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The Influence of Benoît B. Mandelbrot on Mathematics
page 1208

When Does Compromise Prevent More Pollution?
page 1223

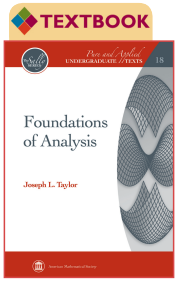
An IMMERSE-Style Course Brings a Research Experience to Students and Faculty
page 1237

Interdisciplinary Research—Mathematical Interactions Viewed from Four Portrayals
page 1246

San Diego Meeting
page 1323

AMERICAN MATHEMATICAL SOCIETY

Foundations of Analysis



Joseph L. Taylor,
University of Utah,
Salt Lake City, UT

This book's two main goals are to develop in students the mathematical maturity and sophistication they will need as they move through the upper division curriculum, and to present a rigorous development of both single and several variable calculus, beginning with a study of the properties of the real number system. The presentation is both thorough and concise, with simple, straightforward explanations. The exercises differ widely in level of abstraction and level of difficulty. Each section contains a number of examples.

"An excellent text for students whose future will include contact with mathematical analysis, whatever their discipline might be. It is content-comprehensive and pedagogically sound. There are exercises adequate to guarantee thorough grounding in the basic facts, and problems to initiate thought and gain experience in proofs and counterexamples. Moreover, the text takes the reader near enough to the frontier of analysis at the calculus level that the teacher can challenge the students with questions that are at the ragged edge of research for undergraduate students. I like it a lot."

—***Don Tucker***,
University of Utah

"I have taught our Foundations of Analysis course (based on Joe Taylor's book) several times recently, and have enjoyed doing so. The book is well-written, clear, and concise, and supplies the students with very good introductory discussions of the various topics, correct and well thought-out proofs, and appropriate, helpful examples. The end-of-chapter problems supplement the body of the text very well (and range nicely from simple exercises to really challenging problems)."

— ***Robert Brooks,***
University of Utah

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10/12

The Influence of Benoît B. Mandelbrot on Mathematics

Edited by Michael F. Barnsley and Michael Frame

Michael F. Barnsley

Introduction

We begin this article, which deals largely with Benoît B. Mandelbrot's contributions to and influence upon mathematics, with a quotation from the introduction to *Fractals: Form, Chance, and Dimension* [16]. This essay, together with many pictures and numerous lectures in the same vein, changed the way science looks at nature and had a significant impact on mathematics. It is easy for us now to think that what he says is *obvious*; it was *not*.

> Many important spatial patterns of Nature are either irregular or fragmented to such an extreme degree that Euclid—a term used in this essay to denote all classical geometry—is hardly of any help in describing their form. The coastline of a typical oceanic island, to take an example, is neither straight, nor circular, nor elliptic, and no other classical curve can serve, without undue artificiality in the presentation and organization of empirical measurements and in the search for explanations. Similarly, no surface in Euclid represents adequately the boundaries of clouds or rough turbulent wakes.…
>
> In the present Essay I hope to show that it is possible in many cases to remedy this absence of geometric representation by using a family of shapes I propose to call *fractals*—or *fractal sets*. The most useful among them involve *chance*, and their irregularities are statistical in nature. A central role is played in this study by the concept of *fractal* (or Hausdorff-Besicovitch) *dimension*.…Some fractal sets are curves, others are surfaces, still others are clouds of disconnected points, and yet others are so oddly shaped that there are no good terms for them in either the sciences or the arts. The variety of these forms should be sampled by browsing through the illustrations.…
>
> —Benoît B. Mandelbrot [16, pp. 1–2]

As with the now familiar principle that gravitational force tethers the earth to the sun, it has become hard to imagine what it was like not to know that many physical phenomena can be described using nondifferentiable, rough mathematical objects.

Important fractals such as the Cantor set, the Sierpinski triangle, and Julia sets were well known to some mathematicians, but they were neither visible nor promoted to any practical purpose. To me, looking back, it seems that these beautiful things were hidden behind veils of words and symbols with few diagrams, certainly no detailed pictures; for example, the long text (in French) of Gaston Julia failed to reveal to most people, including most mathematicians, the full wonder of

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the endless arabesques and intricate visual adventures in the boundaries of Fatou domains. It was as though such objects were guarded by the priests of mathematics, occasionally to be displayed, like the monstrance at Benediction, to the inner core of true believers. I was ritually inducted to calculus in my first year at Oxford by Hammersley, who took us through a full proof of the existence of a Weierstrass nowhere differentiable continuous curve from first principles. Half an hour with pictures would have saved a lot of time and would not have tainted our logical skills.

Benoît not only wrested these abstract objects, these contrary children of pure mathematics, out from the texts where they lay hidden, but he also named them and put them to work to help to describe the physical observable world. He saw a close kinship between the needs of pure mathematics and the Greek mythological being Antaeus. In an interview [6] Benoît said, "The son of Earth, he had to touch the ground every so often in order to reestablish contact with his Mother, otherwise his strength waned. To strangle him, Hercules simply held him off the ground. Separation from any down-to-earth input could safely be complete for long periods—but not forever." He also said, "My efforts over the years had been successful to the extent, to take an example, that fractals made many mathematicians learn a lot about physics, biology, and economics. Unfortunately, most were beginning to feel they had learned enough to last for the rest of their lives. They remained mathematicians, had been changed by considering the new problems I raised, but largely went their own way."

John Hutchinson is an example of a pure mathematician who was strongly influenced by Benoît's work.

> In 1979 I was on study leave from the Australian National University, visiting Fred Almgren at Princeton for 6 months, as a result of my then interest in geometric measure theory. While there, Fred suggested I read Mandelbrot's book *Fractals: Form, Chance and Dimension* and look at putting it, or some of it, into a unified mathematical framework. As a result, we organised a seminar in which I spoke about six times as my ideas developed. Participants included, besides Fred and myself, Bob Kohn, Vladimir Schaeffer, Bruce Solomon, Jean Taylor and Brian White. Out of this came my 1981 article "Fractals and self-similarity" [7] in the *Indiana University Math. Journal*, which introduced the idea of an iterated function system (though not with that name) for generating fractal sets, similar ideas for fractal measures, and various structure theorems for fractals. Interestingly, this paper had no citations for a few years, but now it frequently gets in the AMS annual top ten list.
>
> Mandelbrot's ideas were absolutely essential and fundamental for my paper. I still

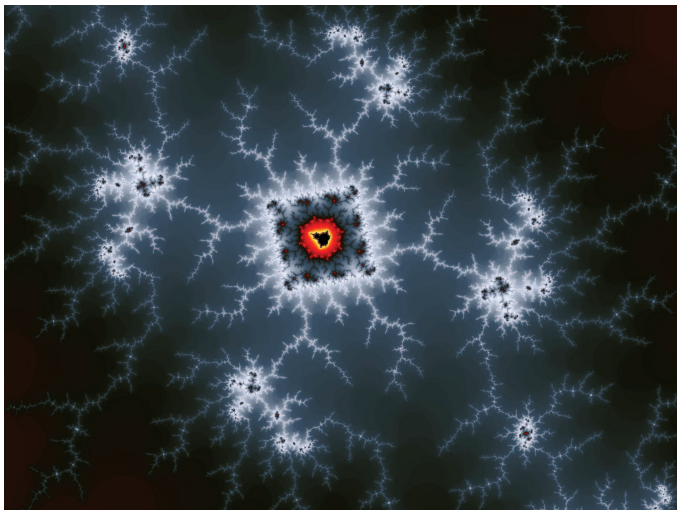

Figure 1. An outlier Mandelbrot set (M-set) (surrounded by yellow, then red) connected via a branch of a tree-like path to the whole M-set. The connectivity of the M-set was conjectured by Benoît in 1980 and established by Adrien Douady and John Hubbard in 1982.

Figure 2. Picture of $\mathcal{F}^{16}(S)$ where $S \subset \mathbb{R}^2$, $\mathcal{F}(S) = f_1(S) \cup f_2(S)$, and $f_1, f_2 : \mathbb{R}^2 \to \mathbb{R}^2$ are affine contractions. The sequence $(\mathcal{F}^n(S))$ converges in the Hausdorff metric to a self-similar set, a fractal, with Hausdorff dimension less than two. This article has been decorated with pictures, in the spirit of Benoît.

have my original copy of his book, signed by Benoît, on the one occasion at Princeton that we met.

—John Hutchinson

Iterated function systems (IFSs) are now a standard framework for handling deterministic fractals, self-similar sets and measures. They were named by this author and Stephen Demko [1], though Benoît thought we should have called them "map bags". He was fascinated by models of leaves with veinlike internal structures made by invariant measures of IFSs.

Hutchinson's paper and the work of many others influenced by Mandelbrot ended a long period where geometry and the use of pictures played little role in mathematics. Mandelbrot believed passionately in pictorial thinking to aid in the development of conjectures and formal proofs. His advocacy has enabled it to be okay once again for mathematicians to do experimental mathematics using pictures.

Mandelbrot's ideas have inspired a huge amount of research, from pure mathematics to engineering, and have resulted in deep theorems; a new acceptance of geometry and pictures as having a role to play in experimental mathematics; and various applications, including image compression and antenna design. The notion of a fractal now forms part of good preuniversity mathematics education, while the mathematical study of fractals has its own specialist areas, including, for example, analysis on fractals [8] and noncommutative fractal geometry [9].

One important idea of Mandelbrot was that various random phenomena, such as stock market prices, are governed by probability distributions with "fat tails". This led him to warn in 2004 that "Financial risks are much underestimated. I think we should take a strongly conservative attitude towards evaluating risks." The subsequent global financial crisis underlined his point.

Prior to editing both this article and [3], we emailed colleagues to ask for memories and comments on Benoît's contributions to mathematics, influence, and personal recollections. We received replies from many: not only mathematicians but artists, physicists, biologists, engineers, and so on. Using these replies we have produced two articles: this one and [3], which is more focused on recollections of the man himself. Our goal has been to put together something special using the words of everyone who wrote but, in general, editing and shortening to avoid repetition of themes.

From early on, Mandelbrot was driven by a desire to do something totally original, to look at problems that others found too messy to consider, and to find some deep unifying principles. As the words in the following contributions show, he succeeded.

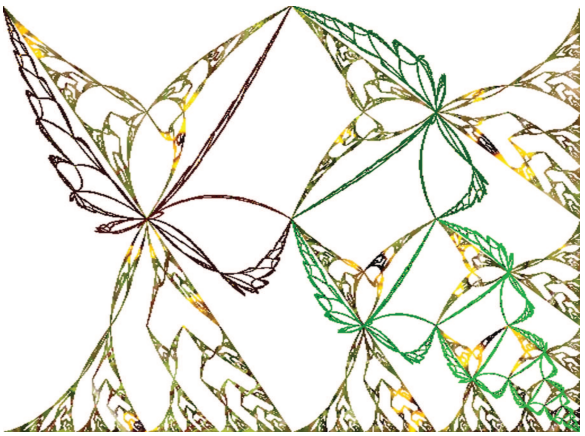

Figure 3. Superposition of the attractors, colored using fractal transformations (see [2]) of two simple bi-affine iterated function systems.

Roger Howe

Participating in a Conversation That Takes Place over Long Spans of Time

One pleasure of doing mathematics is the sense of participating in a conversation that takes place over long spans of time with some of the smartest people who ever lived. Benoît's work on fractals provides a good example of this kind of long-term dialogue.

A significant factor in the invention of calculus was the idea of representing a curve by the graph of a function and, reciprocally, of representing the time variation of a quantity by a curve. This back-and-forth identification allowed one to connect the drawing of tangent lines with finding the rate of change of quantities that vary in time.

When calculus was invented in the seventeenth century, the concept of function was not very precise. Work during the eighteenth century on solving the wave equation using sums of sine and cosine functions led to a sharpening of understanding of the essential properties of functions and of their behavior. This led in the first half of the nineteenth century to the isolation by Cauchy of the notion of continuity, which made clear for the first time the distinction between continuity and differentiability. During the rest of the nineteenth century, mathematicians explored this difference, which contributed to the general unease and insecurity about the foundations of mathematics. Hermite is quoted as "recoiling in horror from functions with no derivatives." The early twentieth century saw the production of

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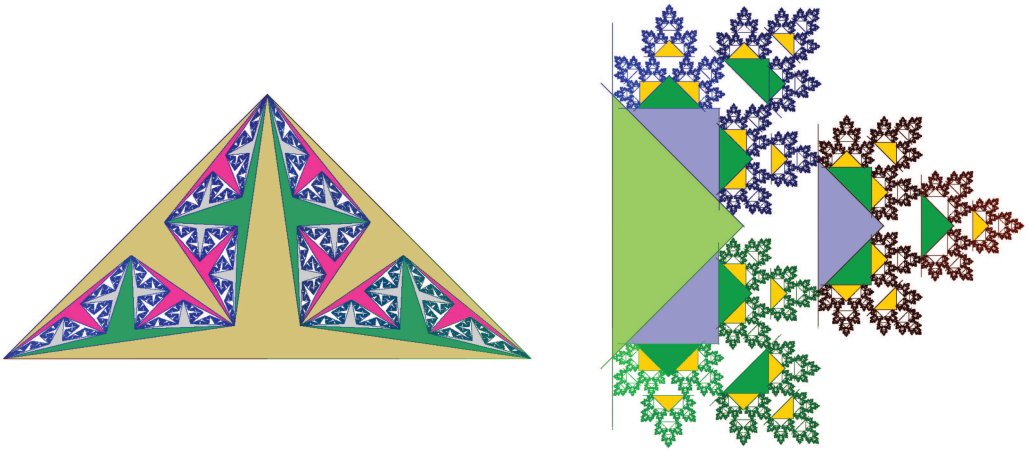

Figure 4. Two illustrations of IFS semigroup tilings. The triangle on the left is tiled with the orbit of a six-sided figure under a system of two affine transformations. The limit set of the set of triangular tiles on the right is the attractor of a system of three affine transformations. A theme of Benoît's work was that the iteration of simple rules (e.g., elementary geometrical transformations) can produce nondifferentiable (rough) objects. Figure from [2]**.**

a menagerie of striking examples (the Cantor set, the Koch snowflake, the Sierpinski carpet, etc.) illustrating the difference between continuity and differentiability. However, for several decades these examples were regarded as exotica, monsters with no relation to the physical world. They were objects only a mathematician would investigate. They were liberated from this marginal status by Mandelbrot, who said, "Wait a minute. A lot of things in the world—clouds, river systems, coastlines, our lungs—are well described by these monsters." Thus started the use of these mathematical objects to study complicated, messy nature.

Ian Stewart

No Lily-White Hands

I first learned about fractals from Martin Gardener's *Scientific American* column. I promptly bought a copy of *Fractals: Form, Chance, and Dimension* [16]. Despite, or possibly because of, its unorthodoxy and scope, it seemed to me that Benoît Mandelbrot had put his finger on a brilliant idea.

I'm pleased that, towards the end of his life, he received due recognition, because it took a long time for the mathematical community to understand something that must have been obvious to him: *fractals were important.* They were a game changer, opening up completely new ways to think about many aspects of the natural world. But for a long time it was not difficult to find professional research mathematicians who stoutly maintained that fractals and chaos were completely useless and that all of the interest in them was pure hype. This attitude persisted into the current century, when fractals had been around for at least twenty-five years and chaos for forty. That this attitude was narrow-minded and unimaginative is easy to establish, because by that time both areas were being routinely used in branches of science ranging from astrophysics to zoology. It was clear that the critics hadn't deigned to sully their lily-white hands by picking up a random copy of *Nature* or *Science* and finding out what was in it.

To be sure, Mandelbrot was not a conventional academic mathematician, and his vision often carried him into realms of speculation. And it was easy to maintain that he didn't really do much that was truly novel—fractal dimension had been invented by Hausdorff, the snowflake curve was a century old, and so on. Mathematicians would have cheerfully gone on employing Hausdorff-Besicovitch dimension to consider such questions as finding a set of zero dimension that covers every polygon, but they would not have figured out that quantifying roughness would make it possible to apply that kind of geometry to clouds, river basins, or how trees damp down the energy of a hurricane.

Mandelbrot's greatest strength was his instinct for unification. He was the first person to realize that, scattered around the research literature, often in obscure sources, were the germs of a coherent framework that would allow mathematical models to go beyond the smooth geometry of manifolds, a reflex assumption in most areas, and tackle the irregularities of the natural world

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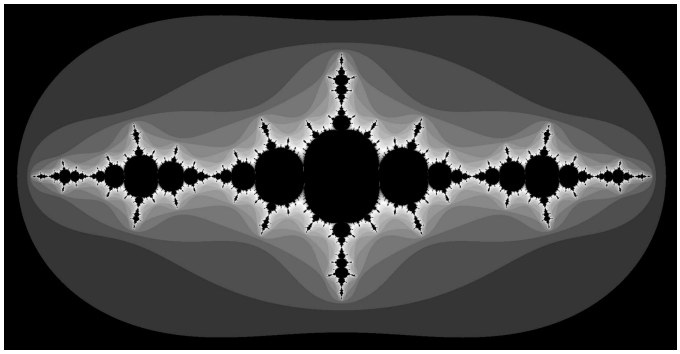

Figure 5. A Julia set associated with the first cascade of period doubling bifurcations of the logistic equation. Julia sets for quadratic maps are intimately related to the Mandelbrot set. Benoît was one of the first to use computers to make pictures of mathematical objects: computations which took hours to run on expensive mainframes can now be performed in seconds on handheld devices. This image and Figures 1 and 13 were computed using free software (Fractile Plus) on an iPad.

in a systematic fashion. It took many years before these ideas began to pay off, but that's how pioneering mathematics often goes.

The conjecture whose proof so pleased him (see [3, contribution by Ian Stewart]) was the work of Gregory Lawler, Oded Schramm, and Wendelin Werner in their paper "The dimension of the planar Brownian Frontier is 4/3" [10]. It is part of the work for which Werner received a Fields Medal, and it shows that fractals have given rise to some very deep mathematics. I suspect that only now are we beginning to see the true legacy of Mandelbrot's ideas, with a new generation of researchers that has grown up to consider chaos and fractals to be as reasonable and natural as periodic motion and manifolds. Mandelbrot was a true pioneer, one of the greatest mathematical visionaries of the twentieth and early twenty-first centuries.

David Mumford

Benoît Told Me: "Now You Can See These Groups and See Teichmüller Space!"

Benoît Mandelbrot had two major iconoclastic themes. First, that most of the naturally occurring measurements of the world were best modeled by nondifferentiable functions, and second, the histograms of these measurements were best modeled by heavy-tailed distributions. Even if he did not bring a new unifying law like Newton's $F = ma$ and even if he did not have the deep and subtle theorems that make waves in the pure math community, this vision was revolutionary. What his lectures made clear was that fractal behavior and outlier events were everywhere around us, that we needed to take these not as exceptions but as the norm. For example, my own work in vision led me later on to express his ideas about outliers in this way: that the converse of the central limit theorem is true, namely, *the only naturally occurring normal distributions are ones which are averages of many independent effects.*

Benoît's immediate effect on my work was to reopen my eyes to the pleasure and mathematical insights derived from computation. I had played with relay-based computers in high school and with analog computer simulations of nuclear reactors in two summer jobs. But at the time I thought that only white-coated professionals could handle the IBM mainframes and puzzled over what in heaven's name my colleague Garrett Birkhoff meant when I read "$x = x + 1$" in some of his discarded code. But Benoît told us that complex iterations did amazing things that had to be seen to be believed. These came in two types: the limiting behavior of iterations of a single analytic function and the limiting behavior of discrete groups of Möbius transformations. The second of these connected immediately to my interests. I was always alert to whatever new tool might be available for shedding any sort of light on moduli spaces, whether it was algebro-geometric, topological, characteristic p point counting, or complex analytic. I had sat at the feet of Ahlfors and Bers and learned about Kleinian groups and how they led to Teichmüller spaces and hence to moduli spaces. Benoît told me, "Now you can see these groups and see Teichmüller space!"

I found an ally in Dave Wright, learned C, and with Benoît's encouragement, we were off and running. When he returned to his position at the IBM Watson Lab, he set up a joint project with us, and we visited him and his team there. Later, Curt McMullen, who also appreciated the power and insight derived from these experiments, joined us. It turned out that, in the early hours of the morning, their mainframes had cycles to spare, and we would stagger in each morning to see what these behemoths had churned out. There was no way to publish such experiments then, but Dave and I astonished the summer school at Bowdoin with a live demo on a very primitive machine of a curvy twisting green line as it traced the limit point set of a quasi-Fuchsian group. Ultimately, we followed Benoît's lead in his *Fractal Geometry of Nature* [18] and, with Caroline Series, published our images in a semipopular book, *Indra's Pearls* [27]. One anecdote: We liked to analyze our figures,

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estimating, for example, their Hausdorff dimension. We brought one figure we especially liked to Watson Labs and, thinking to test Benoît, asked him what he thought its Hausdorff dimension was. If memory serves, he said, "About 1.8", and indeed we had found something like 1.82. He was indeed an expert!

Hillel Furstenberg

He Changed Fundamentally the Paradigm with Which Geometers Looked at Space

Let me begin with some words of encouragement to you on this project, dedicated to memorializing an outstanding scientist of our times and one we can be proud of having known personally.

What do you see as Benoît's most important contributions to mathematics, mathematical sciences, education, and mathematical culture?

