Probability	Statistics	Applied Math.	Numerical Analysis/ Approxi-mations	Linear Nonlinear Optim./ Control	Differential, Integral, & Difference Equations	Math. Education	Other/ Unknown	TOTAL
Group I (Public)		14	15	11	9	5	0	4	3	1	7	0	1	**70**
Group I (Private)		11	3	16	5	1	2	4	6	2	5	0	2	**57**
Group II		10	8	9	4	0	2	4	4	1	6	2	0	**50**
Group III		7	3	2	1	0	3	3	0	0	3	0	0	**22**
Group IV		0	0	0	0	4	34	0	0	0	1	0	2	**41**
Group Va		0	1	1	1	0	1	4	1	1	2	0	0	**12**
Master's		9	6	6	4	2	7	3	1	4	11	3	1	**57**
Bachelor's		19	14	16	17	3	6	7	6	2	6	5	3	**104**
Two-Year College		4	1	2	1	0	1	0	0	0	1	1	0	**11**
Other Academic Dept.		4	0	3	5	2	26	13	4	1	4	5	2	**69**
Research Institute/ Other Nonprofit		3	1	1	2	1	5	3	1	0	0	0	0	**17**
Government		2	1	1	2	1	19	4	7	0	2	0	0	**39**
Business and Industry		11	9	7	12	7	69	23	13	4	9	0	4	**168**
Non-U.S. Academic		12	9	13	4	2	18	6	0	5	9	2	0	**80**
Non-U.S. Nonacademic		3	1	0	0	1	7	1	1	0	1	0	0	**15**
Not Seeking Employment		2	1	1	3	0	3	4	0	0	1	0	0	**15**
Still Seeking Employment		9	2	5	4	3	10	8	0	1	6	1	0	**49**
Unknown (U.S.)		9	5	6	9	0	34	10	6	1	8	5	1	**94**
Unknown (non-U.S.)*		8	1	8	2	2	8	0	4	1	4	0	0	**38**
Column Total		**137**	**81**	**108**	**85**	**34**	**255**	**101**	**57**	**24**	**86**	**24**	**16**	**1008**
Column Subtotals	Male	106	67	78	60	27	152	76	45	19	64	14	8	**716**
	Female	31	14	30	25	7	103	25	12	5	22	10	8	**292**

*Includes those whose status is reported as "unknown" or "still seeking employment".

Table 3B: Employment Status of 2000–01 U.S. New Doctoral Recipients in the Mathematical Sciences by Type of Degree-Granting Department

TYPE OF EMPLOYER		TYPE OF DOCTORAL DEGREE-GRANTING DEPARTMENT: Group I (Public) Math	Group I (Private) Math	Group II Math	Group III Math	Group IV Statistics	Group Va Applied Math	ROW TOTAL	ROW SUBTOTAL Male	ROW SUBTOTAL Female
Group I (Public)		41	11	10	4	1	3	**70**	53	17
Group I (Private)		26	25	1	0	2	3	**57**	47	10
Group II		17	6	16	7	3	1	**50**	35	15
Group III		11	1	3	4	2	1	**22**	17	5
Group IV		1	2	1	0	37	0	**41**	27	14
Group Va		6	1	0	0	0	5	**12**	10	2
Master's		4	3	23	18	6	3	**57**	42	15
Bachelor's		24	8	40	27	5	0	**104**	70	34
Two-Year College		4	1	2	4	0	0	**11**	6	5
Other Academic Dept.		10	6	12	9	23	9	**69**	43	26
Research Institute/ Other Nonprofit		2	6	1	1	5	2	**17**	12	5
Government		3	3	8	4	17	4	**39**	22	17
Business and Industry		24	15	25	21	59	24	**168**	129	39
Non-U.S. Academic		21	13	19	5	16	6	**80**	62	18
Non-U.S. Nonacademic		1	3	2	0	6	3	**15**	13	2
Not Seeking Employment		4	2	5	1	3	0	**15**	9	6
Still Seeking Employment		13	7	8	5	10	6	**49**	28	21
Unknown (U.S.)		17	3	23	12	34	5	**94**	66	28
Unknown (non-U.S.)*		4	13	4	3	8	6	**38**	25	13
Column Total		**233**	**129**	**203**	**125**	**237**	**81**	**1008**	**716**	**292**
Column Subtotals	Male	172	107	147	92	139	59	**716**		
	Female	61	22	56	33	98	22	**292**		

*Includes those whose status is reported as "unknown" or "still seeking employment".

Table 3C: Field of Thesis of 2000–01 New Doctoral Recipients by Type of Degree-Granting Department

TYPE OF DOCTORAL DEGREE-GRANTING DEPARTMENT	FIELD OF THESIS: Algebra Number Theory	Real, Comp., Funct., & Harmonic Analysis	Geometry/ Topology	Discr. Math./ Combin./ Logic/ Comp. Sci.	Probability	Statistics	Applied Math.	Numerical Analysis/ Approxi-mations	Linear Nonlinear Optim./ Control	Differential, Integral, & Difference Equations	Math. Education	Other/ Unknown	TOTAL
Group I (Public)	57	27	43	28	8	7	15	10	4	26	0	8	233
Group I (Private)	33	7	30	14	5	2	13	5	3	17	0	0	129
Group II	38	30	22	17	9	7	26	16	8	23	7	0	203
Group III	8	15	12	10	3	18	12	12	4	14	17	0	125
Group IV	0	0	0	0	8	213	8	0	0	0	0	8	237
Group Va	1	2	1	16	1	8	27	14	5	6	0	0	81
Total	137	81	108	85	34	255	101	57	24	86	24	16	1008

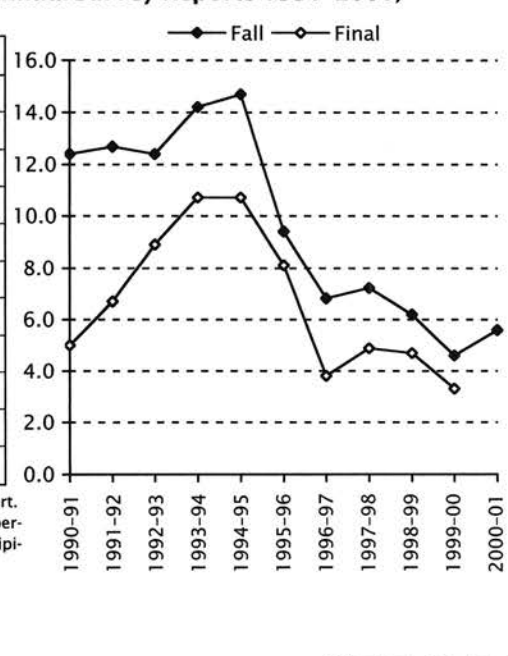
I (Pu), I (Pr), II, and IV were particularly large. Response rates were down slightly, mainly in Groups II and IV.

A department by department analysis showed that overall the drop in response rates only accounted for about 40% of the overall drop in new doctorates granted in 2000–01. It accounted for almost none of the drops in Groups I (Pu), I (Pr), and III, but did account for 75%-80% of the drops in Groups II and IV. It is hoped that response rates can be increased before these results are updated in the 2001 Second Report which will be published in August 2002.

If one considers the new doctoral recipients in all Groups except IV for the six years in Table 2, the numbers are 926, 926, 950, 890, 835, and 771. There has been an 18.8% drop in new doctoral recipients in these departments from 1997–98 to 2000–01. If one considers only Groups I (Pu), I (Pr), and II, there has been a 24.1% drop in new doctoral recipients since 1997–98, from 744 to 565. Figure 2 illustrates these trends.

Table/Figure 4A: Percentage of New Doctoral Recipients Unemployed (as reported in the respective Annual Survey Reports 1991–2001)

Report	Fall	Final
1990-91	12.4	5.0
1991-92	12.7	6.7
1992-93	12.4	8.9
1993-94	14.2	10.7
1994-95	14.7	10.7
1995-96	9.4	8.1
1996-97	6.8	3.8
1997-98	7.2	4.9
1998-99	6.2	4.7
1999-00	4.6	3.3
2000-01	5.6	*



*To appear in the Second Report.
Note: Prior to 1998-99, the percents include new doctoral recipients from Group Vb.

The 2000–01 numbers in Table 2 will be broken down in various ways, such as by sex, in later sections of this report. The names of the 1,008 new doctoral recipients are found on pages 241-258 of this issue of the *Notices*.

Employment Status of 2000–01 U.S. New Doctoral Recipients

Table 3A gives a cross-tabulation of the 1,008 new doctoral recipients in the mathematical sciences: Type of Employer by Field of Thesis. Table 3B gives a cross-tabulation of the same data: Type of Employer by Type of Degree-Granting Department (Group). Table 3C gives a cross-tabulation of these same data: Type of Degree-Granting Department (Group) by Field of Thesis. This table gives a picture of the type of doctoral students being trained in the various groups. These tables contain a wealth of information about the employment of these new doctoral recipients, some of which will be discussed in this report. Keep in mind that the results in this report come from the departments giving the degrees and not from the degree recipients themselves. These tables will be revised using information from the doctoral recipients themselves and they will appear in the 2001 Second Report in August 2002.

The last column (Total) in Table 3A can be used to find the overall unemployment rate. In this and other unemployment calculations in this report, the individuals whose employment status is not known (Unknown (U.S.) and Unknown (non-U.S.)) are first removed, and the unemployment fraction is the number still seeking employment divided by the total number of individuals left after the "Unknowns" are removed. The overall unemployment rate for these data is 5.6%. This figure will be updated later with information gathered from the individual new doctoral recipients. The analogous figure for fall 2000 is 4.6%. Table/Figure 4A shows how this employment rate compares with other years over the past decade. The unemployment rate varies from group to group, with a high of 8.6% for Group Va and a low of 4.5% for both Groups II and III.

There are 717 new doctoral recipients employed in the U.S. Of these, 510 (71.1%) hold academic positions, 39 (5.4%) are employed by government, and 168 (23.4%) hold positions in business and industry. In the First Report for 1999–2000, there were 796 new doctoral recipients employed in the U.S., of which 551 (69.2%) held academic positions, 39 (4.9%) were in government, and 206 (25.9%) were in business and industry.

The number of new doctoral recipients taking jobs in business and industry which had been rising steadily in the mid-1990s has been oscillating for the past four years. Table 4B shows the number of new doctoral recipients who took positions in business and industry by the type of department granting their degree for fall 1998 to fall 2001. Among the 717 new doctoral recipients known to have employment in the U.S. in fall 2001, Group I (Pu) has the smallest percentage taking jobs in business and industry at 13.9% and Group Va the highest at 43.6%.

Table 4B: Number of New Doctoral Recipients Taking Positions in Business and Industry in the U.S. by Type of Degree-Granting Department, Fall 1998 to Fall 2001

Group	I (Pu)	I (Pr)	II	III	IV	Va	Total
Fall 1998	29	27	41	27	70	25	219
Fall 1999	28	19	23	19	57	14	160
Fall 2000	31	23	34	25	79	14	206
Fall 2001	24	15	25	21	59	24	168

Table 4C shows the number of new doctoral recipients who took academic positions in the U.S. by type of department granting their degree for fall 1998 to fall 2001. Among the 717 new doctoral recipients employed in the U.S. 71.1% have academic positions. This percentage is highest for Group I (Pu) at 84.4% and lowest for Groups IV at 52.5% and Va at 49.1%. Table 4D shows how many positions were filled with new doctoral recipients for each type of academic employer. The number taking academic positions in the U.S. dropped off after being relatively high for the past two years.

Table 4C: Number of New Doctoral Recipients Taking U.S. Academic Positions by Type of Degree-Granting Department, Fall 1998 to Fall 2001

Group	I (Pu)	I (Pr)	II	III	IV	Va	Total
Fall 1998	117	97	122	49	84	32	**501**
Fall 1999	157	87	130	70	82	38	**564**
Fall 2000	133	78	112	75	126	27	**551**
Fall 2001	146	70	109	74	84	27	**510**

In fall 2001, 58 new doctoral recipients hold positions in the institution that granted their degree, although not necessarily in the same department. This represents 7.1% of new doctoral recipients who are currently employed and 11.4% of the U.S. academic positions held by new doctoral recipients. In fall 2000 there were also 58 such individuals making up 6.5% of the new doctoral recipients who were employed at the time of the First Report. Fourteen new doctoral recipients have taken part-time positions in fall 2001.

Table 4D: U.S. Academic Positions Filled by New Doctoral Recipients by Type of Hiring Department, Fall 1998 to Fall 2001

Group	I–III	IV	Va	M&B	Other	Total
Fall 1998	177	35	7	177	105	**501**
Fall 1999	221	49	17	175	102	**564**
Fall 2000	209	46	13	158	125	**551**
Fall 2001	199	41	12	161	97	**510**

Information about 2000–01 Female New Doctoral Recipients

Tables 3A and 3B give male and female breakdowns of the new doctoral recipients in 2000–01 by Field of Thesis, by Type of Degree-Granting Department, and by Type of Employer.

Overall, 292 (29.0%) of the 1,008 new doctoral recipients in 2000–01 are female. In 1999–2000, 302 (27.0%) of the new doctoral recipients were female. This percentage varies over the different groups, and these percentages are given in the first row of Table 4E. Following the same trend as in recent years, the percentage is lowest for Group I (Pr), at 17.1%, and highest for Group IV, statistics departments, at 41.4%. The second row of Table 4E gives the percentage of the new doctoral recipients hired who are female for each of the Groups I, II, III, IV and Va. In addition, 26.3% of the new doctoral recipients hired in Group M, master's departments, are female; 32.7% of the new doctoral recipients hired in Group B, bachelor's departments, are female; and 23.2% of new doctoral recipients hired in business and industry are female. The unemployment rate for female new doctoral recipients is 8.4% compared to 4.5% for males and 5.6% overall.

Table 4E: Females as a Percentage of 2000–01 New Doctoral Recipients Produced by and Hired by Doctoral-Granting Groups

%	I (Pu)	I (Pr)	II	III	IV	Va	Total
Produced	26.2	17.1	27.6	26.4	41.4	27.2	**29.0**
Hired	24.3	17.5	30.0	22.7	34.1	16.7	**25.0**

The percentage of female new doctoral recipients within fields of thesis was very similar to previous years, ranging from 17.3% in real, complex, functional, and harmonic analysis to 38.1% in probability or statistics and 41.7% in mathematics education.

Table 4F: Employment Status of 2000–01 U.S. New Doctoral Recipients by Citizenship Status

TYPE OF EMPLOYER	CITIZENSHIP				TOTAL DOCTORAL RECIPIENTS
	U.S. CITIZENS	NON-U.S. CITIZENS			
		Permanent Visa	Temporary Visa	Unknown Visa	
U.S. Employer	393	76	227	21	**717**
U.S. Academic	287	53	155	15	**510**
Groups I, II, III, and Va	105	28	70	8	**211**
Group IV	12	6	22	1	**41**
Non-Ph.D. Department	161	18	56	6	**241**
Research Institute/Other Nonprofit	9	1	7	0	**17**
U.S. Nonacademic	106	23	72	6	**207**
Non-U.S. Employer	11	1	77	6	**95**
Non-U.S. Academic	10	0	66	4	**80**
Non-U.S. Nonacademic	1	1	11	2	**15**
Not Seeking Employment	8	1	4	2	**15**
Still Seeking Employment	28	4	17	0	**49**
SUBTOTAL	440	82	325	29	**876**
Unknown (U.S.)	53	11	27	3	**94**
Unknown (non-U.S.)*	1	0	33	4	**38**
TOTAL	**494**	**93**	**385**	**36**	**1008**

*Includes those whose status is reported as "unknown" or "still seeking employment".

Later sections in this First Report give more information about the female new doctoral recipients who are U.S. citizens and the female new doctoral recipients in Group IV.

Employment Information about 2000–01 New Doctoral Recipients by Citizenship and Type of Employer

Table 4F shows the pattern of employment within broad job categories broken down by citizenship status of the new doctoral recipients. The citizenship status is known for all 1,008 new doctoral recipients in 2000–01.

The unemployment rate for the 494 U.S. citizens is 6.4% compared to 4.2% in 1999–2000. The unemployment rate for non-U.S. citizens is 4.8%. This varies by type of visa. The unemployment rate for non-U.S. citizens with a permanent visa is 4.9%, while that for non-U.S. citizens with a temporary visa is 5.2%.

Among U.S. citizens whose employment status is known, 89.3% are employed in the U.S. Among non-U.S. citizens with a permanent visa whose employment status is known, 92.7% have jobs in the U.S., while this percentage for non-U.S. citizens with a temporary visa is 69.8%.

Table 4G: 2000–01 New Doctoral Recipients Having Employment in the U.S. by Type of Employer and Citizenship

Employer	U.S.	Non-U.S.	Total
U.S. Academic, Groups I–Va	117	135	**252**
U.S. Academic, Other	170	88	**258**
U.S. Nonacademic	106	101	**207**
Total	**393**	**324**	**717**

Table 4G is a cross-tabulation of the 717 new doctoral recipients who have employment in the U.S. by citizenship and broad employment

Table 5: Sex, Race/Ethnicity, and Citizenship of 2000–01 U.S. New Doctoral Recipients

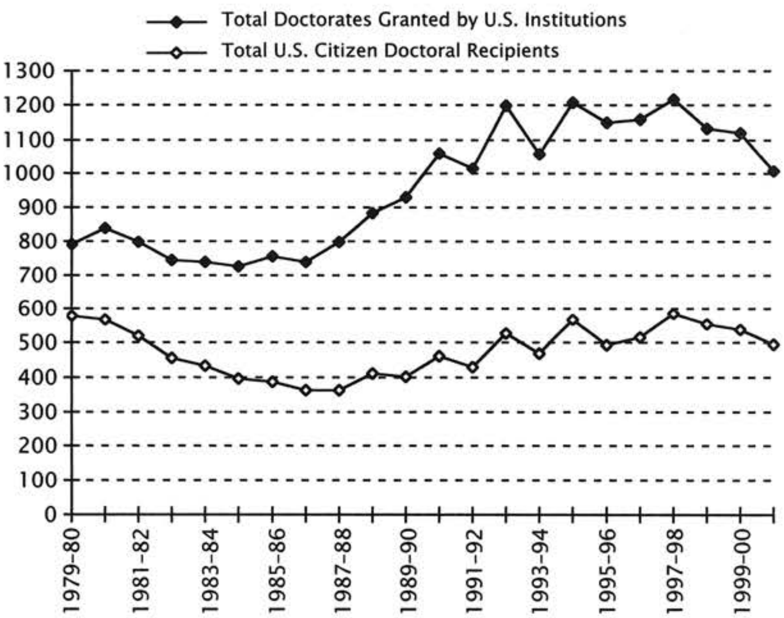
RACIAL/ETHNIC GROUP	MALE					FEMALE					TOTAL
	U.S. CITIZENS	NON-U.S. CITIZENS			Total Male	U.S. CITIZENS	NON-U.S. CITIZENS			Total Female	
		Permanent Visa	Temporary Visa	Unknown Visa			Permanent Visa	Temporary Visa	Unknown Visa		
American Indian or Alaska Native	4	1	0	0	5	1	0	0	0	1	**6**
Asian	18	20	144	15	197	12	14	63	3	92	**289**
Black or African American	6	5	7	0	18	8	1	1	0	10	**28**
Hispanic or Latino	6	1	15	4	26	5	0	4	0	9	**35**
Native Hawaiian or Other Pacific Islander	1	0	1	0	2	1	0	0	0	1	**3**
White	308	29	117	9	463	123	22	30	1	176	**639**
Unknown	0	0	2	3	5	1	0	1	1	3	**8**
TOTAL	**343**	**56**	**286**	**31**	**716**	**151**	**37**	**99**	**5**	**292**	**1008**

Table 6: U.S. Citizen Doctoral Recipients

Year	Total Doctorates by U.S. Institutions	Total U.S. Citizen Doctoral Recipients	%
1975-76	965	722	75
1980-81	839	567	68
1985-86	755	386	51
1990-91	1061	461	43
1995-96	1150	493	43
1996-97	1158	516	45
1997-98	1216	586	48
1998-99*	1133	554	49
1999-00	1119	537	48
2000-01	1008	494	49

*Prior to 1998-99, the counts include new doctoral recipients from Group Vb. In addition, prior to 1982-83, the counts include recipients from computer science departments.

Figure 6A: U.S. Citizen Doctoral Recipients



categories, using numbers from Table 4F. Of the 717 new doctoral recipients having jobs in the U.S., 54.8% are U.S. citizens. Of the 252 new doctoral recipients who took jobs in U.S. doctoral-granting departments, 46.4% are U.S. citizens. Of the 258 who took other academic positions, 65.9% are U.S. citizens. Of the 207 who took nonacademic positions, 51.2% are U.S. citizens.

Of the 393 U.S. citizens employed in the U.S., 29.8% have jobs in a doctoral-granting department, 43.3% are in other academic positions, and 27.0% are in nonacademic positions. For the 324 non-U.S. citizens employed in the U.S., the analogous percentages are 41.7%, 27.2%, and 31.2% respectively.

Figure 6B: U.S. Citizen Doctoral Recipients by Percent

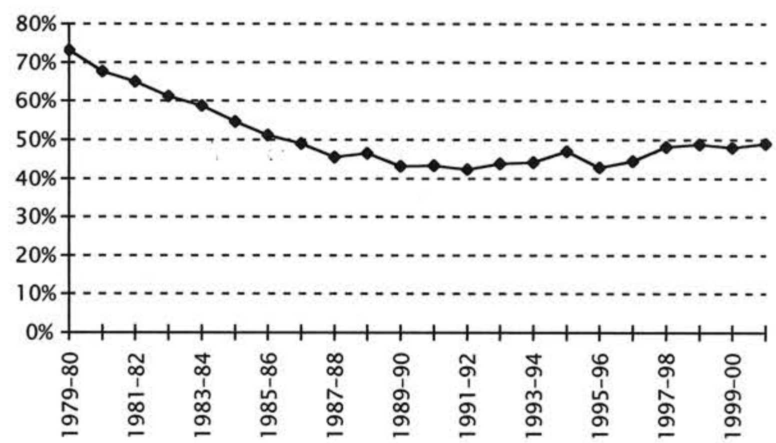


Table 7: U.S. Citizen Doctoral Recipients by Sex

Year	Total U.S. Citizen Doctoral Recipients	Male	Female	% Female
1975-76	722	636	86	12
1980-81	567	465	102	18
1985-86	386	304	82	21
1990-91	461	349	112	24
1995-96	493	377	116	24
1996-97	516	368	148	29
1997-98	586	423	163	28
1998-99*	554	367	187	34
1999-00	537	379	158	29
2000-01	494	343	151	31

*Prior to 1998-99, the counts include new doctoral recipients from Group Vb. In addition, prior to 1982-83, the counts include recipients from computer science departments.

Figure 7: Female U.S. Citizen Doctoral Recipients by Percent

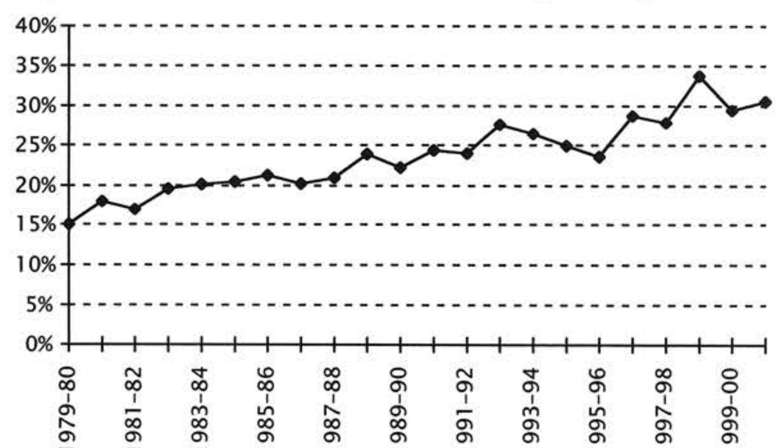


Table 8: Sex and Citizenship of 2000–01 New Doctoral Recipients by Granting Department

Group	I (Pu)		I (Pr)		II		III		IV		Va		Total	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
U.S. Citizen	84	26	45	12	77	35	45	22	62	47	30	9	**343**	**151**
Non-U.S. Citizen	88	35	62	10	70	21	47	11	77	51	29	13	**373**	**141**
Total	**172**	**61**	**107**	**22**	**147**	**56**	**92**	**33**	**139**	**98**	**59**	**22**	**716**	**292**

Sex, Race/Ethnicity, and Citizenship Status of 2000–01 U.S. New Doctoral Recipients

Table 5 presents a breakdown according to sex, racial/ethnic group, and citizenship status of new doctoral recipients. The information reported in this table was obtained in summary form from the departments granting the degrees.

There were 494 (49.0%) U.S. citizens among the 1,008 new doctoral recipients in 2000–01. Table 6, Figure 6A, and Figure 6B give the number of new U.S. doctoral recipients and the number of U.S. citizens back to 1975–76. The percentage of U.S. citizens has remained essentially the same over the last four years.

Among U.S. citizens, 30 are Asians (18 male and 12 female), 14 are Blacks or African Americans (6 male and 8 female), 11 are Hispanics or Latinos (6 male and 5 female), 431 are whites (308 male and 123 female), and 8 are other. Among non-U.S. citizens, there are 259 Asians, 24 Hispanics or Latinos, 208 whites, and 23 are other.

Females make up 30.6% of the 494 U.S. citizens receiving doctoral degrees in the mathematical sciences in 2000–01. This is up from last year but still down from 33.8% in 1998–99, the highest percentage of females among U.S. citizen new doctoral recipients ever reported by the Annual Survey. Among the 514 non-U.S. citizen new doctoral recipients, 141 (27.4%) are female.

Table 7 and Figure 7 give the historical record of U.S. citizen new doctoral recipients, broken down by male and female for past years, going back to 1975–76. The number of male U.S. citizen new doctoral recipients decreased by 36 from 1999–2000.

Table 8 gives a sex by citizenship breakdown of the new doctorates within each of the six types of doctoral granting departments. Among all 1,008 new doctoral recipients, 47.9% of the males and 51.8% of the females are U.S. citizens. The percentage of the new doctoral recipients who are U.S. citizens within the groups is lowest in Group I (Pr) at 44.2% and highest in Group II at 55.2%.

2000–01 New Doctoral Recipients in Group IV

Group IV contains U.S. departments (or programs) of statistics, biostatistics, and biometrics reporting a doctoral program. In the Annual Survey Reports, Group IV is referred to as the Statistics Group. For five years, substantial effort has gone into making Group IV an appropriate set of departments for the Annual Survey, and increasing the number of Group IV departments that respond to the Annual Survey. Progress that has been made with these efforts can be seen in Table 9, which contains six years of information for Group IV. Efforts are still ongoing to increase the response rate in this group.

For 2000–01, Group IV has 86 departments, 12 more than the next largest doctoral group. It contains 30% of all doctoral departments surveyed and the 70 departments responding to the Annual Survey produced 237 new doctoral recipients, 23.5% of all new doctoral recipients in 2000–01.The number of new doctorates granted is down 47 from the number reported last year. A large portion of this drop is due to five less departments responding for 2000–01 and the particular departments that did not respond.

In Table 9, most of the variation in numbers for Group IV during these six years is due to changes in Group IV mentioned in the first paragraph of this section and to the number of departments responding. The last two rows of Table 9 give a split of the 2000–01 results between the 55 statistics departments and the 31 biostatistics and biometrics departments when possible.

Because of its size, it is clear that the data from Group IV have a large effect on the overall results when all doctoral groups are combined. Furthermore, Group IV results are often quite different than those for Groups I (Pu), I (Pr), II, III, and Va. Group IV results can mask important changes in the other doctoral groups. In the following paragraphs some of these differences are presented.

For the Group IV new doctoral recipients, 98 of 237 (41.4%) are female, while 194 of 771 (25.2%) are female in the other doctoral groups. Among the U.S. citizens, females accounted for 47 of the 109 (43.1%) Group IV new doctoral recipients while for the other groups, 104 of 385 (27.0%) were female. Overall 151 of 494 (30.6%) U.S. citizen new doctoral recipients were female.

Of 160 Group IV new doctoral recipients who have employment in the U.S., 59 (36.9%) took jobs in business or industry, while for the other doctoral groups 109 of 557 (19.6%) took jobs in business and industry.

Table 9: Six Years of Information about Group IV: Statistics and Biostatistics Departments

			New Doctoral Recipients in Group IV				New Doctoral Recipients in Probability or Statistics				New Doctoral Recipients Hired by Group IV	
Year	Depts Surveyed	Depts Responding (percent)	Total	Females (percent)	Jobs in Bus & Ind	Percentage Unemployed	Total	Group IV	Other Groups	Percentage Unemployed	Male	Female
1995-96	80	54 (67.5)	172	46 (26.7)	55	3.9	266	171	95	4.8	24	6
1996-97	81	60 (74.1)	197	74 (37.6)	70	4.2	292	187	105	5.1	24	9
1997-98	82	59 (72.0)	213	73 (34.3)	70	3.2	294	199	95	3.7	25	10
1998-99	91	72 (79.1)	243	87 (35.8)	57	4.9	320	240	80	5.8	29	20
1999-00	89	75 (84.3)	284	110 (38.7)	79	2.4	351	278	73	2.0	24	22
2000-01	86	70 (81.4)	237	98 (41.4)	59	5.1	289	*221	**68	5.3	27	14
Statistics	55	47 (85.5)	169	60 (35.5)	48	4.1					15	9
Biostatistics	31	23 (74.2)	68	38 (55.9)	11	8.3					12	5

* Of 221, there were 213 in statistics and 8 in probability. For complete details, see Table 3C.
** Of 68, there were 42 in statistics and 26 in probability. For complete details, see Table 3C.

Of 195 Group IV new doctoral recipients whose employment status is known, 10 (5.1%) are unemployed, while for the other doctoral groups 39 of 681 (5.7%) are unemployed. Fourteen of 41 (34.1%) new doctoral recipients hired by Group IV departments were female, down from last year's 47.8%. For the other doctoral groups, 49 of 211 (23.2%) new doctoral recipients hired were female, up from last year's 16.2%.

Group IV had 221 new doctoral recipients with field of thesis in probability (8) or statistics (213) and the other doctoral departments had 68 with field of thesis in probability (26) or statistics (42). The distribution of these 68 degrees among the various groups can be found in Table 3C. The number of new doctoral recipients with theses in probability or statistics (289) is larger than any other field, with algebra and number theory next with 137. The unemployment rate for new doctoral recipients in probability or statistics is 5.3% compared to 5.7% for new doctoral recipients in all other fields combined.

Faculty Salary Survey

The charts on the following pages display faculty salary data for Groups I (Pu), I (Pr), II, III, IV (Statistics), IV (Biostatistics), Va, M, and B: faculty salary distribution by rank, mean salaries by rank, information on quartiles by rank, and the number of returns for the group. Results reported here are summaries based on the departments who responded to this portion of the Annual Survey. This is the first year that salary information has been reported separately for statistics departments and biostatistics and biometrics departments in Group IV.

Table 10 provides the departmental response rates for the 2001 Faculty Salary Survey. Departments were asked to report for each rank the number of tenured and tenure-track faculty whose 2001-02 academic-year salaries fell within given salary intervals. Reporting salary data in this fashion eliminates some of the concerns about confidentiality but does not permit determination of actual quartiles. What can be determined is the salary interval in which the quartiles occur; the salary intervals containing the quartiles are denoted by <n, n+5> or <n, n+10>, whichever is appropriate. The endpoints of these intervals are in thousands of dollars.

Since departments in Group I, II, and III were changed in 1995-96 (see definitions of the groups on page 231), comparisons are possible only to the last five year's data. In addition, prior to the 1998 survey, Groups Va and Vb were reported together as Group V.

Table 10: Faculty Salary Response Rates

Departments	Number	Percent
Group I (Public)	19 of 25	76.0
Group I (Private)	15 of 23	65.2
Group II	42 of 56	75.0
Group III	62 of 74	83.8
Group IV (Statistics)	43 of 55	78.2
Group IV (Biostatistics)	15 of 31	48.4
Group Va	12 of 18*	66.7
Group M	102 of 202	50.5
Group B	357 of 1028	34.7

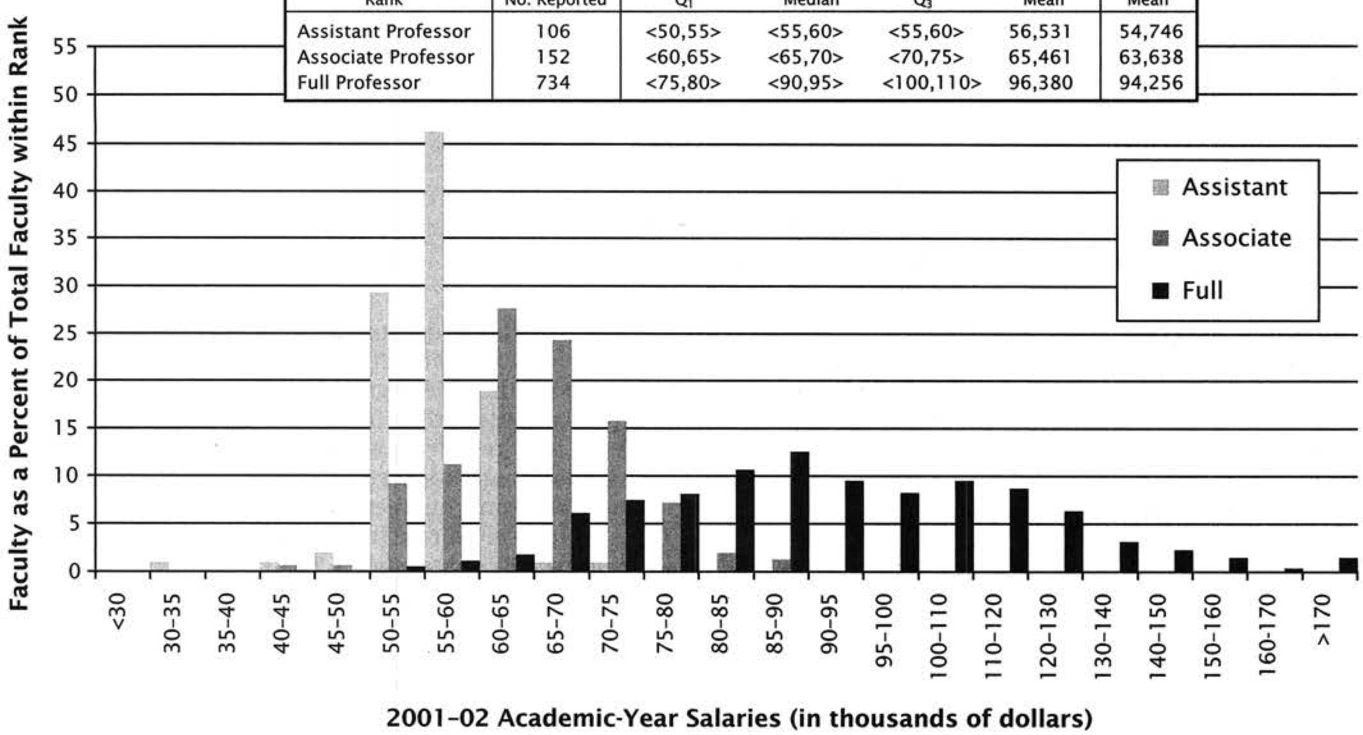
* The population for Group Va is slightly less than for the Doctorates Granted Survey because some departments grant degrees but do not formally "house" faculty and their salaries.

Group I (Public) Faculty Salaries

Doctoral degree-granting departments of mathematics (25)

19 responses (76.0%)

Rank	2001-02 No. Reported	2001-02 Q_1	2001-02 Median	2001-02 Q_3	2001-02 Mean	2000-01 Mean
Assistant Professor	106	<50,55>	<55,60>	<55,60>	56,531	54,746
Associate Professor	152	<60,65>	<65,70>	<70,75>	65,461	63,638
Full Professor	734	<75,80>	<90,95>	<100,110>	96,380	94,256

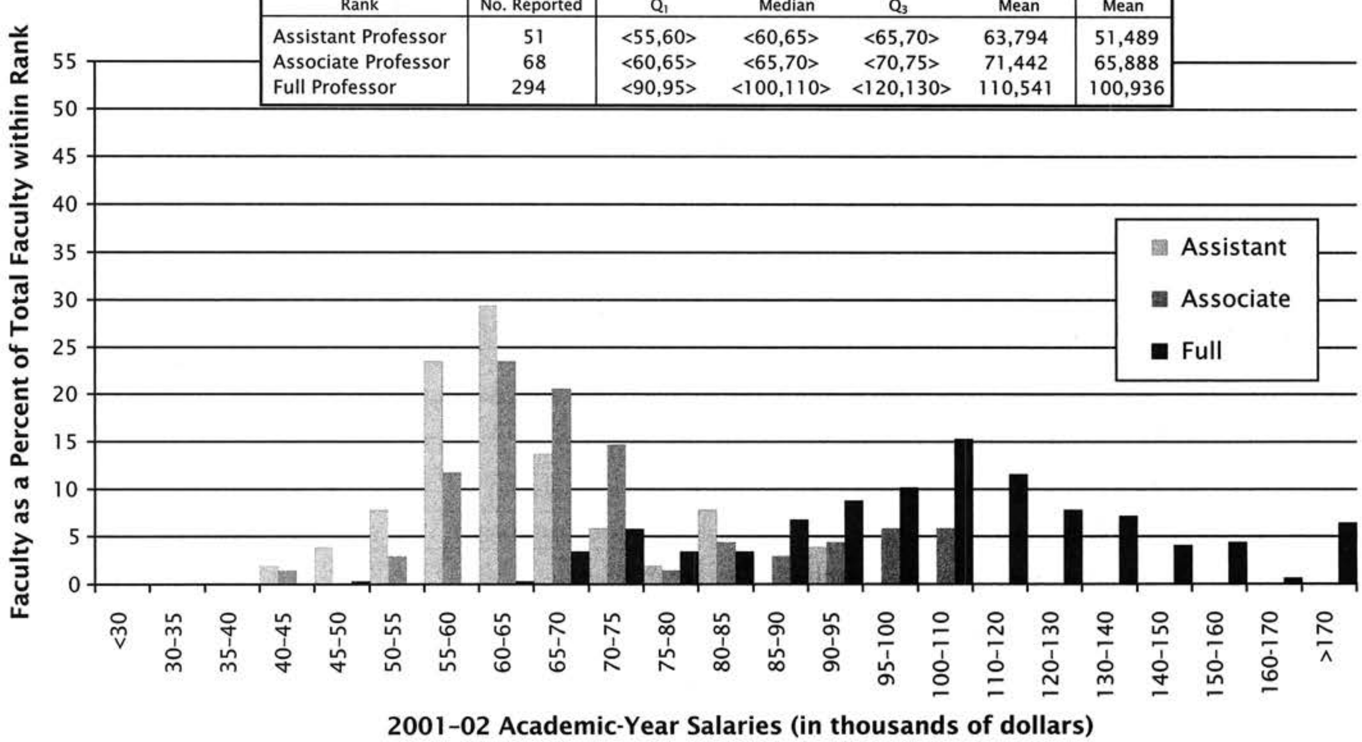


Group I (Private) Faculty Salaries

Doctoral degree-granting departments of mathematics (23)

15 responses (65.2%)

Rank	2001-02 No. Reported	2001-02 Q_1	2001-02 Median	2001-02 Q_3	2001-02 Mean	2000-01 Mean
Assistant Professor	51	<55,60>	<60,65>	<65,70>	63,794	51,489
Associate Professor	68	<60,65>	<65,70>	<70,75>	71,442	65,888
Full Professor	294	<90,95>	<100,110>	<120,130>	110,541	100,936

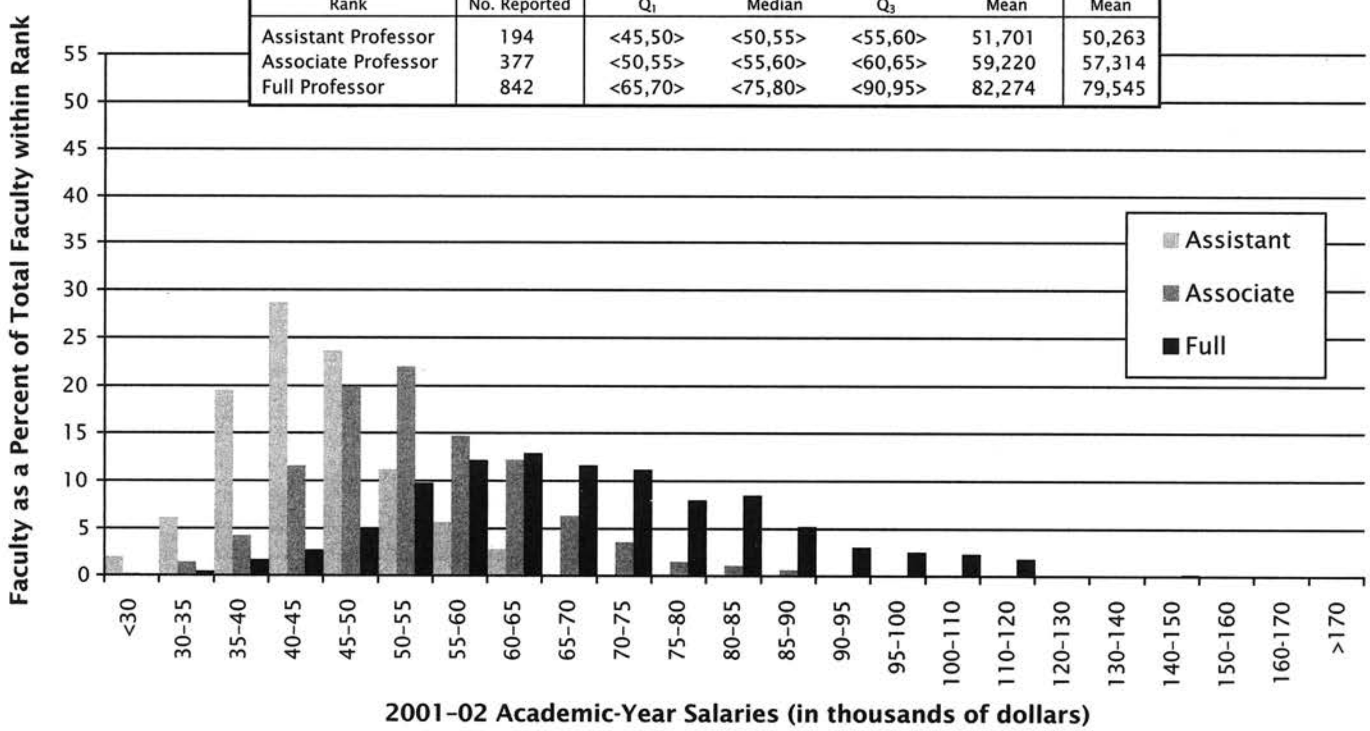


Group II Faculty Salaries

Doctoral degree-granting departments of mathematics (56)

42 responses (75.0%)

Rank	No. Reported	Q_1	Median	Q_3	Mean	2000–01 Mean
	2001–02					
Assistant Professor	194	<45,50>	<50,55>	<55,60>	51,701	50,263
Associate Professor	377	<50,55>	<55,60>	<60,65>	59,220	57,314
Full Professor	842	<65,70>	<75,80>	<90,95>	82,274	79,545

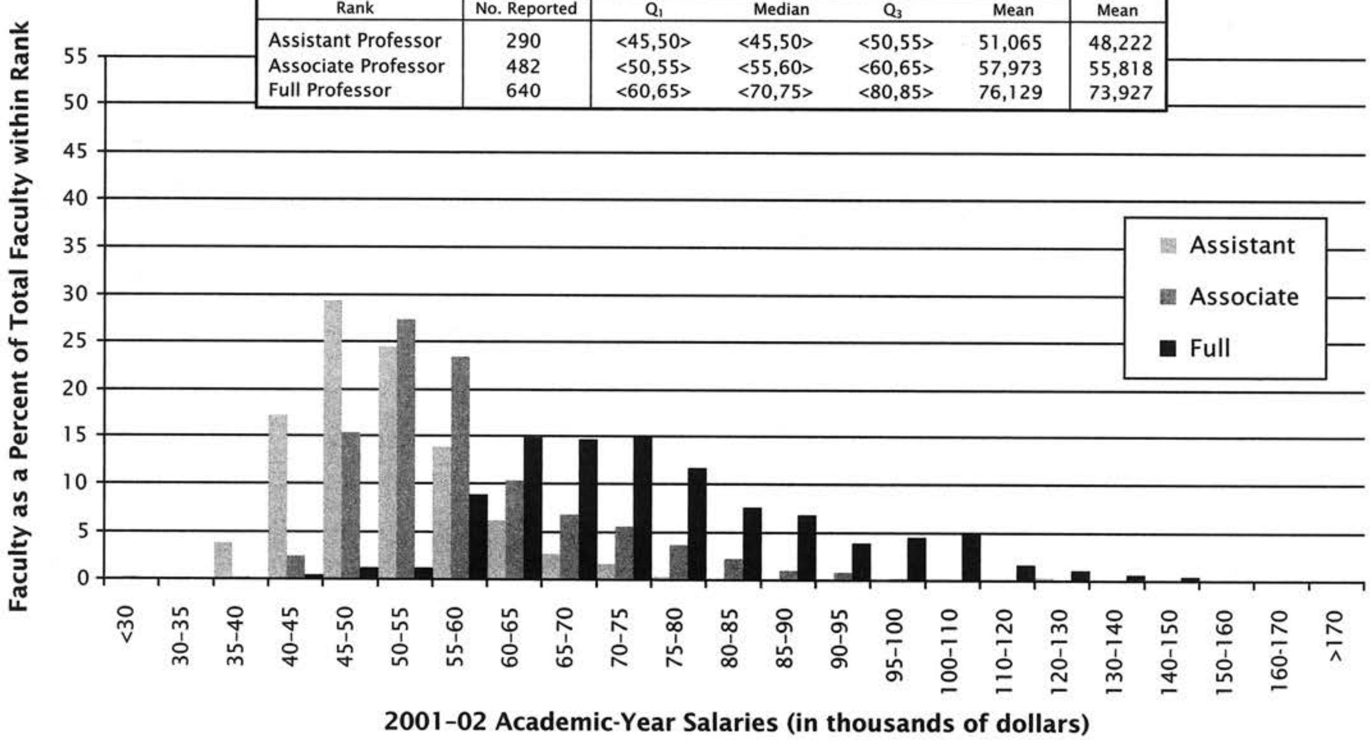


Group III Faculty Salaries

Doctoral degree-granting departments of mathematics (74)

62 responses (83.8%)

Rank	No. Reported	Q_1	Median	Q_3	Mean	2000–01 Mean
	2001–02					
Assistant Professor	290	<45,50>	<45,50>	<50,55>	51,065	48,222
Associate Professor	482	<50,55>	<55,60>	<60,65>	57,973	55,818
Full Professor	640	<60,65>	<70,75>	<80,85>	76,129	73,927

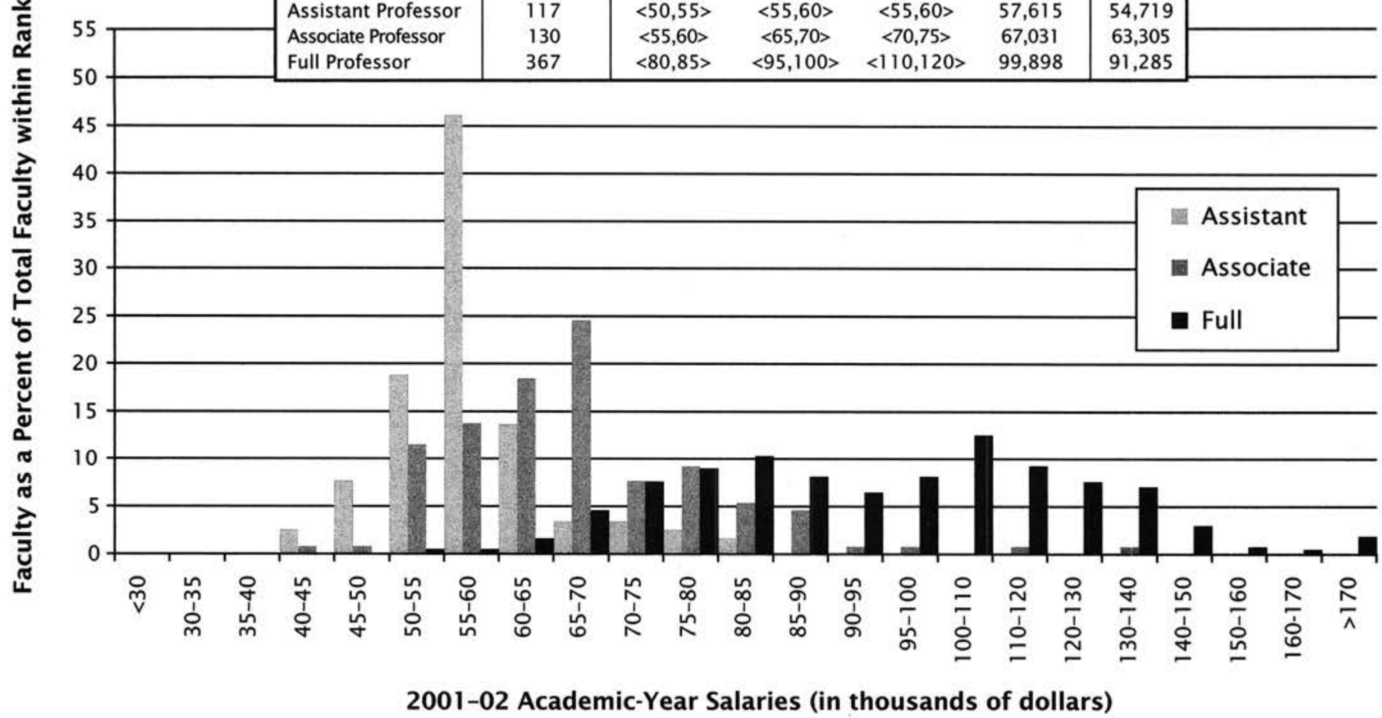


Group IV (Statistics) Faculty Salaries

Doctoral degree-granting departments of statistics (55)

43 responses (78.2%)

Rank	No. Reported	2001-02 Q1	2001-02 Median	2001-02 Q3	2001-02 Mean	2000-01 Mean
Assistant Professor	117	<50,55>	<55,60>	<55,60>	57,615	54,719
Associate Professor	130	<55,60>	<65,70>	<70,75>	67,031	63,305
Full Professor	367	<80,85>	<95,100>	<110,120>	99,898	91,285

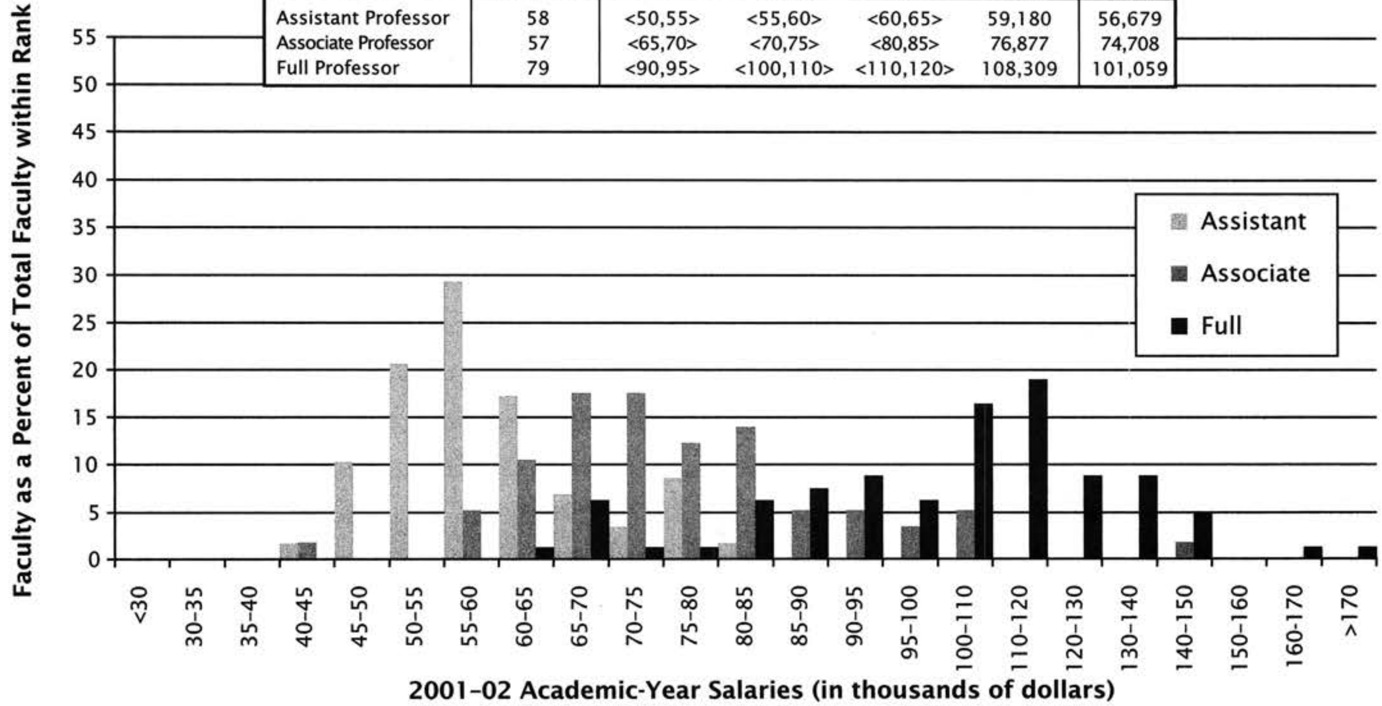


Group IV (Biostatistics) Faculty Salaries

Doctoral degree-granting departments of biostatistics and biometrics (31)

15 responses (48.4%)

Rank	No. Reported	2001-02 Q1	2001-02 Median	2001-02 Q3	2001-02 Mean	2000-01 Mean
Assistant Professor	58	<50,55>	<55,60>	<60,65>	59,180	56,679
Associate Professor	57	<65,70>	<70,75>	<80,85>	76,877	74,708
Full Professor	79	<90,95>	<100,110>	<110,120>	108,309	101,059

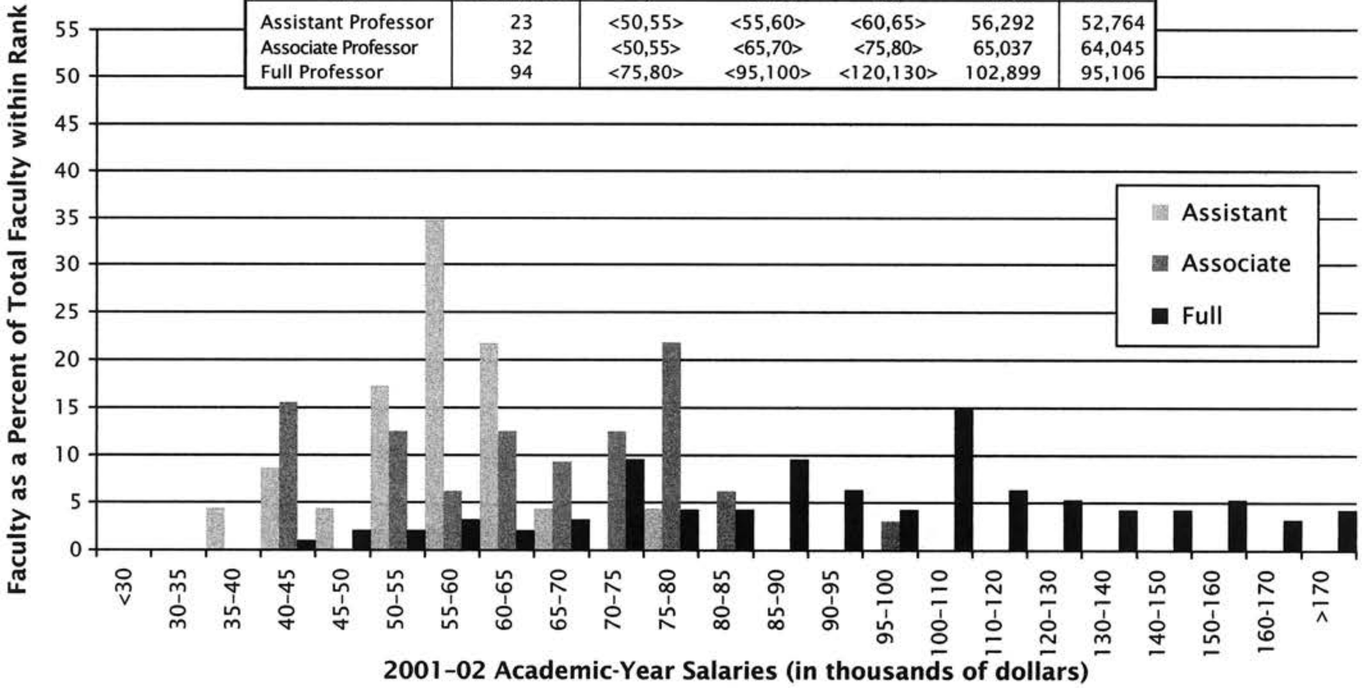


Group Va Faculty Salaries

Doctoral degree-granting departments of applied mathematics (18)

12 responses (66.7%)

Rank	2001-02 No. Reported	2001-02 Q_1	2001-02 Median	2001-02 Q_3	2001-02 Mean	2000-01 Mean
Assistant Professor	23	<50,55>	<55,60>	<60,65>	56,292	52,764
Associate Professor	32	<50,55>	<65,70>	<75,80>	65,037	64,045
Full Professor	94	<75,80>	<95,100>	<120,130>	102,899	95,106

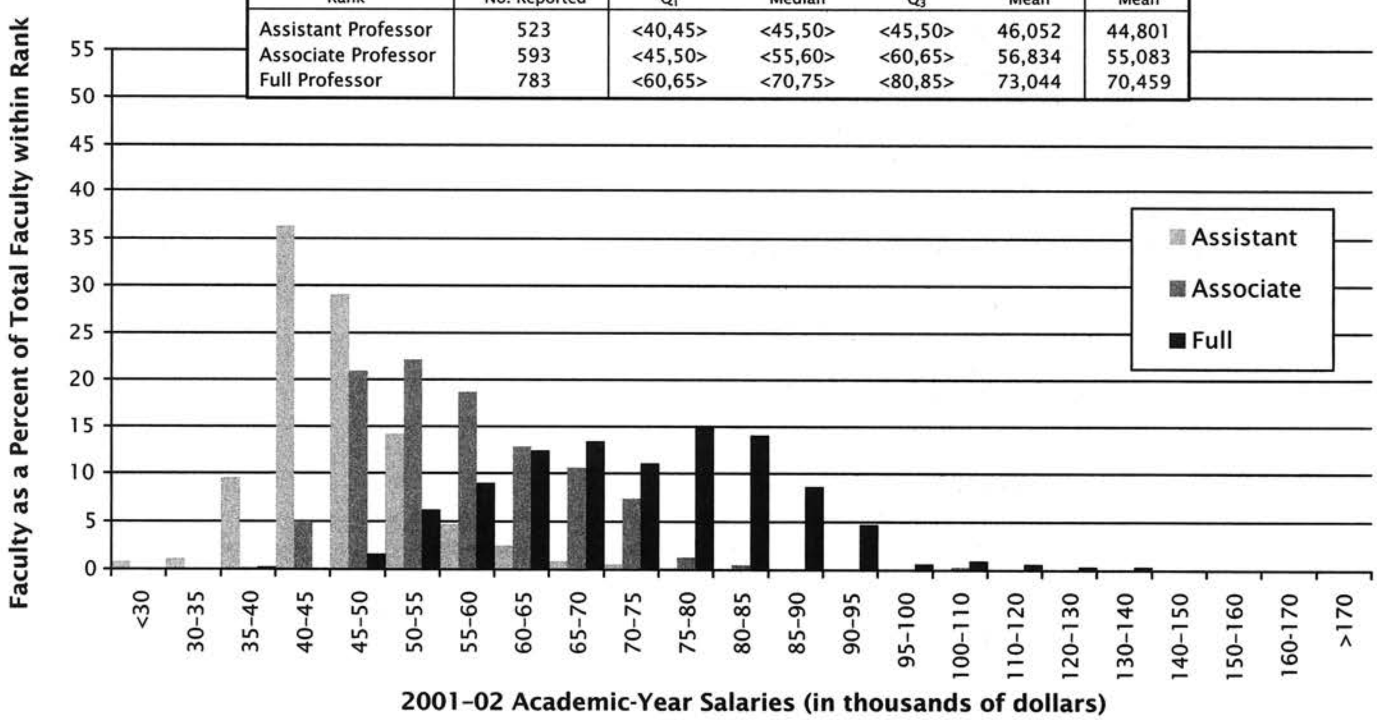


Group M Faculty Salaries

Master's degree-granting departments of mathematics (202)

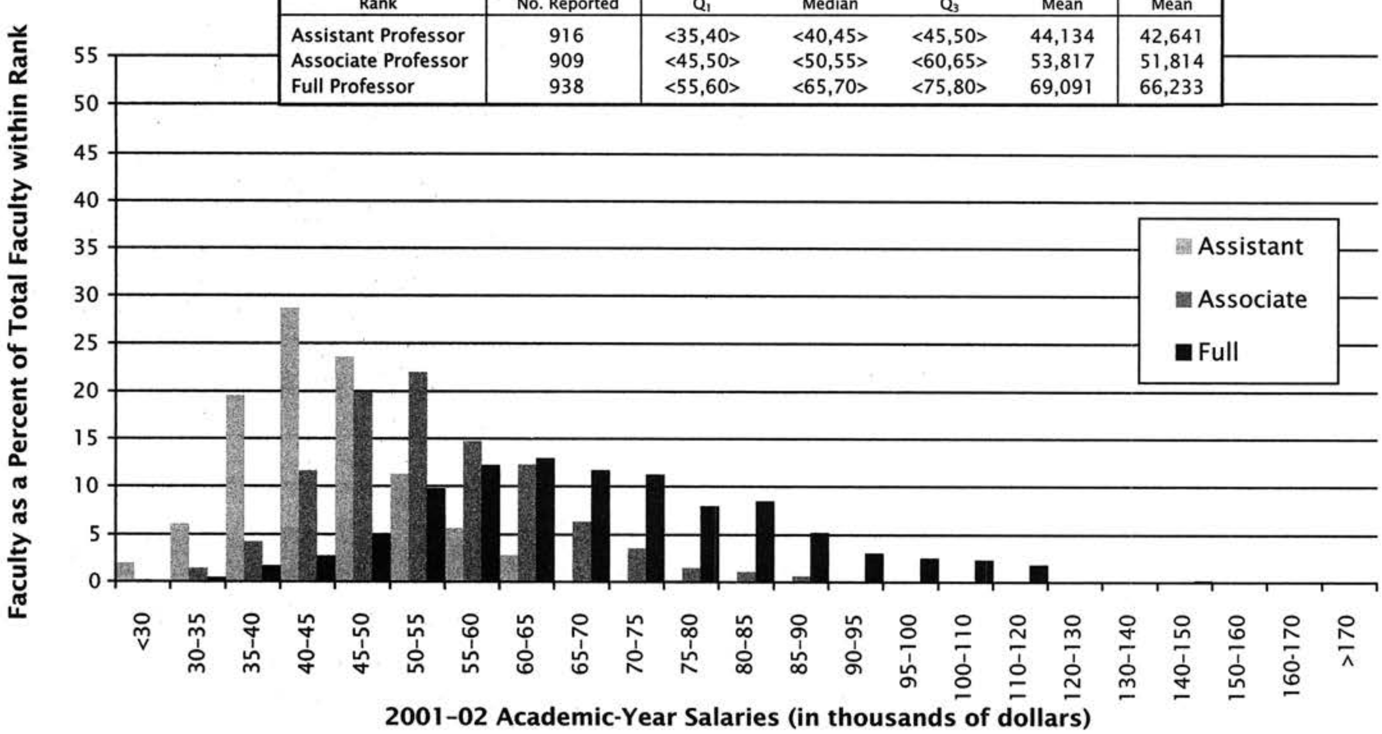
102 responses (50.5%)

Rank	2001-02 No. Reported	2001-02 Q_1	2001-02 Median	2001-02 Q_3	2001-02 Mean	2000-01 Mean
Assistant Professor	523	<40,45>	<45,50>	<45,50>	46,052	44,801
Associate Professor	593	<45,50>	<55,60>	<60,65>	56,834	55,083
Full Professor	783	<60,65>	<70,75>	<80,85>	73,044	70,459



Group B Faculty Salaries
Bachelor's degree-granting departments of mathematics (1,028)
357 responses (34.7%)

Rank	2001-02 No. Reported	2001-02 Q_1	2001-02 Median	2001-02 Q_3	2001-02 Mean	2000-01 Mean
Assistant Professor	916	<35,40>	<40,45>	<45,50>	44,134	42,641
Associate Professor	909	<45,50>	<50,55>	<60,65>	53,817	51,814
Full Professor	938	<55,60>	<65,70>	<75,80>	69,091	66,233



Acknowledgments

The Annual Survey attempts to provide an accurate appraisal and analysis of various aspects of the academic mathematical sciences scene for the use and benefit of the community and for filling the information needs of the professional organizations. Every year, college and university departments in the United States are invited to respond. The Annual Survey relies heavily on the conscientious efforts of the dedicated staff members of these departments for the quality of its information. On behalf of the Annual Survey Data Committee and the Annual Survey staff, we thank the many secretarial and administrative staff members in the mathematical sciences departments for their cooperation and assistance in responding to the survey questionnaires.

Previous Annual Survey Reports

The 2000 First, Second, and Third Annual Survey Reports were published in the *Notices* of the AMS in February, August, and September 2001 issues, respectively. These reports and earlier reports as well as a wealth of other information from these survey are available on the AMS website at *www.ams.org/employment/surveyreports.html*.

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D. O. Loftsgaarden, D. C. Rung, and A. E. Watkins, *Statistical abstract of undergraduate programs in the mathematical sciences in the U.S.*, Fall 1995 CBMS Survey, MAA Reports No. 2, 1997.

D. E. McClure, *Academic hiring survey, 1991–1992, Notices* Amer. Math. Soc. **39** (1992), 311–316.

——, *Employment experiences of 1990–1991 U.S. institution doctoral recipients in the mathematical sciences, Notices* Amer. Math. Soc. **42** (1995), 754–764.

National Research Council, *Strengthening the Linkage Between the Sciences and the Mathematical Sciences*, National Academy Press, Washington, DC, 2000.

——, *U.S. Research Institutes in the Mathematical Sciences: Assessment and Perspectives*, National Academy Press, Washington, DC, 1999.

——, *Summary Report 1996, Doctorate Recipients from United States Universities*, National Academy Press, Washington, DC, 1998.

——, *Research-Doctorate Programs in the United States: Continuity and Change*, National Academy Press, Washington, DC, 1995.

National Science Board, *Science and Engineering Indicators—2000* (NSB 00-1), National Science Foundation, Arlington, VA, 2000.

National Science Foundation, *Science and Engineering Degrees: 1966–97* (NSF 00-310), Detailed Statistical Tables, Arlington, VA, 2000.

——, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1989–97* (NSF 00-311), Detailed Statistical Tables, Arlington, VA, 2000.

——, *Science and engineering doctorate awards: 1998* (NSF 00-304), Detailed Statistical Tables, Arlington, VA, 2000.

——, *Graduate Students and Postdoctorates in Science and Engineering: Fall 1998* (NSF 00-322), Arlington, VA, 2000.

——, *Characteristics of Doctoral Scientists and Engineers in the United States: 1997* (NSF 00-308), Detailed Statistical Tables, Arlington, VA, 1999.

——, *Women, Minorities, and Persons with Disabilities in Science and Engineering: 1998* (NSF 99-338), Arlington, VA, 1999.

——, *Statistical Profiles of Foreign Doctoral Recipients in Science and Engineering: Plans to Stay in the United States* (NSF 99-304), Arlington, VA, 1998.

——, *Who Is Unemployed? Factors Affecting Unemployment Among Individuals with Degrees in Science and Engineering*, Higher Education Surveys Report (NSF 97-336), Arlington, VA, 1997.

Definitions of the Groups

As has been the case for a number of years, much of the data in these reports is presented for departments divided into groups according to several characteristics, the principal one being the highest degree offered in the mathematical sciences. Doctoral-granting departments of mathematics are further subdivided according to their ranking of "scholarly quality of program faculty" as reported in the 1995 publication *Research-Doctorate Programs in the United States: Continuity and Change.*[1] These rankings update those reported in a previous study published in 1982.[2] Consequently, the departments which now comprise Groups I, II, and III differ significantly from those used prior to the 1996 survey.

The subdivision of the Group I institutions into Group I Public and Group I Private was new for the 1996 survey. With the increase in number of the Group I departments from 39 to 48, the Annual Survey Data Committee judged that a further subdivision of public and private would provide more meaningful reporting of the data for these departments.

Brief descriptions of the groupings are as follows:

Group I is composed of 48 departments with scores in the 3.00–5.00 range. Group I Public and Group I Private are Group I departments at public institutions and private institutions respectively.

Group II is composed of 56 departments with scores in the 2.00–2.99 range.

Group III contains the remaining U.S. departments reporting a doctoral program, including a number of departments not included in the 1995 ranking of program faculty.

Group IV contains U.S. departments (or programs) of statistics, biostatistics, and biometrics reporting a doctoral program.

Group V contains U.S. departments (or programs) in applied mathematics/applied science, operations research, and management science which report a doctoral program.

Group Va is applied mathematics/applied science; Group Vb, which is no longer surveyed as of 1998–99, was operations research and management science.

Group M contains U.S. departments granting a master's degree as the highest graduate degree.

Group B contains U.S. departments granting a baccalaureate degree only.

Listings of the actual departments which comprise these groups are available on the AMS Web site at `www.ams.org/employment/`.

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[1]Research-Doctorate Programs in the United States: Continuity and Change, *edited by Marvin L. Goldberger, Brendan A. Maher, and Pamela Ebert Flattau, National Academy Press, Washington, DC, 1995.*

[2]*These findings were published in* An Assessment of Research-Doctorate Programs in the United States: Mathematical and Physical Sciences, *edited by Lyle V. Jones, Gardner Lindzey, and Porter E. Coggeshall, National Academy Press, Washington, DC, 1982. The information on mathematics, statistics, and computer science was presented in digest form in the April 1983 issue of the* Notices, *pages 257–67, and an analysis of the classifications was given in the June 1983* Notices, *pages 392–3.*

Mathematics People

2001 Fermat Prize Awarded

The 2001 Fermat Prize in Mathematics has been awarded to Richard Taylor of Harvard University and Wendelin Werner of the Université de Paris-Sud. Taylor was honored for his many contributions to the study of connections between Galois representations and automorphic forms. Werner was honored for his work on intersection exponents of Brownian motion and their impact on theoretical physics.

The Fermat Prize is presented every two years and carries a monetary award of 100,000 FF (approximately $15,500). The prize recognizes the work of one or more mathematicians in the areas in which Pierre de Fermat worked, specifically, principles of variational theory, foundations of the calculus and probability, analytic geometry, and number theory. The award is administered by the Université Paul Sabatier and sponsored by Astrium Sas.

Previous recipients of the Fermat Prize are: Abbas Bahri and Kenneth A. Ribet (1989), Jean-Louis Colliot-Thélene (1991), Jean-Michel Coron (1993), Andrew J. Wiles (1995), Michel Talagrand (1997), and F. Bethuel and F. Helein (1999).

—J.-B. Hiriart-Urruty, Université Paul Sabatier

Whitt Awarded von Neumann Prize

The 2001 John von Neumann Theory Prize, the highest prize given in the field of operations research and management science, has been awarded to Ward Whitt of AT&T Laboratories.

The $5,000 prize, presented by the Institute for Operations Research and the Management Sciences (INFORMS), was awarded to Whitt "for his exceptionally broad and profound contributions to queuing theory, applied probability and stochastic modeling." His work has involved multiple channel queues in heavy traffic, the continuity of queues, and functional central limit theorems. He has also advanced the fields of communication network performance analysis and traffic modeling, "combining practical insights with limit theorems to develop fundamental tools."

—From an INFORMS announcement

NRC-Ford Foundation Minority Fellowships Awarded

The names of the recipients of Ford Foundation Minority Fellowships for 2001 have been announced. The fellowship programs are administered by the National Research Council for the purpose of increasing the presence of underrepresented groups among faculty members in colleges and universities. The recipients were selected based on merit and promise of future achievement.

Daniel A. Wiley of Cornell University was awarded a Predoctoral Fellowship. He is a student in the field of applications of mathematics. Paul A. Loya of the Massachusetts Institute of Technology received a Postdoctoral Fellowship. He is a student of geometry.

—From an NRC announcement

AAAS Fellows Elected

Five mathematicians have been elected as Fellows of the Mathematics Section of the American Association for the Advancement of Science. The new fellows are Jonathan M. Borwein, Simon Fraser University; John Guckenheimer, Cornell University; Bernard J. Matkowsky, Northwestern University; Reinhard Schultz, University of California, Riverside; and Ian N. Stewart, University of Warwick, United Kingdom.

In addition, Elwyn R. Berlekamp of the University of California, Berkeley, was elected a Fellow of the Information, Computing, and Communication Section.

—From an AAAS announcement

Correction

The December 2001 issue of the *Notices* carried the list of speakers for the International Congress of Mathematicians 2002 (ICM 2002), to be held in Beijing in August. After the issue had gone to print, one of the section speakers withdrew (Robert Frederick Coleman of the University of California, Berkeley), and a section speaker was added (Karl Rubin of Stanford University). In addition, the affiliation given for Liming Ge was incomplete; it is the Chinese Academy of Sciences, China, and the University of New Hampshire, USA. The most up-to-date information about ICM 2002 is available on the Web at `http://www.icm2002.org.cn/`.

Mathematics Opportunities

COBASE Collaborative Grants

With funding from the National Science Foundation (NSF), the Office for Central Europe and Eurasia of the National Research Council, the operating arm of the National Academies, offers grants to individual American specialists who plan to establish new research partnerships with their colleagues from Central/Eastern Europe (CEE) and the Newly Independent States (NIS). This program is designed primarily to prepare these new partnerships for competition in NSF programs. Although proposals are accepted for collaborative research in all fields of basic science supported by NSF, this year the Collaboration in Basic Sciences and Engineering (COBASE) program has added three topical focus areas in which applications will be given special priority. One of these areas is mathematics.

Project Development and Initiation Grants support American specialists who wish to host and/or visit their CEE or NIS colleagues in order to initiate research projects and prepare collaborative research proposals for submission to NSF. U.S. applicants may request support for up to two visits in either or both directions (i.e., either traveling to CEE/NIS or hosting a colleague from the region here in the U.S.), with the total combined duration of the visit(s) not to exceed eight weeks. Each individual visit proposed must be at least two weeks (10–14 days) in length. Grants will be in the range of $2,500 to $10,000.

Participating countries: Armenia, Azerbaijan (traveling only), Bosnia (hosting in U.S. only), Bulgaria, Croatia, Czech Republic, Estonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, (Former Yugoslav Republic of) Macedonia, Moldova, Poland, Romania, Russia (see website for updated list of ineligible partner institutions), Slovakia, Slovenia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan.