Benoît Mandelbrot sold fractals to mathematicians, changing fundamentally the paradigm with which geometers looked at space. Incorporating fractals into mainstream mathematics rather than regarding them as freakish objects will certainly continue to inspire the many-sided research that has already come into being.

Kenneth Falconer

It Was Only on the Fourth or Fifth Occasion That I Really Started to Appreciate What He Was Saying

Benoît's greatest achievement was that he changed the way that scientists view objects and phenomena, both in mathematics and in nature. His extraordinary insight was fundamental to this, but a large part of the battle was getting his ideas accepted by the community. Once this barrier was broken down, there was an explosion of activity, with fractals identified and analyzed everywhere across mathematics, the sciences (physical and biological), and the social sciences.

Benoît realized that the conventional scientific and mathematical approach was not fitted to working with highly irregular phenomena. He appreciated that some of the mathematics needed was there—such as the tools introduced by Hausdorff, Minkowski, and Besicovitch—but was only being used in an esoteric way to analyze specific pathological sets and functions, mainly as counterexamples that illustrated the importance of smoothness in classical mathematics.

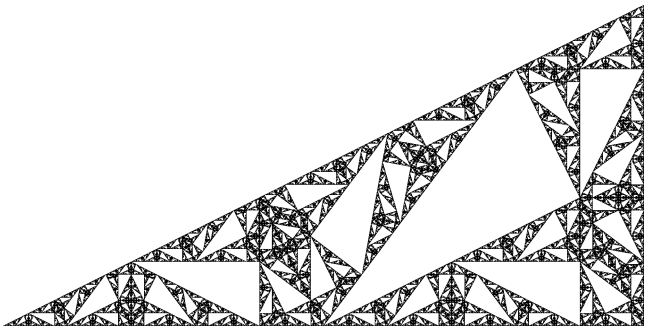

Figure 6. A self-similar fractal of Hausdorff dimension $(4ln2)/ln5 \doteq 1.72$ associated with the pinwheel tiling.

Benoît's philosophy that such "fractal" objects are typical rather than exceptional was revolutionary when proposed. Moreover, he argued that the mathematical and scientific method could and should be adapted to study vast classes of fractals in a unified manner. This was no longer mathematics for its own sake, but mathematics appropriate for studying all kinds of irregular phenomena—clouds, forests, surfaces, share prices, etc.—that had been ignored to a large extent because the tools of classical smooth mathematics were inapplicable.

Benoît also realized that self-similarity, broadly interpreted, was fundamental in the genesis, description, and analysis of fractals and fractal phenomena. Given self-similarity, the notion of dimension is unavoidable, and "fractal dimension" in various guises rapidly became the basic measure of fractality, fuelling a new interest in the early mathematics of Hausdorff, Minkowski, and others.

Benoît had many original ideas, but his presentation of them did not always follow conventional mathematical or scientific styles, and as a result it often took time for his ideas to be understood and sometimes even longer for them to be accepted. A case in point is that of multifractal measures. Multifractals are, in many ways, more fundamental than fractal sets. Many of the now standard notions of multifractals may be found in his 1974 paper in the *Journal of Fluid Dynamics* [14], but this is not an easy paper to fathom, and it was not until the 1980s that the theory started to be appreciated. Benoît suggested that "the community was not yet ready for the concept," but I think the delay was partly because of the way the ideas were presented. I heard Benoît's talk on multifractals many times in the 1980s; he was charismatic, but his explanations were such that it was only on the fourth or fifth occasion that I really started to appreciate what he was saying.

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Figure 7. The left-hand picture illustrates the points in the orbit of a set; the flower picture at center left, under a Möbius transformation. The picture at center right reveals that it is a "tiling", where the initial tile is shown on the right. Mandelbrot caused many to look anew at natural objects in geometrical terms. Figure from [2]**.**

I am one of many whose life and career have been influenced enormously by Benoît and his work, both directly and indirectly. We miss him, but the legacy of his ideas and work will remain with us all and with those who follow.

Bruce J. West

The Intermittent Distribution of the Stars in the Heavens

Benoît's idiosyncratic method of communicating mathematical ideas was both challenging and refreshing. The introduction of geometrical and statistical fractals into the scientific lexicon opened up a new way of viewing nature for a generation of scientists and allowed them to understand complexity and scaling in everything from surface waves on the ocean to the irregular beating of the heart to the sequencing of DNA. This accelerated the early research done by biologists, physicians, and physicists on the understanding of complex phenomena.

The line between what was proven and what was conjecture in Benoît's work was often obscure to me, but in spite of that, or maybe even because of that lack of clarity, I was drawn into discussions on how to apply the mathematics of fractals to complex phenomena. Fractals began as descriptive measures of static objects, but dynamic fractals were eventually used to describe complex dynamic phenomena that eluded description by traditional differential equations. Culturally, fractals formed the bridge between the analytic functions of the nineteenth- and twentieth-century physics of acoustics, diffusion, wave propagation, and quantum mechanics to the twenty-first-century physics of anomalous diffusion, fractional differential equations, fractional stochastic equations, and complex networks.

Benoît identified some common features of complex phenomena and gave them mathematical expression without relying on the underlying mechanisms. I used this approach to extract the general properties of physiological time series, which eventually led to the formation of a new field of medical investigation called *Fractal Physiology*, the title of a book [28] I coauthored in 1995 and the subject of an award-winning book [29] on the fractional calculus. Later, in 2010, I became founding editor-in-chief of the new journal *Frontiers in Fractal Physiology*, which recognizes the importance of fractal concepts in human physiology and medicine.

I first met Benoît when I was a graduate student in physics at the University of Rochester. Elliott Montroll, who had the Einstein Chair in Physics and who had been a vice president for research at IBM, was friends with Benoît and would invite him to come and give physics colloquia. In the late 1960s, before the birth of fractals, I heard Benoît conjecture as to why the night sky was not uniformly illuminated because of the intermittent distribution of stars in the heavens, why the price of corn did not move smoothly in the market but changed erratically, and why the time between messages on a telephone trunkline were not Poisson distributed as everyone had assumed. These problems and others like them struck me as much more interesting than calculating perturbation expansions of a nuclear potential. So I switched fields and became a postdoctoral researcher in statistical physics with Elliott. I have interacted with many remarkable scientists, and Benoît is at the top of that list. I am quite sure that my decision to change fields was based in large part on Mandelbrot's presentations and the subsequent discussion with him and Montroll.

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Marc-Olivier Coppens

Engineering Complexity By Applying Recursive Rules

As a chemical engineering researcher who worked with Benoît since the middle of the 1990s, I benefited a lot from his mentorship. I also miss him a lot as a friend. In 1996, while completing my Ph.D. thesis, I worked closely with him for several months at Yale, sharing an office with Michael Frame. I developed, with Benoît, a new way to

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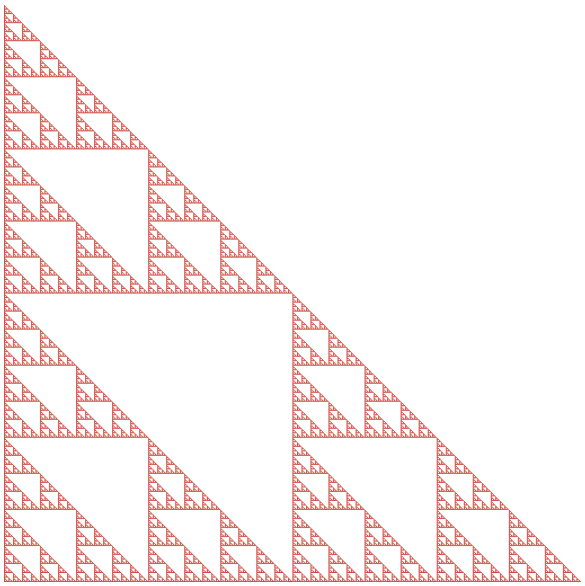

Figure 8. A right-angle Sierpinski triangle. Benoît realized that such objects were not freaks and belonged in mainstream mathematics. Analysis *on* fractals is now a fascinating area of mathematics.

generate multifractals by taking the product of harmonics of periodically extended functions.

Fractals in chemical engineering have affected the modeling and characterization of various porous materials. As Mandelbrot liked to say in later years, fractals are an ideal way to measure "roughness", and roughness is prevalent in chemical engineering and materials science. The roughness of porous media affects transport and reactions in them and hence has a significant impact on chemical engineering. For example, in my thesis I showed how molecular-scale roughness of porous catalysts influences chemical product distributions up to industrial scales.

In my research I have used fractal trees to interpolate efficiently between the micro- and the macroscale, as in nature. Scaling up from the laboratory to the production scale requires preservation of small-scale, controlled features up to larger scales. This challenge is met by distributing or collecting fluid in a uniform way, as is realized by scaling fractal architectures in nature, such as trees, lungs, kidneys, and the vascular network. Specifically, I proposed a fractal, treelike injector to uniformly distribute fluids over a reactor volume, so that the fluids can mix and interact with the reactor contents. This patented fractal injector has proven very efficient for gas-solid fluidized beds. My laboratory is currently developing a fractal fuel cell design, inspired by the structure of the lung.

Benoît has had a major influence on my thinking. To a large extent, thanks or due to the advance

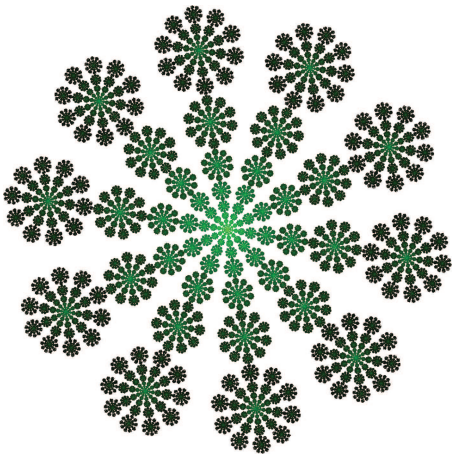

Figure 9. An invariant measure on a fractal attractor of a system of three similitudes has here been rendered in shades of green. (Bright green = greater "density", black=least "density".)

of massively parallel, high-performance computers, chemical, biological, and materials sciences are increasingly atomistic, deconstructing and constructing matter out of individual elements in which the details of each component and its interactions are more and more explicitly accounted for. This atomistic treatment is very powerful and facilitates the study of specific properties of matter. However, sometimes the importance of the forest tends to be lost in looking too closely at one tree. The complementary, holistic view is, in my opinion, extremely powerful as well, as it allows us to see essential features in a phenomenon without the need to resolve every detail. Fractals are an example of this idea, where complexity emerges from the combination of simple rules. A marriage between the holistic and atomistic views can lead us beyond the deficiencies of each one separately.

Nathan Cohen

Complexity Was Well Modeled by Fractals

Mathematicians spar in an uncomfortable match between the pure and applied, in which migration from one to the other is one way, and no one is allowed to do both. But Benoît Mandelbrot did.

My interest in fractals stems from needing to solve real-world problems. In 1985 I was a newly minted Ph.D. in Cambridge (MA). There the general view was that fractals were a "flavor" of the month, and they were treated as an a posteriori paradigm with no evidence of solving problems unsolved in other ways. But I read *The Fractal Geometry*

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Figure 10. A self-affine fractal provides a simple model for the geometry of a fern.

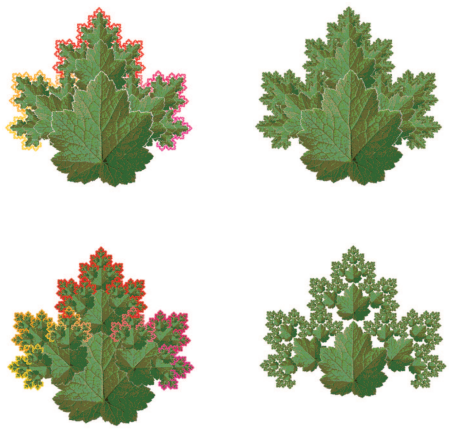

Figure 11. Various pictures constructed from the orbit of a leaf picture under a system of three affine transformations. The limit set of the semigroup is illustrated in red and yellow. Figure from [2].

of Nature and landed a consulting job on stock options pricing. I concluded, as Mandelbrot had surmised decades earlier, that the stock price is not a "random walk", that complexity and noise are often indistinguishable, and that complexity may be modeled by fractals. Market pricing is essentially deterministic, not random. At that time, on a daily basis, traders would run their Black-Scholes models, which assume pricing is a random diffusion process, and bring the results to the floor each morning like racing forms at the horsetrack. They trusted these cheat-sheets to tell them when to buy and sell. But I was able to exploit the limitations of the Black-Scholes model using fractals and made a decent little fortune for someone who had recently been a poverty-stricken student.

The notion of "fractals as antennas" occurred to me in 1987 while attending a lecture by Mandelbrot. I went home and explored this curious idea, which has subsequently become a major theme of my efforts and a field in its own right. Some years later I saw Benoît again at a fractals-in-engineering conference. This was finally the opportunity to converse with him and the first of several lunch meetings and subsequent phone conversations in the last dozen years of his life. No one who had such conversations can forget the brilliant, witty joy of Benoît the polymath. In particular, they helped me to realize that Maxwell's equations require self-similarity for frequency invariance, a fundamental and what should have been obvious result. Now I see many problems that benefit from fractals: metamaterials, a new form of radiative transport, optimization, and fluid mechanics and drag reduction. I only regret that I can't share these with Benoît anymore.

Stéphane Jaffard

Parts of Mathematics Are Totally Bathing in the Ideas That Benoît Introduced

Benoît was one of the first to apply computer graphics to mathematical objects. He used them to develop intuitions and to make either discoveries or deep conjectures.

He also put forward particular entities such as Mandelbrot cascades, the Mandelbrot set, Lévy dusts, and so on as beautiful objects, worthy of study in their own right. At that time, this was orthogonal to the main direction of mathematics towards generalizations and abstract structures. I believe that Benoît's influence on the mathematical community was very helpful in that respect: mathematics was able to admit a down-to-earth component. Some parts of mathematics are now totally bathing in the ideas that Benoît introduced. For example, the idea of scale invariance is everywhere present in the mathematics of signal processing, my area.

More broadly, the notion of fractal probability has been one of the most important unifying concepts in science introduced in the last fifty years. It has allowed scientists with diverse specializations to draw connections between seemingly unrelated subjects and has created unexpected cross-fertilizations. This was driven by the mesmerizing and enthusiastic personality of Benoît.

Note that fractals are one of the few parts of mathematics that can be "shown" to the general

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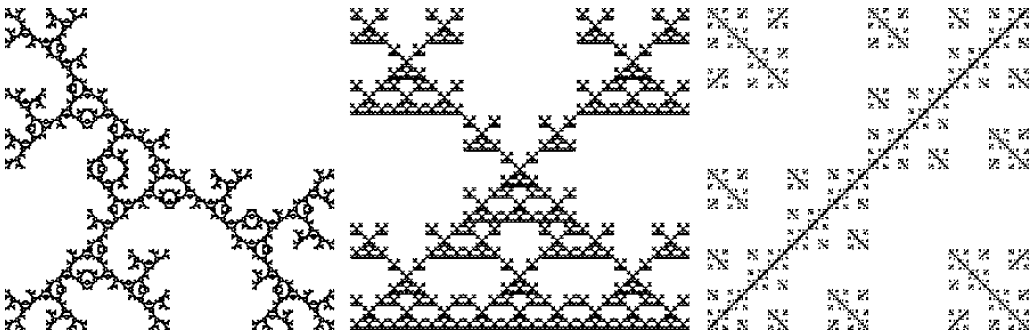

Figure 12. "…[E]ighty students in my fractal geometry course learn in a single class how to generate the fractals pictured here.…"

public. As a teenager, I was influenced by Benoît's fascinating books. They explained a part of mathematics that was under construction yet could be readily understood.

My thesis was on the then-new topic of "wavelets". I worked at École Polytechnique under the supervision of Yves Meyer. Once Benoît visited École Polytechnique, and he heard that a Ph.D. student was working on systems of functions that could be decomposed into elementary blocks, related *inter alia* by dilations and translations. He came to my office, and we had long conversations about new possibilities offered by wavelet analysis. For me, this was the start of interactions which influenced me considerably; it certainly pushed me towards specializing in multifractal analysis, a part of fractals where Mandelbrot's ideas are prevalent. Our interactions resulted in two joint papers on Polya's function, whose graph is space-filling and multifractal (its Lipschitz regularity index jumps everywhere). The interest that Benoît showed in this example, which was quite forgotten at that time, was typical of his fascination for beautiful mathematical objects and the art with which he managed to draw a correspondence between their mathematical beauty and their graphical beauty. In all the conversations that we shared, I was always amazed by the uninterrupted flow of original and brilliant ideas that he very generously shared.

Sir Michael Berry

How to Model…a Surface With No Separation of Scales

In the early 1970s, I was studying radio-wave echoes from the land beneath the ice in Antarctica. Existing theories separated the "geography", supposedly measured by the start of the echo, from the "roughness", indicated by the disorderly echo trail. The separation was modelled by a flat surface ("geography") superimposed on what was single-scale randomness ("roughness"), typically gaussian. I found this not only unappealing but also scientifically absurd: in a natural landscape, any apparent dichotomy must be an illusion, an artifact of the wavelength used to interrogate it. But how to model, or even describe, a surface with no separation of scales? I had no idea until I read Philip Morrison's review of the English edition of Mandelbrot's *Fractals: Form, Chance and Dimension* [16]. I cannot remember being so excited by a book review. It was immediately clear that fractal dimension was the key idea I needed, and this was confirmed by the book itself.

Quickly came the identification of a new class of wave phenomena: "diffractals", that is, waves interacting with fractal objects. In the echo-sounding of landscapes, the interaction is mainly reflection. Later, a grim consequence of an absorption interaction emerged: we realized that the prolonged winter predicted to occur after a nuclear war, because of the absorption of sunlight by smoke, would be significantly intensified by the fact that smoke particles are fractal (it would also be prolonged, because smoke's fractality slows the particles' fall). From the development of quantum chaology in the late 1970s came a conjecture about the spectra of enclosures ("drums") with fractal boundaries: the "surface" correction to the "bulk" Weyl eigenvalue counting formula would scale differently with frequency and depend on the fractal dimension. This generated considerable mathematical activity.

In diffractals it is the objects interacting with the waves, not the waves themselves, that are fractal. But in some phenomena the wave intensity is fractal on a wide range of scales down to the wavelength. One such, unexpected in one hundred fifty years, is the Talbot effect, associated with light beyond diffraction gratings whose rulings have sharp edges: the fractal dimensions of the wave across and along the beam direction are different. All this sprang from Benoît Mandelbrot's insight,

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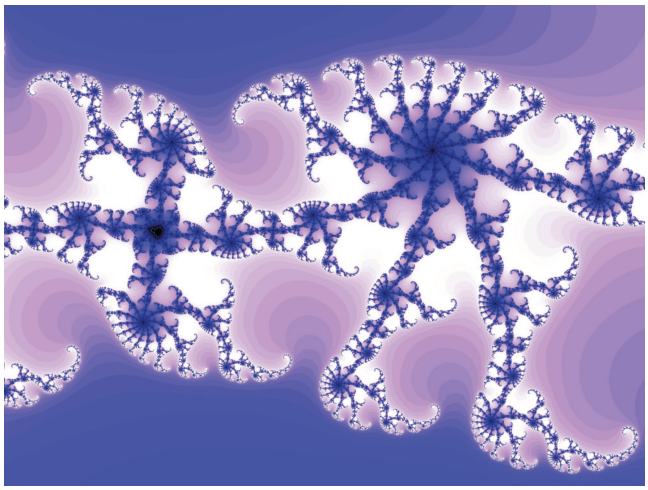

Figure 13. "Zoom in a few times…mysterious spirals of spirals of spirals appear."

meshing perfectly with my preoccupations at the time. For further details, see my earlier tribute [4] or my home page [5].

Michael Frame

I Believe the Classroom Is an Appropriate Stage for a Final View of Benoît's Work

Here I'll give a sketch of the remarkable breadth and depth of Benoît's work, setting most examples in the world I know best, the classroom. That students in college, high school, and elementary school study the concepts Benoît developed filled him with happiness. In his memoirs [26], Benoît describes his reaction to student comments after his lecture, "Uncanny forms of flattery! Each lifted me to seventh heaven! Truly and deeply, each marked a very sweet day! Let me put it more strongly: it is occasions like that that make my life." For this reason, I believe the classroom is an appropriate stage for a final view of Benoît's work.

In September 2010, a few days after Benoît told me of his diagnosis, I watched the eighty students in my fractal geometry course learn in a single class how to generate the fractals pictured in Figure 12 just by looking at the images and understanding a few attributes of plane transformations.

Their surprise and satisfaction are what Benoît gave me, gave the mathematical world. To those who doubt the value of this approach, I say compare a standard geometry class lesson on plane transformations with this day in any fractals class. The combination of visually complex images and the ability to decode these images by a few simple rules explains why fractals are a wonderful tool for teaching geometry.