Eligibility: All applicants must: (1) be U.S. citizens or permanent residents; (2) be affiliated with U.S. universities or other nonprofit research institutions; and (3) possess Ph.D. degrees or equivalent research experience. Foreign counterparts involved must possess CEE/NIS citizenship, be permanently employed at CEE/NIS institutions, and hold Ph.D. (kandidat) degrees or research training and experience equivalent to a doctoral degree. Employees of private companies and the U.S. government generally are not supported under the COBASE program. Each set of partners may receive no more than one COBASE grant, and each individual may be involved in no more than two grants in a four-year period. Generally, those who hold a current NSF grant and are eligible for an NSF international supplement should not apply to this program. NSF's Central and Eastern Europe Program staff (telephone 703-292-8703) can advise regarding applications for NSF international supplements. *However, for projects in the three special topical areas (including mathematics), applicants with current NSF support are eligible to apply.*

Special Opportunities for Junior Investigators: American applicants who have received their doctoral degrees within the past ten years will receive special consideration. The COBASE program allocates at least 25 percent of its grants to researchers in this category in order to encourage beginning investigators to become involved in international collaboration.

Collaborative proposals involving any field of mathematics are welcome, including but not limited to algebra and number theory, analysis, computational mathematics, geometric analysis, statistics and probability, and topology and foundations. Projects in applied mathematics involving collaborations with specialists from other fields such as the biological, computer, and environmental sciences are also encouraged. Collaborative research proposals involving the modeling of complexity are particularly welcome.

The postmarking deadline for proposals is **April 15, 2002**. For application forms and instructions, visit the website `http://www.nationalacademies.org/oia/`. For more information, telephone 202-334-2644, send a fax to 202-334-2614, or e-mail: `ocee@nas.edu`.

—From a National Academies announcement

IAS/Park City Mathematics Institute

The Institute for Advanced Study (IAS)/Park City Mathematics Institute (PCMI) will hold its 2002 summer session June 30–July 20, 2002, in Park City, Utah. The research topic is automorphic forms and applications. The organizers are Peter Sarnak (Princeton University) and Freydoon Shahidi (Purdue University). The education topic is knowledge of mathematics for teaching.

The IAS/PCMI began in 1991 at the University of Utah as a National Science Foundation Regional Geometry Institute. In 1993 the Institute for Advanced Study assumed sponsorship of the program. Each summer the PCMI offers an integrated set of programs for researchers, postdoctorates, graduate and undergraduate students, and teachers.

Further information on the summer program and other IAS/PCMI activities, as well as on application procedures, is available at the website `http://www.admin.ias.edu/ma/`.

—From an IAS/PCMI announcement

Reference and Book List

*The **Reference** section of the* Notices *is intended to provide the reader with frequently sought information in an easily accessible manner. New information is printed as it becomes available and is referenced after the first printing. As soon as information is updated or otherwise changed, it will be noted in this section.*

Contacting the *Notices*

The preferred method for contacting the *Notices* is electronic mail. The editor is the person to whom to send articles and letters for consideration. Articles include feature articles, memorial articles, communications, opinion pieces, and book reviews. The editor is also the person to whom to send news of unusual interest about other people's mathematics research.

The managing editor is the person to whom to send items for "Mathematics People", "Mathematics Opportunities", "For Your Information", "Reference and Book List", and "Mathematics Calendar". Requests for permissions, as well as all other inquiries, go to the managing editor.

The electronic-mail addresses are `notices@math.tamu.edu` in the case of the editor and `notices@ams.org` in the case of the managing editor. The fax numbers are 979-845-6028 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Upcoming Deadlines

January 15, 2002: Applications for AMS-AAAS Mass Media Fellowships. See `http://ehr.aaas.org/ehr/` (click the "Projects" link) or contact Katrina Malloy, Program Coordinator, AAAS Mass Media Science and Engineering Fellows Program, 1200 New York Avenue, NW, Washington, DC 20005; telephone 202-326-6760; fax 202-371-9849. Or contact the AMS Washington Office, 1527 Eighteenth Street, NW, Washington, DC 20036; telephone 202-588-1100; fax 202-588-1853; e-mail: `amsdc@ams.org`.

January 15, 2002: Applications for National Research Council Research Associateship Program. See `http://www4.nationalacademies.org/pga/rap.nsf/`, or contact the National Research Council, Associateship Programs (TJ 2114), 2101 Constitution Avenue, NW, Washington, DC 20418; telephone 202-334-2760; fax 202-334-2759; e-mail: `rap@nas.edu`.

January 16, 2002: Applications for National Defense Science and

Where to Find It

A brief index to information that appears in this and previous issues of the *Notices*.

Engineering Graduate Fellowships. See http://www.asee.org/ndseg/html/preface.htm, or contact NDSEG Fellowship Program, c/o American Society for Engineering Education, 1818 N Street, NW #600, Washington, DC 20036; telephone 202-331-3516; fax 202-265-8504; e-mail: ndseg@asee.org.

January 21, 2002: Applications for AWM Workshop for Women Graduate Students and Postdocs. See http://www.awm-math.org/.

January 31, 2002: Applications for postdoctoral fellowships at the Institut Mittag-Leffler. See http://www.ml.kva.se/.

January 31, 2002: Applications for IMU travel grants for ICM 2002. See http://elib.zib.de/IMU/.

February 1, May 1, October 1, 2002: Applications for NSF/AWM Travel Grants for Women. See http://www.awm-math.org/travelgrants.html; telephone 301-405-7892; e-mail: awm@math.umd.edu.

February 1, 2002: Applications for NSF/AWM Mentoring Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone 301-405-7892; e-mail: awm@math.umd.edu.

March 1, 2002: Nominations for Third World Academy of Sciences (TWAS) Awards in Basic Sciences. See http://www.ictp.trieste.it/~twas/Awards_Info.html.

March 31, 2002: Nominations for 2002 Prize for Achievement in Information-Based Complexity. Send nominations to Joseph Traub, traub@santafe.edu.

April 15, 2002: Applications for National Research Council Research Associateship Program. See http://www4.nationalacademies.org/pga/rap.nsf/, or contact the National Research Council, Associateship Programs (TJ 2114), 2101 Constitution Avenue, NW, Washington, DC 20418; telephone 202-334-2760; fax 202-334-2759; e-mail: rap@nas.edu.

April 15, 2002: Proposals for COBASE collaborative grants. See "Mathematics Opportunities" in this issue.

May 1, 2002: Nominations for Lobachevskii Medal. See http://www.ksu.ru/lobmed/.

May 15, 2002: Applications for fall semester of Math in Moscow and for AMS scholarships. See http://www.mccme.ru/mathinmoscow/, or contact Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax +7095-291-65-01; e-mail: mim@mccme.ru. For information about and application forms for the AMS scholarships, see http://www.ams.org/careers-edu/mimoscow.html, or contact Math in Moscow Program, Professional Services Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904; e-mail: prof-serv@ams.org.

August 15, 2002: Applications for National Research Council Research Associateship Program. See http://www4.nationalacademies.org/pga/rap.nsf/, or contact the National Research Council, Associateship Programs (TJ 2114), 2101 Constitution Avenue, NW, Washington, DC 20418; telephone 202-334-2760; fax 202-334-2759; e-mail: rap@nas.edu.

October 15, 2002: Applications for spring semester of Math in Moscow and for AMS scholarships. See http://www.mccme.ru/mathinmoscow/, or contact Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax +7095-291-65-01; e-mail: mim@mccme.ru. For information about and application forms for the AMS scholarships, see http://www.ams.org/careers-edu/mimoscow.html, or contact Math in Moscow Program, Professional Services Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904; e-mail: prof-serv@ams.org.

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The National Science Board is the policymaking body of the National Science Foundation. The names and affiliations of the board members follow.

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The contact information for the Board is: National Science Board, National Science Foundation, 4201 Wilson Boulevard, Suite 1225, Arlington, VA 22230; telephone 703-292-7000; fax 703-292-9008; World Wide Web `http://www.nsf.gov/nsb/`.

Book List

*The **Book List** highlights books that have mathematical themes and hold appeal for a wide audience, including mathematicians, students, and a significant portion of the general public. When a book has been reviewed in the* Notices, *a reference is given to the review. Generally the list will contain only books published within the last two years, though exceptions may be made in cases where current events (e.g., the death of a prominent mathematician, coverage of a certain piece of mathematics in the news) warrant drawing readers' attention to older books. Suggestions for books to include on the list may be sent to the managing editor, e-mail:* `notices@ams.org`.

Battle of Wits: The Complete Story of Codebreaking in World War II, by Stephen Budiansky. Free Press, October 2000. ISBN 0-684-85932-7.

The Bit and the Pendulum: How the New Physics of Information Is Revolutionizing Science, by Tom Siegfried. John Wiley & Sons, February 2000. ISBN 0-47132-174-5.

The Book of Nothing: Vacuums, Voids, and the Latest Ideas about the Origins of the Universe, by John D. Barrow. Pantheon Books, April 2001. ISBN 0-375-42099-1.

The Brain: Unraveling the Mystery of How It Works (The Neural Network Process), by Thomas L. Saaty. RWS Publications, 2000. ISBN 1-888603-02-X.

Calculated Bets: Computers, Gambling, and Mathematical Modeling to Win, by Steven S. Skiena. Cambridge University Press, September 2001. ISBN 0-521-00962-6.

Chaotic Elections! A Mathematician Looks at Voting, by Donald G. Saari. AMS, April 2001. ISBN 0-8218-2847-9.

The Colossal Book of Mathematics: Classic Puzzles, Paradoxes, and Problems, by Martin Gardner. W.W. Norton & Company, August 2001. ISBN 0-393-02023-1.

Computers Ltd.: What They Really Can't Do, by David Harel. Oxford University Press, November 2000. ISBN 0-198-50555-8.

A Concise History of Mathematics, by Dirk J. Struik. Dover Publications, 1987. ISBN 0-486-60255-9. (Reviewed June/July 2001.)

Conned Again, Watson! Cautionary Tales of Logic, Math, and Probability, by Colin Bruce. Perseus Publishing, January 2001. ISBN 0-7382-0345-9.

Conquering Statistics: Numbers without the Crunch, by Jefferson Hane Weaver. Perseus Publishing, paperback edition, August 2001. ISBN 0-732-820495-1.

Conversations with a Mathematician: Math, Art, Science, and the Limits of Reason, by Gregory J. Chaitin. Springer, November 2001. ISBN 1-85233-549-1.

Creators of Mathematics: The Irish Connection, by Ken Houston. University College Dublin Press, September 2000. ISBN 1-900-62149-5.

Crypto: How the Code Rebels Beat the Government—Saving Privacy in *the Digital Age*, by Steven Levy. Viking Press, January 2001. ISBN 0-67085-950-8.

Damned Lies and Statistics: Untangling Numbers from the Media, Politicians, and Activists, by Joel Best. University of California Press, May 2001. ISBN 0-520-21978-3.

The Difference Engine: Charles Babbage and the Quest to Build the First Computer, by Doron Swade. Viking Press, September 2001. ISBN 0-670-91020-1.

The Dream Machine: J. C. R. Licklider and the Revolution That Made Computing Personal, by M. Mitchell Waldrop. Viking Press, 2001. ISBN 0-670-89976-3.

* *The Essential John Nash*, Harold Kuhn and Sylvia Nasar, editors. Princeton University Press, December 2001. ISBN 0-691-09527-2.

Euclid's Window: The Story of Geometry from Parallel Lines to Hyperspace, by Leonard Mlodinow. Free Press, April 2001. ISBN 0-684-86523-8.

Exploring Randomness, by Gregory J. Chaitin. Springer, December 2000. ISBN 1-852-33-417-7. (Reviewed October 2001.)

Finite vs. Infinite, Contributions to an Eternal Dilemma, Cristian S. Calude and Gheorghe Paun, editors. Springer, March 2000. ISBN 1-852-33251-4.

Flatterland: Like Flatland, Only More So, by Ian Stewart. Perseus Publishing, May 2001. ISBN 0-7382-0442-0.

Fooled by Randomness: The Hidden Role of Chance in the Markets and Life, by Nassim Nicholas Taleb. Texere, October 2001. ISBN 1-587-99071-7.

The Fractal Murders, by Mark Cohen. E-book published by Southern Cross Review, 2001. World Wide Web: `www.southerncrossreview.org`.

Fragments of Infinity: A Kaleidoscope of Math and Art, by Ivars Peterson. John Wiley & Sons, October 2001. ISBN 0-471-16558-1.

Gödel: A Life of Logic, by John L. Casti and Werner DePauli. Perseus Publishing, August 2000. ISBN 0-7382-0274-6. (Reviewed September 2001.)

The Hilbert Challenge, by Jeremy J. Gray. Oxford University Press, December 2000. ISBN 0-198-50651-1.

The Hole in the Universe: How Scientists Peered over the Edge of Emptiness and Found Everything, by K. C. Cole. Harcourt Brace, January 2001. ISBN 0-151-00398-X.

How the Other Half Thinks: Adventures in Mathematical Reasoning, by Sherman Stein. McGraw-Hill, July 2001. ISBN 0-071-37339-X.

How to Solve It: Modern Heuristics, by Zbigniew Michalewicz and David B. Fogel. Springer, December 1999. ISBN 3-540-66061-5.

In Code: A Mathematical Journey, by Sarah Flannery and David Flannery. Workman Publishing, May 2001. ISBN 0-761-12384-9.

Logical Dilemmas: The Life and Work of Kurt Gödel, by John Dawson. A K Peters, December 1997. ISBN 1-56881-025-3. (Reviewed September 2001.)

* *Mathematical Mountaintops: The Five Most Famous Problems of All Time*, by John Casti. Oxford University Press, October 2001. ISBN 0-195-14171-7.

Mathematics and the Roots of Postmodern Thought, by Vladimir Tasic. Oxford University Press, 2001. ISBN 0-195-13967-4.

Mathematics Galore: Masterclasses, Workshops, and Team Projects in Mathematics and Its Applications, by C. J. Budd and C. J. Sangwin. Oxford University Press, June 2001. ISBN 0-198-50769-0 (hardcover), 0-198-50770-4 (paperback).

The Measure of the World, by Denis Guedj. University of Chicago Press, October 2001. ISBN 0-226-31030-2.

A New Kind of Science, by Stephen Wolfram. Wolfram Media, Inc., October 2001. ISBN 1-579-55008-8.

Newton's Tyranny: The Suppressed Scientific Discoveries of John Flamsteed and Stephen Gray, by David H. Clark and Stephen P. H. Clark. W. H. Freeman, October 2000. ISBN 0-716-74215-2.

Number: From Ahmes to Cantor, by Midhat Gazalé. Princeton University Press, March 2000. ISBN 0-691-00515-X. (Reviewed August 2001.)

The Parrot's Theorem, by Denis Guedj. St. Martin's Press, September 2001. ISBN 0-312-28055-6. (Reviewed March 2001.)

Proofs from THE BOOK, by M. Aigner and G. M. Ziegler. Revised and expanded second edition, Springer, January 2001. ISBN 3-540-67865-4. (First edition reviewed August 1999.)

Ptolemy's Geography, translated by J. Lennart Berggren and Alexander Jones. Princeton University Press, November 2000. ISBN 0-691-01042-0.

* *The Quest for the Quantum Computer*, by Julian Brown. Touchstone Books, August 2001. ISBN 0-684-87004-5.

Radical Equations: Math Literacy and Civil Rights, by Robert P. Moses and Charles E. Cobb Jr. Beacon Press, February 2001. ISBN 0-807-03126-7.

Sacred Geometry, by Miranda Lundy. Walker & Company, April 2001. ISBN 0-802-71382-3.

The Search for Mathematical Roots, 1870–1940: Logics, Set Theories, and the Foundations of Mathematics from Cantor through Russell to Gödel, by I. Grattan-Guinness. Princeton University Press, February 2001. ISBN 0-691-0587-1.

The Story of Mathematics, by Richard Mankiewicz. Princeton University Press, February 2001. ISBN 0-691-08808-X.

Things a Computer Scientist Rarely Talks About, by Donald Knuth. Center for the Study of Language and Information, July 2001. ISBN 1-57586-327-8.

* *Thinks*, by David Lodge. Viking Press, May 2001. ISBN 0-670-89984-4.

Triangle of Thoughts, by Alain Connes, André Lichnerowicz, and Marcel Paul Schützenberger. AMS, July 2001. ISBN 0-8218-2614-X.

* *Turing and the Universal Machine: The Making of the Modern Computer*, by Jon Agar. Totem Books, June 2001. ISBN 1-840-46250-7.

* *Understanding Mathematics for Aircraft Navigation*, by James S. Wolper. McGraw-Hill, May 2001. ISBN 0-07-137572-4.

The Universal Computer: The Road from Leibniz to Turing, by Martin Davis. W.W. Norton & Company, October 2000. ISBN 0-393-04785-7. (Reviewed May 2001.)

The Universal History of Computing: From the Abacus to the Quantum Computer, by Georges Ifrah; translated from the French and with notes by E. F. Harding, assisted by Sophie Wood, Ian Monk, Elizabeth Clegg, and Guido Waldman. John Wiley & Sons, November 2000. ISBN 0-471-39671-0. (Reviewed in January 2002 and in this issue.)

The Universal History of Numbers: From Prehistory to the Invention of the Computer, by Georges Ifrah; translated from the French by David Bellos, E. F. Harding, Sophie Wood, and Ian Monk. John Wiley & Sons, December 1999. ISBN 0-471-37568-3. (Reviewed in January 2002 and in this issue.)

The Universe in a Nutshell, by Stephen Hawking. Bantam Doubleday Dell, November 2001. ISBN 0-553-80202-X.

The Unknowable, by Gregory J. Chaitin. Springer, August 1999. ISBN 9-814-02172-5. (Reviewed October 2001.)

What Is Mathematics? An Elementary Approach to Ideas and Methods, by Richard Courant and Herbert Robbins; second edition, revised by Ian Stewart. Oxford University Press, August 1996. ISBN 0-195-10519-2. (Reviewed December 2001.)

* *What Shape Is a Snowflake?*, by Ian Stewart. W. H. Freeman & Co, November 2001. ISBN 0-716-74794-4.

Where Mathematics Comes From: How the Embodied Mind Brings Mathematics into Being, by George Lakoff and Rafael Núñez. Basic Books, October 2000. ISBN 0-465-03770-4. (Reviewed November 2001.)

White Light, by Rudy Rucker. Four Walls Eight Windows, April 2001. ISBN 1-56858-198-X.

Women Becoming Mathematicians: Creating a Professional Identity in Post-World War II America, by Margaret A. M. Murray. MIT Press, September 2000. ISBN 0-262-13369-5. (Reviewed August 2001.)

The Zen of Magic Squares, Circles, and Stars: An Exhibition of Surprising Structures across Dimensions, by Clifford A. Pickover. Princeton University Press, January 2001. ISBN 0-691-07041-5.

**Added to "Book List" since the list's last appearance.*

Doctoral Degrees Conferred

2000–2001

ALABAMA

Auburn University (10)

DISCRETE AND STATISTICAL SCIENCES

Abueida, Atif Aliyan, The full embedding problem.

Ashe, David James, Partial 6-cycle systems with any specified forest or 2-regular leave.

Foster, Michelle J., Operations on probalistic finite state source automata.

MATHEMATICS

De Pasquale, Horacio, Dual Riesz bases and the canonical operator.

Goeden-Fick, Kathleen, 2nth order boundary value problems with alternating order boundary.

Metcalf, Leigh, An extension of the Reidemeister intersection classes.

Nwogbaga, Agashi, New characterizations of Besov and Triebel-Lizorkin space.

Nyuydinkong, Griffith, On location of zeros and polar derivatives of polynomials.

Peterson, Lisa, Convergence of random measures on Polish spaces.

Zhang, Chaowen, Simple modules with character height zero and exceptional weight for the restricted special, Hamiltonian, and contact algebras.

University of Alabama, Tuscaloosa (6)

INFORMATION SYSTEMS, STATISTICS, AND MANAGEMENT SCIENCE

Busby, Kevin, Interpreting out-of-control signals from Hotelling's T^2 chart.

Kaddoura, Mawla, Density estimation through kernel estimation-based empirical characteristic function.

Meleth, Sreelatha, Analyzing data sets with a mixture of Mar and Ninr data: assessing the impact of sample size and proportion missing on estimates.

Wang, Lei, Longitudinal ecologic study with temporal-spatially correlated data: comparison of alternative models.

MATHEMATICS

Barov, Stoyu, On sets with convex shadows.

Krishnan, Srilal, Principal ideals in subalgebras of groupoid C^*-algebras.

ARIZONA

Arizona State University (5)

APPLIED MATHEMATICS

Fosser, Cecilia, Statistics in stochastic automata model for the spread of disease among mobile individuals.

Rao, Anupama, Titan, Triton, Pluto and Kuiper belt objects: a study of past and present atmospheres with grey and nongrey models.

MATHEMATICS

Shetty, Sachin, Characterization and reconstruction of finite signals using spectral information.

Wang, Chengde, Sequenceabiliity, R-sequenceability, and harmoniousness of finite groups.

Yang, Jinling, An evolutionary epidemic model with application to type A influenza.

University of Arizona (5)

MATHEMATICS

Cunningham, Geoffrey, Sums of squares in function fields of elliptic curves.

Edmunds, Jeffrey, A study of a stage-structured model of two competing species.

Kim, Seog Young, Vector bundles on an elliptic curve over a discrete valuation ring.

Marshall, David, Galois groups and Greenberg's conjecture.

Marshall, Susan Hammond, Crystalline representations and Neron models.

ARKANSAS

University of Arkansas (2)

MATHEMATICAL SCIENCES

Aberra, Dawit, The reflection principle, the Schwarz potential and quadrature.

Mann, Casey, On Heesch's problem and other tiling problems.

CALIFORNIA

California Institute of Technology (4)

APPLIED MATHEMATICS

Hu, Gang, Singularity formation in three-dimensional vortex sheets.

Louie, Michael, Numerical study of pattern forming processes in models of rotating Rayleigh-Bénard convection.

Tokman, Mayya, Magnetohydrodynamic modeling of solar magnetic arcades using exponential propagation methods.

MATHEMATICS

Killip, Rowan, Perturbations of one-dimensional Schrodinger operators preserving the absolutely continuous spectrum.

Claremont Graduate University (2)

MATHEMATICS

Verzi, Diana W., A mathematical description of diagrammatic models for structural changes in dendritic spines.

Villasana de villegas, Minaya, A delay differential equation model for tumor growth.

Stanford University (10)

MATHEMATICS

Bertelson-Volckaert, Melanie, Foliations associated to regular Poisson structures.

Butscher, Adrian, Deformation theory of minimal Lagrangian submanifolds.

The above list contains the names and thesis titles of recipients of doctoral degrees in the mathematical sciences (July 1, 2000, to June 30, 2001) reported in the 2001 Annual Survey of the Mathematical Sciences by 212 departments in 151 universities in the United States. Each entry contains the name of the recipient and the thesis title. The number in parentheses following the name of the university is the number of degrees listed for that university. A supplementary list, containing names received since compilation of this list, will appear in a summer 2002 issue of the *Notices*.

Castelvecchi, Davide, The foliated Morse inequalities.

Choi, Young-tun, Positively oriented ideal triangulations of hyperbolic three-manifolds.

Cotton, Peter, An analytic approach to Ornstein-Uhlenbeck processes with fluctuating parameters and applications in the modeling of fixed income securities.

Ha, Seungyeal, L'stability for systems of conservation laws with a non-resonant moving source.

Lee, Roger, Implied and local volatilities under stochastic volatility.

Sha, Xin Wei, Differential geometric performance and the technologies of writing.

Wang, Xiaodong, On the geometry of conformally compact Einstein manifolds.

SCIENTIFIC COMPUTATION & COMPUTATIONAL

Wang, Gao Feng, Coupled electromagnetic and device level investigations of metal-insulator-semiconductor interconnects.

University of California, Berkeley (32)

BIOSTATISTICS

Bryan, Jennifer, Methods for gene expresion analysis using DNA microarrays.

Bureau, Alexandre, Genetic linkage analysis based on identity by descent in large pedigrees using Markov chain Monte Carlo Methods.

Pavlic, Maja, Estimating the number of components in a mixture and analysis of recurrent events with time dependent covariates in the presence of dependent censoring.

Quale, Christopher, Nonparametric and semiparametric methods for three incomplete data structures.

Weingart, Michal, Edge effect correction for the nearest neighbor method.

MATHEMATICS

Abhyankar, Kashi, Smale strategies for prisoner's dilemma type games.

Buraztyn, Henrique, Morita equivalence in deformation quantization.

Clemens, John Daniel, Description set theory, equivalence relations, and classification problems in analysis.

Davis, Benjamin L., On Poisson spaces associated to finitely generated Poisson R-algebras.

Edwards, Karen E., Stabilizations of Heegaard splittings with respect to connectsumms of 3-manifolds.

Flynn, John, Near-exceptionality over finite fields.

Gomez, Concetta, Definability in p-adic power series rings.

Greene, Devin, On certain invariants in multivariable operator theory.

Grinshpan, Anatolii, Electrostatics and Dirichlet spaces.

Heitsch, Christine, Computational complexity of generalized pattern matching.

Huang, Hsiang-Ping, Commutators associated to a subfactor and its relative commutants.

King, Oliver Davis, A mass formula for unimodular lattices with no roots.

Li, Cheng, Model-based analysis of oligonuckofide arrays.

McMurdy, Kenneth, A splitting criterion for Galonic representative associated to exceptional modular forms.

Murray, Will, Frobenius algebras, independence of field, and quadratic forms.

Mustata, Mircea, Singularities and jet schemes.

Olsson, Martin, Log algebraic stacks and moduli of log schemes.

Portilheiro, Manuel, Weak solutions for contractive nonlinear equations and prabolic relaxation limits.

Pramanik, Malabika, Weighted integrals in RZ and the maximal conjugated Calderon-Zygmund operator.

Schleimer, Saul David, Almost normal Heegard splittings.

Schneiderman, Robert Roland, 4-dimensional intersection numbers of knots and links in 3-manifolds.

Shomron, Noam, Representations of Cartan type Lie superalgebras.

Smith, Greg, Computational methods for studying sheaves.

Vladimirsky, Alexander, Fast methods for static Hamilton-Jacobi partial differential equations.

Wasserman, David Robert, Epimorphisms and dominions in varities of lattices.

Yakimov, Milen, Geometry of complex reductive Poisson-Lie groups.

Zoble, Aaron, Stationary reflection and the determinacy of inductive games.

University of California, Davis (11)

MATHEMATICS

Casey, Michael, Stochastic limit laws for stochastic programming.

Henry, Jennifer, On generating a diminimal set of polyhedral maps on the torus.

Parsons, Regina, The effects of increased attention to the calculus foundations when teaching definite integrals.

Starr, Shannon, Some properties for the low-lying spectrum of the ferromagnetic, quantum XXZ spin system.

Thoo, John, Nonlinear waves in random media.

Tyler, Eiko, Manifolds on which analysis meets topology—a historical approach.

Williams, Matthew, Numerical methods for tracking interfaces with surface tension in 3-D mold-filling processes.

STATISTICS

Chang, Lin Jen-Jen, Simulation and synthesis of high-dimensional data and related issues.

Dubin, Joel, Nonparametric methods for multivariate longitudinal data.

Hanson, Timothy, Applied Bayesian semiparametric methods with special application to the A.F.T. model and to hierarchical models for screening.

Nguyen, Danh, Statistical analysis of gene expression data from DNA mocroarrays based on partial least squares and related dimension reduction.

University of California, Irvine (2)

MATHEMATICS

Landrigan, Michael, Log-dimensional properties of spectral measures.

Yang, Roger, Newton polygons of L-functions of polynomials of the form $X^d + \lambda X$.

University of California, Los Angeles (14)

MATHEMATICS

Barakat, Wissam, Levy randon fields on symmetric Riemannian spaces of noncompact type.

Barquero, Pedro, Norm principle for algebraic group.

Caibou, Frederic, Rate equations in materials sciences and simulation of multiphase flows.

Carter, Jamylle, Dual method for total variation-based image restoration.

Emerson, Nathaniel, The combinatorics of polynomials with disconnected Julia sets.

Fischman, Ami, On the image of lambda-adic Galois representations.

Gray, Maolison, Remote sensing of atmospheric parameters using forward scattering.

Kisisel, Ali, The hamiltonian structure of discrete KP equations.

Li, Chun Che, Kuznietsov trace formula and asymptotic behaviour of Hecke eigenvalues.

Nguyen, Duc, A boundary condition capturing method for incompressible flame discontinuities.

Nikshych, Deritri, Quantum groupoids, their representation categories, symmetries of von Neumann factors, and dynamical quantum groups.

Sherman, David, The application of modular algebras to relative tensor products and noncommutative L^p modules.

Wu, Hsin Tai, On p-adic Hilbert modular adjoint L-functions.

Zarikian, Vrej, Complete one-sided M-ideals in operator spaces.

University of California, San Diego (11)

MATHEMATICS

Aksoylu, Burak, Adaptive multilevel numerical methods with applications in diffusive bimolecular reactions.

Gallo, Teresa, Combinatorial bases for modules of coinvariants.

Halleck, Ezra, Magic square subclasses as linear diophantine equations.

Langley, Thomas, The plethysm of two Schur functions at hook, near-hook, and two-row shapes and a class of (q,t)-symmetric functions arising from plethysm.

Little, David, q-enumeration of classical combinatorial structures.

Marquez, Francisco, On Cayley graphs for subgroups of $GL(3,p)$.

McElroy, Tucker, Statistical inference for model parameters of time series exhibiting the Noah and Joseph effects.

Minei, Marvin, Three block diagonalization methods for the finite graph.

Ribando, Jason, Probabilistic methods for efficient triangulations of the n-cube.

Szczepanski, Amy, From Jacobson rings to the Jacobson conjecture.

Tuba, Imre, Braid representations and tensor categories.

University of California, Santa Barbara (5)

STATISTICS & APPLIED PROBABILITY

Acharyya, Suddhasatta, Some problems in nonparametric resampling inference.

Hau, Seonkoo, Portfolio mangement with stable distributions.

Karcher, Peter, Markov chain Monte Carlo stochastic approximation algorithms and generalized non-parametric mixed effects models.

Ke, Chunlei, Semi-parametric nonlinear regression and mixed effects models.

Mackey, Howard, Diagnostic for binary response mixed models.

University of Southern California (6)

MATHEMATICS

Goukasian, Levon, Lyapunov exponents for small perturbations of nilpotent and Hamiltonian systems.

Nestler, Andrew, Algebraic K-theory of curves and surfaces over finite fields.

Stroila, Matei, Arithmetic rigidity and algebraic cycles.

Uzun, Hasan, On maximum local roughness of random droplets in two dimensions.

Will, Oliver, Statistical inference in the fossil record.

Zou, Xiaorong, Geometry of the frame bundle.

COLORADO

Colorado School of Mines (1)

MATHEMATICAL AND COMPUTER SCIENCES

Wang, Lan, Estimation of multi-valued Green's function by dynamic ray tracing and true amplitude Kirchoff inversion in 4-D heterogeneous media.

Colorado State University (6)

MATHEMATICS

Erdmann, Melissa Claire, Cell exclusion algorithms.

Martin, Shawn Bryan, Techniques in support vector classification.

STATISTICS

Bronson, Douglas, Bootstrapping stochastic systems in survival analysis.

Streett, Sarah, Some observation driven models for time series.

Thompson, Sandra, Bayesian model averaging and spatial prediction.

Trindade, Adao Alexandre, Modified algorithms for multivariate subset autoregression.

University of Colorado, Boulder (8)

APPLIED MATHEMATICS

Akmaev, Slava, Phylogenetic approach to molecular structure prediction.

Bloechle, Brian, On The Taylor dispersion of reactive solutes in a parallel-plate fracture-matrix system.

Chartier, Timothy, Element-based algebraic multigrid (AMGe) and spectral AMGe.

Codd, Andrea, Elasticity-fluid coupled systems and elliptic grid generation (ECG) based on first-order system least squares (FOSLS).

Jarman, Ken, Stochastic immiscible flow with moment equations.

MacMillan, Hugh, First-order system least squares and electrical impedance tomography.

Robins, Vanessa, Computational topology at multiple resolutions.

Trubatch, David, Topics in solitons and inverse scattering: I. Discretization of the vector nonlinear Schrödinger equation. II. A new class of "reflectionless" potentials of the nonstationary Schrödinger equation and solutions of the Kadomtsev-Petviashvili I equation.

University of Colorado, Denver (7)

BIOSTATISTICS

Ellison, Misoo, Estimation of responder cell frequency and binomial three-level nonlinear mixed effects model in limiting dilution assays.

Joseph, Coll, Multivariate generalized linear mixed models with serial correlation: a state space approach with applications in HIV/AIDS.

Mikulich, Susan, Application of multivariate growth curve and univariate mixed models approaches to the cosinor analysis of spontaneous motility data.

Tooze, Janet, Analysis of repeated measures data with clumping at zero.

Xu, Xuesheng, The analysis of longitudinal binary data using a state space approach.

MATHEMATICS

Doherty, Faun, Topics on domination graphs of tournaments.

Emsermann, Markus, Variance reduction with quasi control variates.

University of Northern Colorado (4)

MATHEMATICAL SCIENCES

Fatholah, Kassemi, Pre-service teacher's conceptual understanding of rational numbers.

Medina, Elsa, Student understanding of span, linear independence, and basis in an elementary linear algebra class.

Perrine, Vicki, Effects of a problem-solving mathematics classroom on the proportional reasoning of preservice teachers.

Zderad, Jon, Understanding a student's oral, written and pictoral mathematical voice through engagement in and reflection on classroom episodes.

CONNECTICUT

University of Connecticut (11)

MATHEMATICS

Englert, Burkhard, A necessary and sufficient condition for embedding principally decomposable finite lattices into the c.e. degrees preserving greatest element.

Galperin, Yevgeniy, Uncertainty principles as embeddings of modulation spaces.

Han, Lixing, Trust region methods for unconstrained optimization.

Kang, Sheon Young, Numerical solution of integral equations with non-smooth kernels and applications.

Kanuni, Muge, Dense ideals and maximal quotient rings of incidence algebras.

Pascu, Mihai, Probabilistic approaches to eigenvalue problems.

Rasoanaivo, Guy, Stochastic modeling for long-term care insurance.

Stricevic, Slaven, Continuous time models.

STATISTICS

Banerjee, Sudipto, Multivariate spatial modeling in Bayesian settings.

Kottas, Athanasios, Bayesian nonparametric and semiparametric modeling using dirichlet process mixing: full inference with novel applications.

Patra, Kaushik, Innovative approaches to reliability and survival analysis.

Wesleyan University (2)

MATHEMATICS

Recoder-Nunez, Luis, Three classes of dense subspaces of products.

Tysdal, Kimberly, Dependent edges in acyclic orientations of graphs.

Yale University (6)

MATHEMATICS

Comerford, Mark D., Properties of Julia sets for the arbitrary composition of monic polynomials with uniformly bounded coefficients.

Coppi, Andreas, Least-square generalized quadratures and a fast stable numerical method for the Calderon commutator.

Liakhovskaia, Anna V., Structure and representations of small quantum groups.

Malkin, Anton, Geometric methods in the theory of Hall algebrasCT;Yale University;Mathematics.

Yun, Aaram, Discrete subgroups of the special linear group with thin limit sets.

STATISTICS

Novak, Laura, Classification and prediction of stock price behavior.

DELAWARE

University of Delaware (3)

MATHEMATICAL SCIENCES

Berensel Tanoglu, Gamze, Phase boundaries and anisatrophy via multiple order parameter theory for an FCC alloy.

Li, Pingqian, Boundary value problems for generalized n hypercomplex equations.

Naire, Shailesh, Gravitationally-driven drainage of thin films.

DISTRICT OF COLUMBIA

George Washington University (2)

MATHEMATICS

Ankney, Rachelle, The geometries $PG(n-1,q) \setminus PG(k-1,q)$.

Pirnazar, Amir, Girth, genus, and fractional chromatic number.

Howard University (2)

MATHEMATICS

Farmer, Shurron M., The analysis of a two-age-class single species, discrete-time climax population model.

Fleming, Jeffrey S., Weighted and parameter dependent Bergman projection, Bergman kernel, and D-bar equations on weakly pseudo convex complete Kahler manifolds.

FLORIDA

Florida Institute of Technology (2)

MATHEMATICAL SCIENCES

Terbeche, Mekki, Sequential design for estimation.

Yakar, Coskun, Stability analysis of nonlinear differential systems with initial time difference.

Florida State University (7)

MATHEMATICS

Arsuaga, Javier, Using knots as an assay for DNA organization inside bacteriophase P4 capsids.

Denny, Jeffrey, Geometry of proteins with applications to solid-state NMR.

Felkel, Brian, Decay estimates on oscillatory integrals with polynomial phase.

Jia, Hong-qi, Classification of QC Hopf algebras.

Szecsei, Denise, A convolution property of some measures with self similar fractal support.

Vazquez, Maria, Tangle analysis of site-specific recombination: Gen and Xer systems.

STATISTICS

Zhang, Shaojun, Building tracking portfolios and modeling risk management programs.

University of Central Florida (2)

MATHEMATICS

Al-Habash, Ammar, The aperture averaged scintillation of the intensity of a gaussian laser beam propagated through strong optical turbulence and reflected by various targets.

Boissy, Young, Parameter estimates for fractional autoregressive spatial processes.

University of Florida (9)

MATHEMATICS

Bodmann, Bernhard, Path integrals.

Riazati, Farzan, On the lattice of Π_1^0 classes.

Shaska, Tanush, Curves of genus two covering elliptic curves.

Tomerlin, Andrew, Representation and realization of bounded holomorphic functions defined on a polydomain.

White, Richard, An algebraic characterization of Minkowski space.

Yi, Tae-il, A classification of tree and applicaton of topology and graph theory to neurosurgery.

STATISTICS

Cantrell, Amy, On the strong law of large numbers for sums of random elements in Banach spaces.

McGoff, Philip, A unified approach to process optimization.

Robinson, Kevin, Quantile dispersion graphs for design comparisons for logistic models and other modelling issues.

University of South Florida (6)

MATHEMATICS

Benko, David, Approximation by weighted polynomials.

Dai, Ming, Identification of the parameters of a multivariate normal distribution by the distributions of maximum.

Jelsovsky, Daniel, Quandle cohomology and state-sum invariants of knots.