A few weeks later in the course, I showed these pictures again and asked the class to find their dimensions. Immediately, they answered $\log(3)/\log(2)$ and $\log(6)/\log(3)$ for the first two, and after a moment, $\log((-1+\sqrt{3})/2)/\log(1/2)$ for the third. That thousands, maybe tens of thousands, of students know how to compute and interpret dimensions and that dimension measures complexity and roughness of objects mathematical (Julia sets, Kleinian group limit sets), physical (aggregation clusters, the distribution of galaxies), biological (pulmonary, nervous, and circulatory systems), and artistic (Pollock's drip paintings, at least according to some) are due to Benoît. Some knew bits of the picture; Benoît assembled the whole and got many, many others working on measuring and interpreting dimensions.

For the teacher of a fractals class, the best moment occurs during the day the Mandelbrot set is introduced. The formula $z_{n+1} = z_n^2 + c$ is simplicity itself. Describe the iteration process and the color coding, start the program running (seconds now for images that burned hours or days with the personal computers of the mid-1980s), and wait. (See Figure 1.) Startling baroque beauty, but from a class jaded by CGI effects, only a few polite "Oohs" and "Ahhs". Zoom in a few times near the boundary; mysterious spirals of spirals of spirals appear. (See Figure 13). A bit more emphatic exclamations of surprise, and then, "You do remember this is produced by iterating $z_{n+1} = z_n^2 + c$, don't you?" Expressions of disbelief and occasional profanity follow.

Another day or two describing the known geometry of the Mandelbrot set, the arrangement of the cyclic components, the infinite cascade of ever smaller copies of the whole set, and this complicated object starts to seem familiar. Then state the hyperbolicity conjecture and point out it remains a conjecture despite two decades of work by brilliant mathematicians. Beautiful pictures for sure; deep, deep mathematics, you bet.

Some Key Events in the Life of Benoît B. Mandelbrot

1924 Born in Warsaw, Poland, 20 November
1936 Moved to Paris
1939 Moved to Tulle
1947 Ingenieur diploma, École Polytechnique
1948 M.S. aeronautics, CalTech
1952 Ph.D. mathematics, University of Paris
1953 Postdoc at MIT, then IAS postdoc of von Neumann
1955 Married Aliette Kagan
1958 Moved to the U.S., joined IBM Thomas J. Watson
1963 Publication of "On the variation of certain speculative prices", [11] and "The stable Paretian income distribution, when the apparent exponent is near two" [12]
1967 Publication of "How long is the coast of Great Britain?" [13]
1972 Visiting professor of physiology, Albert Einstein College of Medicine
1974 Publication of "Intermittent turbulence in self-similar cascades: Divergence of high moments and dimension of the carrier" [14]
1975 Publication of *Les Objets Fractals: Forme, Hasard et Dimension* [15]
1977 Publication of *Fractals: Form, Chance, and Dimension* [16]
1979 Began studying the Mandelbrot set; formulated the MLC (Mandelbrot set is locally connected) conjecture
1980 Publication of "Fractal aspects of the iteration of $z \to \lambda z(1-z)$ for complex λ and z" [17]; formulated the question that the Mandelbrot set is connected
1982 Publication of *The Fractal Geometry of Nature* [18]; Fellow of the American Academy of Arts and Sciences; formulated the 4/3 conjecture and that the inside and outside of the Brownian boundary curve are statistically self-similar; connectivity of the Mandelbrot set proved by Douady and Hubbard
1984 TED lecture; formulated the n^2 conjecture, proved by Guckenheimer and McGehee
1985 Barnhard Medal, U.S. National Academy of Sciences; formulated the conjecture that the boundary of the Mandelbrot set has dimension 2
1986 Franklin Medal, Franklin Institute; D.Sc., Syracuse University
1987 Foreign associate, U.S. National Academy of Sciences; Abraham Robinson Adjunct Professor of Mathematical Sciences at Yale; D.Sc., Boston University
1988 Steinmetz Medal, IEEE; Science for Art Prize, Moet-Hennessy-Louis Vuitton; CalTech Alumni Distinguished Service Award; Humboldt Preis, Humboldt-Stifftung; honorary member, United Mine Workers of America; D.Sc., SUNY Albany, Universität Bremen
1989 Chevalier, National Legion of Honor, Paris; Harvey Prize for Science and Technology, Technion; D.Sc., University of Guelph
1990 Fractals and Music, Guggenheim Museum, with Charles Wuorinen
1991 Nevada Prize
1992 D.Sc., University of Dallas
1993 Wolf Prize in Physics; D.Sc., Union College, Universitè de Franche-Comtè, Universidad Nacional de Buenos Aires

1994 Honda Prize; J.-C. Yoccoz awarded the Fields Medal, in part for his work on MLC; Shishikura proved the Mandelbrot set boundary has dimension 2
1995 D.Sc., Tel Aviv University
1996 Médaille de Vermeil de la Ville de Paris
1997 Publication of *Fractals and Scaling in Finance* [19]
1998 Foreign member, Norwegian Academy of Sciences and Letters; C. McMullen awarded the Fields Medal, in part for his work on MLC; D.Sc., Open University London, University of Business and Commerce Athens
1999 Sterling Professor of Mathematical Sciences at Yale; John Scott Award; publication of *Multifractals and 1/f Noise* [20]; publication of "A multifractal walk down Wall Street" [21]; D.Sc., University of St. Andrews
2000 Lewis Fry Richardson Award, European Geophysical Society
2001 Member, U.S. National Academy of Sciences; publication of "Scaling in financial prices, I – IV"
2002 Sven Berggren Priset, Swedish Academy of Natural Sciences; William Proctor Prize, Sigma Xi; Medaglia della Prezidenza della Republica Italiana; publication of *Gaussian Self-Affinity and Fractals* [22] and of *Fractals, Graphics, and Mathematics Education* [23]; D.Sc., Emory University
2003 Japan Prize for Science and Technology; Best Business Book of the Year Award, Financial Times Deutschland, for *The (Mis)Behavior of Markets* [25]
2004 Member, American Philosophical Society; publication of *Fractals and Chaos. The Mandelbrot Set and Beyond* [24], and (with R. Hudson of *The (Mis)Behavior of Markets* [25]
2005 Sierpinski Prize, Polish Mathematical Society; Casimir Frank Natural Sciences Award, Polish Institute of Arts and Sciences of America; Battelle Fellow, Pacific Northwest Labs; D.CE., Politecnio, Torino
2006 Officer, National Legion of Honor, Paris; Einstein Public Lecture, AMS Annual Meeting; Plenary Lecture, ICM; W. Werner awarded the Fields Medal for proving (with G. Lawler and O. Schramm) the 4/3 conjecture; Doctor of Medicine and Surgery, University degli Studi, Bari, Puglia
2010 D.Sc., Johns Hopkins University; TED lecture; S. Smirnov awarded the Fields Medal for work on percolation theory and SLE related to the 4/3 conjecture.
Died in Cambridge, MA, 14 October

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When Does Compromise Prevent More Pollution?

C. Clemons, J. Cossey, M. Ferrara, S. Forcey, T. Norfolk, G. Obeng, D. Ricciardi, and G. Young

Introduction

The word that economists use for a side effect of production is *externality*. This seemingly neutral term has earned a negative connotation. Externalities, like side effects in general, are usually unwelcome.

The discovery of a natural resource in new abundance is followed by a rapid growth in the industry of extracting it—and an equally rapid rise in pollution of the habitats nearby. There will be a cleanup cost, and it must be paid by those benefitting from the resource. That includes the firm that is polluting and the taxpayers who are happy to purchase the product at the pump or through their furnaces. Two questions are raised. It must be decided when the cost should be paid—as prevention or as cure—and who should pay what percentage of each. The regulator's objective is to find a balance between public safety, economic prosperity, and tax revenues.

Figure 1. Treated fracking fluid headed for Black Lick Creek in Indiana County, Pa. Photo by Seamus Murphy/VII, as seen in [4].

Using a mathematical model will always fall short when politics and psychology are major factors. Philosophical justification for studying a social problem mathematically is found in *demonstrating that a solution exists.* This emphasized phrase is the punch line of a joke involving fire and a mathematician with a pitcher of water, but it can also support an argument for action.

Main Theorem

By compromise, we refer to the mutual decision of government and industry to each pay for some fraction of pollution abatement. In game theory terms, compromise is a mixed equilibrium

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strategy. We prove that in certain situations there are simultaneously several Nash equilibria. For example, there are games with three simultaneous equilibria: one strategy where the firm alone pays to prevent pollution, another where only the government does, and a third in which the two players pay for precisely calculated percentages of the preventative controls. We show that the third, mixed, strategy often results in a greater amount of prevented pollution while finding a compromise between corporate profit and tax revenues. Here is a more precise statement, regarding the game we describe in Table 2 and the subsection "Proof of Theorem 1".

Theorem 1. *If the product of the best-case prevention-to-cleanup cost ratios for a firm and a regulator is less than the difference of the cube and the square of the fraction of pollution prevented, then the mixed equilibrium strategy prevents more pollution than either pure equilibrium strategy. The converse is also true.*

The symbolic statement of the hypothesis of this theorem is $FR < \delta^2 - \delta^3$. The definitions are discussed in the subsection "The Model". The proof is found in the subsection "Proof of Theorem 1". Theorems 3 and 4 show how the hypothesis is changed when the Pigouvian tax varies in the game. There is a quite concrete implication of Theorem 1:

Corollary 2. *If the product of the prevention-to-cleanup cost ratios for a firm and a regulator is greater than $\frac{4}{27}$, then the mixed equilibrium strategy prevents less pollution than either pure equilibrium strategy.*

Assumptions and Justifications

The chief justification for all our assumptions is this: we restrict our attention to a simple case that allows us to tractably describe the effects of policy on an economic game involving pollution.

We assume there are only two players: Player 1 is the regulator and Player 2 is the firm. Before the game the regulator decides the values of two game parameters: the corporate income tax and the percentage of expected cleanup cost to be covered by the firm, the pollution tax known as a *Pigouvian* tax. The regulator spends from its income tax revenue to cover the remaining percentage of cleanup costs. Cleanup costs are incurred in correcting the effects of either an accidental spill or intentional dumping of less-than-pristine wastewater into the environment. Corrective action could include habitat restoration, resettlement, covering medical bills, and compensating losses.

In the game proper both the firm and the regulator decide independently whether or not to pay for a given preventative measure, which we call the *optional control* of pollution. Example controls include paying for extra quality control (inspectors) or preventative technology (oil well monitoring). They might also include paying for actual cleaning technology, such as additional carbon dioxide scrubbers at a coal-burning plant or filtering of wastewater at a fracking operation. There are four possible outcomes in this nonzero sum game, and the payoff values are expected values, not random.

The firm gets to deduct the cost of optional prevention from their taxable corporate profit. The Pigouvian pollution tax however is not deductible. This latter pollution tax is assessed as a tax on production, so the question of detection of pollution is not relevant. We study the effect on the game when the rate of the pollution tax, as a percentage of cleanup covered by the firm, varies depending on whether the voluntary optional controls are applied.

The expected amount of pollution depends on the quantity of production. The profit realized by the firm is the difference between the price it can charge and the cost of producing that quantity, including the costs of pollution abatement. We assume a perfectly competitive market and a constant price per unit of production. This eliminates the possibility that the costs of pollution abatement might be simply passed on to the consumers.

Our most important assumption is that the quantity of production (per year) will remain constant throughout the game, regardless of the variations in the costs of pollution prevention and pollution cleanup to the firm. Since the cost as a function of quantity produced is almost certainly nonlinear, our assumption is only justified in situations where the practical optimum level of production is constrained away from the theoretical optimum that would maximize profit for the firm, even after the extra costs are factored in.

Thus, although the four different strategies for the firm and regulator result in four different payoff curves for the firm, that payoff is always maximized at the same right-hand limit, a production quantity called Q_{max} that is determined by technological, logistical, or legal constraints. We illustrate this in Figure 3. For instance, the amount of natural gas or oil produced by a fracking well or wells may be limited by the carrying capacity of a pipeline. Alternately, the land available for drilling might be limited, so that a company operating the wells on that land is operating at capacity but has no way to expand its operations even though theoretically it is producing less than would maximize profit. Finally, there might be a legal limit, for instance, on water usage, that

	Firm Controls	Firm does not Control
Regulator controls	I	III
Reg. does not control	II	IV

Table 1. Labels for the four game outcomes.

forces the operation to stay at or below a certain rate of production.

The goal of our analysis is to show where the Nash equilibria lie in a list of cases. A Nash equilibrium is a set of strategies (one for each of our two players) for which the payoffs are maximized for each player when the other player's strategy is held constant [6]. We assume that the choices for preventative controls made by the regulator and the firm will stabilize: they will fall into a Nash equilibrium, mixed or pure.

Our study is comparable to a snapshot, although we will mention how the decisions might be made in sequence or repeatedly over a series of years. Recent studies of similar situations have opted to simplify the number of varying factors while adding realistic complexity to their treatment of the passage of time. In [7] Tapiero considers a very similar game; to his model we add the factor δ (effectiveness of the controls) and the variable Pigouvian penalties. In [8] the same author considers the game in a queueing framework. The game is rendered tractable in that paper by deriving the model from equilibrium arguments of the queue. In [1] the authors study polluter/regulator games as stochastic processes, to be solved using control theory.

The Model

Several constant values are given at the start of the game, and several variables may be set by the regulating agency. The constant values include the profit and costs of preventative controls (for the time period determined by the application). Also, we assume there exists a probability of pollution depending on quantity of production, which is therefore a constant since production is assumed constant. This probability can be interpreted as the frequency or the likelihood of pollution, or as the fraction of total pollutant released. Either way, the probability p multiplied by the cost of pollution Δ can be interpreted as the expected cost of cleanup for the time period. Finally, there is the fraction δ of cleanup costs prevented by a set of optional controls: we assume it to be the same whether those controls are implemented by the firm or by the regulator.

The constants are:

P_F ... the profit being achieved by the firm, before tax and before paying for any voluntary preventative controls and mandatory cleanup costs,

C_F ... the cost to the firm of optional control,

C_R ... the cost to the regulator of optional control,

$p\Delta$ ... the total expected cleanup costs,

δ ... the effectiveness of the optional controls,

obeying: $P_F > 0$, $0 \le p \le 1$, and $0 \le \delta \le 1$.

Thus if either just the firm or just the regulator applies optional controls, the remaining expected cost of cleanup is $(1-\delta)p\Delta$. If both sets of optional controls are applied then the cost of cleanup is decreased again, leaving the remaining cost of cleanup, $(1-\delta)^2 p\Delta$. A possible future study might introduce two different strengths, δ_f and δ_r, for two different controls purchased by the firm and by the regulator. Here, though, we are considering only one sort of control at a time. Thus the regulator's purchase can be seen as a subsidy of pollution control actually performed by the firm. That also explains why we consider two separate costs of control: the regulator may not pay the same for a filter as would a private firm.

The variables determined by the regulator (via its policymaking body) are the tax rate applied to the firm's profit and the variable percentages of cleanup cost covered by the regulator. Tax is assessed before any cleanup costs incurred by the firm but after any optional preventative control costs are subtracted from the profits.

τ ... the corporate tax rate on profit minus any cost of controls,

α_1 ... the percentage of cleanup costs paid by the regulator if the firm opts for extra controls,

α_3 ... the percentage of cleanup costs paid by the regulator when the firm does not apply extra controls but the regulator does,

α_4 ... the percentage of cleanup costs paid by the regulator if neither firm nor regulator opt for extra controls.

For instance, if neither the regulator nor the firm adopts the optional controls, then the cost of cleanup for the regulator is $\alpha_4 p\Delta$ and the cost of cleanup to the firm is $(1-\alpha_4)p\Delta$. If only the

Table 2. The payoff matrix: Firm's payoff is above regulator's in each cell.

	Firm controls (y)	Firm does not control $(1-y)$
Regulator controls (x)	$f_1 = (1-\tau)(P_F - C_F) - (1-\delta)^2 p\Delta(1-\alpha_1)$ $r_1 = \tau(P_F - C_F) - C_R - (1-\delta)^2 p\Delta\,\alpha_1$	$f_3 = (1-\tau)P_F - (1-\delta)p\Delta(1-\alpha_3)$ $r_3 = \tau P_F - C_R - (1-\delta)p\Delta\,\alpha_3$
Reg. does not control $(1-x)$	$f_2 = (1-\tau)(P_F - C_F) - (1-\delta)p\Delta(1-\alpha_1)$ $r_2 = \tau(P_F - C_F) - (1-\delta)p\Delta\,\alpha_1$	$f_4 = (1-\tau)P_F - p\Delta(1-\alpha_4)$ $r_4 = \tau P_F - p\Delta\,\alpha_4$

firm adopts the extra controls, then the cost of cleanup to the regulator is $\alpha_1(1-\delta)p\Delta$.

The subscripts used on the variable α correspond to outcomes (labeled by corresponding Roman numerals) in the 2×2 game shown in Table 1. The subscript 2 is not used, since we assume that if the firm adopts controls then it is guaranteed a single percentage α_1. The percentages $(1-\alpha_i)$ multiplied by the expected cost of cleanup can be interpreted as the penalties paid by the firm for polluting. Here we assume that $0 \le \alpha_i \le 1$, but an easy extension would allow negative values of α_i to indicate penalties beyond the cost of cleanup.

The payoff for the firm is the amount of after-tax profit remaining after paying for cleanup and/or prevention. Similarly, the payoff for the regulator is the amount of tax revenue retained. Table 2 shows the payoff for the firm above the payoff for the regulator in each of the four outcomes from Table 1.

We have also introduced new variables in Table 2. These will be useful in describing mixed strategies. If pollution is being filtered, x and y are the proportions of the full strength of the filtering mechanism. That is, the regulator purchases a filter that has only fraction x of effectiveness δ, and the firm purchases a filter of fractional strength $y\delta$. Alternatively, in a series of time periods, perhaps multiple years, the variable x could be the proportion of the years for which the regulator adopts preventative controls, while the variable y is the proportion of the years for which the firm controls. Or, if there are a number of extraction wells (or mines or power plants), x and y may also be interpreted as the proportions of facilities with extra controls applied by the regulator or firm respectively.

We will assume that the controls, such as a pair of filters of fractional strengths x and y, are used by the firm in a coordinated fashion. Thus the expected fraction (frequency) of the pollution released into the environment is given by

$$(1-x\delta)(1-y\delta)p.$$

Notice that this expression is derived either by considering the remaining fraction of pollution after successively subtracting the two fractions $x\delta$ and $y\delta$ or alternatively by applying x and y to the respective amounts of pollution in Table 2, as in the calculation of the mixed payoffs.

Analyzing the Game

Penalties

The following analysis will be organized into sections comparing the results for several ways of choosing values for α_i. In each we will compare the pure and mixed strategies. The cases we consider are as follows:

(1) $\alpha_1 = \alpha_3 = \alpha_4$,
(2) $\alpha_1 = \alpha_3 > \alpha_4$,
(3) $\alpha_1 = \alpha_3 < \alpha_4$,
(4) $\alpha_1 > \alpha_3 = \alpha_4$.

Since α_i is the fraction of cleanup covered by the regulator, a smaller value of this fraction can be considered a contingent penalty levied on the firm. In case (1) the penalty is uniform: there is no contingent portion of the penalty based on the optional controls. In case (2) the contingent penalty is only applied if neither the firm nor the regulator pays for extra controls. Here the regulator rather generously waives the penalty on the firm for not controlling as long as the regulator pays for the additional controls itself. Case (3) is the reverse situation: the contingent penalty is waived only when neither the firm nor the regulator pays for extra controls. Finally, in case (4) the contingent penalty is applied whenever the firm opts not to take the extra preventative measures.

Commonalities

Before considering these cases we perform the analysis common to all of them. First we define two new quantities from the given constants. Both quantities are defined using the fraction α_1. Recall that α_1 gives the fraction of cost of cleanup paid by the regulator in the best-case scenario, when both parties simultaneously pay for extra prevention. We can refer to the following ratios as *best-case cost ratios*. By F we denote the ratio of control cost to cleanup cost for the firm, and by R the same ratio for the regulator:

$$F = \frac{(1-\tau)C_F}{(1-\alpha_1)p\Delta} \quad \text{and} \quad R = \frac{C_R}{\alpha_1 p\Delta}.$$

Pure Equilibria. A pure equilibrium is when one of the four cells in the game describes a Nash equilibrium, that is, when $x, y \in \{0, 1\}$. Pure Nash equilibrium strategies exist in the regions of Table 1 when the following inequalities hold:

I $f_1 \geq f_3$ and $r_1 \geq r_2$. Thus

$$F \leq (1-\delta)\frac{1-\alpha_3}{1-\alpha_1} - (1-\delta)^2 \quad \text{and} \quad R \leq \delta - \delta^2.$$

II $f_2 \geq f_4$ and $r_2 \geq r_1$. Thus

$$F \leq \frac{1-\alpha_4}{1-\alpha_1} - 1 + \delta \quad \text{and} \quad R \geq \delta - \delta^2.$$

III $f_3 \geq f_1$ and $r_3 \geq r_4$. Thus

$$F \geq (1-\delta)\frac{1-\alpha_3}{1-\alpha_1} - (1-\delta)^2 \quad \text{and} \quad R \leq \frac{\alpha_4}{\alpha_1} - (1-\delta)\frac{\alpha_3}{\alpha_1}.$$

IV $f_4 \geq f_2$ and $r_4 \geq r_3$. Thus

$$F \geq \frac{1-\alpha_4}{1-\alpha_1} - 1 + \delta \quad \text{and} \quad R \geq \frac{\alpha_4}{\alpha_1} - (1-\delta)\frac{\alpha_3}{\alpha_1}.$$

Mixed Equilibria. Whether or not a pure strategy exists, there may also be mixed strategies that represent equilibria. If the firm controls y percent of the time and the regulator controls x percent of the time, then their respective payoffs are

$$f_m = y(xf_1 + (1-x)f_2) + (1-y)(xf_3 + (1-x)f_4),$$

$$r_m = x(yr_1 + (1-y)r_3) + (1-x)(yr_2 + (1-y)r_4).$$

A Nash equilibrium occurs when the firm and regulator choose percentages x and y such that neither could get a better payoff by unilaterally changing its choice. That means f_m would be at a local max in the y direction and r_m would be at a local max in the x direction. So we set partial derivatives equal to zero: $\partial_y f_m = 0$ and $\partial_x r_m = 0$. Solving yields

$$x = (f_4 - f_2)/(f_1 - f_2 - f_3 + f_4)$$

and

$$y = (r_4 - r_3)/(r_1 - r_3 - r_2 + r_4).$$

Thus, via simplifying and writing in terms of F and R:

$$x = \frac{(1-\delta)(1-\alpha_1) - (1-\alpha_4) + (1-\tau)C_F/p\Delta}{(1-\delta)(1-\alpha_1) - (1-\alpha_4) + (1-\delta)(1-\alpha_3) - (1-\delta)^2(1-\alpha_1)}$$
$$= \frac{F + 1 - \delta - \frac{1-\alpha_4}{1-\alpha_1}}{\delta - \delta^2 + (1-\delta)\frac{1-\alpha_3}{1-\alpha_1} - \frac{1-\alpha_4}{1-\alpha_1}}$$

and

$$y = \frac{(1-\delta)\alpha_3 - \alpha_4 + C_R/p\Delta}{(1-\delta)\alpha_3 - \alpha_4 + (\delta - \delta^2)\alpha_1}$$
$$= \frac{R + (1-\delta)\frac{\alpha_3}{\alpha_1} - \frac{\alpha_4}{\alpha_1}}{\delta - \delta^2 + (1-\delta)\frac{\alpha_3}{\alpha_1} - \frac{\alpha_4}{\alpha_1}}.$$

Remark 1. In theory the rates τ and α_i could be set to ensure an equilibrium in which both players prevent additional pollution or to avoid the situation in which neither do. Realistically, the cost to the overall economy might be too high. There will often be a mixed strategy. Here policy might be set in order to maximize both x and y (as close to 1 as possible). Ideally then we set $y = 1$ and find

$$\alpha_1 = \frac{C_R}{(\delta - \delta^2)p\Delta}.$$

Then setting $x = 1$ leads to

$$\tau = 1 - \frac{(1-\delta)(1-\alpha_3) - (1-\delta)^2(1-\alpha_1)}{C_F/p\Delta}.$$

Case 1

We begin with the "base" case, in which the percentage of responsibilities for cleanup are always the same: $\alpha_1 = \alpha_3 = \alpha_4$.

Now the pure equilibria, using the labels from Table 1, occur when:

I. $F \leq \delta - \delta^2$ and $R \leq \delta - \delta^2$,
II. $F \leq \delta$ and $R \geq \delta - \delta^2$,
III. $F \geq \delta - \delta^2$ and $R \leq \delta$,
IV. $F \geq \delta$ and $R \geq \delta$.

Notice that if outcome I is an equilibrium, then $F \leq F + \delta^2 \leq \delta$ and $R \leq R + \delta^2 \leq \delta$. Thus $f_1 \geq f_3$ and $f_2 \geq f_4$, showing that controlling for pollution is a dominant strategy for the firm and the same is true for the regulator. Similarly, if outcome IV is an equilibrium, then not controlling pollution is dominant for both players.

For the mixed strategies, the requirement that x, y are both nonnegative fractions of 1 implies that $\delta - \delta^2 \leq F \leq \delta$ and that $\delta - \delta^2 \leq R \leq \delta$.

We can illustrate these equilibria as regions on a graph, where the axes are labeled by F and R. Figure 2 shows the results.

Remark 2. If our ideal is minimizing pollution, then we look at how we might achieve equilibrium either in region I (a pure strategy) or in a

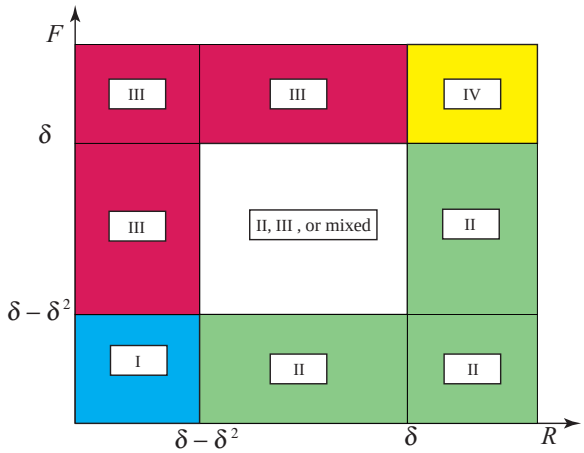

Figure 2. Nash equilibria relative to F and R in Case 1.

mixed strategy as close as possible to it. Hence we choose

$$\alpha_1 = \frac{C_R}{(\delta - \delta^2)p\Delta}$$

and then

$$\tau = 1 - \frac{(\delta - \delta^2)p\Delta - C_R}{C_F}.$$

Using these approximate values for α_1 and τ in the definitions of F and R gives

$$FR = \delta^2 - \delta^3 - (\delta^3 - \delta^4) < \delta^2 - \delta^3.$$

This inequality is the hypothesis of Theorem 1, which is expected, since maximizing x and y should also maximize pollution prevention.

Example 1. We look at a simple example to illustrate several of the facts just described:

Given	Calculated
$P_F = 1000$	$F = 0.192$
$\Delta = 500$	$R = 0.32$
$C_F = 40$	$\delta - \delta^2 = 0.1875$
$C_R = 40$	$x = 0.992$
$\alpha_1 = \alpha_3 = \alpha_4 = 0.5$	$y = 0.764$
$\tau = 0.4$	$f_m = 568$
$\delta = 0.75$	$r_m = 334.436$
$p = 0.5$	

Figure 3 shows a hypothetical pretax profit curve and four hypothetical payoff curves for the firm. Over the constraining quantity Q_{max} we find the four payoff values that are calculated using the formulas from Table 2. Since F and R lie between δ and $\delta - \delta^2$, we predict three equilibria, two pure and one mixed, in the resulting game:

Example 1.	Firm controls	Firm does not control
Reg. controls	$f_1 = 568.1875$ $r_1 = 336.1875$	$f_3 = 568.75$ $r_3 = 328.75$
Reg. does not control	$f_2 = 544.75$ $r_2 = 352.75$	$f_4 = 475$ $r_4 = 275$

The two pure equilibria are as predicted in outcomes II and III, and the mixed equilibrium is found at $x = 0.992$ and $y = 0.764$. The two pure equilibria both result in a new frequency of pollution given by $(1 - \delta)p = 0.125$. The mixed strategy, however, gives a new frequency of pollution, $(1 - x\delta)(1 - y\delta)p = 0.0546$. Thus the mixed strategy has better than halved the expected amount of pollution from either pure strategy. At the same time, the payoff for the regulator in the mixed strategy is $r_m = 334.436$, better than one of the equilibria strategies. The firm is happy about the mixed strategy, since its payoff is $f_m = 568$, only slightly less than in its best-case pure equilibrium strategy.

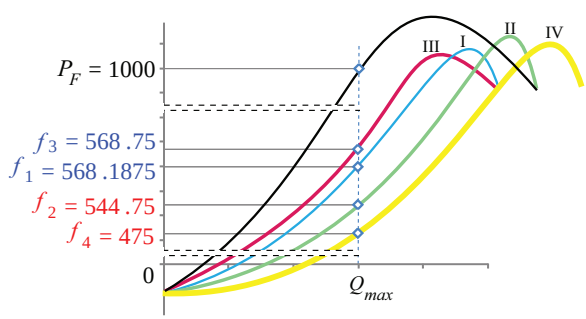

Figure 3. A hypothetical profit curve and four payoff curves depending on the strategies chosen in the game of our first example. The cost functions are unknown, but our assumption is that the maximum payoffs are found at a constraining limit on production.

Proof of Theorem 1. The preceding example leads us to investigate the question of when, in general, the mixed strategy turns out to prevent more pollution than either pure strategy (where just one player controls the pollution). This happens when

$$(1 - x\delta)(1 - y\delta)p < (1 - \delta)p,$$

which reduces quickly to

$$xy\delta < x + y - 1.$$

In the current case, when no extra penalties depend on the chosen strategy, we have

$$x = \frac{\delta - F}{\delta^2} \quad \text{and} \quad y = \frac{\delta - R}{\delta^2}.$$

Then the condition becomes

$$FR < \delta^2 - \delta^3,$$

which is the proof of Theorem 1.

In the preceding example, $\delta^2 - \delta^3 = .1406$ and $FR = 0.0614$, illustrating the predictive power of the theorem.

The corollary to Theorem 1 states that if $FR > \frac{4}{27}$, then the mixed strategy prevents less pollution than the pure ones. This is seen by noting that the maximum value of $\delta^2 - \delta^3$ for $0 \le \delta \le 1$ occurs at $\delta = \frac{2}{3}$. In Figure 4 we see the entire curve.

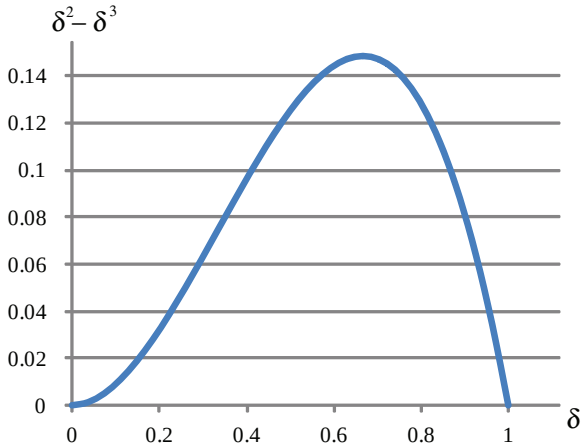

Figure 4. The maximum of this curve is $\frac{4}{27}$.

Case 2

Here the penalty on the firm is waived if the firm does not control but the regulator does. This might seem counterintuitive, but it may be coupled with higher taxes. When $\alpha_1 = \alpha_3 > \alpha_4$, the pure equilibria, again using the labels from Table 1, occur when

I. $F \le \delta - \delta^2$ and $R \le \delta - \delta^2$,

II. $F \le \delta + \frac{\alpha_1 - \alpha_4}{1 - \alpha_1}$ and $R \ge \delta - \delta^2$,

III. $F \ge \delta - \delta^2$ and $R \le \delta - \left(1 - \frac{\alpha_4}{\alpha_1}\right)$,

IV. $F \ge \delta + \frac{\alpha_1 - \alpha_4}{1 - \alpha_1}$ and $R \ge \delta - \left(1 - \frac{\alpha_4}{\alpha_1}\right)$.

For the mixed strategies, the requirement that x be a nonnegative fraction of 1 implies that

$$\delta - \delta^2 \le F \le \delta + \frac{\alpha_1 - \alpha_4}{1 - \alpha_1}.$$

The requirement that y be a nonnegative fraction of 1 leads to two subcases:

(2a) If $1 - \frac{\alpha_4}{\alpha_1} < \delta^2$, then

$$\delta - \delta^2 \le R \le \delta - \left(1 - \frac{\alpha_4}{\alpha_1}\right).$$

(2b) If $1 - \frac{\alpha_4}{\alpha_1} > \delta^2$, then

$$\delta - \left(1 - \frac{\alpha_4}{\alpha_1}\right) \le R \le \delta - \delta^2.$$

Figures 5 and 6 show the results for subcases (2a) and (2b) respectively.

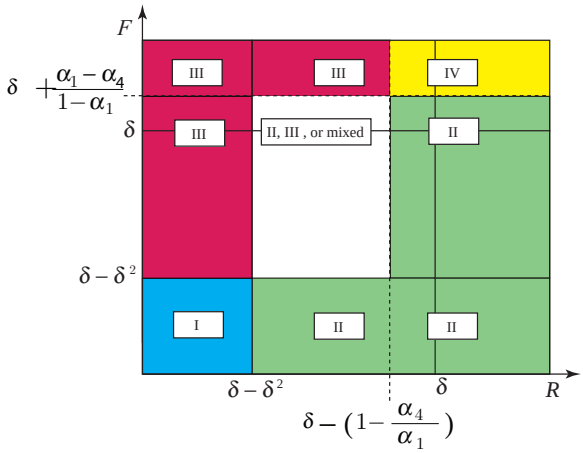

Figure 5. Results of subcase (2a), when $1 - \frac{\alpha_4}{\alpha_1} < \delta^2$.

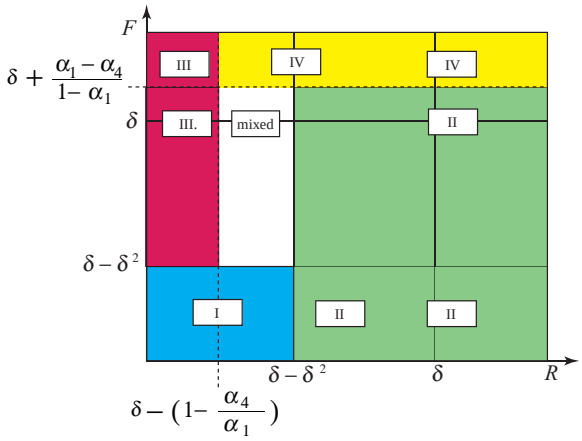

Figure 6. Results of subcase (2b), when $1 - \frac{\alpha_4}{\alpha_1} > \delta^2$.

Remark 3. In both figures showing Case 2 we see that the region marked II has increased in area relative to the region marked II in Case 1. We can argue qualitatively from these figures that all else being equal, the situation in which the firm is the only controller is more likely to occur in Case 2.

Since subcase (2a) has the possibility of three equilibria, we again consider what conditions guarantee that the mixed equilibrium will result in greater pollution abatement.

Theorem 3. *In subcase* (2a), *the mixed equilibrium will result in greater pollution abatement if and only if*

$$FR + \frac{1-\delta}{\alpha_1}\left(\frac{\alpha_1-\alpha_4}{1-\alpha_1}\right) \times (\alpha_1 - \alpha_4 + \delta - 2\alpha_1\delta + \alpha_1 R - (1-\alpha_1)F) < \delta^2 - \delta^3.$$

Proof. As in Theorem 1 the mixed equilibrium prevents more pollution when $xy\delta < x+y-1$. Here we use the conditions of subcase (2a) and do some algebraic reducing. The simplification was first performed by hand and then checked by computer. □

Example 2. We illustrate the first subcase (2a) with another simple example.

Given	Calculated
$P_F = 1000$	$F = 0.2479$
$\Delta = 250$	$R = 0.2478$
$C_F = 55$	$\delta - \delta^2 = 0.45 - 0.2025 = 0.2475$
$C_R = 7$	$x = 0.998$
$\alpha_1 = \alpha_3 = 0.226$	$y = 0.997$
$\alpha_4 = 0.2$	$1 - \frac{\alpha_4}{\alpha_1} = 0.115$
$\tau = 0.564$	$\delta - (1 - \frac{\alpha_4}{\alpha_1}) = 0.335$
$\delta = 0.45$	$f_m = 382.717$
$p = 0.5$	$r_m = 517.513$

Here the values of F and R fall in the range for which there are three equilibria. Within this example we have decided to also minimize pollution. To do so, we have calculated and used the near-optimal values

$$\alpha_1 \sim \frac{C_R}{(\delta-\delta^2)p\Delta} \sim 0.226$$

and

$$\tau \sim 1 - \frac{(\delta-\delta^2)p\Delta - C_R}{C_F} \sim 0.565.$$

These choices for τ and α_1 ensure that x and y are close to 1. Here is the game:

Example 2.	Firm controls	Firm does not control
Reg. controls	$f_1 = 382.75$ $r_1 = 517.434$	$f_3 = 382.7875$ $r_3 = 541.4625$
Reg. does not control	$f_2 = 358.8$ $r_2 = 517.442$	$f_4 = 336$ $r_4 = 539$

As predicted, there are three equilibria, including the two pure strategies at II and III. The inequality in Theorem 3 holds in this example: filling in the given values gives $0.0863 < 0.1114$. That fact predicts the next: the two pure equilibria both result in a new frequency of pollution given by $(1-\delta)p = 0.275$, while the mixed strategy gives the much lower frequency of pollution $(1-x\delta)(1-y\delta)p = 0.152$.

Example 3. We return to a variation of our simple example to illustrate the second subcase (2b).

Given	Calculated
$P_F = 1000$	$F = 0.44$
$\Delta = 250$	$R = 0.187$
$C_F = 55$	$\delta - \delta^2 = 0.45 - 0.2025 = 0.2475$
$C_R = 7$	$x = 0.443$
$\alpha_1 = \alpha_3 = 0.3$	$y = 0.535$
$\alpha_4 = 0.2$	$1 - \frac{\alpha_4}{\alpha_1} = 0.33$
$\tau = 0.3$	$\delta - (1 - \frac{\alpha_4}{\alpha_1}) = 0.1167$
$\delta = 0.45$	$f_m = 622.96$
$p = 0.5$	$r_m = 268.5$

Since F lies between δ and $\delta - \delta^2$ and R between $\delta - (1 - \frac{\alpha_4}{\alpha_1})$ and $\delta - \delta^2$, we predict only one mixed equilibrium:

Example 3.	Firm controls	Firm does not control
Reg. controls	$f_1 = 635.03$ $r_1 = 265.156$	$f_3 = 651.875$ $r_3 = 272.375$
Reg. does not control	$f_2 = 613.375$ $r_2 = 262.875$	$f_4 = 600$ $r_4 = 275$

As expected, here there is only the mixed equilibrium.

Case 3

Here a penalty on the firm is applied whenever either the regulator or the firm is paying for extra controls. This is really counterintuitive, and we include it for contrast. If $\alpha_1 = \alpha_3 < \alpha_4$, then pure equilibria occur just as in Case 2 when

I. $F \le \delta - \delta^2$ and $R \le \delta - \delta^2$,
II. $F \le \delta + \frac{\alpha_1-\alpha_4}{1-\alpha_1}$ and $R \ge \delta - \delta^2$,
III. $F \ge \delta - \delta^2$ and $R \le \delta - \left(1 - \frac{\alpha_4}{\alpha_1}\right)$,
IV. $F \ge \delta + \frac{\alpha_1-\alpha_4}{1-\alpha_1}$ and $R \ge \delta - \left(1 - \frac{\alpha_4}{\alpha_1}\right)$.

For the mixed strategies, the requirement that y be a nonnegative fraction of 1 implies that

$$\delta - \delta^2 \le R \le \delta - \left(1 - \frac{\alpha_4}{\alpha_1}\right).$$

The requirement that x be a nonnegative fraction of 1 leads to two subcases:

(3a) If $\frac{\alpha_4-\alpha_1}{1-\alpha_1} < \delta^2$, then

$$\delta - \delta^2 \le F \le \delta - \frac{\alpha_4-\alpha_1}{1-\alpha_1}.$$

(3b) If $\frac{\alpha_4-\alpha_1}{1-\alpha_1} > \delta^2$, then

$$\delta - \frac{\alpha_4 - \alpha_1}{1 - \alpha_1} \le F \le \delta - \delta^2.$$

Figures 7 and 8 show the results for subcases (3a) and (3b) respectively.

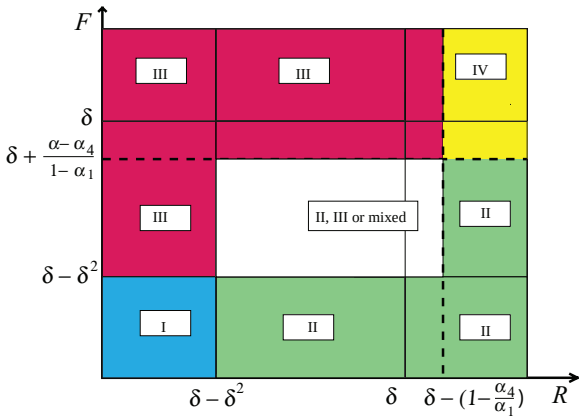

Figure 7. Results of subcase (3a).

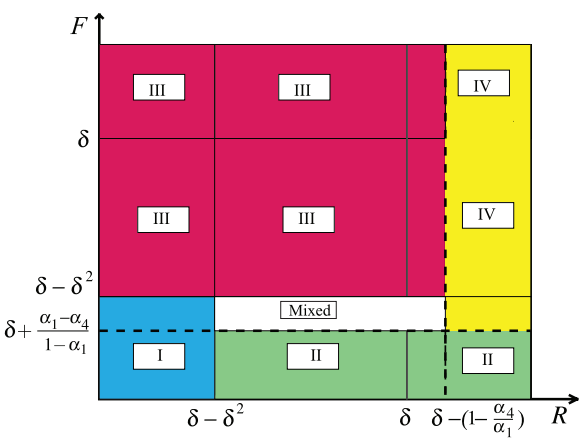

Figure 8. Results of subcase (3b).