Maymeskul, Victor, On some problems in complex and multivariate approximation and interpolation.

Roberts, Henry, Predicting the performance of software via the power law process.

Yanez, George, Statistical modeling of epidemic disease propagation via branching processes and bayesian inference.

GEORGIA

Emory University (9)

BIOSTATISTICS

Allen, Andrew, Multivariate random length and missing data.

Price, Dionne, Survival models for heterogeneous populations with cure.

MATHEMATICS & COMPUTER SCIENCE

Bailey, Dionne, Computational approaches to representation theorems for finitely generated real algebras.

Brania, Abdelkrim, The controlled modulus condition and quasiconformality in metric spaces.

Hynds, Emily, 2-factors and line graphs.

Kanarsky, Margarita, On quasicircles and dilatations of quasisymmetric homeomorphisms.

Robinson, Maria, Classification of Heegaard splittings for (compact nonorientable surface) $\times S^1$.

Skokan, Jozef, Uniformity of set systems.

Xu, Taixi, Finite dimensional completely integrable Hamiltonian systems associated with soliton equations.

Georgia Institute of Technology (9)

MATHEMATICS

Baker, Anthony, Bounding entropy and finding symbolic dynamics via the spectrum of the Conley index.

Gonzalez, Luis, Some generalizations of the Knaster-Kuratowski-Mazurkiewics theorem.

Harrelson, Dyana, Dependence and limit theorems for stationary infinitely divisible sequences.

Jacobs, Denise, Multiwavelets in higher dimensions.

Labate, Demetrio, Time-frequency analysis of pseudodifferential operators.

McShine, Lisa, Random sampling of combinatorial structures.

Rivera, Roberto, On properties of completely flexible loops.

Thomson, Jan McDonald, Cyclically 5-connected graphs. Their relevance to Tutte's 4-flow conjecture.

Vougalter, Vitali, Diamagnetic behavior of sums of Dirichlet eigenvalues.

University of Georgia (11)

MATHEMATICS

Croot, Ernest, Unit fractions.

Cutter, Pamela, Finding prime pairs with particular gaps and square free parts of polynomials.

Khalil, Dina, On the p-divisibility of class numbers of quadratic fields.

Xu, Xiangming, Construction of two dimensional non separable orthonormal wavelets of short support.

Zhang, Mucheng, Calculation of transfer maps and associated primes.

STATISTICS

Berenhaut, Kenneth, Geometric renewal conversion rates and discrete life time distribution class.

Fukasawa, Takeshi, Inference for nonlinear state space models.

Lee, Li-Jen, Modeling the malaria epidemic.

Qi, Yongcheng, Abyesian minimum hellinger distance approaches to inference with application.

Smith, David, Bayesian & minimum hellinger distance approaches to inference of applications.

Smith, Wendy, Asymptotic & small sample properties for dependent bootstrapping.

HAWAII

University of Hawaii (1)

MATHEMATICS

Higa, Jonathan, Application of logic to probability.

IDAHO

Idaho State University (2)

MATHEMATICS

Priddy, Jerry, An algorithm to construct generator matrices for shortened cyclic codes.

Skoug, Muriel, On certain classes of cones of linear transformations on matrices.

ILLINOIS

Illinois State University (6)

MATHEMATICS

Benson, Carol, Assessing students' thinking in modeling probability contexts.

Lannin, John, Developing middle school students' understanding of recursive and explicit reasoning.

Leonard, Bill, Implementation of a computer algebra system in the calculus classroom: a multiple case study.

Marshall, Gerald, Using the history of mathematics to improve secondary student's attitudes toward mathematics.

Muckerheide, Paul, Becoming standards-like: changes in elementary preservice teachers through reflective intervention.

Polaki, Victor, Using instruction to trace Basotho elementary students' growth in probabilistic thinking.

Northern Illinois University (5)

MATHEMATICAL SCIENCES

Butler, Svetlana, Q-functions, extreme points and density theorems in the space of quasi measures.

Molefe, Daniel, Survival function estimation when lifetime and censoring time are dependent.

Park, Hyung Kor, Studies on matrices under phi maps.

Riehl, Suzanne, Spectral functions associated with Sturm-Liouville and Dirac equations.

Weiss, Matthias, Limit point action of discrete Mobius groups.

Northwestern University (11)

MATHEMATICS

Mauger, Justin, The cohomology of Lie algebras associated with p-groups.

Moar, Scott, Trapping regions for unstable manifolds via prime ends.

Pushin, Oleg, Steenrod operations in motivic cohomology.

Qian, Tifei, Heteroclinic orbits and chaotic invariant sets for monotone twist maps.

Stawiska, Margarete, Repellers for regular polynomial endomorphisms C^k.

Thatcher, Scott, Rank-two Hecke eigenfunctions on elliptic curves.

Wiseman, James, Sofic shifts and the Conley index.

Wu, Tao, On Grayson's motivic complexes.

STATISTICS

Huang, Shuguang, Higher-order inference in models for census survival data.

Li, Hua, An exponential response model for bivariate association.

Liu, Xian-Iang, Model selection in unbiased equations.

University of Chicago (14)

MATHEMATICS

Bolt, Michael, Vanishing properties and spectral analysis in the Kerzman-Stein theory.

Cushman, Matthew, The motivic fundamental group.

Fausk, Halvard, The non-positive equivariant stems.

French, Christopher, The equivariant J-homomorphism.

Hemmer, David, Extensions of hook and completely splittable modules for the symmetric group.

Li, Paul, On the universal embeddings of the binary symplectic and unitary dual polar spaces.

Oberman, Adam, Level set motion by advection, growth, and mean curvature as a model for combustion.

Ou, Winston, Natural extremal operators on BMO and A^∞: symmetries and near-reciprocities.

Prasad, Amritanshu, The almost unramified discrete spectrum for split groups over a rational function field.

Schmitz, David, Finite subgroups of formal groups.

STATISTICS

Craiu, Virgil Radu, Multivalent framework for approximate and exact sampling and resampling.

Song, Seongjoo, Options and discontinuity: an asymptotic decomposition for trading algorithms.

Wit, Ernst, The categorical imperative: extendibility considerations for statistical models.

Zhang, Lan, From Martingales to ANOVA: implied and realized volatility.

University of Illinois, Urbana-Champaign (23)

MATHEMATICS

Baxter Bauer, Kristine, On Hopf algebra type and rational decompositions of functors.

Chaoha, Phichet, Obstructions for constructing the Taylor tower of finite degree functions of spectra.

Chiang, River, Complexity one Hamiltonian Su(2) actions.

Choi, Geumlan, A certain generalization of Rogers Ramanujan continued fraction.

Hill, Christopher, Uniform distribution, Behrend sequences, and some spaces of arithmetic functions.

Ho, Kejia, Kolmogorov complexity, strong reducibilities, and computably enumerable sets.

Hyeon, Donghoon, Moduli questions for augmented bundles.

Jiang, Tao, Some problems in structural and extremal graph theory.

Kahng, Byunqik, Dynamics of sympletic piecewise affine elliptic rotation maps on tori.

Kapitza, Paul, On small geometric invariants of 3-manifolds.

Kilmurray, Donough, Geometry on affine actions.

Lee, Donghi, Some conjectures on free groups in combinatorial group theory.

Pomper, Markus, Double dual types of Banach spaces.

Retzlaff, Todd, The rate of decay of concentration functions on locally compact groups.

Scalari, Alberto, Stationary discs and CR geometry.

Sohn, Jaebum, q-continued fractions and related q-series.

Steichen, Jennifer, Heavy traffic limit theorems for the closed Lu-Kumar network.

Yi, Jinhee, The construction and applications of modular equations.

Yifan, Yang, Topics in analytic, combinatorial and probabilistic number theory.

STATISTICS

Froelich, Amy Goodwin, Assessing unidimensionality of test items and some asymptotics of parametric item response theory.

Galfalvy, Hanga, Censored regression models with applications for infrastructure degradation studies.

Liu, Li, Building a nonparametric model after dimension reduction.

Trachtenberg, Felicia, Contributions to estimation in item response theory.

INDIANA

Indiana University, Bloomington (7)

MATHEMATICS

Jadallah, Hala, The onset of superconductivity in a domain with a corner.

Jakelic, Dijana, Structure of some representations of quantum groups, their crystal bases and completions.

Kim, Se-Goo, Polynomial splittings of Casson-Gordon invariants.

Kostov, Stoyko, Norm-ideal perturbations and simultaneous diagonalization of sets of operators.

Oh, Myunghyun, Stability analysis of periodic solutions ov viscous conservation laws.

Perdomo, Oscar, First eigenvalue and index: two characterizations of Clifford minimal hypersurfaces of spheres.

Wojnar, Gregory, Generalized Wishart distributions on convex homogeneous cones.

Purdue University (13)

MATHEMATICS

Asgari, Mahdi, On holomorphy of local Langlands L-functions.

Jackson, Michael, Vector bundles over BG whose Euler classes are effective.

Ko, Yangsuk, Analysis of solutions to a Ginzburg-Landau system for layered superconductors.

Mendez, Pedro, Sharp estimates of Dirichlet heat kernels of the Laplacian, fractional Laplacian and applications.

Osawa, Ryo Ichi, A surface, integral points an automorphism groups.

Patyi, Imre, Analytic cohomology vanishing in infinite dimensions.

Shin, Eunjee, On the analysis of a nonisothermal model for superconductivity.

Vassilev, Dimiter, Yamabe equations on Carnot groups.

Wu, Lih-Ing, On bifurcations of codimension greater than two arising from a childhood disease model.

Zhuang, Gongyuan, Convergence analysis of a domain decomposition method for separable PDE.

STATISTICS

Mukhopadhyay, Nitai Das, Bayesian model selection for high dimensional models with prediction error loss and 0-1 loss.

Tsai, Wen-Chi, Some contributions to stochastic geometry.

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IOWA

Iowa State University (10)

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Hayrapetyan (Airapetyan), Ruben, Nonlinear problems and applications.

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University of Kentucky (8)

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Louisiana State University, Baton Rouge (8)

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Johns Hopkins University (11)

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Arras, John, Poisson summation in harmonic analysis.

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Boston University (12)

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Harvard University (16)

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Northeastern University (3)

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Tufts University (1)

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MICHIGAN

Central Michigan University (1)

MATHEMATICS

Seaman, Carol, Students' use of spatial visualization with the aid of technology in the learning of three-dimensional calculus concepts.

Michigan State University (12)

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Draghici, Liliana, Some aspects of polya tree and Dykstra-Lund priors.

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Sikorskii, Alla, Diffusion approximation for solutions of perturbed differential equations.

Michigan Technological University (1)

MATHEMATICAL SCIENCES

Chateauneuf, Mark, Covering arrays.

Oakland University (1)

MATHEMATICS & STATISTICS

Hou, Xeuzhang, Analysis and control of a torsional flexible robot arm—an operator approach.

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Dabija, Marius, Algebraic and geometric dynamics in several complex variables.

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Wayne State University (3)

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Western Michigan University (3)

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Erwin, David, Cost domination in graphs.

STATISTICS

Hanson, Boyd, A comparison of methods of detection of qualitative interaction in multicenter trials.

Zeitler, David, Empirical spectral analysis of random number generators.

MINNESOTA

University of Minnesota, Minneapolis (5)

STATISTICS

Binns, Pamela, Aperiodic response time distributions in queues with guaranteed deadlines for periodic tasks.

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Dobbin, Kevin, Stochastic permutation models for treatment selection processes with applications to causal inference.

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University of Minnesota (6)

BIOSTATISTICS

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MISSISSIPPI

Mississippi State University (1)

MATHEMATICS & STATISTICS

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University of Mississippi (1)

MATHEMATICS

Aldridge, Gwen, Bayesian bootstrap procedures for clustered binary data having unbalanced design.

MISSOURI

St. Louis University (1)

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University of Missouri, Columbia (1)

STATISTICS

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University of Missouri, Kansas City (1)

MATHEMATICS & STATISTICS

Delaware, Richard Raymond, Sets whose Hausdorff measure equals method I outer measure.

Washington University (4)

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Retsek, Dylan, The kernel supremum property and norms of composition operators.

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Napoli, Joseph, Optimal communication strategies for robotic networks.

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MONTANA

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Jacklitch, Jim, Homeomorphisms of one-dimensional hyperbolic attractors.

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University of Montana (1)

MATHEMATICAL SCIENCES

Oberg, Todd, In investigation of undergraduate calculus students' conceptual understanding of the definite integral.

NEBRASKA

University of Nebraska, Lincoln (9)

MATHEMATICS & STATISTICS

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Agre, Keith, Initial-boundary value problems for nonlinear wave equations.

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Sapko, Victoria, Local cohomology and numerical semigroups.

Strei, Teresa, Global regularity of nonlinear wave equations.

NEW HAMPSHIRE

Dartmouth College (2)

MATHEMATICS

Laison, Joshua D., Tube representations of ordered sets.

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University of New Hampshire (2)

MATHEMATICS

Gerson, Hope, Making connections: compartmentalization in pre-calculus students' understanding of functions.

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NEW JERSEY

New Jersey Institute of Technology (4)

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James, Adrienne, A dynamical model of the distributed interaction of intracellular signals.

Ma, Xiaoqun, Efficient inversion methods in underwater acoustics.

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Princeton University (13)

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Lvou, Alexey, Combinatorial techniques for database searching.

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Rutgers University, New Brunswick (3)

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Shoung, Jym-Ming, Isotonic regression and mode estimation.

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Rutgers University, Newark (2)

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Martin, Ryan, On graph packing, induced subgraphs and intersecting hypergraphs.

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NEW MEXICO

New Mexico State University (1)

MATHEMATICAL SCIENCES

Rhodes, Mark, An algorithm for the computation of adjoints of monomial ideals.

University of New Mexico (6)

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Barcan, Mugurel A., The affine line modulo isogeny.

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NEW YORK

City University of New York, Graduate Center (5)

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Clarkson University (1)

MATHEMATICS & COMPUTER SCIENCE

Boswell, Carroll, Classification and solution of sixth degree equations.

Columbia University (4)

BIOSTATISTICS

Hsu, Yanzhi, Repeated measures with censored data.

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Lu, Hao, Topics in Bayesian and computational statistics.

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Howle, Victoria, Efficient iterative methods for ill-conditioned linear and nonlinear network problems.

Jonsson, Gudbjorn, Eigenvalue methods for accurate solution of polynomial equations.

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Stenson, Cathrine, Linear inequalities for flag F-vectors of polytopes.

Waltz, Anke, On the Bellows conjecture.

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Courant Institute, New York University (13)

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Aguilar, Juan Carlos, Anisotropic adaptive refinement algorithms for finite element methods.

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Rensselaer Polytechnic Institute (4)

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State University of New York, Albany (1)

MATHEMATICS & STATISTICS

Rocca, Charles, Finite and boundary test elements.

State University of New York, Binghamton (8)

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Ardanza-Trevijano, Sergio, Exotic smooth structures on non-locally symmetric negatively curved manifolds.

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Joita, Cezar, Projections of Runge domains, covering spaces with parameters and traces of locally hyperconvex Stein domains.

Nichita, Florin, Non-linear equations, quantum groups and duality theorems.

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Chang, Chu-Fei, Multi-sensory virtual design environments.

Estkowski, Regina, The complexity of polygonal simplification with applications to geographic information systems.

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University of Rochester (2)

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NORTH CAROLINA

Duke University (5)

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MATHEMATICS

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NORTH DAKOTA

North Dakota State University (2)

MATHEMATICS

Krygin, Andrei, Some properties of coboundaries in measurable dynamics.

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Galster, Dwight, Analysis of data equally spaced on a circle.

OHIO

Bowling Green State University (3)

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Kent State University (5)

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University of Akron (1)

MATHEMATICS AND COMPUTER SCIENCE

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OKLAHOMA

Oklahoma State University (2)

STATISTICS

Blum, James, Conservative confidence regions for kernel estimates of the varying coefficient model.

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University of Oklahoma, Health Sci. Ctr. (2)

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Oregon State University (3)

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Portland State University (1)

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University of Oregon (3)

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Lehigh University (1)

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University of Pennsylvania (8)

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Mao, Wenxin, Free knot polynomial spline confidence intervals.

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University of Pittsburgh (7)

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Ezekiel, Soundararajan, Computational fractal methods for image analysis and compression.

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RHODE ISLAND

Brown University (8)

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University of Rhode Island (3)

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Sparks, Rebecca, Rational functions whose zeros and poles are constrained by conditions arising in control.

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Clemson University (11)

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Medical University of South Carolina (2)

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University of South Carolina, Columbia (6)

EPIDEMIOLOGY & BIOSTATISTICS

Moore, Charity, Logistic regression with incomplete covariate data in complex survey sampling.

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TENNESSEE

University of Tennessee (6)

MATHEMATICS

Cummings, Peter, Analysis of finite element based numerical methods for acoustic waves, elastic waves, and fluid-solid interactions in the frequency domain.

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Vanderbilt University (1)

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TEXAS

Rice University (9)

COMPUTATIONAL & APPLIED MATHEMATICS

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Klampfl, Erica, A mixed integer nonlinear formulation for improving membrane filtration water treatment plant design.

Sinkevich, Olena, Optimization for parameter estimation with application to transmission electron microscopy.

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Southern Methodist University (3)

MATHEMATICS

Antohe, Valeria, Computational methods for Hamiltonian systems.

Jiang, Qiaoyuan, Characteristic finite element methods for degenerate parabolic problems and their application to two-phase in porous media.

STATISTICAL SCIENCE

Lee, Euikyoo, Bayesian hierarchical spatiotemporal models with application to the modeling of Hanford site tritum concentrations.

Texas A & M University (15)

MATHEMATICS

Arnold, Richard, Homogenization and global existence of solutions to reaction-diffusion systems.

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Texas Tech University (2)

MATHEMATICS AND STATISTICS

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University of Houston (3)

MATHEMATICS

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University of North Texas (2)

MATHEMATICS

Hanus, Pawel, Example and applications of infinite iterated function systems.

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University of Texas, Arlington (2)

MATHEMATICS

Hua, Ye, Multivariate failure time analysis when only time-to-first failure is observed.

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University of Texas, Austin (15)

MATHEMATICS

Abad, Juan, Renormalization invariant tori, and periodic orbits for Hamiltonian flows.

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Kalisch, Henrik, Models for internal waves in two-fluid systems.

Momken, Bahareh, Fluid flow and deformable multi-porus media.

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Deb, Manas, Solution of partial differential equations (SPDEs) using Galerkin method: theory and applications.

Gerde, Eric, Fracture and friction.

Hamner, Mark, Bayesian point estimates in finite population sampling.

Jester, William, Interactive numerical simulation of riser interference phenomena in offshore structures.

Kirby, Robert, Local time stepping and a posteriori estimates for flow and transport in porous media.

Rhodes, Phillip, Statistical signal processing algorithms.

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University of Texas (3)

BIOMETRY

Correa, Arlene, Modeling a health promotion campaign process.

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UTAH

Brigham Young University (1)

MATHEMATICS

Andrist, Kathryn, A 3-manifold with non-trivial fundamental group which does not admit non-trivial group actions.

University of Utah (3)

MATHEMATICS

Kong, Jian, Schubert calculus on flag manifolds.

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Xie, Xiangdong, Tits boundary and quasi-isometries between CAT(o) z-complexes.

VIRGINIA

University of Virginia (4)

MATHEMATICS

Ahearn, Stephen, Product structures on generalized Eilenberg-Moore spectral sequences.

Hellings, Christian, Two-isometries on Pontryagin spaces.

Kelton, Suzanne, Involutions fixing $\mathbb{R}P^j \cup F^n$.

Williams, Todd, Option pricing and branching processes.

Virginia Commonwealth University (3)

BIOSTATISTICS

Crofts, Theresa, Accounting for treatment by noise factor interactions in sample size determination for the generalized linear mixed model.

Meadows, Stephanie, Optimal experimental designs for detecting departures from additivity in drug/chemical mixtures.

Shih, Margaret, Titrating and evaluating multiple drug regimens within subjects.

Virginia Polytechnic Institute & State University (4)

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Beverly, Lesa, The creation of algorithms designed for analyzing periodic surfaces of crystals and mineralogically important sites in molecular models of crystals: understanding the election density function through visual examination of the curvature and shape of the equi-value Laplacian surfaces.

Hoggard, John, Accuracy of computer generated approximation to Julia sets.

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Noble, Robert, Multivariate applications of Bayesian model averaging.

WASHINGTON

University of Washington (31)

APPLIED MATHEMATICS

Knaub, Karl R., On the asymptotic behavior of internal layer solutions of advection-diffusion-reaction equations.

Luke, David Russell, Analysis of optical wavefront reconstruction and deconvolution in adaptive optics.

Moskowitz, Benjamin Michael, An analysis of frictional feedback in the Madden-Julian oscillation.

Obrist, Dominik, On the stability of the swept leading-edge boundary layer.

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Arbogast, Patrick, Statistical methods for case-control studies.

Chapman, Nicola, Genome descent in isolated populations.

Dasgupta, Abhijit, Parametric identifiability and related problems.

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Dunning, Andrew, Aspects of matching and power in group randomized trials.

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Lystig, Theodore, Evaluation of hidden Markov models.

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Warnes, Gregory, The normal kernel coupler: an adaptive Markov chain Monte Carlo method for efficiently sampling from multi-modal distributions.

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Arden, Gregory, Approximation properties of subdivision surfaces.

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Nandy, Rajesh, Estimation of spectral gap using coupling techniques.

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Ratzkin, Jesse, The end-to-end gluing construction for surfaces of constant mean curvature.

Schneider, David, Nonholonomic Euler-Poincare equations and stability in Chaplygn's sphere.

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Wegelin, Jacob A., Latent models for cross-covariance.

Washington State University (2)

PURE & APPLIED MATHEMATICS

Felt, Andrew, A computational evaluation of interior point cutting plane algorithms for the stochastic programs.

Pierce, Donna, Planar functions.

WISCONSIN

Marquette University (2)

MATHEMATICS, STATISTICS & COMPUTER SCIENCE

Manuel, Albert, Mathematical model for evaluation of velocity profile effects on cross-sectional concentration with application to x-ray imaging.

Murphy, Brian, Modeling the time to engrafement of white blood cells and platelets following autologous peripheral blood stem cell tran.

Medical College of Wisconsin (1)

BIOSTATISTICS

Wu, Jingtao, Statistical methods for discretizing a continuous covariate in a censored data regression problem.

University of Wisconsin, Madison (24)

MATHEMATICS

Berger, Kurt, Asymptotic and numerical analysis of free surface flows: lump solitons and wave turbulence.

Borges, Maria, Homoclinic and heteroclinic solutions for a Hamiltonian system in the plane.

Chen, Bohui, A smooth compactification of moduli of instanton and its application.

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Kung, David Tsung-Shiao, Local smoothing phenomena for operators failing the cinematic curvature condition.

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MacNair, Simon, Valuation problems in incomplete markets.

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Chan, Kin-Yee, Logistic regression trees.

Chen, Yonghua, Flexible group sequential designs for clinical trials.

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WYOMING

University of Wyoming (3)

MATHEMATICS

Suwilo, Saib, On 2-exponents of 2-digraphs.

STATISTICS

Newton, Brian, A critical study of the varimax rotation method, with a comparison to Bieber's invariance solution for one-sample.

Safer, Alan, Neural networks and MARS for prediction using legal insider stock trading data.

Doctoral Degrees Conferred 1999–2000

Supplementary List

The following list supplements the list of thesis titles published in the 2001 *Notices*, pages 253–271.

CALIFORNIA

University of California, Santa Barbara (1)

STATISTICS & APPLIED PROBABILITY

Mackey, Howard, Diagnostic for binary response mixed models.

NORTH CAROLINA

Duke University (1)

STATISTICS & DECISION SCIENCES

Liu, Jane, Bayesian time series: Analyis methods usings simulation-based computation.

OKLAHOMA

University of Oklahoma (1)

MATHEMATICS

Allali, Mohamed, Digital signal processing on the unit sphere: interpolation, equidistribution and compresssion via Ramanujan set of rotations and planar wavelets.

PENNSYLVANIA

Pennsylvania State University (1)

STATISTICS

Pitman, Jennifer, Adaptive splines and genetics algorithms for optimal statistical modeling.

From the AMS

2001 Election Results

In the elections of 2001 the Society elected a president elect, vice president, a trustee, five members at large of the Council, two members of the Editorial Boards Committee, and three members of the Nominating Committee. Terms for these positions are three years beginning on 1 February 2002 and ending on 31 January 2005, except for the president elect, whose term is for one year (followed by duties as president and as immediate past president), and for the trustee, whose term is for five years ending on 31 January 2007. Members elected to the Nominating Committee begin serving immediately, and their terms end on 31 December 2004.

President Elect

Elected as the new president elect is **David Eisenbud** from the Mathematical Sciences Research Institute.

Vice President

Elected as the new vice president is **Hugo Rossi** from the University of Utah.

Trustee

Elected as the new trustee is **Carol S. Wood** from Wesleyan University.

Members at Large of the Council

Elected as new members at large of the Council are
Colin C. Adams from Williams College
Sylvia T. Bozeman from Spelman College
Irene M. Gamba from the University of Texas at Austin
Henri A. Gillet from the University of Illinois at Chicago
David R. Morrison from Duke University

Editorial Boards Committee

Elected as new members of the Editorial Boards Committee are
Clifford J. Earle from Cornell University
Svetlana Jitomirskaya from the University of California, Irvine

Nominating Committee

Elected as new members of the Nominating Committee are
Sheldon Axler from San Francisco State University
Robert M. Fossum from the University of Illinois at Urbana-Champaign
Jane Hawkins from the University of North Carolina at Chapel Hill

Amendments to the Bylaws

Amendments to the Bylaws concerning voting mechanics were approved.

Suggestions for elections to be held in the fall of 2002 are solicited by the 2002 Nominating Committee. Positions to be filled in the 2002 election are: vice president, trustee, and five members at large of the Council. Suggestions should be sent to the secretary.

Suggestions for nominations for two positions on the Editorial Boards Committee and three positions on the 2003 Nominating Committee can also be sent to the secretary:

Robert J. Daverman, Secretary
American Mathematical Society
312D Ayres Hall
University of Tennessee
Knoxville, TN 37996-1330
`secretary@ams.org`

The deadline for suggestions is 28 February 2002.

CALL FOR SUGGESTIONS

There will be a number of contested seats in the 2002 AMS Elections. Your suggestions are wanted by:

The Nominating Committee
for vice president, trustee,
and five members at large of the council

and by

The President
for three Nominating Committee members
and two Editorial Boards Committee members.

In addition

The Editorial Boards Committee
requests suggestions for appointments to
various editorial boards of Society publications.

Send your suggestions for any of the above to:

Robert J. Daverman, Secretary
American Mathematical Society
312D Ayres Hall
University of Tennessee
Knoxville, TN 37996-1330
e-mail: `secretary@ams.org`

The deadline for suggestions is 28 February 2002.

2002 AMS Election

Nominations by Petition

Vice President or Member at Large

One position of vice president and member of the Council *ex officio* for a term of three years is to be filled in the election of 2002. The Council intends to nominate at least two candidates, among whom may be candidates nominated by petition as described in the rules and procedures.

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

Petitions are presented to the Council, which, according to Section 2 of Article VII of the bylaws, makes the nominations. The Council of 23 January 1979 stated the intent of the Council of nominating all persons on whose behalf there were valid petitions.

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

Editorial Boards Committee

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

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

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

Nominating Committee

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

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

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

Rules and Procedures

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

1. To be considered, petitions must be addressed to Robert J. Daverman, Secretary, American Mathematical Society, 312 D Ayres Hall, University of Tennessee, Knoxville, TN 37996-1330, and must arrive by 28 February 2002.
2. The name of the candidate must be given as it appears in the *Combined Membership List* (*CML*). If the name does not appear in the list, as in the case of a new member or by error, it must be as it appears in the mailing lists, for example on the mailing label of the *Notices*. If the name does not identify the candidate uniquely, append the member code, which may be obtained from the candidate's mailing label or the Providence office.
3. The petition for a single candidate may consist of several sheets each bearing the statement of the petition, including the name of the position, and signatures. The name of the candidate must be exactly the same on all sheets.
4. On the next page is a sample form for petitions. Copies may be obtained from the secretary; however, petitioners may make and use photocopies or reasonable facsimiles.
5. A signature is valid when it is clearly that of the member whose name and address is given in the left-hand column.
6. The signature may be in the style chosen by the signer. However, the printed name and address will be checked against the *Combined Membership List* and the mailing lists. No attempt will be made to match variants of names with the form of name in the *CML*. A name neither in the *CML* nor on the mailing lists is not that of a member. (Example: The name Robert J. Daverman is that of a member. The name R. Daverman appears not to be.)
7. When a petition meeting these various requirements appears, the secretary will ask the candidate to indicate willingness to be included on the ballot. Petitioners can facilitate the procedure by accompanying the petitions with a signed statement from the candidate giving consent.

Nomination Petition for 2002 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 February, 2003.

Name and address (printed or typed)	
	Signature
	Signature
	Signature
	Signature
	Signature
	Signature

Add this Cover Sheet to all of your Academic Job Applications

How to use this form

1. Using the facing page or a photocopy, (or visit the AMS web site for a choice of electronic versions at www.ams.org/coversheet/), fill in the answers which apply to *all* of your academic applications. Make photocopies.

2. As you mail each application, fill in the remaining questions neatly on one cover sheet and include it *on top of* your application materials.

The purpose of the cover form is to aid department staff in tracking and responding to each application for employment. Mathematics departments in Bachelor's-, Master's-, and Doctorate-granting institutions are expecting to receive the form from each applicant, along with the other application materials they require.

The AMS suggests that applicants and employers visit the Job Application Database for Mathematicians (www.mathjobs.com), a new electronic resource being offered by the AMS (in partnership with Duke University) for the first time in 2001-02. The system provides a way for applicants to produce printed coversheet forms, apply for jobs, or publicize themselves in the "Job Wanted" list. Employers can post a job listing, and once applications are made, search and sort among their applicants. Note-taking, rating, e-mail, data downloading and customizable EOE funnctions are available to employers. Also, reference writers can submit their letters online. A paperless application process is possible with this system, however; employers can choose to use any portion of the service. It is hoped that departments hiring for postdoc positions, especially, will utilize the system this year. There will be no fees for any services this year. This system was developed at the Duke University Department of Mathematics, and was tested by a group of departments in 2000-01.

Please direct all questions and comments to: emp-info@ams.org.

Academic Employment in Mathematics

AMS STANDARD COVER SHEET

Last Name ______________________________

First Name ______________________________

Middle Names ______________________________

Address *through next June* ______________________ **Home Phone**

______________________ ______________

______________________ **e-mail Address**

______________________ ______________

Current Institutional Affiliation **Work Phone**

______________________ ______________

Highest Degree Held or Expected ______________________

Granting Institution ______________ **Date (optional)** ______________

Ph.D. Advisor ______________________

Ph.D. Thesis Title (optional) ______________________

Indicate *the mathematical subject area(s) in which you have done research using, if applicable, the Mathematics Subject Classification printed on the back of this form or on e-MATH. If listing more than one number, list first the one number which best describes your current primary interest.*

Primary Interest ______________________

Secondary Interests *optional* ______________________

Give a brief synopsis *of your current research interests (e.g. finite group actions on four-manifolds). Avoid special mathematical symbols and please do not write outside of the boxed area.*

____

____

Most recent, if any, position held *post Ph.D.*

University or Company ______________________

Position Title ______________________

Indicate the position for which you are applying and position posting code, if applicable

____

If unsuccessful for this position, would you like to be considered for a temporary position?

☐ Yes ☐ No If yes, please check the appropriate boxes.

☐ Postdoctoral Position ☐ 2+ Year Position ☐ 1 Year Position

List the names, affiliations, and e-mail addresses *of up to four individuals who will provide letters of recommendation if asked. Mark the box provided for each individual whom you have already asked to send a letter.*

☐ ______________________________

☐ ______________________________

☐ ______________________________

☐ ______________________________

This form is provided courtesy of the American Mathematical Society.

This cover sheet is provided as an aid to departments in processing job applications. It should be included with your application material.

Please print or type. Do not send this form to the AMS.

AMERICAN MATHEMATICAL SOCIETY · ΤΡΗΤΟΣ ΜΗ ΕΙΣΙΤΩ ΑΓΕΩΜΕ · FOUNDED 1888

2000 Mathematics Subject Classification

00 General
01 History and biography
03 Mathematical logic and foundations
05 Combinatorics
06 Order, lattices, ordered algebraic structures
08 General algebraic systems
11 Number theory
12 Field theory and polynomials
13 Commutative rings and algebras
14 Algebraic geometry
15 Linear and multilinear algebra, matrix theory
16 Associative rings and algebras
17 Nonassociative rings and algebras
18 Category theory, homological algebra
19 *K*-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
37 Dynamical systems and ergodic theory
39 Difference and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
49 Calculus of variations and optimal control, optimization
51 Geometry
52 Convex and discrete geometry
53 Differential geometry
54 General topology
55 Algebraic topology
57 Manifolds and cell complexes
58 Global analysis, analysis on manifolds
60 Probability theory and stochastic processes
62 Statistics
65 Numerical analysis
68 Computer science
70 Mechanics of particles and systems
74 Mechanics of deformable solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
83 Relativity and gravitational theory
85 Astronomy and astrophysics
86 Geophysics
90 Operations research, mathematical programming
91 Game theory, economics, social and behavioral sciences
92 Biology and other natural sciences
93 Systems theory, control
94 Information and communication, circuits
97 Mathematics education

Mathematics Calendar

The most comprehensive and up-to-date Mathematics Calendar information is available on e-MATH at `http://www.ams.org/mathcal/`.

February 2002

* 22–24 **The Third Annual Colloquiumfest**, Univ. of Saskatchewan, Saskatoon, Canada.

Topics: Algebraic Geometry, Real Algebraic Geometry and Computational Algebra.

Organizers: F.-V. Kuhlmann, S. Kuhlmann, M. Marshall.

Speakers: The list of invited speakers includes: V. Astier (Dublin), R. Auer (Groningen), T. Craven (Hawaii), D. Cutkosky (Missouri), H. Knaf (Kaiserslautern), J. Koenigsmann (Basel), E. Mosteig (Tulane), P. A. Parrilo (ETH Zürich), F. Pop (Bonn/Princeton)*, M. van der Put (Groningen)*, T. Smith (Cincinatti), B. Sturnfels (Berkeley), M. Tressl (Regensburg). (* = to be confirmed).

Information: `http://math.usask.ca/fvk/Mb3.htm`; e-mail: `valth@math.usask.ca`; Contact address: 106 Wiggins Road, Saskatoon, SK, S7N 5E6, Canada phone: (306) 966-6111 - fax: (306) 966-6086.

March 2002

* 11–June 14 **Large Scale Communications Networks**, Institute for Pure and Applied Mathematics, UCLA, Los Angeles, California.

Organizers: J. Doyle (Caltech), E. Feron, R. Murray, W. Willinger (AT&T Research Labs), D. Estrin (UCLA), K. Lerman (USC/ISI), F. Kelly (Cambridge), D. Donoho (Stanford), and M. Green (IPAM and UCLA).

Program: Large Scale Communications Networks. The Internet has become a gold mine for new, exciting, and challenging mathematical problems, where scale, complexity, and dynamic play key roles. The goal of this program on the interface between the mathematical/physical sciences and computer/engineering sciences is to initiate, facilitate, or foster interactions among researchers with diverse backgrounds who seek to unravel the ill-understood dynamics of large-scale complex internetworks such as the Internet. The program will commence with tutorials, then feature three key workshops and will conclude with a conference at Lake Arrowhead. WORKSHOP I: Large-Scale Communication Networks: Topology, Routing, Traffic, and Control. WORKSHOP II: Large-Scale Engineering Networks: Robustness, Verifiability, and Convergence. WORKSHOP III: On Massively Distributed Self-Organizing Networks.

Information: Full details of the program and its workshops can be found at `http://www.ipam.ucla.edu/programs/cn2002/`. Program specific questions can be addressed to `cn2002@ipam.ucla.edu`. Funding is available for graduate students, post-docs, and young academics in the junior stages of their career who wish to attend the entire program. Application form is available on program website.

* 23–25 **Geometric Analysis for the 21st Century: Conference in honour of R. B. Melrose**, MIT, Cambridge, Massachusetts.

Description: The conference honors R. Melrose on the occasion of the 25 years that he has been on the faculty of MIT. The lectures cover a wide range of topics related to Melrose's interests: scattering theory, spectral theory, microlocal analysis, harmonic analysis, several complex variables, inverse problems.

Speakers: N. Burq, C. Epstein, C. Fefferman, M. Ikawa, V. Ivrii, P. Lax, V. Petkov, P. Sarnak, J. Sjöstrand, T. Tao, D. Tataru, M. Taylor, G. Uhlmann, S. Zelditch.

Organizers: V. Guillemin, R. Mazzeo, A. Vasy, M. Zworski.

Information: `andras@math.mit.edu`, `http://math.mit.edu/~andras/rbmconf.html`.

* 25–28 **Finite Volume Methods for Hyperbolic Conservation Laws: with Applications to Compressible Flow and Environmental**

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 and symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. A complete list of meetings of the Society can be found on the last page of each issue.

An announcement will be published in the *Notices* if it contains a call for papers and specifies the place, date, subject (when applicable), and the speakers; a second 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 every third 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 the 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 the *Notices* in care of the American Mathematical Society in Providence or electronically to `notices@ams.org` or `mathcal@ams.org`.

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 the *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.

The complete listing of the Mathematics Calendar will be published only in the September issue of the *Notices*. The March, June, and December issues will include, along with new announcements, references to any previously announced meetings and conferences occurring within the twelve-month period following the month of those issues. New information about meetings and conferences that will occur later than the twelve-month period will be announced once in full and will not be repeated until the date of the conference or meeting falls within the twelve-month period.

The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through the AMS website on the World Wide Web. To access the AMS website, use the URL: `http://www.ams.org/`.