Remark 4. In both figures showing Case 3 we see that the region marked III has increased in area relative to the region marked III in Case 1. We can argue qualitatively from these figures that all else being equal, the situation in which the regulator is the only controller is more likely to occur in Case 3.

Case 4

Common sense leads us to the case in which a penalty is applied whenever the firm fails to implement optional controls. Thus $\alpha_1 > \alpha_3 = \alpha_4$. To simplify the notation we define

$$\beta = \frac{\alpha_1 - \alpha_4}{1 - \alpha_1}(1 - \delta) - \delta^2.$$

Now the pure equilibria are

I. $F \le \delta + \beta$ and $R \le \delta - \delta^2$,
II. $F \le \delta + \frac{\alpha_1-\alpha_4}{1-\alpha_1}$ and $R \ge \delta - \delta^2$,
III. $F \ge \delta + \beta$ and $R \le \delta\frac{\alpha_4}{\alpha_1}$,
IV. $F \ge \delta + \frac{\alpha_1-\alpha_4}{1-\alpha_1}$ and $R \ge \delta\frac{\alpha_4}{\alpha_1}$.

For the mixed strategies, the requirement that x be a nonnegative fraction of 1 implies that

$$\delta + \beta \le F \le \delta + \frac{\alpha_1 - \alpha_4}{1 - \alpha_1}.$$

The requirement that y be a nonnegative fraction of 1 leads to two subcases:

(4a) If $1 - \frac{\alpha_4}{\alpha_1} < \delta$, then

$$\delta - \delta^2 \le R \le \delta\frac{\alpha_4}{\alpha_1}.$$

(4b) If $1 - \frac{\alpha_4}{\alpha_1} > \delta$, then

$$\delta\frac{\alpha_4}{\alpha_1} \le R \le \delta - \delta^2.$$

Since subcase (4a) has the possibility of three equilibria, we again consider what conditions guarantee that the mixed equilibrium will result in greater pollution abatement.

Theorem 4. *In subcase* (4a), *the mixed equilibrium will result in greater pollution abatement if and only if*

$$FR + \frac{1-\delta}{\alpha_1}\left(\frac{\alpha_1 - \alpha_4}{1 - \alpha_1}\right) \times (\alpha_1 - \alpha_4 + \delta - 2\alpha_1\delta - (1 - \alpha_1)F) < \delta^2 - \delta^3.$$

Proof. As in Theorem 1, the mixed equilibrium prevents more pollution when $xy\delta < x + y - 1$. Here we use the conditions of subcase (4a) and do some algebraic reducing. The simplification was first performed by hand and then checked by computer. □

Figures 9, 10, 11, and 12 show the results for subcases (4a) and (4b) with $\beta > 0$ and $\beta < 0$ respectively.

Remark 5. In all figures showing subcase 4 we see that the regions marked I and II have increased in area relative to the similarly marked regions for Case 1. We can argue qualitatively from these figures that all else being equal, the situation in which the firm is the only controller is more likely to occur in Case 4. Even more importantly, the optimal situation in which both players control pollution is most likely in Case 4.

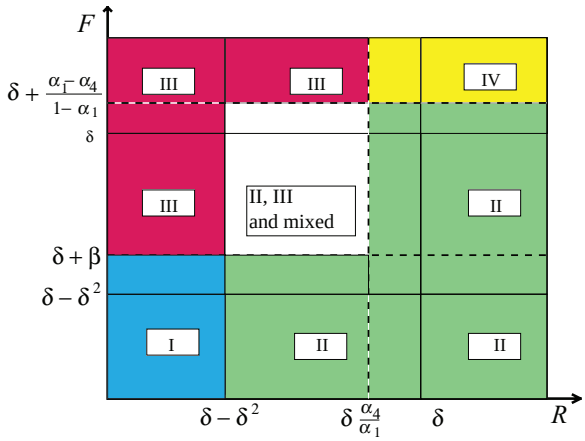

Figure 9. Results of subcase (4a), $\beta > 0$.

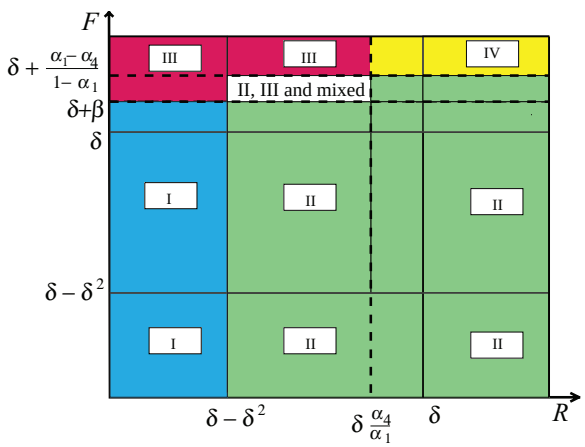

Figure 10. Results of subcase (4a), $\beta < 0$.

Example 4. Here is an example that illustrates subcase 4a with $\boldsymbol{\beta < 0}$ and with three equilibria:

Given	Calculated	
$P_F = 1000$	$F = 0.384$	$\beta = -0.4625$
$\Delta = 500$	$R = 0.24$	$\delta + \beta = 0.2875$
$C_F = 80$		$\delta - \delta^2 = 0.1875$
$C_R = 30$	$x = 0.888$	
$\alpha_1 = 0.5$	$y = 0.8$	$\delta \frac{\alpha_3}{\alpha_1} = .45$
$\alpha_3 = \alpha_4 = 0.3$	$f_m = 541.565$	
$\tau = 0.4$	$r_m = 334.4$	$\delta + \frac{\alpha_1 - \alpha_3}{1-\alpha_1} = 1.15$
$\delta = 0.75$		
$p = 0.5$		

Example 4.	Firm controls	Firm does not control
Reg. controls	$f_1 = 544.1875$ $r_1 = 330.1875$	$f_3 = 556.25$ $r_3 = 351.25$
Reg. does not control	$f_2 = 520.75$ $r_2 = 336.75$	$f_4 = 425$ $r_4 = 325$

The two pure equilibria are as predicted in outcomes II and III, and the mixed equilibrium is found at $x = 0.888$ and $y = 0.8$. The two pure equilibria both result in a new frequency of pollution given by $(1 - \delta)p = 0.125$. The mixed strategy, however, gives a new frequency of pollution, $(1 - x\delta)(1 - y\delta)p = 0.06678$. Thus the mixed strategy has nearly halved the expected amount of pollution from either pure strategy.

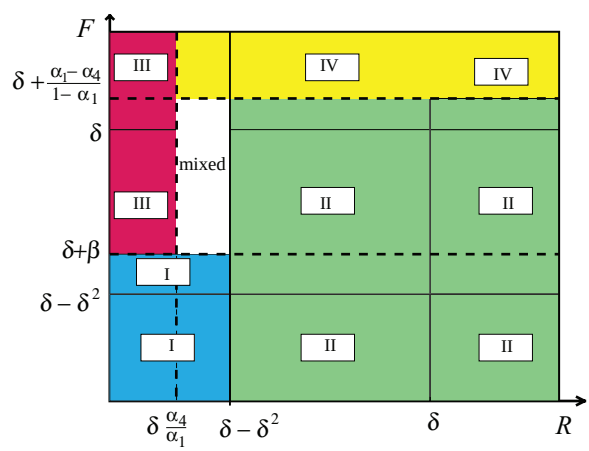

Figure 11. Results of subcase (4b), with $\beta < 0$.

Example 5.	Firm controls	Firm does not control
Reg. controls	$f_1 = 481.4875$ $r_1 = 275.9875$	$f_3 = 493.25$ $r_3 = 324.75$
Reg. does not control	$f_2 = 451.75$ $r_2 = 275.75$	$f_4 = 425$ $r_4 = 325$

Example 5. Here is a final example from subcase (4b) with $\beta > 0$:

Given	Calculated	
$P_F = 1000$	$F = 0.576$	$\beta = 0.0919$
$\Delta = 500$	$R = 0.236$	$\delta + \beta = 0.4819$
$C_F = 120$		$\delta - \delta^2 = 0.2379$
$C_R = 29.5$	$x = 0.6946$	
$\alpha_1 = 0.5$	$y = 0.5128$	$\delta \frac{\alpha_3}{\alpha_1} = .234$
$\alpha_3 = \alpha_4 = 0.3$	$f_m = 472.405$	
$\tau = 0.4$	$r_m = 299.744$	$\delta + \frac{\alpha_1 - \alpha_3}{1-\alpha_1} = 0.79$
$\delta = 0.39$		
$p = 0.5$		

Since $\delta + \beta \le F \le \delta + \frac{\alpha_1 - \alpha_3}{1-\alpha_1}$ and $\delta \frac{\alpha_3}{\alpha_1} \le R \le \delta - \delta^2$, we predict only one mixed equilibrium:

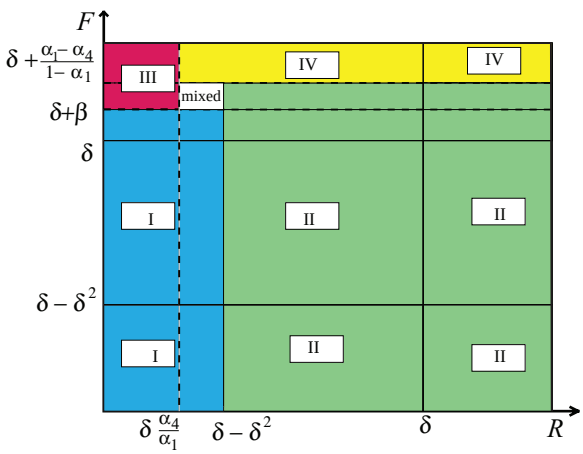

Figure 12. Results of subcase (4b), with $\beta > 0$.

Conclusions

The application of our results would theoretically be to inform policymakers of the likely outcomes of their decisions. The regulator gets to choose the game that will be played and then gets to make the first move. If there is a preferred outcome, especially if it is preferred on the basis of nonmonetary goals, then the policy may be set in such a way as to make that outcome more likely. Here the nonmonetary preferred outcome is usually that of less pollution, since loss of life and extinction of species are difficult to account for in a payoff matrix.

Our results can instruct policymakers at several levels. In an ideal situation, the corporate tax rate and Pigouvian taxes can be adjusted, as in Remarks 1 and 2, to force the game outcomes to have equilibria with low pollution. The real world usually is not ideal, however. Often the policymakers are held financially accountable first and morally accountable second. Of course we are being tongue-in-cheek. It is not simple to separate fiscal efficiency from public welfare.

When the penalties and taxes are fixed by prior factors (perhaps political), it may at first appear that the regulator faces an impossible choice between a financially inferior strategy and a strategy that sacrifices safety or biodiversity for maximizing tax revenue. However, the strength of our analysis is that it can often uncover win-win options: mixed strategies that allow the regulator to choose a policy that is at an equilibrium with less pollution than either pure strategy and higher tax revenue and after-tax profits than in the worst-case pure equilibria for the respective players. In the examples where there were three equilibria, the combined payoffs $f_m + r_m$ were larger than either $f_2 + r_2$ or $f_3 + r_3$.

Of course "win-win" is a philosophically presumptuous claim. For context we point out that our examples with three equilibria are reminiscent of the classic game of chicken. The two players can either swerve or barrel on straight ahead towards collision. The pure equilibria are when only one player swerves. In our games swerving corresponds to controlling pollution. Thus the interpretation in which x and y are frequencies of control is not so palatable; one head-on crash is more than the public can risk. We prefer the application in which x and y are the relative strengths of two filters applied in tandem.

Importantly, in these mixed equilibria the firm cannot gain from altering its amount of prevention. Thus the government can set its own subsidy of pollution prevention at the mixed equilibria rate. Then it can hope that the firm will follow suit rationally, or at least it can encourage the firm to pay its share on the basis that it has nothing to lose by doing so. In fact, the good public relations gained by the firm will then be a cost-free benefit.

Finally, by examining four cases of penalty policy, we showed that setting the rates of a variable Pigouvian tax can change the game. First, the different subcases have different numbers of possible simultaneous equilibria. Then in Remarks 3, 4, and 5 we point out how the different cases lead to different likelihoods of either or both players controlling pollution.

Further study is warranted by the cases in which there is only one mixed strategy. It has been conjectured that these may harbor *semi-antagonistic equilibrium points*, as defined in [2]. These are points for which neither player's payoff is optimized but for which the environment may reap the benefit. We are thankful to the author of [2] for pointing out this possibility. We also thank Francesco Renna for helpful discussions and advice.

Even more future directions of this research might include taking into account more strategic

choices for both firm and government. For instance, cases when lobbying by the firm can affect the tax and penalty rates have been studied in [3]. Also, it has been argued that subsidies can be counterproductive if they lead to many more polluting firms entering the market, e.g., in [5]. The model we study here should extend to those more complex situations, where it could again be used to answer the question, when does compromise prevent more pollution?

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An IMMERSE-Style Course Brings a Research Experience to Students and Faculty

Ellen Veomett

A common challenge that new faculty face at primarily teaching institutions is finding the time and energy for research. With all of the day-to-day duties of a large course load, new course preps, committee work, and service to the college and community, how does a young faculty member keep her research program alive? More than that, recently there has been a (very positive, in my opinion) push towards including undergraduate students in research projects, as well as a (very positive again) push towards "bridging the gap" between an undergraduate and graduate degree.

I recently had the pleasure of participating in a summer program that allowed me to address these issues. While not every young faculty member can participate in such a program, every young faculty member *can* do what I did the following year: teach a similar course at her home institution. This article is intended to explain the course, as well as how it can be successfully adapted to a "regular" semester-length or quarter-length course.

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The IMMERSE-Style Course

This "miracle" course which achieves so much has at its core a single goal: getting the students to read a research paper. The instructor teaches the students any material they need to know in advance of reading the paper, and then they read the paper.

The first time I taught such a course was during the summer IMMERSE program at the University of Nebraska (IMMERSE stands for Intensive Mathematics: a Mentoring, Education and Research Summer Experience). For about six weeks I met with twenty students three hours a day, four days a week. The students were all staying on campus together in dorms, all entering Ph.D. programs in the fall, and all being paid for their time. They were also taking two courses of this type. Thus they were spending twenty-four hours a week in class learning to read two research papers (one falling under the analysis umbrella, the other algebra).

The second time I taught the course was at Cal State University East Bay in Hayward, CA. This was a regular course, meeting twice a week for two hours over a 10-week quarter. Cal State East Bay is a commuter campus with an extremely diverse student background. All eleven of the students in my class were Masters students; to my knowledge, three of them were planning on eventually finishing a Ph.D. program. These students were all taking other courses, most were also working, and most were taking comprehensive exams at the end of the quarter.

Even with the great differences in situation and population, both of these groups of students thrived and had a great appreciation for the course. Of course, a certain amount of interest and motivation is required of any student wishing to complete such a course. So long as participation in a course such as this is not compulsory, I suspect that any student deciding to "sign on" already has the requisite drive.

The Benefits of an IMMERSE-Style Course

The greatest benefit for the students is the *experience* of the course. The students have a chance to struggle with topics that are on the edge of their mathematical understanding. With the right kind of nudging, they will be able to, on their own, piece together new knowledge and master new results. This experience of a slow struggle eventually ending in a deep understanding is extremely empowering. The more chances students have to encounter great reward for great struggle, the more students will be willing to undergo that great struggle in the future.

Students will additionally benefit from the material they learn. When reading a modern research paper, students have the opportunity to learn new topics and ideas that they would not normally be exposed to in the typical studies for an undergraduate or master's degree. While areas of mathematics tend to be artificially separated for the purposes of teaching, an IMMERSE-style course helps students see how various types of mathematics interact in research. The students also leave such a course having a much better understanding of mathematics research, as well as the typical structure and design of a research paper.

Comments that students made anonymously in both of the courses that I taught suggest that the above benefits were indeed achieved:

> With the topics introduced by the professor, and the given assignments, it was challenging enough to cause occasional despair but attainable enough to have some highs induced by new understanding. . . . For me the course was a revelation. You mean I can understand an advanced research paper? You've got to be kidding me!!! . . . I learned that with the right amount of patience, desire and resources it is possible. —Cal State student

> At times I felt that the material was really difficult, but that made it more satisfying when I finally understood it. I'm now looking forward to taking analysis in grad school. —IMMERSE student

> What was probably most beneficial and most enjoyable was seeing a number of different areas of math come together for use in interesting ways. In most classes topics are compartmentalized, however the paper we studied in particular was really a cohesion of some usually very different topics. —Cal State student

> I would certainly say I've increased my analysis skills and have especially learned a lot about how to get through research papers. —IMMERSE student

Finally, the instructor herself receives many benefits by teaching a course focused on reading a research paper. She has the time and incentive to read a very important paper that will help her in her own research. She is renewed by the chance to think about recent mathematical discoveries. And, of course, she also has the chance to experience that great "aha moment" when she successfully reads through and understands something complicated. Even designing a course that helps to make those "aha moments" more accessible to students is itself a rewarding task.

How-To

Now that I've thoroughly convinced you that you'd like to teach such a course, I'll let you know my suggestions on how to do so based on my experiences. The first step is to choose a good paper. The paper should be on the shorter side, probably not more than 10–15 pages. I chose a paper by Bourgain [1] that was seven pages long (albeit a very dense seven pages). The paper should be something which greatly interests you and about which you have at least a little knowledge. That way, you will be happily willing to put in the hard work required to design the course. Finally, the paper should be important. By important, I mean that it should be relatively new and highly referenced. You and your students will be doing a lot of work with this paper; why not choose something that has a good chance of being useful in your future research careers? In my search for the right paper, I heavily used the "citations" search option on MathSciNet as a way of finding those "important" papers.

Once the paper is chosen, the course is designed around it. After a first cursory reading, you can see what topics the students will need to know before first encountering the paper. If you don't know the students who will be taking the course, it may be helpful to send them a survey in advance in order to better appreciate the variety of the students' backgrounds. Both times I taught this course, there were two relatively distinct stages: the lecture stage and the reading stage.

The Lecture Stage

The lecture stage is the time when the students are learning the material that they need to know before reading the paper. Both times I taught the course, this lasted the first half of the term (three weeks at IMMERSE, five weeks at Cal State). For me, the lecture stage was similar to a typical course in that I was lecturing each time we met, and the students were regularly doing homework on the topics from lecture. The homework problems were generally intended to help ingrain understanding and familiarity with the topics, although sometimes I could include things that came directly from the paper. For example, early in the course we were learning about metric spaces, and I assigned the following problem, which appeared as a statement without proof in the paper:

> Let X be a metric space, let $A \subset X$ and let $x, y \in X$. Define
> $$d(x, A) = \inf\{d(x, a) : a \in A\}.$$
> Prove that
> $$|d(x, A) - d(y, A)| \leq d(x, y).$$

As we were nearing the end of the lecture stage, I assigned the following:

> Let (X, d_X) be a metric space and suppose that X has finitely many points in it. Say that X has n points in it so that we can label $X = \{x_1, x_2, x_3, \ldots, x_n\}$. Consider the map
> $$F : (X, d_X) \to (\mathbb{R}^n, ||\cdot||_\infty)$$
> defined by
> $$F(x_i) = (d_X(x_1, x_i), d_X(x_2, x_i), d_X(x_3, x_i), \ldots, d_X(x_n, x_i))$$
> for each $i = 1, 2, 3, \ldots, n$.
> (1) For $x_1, x_2 \in X$, calculate
> $$||F(x_1) - F(x_2)||_\infty.$$
> (2) Prove that
> $$||F||_{\text{Lip}}||F^{-1}||_{\text{Lip}} = 1.$$

The second of the two parts appeared as a statement without proof in the paper.

The main way in which the lecture stage differed from a typical lecture course was that it included student presentations. These were short presentations of homework problems given by students. When I taught this course through the IMMERSE program, the students knew perhaps the day of (or the day before) that they would be presenting a particular problem. At Cal State East Bay, the homework that I handed out had a list of problems to be handed in and another list of problems to be presented. The students volunteered to present a problem the day it was listed as its presentation day.

There were several reasons I included student presentations. The main reason was that I wanted the students to begin feeling comfortable with feeling uncomfortable. Reading a research paper is often frustrating and confusing, and those uncomfortable feelings will often discourage someone who is not used to experiencing them. I believe that the act of explaining something in front of the class gave my students a chance to become accustomed to feeling "out of their element", as well as the confidence to believe that they belonged in the class. It also helped them to feel camaraderie with their classmates (everyone had to present), which was important for the reading stage of the course.

The Reading Stage

Once the students know enough of the background mathematics, the reading stage begins. This stage includes three main parts:

(1) Prepaper Problems,
(2) Reading,
(3) Clarification/Enrichment Presentations,

all of which occur throughout the reading stage.

Prepaper problems replace regular homework problems during this time of the course. They are created as follows: when reading through the paper, you will see places (maybe many places) where the reader will need to "fill in the gaps". Perhaps this is simply using a well-known fact, or perhaps it is fleshing out an outlined argument, or perhaps it is completing a hidden computation. Whatever it may be, a prepaper problem is a homework problem that mimics what the students will need to do when they come to that place in the paper. Since the problem *mimics* the elaboration that must be made in order to understand the paper (but isn't the precise argument), the students are *not* being spoon-fed, nor do they feel as though they are. Rather, having seen a similar argument previously, when they encounter it in the paper they will have some familiarity with how to proceed.