Problems, Avenida Palace Hotel, Barcelona, Spain.

Organizers: Numeritek Limited UK.

Lecturer: E. F. Toro, OBE.

Information: Further details on the course will be mailed on request. Please send enquiries to course@numeritek.com. See Amazon Customer Reviews: http://www.amazon.com/exec/obidos/ASIN/3540659668/numeritekwebsite/002-0541493-1273839/.

*27-29 **10emes Journees du Groupe MODE de la SMAI (10th Meeting of the MODE Group of the SMAI)**, Montpellier, France.

Organizing committee: H. Attouch (Univ. Montpellier II), M. Bergounioux (Univ. of Orleans), J.-F. Crouzet (Univ. Montpellier II), M.-O. Czarnecki (Univ. Montpellier II), P. Marechal (Univ. Montpellier II).

Scientific Committee: J.-B. Baillon (Univ. Paris I), J-F. Bonnans (INRIA), O. Hudry (Telecom, Paris), B. Lemaire (Univ. Montpellier II, President), J. Maeght (Artelys), J.-P. Penot (Univ. de Pau), J.-P. Raymond (Univ. of Toulouse), S. Sorin (Univ. Paris 6).

Information: http://www.math.univ-montp2.fr/MODE2002/.

*28-29 **2002 ASL Spring Meeting (with APA)**, Seattle Westin, Seattle, Washington.

Information: This meeting will be held jointly with the Annual Meeting of the Pacific Division of the American Philosophical Association, which will take place on March 27-30, 2002. The focus of the ASL meeting is "Predicativity: Problems and Prospects", for which the invited speakers are J. Avigad, S. Feferman, and G. Hellman. The Program Committee members for the ASL meeting are: G.A. Antonelli and P. Mancosu (Chair). For further information, contact P. Mancosu, e-mail: mancosu@socrates.berkeley.edu; for hotel information visit http://www.apa.udel.edu/apa/divisions/pacific/.

*29-31 **CombinaTexas: Combinatorics in the South-Central U.S.**, University of North Texas, Denton, Texas.

Organizers: C. H. Yan (Texas A&M Univ.), J. McCammond (Texas A&M Univ.), J. Kung (Univ. of North Texas), N. Brand (Univ. of North Texas).

Description: This is the third annual meeting of CombinaTexas, a conference series intended to increase communication between mathematicians in the region, promote the research of the regional combinatorics community, and bring in leading combinatorialists from elsewhere. There will also be a poster session, for which we welcome submissions. There are no registration fees, and limited support for participants is available.

Main Speakers: L. Billera, I. Pak, V. Reiner, J. Spencer, R. Thomas, M. Wachs.

Information: http://www.math.tamu.edu/~jon.mccammond/combinatexas/2002/.

May 2002

*16-19 **IX International Conference Devoted to the Memory of Academician Mykhailo Kravchuk (1892-1942)**, Kyiv, Ukraine.

Organizers: National Technical Univ. of Ukraine (KPI), Inst. of Mathematics of NASU, National Shevchenko Univ., National Drahomanov Pedagogical Univ.

Topics: 1) Differential and integral equations, its applications; 2) Algebra, geometry: mathematical and numerical analysis; 3) Theory of probability and mathematical statistics; 4) History, methods of teaching of mathematics.

Deadlines: Abstracts of one page by March 1, 2002. Opening ceremony May 16, 2002.

Official Languages: English, Ukrainian, Russian.

Information: Ukraine, 03056, Kyiv-56, Peremohy Ave. 37, National Technical University (KPI), Phys.-math. Department, Corpus 7, room 437, M. Kravchuk Conference, N. Virchenko; tel. (380) 44 441 1 441; e-mail: syta@imath.kiev.ua.

June 2002

*1-2 **Conference in Honor of Jan Mycielski**, University of Colorado, Boulder, Colorado.

Description: This conference honors the work of Jan Mycielski on the occasion of his seventieth birthday and his retirement from the University of Colorado. The subject of the conference is understood to include all of Jan's wide mathematical interests-logic, paradoxical decompositions, quantum mechanics, set theory, philosophy of mathematics, theory of games, models of learning, and the brain, to name only the most central of them.

Information: Details are available at the conference website: http://euclid.colorado.edu/~jmconf/main.html.

*1-4 **2002 ASL Annual Meeting**, Las Vegas, Nevada.

Description: The Thirteenth Annual Goedel Lecture will be delivered by H. Friedman. There also will be special sessions, with organizers in parentheses, on: Education (J. Larson). Logic in Computer Science (E. Clarke and N. Shankar), Philosophy of Mathematics (W. Tait), and Set Theory (H. Woodin). The members of the Program Committee are G. Cherlin, D. Dubose, W. Goldfarb, J. Larson, A. Scedrov, and T. Slaman (Chair). The Local Organizing Committee includes D. Burke, D. Dubose (Chair), and J. Mourad. Abstracts of contributed talks submitted by ASL members will be published in The Bulletin of Symbolic Logic if they satisfy the Rules for Abstracts (see http://www.aslonline.org/asl/meetings/aslmeet.html#XXX282/).

Invited speakers include: S. Adams, E. Clarke, G. Hjorth, E. Jaligot, S. Lavine, Z. Sela, N. Shankar, S. Simpson, S. Todorcevic, W. Tait, H. Woodin, and J. Young.

Deadline: Abstracts must be received by the deadline of February 15, 2002, at the ASL Business Office: ASL, Box 742, Vassar College, 124 Raymond Avenue, Poughkeepsie, New York 12604, USA; Fax: 1-845-437-7830; e-mail: asl@vassar.edu.

*3-9 **BIOCOMP2002: Topics in Biomathematics and Related Computational Problems at the Beginning of the Third Millennium**, Vietri sul Mare (Amalfi Coast), Italy.

Invited Speakers (who have all already agreed to participate): M. Abeles (Israel), K. Aihara (Japan), S. Amari (Japan), J. M. Bower (USA), A. R. Bulsara (USA), R. Bürger (Austria), R. J. De Boer (The Netherlands), O. Diekmann (The Netherlands), P. Erdi (Hungary), G. B. Ermentrout (USA), L. Glass (Canada), L. J. Gross (USA), M. Gyllenberg (Finland), K. P. Hadeler (Germany), T. G. Hallam (USA), T. Hida (Japan), A. Holden (UK), F. C. Hoppensteadt (USA), H. Hotani (Japan), Y. Iwasa (Japan), S. A. Kauffman (USA), V. Lanska (Czech Republic), K. N. Leibovic (USA), S. A. Levin (USA), A. Lloyd (USA), A. Longtin (Canada), M. C. Mackey (Canada), M. Mimura (Japan), R. Moreno Diaz Jr. (Spain), F. Moss (USA), K. Nakagawa (Japan), T. Nomura (Japan), F. Oosawa (Japan), G. Oster (USA), K. Pakdaman (France), A. S. Perelson (USA), S. Petrovskii (Russia), A. D. Rand (UK), R. Renaut (USA), J. M. Rinzel (USA), J. -P. Rospars (France), M. Sato (Japan), J. P. Segundo (USA), H. Seno (Japan), T. Turova (Sweden), S. Usui (Japan), A. T. Winfree (USA), T. Yanagida (Japan), Yoshizawa (Japan).

Information on the Venue, Abstract Submissions, and Registration: http://www.dma.unina.it/~biocomp/ or contact L. M. Ricciardi, Dipartimento di Matematica e Applicazioni "Renato Caccioppoli", Università di Napoli Federico II, Via Cintia, 80126 Napoli, Italy; Phone +39-081-675666 or +39-081-7663503; fax +39-081-675665; e-mail: BIOCOMP2002@unina.it.

*5-9 **Hawaii International Conference on Statistics and Related Fields**, Sheraton Waikiki Hotel, Honolulu, Hawaii.

Workshops: Presession workshops will be held on June 5, with the concurrent sessions to start on Thursday, June 6, 2002. Send submissions or inquiries to statistics@hcstatistics.org or contact us at Hawaii International Conference on Statistics, 2440 Campus Road, #517, Honolulu, Hawaii 96822; tel: 808-223-1748; fax: 808-947-2420; http://www.hcstatistics.org/.

*16-20 **Conference on Analysis and Probability on Fractals**, Cornell University, Ithaca, New York.
Organizing Committee: R. Strichartz, Cornell Univ.; M. Barlow, Univ. of British Columbia; J. Kigami, Kyoto Univ.; A. Teplyaev, UCal Riverside.
Information: http://www.math.cornell.edu/.

*16-23 **Second Russian-German Geometry Meeting Dedicated to 90th Anniversary of A. D. Alexandrov**, Euler International Mathematical Institute, St Petersburg, Russia.
Organizers: Steklov Institute of Mathematics (St. Petersburg), Mathematisches Institut Der Universitat Bonn, Sobolev Institute of Mathematics (Novosibirsk).
Topics: Differential geometry, nonlinear differential equations in geometry, geometric analysis, singular spaces, foundations of geometry, applications of geometry to mathematical physics and algebra.
Deadline for registration: April 15, 2002.
Contact Information: e-mail: geo2@imi.ras.ru; geometry@math.uni-bonn.de; geometry@math.nsc.ru; fax: 7 (812) 3105377; 7 (812) 2345819; URL: http://www.pdmi.ras.ru/EIMI/2002/geo2/.

*28-30 **MathML 2002: MathML and Math on the Web International Conference**, Hickory Ridge Conference Center, Chicago, Illinois.
Description: The MathML conference provides a forum to present and discuss current research and applications, with major emphasis on MathML and technologies that ease the use of mathematical and scientific content on the web. It is the aim of this conference to bring together those people involved in creating the future of mathematics on the web. The conference embraces all areas of MathML technologies, including authoring, rendering, content management, collaboration, searching, archiving, and conversion. Of interest is work involving courseware or other technologies, such as XML, XSLT, web services, typesetting, and computer algebra, provided it relates principally to web-based mathematical communication.
Format: The conference format includes invited speakers, tutorials, contributed papers, posters, and software demonstrations. Participation is sought in all areas.
Information: General inquiries about the conference should be forwarded to info@mathmlconference.org. Additional conference details and submission guidelines are available at: http://www.mathmlconference.org/.

July 2002

*7-10 **ISSAC 2002 International Symposium on Symbolic and Algebraic Computation**, University of Lille I, France.
Important Dates: Deadline for submissions: January 7, 2002; notification of acceptance: February 28, 2002; camera-ready copy received: March 22, 2002.
Conference Topics: Topics of the meeting include, but are not limited to: algorithmic mathematics, computer science, applications.
Best Student Author Award: This award will be given to the best student author. An author is eligible if full-time student at the time of submission; this should be indicated.
Information: http://www.lifl.fr/issac2002/.

*8-12 **Harmonic Maps, Minimal Surfaces and Geometric Flows**, University of Bretagne Occidentale, Brest, France.
Information: http://maths2.univ-brest.fr/~brest2002/.

*8-19 **Biomathematics Euro Summer School: Dynamical Systems in Physiology and Medicine**, Urbino, Italy.
Purpose: The purpose of the school is to present some fields of application of mathematical modelling of dynamical systems to physiology and medicine and concurrently to give a presentation of some of the mathematical techniques used in such modelling.
The school will offer five courses centered on the biological background and on the mathematical modelling of relevant biomedical phenomena: the spread of cardiac electrical excitation, with the possible study of arrhytmias; the physiology of blood flow in the pulmonary circulation; the system controlling glucose blood levels by means of the hormone insulin; the activity and synchronisation of neurones; the mechanism of production of blood cells with attendant regulations and possible derangements. A workshop on current status and clinical usefulness of mathematical models of the glucose-insulin system, attended by international experts in the field, will complement the courses.
Support: Financial support is available for participants.
Organizing Committee: O. Arino, E. Beretta, A. De Gaetano (Managing Director), S. Panunzi, and F. Solimano.
Language: The official language of the school is English.
Information: If you are interested in coming to the school, please fill in the contact form on the school's web page and you will be kept up to date with all developments. http://www.biomatematica.it/urbino2002/.

*18-19 **First Announcement and Call for Papers: MFCSIT2002, Second Irish Conference on the Mathematical Foundations of Computer Science and Information Technology**, National University of Ireland, Galway, Ireland.
Main Speakers: D. Holt (Warwick), http://www.maths.warwick.ac.uk/~dfh/; W. Lawvere (Buffalo, New York), http://www.acsu.buffalo.edu/~wlawvere/; P. Jeavons (Oxford), http://web.comlab.ox.ac.uk/oucl/work/peter.jeavons/; M. Hennessy (Sussex), http://www.cogs.susx.ac.uk/users/matthewh/; D. MacKay (Cambridge), http://wol.ra.phy.cam.ac.uk/mackay/; M. Sofroniou (Wolfram Research), http://www.wri.com/.
Organizing Committee: M. MacanAirchinnigh (Computer Science, Trinity College, Dublin), A. K. Seda (Mathematics, NUI, Cork), M. Schellekens (Computer Science, NUI,Cork), T. Hurley (Mathematics, NUI, Galway), S. Flynn (Information Technology, NUI, Galway), M. McGettrick (Information Technology, NUI, Galway) N. Madden (Mathematics, NUI, Galway).
Information: Contact: MFCSIT2002@grobner.nuigalway.ie; http://grobner.nuigalway.ie/MFCSIT2002/.

*21-August 3 **Summer School on Applications of Advanced Mathematical and Computational Methods to Atmospheric and Oceanic Problems**, National Center for Atmospheric Research (NCAR), Boulder, Colorado.
Description: The purpose of this interdisciplinary summer school is to bring together graduate students and specialists of meteorology and oceanography and applied mathematicians interested in such problems.
Topics: The summer school consists of background pedagogical lectures in the mornings, invited lectures and informal discussions in the afternoons. The background pedagogical lectures cover topics in mathematical methods (nonlinear systems, functional analysis, asymptotic techniques and stochastic methods), computational methods (multilevel modeling and adaptive methods, implicit methods, and Lagrangian methods), and science problems (atmospheric basics, Hamiltonian fluid dynamics, reduced systems, oceanography, and turbulence). The invited talks as well as the informal discussions will cover several important scientific issues; both state-of-the-art knowledge and future directions will be addressed.
Coordinators: R. Temam (Indiana Univ.), J. Tribbia (NCAR), S. Wang (Indiana Univ.).
Information: Both students and young scientists in the relevant fields are encouraged to participate, and partial financial support is available. For information, contact one of the coordinators or B. Hansford at NCAR, barbm@ucar.edu. See also http://php.indiana.edu/~iuisc/mcao02.htm.

*22-26 **Universal Algebra and Lattice Theory**, University of Szeged, Szeged, Hungary.

Invited Speakers: J. Berman, P. Dehornoy, M. Goldstern, E. W. Kiss, M. Maroti, P. P. Palfy, I. G. Rosenberg.
Program Committee: J. Jezek, K. Kearnes, R. Poschel, A. Romanowska, A. Szendrei, R. Willard.
Organizers: L. Szabo, A. Szendrei.
Information: For further information visit the conference home page at `http://www.math.u-szeged.hu/confer/algebra/2002/` or send an e-mail to `algebra@server.math.u-szeged.hu`.

August 2002

*5-10 **6th Brazilian School of Probability**, Praia das Toninhas, Ubatuba, São Paulo, Brazil.
Aim: The school is intended as a forum to discuss new developments in probability and related areas, an occasion to detect new directions of research and to establish new collaborations and an opportunity for the students to begin their scientific life. Activities will include mini-courses, plenary talks by invited speakers, short communications and several problem sections to be delivered by senior invited researchers.
Invited Speakers: P. Collet (Ecole Polytechnic, France), B. Prum (Genopole Evry), S. Asmussen (Lundt Univ., Sweden), G. Giacomin (Paris 7, France), Y. Peres (Berkeley, USA), R. Schinazi (Univ. d'Aix Marseille, France) .
Organizing committee: R. Fernandez, Coordinator; L. R. Fontes (IME-USP, Brazil); N. Lopes Garcia (IME-Unicamp, Brazil); F. Prates Machado (IME-USP, Brazil); G. Maillard (Univ. de Rouen, France).
Information: `ebp6@ime.usp.br`.

*27-31 **7th International Symposium on Generalized Convexity/Monotonicity**, Institute of Mathematics, Hanoi, Vietnam.
Description: The symposium is aimed at bringing together researchers from all continents to report their latest results and to exchange new ideas in the field of generalized convexity and generalized monotonicity and its applications in optimization, control, stochastics, economics, management science, finance, engineering and related areas.
Invited speakers: J. Borwein, R. E. Burkard, B. Mordukhovich, H. Tuy.
Program Committee: J. E. Martinez-Legaz (co-chair), P. H. Sach (co-chair), R. Cambini, J. P. Crouzeix, A. Eberhard, N. Hadjisavvas, S. Komlosi, D. T. Luc, S. Schaible.
Co-chairs of the Organizing Committee: N. D. Cong, D. T. Luc.
Deadlines: Deadline for visa application with help of local organizers, April 15, 2002. Deadline for registration and submission of abstracts, June 30, 2002. Notification of acceptance, July 15, 2002.
Information: Visit `http://www.math.ac.vn/conference/gcm7/` or contact Dr. N. D. Cong, Hanoi Institute of Mathematics, P. O. Box 631, Bo Ho, Hanoi, Vietnam, `ndcong@thevinh.ncst.ac.vn`.

*29-September 3 **Stochastic Analysis**, German Science Center, Beijing, China.
Organizers: S. Albeverio (Bonn), Z. M. Ma (Beijing), M. Röckner (Bielefeld).
Scientific Committee: L. Accardi, A. B. Cruzeiro, E. Bolthausen, M. F. Chen, K.D. Elworthy, H. Föllmer, M. Fukushima , F. Götze, L. Gross, N. Krylov, P. Malliavin, D. Nualart, G. Da Prato. J. A. Yan.
Topics: 1. Geometry on path space; 2. Infinite dimensional analysis, Dirichlet forms, measure-valued processes; 3. Noncommutative and quantum probability; 4. Pseudo-differential operators and jump processes; 5. Random media; 6. Statistical mechanics and particle systems; 7. Stochastic finance; 8. Stochastic methods in hydrodynamics and quantum field theory; 9. Stochastic partial differential equations.
Invited Speakers: A. B. Cruzeiro, B. Driver, A. Eberle, D. Elworthy, S. Fang, W. Stannat, F. Y. Wang, L. Accardi, U. Franz, K. R. Parthasarathy, M. Skeide, Y. G. Lu, B. Zegarlinski, M. F. Chen, W. Hoh, L. Bogachev, E. Bolthausen, J. D. Deuschel, F. Götze, F. Merkl, E. Presutti, D. Filipovic, Z. Brzezniak, H. Gottschalk, A. Sengupta, S. Cerrai , A. Debussche, V. Lotoski.
Information: e-mail: `conference@wiener.iam.uni-bonn.de`.

September 2002

*11-18 **NSEC8: Navier-Stokes Equations and Related Topics**, Euler International Mathematical Institute, St. Petersburg, Russia.
Scope: The conference is focused on mathematical problems arising in the theory of viscous fluids such as existence and uniqueness of solutions, differentiability properties of solutions, long-time behavior, and applications of the above topics to the analysis of contemporary problems in fluid mechanics.
Topics: Papers are solicited in all research areas related to mathematical problems in the theory of viscous fluids, including, but not limited to: compressible and incompressible Navier-Stokes equations; mathematical analysis of NS equations in bounded and unbounded domains; existence and regularity of solutions; stability and long time behavior of solutions, asymptotical analysis; properties of solutions in domains with nonsmooth boundaries; inviscid fluids; mathematical modeling of fluids with complex rheology; models of non-Newtonian fluids; visco-plastic and visco-elastic fluids; fluids with complex rheology (electrorheological fluids, magnetorheological fluids, etc.); mathematical aspects of computational analysis; approximation methods for compressible and incompressible viscous flows; convergence of finite element, finite volume, finite difference, and spectral methods; a priori and a posteriori estimates of the accuracy of approximations.
Program Committee: O. Ladyzhenskaya (St. Petersburg) (chairman); H. Amann (Zurich); H. Beirao da Veiga (Pisa); C. Fefferman (Princeton); Y. Giga (Hokudai); M. Gunzburger (Iowa); R. Kohn (New York); V. Pukhnachev (Novosibirsk); G. Seregin (St. Petersburg); V. Solonnikov (St. Petersburg).
Information: URL: `http://www.pdmi.ras.ru/EIMI/2002/NSEC8/`; e-mail: `nsec8@imi.ras.ru`; fax: 7 (812) 3105377; 7 (812) 2345819.

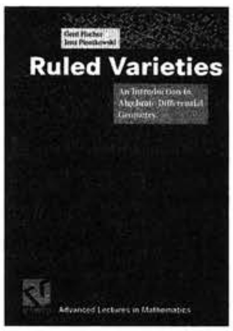
December 2002

*9-13 **Title 27th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing (27ACCMCC)**, The University of Newcastle, Newcastle, NSW, Australia.
Topics: 27ACCMCC is a forum in which researchers can present their work and exchange ideas with others in their field.Topics of interest cover all areas of combinatorial mathematics, combinatorial computing, and combinatorial optimization.
Invited Speakers: D. Cvetkovic (Univ. of Belgrade); M. Fellows (Univ. of Newcastle); M. Miller (Univ. of Newcastle); A. Rosa (McMaster Univ.); J. Siran (Slovak Univ. of Technology).
Organizers: L. Brankovic (Univ. of Newcastle); R.Webber (Univ. of Newcastle); N. Natchimuthu (Univ. of Newcastle); L. Mathieson (Univ. of Newcastle); M. Skerritt (Univ. of Newcastle).
Information: `http://www.cs.newcastle.edu.au/~accmcc/`; `accmcc@cs.newcastle.edu.au`.

New Publications Offered by the AMS

Algebra and Algebraic Geometry

Supplementary Reading



Ruled Varieties

An Introduction to Algebraic Differential Geometry

Gerd Fischer and **Jens Piontkowski**, *Heinrich-Heine Universität, Düsselfdorf, Germany*

A publication of the Vieweg Verlag.

The simplest surfaces, aside from planes, are the traces of a line moving in ambient space or, more precisely, the unions of one-parameter families of lines. The fact that these lines can be produced using a ruler explains their name, "ruled surfaces". The mechanical production of ruled surfaces is relatively easy, and they can be visualized by means of wire models. These models are not only of practical use, but also provide artistic inspiration.

Mathematically, ruled surfaces are the subject of several branches of geometry, especially differential geometry and algebraic geometry. In classical geometry, especially differential geometry and algebraic geometry. In classical geometry, we know that surfaces of vanishing Gaussian curvature have a ruling that is even developable. Analytically, developable means that the tangent plane is the same for all points of the ruling line, which is equivalent to saying that the surface can be covered by pieces of paper. A classical result from algebraic geometry states that rulings are very rare for complex algebraic surfaces in three-space: Quadrics have two rulings, smooth cubics contain precisely 27 lines, and in general, a surface of degree at least four contains no line at all. There are exceptions, such as cones or tangent surfaces of curves. It is also well-known that these two kinds of surfaces are the only developable ruled algebraic surfaces in projective three-space.

The natural generalization of a ruled surface is a ruled variety, i.e., a variety of arbitrary dimension that is "swept out" by a moving linear subspace of ambient space. It should be noted that a ruling is not an intrinsic but an extrinsic property of a variety, which only makes sense relative to an ambient affine or projective space. This book considers ruled varieties mainly from the point of view of complex projective algebraic geometry, where the strongest tools are available. Some local techniques could be generalized to complex analytic varieties, but in the real analytic or even differentiable case there is little hope for generalization: The reason being that rulings, and especially developable rulings, have the tendency to produce severe singularities.

As in the classical case of surfaces, there is a strong relationship between the subject of this book, ruled varieties, and differential geometry. For the purpose of this book, however, the Hermitian Fubini-Study metric and the related concepts of curvature are not necessary. In order to detect developable rulings, it suffices to consider a bilinear second fundamental form that is the differential of the Gauss map. This method does not give curvature as a number, but rather measures the degree of vanishing of curvature; this point of view has been used in a fundamental paper of Griffiths and Harris. One of the purposes of this book is to make parts of this paper more accessible, to give detailed and more elementary proofs, and to report on recent progress in this area.

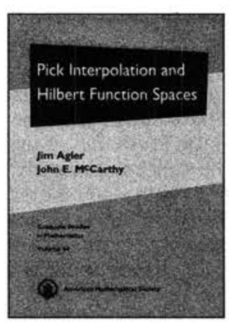
The AMS is exclusive distributor in North America, and non-exclusive distributor worldwide except in Germany, Switzerland, Austria, and Japan.

Contents: Review from classical differential and projective geometry; Grassmannians; Ruled varieties; Tangent and secant varieties; Bibliography; Index; List of symbols.

Vieweg Advanced Lectures in Mathematics

May 2001, 141 pages, Softcover, ISBN 3-528-03138-7, 2000 *Mathematics Subject Classification*: 14M99, 53A20, **All AMS members $41**, List $45, Order code VWALM/8N

Analysis



Pick Interpolation and Hilbert Function Spaces

Jim Agler, *University of California at San Diego,* and **John E. McCarthy**, *Washington University, St. Louis, MO*

The book first rigorously develops the theory of reproducing kernel Hilbert spaces. The authors then discuss the Pick problem of finding the function of smallest H^∞ norm that has specified values at a finite number of points in the disk. Their viewpoint is to consider H^∞ as the multiplier algebra of the Hardy space and to use Hilbert space techniques to solve the problem. This approach generalizes to a wide collection of spaces.

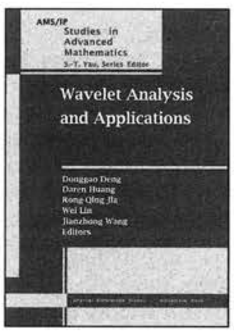
The authors then consider the interpolation problem in the space of bounded analytic functions on the bidisk and give a complete description of the solution. They then consider very general interpolation problems. The book includes developments of all the theory that is needed, including operator model theory, the Arveson extension theorem, and the hereditary functional calculus.

Contents: Prerequisites and notation; Introduction; Kernels and function spaces; Hardy spaces; $P^2(\mu)$; Pick redux; Qualitative properties of the solution of the Pick problem in $H^\infty(\mathbb{D})$; Characterizing kernels with the complete Pick property; The universal Pick kernel; Interpolating sequences; Model theory I: Isometries; The bidisk; The extremal three point problem on $\mathbb{D}^2$; Collections of kernels; Model theory II: Function spaces; Localization; Schur products; Parrott's lemma; Riesz interpolation; The spectral theorem for normal m-tuples; Bibliography; Index.

Graduate Studies in Mathematics, Volume 44

March 2002, approximately 328 pages, Hardcover, ISBN 0-8218-2898-3, 2000 *Mathematics Subject Classification*: 47A57, 30E05, 46E20, 32A70, **All AMS members $39**, List $49, Order code GSM/44N

Applications



Wavelet Analysis and Applications

Donggao Deng, *Zhongshan University, Guangzhou, People's Republic of China*, **Daren Huang**, *Zhejiang University, Hangzhou, People's Republic of China*, **Rong-Qing Jia**, *University of Alberta, Edmonton, AB, Canada*, **Wei Lin**, *Zhongshan University, Guangzhou, People's Republic of China*, and **Jianzhong Wang**, *Sam Houston State University, Huntsville, TX*, Editors

Wavelet analysis has been one of the major research directions in science in the last decade. More and more mathematicians and scientists join this exciting research area. Certainly, wavelet analysis has had a great impact in areas such as approximation theory, harmonic analysis, and scientific computation. More importantly, wavelet analysis has shown great potential in applications to information technology such as signal processing, image processing, and computer graphics.

China has played a significant role in this development of wavelet analysis as evidenced by many fruitful theoretical results and practical applications. A conference on wavelet analysis and its applications was organized to exchange ideas and results with international research groups at Zhongshan University (Guangzhou, China). This volume contains the proceedings from that conference.

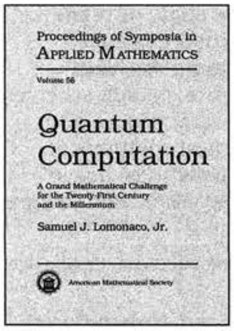
Comprised here are selected papers from the conference, covering a wide range of research topics of current interest. Many significant results are included in the study of refinement equations and refinable functions, properties and construction of wavelets, spline wavelets, multi-wavelets, wavelet packets, shift-invariant spaces, approximation schemes and subdivision algorithms, and tilings. Several papers also focus on applications of wavelets to numerical solutions of partial differential equations and integral equations, image processing and facial recognition, computer vision, and feature extraction from data.

Titles in this series are copublished with International Press, Cambridge, MA.

Contents: **A. Aldroubi**, **Q. Sun**, and **W.-S. Tang**, Non-uniform sampling in multiply generated shift-invariant subspaces of $L^p(\mathbb{R}^d)$; **R. Ashino**, **C. Heil**, **M. Nagase**, and **R. Vaillancourt**, Multiwavelets, pseudodifferential operators and microlocal analysis; **S. Basu**, **C. A. Micchelli**, and **P. Olsen**, A maximum entropy criterion for feature extraction; **O. Bratteli** and **P. E. T. Jorgensen**, Wavelet filters and infinite-dimensional unitary groups; **G. J. Chae**, **H. O. Kim**, and **R. Y. Kim**, On the Cohen-type conditions for the stabiltiy of shifts of a refinable function; **W. Chen** and **W. Lin**, Trigonometric Hermite wavelet and natural integral equations for Stokes problem; **D.-Q. Dai**, Vision, harmonic oscillator and wavelets; **T. N. T. Goodman** and **S. L. Lee**, Some properties of refinable splines; **L. Gori** and **F. Pitolli**, On some applications of a class of totally positive bases; **B. Han** and **S. D. Riemenschneider**, Interpolatory biorthogonal wavelets and CBC algorithm; **D. P. Hardin** and **T. A. Hogan**, Constructing orthogonal refinable function vectors with prescribed approximation order and smoothness; **D. Huang**, **Z. Wang**, and **Z. Zhang**, On M-band wavelets having three vanishing moments; **R.-Q. Jia** and **Q.-T. Jiang**, Approximation power of refinable vectors of functions; **J. Ning**, Wavelet decomposition under translate; **H. O. Kim** and **J. K. Lim**, Applications of shift-invariant space theory to some problems of multi-resolution analysis of $L^2(\mathbb{R}^d)$; **I. Kirat** and **K.-S. Lau**, On the connectedness and classification of self-affine tiles; **X.-z. Liang** and **M.-c. Liu**, Wavelet-Galerkin methods for second kind integral equations; **S. Li**, Convergence of cascade algorithms in $L_p (0 < p < 1)$; **I. Ya. Novikov**, Asymptotics of zeros of Bernstein polynomials that are related to modified Daubechies wavelets; **Q. Sun**, Homogeneous and nonhomogeneous refinable distributions in $F^{q,\gamma}$; **J. Tang**, **S. Kawato**, and **J. Ohya**, A wavelet transform based face recognition system and its applications; **J. Wang**, Spline wavelets in numerical resolution of partial differential equations; **M. V. Wickerhauser**, Basis and convergence properties of wavelet packets; **L. Yang** and **Y. Y. Tang**, A wavelet-based characterization of curves; **P. C. Yuen**, **G. C. Feng**, **J. H. Lai**, and **D. Q. Dai**, Face processing and recognition technology; **D.-X. Zhou**, The p-norm joint spectral radius and its applications in wavelet analysis.

AMS/IP Studies in Advanced Mathematics, Volume 25

February 2002, 326 pages, Softcover, ISBN 0-8218-2991-2, 2000 *Mathematics Subject Classification*: 42C40, **All AMS members $44**, List $55, Order code AMSIP/25N



Quantum Computation

A Grand Mathematical Challenge for the Twenty-First Century and the Millennium

Samuel J. Lomonaco, Jr., Editor

This book presents written versions of the eight lectures given during the AMS Short Course held at the Joint Mathematics Meetings in Washington, D.C. The objective of this course was to share with the scientific community the many exciting mathematical challenges arising from the new field of quantum computation and quantum information science. The course was geared toward demonstrating the great breadth and depth of this mathematically rich research field. Interrelationships with existing mathematical research areas were emphasized as much as possible. Moreover, the course was designed so that participants with little background in quantum mechanics would, upon completion, be prepared to begin reading the research literature on quantum computation and quantum information science.

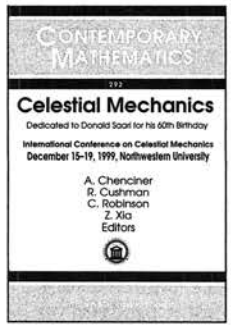
Based on audience feedback and questions, the written versions of the lectures have been greatly expanded, and supplementary material has been added. The book features an overview of relevant parts of quantum mechanics with an introduction to quantum computation, including many potential quantum mechanical computing devices; introduction to quantum algorithms and quantum complexity theory; in-depth discussion on quantum error correcting codes and quantum cryptography; and finally, exploration into diverse connections between quantum computation and various areas of mathematics and physics.

Contents: *An invitation to quantum computation:* **S. J. Lomonaco, Jr.**, A Rosetta stone for quantum mechanics with an introduction to quantum computation; **H. E. Brandt**, Qubit devices; *Quantum algorithms and quantum complexity theory:* **S. J. Lomonaco, Jr.**, Introduction to quantum algorithms; **S. J. Lomonaco, Jr.**, Shor's quantum factoring algorithm; **U. V. Vazirani**, A survey of quantum complexity theory; **S. J. Lomonaco, Jr.**, Grover's quantum search algorithm; *Quantum error correcting codes and quantum cryptography:* **D. Gottesman**, An introduction to quantum error correction; **S. J. Lomonaco, Jr.**, A talk on quantum cryptography or how Alice outwits Eve; *More mathematical connections:* **A. Kitaev**, Topological quantum codes and anyons; **L. H. Kauffman**, Quantum topology and quantum computing; **S. J. Lomonaco, Jr.**, An entangled tale of quantum entanglement; Index.

Proceedings of Symposia in Applied Mathematics, Volume 58

February 2002, approximately 436 pages, Hardcover, ISBN 0-8218-2084-2, 2000 *Mathematics Subject Classification*: 81-01, 81-02, 81P68, 68Q05, 94A60; 22E70, 57M99, 81V80, 94A15, **Individual member $41**, List $69, Order code PSAPM/58N

Differential Equations



Celestial Mechanics

Dedicated to Donald Saari for his 60th Birthday

A. Chenciner, *Institute de Mécanique Céleste, Paris, France*, **R. Cushman**, *University of Utrecht, Netherlands*, and **C. Robinson** and **Z. Xia**, *Northwestern University, Evanston, IL*, Editors

This volume reflects the proceedings from an international conference on celestial mechanics held at Northwestern University (Evanston, IL) in celebration of Donald Saari's sixtieth birthday. Many leading experts and researchers presented their recent results.

Don Saari's significant contribution to the field came in the late 1960s through a series of important works. His work revived the singularity theory in the n-body problem which was started by Poincaré and Painlevé. Saari's solution of the Littlewood conjecture, his work on singularities, collision and noncollision, on central configurations, his decompositions of configurational velocities, etc., are still much studied today and were reflected throughout the conference.

This volume covers various topics of current research, from central configurations to stability of periodic orbits, from variational methods to diffusion mechanisms, from the dynamics of secular systems to global dynamics of the solar systems via frequency analysis, from Hill's problem to the low energy transfer orbits and mission design in space travel, and more. This classic field of study is very much alive today and this volume offers a comprehensive representation of the latest research results.

Contents: **A. Albouy** and **J. Llibre**, Spatial central configurations for the $1 + 4$ body problem; **E. Belbruno**, Analytic estimation of weak stability boundaries and low energy transfers; **F. Beukers** and **R. Cushman**, The complex geometry of the spherical pendulum; **A. Chenciner**, Action minimizing periodic orbits in the Newtonian n-body problem; **M. Corbera** and **J. Llibre**, On symmetric periodic orbits of the elliptic Sitnikov problem via the analytic continuation method; **W. S. Koon**, **J. E. Marsden**, **S. D. Ross**, and **M. W. Lo**, Constructing a low energy transfer between Jovian moons; **E. A. Lacomba**, **J. Llibre**, and **E. Perez-Chavela**, The generalized Sitnikov problem; **C. Marchal**, Reflexions on the future of celestial mechanics; **R. Moeckel**, Generic drift on Cantor sets of annuli; **R. Montgomery**, Action spectrum and collisions in the planar three-body problem; **P. H. Rabinowitz** and **E. W. Stredulinsky**, A variational shadowing method; **C. Robinson**, Symbolic dynamics for transition tori; **C. Simó**, Dynamical properties of the figure eight solution of the three-body problem; **Y.-S. Sun**, **J.-L. Zhou**, **J.-Q. Zheng**, and **M. Valtonen**, Diffusion in comet motion; **Q. Wang**, The Hill's region of the four-body problem; **Z. Xia**, Some of the problems that Saari didn't solve.

Contemporary Mathematics, Volume 292

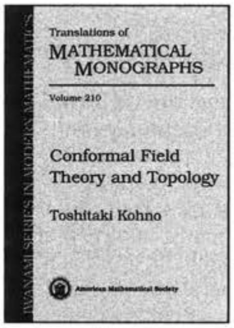
February 2002, approximately 238 pages, Softcover, ISBN 0-8218-2902-5, LC 2001055364, 2000 *Mathematics Subject Classification*: 70Fxx, 70Hxx, 37N05, 37Jxx, **Individual member $41**, List $69, Order code CONM/292N

Geometry and Topology

Supplementary Reading

Conformal Field Theory and Topology

Toshitaki Kohno, *University of Tokyo, Japan*



Geometry and physics have been developed with a strong influence on each other. One of the most remarkable interactions between geometry and physics since 1980 has been an application of quantum field theory to topology and differential geometry. This book focuses on a relationship between two-dimensional quantum field theory and three-dimensional topology which has been studied intensively since the discovery of the Jones polynomial in the middle of the 1980s and Witten's invariant for 3-manifolds derived from Chern-Simons gauge theory. An essential difficulty in quantum field theory comes from infinite-dimensional freedom of a system. Techniques dealing with such infinite-dimensional objects developed in the framework of quantum field theory have been influential in geometry as well. This book gives an accessible treatment for a rigorous construction of topological invariants originally defined as partition functions of fields on manifolds.