Here is an example of a prepaper problem:

> Recall from class that if $F : (X, ||\cdot||_X) \to (Y, ||\cdot||_Y)$ is linear, then
> $$||F||_{\text{Lip}} = \sup\{||F(x)|| : x \in X, ||x||_X = 1\}.$$
> (1) Consider the map $f : (\mathbb{R}^2, ||\cdot||_\infty) \to (\mathbb{R}^2, ||\cdot||_1)$ defined by
> $$f((x, y)) = (2x, -y).$$
> (a) Convince yourself that f is linear.
> (b) What is $||f||_{\text{Lip}}$?

(2) Consider the map $g : (\mathbb{R}^n, ||\cdot||_\infty) \to (\mathbb{R}^n, ||\cdot||_1)$ defined by

$$g(x_1, x_2, x_3, \ldots, x_n) = (x_1, 2x_2, 3x_3, \ldots, nx_n).$$

(a) Convince yourself that g is linear.
(b) What is $||g||_{\text{Lip}}$?

This problem was intended to prepare the students for the first section of Bourgain's paper [1], where he defines a function that is essentially from $(\mathbb{R}^n, \|\cdot\|_\infty)$ to $(\mathbb{R}^n, \|\cdot\|_1)$ and states an upper bound on the Lipschitz norm $\|\cdot\|_{\text{Lip}}$ of that function. This function, like the two functions f and g above, is a diagonal linear function. The description of the function is relatively dense, and so the students must go through some effort to simply understand the function, and then they must go through some work to calculate an upper bound on the Lipschitz norm. Having calculated the Lipschitz norm of a diagonal linear function beforehand, they were able to get through that part of the paper without either getting bogged down with frustration or feeling like the paper had been explained to them in advance.

Another straightforward place to use a prepaper problem is in the case of a computation. For example, Bourgain [1] states that

$$\sum_{j=1}^{n-1} \binom{n}{j} \left(1 - \frac{M}{n}\right)^{j(n-j)} < \frac{1}{50}$$

if $M > C\log(n)$. Since this statement is nonobvious upon inspection, I broke the computation down into several chewable pieces. Specifically, I first asked students to show

$$(1-x)^p \le e^{-xp} \text{ for all } x \in (0,1), p > 0,$$

giving a hint for an argument using only concepts from differential calculus. Then they were asked to split the sum into two pieces:

(1) (a) Argue that

$$\sum_{i=\frac{2}{5}n}^{\frac{3}{5}n} \binom{n}{i} \le 2^n.$$

(b) Let $C > 0$ and assume that $C\frac{\log(n)}{n} < 1$. Use your above estimate to give an upper bound for

$$\sum_{i=\frac{2}{5}n}^{\frac{3}{5}n} \binom{n}{i} \left(1 - C\frac{\log(n)}{n}\right)^{i(n-i)}.$$

(Hint: Remember that $(1-x)^p \le e^{-xp}$ for all $x \in (0,1), p > 0$.) Show that, for example, if $n \ge 30$ and $C \ge 8$, then the above sum is no more than $\frac{1}{100}$.

(2) Suppose $C\frac{\log(n)}{n} < 1$ and consider the sum

$$\sum_{i=1}^{2n/5} \binom{n}{i} \left(1 - C\frac{\log(n)}{n}\right)^{i(n-i)} + \sum_{i=3n/5}^{n-1} \binom{n}{i} \left(1 - C\frac{\log(n)}{n}\right)^{i(n-i)}.$$

(a) As i increases from 1 to $2n/5$, show that the terms

$$\binom{n}{i} \left(1 - C\frac{\log(n)}{n}\right)^{i(n-i)}$$

decrease by calculating the ratio of successive terms. Specifically, show that the ith term divided by the $(i-1)$th term is < 1. (Hint: Remember that $(1-x)^p \le e^{-xp}$ for all $x \in (0,1), p > 0$.)

(b) (i) Show that the ith terms and the $(n-i)$th terms in the sum are the same.
(ii) Show that the sum is less than $\frac{1}{100}$ if, for example, $n \ge 30$ and $C \ge 8$.

This gave students much more direction in terms of how to argue a complicated inequality and in general made the process much less daunting while still in the end asking them to prove the inequality. When the students encountered the claimed inequality, they already knew how to prove it and thus could focus on the argument for how the equation $\sum_{j=1}^{n-1} \binom{n}{j} \left(1 - \frac{M}{n}\right)^{j(n-j)}$ comes into play rather than getting entangled in the computation.

The reading stage of the course also includes, of course, reading. A good portion of this should happen in groups during class time. The students work through sections of the paper and discuss with each other how to get from one step to the next. Doing this in groups allows the students to keep each other motivated, and it helps them to work through the paper at the same pace. Doing this during class time allows you to answer their questions as they arise. It also allows you to listen in on the discussions and steer them in the right direction if a group starts veering away from helpful ideas. It is important to let the students struggle but not get stuck in a rut. I recommend assigning the groups that the students work in (so that they are balanced) but rotating groups every week or so (so that they can become reenergized by new reading partners).

Finally, the reading stage includes clarification and enrichment presentations. This may include a continuation of lectures on the topics that had been previously introduced, and it may include lectures on topics that help to orient the paper within a field of study. For example, I lectured on measure concentration and the F. John Ellipsoid. These topics were alluded to in the paper [1],

and these lectures allowed the students to get a flavor of techniques and ideas used in metric geometry. Presentations should also be given to "wrap up" sections of the paper. This allows all of the students to both fully understand what they had discussed in their small groups as well as understand the context of the paper. During the IMMERSE course, I had students present sections of the paper, while I explained the general context and significance of the questions addressed in the paper. At Cal State East Bay, in the interest of saving time, I did all of the "wrap-up" presentations myself.

Last Thoughts

In an effort to help you as you plan a similar course, I have posted a few resources on my webpage:
`https://sites.google.com/a/stmarys-ca.edu/ellen-veomett/immerse-course-resources`
There you can find the schedule that I used when teaching the course at Cal State, as well as some sample lectures and assignments. These will give you an even more concrete idea of the implementation of an IMMERSE-style course.

While I do think that this kind of course can be held at any institution with a motivated faculty member and motivated students, there were some wonderful resources that I had the first time I taught this course through the IMMERSE program. First, I had a University of Nebraska faculty member (Jamie Radcliffe) who acted as my mentor. He gave feedback on the course design, shared his favorite examples so that I could include them in the course, and helped me to thrash out the complicated arguments in the paper. Second, I had the aid of three University of Nebraska graduate students (Joe Geisbauer, Lauren Keough, and Zahava Wilstein). These graduate students helped the IMMERSE students as they were doing group work, checked the IMMERSE students' written homework, and also read through my lecture notes and homework sets in advance, catching many errors and typos before they were a problem. Without all of this help, the course preparation would have been much more daunting, time-consuming, and lonely.

Similar resources may be available for you at your institution: perhaps you have a trusted colleague who you know would help you to bounce ideas around, and perhaps you have funding for student assistants. If not, the burden will be much more on you in terms of finding the time for all of the preparation involved and the motivation to craft a cohesive and thorough course. The results of the course are well worth it, though. You will be reinvigorated in your research, and the students will be exposed to new ideas and new ways of learning. Both you and your students will feel the satisfaction of receiving great reward for great struggle.

Acknowledgments

I would like to thank Joe Geisbauer, Lauren Keough, Zahava Wilstein, and in particular Jamie Radcliffe, whose help was invaluable in making the IMMERSE course a success. I would also like to thank the University of Nebraska for hosting the IMMERSE program, the NSF for supporting it (DMS-0838463), Tom Marley for directing it the summer of 2010, and Cal State East Bay for giving me the chance to teach the course again. Finally, I would like to thank my husband, Aaron, for his love, support, and advice.

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WHAT IS...

a Scissors Congruence?

Johan L. Dupont

Two polyhedra in Euclidean 3-space are called *scissors congruent* (s.c.) if they can be subdivided into the same finite number of smaller polyhedra such that each piece in the first polyhedron is congruent to one in the second. If two polyhedra are s.c., then they clearly have the same volume; and for the analogous notion of s.c. in the plane, it was probably known already by the Greeks that two polygons are s.c. if and only if they have the same area. However, based on some remarks in a letter by C. F. Gauss (1844), D. Hilbert included on his famous list of mathematical problems (1900) the question of finding two polyhedra of the same volume that could be proven *not* to be s.c. This is Hilbert's 3rd problem, and it was solved by M. Dehn (1901), who found a necessary condition for two polyhedra to be s.c. that he showed was not satisfied for the cube and the regular tetrahedron of the same volume. Finally, J. P. Sydler (1965) showed that equal volume together with Dehn's condition are also sufficient for s.c. of two polyhedra in Euclidean 3-space.

The notion of s.c. of *polytopes* makes sense in all dimensions, as well as in *spherical* or even *hyperbolic* geometry. As a model for hyperbolic n-space $\mathcal{H}^n$ we use the upper half space in $\mathbb{R}^n$, consisting of points whose last coordinate is positive, and in this model hyperbolic *lines*, *planes*, etc., are Euclidean half circles (or lines), half spheres (or half planes), etc., perpendicular to the boundary. Now a polytope in Euclidean ($\mathbb{R}^n$), spherical (S^n), or hyperbolic n-space ($\mathcal{H}^n$) is a compact body that can be decomposed into finitely many *simplices*. In turn, a simplex is the intersection of $n+1$ half spaces whose boundaries are in general position. Thus we have the Generalized Hilbert 3rd Problem (GH3) of finding necessary and sufficient conditions for two polytopes in $X = \mathbb{R}^n, S^n$ or $\mathcal{H}^n$ to be s.c. For this problem one introduces an abelian group, the s.c. group $\mathcal{P}(X)$ consisting of finite formal sums of symbols $+[P]$ or $-[P]$ for P any polytope of X, subject to the relations (i) $[P] = [P'] + [P'']$ if P decomposes into P' and P'', (ii) $[P] = [gP]$ if g is an isometry of X. In these terms the above problem is to find (computable) invariants like the volume and to show that two polytopes are equivalent in $\mathcal{P}(X)$ if and only if they have the same invariants. For example, "volume" (or "area" in dimension 2) gives rise to a homomorphism V_X from $\mathcal{P}(X)$ to the reals $\mathbb{R}$. Dehn's condition can be expressed by another homomorphism, the *Dehn invariant* from $\mathcal{P}(\mathbb{R}^3)$ to another abelian group, the *tensor product*, consisting of finite formal sums of symbols $l \otimes v$, where l and v are respectively a real number and a real number modulo 1 and where the tensor symbol is additive in both variables l and v. Then the Dehn invariant for a polyhedron P is defined by the sum of tensors $l \otimes v$ for all edges of P, where l, respectively v, is the *length* of the edge, respectively the *dihedral angle* at the edge, divided by 2π. Thus Sydler's theorem just states that two polyhedra in $\mathbb{R}^3$ are s.c. if and only if they have the same volume and Dehn invariant. A similar result in dimension 4 was shown by B. Jessen (1972). But in higher-dimensional Euclidean spaces the GH3 is still open.

The interest in s.c. has gradually increased since it was noticed about thirty years ago that

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the s.c. group $\mathcal{P}(X)$ is closely related to the *homology groups* of the isometry group for the geometry of X as a discrete group. In fact, GH3 is related to difficult problems in homological algebra and algebraic K-theory. In the following we shall concentrate on the cases $X = S^3$, respectively $\mathcal{H}^3$. Again, in these cases the Dehn invariant is a well-defined homomorphism, and its kernel is the 3rd homology group of the orthogonal groups O(4), respectively O(1,3). Hence GH3 in these cases is equivalent to calculating the homology groups of these Lie groups as discrete groups. Taken together, the s.c. groups for S^3 and $\mathcal{H}^3$ have a simple algebraic description as follows: Let $\mathcal{P}_{\mathbb{C}}$ be the abelian group consisting of formal sums of symbols $+[z]$ or $-[z]$, where z is a complex number different from 0 and 1 and subject to a certain 5-term relation for each pair of distinct such numbers. Now consider the involution t given by complex conjugation of the symbols. Then $\mathcal{P}(\mathcal{H}^3)$ is isomorphic to the subgroup $\mathcal{P}^-$ of elements x satisfying $t(x) = -x$, and $\mathcal{P}(S^3)$ is essentially isomorphic to the subgroup $\mathcal{P}^+$ of elements x satisfying $t(x) = x$. Geometrically, if we use the upper half space model for hyperbolic 3-space with the Riemann sphere $\mathbb{C}\cup\infty$ as boundary, then each symbol $[z]$ above corresponds to a hyperbolic tetrahedron with vertices $(\infty, 0, 1, z)$. In fact, it is well known that any 4-tuple of points on the Riemann sphere can be brought into this form by the action of a *Möbius transformation*, i.e., a map that extends to an isometry of hyperbolic space. In these terms the above-mentioned 5-term identity corresponds to the following s.c.: Consider a 5-tuple (u, v, w, x, y) of points on the Riemann sphere. Then the union of the two hyperbolic tetrahedra (u, w, x, y) and (u, v, w, y) can be decomposed into the three tetrahedra $(v, w, x, y), (u, v, x, y), (u, v, w, x)$ (cf. the schematic description in the figure). The relation to spherical geometry is more indirect, and we shall not go into that. Now, if we consider $\mathcal{P}_{\mathbb{C}}$ as the sum of $\mathcal{P}^+$ and $\mathcal{P}^-$, then the two Dehn-invariants together define an invariant for $\mathcal{P}_{\mathbb{C}}$, which has a simple algebraic description in terms of the symbols $[z]$, and the kernel is the 3rd homology group of the group $\mathrm{Sl}(2, \mathbb{C})$ of 2×2 matrices of determinant 1, i.e., the group of Möbius transformations mentioned above.

Using the algebra of $\mathcal{P}_{\mathbb{C}}$, one can prove that it is a *divisible group*; that is, for every integer n and element x there is a y such that $x = ny$. Hence the same thing is true for the s.c. groups; i.e., any spherical or hyperbolic polyhedron can be subdivided into n s.c. pieces. For $n = 2$, this is true in all dimensions and all three geometries by a direct geometric construction often attributed to C. L. Gerling, a contemporary of Gauss. Another

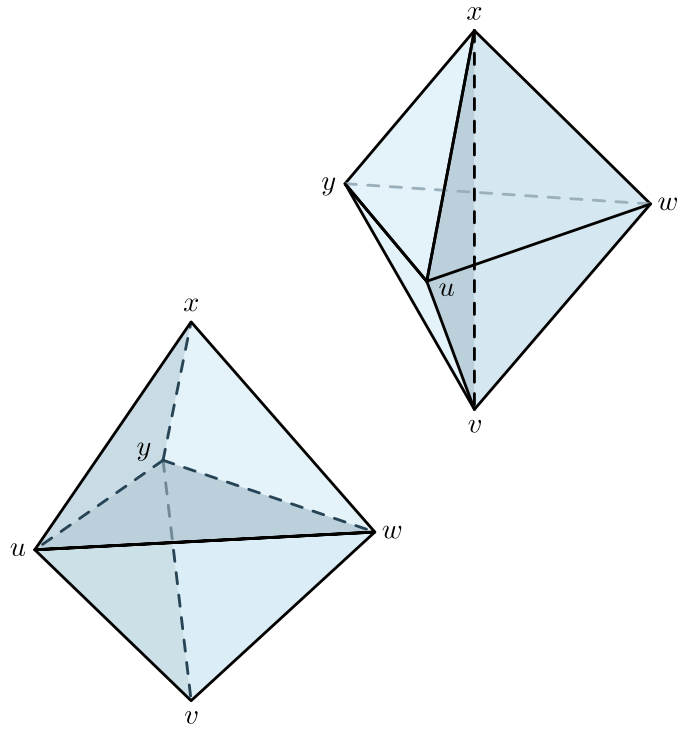

Figure 1. Two schematic decompositions of the polytope *uvwxy*.

consequence is that the 3rd homology group of $\mathrm{Sl}(2, \mathbb{C})$ as a discrete group is also divisible. This originally gave the first nontrivial example of the so-called Friedlander-Milnor conjecture, which essentially determines the homology of a Lie group as a discrete group except for components that are rational vector spaces. The latter, however, can be rather large. Now this conjecture has been proved in many cases and is a subject of current investigation.

Furthermore, if we let V_S, respectively V_H, denote the volume homomorphism for S^3, respectively $\mathcal{H}^3$, then $C = V_S + iV_H$ gives rise to a well-defined homomorphism of the homology group to the complex numbers modulo the integers: the *characteristic homomorphism* in the sense of Cheeger-Chern-Simons. In terms of the symbols $[z]$ above, this is essentially given by the *dilogarithmic function*, which is an integral of $\log(1-z)/z + \log z/(1-z)$ and which respects the 5-term defining relation for $\mathcal{P}_{\mathbb{C}}$. Some general further relations for this function involving a pair of Dynkin diagrams, which were conjectured by the physicist A. B. Zamolodchikov, have recently been proven by B. Keller and others using quivers in representation theory. Thus questions related to s.c. occur in many different areas of mathematics, particularly in algebra, geometry, and number theory.

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As an example of an application of the theory of arithmetic groups to s.c., let us mention that, by some theorems of A. Borel (1977), it follows that if one restricts to spherical or hyperbolic polyhedra with vertices whose coordinates are algebraic numbers, then two such P and P' are s.c. if and only if (i) P and P' have the same volume and Dehn invariant, and furthermore (ii) $V_H \circ A_*([P]-[P']) = 0$ for all field automorphisms A of the complex field, where A_* is the induced map on $\mathcal{P}_{\mathbb{C}}$ given by applying A to each symbol. This result is of particular interest in the theory of hyperbolic manifolds, since a *fundamental domain* in this connection is a hyperbolic polyhedron with algebraic vertices. Surprisingly, it also has applications in the spherical case. Thus one can give infinitely many concrete examples (see [1, Thm. 11.19]) from which it follows that one of the following natural conjectures cannot be true: (1) (Jessen) Volume and Dehn invariant determine s.c. for spherical polyhedra, (2) (Schläffli), (Cheeger-Simons) A 3-dimensional spherical simplex with all dihedral angles being rational multiples of π has volume a rational multiple of the volume of S^3 (i.e., $2\pi^2$). The first conjecture is motivated by the Euclidean case, the second by the analogous fact for areas of spherical triangles and by a few cases for which the volume is actually known and which satisfy the conjecture for trivial reasons. However, it follows that at most only one of these conjectures can be true.

References for Further Reading

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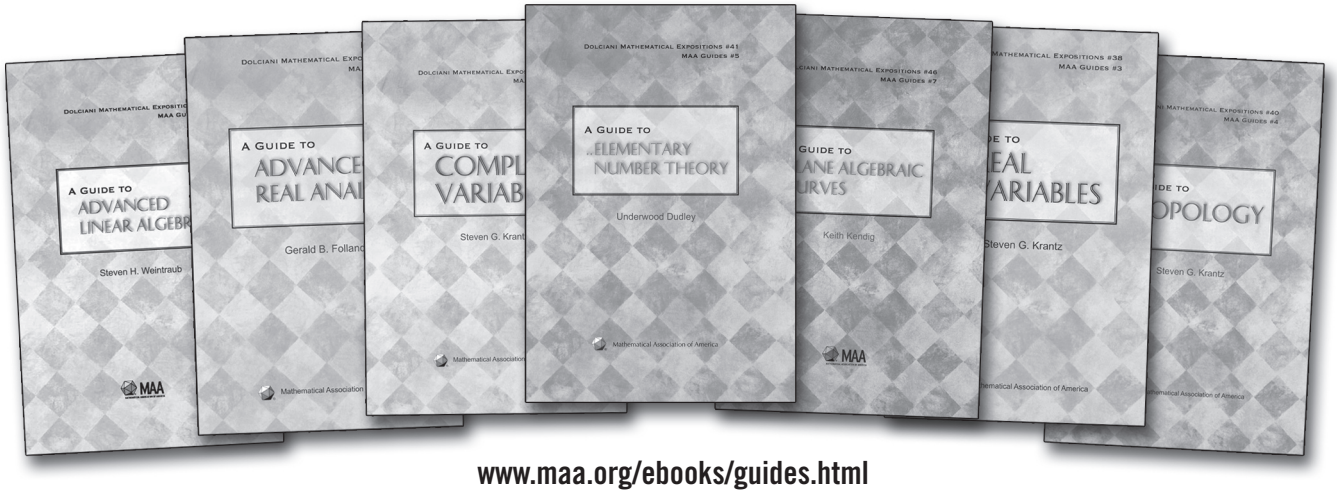

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Interdisciplinary Research—Mathematical Interactions Viewed from Four Portrayals

Goong Chen

Introduction: Interdisciplinarity with Mathematics

You've been approached by a colleague from the college of agriculture at your university, asking you to help solve a mathematical problem. You've pondered curious problems from engineering, physics, chemistry, biology, or social sciences and wanted to delve deeper into them. You've read calls from funding agencies inviting mathematicians' participation, and suddenly someone from another department of your university is organizing a drive to submit a group proposal and is giving you a cold call to solicit your input and cooperation. He is also promising a share of summer grant support for you if the proposal is funded.