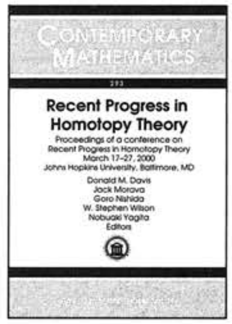
The book is organized as follows: The Introduction starts from classical mechanics and explains basic background materials in quantum field theory and geometry. Chapter 1 presents conformal field theory based on the geometry of loop groups. Chapter 2 deals with the holonomy of conformal field theory. Chapter 3 treats Chern-Simons perturbation theory. The final chapter discusses topological invariants for 3-manifolds derived from Chern-Simons perturbation theory.

This item will also be of interest to those working in mathematical physics.

Contents: Geometric aspects of conformal field theory; Jones-Witten theory; Chern-Simons perturbation theory; Further developments and prospects; Bibliography; Index.

Translations of Mathematical Monographs (*Iwanami Series in Modern Mathematics*), Volume 210

March 2002, approximately 174 pages, Softcover, ISBN 0-8218-2130-X, 2000 *Mathematics Subject Classification*: 54C40, 14E20; 46E25, 20C20, **All AMS members $28**, List $35, Order code MMONO/210N



Recent Progress in Homotopy Theory

Donald M. Davis, *Lehigh University, Bethlehem, PA*, **Jack Morava**, *Johns Hopkins University, Baltimore, MD*, **Goro Nishida**, *Kyoto University, Japan*, **W. Stephen Wilson**, *Johns Hopkins University, Baltimore, MD*, and **Nobuaki Yagita**, *Ibaraki University, Japan*, Editors

This volume presents the proceedings from the month-long program held at Johns Hopkins University (Baltimore, MD) on homotopy theory, sponsored by the Japan-U.S. Mathematics Institute (JAMI). The book begins with historical accounts on the work of Professors Peter Landweber and Stewart Priddy. Central among the other topics are the following:

1. classical and nonclassical theory of H-spaces, compact groups, and finite groups,
2. classical and chromatic homotopy theory and localization,
3. classical and topological Hochschild cohomology,
4. elliptic cohomology and its relation to Moonshine and topological modular forms, and
5. motivic cohomology and Chow rings.

This volume surveys the current state of research in these areas and offers an overview of future directions.

Contents: *Two papers on the history of topology:* **H. Miller**, A marriage of manifolds and algebra: The mathematical work of Peter Landweber; **N. Minami**, Some mathematical influences of Stewart Priddy; *Research papers:* **M. Bendersky** and **R. D. Thompson**, Some properties of the K-theory completion; **R. R. Bruner**, **D. M. Davis**, and **M. Mahowald**, Nonimmersions of real projective spaces implied by tmf; **M. Brunetti**, High Euler characteristics for almost extraspecial p-groups; **Y. Hemmi**, Unstable p-th order operation and H-spaces; **M. Mahowald** and **M. Hopkins**, The structure of 24 dimensional manifolds having normal bundles which lift to $BO[8]$; **P. Hu** and **I. Kriz**, The homology of BPO; **M. Inoue**, $\mathcal{A}$-generators of the cohomology of the Steinberg summand $M(n)$; **J. P. Lin**, Commutators in the homology of H-spaces; **J. E. McClure** and **J. H. Smith**, A solution of Deligne's Hochschild cohomology conjecture; **M. Mimura** and **T. Nishimoto**, Hopf algebra structure of Morava K-theory of the exceptional Lie groups; **J. Martino** and **S. Priddy**, Minami-Webb type decompositions for compact Lie groups; **D. C. Ravenel**, The method of infinite descent in stable homotopy theory I; **K. Shimomura**, The homotopy groups $\pi_*(L_nT(m) \wedge V(n-2))$; **D. Tamaki**, The fiber of iterated Freudenthal suspension and Morava K-theory of $\Omega^k S^{2\ell+1}$; **M. Tanabe**, On K-flat and K-moonshine-like elements in elliptic cohomology; **T. Torii**, The geometric fixed point spectrum of $(\mathbf{Z}/p)^k$ Borel cohomology for E_n and its completion; **V. Voevodsky**, A possible new approach to the motivic spectral sequence for algebraic K-theory; **C. W. Wilkerson, Jr.**, Rings of invariants and inseparable forms of algebras over the Steenrod algebra; **N. Yagita**, Chow rings of classifying spaces of extraspecial p groups.

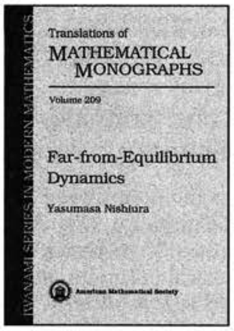
Contemporary Mathematics, Volume 293

March 2002, approximately 408 pages, Softcover, ISBN 0-8218-2801-0, 2000 *Mathematics Subject Classification*: 55-XX, 57-XX, **Individual member $59**, List $99, Order code CONM/293N

Mathematical Physics

Far-from-Equilibrium Dynamics

Yasumasa Nishiura, *Hokkaido University, Sapporo, Japan*



This book is devoted to the study of evolution of nonequilibrium systems. Such a system usually consists of regions with different dominant scales, which coexist in the space-time where the system lives. In the case of high nonuniformity in special direction, one can see patterns separated by clearly distinguishable boundaries or interfaces.

The author considers several examples of nonequilibrium systems. One of the examples describes the invasion of the solid phase into the liquid phase during the crystallization process. Another example is the transition from oxidized to reduced states in certain chemical reactions. An easily understandable example of the transition in the temporal direction is a sound beat, and the author describes typical patterns associated with this phenomenon.

The main goal of the book is to present a mathematical approach to the study of highly nonuniform systems and to illustrate it with examples from physics and chemistry. The two main theories discussed are the theory of singular perturbations and the theory of dissipative systems. A set of carefully selected examples of physical and chemical systems nicely illustrates the general methods described in the book.

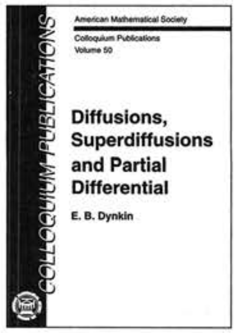
This item will also be of interest to those working in differential equations.

Contents: Separation and unification of scales; Amplitude equations; Marginal stability criterion and pattern selection; Pattern formation; Method of singular limit analysis; Transient dynamics; Future perspectives; Bibliography; Index.

Translations of Mathematical Monographs (*Iwanami Series in Modern Mathematics*), Volume 209

March 2002, approximately 336 pages, Softcover, ISBN 0-8218-2625-5, 2000 *Mathematics Subject Classification*: 34D15, 35B25, 35B32, 35B40, 35K57, 37D10, 37L10, 74N20, **All AMS members $47**, List $59, Order code MMONO/209N

Probability



Diffusions, Superdiffusions and Partial Differential Equations

E. B. Dynkin, *Cornell University, Ithaca, NY*

Interactions between the theory of partial differential equations of elliptic and parabolic types and the theory of stochastic processes are beneficial for both probability theory and analysis. At the beginning, mostly analytic results were used by probabilists. More recently, analysts (and physicists) took inspiration from the probabilistic approach. Of course, the development of analysis in general and of the theory of partial differential equations in particular, was motivated to a great extent by problems in physics. A difference between physics and probability is that the latter provides not only an intuition, but also rigorous mathematical tools for proving theorems.

The subject of this book is connections between linear and semilinear differential equations and the corresponding Markov processes called diffusions and superdiffusions. Most of the book is devoted to a systematic presentation (in a more general setting, with simplified proofs) of the results obtained since 1988 in a series of papers of Dynkin and Dynkin and Kuznetsov. Many results obtained originally by using superdiffusions are extended in the book to more general equations by applying a combination of diffusions with purely analytic methods. Almost all chapters involve a mixture of probability and analysis.

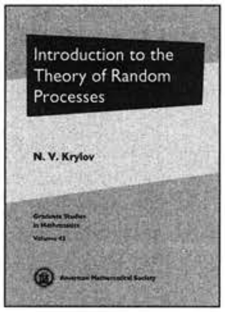
Similar to the other books by Dynkin, *Markov Processes* (Springer-Verlag), *Controlled Markov Processes* (Springer-Verlag), and *An Introduction to Branching Measure-Valued Processes* (American Mathematical Society), this book can become a classical account of the presented topics.

This item will also be of interest to those working in differential equations.

Contents: Introduction; *Parabolic equations and branching exit Markov systems:* Linear parabolic equations and diffusions; Branching exit Markov systems; Superprocesses; Semilinear parabolic equations and superdiffusions; *Elliptic equations and diffusions:* Linear elliptic equations and diffusions; Positive harmonic functions; Moderate solutions of $Lu = \psi(u)$; Stochastic boundary values of solutions; Rough trace; Fine trace; Martin capacity and classes $\mathcal{N}_1$ and $\mathcal{N}_0$; Null sets and polar sets; Survey of related results; Basic facts of Markov processes and Martingales; Facts on elliptic differential equations; Epilogue; Bibliography; Subject index; Notation index.

Colloquium Publications, Volume 50

March 2002, approximately 240 pages, Hardcover, ISBN 0-8218-3174-7, 2000 *Mathematics Subject Classification*: 60J60, 35Jxx; 35K55, 60J65, **All AMS members $39**, List $49, Order code COLL/50N



Introduction to the Theory of Random Processes

N. V. Krylov, *University of Minnesota, Minneapolis*

This book concentrates on some general facts and ideas of the theory of stochastic processes. The topics include the Wiener process, stationary processes, infinitely divisible processes, and Itô stochastic equations.

Basics of discrete time martingales are also presented and then used in one way or another throughout the book. Another common feature of the main body of the book is using stochastic integration with respect to random orthogonal measures. In particular, it is used for spectral representation of trajectories of stationary processes and for proving that Gaussian stationary processes with rational spectral densities are components of solutions to stochastic equations. In the case of infinitely divisible processes, stochastic integration allows for obtaining a representation of trajectories through jump measures. The Itô stochastic integral is also introduced as a particular case of stochastic integrals with respect to random orthogonal measures.

Although it is not possible to cover even a noticeable portion of the topics listed above in a short book, it is hoped that after having followed the material presented here, the reader will have acquired a good understanding of what kind of results are available and what kind of techniques are used to obtain them.

With more than 100 problems included, the book can serve as a text for an introductory course on stochastic processes or for independent study.

Other works by this author published by the AMS include, *Lectures on Elliptic and Parabolic Equations in Hölder Spaces* and *Introduction to the Theory of Diffusion Processes.*

Contents: Generalities; The Wiener process; Martingales; Stationary processes; Infinitely divisible processes; Itô stochastic integral; Bibliography; Index.

Graduate Studies in Mathematics, Volume 43

March 2002, approximately 240 pages, Hardcover, ISBN 0-8218-2985-8, 2000 *Mathematics Subject Classification*: 60-01; 60G99, **All AMS members $28**, List $35, Order code GSM/43N

Previously Announced Publications

Assistantships and Graduate Fellowships 2001

Review of a previous edition:

This directory is a tool for undergraduate mathematics majors seeking information about graduate programs in mathematics. Although most of the information can be gleaned from the Internet, the usefulness of this directory for the prospective graduate student is the consistent format for comparing different mathematics graduate programs without the hype. Published annually, the information is up-to-date, which is more than can be said of some Websites. Support for graduate students in mathematics is a high priority of the American Mathematical Society, which also provides information for fellowships and grants they offer as well as support from other societies and foundations. The book is highly recommended for academic and public libraries.

—American Reference Books Annual

This publication is an indispensable source of information for students seeking support for graduate study in the mathematical sciences. Providing data from a broad range of academic institutions, it is also a valuable resource for mathematical sciences departments and faculty.

Assistantships and Graduate Fellowships brings together a wealth of information about resources available for graduate study in mathematical sciences departments in the U.S. and Canada. Information on the number of faculty, graduate students, and degrees awarded (bachelor's, master's, and doctoral) is listed for each department when available. Stipend amounts and the number of awards available are given, as well as information about foreign language requirements. Numerous display advertisements from mathematical sciences departments throughout the country provide additional information.

Also listed are sources of support for graduate study and travel, summer internships, and graduate study in the U.S. for foreign nationals. Finally, a list of reference publications for fellowship information makes *Assistantships and Graduate Fellowships* a centralized and comprehensive resource.

October 2001, approximately 144 pages, Softcover, ISBN 0-8218-2881-9, 2000 *Mathematics Subject Classification*: 00-XX, **Individual member $12**, List $21, Order code ASST/2001RT202

Combined Membership List 2001–2002

The *Combined Membership List* (CML) is a comprehensive directory of the membership of the American Mathematical Society, the American Mathematical Association of Two-Year Colleges, the Association for Women in Mathematics, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics.

There are two lists of individual members. The first is a complete alphabetical list of all members in all five organizations. For each member, the CML provides his or her address, title, department, institution, telephone number (if available), and electronic address (if indicated), and also indicates membership in the five participating societies. The second is a list of individual members according to their geographic locations. In addition, the CML lists academic, institutional, and corporate members of the five participating societies providing addresses and telephone numbers of mathematical sciences departments.

The CML is distributed on request to AMS members in even-numbered years. MAA members can request the CML in odd-numbered years from the MAA. The CML is an invaluable reference for keeping in touch with colleagues and for making connections in the mathematical sciences community in the United States and abroad.

February 2002, 304 pages, Softcover, ISBN 0-8218-2882-7, 2000 *Mathematics Subject Classification*: 00-XX, **Individual member $41**, List $68, Institutional member $54, Order code CML/2001/2002RT202

Mathematical Sciences Professional Directory, 2002

This annual directory provides a handy reference to various organizations in the mathematical sciences community. Listed in the directory are the following: officers and committee members of over thirty professional mathematical organizations (terms of office and other pertinent information are also provided in some cases); key mathematical sciences personnel of selected government agencies; academic departments in the mathematical sciences; mathematical units in nonacademic organizations; and alphabetic listings of colleges and universities. Current addresses, telephone numbers, and electronic addresses for individuals when provided are listed in the directory.

March 2002, approximately 241 pages, Softcover, ISBN 0-8218-2883-5, 2000 *Mathematics Subject Classification*: 00-XX, List $53, Institutional member $42, Order code PRODIR/2002RT202

Sub-Laplacians with Drift on Lie Groups of Polynomial Volume Growth

Georgios K. Alexopoulos, *University of Paris, Orsay, France*

This item will also be of interest to those working in analysis.

Memoirs of the American Mathematical Society, Volume 155, Number 739

February 2002, 101 pages, Softcover, ISBN 0-8218-2764-2, LC 2001045834, 2000 *Mathematics Subject Classification*: 22E25, 22E30, 43A80, 22E15, **Individual member $29**, List $49, Institutional member $39, Order code MEMO/155/739RT202

Supplementary Reading

Lyapunov Exponents and Smooth Ergodic Theory

Luis Barreira, *Instituto Superior Técnico, Lisboa, Portugal*, and **Yakov B. Pesin**, *Pennsylvania State University, University Park*

This book is a systematic introduction to smooth ergodic theory. The topics discussed include the general (abstract) theory of Lyapunov exponents and its applications to the stability theory of differential equations, stable manifold theory, absolute continuity, and the ergodic theory of dynamical systems with nonzero Lyapunov exponents (including geodesic flows).

The authors consider several nontrivial examples of dynamical systems with nonzero Lyapunov exponents to illustrate some basic methods and ideas of the theory.

This book is self-contained. The reader needs a basic knowledge of real analysis, measure theory, differential equations, and topology. The authors present basic concepts of smooth ergodic theory and provide complete proofs of the main results. They also state some more advanced results to give readers a broader view of smooth ergodic theory. This volume may be used by those nonexperts who wish to become familiar with the field.

University Lecture Series, Volume 23

October 2001, 151 pages, Softcover, ISBN 0-8218-2921-1, LC 2001045882, 2000 *Mathematics Subject Classification*: 37D25, 37C40, **All AMS members $23**, List $29, Order code ULECT/23RT202

Sur Les Inégalités de Sobolev Logarithmiques

S Blanchere, D Chafai, P Fougeres, I Gentil, F Malrieu, C Roberto, and **G Scheffer**

A publication of the Société Mathématique de France.

This book is an overview of logarithmic Sobolev inequalities. These inequalities have been the subject of intense activity in recent years, from analysis and geometry in finite and infinite dimensions to probability theory and statistical mechanics. And many developments are still to come.

The book is a "pedestrian approach" to logarithmic Sobolev inequalities, accessible to a wide audience. It is divided into several chapters of independent interest. The fundamental example of the Bernoulli and Gaussian distributions is the starting point for logarithmic Sobolev inequalities, as they were defined by Gross in the mid-seventies. Hypercontractivity and tensorisation form two main aspects of these inequalities, which are actually part of the larger family of classical Sobolev inequalities in functional analysis.

A chapter is devoted to the curvature-dimension criterion, which is an efficient tool for establishing functional inequalities. Another chapter describes a characterization of measures which satisfy logarithmic Sobolev or Poincaré inequalities on the real line, using Hardy's inequalities.

Interactions with various domains in analysis and probability are developed. A first study deals with the concentration of measure phenomenon, which is useful in statistics as well as geometry. The relationships between logarithmic Sobolev inequalities and the transportation of measures are considered, in particular through their approach to concentration. A control of the speed of convergence to equilibrium of finite state Markov chains is described in terms of the spectral gap and the logarithmic Sobolev constants. The last part is a modern reading of the notion of entropy in information theory and of the several links between information theory and the Euclidean form of the Gaussian logarithmic Sobolev inequality. The genesis of these inequalities can be traced back to the early contributions of Shannon and Stam.

This book focuses on the specific methods and the characteristics of particular topics, rather than the most general fields of study. Chapters are mostly self-contained. The bibliography, without being encyclopedic, tries to give a rather complete state of the art on the topic, including some very recent references.

Panoramas et Synthèses, Number 10

July 2001, 213 pages, Softcover, ISBN 2-85629-105-8, 2000 *Mathematics Subject Classification*: 60J60, 26D10, 58D25, 39B72, 58J65, 47D07, 60J10, 94A15, 94A17, **Individual member $40**, List $44, Order code PASY/10RT202

Rotation C*-Algebras and Almost Mathieu Operators

Florin-Petre Boca

A publication of the Theta Foundation.

This book delivers a swift, yet concise, introduction to some aspects of rotation C^*-algebras and almost Mathieu operators.

The two topics come from different areas of analysis: operator algebras and the spectral theory of Schrödinger operators, but can be approached in a unified way. The book does not try to be the definitive treatise on the subject, but rather presents a survey highlighting the important results and demonstrating this unified approach.

For each real number α, the rotation C^*-algebra A_α can be abstractly defined as the universal C^*-algebra generated by two elements U and V subject to the relation $UV = e^{2\pi i\alpha}VU$. When α is an integer, A_α is isomorphic to the commutative C^*-algebra of continuous functions on a two-dimensional torus. When α is not an integer, the algebra is sometimes called a non-commutative 2-torus. In this respect, some of the methods you will find here can be regarded as a sort of non-commutative Fourier analysis. An almost Mathieu operator is a type of self-adjoint operator on the Hilbert space $\ell^2 = \ell^2(\mathbf{Z})$.

The exposition is geared toward a wide audience of mathematicians: researchers and advanced students interested in operator algebras, operator theory and mathematical physics. Readers are assumed to be acquainted with some functional analysis, such as definitions and basic properties of C^*-algebras and von Neumann algebras, some general results from ergodic theory, as well as the Fourier transform (harmonic analysis) on elementary abelian locally compact groups of the form $\mathbf{R}^d \times \mathbf{Z}^k \times \mathbf{T}^1 \times F$, where F is a finite group.

Much progress has been made on these topics in the last twenty years. The present book will introduce you to the subjects and to the significant results.

Distributed worldwide, except in Romania, by the AMS.

Number 2

June 2001, 172 pages, Hardcover, ISBN 973-99097-7-9, 2000 *Mathematics Subject Classification*: 46L35, 81Q15, 47B39; 46L85, 81Q10, 47B36, **All AMS members $22**, List $28, Order code THETA/2RT202

The Submanifold Geometries Associated to Grassmannian Systems

Martina Brück and **Xi Du**, **Joonsang Park**, *Dongguk University, Seoul, Korea*, and **Chuu-Lian Terng**, *Northeastern University, Boston, MA*

Memoirs of the American Mathematical Society, Volume 155, Number 735

February 2002, 95 pages, Softcover, ISBN 0-8218-2753-7, LC 2001045782, 2000 *Mathematics Subject Classification*: 53-XX, 35-XX, **Individual member $29**, List $48, Institutional member $38, Order code MEMO/155/735RT202

Homotopy Theory of Diagrams

Wojciech Chachólski, *Yale University, New Haven, CT*, and **Jérôme Scherer**, *Université de Lausanne, Switzerland*

Memoirs of the American Mathematical Society, Volume 155, Number 736

February 2002, 90 pages, Softcover, ISBN 0-8218-2759-6, LC 2001045783, 2000 *Mathematics Subject Classification*: 55U35, 18G55; 18G10, 18F05, 55U30, 55P65, **Individual member $29**, List $48, Institutional member $38, Order code MEMO/155/736RT202

A Stability Index Analysis of 1-D Patterns of the Gray-Scott Model

Arjen Doelman, *University of Amsterdam, Netherlands*, **Robert A. Gardner**, *University of Massachusetts, Amherst*, and **Tasso J. Kaper**, *Boston University, MA*

Memoirs of the American Mathematical Society, Volume 155, Number 737

February 2002, 64 pages, Softcover, ISBN 0-8218-2739-1, LC 2001045832, 2000 *Mathematics Subject Classification*: 35K57, 35B35, 35B25; 35B32, 34C37, 34E15, **Individual member $25**, List $42, Institutional member $34, Order code MEMO/155/737RT202

Global Differential Geometry: The Mathematical Legacy of Alfred Gray

Marisa Fernández, *University of the Basque Country, Bilbao, Spain*, and **Joseph A. Wolf**, *University of California at Berkeley*, Editors

Alfred Gray's work covered a great part of differential geometry. In September 2000, a remarkable International Congress on Differential Geometry was held in his memory in Bilbao, Spain. Mathematicians from all over the world, representing 24 countries, attended the event.

This volume includes major contributions by well known mathematicians (T. Banchoff, S. Donaldson, H. Ferguson, M. Gromov, N. Hitchin, A. Huckleberry, O. Kowalski, V. Miquel, E. Musso, A. Ros, S. Salamon, L. Vanhecke, P. Wellin and J.A. Wolf), the interesting discussion from the round table moderated by J.-P. Bourguignon, and a carefully selected and refereed selection of the Short Communications presented at the Congress.

This book represents the state of the art in modern differential geometry, with some general expositions of some of the more active areas: special Riemannian manifolds, Lie groups and homogeneous spaces, complex structures, symplectic manifolds, geometry of geodesic spheres and tubes and related problems, geometry of surfaces, and computer graphics in differential geometry.

Contemporary Mathematics, Volume 288

January 2002, 457 pages, Softcover, ISBN 0-8218-2750-2, LC 2001053300, 2000 *Mathematics Subject Classification*: 22E15, 53A10, 53A30, 53B35, 53C15, 53C20, 53C23, 53C25, 53C55, 53D05, **Individual member $71**, List $118, Institutional member $94, Order code CONM/288RT202

Multiparticle Quantum Scattering in Constant Magnetic Fields

Christian Gérard, *Ecole Polytechnique, Paris, France*, and **Izabella Łaba**, *University of British Columbia, Vancouver, BC, Canada*

This monograph offers a rigorous mathematical treatment of the scattering theory of quantum N-particle systems in an external constant magnetic field. In particular, it addresses the question of *asymptotic completeness*, a classification of all possible trajectories of such systems according to their asymptotic behaviour. The book adopts the so-called time-dependent approach to scattering theory, which relies on a direct study of the Schrödinger unitary group for large times. The modern methods of spectral and scattering theory introduced in the

1980's and 1990's, including the Mourre theory of positive commutators, propagation estimates, and geometrical techniques, are presented and heavily used. Additionally, new methods were developed by the authors in order to deal with the (much less understood) phenomena due to the presence of the magnetic field.

The book is a good starting point for graduate students and researchers in mathematical physics who wish to move into this area of research. It includes expository material, research work previously available only in the form of journal articles, as well as some new unpublished results. The treatment of the subject is comprehensive and largely self-contained, and the text is carefully written with attention to detail.

This item will also be of interest to those working in differential equations.

Mathematical Surveys and Monographs, Volume 90

January 2002, 242 pages, Hardcover, ISBN 0-8218-2919-X, LC 2001053521, 2000 *Mathematics Subject Classification*: 35P25, 35Q40, 34L25, 47A40, 81U10, **Individual member $38**, List $64, Institutional member $51, Order code SURV/90RT202

Generalized Whittaker Functions on $SU(2,2)$ with Respect to the Siegel Parabolic Subgroup

Yasuro Gon, *Saitama University, Japan*

Memoirs of the American Mathematical Society, Volume 155, Number 738

February 2002, 116 pages, Softcover, ISBN 0-8218-2763-4, LC 2001045784, 2000 *Mathematics Subject Classification*: 11F70; 22E45, **Individual member $29**, List $49, Institutional member $39, Order code MEMO/155/738RT202

Lectures on Algebraic Model Theory

Bradd Hart and **Matthew Valeriote**, *McMaster University, Hamilton, ON, Canada*, Editors

In recent years, model theory has had remarkable success in solving important problems as well as in shedding new light on our understanding of them. The three lectures collected here present recent developments in three such areas: Anand Pillay on differential fields, Patrick Speissegger on o-minimality and Matthias Clasen and Matthew Valeriote on tame congruence theory.

Fields Institute Monographs, Volume 15

December 2001, 111 pages, Hardcover, ISBN 0-8218-2705-7, LC 2001053718, 2000 *Mathematics Subject Classification*: 03C64; 12L12, 03C05, **Individual member $18**, List $30, Institutional member $24, Order code FIM/15RT202

Introduction to Quantum Groups and Crystal Bases

Jin Hong and **Seok-Jin Kang,** *Korea Institute for Advanced Study, Seoul*

The notion of a "quantum group" was introduced by V.G. Dinfeld and M. Jimbo, independently, in their study of the quantum Yang-Baxter equation arising from 2-dimensional solvable lattice models. Quantum groups are certain families of Hopf algebras that are deformations of universal enveloping algebras of Kac-Moody algebras. And over the past 20 years, they have turned out to be the fundamental algebraic structure behind many branches of mathematics and mathematical physics, such as solvable lattice models in statistical mechanics, topological invariant theory of links and knots, representation theory of Kac-Moody algebras, representation theory of algebraic structures, topological quantum field theory, geometric representation theory, and C^*-algebras.

In particular, the theory of "crystal bases" or "canonical bases" developed independently by M. Kashiwara and G. Lusztig provides a powerful combinatorial and geometric tool to study the representations of quantum groups. The purpose of this book is to provide an elementary introduction to the theory of quantum groups and crystal bases, focusing on the combinatorial aspects of the theory.

Graduate Studies in Mathematics, Volume 42

March 2002, approximately 328 pages, Hardcover, ISBN 0-8218-2874-6, LC 2001053274, 2000 *Mathematics Subject Classification*: 17B37, 17B65; 81R50, 82B23, **All AMS members $39**, List $49, Order code GSM/42RT202

Dynamical, Spectral, and Arithmetic Zeta Functions

Michel L. Lapidus, *University of California, Riverside*, and **Machiel van Frankenhuysen**, *Rutgers University, Piscataway, NJ*, Editors

The original zeta function was studied by Riemann as part of his investigation of the distribution of prime numbers. Other sorts of zeta functions were defined for number-theoretic purposes, such as the study of primes in arithmetic progressions. This led to the development of L-functions, which now have several guises. It eventually became clear that the basic construction used for number-theoretic zeta functions can also be used in other settings, such as dynamics, geometry, and spectral theory, with remarkable results.

This volume grew out of the special session on dynamical, spectral, and arithmetic zeta functions held at the annual meeting of the American Mathematical Society in San Antonio, but also includes four articles that were invited to be part of the collection. The purpose of the meeting was to bring together leading researchers, to find links and analogies between their fields, and to explore new methods. The papers discuss dynamical systems, spectral geometry on hyperbolic manifolds, trace formulas in geometry and in arithmetic, as well as computational work on the Riemann zeta function.

Each article employs techniques of zeta functions. The book unifies the application of these techniques in spectral geometry, fractal geometry, and number theory. It is a comprehensive volume, offering up-to-date research. It should be useful to both graduate students and confirmed researchers.

This item will also be of interest to those working in number theory and geometry and topology.

Contemporary Mathematics, Volume 290

January 2002, 195 pages, Softcover, ISBN 0-8218-2079-6, LC 2001053944, 2000 *Mathematics Subject Classification*: 11F67, 11Mxx, 11Y35, 11N05, 28A80, 30F40, 37Axx, 58J35, **Individual member $29**, List $49, Institutional member $39, Order code CONM/290RT202

The Geometrical Study of Differential Equations

Joshua A. Leslie and **Thierry P. Robart**, *Howard University, Washington, DC*, Editors

This volume contains papers based on some of the talks given at the NSF-CBMS conference on "The Geometrical Study of Differential Equations" held at Howard University (Washington, DC). The collected papers present important recent developments in this area, including the treatment of nontransversal group actions in the theory of group invariant solutions of PDEs, a method for obtaining discrete symmetries of differential equations, the establishment of a group-invariant version of the variational complex based on a general moving frame construction, the introduction of a new variational complex for the calculus of difference equations and an original structural investigation of Lie-Bäcklund transformations. The book opens with a modern and illuminating overview of Lie's line-sphere correspondence and concludes with several interesting open problems arising from symmetry analysis of PDEs. It offers a rich source of inspiration for new or established researchers in the field.

This book can serve nicely as a companion volume to a forthcoming book written by the principle speaker at the conference, Professor Niky Kamran, to be published in the AMS series, CBMS Regional Conference Series in Mathematics.

Contemporary Mathematics, Volume 285

November 2001, 205 pages, Softcover, ISBN 0-8218-2964-5, LC 2001045702, 2000 *Mathematics Subject Classification*: 17-XX, 20-XX, 22-XX, 34-XX, 35-XX, 39-XX, 51-XX, 53-XX, **Individual member $30**, List $50, Institutional member $40, Order code CONM/285RT202

Mathematical Physics in Mathematics and Physics

Quantum and Operator Algebraic Aspects

Roberto Longo, *University of Rome II, Italy*, Editor

The beauty and the mystery surrounding the interplay between mathematics and physics is captured by E. Wigner's famous expression, "The unreasonable effectiveness of mathematics". We don't know why, but physical laws are described by mathematics, and good mathematics sooner or later finds applications in physics, often in a surprising way.

In this sense, mathematical physics is a very old subject—as Egyptian, Phoenician, or Greek history tells us. But mathematical physics is a very modern subject, as any working mathematician or physicist can witness. It is a challenging discipline that has to provide results of interest for both mathematics and physics. Ideas and motivations from both these sciences give it a vitality and freshness that is difficult to find anywhere else.

One of the big physical revolutions in the twentieth century, quantum physics, opened a new magnificent era for this interplay. With the appearance of noncommutative analysis, the role of classical calculus has been taken by commutation relations, a subject still growing in an astonishing way.

A good example where mathematical physics showed its power, beauty, and interdisciplinary character is the Doplicher-Haag-Roberts analysis of superselection sectors in the late 1960s. Not only did this theory explain the origin of statistics and classify it, but year after year, new connections have merged, for example with Tomita-Takesaki modular theory, Jones theory of subfactors, and Doplicher-Roberts abstract duality for compact groups.

This volume contains the proceedings of the conference, "Mathematical Physics in Mathematics and Physics", dedicated to Sergio Doplicher and John E. Roberts held in Siena, Italy. The articles offer current research in various fields of mathematical physics, primarily concerning quantum aspects of operator algebras.

Fields Institute Communications, Volume 30

December 2001, 451 pages, Hardcover, ISBN 0-8218-2814-2, LC 2001045989, 2000 *Mathematics Subject Classification*: 81-06, 46-06; 81T05, 47L90, **Individual member $71**, List $119, Institutional member $95, Order code FIC/30RT202

Recommended Text

Lectures on Monte Carlo Methods

Neal Madras, *York University, Toronto, ON, Canada*

Monte Carlo methods form an experimental branch of mathematics that employs simulations driven by random number generators. These methods are often used when others fail, since they are much less sensitive to the "curse of dimensionality", which plagues deterministic methods in problems with a large number of variables. Monte Carlo methods are used in many fields: mathematics, statistics, physics, chemistry, finance, computer science, and biology, for instance.

This book is an introduction to Monte Carlo methods for anyone who would like to use these methods to study various kinds of mathematical models that arise in diverse areas of application. The book is based on lectures in a graduate course given by the author. It examines theoretical properties of Monte Carlo methods as well as practical issues concerning their computer implementation and statistical analysis. The only formal prerequisite is an undergraduate course in probability.

The book is intended to be accessible to students from a wide range of scientific backgrounds. Rather than being a detailed treatise, it covers the key topics of Monte Carlo methods to the depth necessary for a researcher to design, implement, and analyze a full Monte Carlo study of a mathematical or scientific problem. The ideas are illustrated with diverse running examples. There are exercises sprinkled throughout the text. The topics covered include computer generation of random variables, techniques and examples for variance reduction of Monte Carlo estimates, Markov chain Monte Carlo, and statistical analysis of Monte Carlo output.

Fields Institute Monographs, Volume 16

January 2002, 103 pages, Hardcover, ISBN 0-8218-2978-5, LC 2001053551, 2000 *Mathematics Subject Classification*: 65C05, 60-01; 60J10, 65C10, 82B80, **All AMS members $24**, List $30, Order code FIM/16RT202

Independent Study

A Tour of Subriemannian Geometries, Their Geodesics and Applications

Richard Montgomery, *University of California, Santa Cruz*

Subriemannian geometries, also known as Carnot-Caratheodory geometries, can be viewed as limits of Riemannian geometries. They also arise in physical phenomenon involving "geometric phases" or holonomy. Very roughly speaking, a subriemannian geometry consists of a manifold endowed with a distribution (meaning a k-plane field, or subbundle of the tangent bundle), called *horizontal* together with an inner product on that distribution. If $k = n$, the dimension of the manifold, we get the usual Riemannian geometry. Given a subriemannian geometry, we can define the distance between two points just as in the Riemannin case, except we are only allowed to travel along the horizontal lines between two points.

The book is devoted to the study of subriemannian geometries, their geodesics, and their applications. It starts with the simplest nontrivial example of a subriemannian geometry: the two-dimensional isoperimetric problem reformulated as a problem of finding subriemannian geodesics. Among topics discussed in other chapters of the first part of the book we mention an elementary exposition of Gromov's surprising idea to use subriemannian geometry for proving a theorem in discrete group theory and Cartan's method of equivalence applied to the problem of understanding invariants (diffeomorphism types) of distributions. There is also a chapter devoted to open problems.

The second part of the book is devoted to applications of subriemannian geometry. In particular, the author describes in detail the following four physical problems: Berry's phase in quantum mechanics, the problem of a falling cat righting herself, that of a microorganism swimming, and a phase problem arising in the N-body problem. He shows that all these problems can be studied using the same underlying type of subriemannian geometry: that of a principal bundle endowed with G-invariant metrics.

Reading the book requires introductory knowledge of differential geometry, and it can serve as a good introduction to this new exciting area of mathematics.

Mathematical Surveys and Monographs, Volume 91

December 2001, 259 pages, Hardcover, ISBN 0-8218-1391-9, LC 2001053538, 2000 *Mathematics Subject Classification*: 58E10, 53C17, 53C23, 49Q20, 58A30, 53C22, 58A15, 58D15, 58E30, **Individual member $41**, List $69, Institutional member $55, Order code SURV/91RT202

Independent Study

Operators, Functions, and Systems: An Easy Reading

Volume 1: Hardy, Hankel, and Toeplitz

Nikolai K. Nikolski, *University of Bordeaux I, Talence, France, and Steklov Institute of Mathematics, St. Petersburg, Russia*

This unique book combines four formally distinct topics of modern analysis and its applications:

A. Hardy classes of holomorphic functions

B. Spectral theory of Hankel and Toeplitz operators

C. Function models for linear operators and free interpolations, and

D. Infinite-dimensional system theory and signal processing

This volume, Volume I, contains Parts A and B; Volume II contains Parts C and D.

Hardy classes of holomorphic functions: This topic is known to be the most powerful tool of complex analysis for a variety of applications, starting with Fourier series, through the Riemann ζ-function, all the way to Wiener's theory of signal processing.

Spectral theory of Hankel and Toeplitz operators: These now become the supporting pillars for a large part of harmonic and complex analysis and for many of their applications. In this book, moment problems, Nevanlinna-Pick and Carathéodory interpolation, and the best rational approximations are considered to illustrate the power of Hankel and Toeplitz operators.

Function models for linear operators and free interpolations: This is a universal topic and, indeed, is the most influential operator theory technique in the post-spectral-theorem era. In this book, its capacity is tested by solving generalized Carleson-type interpolation problems.

Infinite-dimensional system theory and signal processing: This topic is the touchstone of the three previously developed techniques. The presence of this applied topic in a pure mathematics environment reflects important changes in the mathematical landscape of the last 20 years, in that the role of the main consumer and customer of harmonic, complex, and operator analysis has more and more passed from differential equations, scattering theory, and probability, to control theory and signal processing.

The book is geared toward a wide audience of readers, from graduate students to professional mathematicians. It develops an elementary approach while retaining an expert level that can be applied in advanced analysis and selected applications.