Do any of the above situations sound familiar to you? If not, then you will surely encounter these scenarios more and more in the future. We are living in an ever more complex world. Interactions among mathematicians themselves and, more importantly, engagements between mathematicians and those in other disciplines are on the rise. Interdisciplinary research involving mathematics almost inevitably is becoming the trend, as the *universality* of mathematics can be felt in so many different forms. A quick survey of several major contemporary research themes shows what relevant disciplines are involved and where mathematical components are either present or in demand:

(A) *Bioinformatics*: biology, computer science, probability and statistics, medicine, systems theory, combinatorics, optimization, . . . ;

(B) *Nanotechnology*: physics, chemistry, electrical and chemical engineering, mathematical analysis, . . . ;

(C) *Genomics*: genetics, molecular and cell biology, biochemistry, scientific computing, . . . ;

(D) *Proteomics*: pharmaceuticals, biology, chemistry, physics, scientific computing, . . . ;

(E) *Conflict and resolution*: sociology, psychology, political science, game and control theory, stability and chaos, . . . ;

(F) *Homeland security and the war on terrorism*: engineering, cybernetics, finance and banking, cryptography, social sciences, linguistics, search algorithms, tomography, mathematics in general, . . . ;

(G) *Renewable energy technology*: engineering, physics, chemistry, fluid dynamics, computational mechanics and mathematics, . . . ;

(H) *Climate change and global warming*: atmospheric science, chemistry, physics, oceanography, glaciology, forestry, soil science, mathematical modeling, ...

According to a 330-page government- and industry-commissioned report published by the National Academy Press [2], a definition is given as follows:

> Interdisciplinary research (IDR) is a mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of

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specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice.

Clearly, the topics listed in (A)–(H) must be administered in such a way as to achieve success. Interdisciplinary research necessarily is the only way that scientists, mathematicians, engineers, and social scientists can collectively contribute and share their different specialized perspectives, knowledge, and skills to address wide-ranging issues and attack pressing real-world problems that no single discipline alone can resolve [1]. New opportunities are constantly emerging for mathematicians to participate in interdisciplinary research.

The conduct and management of interdisciplinary research can be coarsely divided into three classes according to their scales:

(i) *Macro-scale*: A project on the national scale requiring great commitment of resources. An example is the Manhattan Project, which was imperative for a wartime nation, or a mission to the moon.

(ii) *Meso-scale*: Interdisciplinary research activities conducted at the levels of universities, colleges, institutes, departments, commercial companies, etc., where hirings of clusters or mission-/objective-oriented team formations are made, often driven by funding, budget availability for interdisciplinary research support structures, or the development of targeted products.

(iii) *Micro-scale*: Interdisciplinary research activities conducted by just a few individuals, based on necessity or otherwise simply out of curiosity.

There exists a large amount of literature on interdisciplinary research, for instance articles [3, 4, 7, 8, 9, 10, 11], where interested readers can see the effects and benefits of, barriers to, funding for, and management and educational programs of interdisciplinary research. Most of them deal with macro- and meso-scale interdisciplinary research, especially the latter. There are now many mathematical science institutes in the United States and the rest of the world where activities in applications of mathematics and interdisciplinary research are bustling. This marks a significant change and progress over two decades ago. Even so, at the most fundamental level, interdisciplinary research still depends on *interactions between individuals* regardless of whether the actions take place within or outside any academic institute or program. For this reason, the author is writing this essay on interdisciplinary research in narrow mode, only at the micro-scale (iii) level. It was meant to be written in a narrative manner in the hope of conveying and sharing some real sense and experience rather than the abstract notion of what "interdisciplinary mathematical research" is about. The author considered making the presentation in anonymous, third-person form in order to minimize any egocentric tendency, but had to give up that when faced with the need to cite pertinent references wherein his name appears as coauthor. In what follows, the author will revert to the first person "I". I write about my life-changing personal experiences in working interdisciplinarily, viewed through the portrayals of four outstanding collaborators. This article is not about me—rather, it is about collaboration in practice in which I was an active participant. I beg the reader's understanding in advance.

During my career as an applied analyst and applied mathematician, I have worked with many researchers outside mathematics. Many of my papers are not published in traditional mathematics journals. For example, only about 75 percent of my papers/books are listed in MathSciNet of the American Mathematical Society. I am guessing that the reason for this is that many of my papers were published in engineering, physics, and chemistry journals. Owing to my strong personal interests in various problems originating from engineering and science, I have a good number of collaborators who are not mathematicians by discipline. In the following four sections, I describe my work with four of these collaborators as some of the highlights.

Dr. Philip J. Morris, Aerospace Engineer

In the late 1970s I was just a young assistant professor teaching in the math department of Penn State University, whose engineering college has a strong reputation. I was assigned to teach graduate-level numerical analysis courses annually. I noticed that in my classes there would always be a number of high-quality graduate students from the aerospace engineering department. Pretty soon I learned from them that they were sent to take my course by their advisor, Dr. Morris.

Dr. Morris was an associate professor of aerospace engineering at that time, six years my senior. His specialties are aeroacoustics, turbulence modeling, and computational fluid dynamics (CFD). As with many engineering faculty and scientists from western Europe, his mathematical background is strong. Even though occasionally he joked about mathematicians' obsession with rigor and proofs, he really cared about mathematics, whether theoretical or numerical. Dr. Morris confided that actually he had never taken a graduate class in math; in retrospect, he believes that he would have benefitted very much, and this is why he encourages his graduate students

to take as much applied mathematics as they can fit into their schedules.

One amusing story comes to mind when reminiscing about one of his graduating students in a Ph.D. defense exam. I asked that student, "What is the definition of a Hilbert space?" The student staggered. Dr. Morris came to the rescue by saying that he thought that the Hilbert space was the office occupied by Professor David Hilbert at Göttingen.

Dr. Morris has written many numerical subroutines and software for the computation of aeroacoustic and fluid fields. His designs of such algorithms are rather ingenious and elegant, featuring high-order asymptotic and perturbation expansions and Gaussian quadratures. Over his career, he and his graduate students have produced and accumulated a large amount of such custom-designed numerical software. Many of his subroutines have required long periods of development and have the capability to predict jet or underwater acoustic fields. Dr. Morris's personal stockpile of aeroacoustic numerics probably is the largest in the world. He does not do classified research, but he does need to be aware of ITAR (International Traffic in Arms Regulations) issues regarding the usage of his code by non-U.S. persons in order to safeguard U.S. national security and to follow the U.S. Arms (and Technology) Export Control Act.

Dr. Morris has always been rather generous toward me regarding the usage of his numerical software. During that time, my collaborator, Dr. Jianxin Zhou, and I spent a good deal of time developing *boundary element methods* (BEM) for numerical solutions of PDEs. In the process, the numerical quadrature and approximations of special functions such as Bessel, Hankel, Mathieu, Struve functions, etc., are needed. With invaluable help from Dr. Morris and a couple of his Ph.D. students, Dr. Zhou and I were able to develop boundary element numerical schemes of high accuracy. Our efforts in this direction came to fruition in the publication of a BEM book (Chen and Zhou [12]) by Academic Press in 1991. This book was further revised and expanded to include some nonlinear equations. Its new edition was published in 2010 by Atlantis Press [13].

Dr. Morris and I—sometimes together with his Ph.D. students—have written about half a dozen papers. In one of the papers, ideas from BEM were used in the calculation of jet noise. He listed me as a coauthor. The paper later won an American Institute of Aeronautics and Astronautics (AIAA, the professional society for aerospace engineers) Best Paper Award at the AIAA 12th Aeroacoustics Conference in San Antonio, Texas, in 1994. I must confess that my contributions to that paper were minimal.

Dr. Morris does extensive consulting for industry and government. He regularly attends panel meetings and reviews at NASA, DOD, and DOE labs. He also visits the General Electric, Pratt & Whitney, and Rolls Royce jet engine divisions in order to talk with factory technical staff and management. One day, he asked me to help him to review the mathematics portion of a European engineering research proposal related to the liquid fuel-sloshing motion in a satellite. This was a new experience, as I had never dealt with any "real-world" research problems in applied math. I tried to read carefully the fluid-dynamic partial differential equations and the proposed numerical schemes, and managed to write a page of comments as a review report for Dr. Morris. In reflection, I must again confess that I probably did not do a first-rate job, as the only things I knew up to that time were textbook derived. A week later, Dr. Morris submitted his review report to the soliciting European agency and an honorarium check followed, which he generously shared with me for my services. I asked him what the recommendation and conclusion of his review report was. He said that the *mathematical model of the fuel-sloshing motion is incorrect*. Therefore, the proposal had to be rejected or significantly modified. I kicked myself for not having discovered this fundamental point. But in my own defense, during that time (the early 1980s when this event took place), mathematical modeling was not yet the focal topic in applied math that it is today. Applied mathematicians in that era tended to study whatever problems, in formulated form, were given to them. That explained and led to my failure to scrutinize a most fundamental issue of the correctness of the modeling PDEs. Dr. Morris himself obviously knew the fuel-sloshing motion well, but as far as the instability of sloshing fluid motion in a satellite fuel tank is concerned, he was further aided at that time by a Ph.D. student, Thomas J. Bridges, who had studied such a research problem quite carefully elsewhere three years before. Bridges's insights and input helped Dr. Morris to discover the deficiency of the proposal's mathematical model. Bridges also shared part of the consulting fee from Dr. Morris. I have written a couple of joint papers with Dr. Bridges, who later became an applied mathematician (but his Ph.D. degree was in aerospace engineering) and has made a brilliant mathematical career for himself.

I left Penn State University in 1987. Within a couple of years, Dr. Morris was given the prestigious endowed Boeing/A.D. Welliver Professorship at Penn State's aerospace engineering department, a position that he continues to hold to this day.

After my departure, the spatial separation has diluted our opportunities to interact closely for more than two decades. But two years ago we again found common interest, this time in wind energy research, so he and I joined forces on writing research proposals. This year (2012), we again wrote several papers together. Even if funding for those proposals is not successful, we still plan to write a couple of joint papers together on the basis of our recently renewed discussions.

Dr. Marlan O. Scully, Physicist

Dr. Scully is eleven years my senior. He is an accomplished physicist with whom I became acquainted through the introduction of a mathematical physicist colleague, Dr. Stephen A. Fulling, in my math department at Texas A&M. When I first met him during the mid/late 1990s, Dr. Scully held a membership in Academia Europaea (The Academy of Europe). A few years later he was elected a member of the U.S. National Academy of Sciences.

Dr. Scully comes from an outstanding physics lineage. His academic great-grandfather is Max Born. (Max Born wanted to study mathematics under David Hilbert at Göttingen, but Hilbert soon recognized that Born had even greater talent in physics, so Hilbert advised Born to take up physics instead [16]. Born's doctoral dissertation was supervised by Carl Runge of Runge-Kutta fame, and Born won the 1954 Nobel Prize in physics (shared with Walther Bothe).) Dr. Scully's academic grandfather and father are, respectively, J. Robert Oppenheimer and Willis Lamb. Lamb shared the Nobel Prize in physics in 1955 with Polykarp Kusch. Dr. Scully has written many joint papers with Nobel physics winners: Glauber, Lamb, Schwinger, Townes, etc. Dr. Scully founded the Institute for Quantum Science and Engineering (IQSE) on campus. IQSE has hosted many Nobel physicists. I often wonder if I may be the mathematician who has shaken the hands of the most Nobel physicists through my affiliation with IQSE.

Dr. Scully has a great love for physics. He also has great respect for mathematics, for the useful role that mathematics plays in physics. He often evaluates complex contour integrals himself and challenges me. (Remember those real or complex improper integrals requiring the choice of special infinitely long paths and residue evaluations?) He once claimed that about 60 percent of the mathematics used in physics involves asymptotic or perturbation expansions and estimates. These are obviously his favorite mathematical topics and tools. The only reservation he has about mathematics, however, is that he said he would never read any math papers containing backward E's ($\exists$) and upside down A's ($\forall$). I retorted that those are merely the mathematician's way of simplifying repetitive wordings. If you insist on writing mathematics in a cumbersome way, I laughed, nobody can stop you.

Dr. Scully prefers the *group mode of operation*. When promising new topics emerge or when he or his collaborators encounter technical difficulties, he will call a group meeting of faculty, visitors, postdocs, and Ph.D. students. This sometimes numbers thirty people or more. At such group discussions you are witness to many anecdotes, hunches, critiques, pro and con arguments back and forth, much of which cannot be found anywhere in textbooks or the literature. It is very hard for one not to be stimulated. There is often pizza, sandwiches, or BBQ catering. Such meetings can last several hours.

One of the first research activities I participated in was a research project on *quantum computing*. Dr. Scully would ask people to give tutorials on this subject at a rather rudimentary level so that even "dummies" could understand. He then would hand out organized notes or relevant papers for every participant to read. Further, a set of new problems or assignments was distributed to the group, and the next meeting would be called the following day if he was not travelling.

This is a highly effective way of conducting physics research, where the timing and speed of research publication is everything. For physicists, there is really a sense of urgency permeating the atmosphere. Stress seems to be inevitable. Postdocs and Ph.D. students were chewed out if no good results were produced overnight. Conversely, anyone having made significant progress would be lavished with praise. He occasionally also called me at home late in the night to discuss problems or to check on progress.

A $2M federal funding grant for five years to support quantum computing research for this group came through from DARPA, of which I was a member. Even though my summer salary in that grant was only budgeted for one month per year, Dr. Scully was very generous and actually provided me with three months of summer salary per year by supplementing from his other funding for two years in a row. Those were very successful years for securing funding in his career, and I benefitted from riding his coattails. Through group meetings, workshops, and semiannual reviews by the funding sponsors, and also through my interactions with him, his group, and his and my own Ph.D. students, I gained a substantial knowledge and understanding of quantum computing as well as of quantum mechanics in general. The cumulative outcome of this research support on quantum computing was that I managed to get about a dozen papers published, a U.S. patent approved, and a monograph on *quantum computing devices*

(Chen, Church, Englert, Henkel, Rohwedder, Scully, and Zubairy [14]) published, which was the first monograph on this topic.

The domestic terrorism due to the mailing of white anthrax powder and the resulting fatalities generated considerable fear in homeland security. Dr. Scully, as a laser physicist, understood that an ultrafast laser application, called FAST CARS (*femtosecond adaptive spectroscopic technique for coherent anti-Stokes Raman spectroscopy*), could be useful. Nevertheless, in order to pursue this research, he needed to develop an even deeper understanding of chemical physics and physical chemistry (ChemPhysChem). So, during the summers of 2003 and 2004, he essentially stopped all of his summer travel and stayed home to work with his collaborators, Ph.D. students and postdocs, including me, on ChemPhysChem. We carefully went through the hydrogen atom and molecules, spins and symmetries, molecular bonds and orbitals, electronic structures, numerical modeling of simple bonds and calculations, etc. There was barely a summer day when I was at leisure for nonacademic recreation. At the end of summer 2004, I felt that I had learned a lot about ChemPhysChem (as a mathematician). A major outcome of the two summers of work was a long (145-page) article in [15], for which I was the lead author, although my role was somewhat like that of scribe and editor in putting that work together.

One of the easiest places to catch Dr. Scully is in the hallway of the physics building, where he can be seen discussing problems with his associates almost all the time. The stunning intensity and vigor with which he works are unrivaled among us. It is a joy to work with a genuine lover of physics and mathematics like him.

Dr. Zhigang Zhang, Former Control Engineer

I met Mr. Zhang for the first time in 2000 when I attended an engineering conference at the University of Science and Technology of China (USTC) in the city of Hefei, China. USTC is one of the leading technological universities in mainland China. Mr. Zhang served as my local host at the conference. He was a lecturer in the Department of Automatic Control Engineering at USTC, with a master's degree. He had been teaching at his alma mater for several years already.

In China the existence of automatic control engineering departments is still quite common even today, although in the U.S. automatic control engineering is just a part of the electrical engineering department. In control engineering papers (such as those published in *IEEE Transactions on Automatic Control*), the use of graduate-level operator theory, semigroups, and functional analysis is widespread, so that authors are usually quite well equipped with sound training in the core curriculum of graduate-level mathematics.

I propositioned Mr. Zhang that I would be happy to recruit him to study for his Ph.D. with me in the math department at Texas A&M. He gladly agreed. Within a few months, a graduate assistantship from our Math Department was successfully arranged. So he came.

Mr. Zhang said he experienced "culture shock" while in graduate study at the math department of Texas A&M University when he first came. But he studied well and, within two years, he passed the three qualifying exams—all in one try. (Our failure rate is actually quite high.) So he began to do research and wrote his dissertation.

During that period I was heavily involved in research on quantum computing and chemical physics. Mr. Zhang had solid training in atomic physics as well as in electronic and computer circuit design, so he readily provided help whenever I encountered difficulties in trying to understand physics, chemistry, and computing in my own work. To further prepare his interdisciplinary training, I advised him to take "quantum optics" graduate courses in the physics department and to take molecular computation training offered by the chemistry department. Mr. Zhang did marvelously well in those courses and training. He then tutored me whenever and wherever I needed help. He was one of the Ph.D. students who assisted me most during that period of my career. He was my tutor and study pal.

Upon graduation in 2006, Mr. Zhang became Dr. Zhang. He and I have collaborated on more than half a dozen papers, most of them related either to quantum computing or to atomic/molecular mathematical physics. Dr. Zhang subsequently did postdoctoral work for five years at the University of Houston. He is now working for a consulting company in Houston.

I have directed a total of four Ph.D. students whose undergraduate majors were not math. Doing a math Ph.D. may not have been their #1 choice—as, for example, in Dr. Zhang's case—as it would have been quite difficult for him to secure a graduate assistantship from an electrical engineering department in the United States. But he excelled in studying math at Texas A&M, and he, in turn, helped my own interdisciplinary research.

This is also a great opportunity for me to thank the Graduate Studies Committee of Texas A&M University's math department for their financial support of several Ph.D. students that I have recruited.

Dr. Dudley Herschbach, Chemist

Dr. Herschbach is a legend. He grew up in a blue-collar family near San Jose, California, and nobody else in his family had ever attended college. His father was a contractor who later turned to rabbit breeding. When Dr. Herschbach was young, he helped out the family by working after school. He recalled that the San Jose area used to have many orchards, and he spent summer months picking fruit in order to help with the family's income. But, since childhood, he had always loved science. Many nights he would climb trees to gaze at the stars. He was tall and athletic. He excelled in sports in high school. Upon graduation, he was offered two scholarships: one football and one academic at Stanford. He chose the latter, as the stipends were slightly more generous. (Nowadays, the opposite is mostly true: athletic scholarships are much more generous than academic scholarships.) He played the position of right end for the Stanford Indians (now called the Stanford Cardinal).

At Stanford, Dr. Herschbach studied earnestly in addition to playing football. He loved math and chemistry. He told me that he enjoyed the teaching of Pólya and Szegő in the math department so much that he loaded up his curriculum with the courses taught by these two math professors. After the end of his freshman year, Dr. Herschbach told his football coach that he would be quitting the team. His coach was quite shocked that he would give up the potentially lucrative career of a football player to do something else. Notwithstanding, Dr. Herschbach still received an invitation to try out for the Los Angeles Rams; he declined.

Dr. Herschbach's own higher-education training exemplified interdisciplinarity: he earned a B.S. in mathematics in 1954 and an M.S. in chemistry in 1955, both from Stanford, and an M.A. in physics in 1956 and a Ph.D. in chemical physics in 1958 from Harvard. (Today, the divisions and specializations of various disciplines in science and mathematics are far deeper and wider than they were half a century ago, so that it would be virtually impossible to accomplish such a feat, even for a bright soul, without overtaxing him/herself. Dr. Herschbach is one of the very few I know of who hold such diverse advanced degrees.) Afterwards, he taught at Berkeley and then returned to Harvard. Still in his early thirties, he was elected to the National Academy of Sciences. He received a Nobel Prize in chemistry when he was in his mid-fifties. His nature is cheerful and unassuming. When one expresses admiration for his brilliance and Nobel stature, his "standard" response is always, "It was unintended." Dr. Herschbach has written over four hundred papers. His writings are characterized by the use of sophisticated mathematics, far exceeding the norm in chemistry. It is evident that mathematics has exerted a great influence on the thinking, reasoning, and style of his research. He is also a poet. He read a few of his poems to us, and they sounded quite fun. I once wrote an article and put his name down as a coauthor, hoping that he would consent. He offered many helpful and valuable ideas. He also helped to edit it. When I incorporated the changes he suggested in key words and sentences, the article's literary quality was dramatically improved. However, he adamantly refused to be listed as a coauthor, and, much to my dismay, I had to remove his name.

Dr. Herschbach was hired from Harvard by Texas A&M in 2005 through the efforts of Dr. Scully (from above) in order to further strengthen the research in chemical physics at TAMU. His arrival on campus has spurred new and greater activity in this direction at the Institute for Quantum Science and Engineering. Dr. Herschbach has given us periodic lectures as well as small group tutorials on dimensional scaling (D-scaling) methods in chemical physics, for which he is a founder. This method was first suggested by G. 't Hooft (Nobel Prize in physics, 1999), motivated by quantum chromodynamics and discussed by E. Witten [17]. It embeds a quantum particle from space dimension 3 into space dimension N and lets N tend to infinity. It is rich in mathematical subtleties related to the multiparticle Schrödinger equation and is powerful and challenging. He pointed out to me that the *singular perturbation procedures* therein require rigorous mathematical justification. Under his tutelage, my collaborators and I have succeeded in justifying some of the D-scaling procedures for special cases of the hydrogen atom and the power-law potentials [5], [6]. The general cases are definitely far more challenging and will likely take a long time to resolve.