Mathematical Surveys and Monographs, Volume 92

January 2002, 461 pages, Hardcover, ISBN 0-8218-1083-9, LC 2001053556, 2000 *Mathematics Subject Classification*: 47-02, 30-02, 93-02, 30D55, 47B35, 47A45, 93B05, 93C05, **Individual member $59**, List $98, Institutional member $78, Order code SURV/92RT202

Supplementary Reading

Convex Polyhedra with Regularity Conditions and Hilbert's Third Problem

A R Rajwade

A publication of the Hindustan Book Agency.

Since antiquity, people knew that there are only five regular solids, i.e. polyhedra whose all faces are regular polygons and all solid angles are also regular. These solids are, of course, the tetrahedron, the octahedron, the cube, the icosahedron, and the dodecahedron. Later, much attention was drawn to the question of how to describe polyhedra with other types of regularity conditions. The author puts together many facts known in this direction. He formulates four regularity conditions (two for faces and two for solid angles) and for any combination of their conditions lists all the corresponding polyhedra. In this way, he obtains such very interesting classes of solids as 13 semiregular solids, or 8 deltahedra, or 92 regularly faces polyhedra, etc. In later chapters the author presents some related topics of geometry of solids, like star polyhedra and plane tessellations. In the concluding chapter, a complete solution of the Hilbert 3rd problem is given.

Supplied with many figures, the book can be easily read by anyone interested in this beautiful classical geometry.

Distributed worldwide except in India by the American Mathematical Society.

Number 8

August 2001, 120 pages, Hardcover, ISBN 81-85931-28-3, 2000 *Mathematics Subject Classification*: 13-XX, 14-XX, **All AMS members $26**, List $32, Order code HIN/8RT202

Introduction to the Theory of Differential Inclusions

Georgi V. Smirnov, *University of Porto, Portugal*

A differential inclusion is a relation of the form $\dot{x} \in F(x)$, where F is a set-valued map associating any point $x \in R^n$ with a set $F(x) \subset R^n$. As such, the notion of a differential inclusion generalizes the notion of an ordinary differential equation of the form $\dot{x} = f(x)$. Therefore, all problems usually studied in the theory of ordinary differential equations (existence and continuation of solutions, dependence on initial conditions and parameters, etc.) can be studied for differential inclusions as well. Since a differential inclusion usually has many solutions starting at a given point, new types of problems arise, such as investigation of topological properties of the set of solutions, selection of solutions with given properties, and many others.

Differential inclusions play an important role as a tool in the study of various dynamical processes described by equations with a discontinuous or multivalued right-hand side, occurring, in particular, in the study of dynamics of economical, social, and biological macrosystems. They also are very useful in proving existence theorems in control theory.

This text provides an introductory treatment to the theory of differential inclusions. The reader is only required to know ordinary differential equations, theory of functions, and functional analysis on the elementary level.

Chapter 1 contains a brief introduction to convex analysis. Chapter 2 considers set-valued maps. Chapter 3 is devoted to the Mordukhovich version of nonsmooth analysis. Chapter 4 contains the main existence theorems and gives an idea of the approximation techniques used throughout the text. Chapter 5 is devoted to the viability problem, i.e., the problem of selection of a solution to a differential inclusion that is contained in a given set. Chapter 6 considers the controllability problem. Chapter 7 discusses extremal problems for differential inclusions. Chapter 8 presents stability theory, and Chapter 9 deals with the stabilization problem.

This item will also be of interest to those working in applications.

Graduate Studies in Mathematics, Volume 41

December 2001, 226 pages, Hardcover, ISBN 0-8218-2977-7, LC 2001053414, 2000 *Mathematics Subject Classification*: 34A60, 34D20, 49K24; 49J24, 49J52, 93D15, **All AMS members $27**, List $34, Order code GSM/41RT202

Winter School on Mirror Symmetry, Vector Bundles and Lagrangian Submanifolds

Cumrun Vafa and **S.-T. Yau**, *Harvard University, Cambridge, MA*, Editors

The collection of articles in this volume are based on lectures presented during the Winter School on Mirror Symmetry held at Harvard University. There are many new directions suggested by mirror symmetry which could potentially have very rich connections in physics and mathematics.

This book brings together the latest research in a major area of mathematical physics, including the recent progress in mirror manifolds and Lagrangian submanifolds. In particular, several articles describing homological approach and related topics are included.

Other AMS titles edited by S.-T Yau published in the AMS/IP Studies in Advanced Mathematics series include, *Mirror Symmetry III*, Volume 10, *Mirror symmetry II*, Volume 1, and *Mirror Symmetry I*, Volume 9.

This item will also be of interest to those working in algebra and algebraic geometry.

AMS/IP Studies in Advanced Mathematics, Volume 23

December 2001, 377 pages, Softcover, ISBN 0-8218-2159-8, LC 2001045675, 2000 *Mathematics Subject Classification*: 14-06, 32-06, 81-06, 53D12, 14F05, 14J32, **All AMS members $34**, List $42, Order code AMSIP/23RT202

Algebraic Methods in Statistics and Probability

Marlos A. G. Viana, *University of Illinois at Chicago*, and **Donald St. P. Richards**, *University of Virginia, Charlottesville*, Editors

Algebraic methods and arguments in statistics and probability are well known, from Gauss's least squares principle through Fisher's method of variance decomposition. The relevance of group-theoretic arguments, for example, became evident in the 1980s. Such techniques continue to be of interest today, along with other developments, such as the use of graph theory in modelling complex stochastic systems.

This volume is based on lectures presented at the AMS Special Session on Algebraic Methods and Statistics held at the University of Notre Dame (Indiana) and on contributed articles solicited for this volume. The articles are intended to foster communication between representatives of the diverse scientific areas in which these functions are utilized and to further the trend of utilizing algebraic methods in the areas of statistics and probability.

This is one of few volumes devoted to the subject of algebraic methods in statistics and probability. The wide range of topics covered in this volume demonstrates the vigorous level of research and opportunities ongoing in these areas.

Contemporary Mathematics, Volume 287

December 2001, 340 pages, Softcover, ISBN 0-8218-2687-5, LC 2001045884, 2000 *Mathematics Subject Classification*: 05B20, 60F05, 62A01, 62C10, 62H15; 13P10, 15A52, 20B30, 30E20, 62G08, **Individual member $48**, List $80, Institutional member $64, Order code CONM/287RT202

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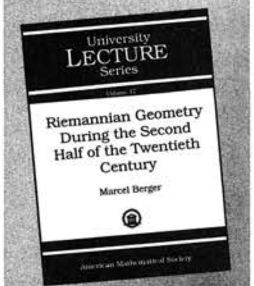

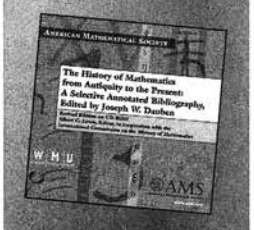

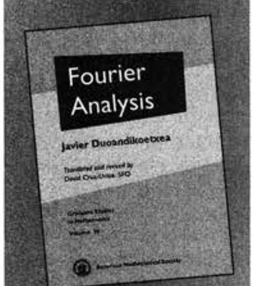

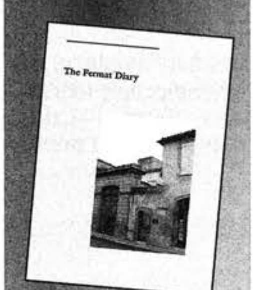

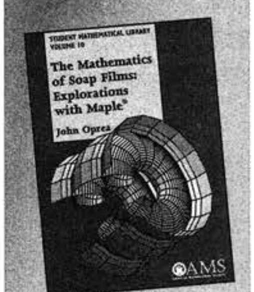

Riemannian Geometry During the Second Half of the Twentieth Century

Marcel Berger, *Institut des Hautes Études Scientifiques, Bures-Sur-Yvette, France*

This is quite an amazing book ... The coverage ... is quite astonishing, both in breadth and in depth ... Another outstanding feature of the book is its extensive cross-referencing ... this feature ... made the book particularly valuable to my students ... they could quickly find out more about a topic which was completely new to them.

—Bulletin of the LMS

Reprint arranged with the approval of the publisher B. G. Teubner (Stuttgart and Leipzig, Germany).

University Lecture Series, Volume 17; 2000; ISBN 0-8218-2052-4; 182 pages; Softcover; **All AMS members $27**, List $34, Order Code ULECT/17CT202

The History of Mathematics from Antiquity to the Present: A Selective Annotated Bibliography, edited by Joseph W. Dauben

OUTSTANDING ACADEMIC TITLE CHOICE 2001

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Albert C. Lewis, *Indiana University-Purdue University, Indianapolis,* Editor

An impressive resource, it has 4,800 annotated bibliographic citations, twice the number of references included in the 1985 print version ... a great addition to the disc is a listing of Internet sites that pertain to the history of mathematics, complete with URL links. This fantastic program is a valuable resource for mathematicians, mathematics historians, teachers and students of mathematics, and any layperson interested in mathematics.

—CHOICE

2000; CD-ROM; ISBN 0-8218-0844-3; **All AMS members $39**, List $49, Order Code HMAPCT202

Fourier Analysis

Javier Duoandikoetxea, *Universidad del País Vasco/Euskal Herriko Unibertsitatea, Bilbao, Spain*

This is a great book and is highly recommended as an introductory textbook to Fourier analysis. The students will have a lot to benefit from in the simple and quick presentation of the book.

—Mathematical Reviews

Graduate Studies in Mathematics, Volume 29; 2001; ISBN 0-8218-2172-5; 222 pages; Hardcover; **All AMS members $28**, List $35, Order Code GSM/29CT202

The Fermat Diary

C. J. Mozzochi, *Princeton, NJ*

This book will undoubtedly be extremely useful to future historians of mathematics. It is very enjoyable to read as well ... it is possible to read and enjoy the book just for the stories about the people involved and to get a taste of the excitement in the number theory community at the time ...

This book can make us feel closer to the way in which Wiles' work was received and is being assimilated by the mathematical world. I recommended it as an addition to both personal and institutional libraries.

—MAA Online

2000; ISBN 0-8218-2670-0; 196 pages; Hardcover; **All AMS members $23**, List $29, Order Code FERMATDCT202

Function Theory in Several Complex Variables

Toshio Nishino, *Kyushu University, Fukuoka, Japan*

This book has its own point of view, and it is one that is not well represented in the more modern books. So it is a welcome addition to the literature ... I conclude by noting that the translation is a particularly mellifluous one. The book is a pleasure to read.

—Mathematical Reviews

Translations of Mathematical Monographs, Volume 193; 2001; ISBN 0-8218-0816-8; 366 pages; Hardcover; **Individual member $77**, List $129, Institutional member $103, Order Code MMONO/193CT202

The Mathematics of Soap Films: Explorations with Maple®

John Oprea, *Cleveland State University, OH*

[The author] provides no more and no less than is necessary to completely derive the mathematical theory of minimal surfaces. Other strengths of the book include the breadth of topics ... the amount of detail included in worked examples and the general readability. Finally the computer component is an added advantage ... some nicely-developed explorations ...

I am very enthusiastic about this book! It would make an excellent text for an undergraduate course in minimal surface theory. ... Enough detail is included so that this book would also be suitable for an independent study. The next time I teach undergraduate differential geometry, my plan is to first teach a lead-in course using Oprea's book. This provides students with easy access to soap film mathematics.

—MAA Online

Student Mathematical Library, Volume 10; 2000; ISBN 0-8218-2118-0; 266 pages; Softcover; **All AMS members $23**, List $29, Order Code STML/10CT202

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CALIFORNIA

UNIVERSITY OF CALIFORNIA, RIVERSIDE
Department of Mathematics
Faculty Position in Analysis (Tenure-Track)

Applications and nominations are invited for a tenure-track faculty position in analysis, beginning July 1, 2002. A doctorate in mathematics is required. Tenure-track applicants are expected to have demonstrated outstanding teaching and research, normally including major contributions beyond the doctoral dissertation. Responsibilities of this position include teaching undergraduate and graduate level courses and seminars, conducting scholarly research, and participating in departmental and university service activities. Established criteria of the University of California will determine salary and level of appointment. To assure full consideration, applicants should send their curriculum vitae, including a list of publications, and have a minimum of three letters of recommendation sent to the address given below by Friday, February 8, 2002. All letters of recommendation are governed by university regulations and laws concerning confidentiality (see Academic Personnel Manual 160). This information can be found at `http://www.ucop.edu/acadadv/acadpers/apm/apm-160.pfd/`.

2002 Analysis Search Committee
Department of Mathematics
University of California, Riverside
Riverside, CA 92521-0135

Applicants are encouraged to use the AMS standardized application form and to indicate their subject area using the AMS subject classification numbers.

The University of California, Riverside is an Affirmative Action/Equal Opportunity Employer. Under Federal Law, the University of California may employ only individuals who are legally authorized to work in the United States as established by providing documents specified in the Immigration Reform and Control Act of 1986.

CONNECTICUT

UNIVERSITY OF CONNECTICUT
Department of Mathematics
Assistant Professor

The Department of Mathematics anticipates several openings for tenure-track positions at the assistant professor level, starting fall 2002. Appointments at higher levels are possible in exceptional cases. Candidates must have a Ph.D. and strong evidence of excellent research and teaching ability. Targeted areas of hiring are financial mathematics and computational methods in mathematics. Preference will also be given to candidates whose research interests strengthen existing programs within the department, in particular, analysis and topology. Salary is commensurate with experience.

The review of applications will begin in December 2001. Send resumé and at least three letters of recommendation to Hiring Committee, Department of Mathematics, U-9, University of Connecticut, Storrs, CT 06269. The University of Connecticut is an Equal Opportunity and Affirmative Action Employer. We encourage applications from underrepresented groups, including minorities, women, and people with disabilities.

UNIVERSITY OF CONNECTICUT
Department of Mathematics
Postdoctoral Fellow

The Department of Mathematics anticipates 3-5 openings for postdoctoral fellow positions beginning in fall 2002. Candidates must have received a Ph.D. within the last four years and demonstrate evidence of excellent teaching ability and outstanding research potential. The positions are for a maximum of three years. Postdoctoral fellows normally teach two courses a semester and are expected to participate in the research activities of the department. Preference will be given to candidates whose research interests intersect those of the permanent faculty.

The review of applications will begin January 1, 2002. Send resumé and at least three letters of recommendation to Hiring Committee, Department of Mathematics, U-9, University of Connecticut, Storrs, CT 06269. The University of Connecticut is an Equal Opportunity and Affirmative Action Employer. We encourage applications

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 2001 rate is \$100 per inch or fraction thereof on a single column (one-inch minimum), calculated from top of headline. Any fractional text of 1/2 inch or more will be charged at the next inch rate. 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.

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There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified advertising.

Upcoming deadlines for classified advertising are as follows: March 2002 issue–December 28, 2001; April 2001 issue–January 25, 2002; May 2002 issue–February 26, 2002; June/July 2002 issue–April 24, 2002; August 2002 issue–May 24, 2002; September 2002 issue–June 26, 2002.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 1373 (vol. 44).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send e-mail to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.

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INDIANA

ST. AMBROSE UNIVERSITY
Mathematics Faculty

Assistant professor, tenure-track position. An earned Ph.D. in mathematics, statistics, or a related field is preferred, but other candidates will be considered. Teaching responsibilities will be 12 credit hours per semester, including calculus-based statistics; qualified candidate may also teach an operations research course for undergraduate mathematics and industrial engineering majors. Advising and committee assignments are expected. St. Ambrose is a private diocesan university. Candidates who are student centered, dedicated to excellence in teaching, and sensitive to the mission of a Catholic university are encouraged to apply. Review of applications will begin March 1st and will continue until the position is filled. Send cover letter, resumé, and contact information for three professional references to Director of Human Resources, St. Ambrose University, 518 W. Locust St., Davenport, IA 52803. AA/EEO

LOUSIANA

TULANE UNIVERSITY
Mathematics Department
Computational Algebra or Geometry/Topology

Position Description:

The Mathematics Department invites applications for a regular, tenure-track position to begin in Fall, 2002. We are interested in applicants whose research interests are in Computational Algebra or in Geometry/Topology. The successful candidate will have demonstrated excellence both in teaching and in research, and there is a preference for research beyond the dissertation. The responsibilities of the position include participating in the research life of the department, teaching undergraduate and graduate courses, participating in departmental seminars and contributing to the department and the university in service.

We also invite applications for two Postdoctoral Assistant Professor positions, also to begin in Fall, 2002. Each is a two-year, non-tenure track position carrying a teaching load of two courses per semester. Candidates will be expected to participate in the research life of the department, and should have a research interest that is compatible with those represented within the department-more information about the faculty can be found at the department's home page `http://www.math.tulane.edu`.

Candidates for all of these positions should have a Ph.D. in Mathematics or a related discipline, and should provide evidence of strong research and teaching. Interested applicants should complete an AMS cover sheet, and send it along with a CV, a description of their research interests, and a teaching statement to:

Hiring Committee
Department of Mathematics
Tulane University
New Orleans, LA 70118
Phone: +1 504 865-5727
fax: +1 504 865-5063
e-mail: `mwm@math.tulane.edu`

In addition, candidates should have letters of reference from at least three individuals forwarded to us as part of their application; at least one of the letters should address the candidate's teaching performance. Applications will be accepted until the positions are filled. Tulane University is an Affirmative Action/Equal Opportunity Employer that is committed to increasing the diversity of its faculty. We therefore especially encourage applications from underrepresented groups.

More information about Tulane's Mathematics Department can be found on our web site, `http://www.math.tulane.edu/`.

MARYLAND

JOHNS HOPKINS UNIVERSITY
Department of Mathematics
3400 N. Charles Street
Baltimore, MD 21218

The Department of Mathematics of the Johns Hopkins University invites applications for one position at the associate or full professor level in the general areas of analysis, algebra, and topology, beginning fall 2002 or later. Preference will be given to candidates whose work is related to mathematical physics in a broad sense. Applicants should send a curriculum vitae to Chair, Hiring Committee, Johns Hopkins University, 3400 N. Charles Street, Kreiger 404, Baltimore, MD 21218. First round preference will be given to applications received by February 1, 2002. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer and actively encourages interest from minorities and women.

UNITED STATES NAVAL ACADEMY
Mathematics Department

The USNA mathematics department anticipates at least one tenure-track position (subject to approval and funding) at the assistant professor level to start in August 2002 or January 2003. Candidates must have a Ph.D., demonstrate a strong commitment to undergraduate teaching, and show potential to continue an active scholarly program. See website `http://www.usna.edu/MathDept/website/Faculty/Hire/Hire.htm` for full information. Tel: 410-293-6700; fax: 410-293-4883; e-mail: `amg@usna.edu`. The United States Naval Academy is an Affirmative Action/Equal Employment Opportunity Employer.

MASSACHUSETTS

WILLIAMS COLLEGE
Department of Mathematics and Statistics
Williamstown, MA 01267

Tenure-track position in statistics, beginning fall 2002, at the rank of assistant professor; in exceptional cases, however, more advanced appointments may be considered. Excellence in teaching and research and a Ph.D. at the time of appointment are required.

Please send a vita and have sent three letters of recommendation on teaching and research to the Statistics Hiring Committee, Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. Evaluation of applications will begin on or after December 10. As an EEO/AA Employer, Williams especially welcomes applications from women and minority candidates.

WILLIAMS COLLEGE
Department of Mathematics and Statistics
Williamstown, MA 01267

Tenure-track position in mathematics or statistics, beginning fall 2002, at the rank of assistant professor; in exceptional cases, however, more advanced appointments may be considered. Excellence in teaching and research and a Ph.D. by time of appointment are required.

Please send a vita and have sent three letters of recommendation on teaching and research to the Hiring Committee, Department of Mathematics and Statistics, Williams College, Williamstown, MA 01267. Evaluation of applications will begin on or after December 10. As an EEO/AA Employer, Williams especially welcomes applications from women and minority candidates.

WORCESTER POLYTECHNIC INSTITUTE
Mathematical Sciences Department

The Worcester Polytechnic Institute (WPI) Department of Mathematical Sciences invites applications for one or more anticipated tenure-track faculty positions in applied or computational mathematics in 2002. Candidates at all academic ranks will be considered.

An earned Ph.D. or equivalent degree is required. Successful candidates must be able to contribute strongly to both the department's research activities and its innovative, project-based educational programs. Areas of research in the department include partial differential equations with applications in fluid and continuum mechanics, composite materials, computational modeling and simulation, numerical analysis, optimization, control theory, discrete mathematics, applied probability, and applied statistics.

WPI is a private and highly selective technological university with an enrollment of 2,700 undergraduates and about 1,100 full- and part-time graduate students. Worcester, located forty miles west of Boston, offers ready access to the diverse economic, cultural, and recreational resources of the region.

The Mathematical Sciences Department has 24 tenured/tenure-track faculty and supports B.S., M.S., and Ph.D. programs in applied and computational mathematics and applied statistics. For additional information, see `http://www.wpi.edu/+math/`.

Qualified applicants should send a detailed curriculum vitae, a one-page statement of specific teaching and research objectives, and the names of four references with mail/e-mail addresses and telephone/fax numbers to: Mathematics Search Committee, Mathematical Sciences Department, WPI, 100 Institute Road, Worcester, MA 01609-2280.

Applications will be considered on a continuing basis beginning October 1, 2001, until the position is filled.

To enrich education through diversity, WPI is an Affirmative Action/Equal Opportunity Employer.

MICHIGAN

EASTERN MICHIGAN UNIVERSITY
Department of Mathematics

Applications are invited for a tenure-track assistant professor position beginning fall semester 2002. A Ph.D. in mathematics and demonstrated excellence in teaching are required. The applicant must have excellent communication skills and a strong commitment to excellence in teaching. In addition, it is expected that the applicant has a good research record with potential for continuing scholarly activity and will actively participate in departmental and professional service. Preference will be given to those with an interest in teaching college geometry. The standard teaching load is 12 credit hours per semester: typically one advanced course and three courses of calculus or below. Applications will be reviewed beginning January 7 and will be accepted until the position is filled or the search is terminated. A letter of application, a resumé, and at least three letters of reference that address the above criteria should be sent to Posting #F0210, Eastern Michigan University, 202 Boone Hall, Ypsilanti, MI 48197. EMU is an Affirmative Action/Equal Opportunity Employer.

MICHIGAN STATE UNIVERSITY
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NEVADA

UNIVERSITY OF NEVADA, LAS VEGAS
Department of Mathematical Sciences

The Department of Mathematical Sciences at the University of Nevada, Las Vegas, is seeking a tenure-track, assistant professor level math education coordinator. The position will start in fall 2002, contingent upon funding. Candidates must hold a Ph.D. in mathematical sciences and have a demonstrated ability and expertise in math education. Duties include coordination of mathematical content courses for elementary and secondary teachers and collaboration with the Department of Curriculum and Instruction in the UNLV College of Education on curricular matters dealing with math education. Other responsibilities include undergraduate and graduate teaching, research publications in refereed journals, and university and professional service. Salary is commensurate with qualifications and experience.

Applicants should send a completed AMS cover sheet, a curriculum vita, and three letters of reference to:

Professor Ebrahim Salehi, Co-chairman
Department of Mathematical Sciences
University of Nevada, Las Vegas
4505 Maryland Parkway
Las Vegas, NV 89154-4020
(702)895-3567 or
e-mail: `salehi@unlv.edu`

Review of applications will begin immediately and will continue until the position is filled. UNLV is an Equal Opportunity/Affirmative Action Employer. Persons are selected on the basis of ability without regard to race, color, sex, national origins, sexual orientation, religion, disability, or veteran status. For more information, see the UNLV World Wide Web site at: `http://www.unlv.edu/`.

NEW JERSEY

RICHARD STOCKTON COLLEGE OF NEW JERSEY
Computational Modeling

Assistant/associate professor, tenure-track, September 2002. We seek an excellent, versatile teacher with a Ph.D.: post-doctoral experience including college teaching is desirable, in computational science, mathematics, or some other area of natural science. Appointment will be in the program appropriate to the candidate's interest and/or background. Specialty area is open but candidates must be able to operate in an undergraduate environment at a liberal arts college. Candidates are expected to have research experience in computer modeling of physical, biological, or ecological systems. Specific duties include teaching courses in computational modeling and in related disciplinary areas at the lower and upper division levels and in the college's general studies curriculum, advising students, establishing a successful research program, and participating in the development of a computational science initiative. Stockton is a state-supported residential liberal arts and sciences college in New Jersey with over 6,000 full-time students enrolled. The anticipated salary is $40,340-$46,392 for the rank of assistant professor and $49,035-$56,394 for the rank of associate professor; may be higher depending on qualifications, experience and increases in the appropriately established compensation plan. Send letter of application, resumé, a brief statement about teaching and learning philosophies, a brief statement about research goals, documentation of degree, and three letters of recommendation to: Dean Dennis Weiss, Faculty of Natural Sciences and Mathematics, P.O. Box 195, AA74, Richard Stockton College, Pomona, NJ 08240-0195. Screening will continue until the position is filled. Stockton is an AA/EOE. Women and minorities are encouraged to apply. R022219

NEW YORK

LEHMAN COLLEGE (CUNY)
Department of Mathematics and Computer Science

Tenure-track positions are available starting September 1, 2002, for assistant/associate professors in mathematics or computer science. Positions require an earned doctorate, outstanding research record or potential, and commitment to excellence in teaching and service. The department is primarily interested in filling positions at the assistant professor rank. Individuals whose qualifications merit the higher rank will also be considered. Application procedure: Send curriculum vitae along with a cover letter and arrange for at least three letters of recommendation to be sent to Prof. Robert Feinerman, Chair, Department of Mathematics and Computer Science, Lehman College, Bronx, NY 10468. Review of applications will begin on February 11, 2002, and will continue until positions are filled. Use of the AMS cover sheet for academic employment is encouraged. Additional information at `http://www.lehman.cuny.edu/` (link to Job Opportunities). AA/EEO/ADA Employer

PENNSYLVANIA

UNIVERSITY OF PITTSBURGH AT BRADFORD
Bradford, Pennsylvania

Anticipated tenure-track assistant professor positions to begin in January 2002 or September 2002. Ph.D. in math earned or near completion. A strong commitment to undergraduate education on a small rural campus and potential in scholarly work are essential. Applicants with computer science or information technology background or a willingness to develop this expertise will be given favorable consideration. Send application letter, vita, official transcripts, and 3 letters of reference to: Dr. Yong-Zhuo Chen, Math Search Committee, University of Pittsburgh at Bradford, 300 Campus Drive, Bradford, PA 16701-2898. Selection process will start as soon as possible and continue until the positions are filled. Women and minorities are encouraged to apply. AA/EOE

RHODE ISLAND

BROWN UNIVERSITY
Department of Mathematics

One professorship at the associate professor or professor level, with tenure to begin July 1, 2003. Candidates should have a distinguished research record and a strong commitment to excellence in undergraduate and graduate teaching. Preference to be given to applicants with research interests consonant with those of the present members of the department (for more information see `http://www.math.brown.edu/faculty/faculty.html`). Qualified individuals are invited to send a vita and arrange for at least five letters of recommendation to be forwarded to: Senior Search Committee, Department of Mathematics, Box 1917, Brown University, Providence, RI 02912. Applications must be postmarked by **February 18, 2002**, in order to receive full consideration. E-mail inquiries can be addressed to `srsearch@math.brown.edu`. Brown University is an Equal Opportunity/Affirmative Action Employer and encourages applications from women and minorities.

TENNESSEE

VANDERBILT UNIVERSITY
Department of Mathematics
1326 Stevenson Center
Nashville, TN 37240

We invite applications for a position in analysis, either at the tenure-track (assistant professor) or tenured (associate or full professor) level. Candidates for a tenure-track appointment should have held the Ph.D. for at least two years and show evidence of outstanding research ability. Candidates for a senior appointment should have a record of exceptional scientific achievement. Evidence of effective teaching is essential. To apply, send the following materials in a single mailing to the attention of Geneva Shilliday at the address above: letter of application (including e-mail address and fax number), the AMS standard cover sheet fully completed, curriculum vitae, and research summary. Do not send additional information (including letters of recommendation) unless requested to do so after our initial screening. Evaluation of the applications will commence immediately and will continue until the position is filled.

Vanderbilt University is an Affirmative Action/Equal Opportunity Employer.

TEXAS

UNIVERSITY OF TEXAS-PAN AMERICAN
Department of Mathematics

The Department of Mathematics, chaired by Professor Lokenath Debnath, invites applications for tenure-track assistant professors. At least two positions are to be filled effective fall semester 2002. Candidates should have promise of developing a strong research program and have a strong commitment to excellence in teaching and professional service. A doctorate in mathematics or a related area by the date of employment is required and recent graduates are especially encouraged to apply. Particular attention will be given to the areas of applied and computational mathematics, mathematics education, and probability and statistics, but all areas of mathematics and mathematical sciences will be considered.

Applicants should include a vita, three letters of recommendation, all higher-education transcripts, and summaries of research and teaching philosophy, and mail to:

Dr. Roger Knobel
Search Committee Chair
Department of Mathematics
University of Texas-Pan American
1201 W. University Drive
Edinburg, TX 78539-2999
e-mail: `knobel@panam.edu`
tel: 956-381-3452

Review of applications will begin immediately and continue until the positions are filled. Salary is competitive and commensurate with qualifications. Additional information about the Department of Mathematics, UTPA, and these positions may be obtained from the website `http://www.math.panam.edu/`. Women and minorities are encouraged to apply. The University of Texas-Pan American is an Equal Opportunity/Affirmative Action employer. (F01/02-68)

CANADA

CARLETON UNIVERSITY
School of Mathematics and Statistics

Applications are invited for tenure-track positions at the assistant professor level starting July 1, 2002. Successful candidates should have a Ph.D. in mathematical or statistical sciences, be research oriented and have excellent teaching skills. Candidates engaged in research in algebra, cryptography, applied statistics, and bioinformatics/biostatistics (or outstanding in other areas) should apply. For full advertisement and instructions for submitting an application see: `http://www.math.carleton.ca/`. Applications will be considered until all positions are filled. Employment equity is university policy. Priority will be given to Canadian and permanent residents of Canada.

HONG KONG

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY
Department of Mathematics

The Department of Mathematics invites applications for faculty positions at the rank of associate professor or assistant professor from all areas of mathematics with preference on statistics and applied mathematics.

Exceptionally strong research and teaching experience is required. Applicants must demonstrate excellence in teaching and proven ability to teach effectively in English.

Starting rank and salary will depend on qualifications and experience. Benefits including medical and dental benefits, and assistance in housing will be provided where applicable. Initial appointment will be on three-year contract. A gratuity will be payable upon successful completion of contract.

Applicants should send a curriculum vitae and ask at least three referees to send letters of recommendations direct, preferably before March 1, 2002, to the Personnel Office, HKUST, Clear Water Bay, Kowloon, Hong Kong [Fax: (852) 2358 0700]. More information about the university is available on the university's homepage `http://www.ust.hk/`.

(Information provided by applicants will be used for recruitment and other employment-related purposes.)

PUERTO RICO

UNIVERSITY OF PUERTO RICO
Department of Mathematics and Computer Science
Rĭo Piedras Campus
San Juan, Puerto Rico

We announce the opening of two tenure-track positions, beginning in August 2002. The candidates should have a Ph.D. in the mathematical sciences and should be willing to teach and supervise thesis at undergraduate and graduate levels. Conversational knowledge of Spanish is a plus.

One position requires a strong commitment to teaching and continuing and directing research in the areas of statistics, probability and its applications, and/or actuarial science.

The second position requires specific interest in the improvement of teaching at the introductory levels and research in any area of mathematical sciences. At least one of the recommendation letters for this position should address teaching.

Salary will depend on qualifications, according to the scale of the University of Puerto Rico, Río Piedras Campus. Please send a curriculum vitae, a letter describing the interest and projects of the candidate, and three letters of recommendation, by mail to the address below. It would be useful to have a copy of the academic transcripts and diplomas. The evaluation of candidates will start on March 1, 2002, and continue until the positions are filled.

UPR is an Equal Opportunity Employer.

University of Puerto Rico, Río Piedras
Department of Mathematics
and Computer Science
Luis Raúl Pericchi, Chairman
PO Box 23355
San Juan, PR 00931-3355
`pericchi@goliath.cnnet.clu.edu`
fax: 787-281-0651

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AIMS AND SCOPE

IMRN provides very fast publication of research articles of high current interest in all areas of mathematics. All articles are fully refereed and are judged by their contribution to advancing the state of the science of mathematics. Issues are published as frequently as necessary. IMRN is expected to publish 36+ issues in 2002. The articles of the IMRN are reviewed/indexed in COMPUMATH Citation Index, INSPEC, ISI Alerting Services, Mathematical Reviews, PubSCIENCE, Science Citation Index, SciSearch, and Zentralblatt für Mathematik.

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IMRN is devoted to advancing the state of the science of mathematics by publishing research articles of high current interest in all fields of mathematics. Articles of any length are welcome and all articles are refereed and judged for correctness, interest, originality, depth, and applicability. There are no page charges. Submissions are made by email to submit@imrn.hindawi.com. An abstract for each article should be included. A copy may also be sent to an editor. Only an acknowledgment from the editorial office officially establishes the date of receipt. Submissions not prepared using TeX should be typed or printed on one side of the page, be double-spaced (including references), have ample margins, and be accompanied by a page that lists all potentially ambiguous notations. Check contact information for submission by fax or post. When articles are accepted, production begins immediately; authors should be available to assist the editorial staff.

FORTHCOMING ARTICLES

- Extended Deformation Functors, *Marco Manetti*
- Extensions of Number Fields with Wild Ramification of Bounded Depth, *Farshid Hajir and Christian Maire*
- Groups of Connected Components and Congruence Ideals Associated with Elliptic Curves, *Shuzo Takahashi*
- Integrable Systems on Quad-Graphs, *Yu. B. Suris and A. I. Bobenko*
- On Families of Triangular Hopf Algebras, *Pavel Etingof and Shlomo Gelaki*
- On Helffer-Sjöstrand's Theory of Resonances, *André Martinez and Amina Lahmar-Benbernou*
- On Purity Theorems for Vector Bundles, *Ofer Gabber*
- On the Topology of Compact Stein Surfaces, *Selman Akbulut and Burak Ozbagci*
- The Cauchy Problem for Wave Maps, *Jalal Shatah and Michael Struwe*
- The Charge Conjugation Orbifold $V_{\mathbb{Z}\alpha}^{+}$ Is Rational When $\langle\alpha,\alpha\rangle/2$ Is Prime, *Toshiyuki Abe*
- The Geometry of the Classical Solutions of the Garnier Systems, *Marta Mazzocco*

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AMERICAN MATHEMATICAL SOCIETY

AMS APPLICATION FOR MEMBERSHIP 2002

JANUARY—DECEMBER

WWW.AMS.ORG/MEMBERSHIP

Please read the "Membership Categories" section of this form to determine the membership category for which you are eligible. Then fill out this application and return it as soon as possible.

Date ______________ **20** ____

Family Name ______ First ______ Middle ______

Place of Birth: ______ City ______ State ______ Country ______

Date of Birth: ______ Day ______ Month ______ Year ______

If formerly a member of AMS, please indicate dates ______

Check here if you are now a member of either ☐ MAA or ☐ SIAM

Degrees, with institutions and dates ______

Present position ______

Firm or institution ______

City ______ State ______ Zip/Country ______

Primary Fields of Interest (choose five from the list at right)

______ ______ ______ ______ ______

Secondary Fields of Interest (choose from the list at right)

______ ______ ______ ______ ______

______ ______ ______ ______ ______

Address for all mail

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Telephone: home: (_____)__________ office: (_____)__________

Fax: (_____)__________

E-mail: ______

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Signature

☐ ***Check here if you would like to receive your dues renewal notices electronically.***

☐ ***Check here to receive free quarterly* PUBLICATIONS UPDATE *by mail.***

Fields of Interest

If you wish to be on the mailing lists to receive information about publications in fields of mathematics in which you have an interest, please consult the list of major headings below. These categories will be added to your computer record so that you will be informed of new publications or special sales in the fields you have indicated.

00 General
01 History and biography
03 Mathematical logic and foundations
05 Combinatorics
06 Order, lattices, ordered algebraic structures
08 General algebraic systems
11 Number theory
12 Field theory and polynomials
13 Commutative rings and algebras
14 Algebraic geometry
15 Linear and multilinear algebra; matrix theory
16 Associative rings and algebras
17 Nonassociative rings and algebras
18 Category theory, homological algebra
19 *K*-theory
20 Group theory and generalizations
22 Topological groups, Lie groups
26 Real functions
28 Measure and integration
30 Functions of a complex variable
31 Potential theory
32 Several complex variables and analytic spaces
33 Special functions
34 Ordinary differential equations
35 Partial differential equations
37 Dynamical systems and ergodic theory
39 Difference and functional equations
40 Sequences, series, summability
41 Approximations and expansions
42 Fourier analysis
43 Abstract harmonic analysis
44 Integral transforms, operational calculus
45 Integral equations
46 Functional analysis
47 Operator theory
49 Calculus of variations and optimal control; optimization
51 Geometry
52 Convex and discrete geometry
53 Differential geometry
54 General topology
55 Algebraic topology
57 Manifolds and cell complexes
58 Global analysis, analysis on manifolds
60 Probability theory and stochastic processes
62 Statistics
65 Numerical analysis
68 Computer science
70 Mechanics of particles and systems
74 Mechanics of deformable solids
76 Fluid mechanics
78 Optics, electromagnetic theory
80 Classical thermodynamics, heat transfer
81 Quantum theory
82 Statistical mechanics, structure of matter
83 Relativity and gravitational theory
85 Astronomy and astrophysics
86 Geophysics
90 Operations research, mathematical programming,
91 Game theory, economics, social and behavioral sciences
92 Biology and other natural sciences
93 Systems theory; control
94 Information and communication, circuits
97 Mathematics Education

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Account number **Expiration date**

Membership Categories

Please read the following to determine what membership category you are eligible for, and then indicate below the category for which you are applying.

Members can purchase a ***multi-year membership*** by prepaying their current dues rate for either two, three, four or five years. This option is not available to category-S, unemployed, or student members.

Introductory ordinary member rate applies to the first five ***consecutive*** years of ordinary membership. Eligibility begins with the first year of membership in any category other than student and nominee. Dues are $52.

For ***ordinary members*** whose annual professional income is below $75,000, the dues are $105; for those whose annual professional income is $75,000 or more, the dues are $140.

Minimum dues for ***contributing members*** are $210. The amount paid which exceeds the higher ordinary dues level and is purely voluntary may be treated as a charitable contribution.

For a ***joint family membership,*** one member pays ordinary dues, based on his or her income; the other pays ordinary dues based on his or her income, less $20. (Only the member paying full dues will receive the *Notices* and the *Bulletin* as a privilege of membership, but both members will be accorded all other privileges of membership.)

The annual dues for ***reciprocity members*** who reside outside the U.S. are $70. To be eligible for this classification, members must belong to one of those foreign societies with which the AMS has established a reciprocity agreement. Annual verification is required. Reciprocity members who reside in the U.S. must pay ordinary member dues ($105 or $140).

The annual dues for ***category-S members,*** those who reside in developing countries, are $16. Members can chose only one privilege journal. Please indicate your choice below.

For either ***students*** or ***unemployed individuals,*** dues are $35, and annual verification

2002 Dues Schedule (January through December)

Ordinary member, introductory rate			☐$52
Ordinary member		☐$105	☐$140
Joint family member (full rate)		☐$105	☐$140
Joint family member (reduced rate)		☐$85	☐$120
Contributing member (minimum $210)			☐
Student member (please verify)[1]			☐$35
Unemployed member (please verify)[2]			☐$35
Reciprocity member (please verify)[3]	☐$70	☐$105	☐$140
Category-S member [4]			☐$16
Multi-year membership	$..........	for..........	years

[1] ***Student Verification*** (sign below)
I am a full-time student at ______________________________

______________________________ currently working toward a degree.

[2] ***Unemployed Verification*** (sign below) I am currently unemployed and actively seeking employment.

[3] ***Reciprocity Membership Verification*** (sign below) I am currently a member of the society indicated on the right and am therefore eligible for reciprocity membership.

____

Signature

[4]☐ *send* **NOTICES** ☐ *send* **BULLETIN**

Reciprocating Societies

- ☐ Allahabad Mathematical Society
- ☐ Australian Mathematical Society
- ☐ Azerbaijan Mathematical Society
- ☐ Balkan Society of Geometers
- ☐ Berliner Mathematische Gessellschaft
- ☐ Calcutta Mathematical Society
- ☐ Canadian Mathematical Society
- ☐ Croatian Mathematical Society
- ☐ Cyprus Mathematical Society
- ☐ Dansk Matematisk Forening
- ☐ Deutsche Mathematiker-Vereinigung
- ☐ Edinburgh Mathematical Society
- ☐ Egyptian Mathematical Society
- ☐ European Mathematical Society
- ☐ Gesellschaft für Angewandte Mathematik und Mechanik
- ☐ Glasgow Mathematical Association
- ☐ Hellenic Mathematical Society
- ☐ Icelandic Mathematical Society
- ☐ Indian Mathematical Society
- ☐ Iranian Mathematical Society
- ☐ Irish Mathematical Society
- ☐ Israel Mathematical Union
- ☐ János Bolyai Mathematical Society
- ☐ The Korean Mathematical Society
- ☐ London Mathematical Society
- ☐ Malaysian Mathematical Society
- ☐ Mathematical Society of Japan
- ☐ Mathematical Society of Serbia
- ☐ Mathematical Society of the Philippines
- ☐ Mathematical Society of the Republic of China
- ☐ Mongolian Mathematical Society
- ☐ Nepal Mathematical Society
- ☐ New Zealand Mathematical Society
- ☐ Nigerian Mathematical Society
- ☐ Norsk Matematisk Forening
- ☐ Österreichische Mathematische Gesellschaft
- ☐ Palestine Society for Mathematical Sciences
- ☐ Polskie Towarzystwo Matematyczne
- ☐ Punjab Mathematical Society
- ☐ Ramanujan Mathematical Society
- ☐ Real Sociedad Matemática Española
- ☐ Saudi Association for Mathematical Sciences
- ☐ Singapore Mathematical Society
- ☐ Sociedad Colombiana de Matemáticas
- ☐ Sociedad Española de Matemática Aplicada
- ☐ Sociedad de Matemática de Chile
- ☐ Sociedad Matemática de la Republica Dominicana
- ☐ Sociedad Matemática Mexicana
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- ☐ Wiskundig Genootschap

R · I · T

Dean of the College of Science

Rochester Institute of Technology

Rochester Institute of Technology is searching for an exceptional individual to become the next Dean of the College of Science. RIT is a privately endowed, coeducational, non-sectarian, technological university located on a 1300-acre campus in suburban Rochester, New York. The Institute enrolls approximately 15,000 full and part-time undergraduate and graduate students preparing for technical and professional careers. Its eight colleges include Applied Science and Technology, Business, Computing and Information Sciences, Engineering, Imaging Arts and Sciences, Liberal Arts, Science, and the primarily federally funded National Technical Institute for the Deaf.

Rochester Institute of Technology is in the midst of a profound redefinition of its activities and emphasis that will result in achieving a more prominent role nationally in both education and research. The College of Science will be an integral component in these plans with a leading role in the enhancement of the Institute's traditionally strong undergraduate education and expanding graduate programs. In doing so, the College will incorporate technological innovation, enriched research opportunities for undergraduates, and the integration of the program offerings of the various departments/colleges. Existing graduate programs in the College will be substantially enhanced and expanded, with additional MS and Ph.D. programs that emphasize interdisciplinary collaboration and applied research. The College comprises of the departments of Allied Health Sciences, Biological Sciences, Chemistry, Mathematics and Statistics, Physics, and the Center for Imaging Science. The annual budget is approximately $15 million. The College of Science has approximately 185 faculty/staff and nearly 1000 students enrolled in 32 degree programs.

The Dean is the chief academic, fiscal, and administrative officer, and has a key role in securing funds for the College's initiatives. We are seeking a dynamic individual, possessing strong interpersonal communication skills along with significant administrative experience, to lead in shaping the future of the College of Science. The successful candidate will have, at a minimum, a Ph.D. in an appropriate discipline for the College of Science, and a record of achievement in scholarship, education, and interaction with government and industry. A demonstrated record of successful attainment of major funding, through the competitive grants process, is essential.

RIT is an equal opportunity, affirmative action employer and invites and encourages applications from women and minorities. Additional information may be obtained at http://www.science.rit.edu. Please respond to: The Search Committee for the Dean of the College of Science, Office of the Provost, Rochester Institute of Technology, 12 Lomb Memorial Drive, Rochester, NY 14623-5604. Review of applications will begin on February 18, 2002.

Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices*. However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Programs and abstracts will continue to be displayed on the AMS website in the Meetings and Conferences section until about three weeks after the meeting is over. Final programs for Sectional Meetings will be archived on the AMS website in an electronic issue of the *Notices* as noted below for each meeting.

Ann Arbor, Michigan

University of Michigan

March 1–3, 2002

Meeting #974

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: January 2002
Program first available on AMS website: January 17, 2002
Program issue of electronic *Notices*: May 2002
Issue of *Abstracts*: Volume 23, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: January 9, 2002

Invited Addresses

Laszlo Babai, University of Chicago, *Title to be announced.*

Nets Katz, Washington University, *Title to be announced.*

Alan Reid, University of Texas at Austin, *Title to be announced.*

Lihe Wang, University of Iowa, *Title to be announced.*

Thaleia Zariphopoulou, University of Texas, Austin, *Pricing and risk management in incomplete markets.*

Special Sessions

Algebraic Combinatorics (Code: AMS SS H1), **Patricia Hersh**, University of Michigan, Ann Arbor, and **Brian D. Taylor**, Wayne State University.

Algebraic Topology (Code: AMS SS F1), **Robert Bruner**, Wayne State University, and **Igor Kriz**, University of Michigan, Ann Arbor.

Biological Applications of Dynamical Systems (Code: AMS SS J1), **J. M. Cushing**, University of Arizona, **Shandelle M. Henson**, Andrews University, and **Anna M. Spagnuolo**, Oakland University.

Commutative Algebra (Code: AMS SS D1), **Florian Enescu** and **Anurag K. Singh**, University of Utah, and **Karen E. Smith**, University of Michigan, Ann Arbor.

Differential Geometry (Code: AMS SS K1), **Lizhen Ji**, **Krishnan Shankar**, and **Ralf Spatzier**, University of Michigan, Ann Arbor.

Hyperbolic Manifolds and Discrete Groups (Code: AMS SS E1), **Richard D. Canary**, University of Michigan, Ann Arbor, and **Alan W. Reid**, University of Texas, Austin.

Integrable Systems and Poisson Geometry (Code: AMS SS C1), **Anthony Block**, University of Michigan, **Philip Foth**, University of Arizona, and **Michael Gekhtman**, University of Notre Dame.

Mapping Class Groups and Geometric Theory of Teichmuller Spaces (Code: AMS SS P1), **Benson Farb**, University of Chicago, **Nikolai Ivanov**, Michigan State University, and **Howard Masur**, University of Illinois, Chicago.

Moduli Spaces (Code: AMS SS G1), **Angela Gibney**, University of Michigan, Ann Arbor.

Numerical Analysis and Applications of Partial Differential Equations (Code: AMS SS L1), **Joan Remski** and **Jennifer Zhao**, University of Michigan, Dearborn.

Partial Differential Equations (Code: AMS SS N1), **Qing Han**, University of Notre Dame, and **Lihe Wang**, University of Iowa.

Quantum Topology in Dimension Three (Code: AMS SS A1), **Charles Frohman**, University of Iowa, and **Joanna Kania-Bartoszynska**, Boise State University.

Stochastic Modeling in Financial Mathematics (Code: AMS SS T1), **Ronnie Sircar**, Princeton University.

Topics in Geometric Function Theory (Code: AMS SS B1), **David A. Herron**, University of Cincinnati, **Nageswari Shanmugalingam**, University of Texas, and **Jeremy T. Tyson**, SUNY at Stony Brook.

Atlanta, Georgia

Georgia Institute of Technology

March 8-10, 2002

Meeting #975

Meeting held in conjunction with the Mathematical Association of America.
Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: January 2002
Program first available on AMS website: January 31, 2002
Program issue of electronic *Notices*: May 2002
Issue of *Abstracts*: Volume 23, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: January 22, 2002

Invited Addresses

Georgia Benkart, University of Wisconsin, Madison, *Title to be announced.*

Robert L. Bryant, Duke University, *Title to be announced.*

Nigel J. Kalton, University of Missouri, Columbia, *Title to be announced.*

James G. Oxley, Louisiana State University, *The interplay between graphs and matroids.*

Special Sessions

Algebraic Combinatorics (Code: SS T1), **Mihai A. Ciucu**, Georgia Institute of Technology.

Automated Reasoning in Mathematics and Logic (Code: SS S1), **Johan G. F. Belinfante**, Georgia Institute of Technology.

Banach Spaces and Their Applications (Code: SS B1), **Peter G. Casazza** and **N. J. Kalton**, University of Missouri-Columbia.

Collaborative Learning Classroom Activities (Code: SS M1), **Sabrina A. Hessinger**, Armstrong Atlantic State University.

Combinatorics and Graph Theory (Code: SS A1), **John M. Harris**, Furman University.

Computation in the Mathematical Sciences (Code: SS X1), **Sabrina A. Hessinger**, Armstrong Atlantic State University, and **Mark D. Cawood**, Clemson University.

Dynamic Equations on Time Scales (Code: SS V1), **Martin J. Bohner**, Florida Institute of Technology, and **Billur Kaymakcalan**, Georgia Southern University.

Elementary Mathematical Modeling (Code: SS L1), **Mary Ellen Davis**, Georgia Perimeter College.

Frames, Wavelets, and Operator Theory (Code: SS K1), **Christopher E. Heil** and **Yang Wang**, Georgia Institute of Technology.

Graphs and Matroids (Code: SS H1), **James G. Oxley** and **Bogdan Oporowski**, Louisiana State University, and **Robin Thomas**, Georgia Institute of Technology.

Harmonic Analysis (Code: SS E1), **Gerd Mockenhaupt** and **Michael T. Lacy**, Georgia Institute of Technology, and **Akos Magyar**, University of Georgia.

Introductory/Elementary Statistics (Code: SS Y1), **Patricia G. Monroe**, Greenville Technical College.

Knot Theory, 3-Manifolds, 4-Manifolds, and Geometric Group Theory (Code: SS C1), **Wolfgang H. Heil**, Florida State University, and **Jose Carlos Gómez-Larrañaga**, CIMAT, Mexico.

Linear Algebra and Matrix Theory (Code: SS N1), **Frank J. Hall** and **Zhongshan Li**, Georgia State University.

Mathematical Models in Biology (Code: SS P1), **Robert D. Fray**, Furman University.

Number Theory (Code: SS R1), **David Penniston**, Furman University.

Numerical Linear Algebra and Its Applications (Code: SS J1), **Michele Benzi**, Emory University, **Steven B. Damelin**, Georgia Southern University, and **James Nagy**, Emory University.

Probability and Combinatorics (Code: SS Z1), **Russell D. Lyons** and **Prasad V. Tetali**, Georgia Institute of Technology.

Quantum Structures (Code: SS D1), **Alexander G. Wilce**, Juniata College, **Richard J. Greechie**, Louisiana Technical University, and **Franklin E. Schroeck**, Florida Atlantic University.

Real World Applications of Mathematics (Code: SS U1), **Mark C. Ginn**, Appalachian State University.

Research on the Mathematical Education of Undergraduates (Code: SS W1), **Joe Wimbish**, Huntingdon College.

Symplectic and Contact Topology (Code: SS Q1), **Margaret Symington**, Georgia Institute of Technology, and **Gordana Matic**, University of Georgia.

Technology and Distance Learning (Code: SS F1), **Tom Morley**, Georgia Institute of Technology, and **Martha Abel**, Georgia Southern University.

Three Bridges from "Applied" to "Mathematics" (Code: SS G1), **Peter Mucha**, **John A. Pelesko**, **John E. McCuan**, and **Guillermo H. Goldsztein**, Georgia Institute of Technology.

Montréal, Quebec Canada

Centre de Recherches Mathématiques, Université de Montréal

May 3–5, 2002

Meeting #976

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: March 2002
Program first available on AMS website: March 21, 2002
Program issue of electronic *Notices*: July 2002
Issue of *Abstracts*: Volume 23, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: January 15, 2002
For abstracts: March 12, 2002

Invited Addresses

Nicholas M. Ercolani, University of Arizona, *Title to be announced.*

Lars Hesselholt, Massachusetts Institute of Technology, *Title to be announced.*

Niky Kamran, McGill University, *Title to be announced.*

Rafael de la Llave, University of Texas at Austin, *Title to be announced.*

Special Sessions

Asymptotics for Random Matrix Models and Their Applications (Code: AMS SS J1), **Nicholas M. Ercolani**, University of Arizona, and **Kenneth T.-R. McLaughlin**, University of North Carolina at Chapel Hill and University of Arizona.

Combinatorial Hopf Algebras (Code: AMS SS C1), **Marcelo Aguiar**, Texas A&M University, and **François Bergeron** and **Christophe Reutenauer**, Université du Québec á Montréal.

Combinatorial and Geometric Group Theory (Code: AMS SS A1), **Olga G. Kharlampovich**, McGill University, **Alexei Myasnikov** and **Vladimir Shpilrain**, City College, New York, and **Daniel Wise**, McGill University.

Commutative Algebra and Algebraic Geometry (Code: AMS SS G1), **Irena Peeva**, Cornell University, and **Hema Srinivasan**, University of Missouri-Columbia.

Curvature and Topology (Code: AMS SS E1), **Regina Rotman**, Courant Institute, New York University, **Christina Sormani**, Lehman College, CUNY, and **Kristopher R. Tapp**, SUNY at Stony Brook.

Function Spaces in Harmonic Analysis and PDEs (Code: AMS SS D1), **Galia D. Dafni** and **Jie Xiao**, Concordia University.

Potential Theory (Code: AMS SS B1), **Paul M. Gauthier**, Université de Montréal, **K. Gowri Sankaran**, McGill University, and **David H. Singman**, George Mason University.

Shape Theory in Dynamics (Code: AMS SS F1), **Alex Clark**, University of North Texas, and **Krystyna M. Kuperberg**, Auburn University.

Spectral Geometry (Code: AMS SS H1), **Dmitry Jakobson**, McGill University, and **Yiannis Petridis**, McGill University and Centre de recherches Mathematiques.

Pisa, Italy

June 12–16, 2002

Meeting #977

First Joint International Meeting between the AMS and the Unione Matematica Italiana.
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: Expired
For abstracts: Abstract submission procedures, including the setting of deadlines, are being arranged by the UMI. Please watch their website at `http://www.dm.unipi.it/%7Emeet2002/` for announcements.

Invited Addresses

Luigi Ambrosio, Scuola Normale Superiore, *Title to be announced.*

Luis A. Caffarelli, University of Texas at Austin, *Title to be announced.*

Claudio Canuto, Politecnico of Torino, *Title to be announced.*

L. Craig Evans, University of California Berkeley, *Title to be announced.*

Giovanni Gallavotti, University of Rome I, *Title to be announced.*

Sergio Klainerman, Princeton University, *Title to be announced.*

Rahul V. Pandharipande, California Institute of Technology, *Title to be announced.*

Claudio Procesi, University of Roma, *Title to be announced.*

Special Sessions

Advances in Complex, Contact, and Symplectic Geometry, **Paolo De Bartolomeis**, University of Firenze, **Yakov Eliashberg**, Stanford University, **Gang Tian**, MIT, and **Giuseppe Tomassini**, Scuola Normale Superiore, Pisa.

Advances in Differential Geometry of PDEs and Applications, **Valentin Lychagin**, University of Heights, Newark, and **Agostino Prastaro**, University of Roma, La Sapienza.

Algebraic Logic and Universal Algebra, **Paolo Agliano**, University of Siena, **Keith A. Kearnes**, University of Colorado, **Franco Montagna**, University of Siena, **Don Pigozzi**, Iowa State University, and **Aldo Ursini**, University of Siena.

Algebraic Vector Bundles, **Vincenzo Ancona**, University of Firenze, **Mohan Kumar**, Washington University, **Giorgio Maria Ottaviani**, University of Firenze, **Christopher Peterson**, Colorado State University, and **Prabhakar Rao**, University of Missouri.

Analytic Aspects of Convex Geometry, **Stefano Campi**, University of Modena, **Richard Gardner**, Western Washington University, **Erwin Lutwak**, Polytechnic University Brooklyn, and **Alijosa Volcic**, University of Trieste.

Classification Theory and Topology of Algebraic Varieties, **Fabrizio Catanese**, University of Goettingen, **Janos Kollar**, Princeton University, and **Shing-Tung Yau**, Harvard University.

Commutative Algebra and the Geometry of Projective Varieties, **Ciro Ciliberto**, University of Roma II, **Anthony Geramita**, University of Genova, **Rick Miranda**, Colorado State University, and **Ferruccio Orecchia**, University of Napoli.

Commutative Algebra: Hilbert Functions, Homological Methods and Combinatorial Aspects, **Aldo Conca**, University of Genova, **Anna Guerrieri**, University of L'Aquila, **Claudia Polini**, University of Oregon, and **Bernd Ulrich**, Michigan State University.

Commutative Rings and Integer-valued Polynomials, **Stefania Gabelli**, University of Roma III, and **Thomas G. Lucas**, University of North Carolina Charlotte.

Complex, Contact and Quaternionic Geometry, **David E. Blair**, Michigan State University, and **Stefano Marchiafava**, University of Roma, La Sapienza.

Contemporary Developments in Partial Differential Equations and in the Calculus of Variations, **Irene Fonseca**, Carnegie Mellon University, and **Paolo Marcellini**, University of Firenze.

Didattica della Dimostrazione, **Ferdinando Arzarello**, University of Torino, **Guershon Harel**, Purdue University, and **Vinicio Villani**, University of Pisa.

Dynamical Systems, **Antonio Giorgilli**, University of Milano-Bicocca, **Stefano Marmi**, Scuola Normale Superiore, Pisa, and **John Norman Mather**, Princeton University.

Elliptic Partial Differential Equations, **Angelo Alvino**, University of Napoli, **Luis Caffarelli**, University of Texas, **Giorgio Talenti**, University of Firenze, and **Vladimir Oliker**, Emory University.

Equazioni di Evoluzione Nonlineari, **Alberto Tesei**, University of Roma, La Sapienza.

Free Boundary Problems, **Ricardo Horacio Nochetto**, College Park, Maryland, and **Augusto Visintin**, University of Trento.

Geometric Properties of Solutions to PDEs, **Donatella Danielli**, Johns Hopkins University, and **Sandro Salsa**, Politecnico of Milano.

Harmonic Analysis, **Fulvio Ricci**, Scuola Normale Superiore, Pisa, and **Elias M. Stein**, Princeton University.

Higher Dimensional Algebra, **John Baez**, University of California, Riverside, and **Giuseppe Rosolini**, University of Genova.

History of Mathematics, **Piers Bursil-Hall**, Cambridge University, **Enrico Giusti**, University of Firenze, and **James J. Tattersall**, Providence College.

Hyperbolic Equations, **Sergiu Klainerman**, Princeton University, and **Sergio Spagnolo**, University of Pisa.

Hyperbolic Systems of Conservation Laws, **Alberto Bressan**, SISSA, Trieste, and **Shi Jin**, University of Wisconsin.

Inverse Boundary Problems and Applications, **Giovanni Alessandrini**, University of Trieste, and **Gunther Uhlmann**, University of Washington.

Jump Processes in Option Pricing Theory, **Claudio Albanese**, University of Toronto, and **Marco Isopi**, University of Bari.

Kolmogorov Equations, **Giuseppe Da Prato**, Scuola Normale Superiore, Pisa, and **Nicolai V. Krylov**, University of Minnesota.

Logarithmic De Rham Cohomology and Dwork Cohomology, **Alan Adolphson**, Oklahoma State University, Stillwater, **Francesco Baldassarri**, University of Padova, **Arthur Ogus**, University of California, Berkeley, and **Steven Sperber**, University of Minnesota, Minneapolis.

Mathematical Problems in Soft Matter Modelling, **Eugene C. Gartland**, Kent State University, and **Epifanio Virga**, University of Pavia.

Mathematical Problems in Transport Theory, **Carlo Cercignani**, Politecnico of Milano, and **Irene Gamba**, University of Texas.

Mathematical Schools: Italy and the United States at the Turn of the Twentieth Century, **Umberto Bottazzini**, University of Palermo, and **Karen Hunger Parshall**, University of Virginia.

Mathematics in Polymer Science, **Antonio Fasano**, University of Firenze, and **Kumbakonam R. Rajagopal**, Texas A&M University.

Microlocal Analysis and Applications to PDE, **Daniele Del Santo**, University of Trieste, **M. K. Venkatesha Murthy**, University of Pisa, and **Daniel Tataru**, Northwestern University.

Nonlinear Analysis, **Antonio Ambrosetti**, SISSA, Trieste, **Vieri Benci**, University of Pisa, **Haim Brezis**, Rutgers University, and **Paul Rabinowitz**, University of Wisconsin.

Nonlinear Elliptic and Parabolic Equations and Systems, **Gary Lieberman**, Iowa State University, and **Antonio Maugeri**, University of Catania.

Nonstandard Methods and Applications in Mathematics, **Alessandro Berarducci**, University of Pisa, **Nigel Cutland**, University of Hull, **Mauro Di Nasso**, University of Pisa, and **David Ross**, University of Hawaii.

Operator Algebras, **Sergio Doplicher**, University of Roma, La Sapienza, and **Edward George Effros**, University of California Los Angeles.

Optimization and Control, **Roberto Triggiani**, University of Virginia, and **Tullio Zolezzi**, University of Genova.

Partial Differential Equations of Mixed Elliptic-Hyperbolic Type and Applications, **Daniela Lupo**, Politecnico of Milano, **Cathleen S. Morawetz**, Courant Institute, and **Kevin R. Payne**, University of Milano.

Periodic Solutions of Differential and Difference Equations, **Massimo Furi**, University of Firenze, and **Mario Umberto Martelli**, Claremont McKenna College.

Poisson Geometry and Integrable Systems, **Franco Magri**, University of Milano, and **Ping Xu**, Pennsylvania State University.

Quantum Cohomology and Moduli Spaces, **Angelo Vistoli**, University of Bologna, and **Aaron Bertram**, University of Utah.

Scaling Limits and Homogenization Problems in Physics and Applied Sciences, **Mario Pulvirenti**, University of Roma, and **George Papanicolaou**, Stanford University.

Semigroups of Operators and Applications, **Francesco Altomare**, University of Bari, and **Frank Neubrander**, Louisiana State University.

Semigroups, Automata, and Formal Languages, **Alessandra Cherubini**, Politecnico of Milano, and **John Meakin**, University of Nebraska-Lincoln.

Simulation via Quantum Computation, **Thomas L. Clarke**, University of Central Florida, Orlando, and **Massimo Pica Ciamarra**, University of Napoli.

Some Mathematics Around Composites, **Robert V. Kohn**, Courant Institute, and **Vincenzo Nesi**, University of Roma, La Sapienza.

Structured Matrix Analysis with Applications, **Dario Andrea Bini**, University of Pisa, and **Thomas Kailath**, Stanford University.

The Topology of 3-manifolds, **Ricardo Benedetti** and **Carlo Petronio**, University of Pisa, **Dale Rolfsen**, University of British Columbia, Vancouver, and **Jeffrey Weeks**, Canton, New York.

Variational Analysis and Applications, **Franco Giannessi**, University of Pisa, **Boris S. Mordukhovich**, Wayne State University, Detroit, **Biagio Ricceri**, University of Catania, and **R. Tyrrell Rockafellar**, University of Washington.

Viscosity Methods in PDEs and Applications, **Piermarco Cannarsa**, University of Roma II, **Italo Capuzzo Dolcetta**, University of Roma, La Sapienza, and **Panagiotis Souganidis**, University of Texas, Austin.

White Noise Theory and Quantum Probability, **Luigi Accardi**, University of Roma, Tor Vergata, and **Hui-Hsiung Kuo**, Louisiana State University.

Portland, Oregon

Portland State University

June 20–22, 2002

Meeting #978

Meeting held in conjunction with the Pacific Northwest Section of the Mathematical Association of America.
Western Section
Associate secretary: Bernard Russo
Announcement issue of *Notices*: April 2002
Program first available on AMS website: May 9, 2002
Program issue of electronic *Notices*: August 2002
Issue of *Abstracts*: Volume 23, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: March 5, 2002
For abstracts: April 30, 2002

AMS Special Sessions

Algebraic Geometry and Combinatorics (Code: AMS SS B1), **Eric Babson** and **Rekha Thomas**, University of Washington, and **Sergey Yuzvinsky**, University of Oregon.

Flat Structures, Moduli Spaces, and Minimal Surfaces (Code: AMS SS F1), **Matthias Weber**, Indiana University, and **Michael Wolf**, Rice University.

Low Dimensional Homotopy and Combinatorial Group Theory (Code: AMS SS H1), **F. Rudolf Beyl** and **Paul Latiolais**, Portland State University, **William A. Bogley**, Oregon State University, and **Micheal N. Dyer**, University of Oregon.

Mathematical Biology (Code: AMS SS D1), **Richard S. Gomulkiewicz**, Washington State University, and **Sebastian Schreiber**, Western Washington University.

Matroid Theory (Code: AMS SS E1), **Jennifer M. McNulty**, University of Montana, and **Nancy Ann Neudauer**, Pacific University.

Qualitative Properties and Applications of Functional Equations (Code: AMS SS A1), **Theodore A. Burton**, Southern Illinois University.

Quantum Topology (Code: AMS SS G1), **Douglas G. Bullock**, **Joanna M. Kania-Bartoszynska**, and **Uwe Kaiser**, Boise State University.

The Quintic Equation: Algebra and Geometry (Code: AMS SS C1), **Jerry Shurman**, Reed College, and **Scott Crass**, California State University, Long Beach.

Boston, Massachusetts

Northeastern University

October 5–6, 2002

Meeting #979

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: August 2002
Program first available on AMS website: August 22, 2002
Program issue of electronic *Notices*: December 2002
Issue of *Abstracts*: Volume 23, Issue 4

Deadlines

For organizers: March 6, 2002
For consideration of contributed papers in Special Sessions: June 18, 2002
For abstracts: August 13, 2002

Invited Addresses

Lou P. van den Dries, University of Illinois, Urbana-Champaign, *Title to be announced.*

Diane Henderson, Pennsylvania State University, *Title to be announced.*

Christopher K. King, Northeastern University, *Title to be announced.*

Xiaobo Liu, University of Notre Dame, *Title to be announced.*

Special Sessions

Developments and Applications in Differential Geometry (Code: AMS SS C1), **Chuu-Lian Terng**, Northeastern University, and **Xiaobo Liu**, University of Notre Dame.

Ergodic Theory and Dynamical Systems (Code: AMS SS B1), **Stanley J. Eigen**, Northeastern University, and **Vidhu S. Prasad**, University of Massachusetts, Lowell.

Modern Schubert Calculus (Code: AMS SS A1), **Frank Sottile**, University of Massachusetts, Amherst, and **Christopher T. Woodward**, Rutgers University.

Number Theory and Arithmetic Geometry (Code: AMS SS D1), **Matthew A. Papanikolas**, Brown University, and **Siman Wong**, University of Massachusetts, Amherst.

Quivers and Their Generalizations (Code: AMS SS E1), **Jerzy M. Weyman** and **Andrei V. Zelevinsky**, Northeastern University.

Madison, Wisconsin

University of Wisconsin-Madison

October 12–13, 2002

Meeting #980

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2002
Program first available on AMS website: August 29, 2002
Program issue of electronic *Notices*: December 2002
Issue of *Abstracts*: Volume 23, Issue 4

Deadlines

For organizers: March 12, 2002
For consideration of contributed papers in Special Sessions: June 25, 2002
For abstracts: August 20, 2002

Invited Addresses

Lawrence Ein, University of Illinois at Chicago, *Title to be announced.*

Eleny Ionel, University of Wisconsin, *Title to be announced.*

Mikhail Safonov, University of Minnesota, *Title to be announced.*

John Sullivan, University of Illinois, Urbana-Champaign, *Title to be announced.*

Special Sessions

Arithmetic Algebraic Geometry (Code: AMS SS A1), **Ken Ono** and **Tonghai Yang**, University of Wisconsin-Madison.

Arrangements of Hyperplanes (Code: AMS SS E1), **Daniel C. Cohen**, Louisiana State University, **Peter Orlik**, University of Wisconsin-Madison, and **Anne Shepler**, University of California, Santa Cruz.

Biological Computation and Learning in Intelligent Systems (Code: AMS SS S1), **Shun-ichi Amari**, RIKEN, **Amir Assadi**, University of Wisconsin-Madison, and **Tomaso Poggio**, Massachusetts Institute of Technology.

Characters and Representations of Finite Groups (Code: AMS SS U1), **Martin Isaacs**, University of Wisconsin, Madison, and **Mark Lewis**, Kent State University.

Combinatorics and Special Functions (Code: AMS SS T1), **Richard Askey** and **Paul Terwilliger**, University of Wisconsin-Madison.

Dynamical Systems (Code: AMS SS P1), **Sergey Bolotin** and **Paul Rabinowitz**, University of Wisconsin-Madison.

Effectiveness Questions in Model Theory (Code: AMS SS J1), **Charles McCoy**, **Reed Solomon**, and **Patrick Speissegger**, University of Wisconsin-Madison.

Geometric Methods in Differential Equations (Code: AMS SS H1), **Gloria Mari Beffa**, University of Wisconsin-Madison, and **Peter Olver**, University of Minnesota.

Geophysical Waves and Turbulence (Code: AMS SS M1), **Paul Milewski**, **Leslie Smith**, and **Fabian Waleffe**, University of Wisconsin-Madison.

Group Cohomology and Homotopy Theory (Code: AMS SS G1), **Alejandro Adem**, University of Wisconsin-Madison, and **Jesper Grodal**, Institute for Advanced Study.

Harmonic Analysis (Code: AMS SS C1), **Alex Ionescu** and **Andreas Seeger**, University of Wisconsin-Madison.

Hyperbolic Differential Equations and Kinetic Theory (Code: AMS SS K1), **Shi Jin**, **Marshall Slemrod**, and **Athanassios Tzavaras**, University of Wisconsin-Madison.

Lie Algebras and Related Topics (Code: AMS SS N1), **Georgia Benkart** and **Arun Ram**, University of Wisconsin-Madison.

Multiresolution Analysis and Data Presentation (Code: AMS SS F1), **Amos Ron**, University of Wisconsin-Madison.

Partial Differential Equations and Geometry (Code: AMS SS D1), **Sigurd Angenent** and **Mikhail Feldman**, University of Wisconsin-Madison.

Probability (Code: AMS SS R1), **David Griffeath**, University of Wisconsin-Madison, and **Timo Seppalainen**, Iowa State University.

Ring Theory and Related Topics (Code: AMS SS L1), **Don Passman**, University of Wisconsin-Madison.

Several Complex Variables (Code: AMS SS B1), **Pat Ahern**, **Xianghong Gong**, **Alex Nagel**, and **Jean-Pierre Rosay**, University of Wisconsin-Madison.

Salt Lake City, Utah

University of Utah

October 26–27, 2002

Meeting #981

Western Section
Associate secretary: Bernard Russo
Announcement issue of *Notices*: September 2002
Program first available on AMS website: September 16, 2002
Program issue of electronic *Notices*: January 2003
Issue of *Abstracts*: Volume 23, Issue 4

Deadlines

For organizers: March 26, 2002
For consideration of contributed papers in Special Sessions: July 10, 2002
For abstracts: September 4, 2002

Orlando, Florida

University of Central Florida

November 9–10, 2002

Meeting #982

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: September 2002
Program first available on AMS website: September 26, 2002
Program issue of electronic *Notices*: January 2003
Issue of *Abstracts*: Volume 23, Issue 4

Deadlines

For organizers: April 10, 2002
For consideration of contributed papers in Special Sessions: July 23, 2002
For abstracts: September 17, 2002

Baltimore, Maryland

Baltimore Convention Center

January 15–18, 2003

Joint Mathematics Meetings, including the 109th Annual Meeting of the AMS, 86th Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL).
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 15, 2002
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Baton Rouge, Louisiana

Louisiana State University

March 14–16, 2003

Southeastern Section
Associate secretary: John L. Bryant
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced

Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 14, 2002
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Bloomington, Indiana

Indiana University

April 4–6, 2003

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 4, 2002
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

New York, New York

Courant Institute

April 12–13, 2003

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 12, 2002
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Seville, Spain

June 18–21, 2003

First Joint International Meeting between the AMS and the Real Sociedad Matematica Española (RSME).
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: May 15, 2002
For abstracts: To be announced

Invited Addresses

Xavier Cabre, Universidad Politècnica de Cataluòa, Barcelona, *Title to be announced.*

Charles Fefferman, Princeton University, *Title to be announced.*

Michael Hopkins, Massachusetts Institute of Technology, *Title to be announced.*

Ignacio Sols, Universidad Complutense, Madrid, *Title to be announced.*

Luis Vega, Universidad del Pais Vasco, Bilbao, *Title to be announced.*

Efim Zelmanov, Yale University, *Title to be announced.*

Special Sessions

Computational Methods in Algebra and Analysis, **Eduardo Cattani**, University of Massachusetts, Amherst, and **Francisco Jesus Castro-Jimenez**, Universidad de Sevilla.

Nonlinear Dispersive Equations, **Gustavo Ponce**, University of California, Santa Barbara, and **Luis Vega**, Universidad del Pais Vascos.

Binghamton, New York

SUNY-Binghamton

October 10–12, 2003

Eastern Section
Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 10, 2003
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Phoenix, Arizona

Phoenix Civic Plaza

January 7–10, 2004

Associate secretary: Bernard Russo
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 2, 2003
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Athens, Ohio

Ohio University

March 26–27, 2004

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 26, 2003
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Atlanta Marriott Marquis and Hyatt Regency Atlanta

January 5–8, 2005

Associate secretary: Lesley M. Sibner
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 5, 2004
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced
For summaries of papers to MAA organizers: To be announced

Meetings and Conferences of the AMS

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The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information** at www.ams.org/meetings/.

Meetings:

Important Information regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 175 in the January 2002 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Several options are available for speakers submitting abstracts, including an easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding. To see descriptions of the forms available, visit http://www.ams.org/abstracts/instructions.html, or send mail to abs-submit@ams.org, typing help as the subject line; descriptions and instructions on how to get the template of your choice will be e-mailed to you.

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Paper abstract forms may be sent to Meetings & Conferences Department, AMS, P.O. Box 6887, Providence, RI 02940. There is a $20 processing fee for each paper abstract. There is no charge for electronic abstracts. Note that all abstract deadlines are strictly enforced. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (See http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

February 14-19, 2002: Annual Meeting of the American Association for the Advancement of Science (AAAS), Boston, MA.

May 20-25, 2002: 6th International Conference on Clifford Algebras and Their Applications to Mathematical Physics, Cookeville, TN.

June 3-8, 2002: Abel Bicentennial Conference 2002, University of Oslo, Norway.

June 7-August 1, 2002: Joint Summer Research Conferences in the Mathematical Sciences, Mount Holyoke College, South Hadley, MA. See pages 1289-1291, November 2001 issue, for details.

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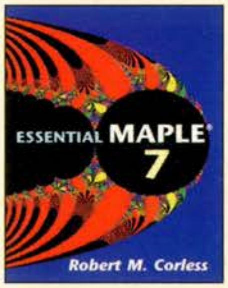

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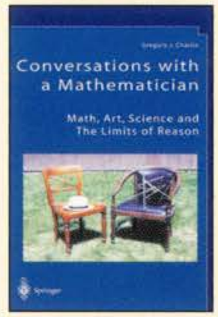

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