So far, I have coauthored two papers with Dr. Herschbach [5], [18]. I cannot equate the coauthorship with being an intellectual equal of his on the topic of chemical physics. I think of it as doing an *apprenticeship* with him, because he has taught me so many things that I cannot learn anywhere else, just like the apprenticeship that I did under Dr. Scully.

Dr. Herschbach has just celebrated his eightieth birthday (2012). He continues to do research. He is also active in science education, arms control and nonproliferation, peaceful negotiations between the Israelis and Palestinians, and other areas. For me, I hope that there will continue to be many opportunities to study with him and to write more joint papers.

Concluding Remarks

It is the author's great fortune to have met so many wonderful collaborators, mathematicians, and interdisciplinarians alike in his career so far. It is fun to collaborate, learn, and get help from your partners and expedite research work. Indeed, in a collaboration of any kind, whether inter- or intradisciplinary, we benefit from our partners. Nevertheless, I am inclined to feel that such benefits appear greater in interdisciplinary research, as we need more help and guidance when we enter large, uncharted territories that are outside our traditional disciplinary zone of comfort, given the condition that our interdisciplinary research collaborators can always be standing by, just an email or a phone call away, to offer assistance.

Interdisciplinary research is a two-way street: we take and we give. Again, from the stories I have told above, I have been blessed by the generosity of my interdisciplinary research mentors, colleagues, and students. Even though I always try to reciprocate in kind, I am not sure if I have indeed paid back enough.

I also have had a few interdisciplinary research endeavors that went nowhere. There were several reasons, I believe, why they did not succeed:

(a) The problem selections and objectives were not sharply delineated at the outset. Oftentimes, envisioned approaches did not pan out. Directions of work were constantly shifting, causing confusion and discontinuities. Initial excitement dwindled with time, while no new enthusiasm emerged.

(b) The problem scope was large and the target ambitious. Much manpower was needed, yet there was no funding to get things off the ground or no way to find partners with the desired specialties or strong commitment.

(c) For *new* potential partners, sometimes close rapport and confidence could not be built or made to last. Personality mismatch can be a big turnoff. Fighting for/over individual credits and authorship rankings should be taboo. I tend to go straight to those who are my long-time friends for help.

(d) I cannot commit enough time and energy to satisfy the needs of many new projects due to other pursuits and daily pressing duties.

Despite certain failures, I rate my own past interdisciplinary research as happy and successful. Through collaborations with my interdisciplinary research partners, I have been able to achieve many successes, far outnumbering the failures. Their contributions have helped to steer the directions of my research and also shape what I am today. It has been, and continues to be, a unique, life-enriching experience.

Acknowledgments

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Book Review

Our Days Are Numbered: How Mathematics Orders Our Lives

The Big Questions: Mathematics

Reviewed by Paul Zorn

Our Days Are Numbered: How Mathematics Orders Our lives
Jason Brown
Emblem Editions
US$16.95, 298 pages
ISBN-13: 978-0771016974

The Big Questions: Mathematics
Tony Crilly
Quercus
US$8.50, 208 pages
ISBN-13: 978-1849166102

Neither of these two good books is—if Amazon popularity rankings are any guide—a big seller. Both rank in the vicinity of *Framley Parsonage* (1861), fourth in Anthony Trollope's six-novel series on Barsetshire life. Countless novels of zombie "life", for that matter, lead our books by wide margins. Both of these books deserve better.

These are refreshingly sunny-minded books. Both authors write in a friendly, easygoing style, emphasizing not just mathematics' usefulness but also its intrinsic interest. And neither author has mathematical or educational axes to grind. Both are more in love with mathematics than angry at Philistines who may dislike or ignore the subject. There is no railing against "innumeracy", poor mathematical pedagogy, unreadable textbooks, or the iniquities of those who would prescribe (or proscribe) technology in mathematics education. Both books are, in quite different ways, about "pure" mathematics: its importance, its usefulness, its interest, its hypnotic allure to "us", and its downright coolness. "Isn't this interesting? Let me show you (a little) more" is the unspoken but constant authorial aside.

Readers are neither assumed to have much mathematical background nor expected to work unduly hard to read either of these books. Few if any calculations are "left to the reader". Mathspeak—"clearly", "it can be shown", "*mutatis mutandis*"—is wholly eschewed. What *is* assumed, especially by Crilly, is some intellectual curiosity, not just about what mathematics does but about what it is.

On the face of it the books address, and will probably attract, nonspecialist but quite different audiences. Brown begins, for instance, with the arithmetic of recipe-scaling, while Crilly gets quickly to Babylonian and Egyptian number systems. But both books make similar intellectual demands on the casual reader, and both contain things completely new or at least unfamiliar—if

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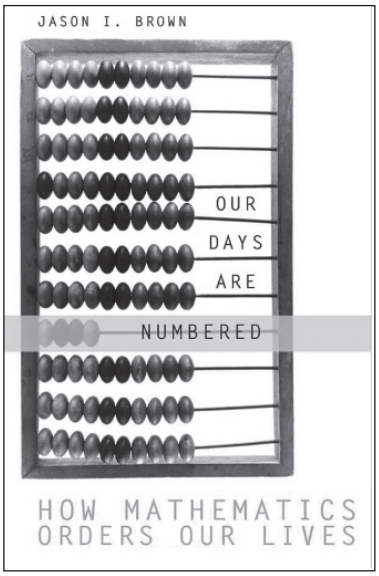
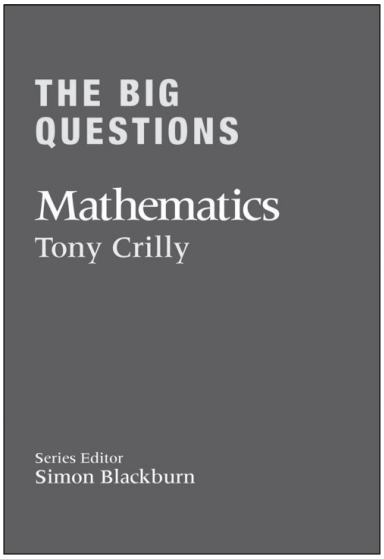
this reviewer is typical—even to grizzled veterans. Most of us veterans, after all, have served in only a few mathematical campaigns on a much broader front.

I've "always known", for instance, some basics concerning Euclid's parallel postulate, various doomed efforts to deduce it from simpler axioms, and where Bolyai, Lobachevsky, and Riemann took these ideas. But I learned reading Crilly that it was John Playfair in 1795 who reformulated Euclid's 5th postulate more directly in terms of parallel lines and that Giovanni Saccheri's early eighteenth-century experiments with non-Euclidean thinking began almost a century earlier. And I learned from Brown about Stein's paradox in statistics, which asserts that three or more parameters, say, long-term batting averages of several players, are better estimated together than separately. Other readers, of course, may know these particular things well but learn something else.





The Big Questions: Mathematics

Tony Crilly is Emeritus Reader in Mathematical Sciences at Middlesex University in England. His book is one in a series of volumes titled *The Big Questions: X*, where *X* may denote, among other choices, Mathematics, Philosophy, Physics, God, and (biggest of all) The Universe.

Every chapter title is one of the advertised big questions. Here are a few of the twenty: What is mathematics for? Is it true? Where do parallel lines meet? What is the mathematics of the universe? What shape is the universe? Can we create an unbreakable code? Is there anything left to solve? Winnowing the "big" from the "small" in any field is inherently controversial—and interesting. One can certainly quibble with some of Crilly's particular choices. I would have expected, for instance, to see more "big questions" arising from biology and from electronic computing and communication, but neither "genomics" nor "Internet" appears in the index. Nevertheless, all of the questions Crilly does raise seem to me defensibly "big", and I find his exposition invariably inviting, readable, and (a pleasant but unusual combination) at once serious and informal. Crilly's discussion is also broadly learned, ranging well beyond mathematics and its history. Samuel Taylor Coleridge, Alexander Pope, and Mark Twain all appear in the index, for instance, as do Braque, Cezanne, and Picasso.

Crilly's exploration of each question is necessarily broad and general. But it's also surprisingly deep in places. Crilly explains, for instance, not only that Grigori Perelman solved the three-dimensional Poincaré conjecture but also something of what the conjecture says, its relationship to the larger problem of classifying three-dimensional manifolds, and the surprising fact that Perelman's solution used techniques from heat diffusion rather than the "usual" topological tools. Crilly's discussion of symmetry, too, goes beyond the usual geometric setting to encompass the algebraic or symbolic symmetry inherent in various forms of duality. In this context I enjoyed learning or relearning the striking dual, or "twin", theorems of Pascal and Brianchon on hexagons with inscribed or circumscribed ellipses.

Among the most admirable features of *Questions* for me is the author's willingness to draw conclusions, sum things up, and sometimes go out on limbs, even beyond the essentially audacious project of the book itself. Crilly speculates, for instance, about what Pythagoras might have thought about this or that. He doesn't hesitate to describe Newton's inverse square law as among the greatest of all formulae or to assert that "the ingenious powers of the human mind can always surpass the computational capacity of a machine" (p. 190). Readers need not agree with every one of these judgments to find them interesting, useful, and thought-provoking.

Our Days are Numbered

Jason Brown is a professor of mathematics at Dalhousie University in Canada. His project, perhaps less academically ambitious than Crilly's but also nicely executed, is to point to basic mathematics implicit in everyday life and thence to more subtle and more interesting underlying mathematical ideas, methods, and ways of thinking. Most of Brown's topics are standards of the math-is-useful genre: unit conversions, graphical representations, mathematical

games, probability and statistics of everyday risks and decisions, Google's PageRank algorithm, fractals, coding, and Internet security. But Brown treats them all engagingly, in a mildly self-deprecating style, and takes many opportunities to use what mathematical readers might consider common knowledge to point in deeper directions. Stein's paradox, mentioned above, is one example. Others include Benford's law on the predominance of smaller digits in certain data sets and the neat fact—Brown links it to global warming—that the expected number of "records" in a *random* time series of n observations is around $\log n$.

Brown's sprightliest chapters, to this reader's taste, are the last few, on mathematics and music. Both subjects are favorites of the author, a former professional rock guitarist and son of an audiophile. Brown explores, not unexpectedly, the modular arithmetic of rhythms and scales and the numerical problems inherent in instrument tuning. But, unusually, he applies his dual expertise to offer lively mathematical analysis of specific rock music, musicians, and their characteristic tricks, like "tickling". Who knew, for instance, that the surprising energy of the Beatles' "I Want to Hold Your Hand" derives from a four-note upward shift of a standard chord progression?

My favorite chapter of all is Brown's last, in which he describes applying Fourier methods to a then-unsolved musicological question: Who played what on the famous opening chord (known generally as The Chord; Brown calls it the greatest chord in rock and roll) to the Beatles' "A Hard Day's Night"? Disentangling the chord's harmonics with a discrete Fourier transform revealed to Brown, in 2004, that The Chord involved not only the Beatles' three guitars but also George Martin's grand piano in the Abbey Road studio. NPR, the BBC, and the *Wall Street Journal* all took due notice.

The Big Picture

Few books strike any reader as perfect, and these are no exception, even beyond the debatable choices every author makes. I found the day-in-a-mathematician's-life structure of Brown's book slightly lame in spots, and I noticed a few typos and the odd solecism. Crilly says "multiplication" and "addition" when I think he means "product" and "sum". But these are minor quibbles, not real defects; both books are nicely written and carefully edited.

Both books deserve better Amazon rankings, longer (nonzombie) lives, and broader audiences than they seem likely to enjoy. In their very different ways, both are readable, engaging, and enthusiastic, and give convincing accounts of mathematics and why everyone should admire, care about, and enjoy our subject.

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Low-dimensional Topology, Geometry, and Dynamics
Fall 2013: September 9 – December 6

Network Science and Graph Algorithms
Spring 2014: February 3 – May 9

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One in a Million—Remembrances of Laurie Snell (1925–2011)

Dan Rockmore

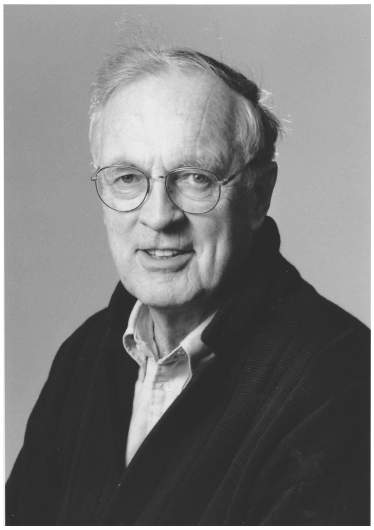

Photo by Joseph Mehling, ©The Trustees of Dartmouth College.

Laurie Snell

When I arrived at Dartmouth College in the fall of 1991, at the recommendation of my thesis advisor, Persi Diaconis, one of the first people I looked up was Laurie Snell. Like many people (as I was later to find out), I was surprised when I discovered that in fact "Laurie" was not a woman, but rather, a man—a tall, amiable, and wonderfully friendly man who happened to know a lot about probability besides having coauthored my favorite book on Markov chains. Over twenty years we became the best of friends and from time to time collaborators too on aspects of his *Chance* project, to which he devoted much of his energies during his emeritus years. I miss him deeply.

Below is a stroll through Laurie's life, decorated by the reminiscences of several of Laurie's friends and colleagues and even by some of Laurie's own stories. What comes through is a man of great intelligence, humility, and warmth, a lover of tradition, and a loyal friend, but also a person of endless curiosity and boundless energy, a fine maker of mathematics but perhaps an even better communicator of the subject. At the heart of any great communicator is a great storyteller, and one of Laurie's chief joys was hearing and telling tales about family and friends—some mathematicians, others not—often over a languid evening of dinner, drinks, and always dessert. I like to think that he would have enjoyed reading this—or even better, hearing it, surrounded by laughter, deeply happy in what was his favorite environment, the warm glow of friendship.

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Before Dartmouth

It seems as if Laurie was always at Dartmouth College, but in fact he had a life before that. Born James Laurie Snell on January 15, 1925, he grew up in Wheaton, Illinois, the youngest of the three children (all boys) of Lucille Ziegler Snell and Roy Judson Snell. Lucille was a piano teacher and performer (Laurie had a lifelong love of music). Roy was a very successful writer, best known as the author of mystery and adventure books for boys and girls (seventy-eight in all!) and a scriptwriter for the *Jack Armstrong, The All-American Boy* radio show.

Laurie received his B.A. from the University of Illinois, served for several years in the navy, and then returned to Illinois for graduate studies, receiving his Ph.D. under the direction of the famous probabilist J. L. Doob. Laurie and Doob stayed in close touch over the years, and Laurie forever affectionately referred to Doob as "my teacher". Laurie's thesis [7] focused on extending to submartingales results by Doob related to various martingale convergence questions. A discrete time martingale is a sequence of random variables with finite expectation such that if we view the sequence as the "fortune" of a game (or gamble), then (in Laurie's own words) "a martingale is a fair game, a

supermartingale represents an unfavorable game and a submartingale a favorable game. [8]"

Laurie recalls in his obituary for Doob [8] how he came to work with "the great man": *Doob kept a card file of ideas for theses. When he got a new graduate student he would pull out a card and suggest the problem on the card. If the student could not solve it, Doob put it back in the file and chose the next card…I succeeded on the third card, which proposed extending to submartingales an inequality called the 'upcrossing inequality' that Doob proved for martingales…It turned out to be easy to think of the submartingale as the price of the stock…Actually it turned out to be too easy because Doob said that a thesis had to be at least 30 pages long, so I would have to find something else to pad it with.*

The best-known result in Laurie's thesis is "the Snell Envelope", the smallest supermartingale dominating the given payoff process or, as Laurie's longtime friend and colleague Peter Doyle puts it, "Everyone knows that you should quit when you are ahead. To decide whether you are far enough ahead to quit, you compute the Snell Envelope." The Snell Envelope continues to play an important role in the analysis of many stochastic processes.

From Urbana, at Doob's urging, Laurie took a three-year position at Princeton as a Fine Instructor, mainly to be around legendary probabilist William Feller and a young Al Tucker, who at that time was just inventing linear programming. Life in Princeton was not all mathematics. Laurie was always a very sociable person and chance brought him a lifelong companion, Joan. They were engaged just three weeks after meeting. Joan was a great match for Laurie: a fine musician, fluent in French, and as befits her deep interest in and degree in English literature, an outstanding editor. Joan was often the first and last reader of Laurie's books, and no edition of *Chance News* (more on that later) left Laurie's computer without Joan's final proofreading.

While at Princeton, Laurie learned from his calculus students that in the philosophy department there was a young assistant professor who often posed probability problems for his classes. Laurie recalled that he told his students that "Philosophers did not know mathematics, so their professor's solutions were probably wrong." He goes on to say, "I later learned that their professor was John Kemeny."[1] Even a probabilist loses a bet from time to time.

Early Years at Dartmouth—Life with Kemeny[2]

Kemeny was lured away from Princeton by the challenge and charge to rebuild the Dartmouth mathematics department, and Laurie was one of the first hires. In those days before the interstate highway system, Dartmouth was both isolated and insulated, and this close environment certainly served to quickly cement Laurie and Kemeny's productive collaboration and deep friendship, which expanded to include the families, which for the Snells eventually included a son, John, and a daughter, Mary Paige. Some of the most important mathematical work that Laurie was to do at Dartmouth was related to various generalizations of Markov theory, much of it accomplished with Kemeny. Kemeny and Snell wrote some joint papers in probability in the late 1950s, and their books on "finite mathematics" led them to a special interest in Markov chains with a finite state space, summarized in their 1960 classic, *Finite Markov Chains* [2]. Important examples of Markov chains, however, also involved a countably infinite number of states, and Kemeny and Snell turned their attention to this entire class of chains, which are called *denumerable*.

In the important case in which all states communicate, they are either all recurrent or all transient. For the transient case, there is a potential theory and there is a boundary theory. The potential theory is modeled on the relationship between Brownian motion and the classical potential theory associated with static electrical charges (signed measures) in $\mathbf{R}^3$. The theories are linked (and are effectively equivalent) via the interpretation of the potential kernel in terms of the distributions for Brownian motion.

For a transient Markov chain with transition matrix P, the analog of the potential kernel is the matrix $\sum_{n=0}^{\infty} P^n$. Doob and G. A. Hunt developed a potential theory in this setting in the late 1950s. The theory does not work in the recurrent case. A modification is needed to have a recurrent potential theory, and Kemeny and Snell developed this theory in a collection of papers in 1961, at the same time redoing the transient case in matrix notation and showing the parallels of the recurrent and transient theories.

Creation of a boundary theory was also inspired by the classical case. Therein a boundary theory for a nice bounded region of $\mathbf{R}^n$ writes each positive harmonic function in the region as the integral over the boundary of the product $K(x,b)\,d\mu(b)$, where $d\mu$ is the boundary value measure for that harmonic function and where the Poisson kernel $K(x,b) = (\partial/\partial n)G(x,b)$ is the outward normal derivative of the potential kernel at the boundary point b. For general regions, possibly with a messy topological boundary, the classical theory has to be redone completely. The reworked theory is due to R. S. Martin and appeared in 1941. Analogs for Markov chains of Martin's boundary theory were produced independently by Doob and T. Watanabe, and by G. Hunt in the early 1960s. Kemeny and Snell, along with a precocious Dartmouth undergraduate Tony Knapp (later a professor of mathematics at Cornell and SUNY Stony Brook where he's now emeritus, as well as a former editor of the *Notices*), collected

[1] *Personal communication: "Memory of Kemeny" (2011), p. 10.*

[2] *Thanks to Anthony Knapp for providing much of the technical material in this section.*

these results, as well as a recurrent boundary theory of their own in a book *Denumerable Markov Chains* [3], which developed as an outgrowth of an undergraduate course on these matters for which Tony (as research assistant to Laurie) was a note taker. Knapp and Hans Föllmer (emeritus professor of mathematics at the Humboldt University of Berlin) recall those early Dartmouth days:

> *A. Knapp:* By 1959 when I was a freshman, except for three of the old guard who remained, all the other faculty were under forty. The place was a beehive of education, and the faculty and students functioned as an extended family. Faculty members made the mathematics majors a part of their lives—hanging out with them, hiring them as babysitters, inviting them to their homes as dinner guests, and so on, and generally caring about their lives beyond mathematics. I think of Snell as the chief architect of this atmosphere.
>
> The department moved into its own new building in 1961, with Kemeny in a corner office and with Snell still at his right hand. Multiple books were in progress in the department. Snell would sing in the hall, and one could hear him approaching from a long way off. As he would enter the lounge, he would sometimes call out, "Who's for a game of Hearts?" He was *very* good at Hearts.
>
> Kemeny and Snell had completely different personalities, yet they had great confidence in each other. Neither could have succeeded as well without the other. Snell was full of ideas, had a thorough intuitive grasp of probability, and had a command of the literature. Kemeny was a dynamo, able to work out long complex proofs and find just the right example to illustrate matters.
>
> *H. Föllmer:* I first set eyes on Laurie Snell in Paris in the fall of 1965. Laurie was giving lectures on the potential theory of Markov chains at the Institut Henri Poincaré, and I had just arrived from Göttingen to study in Paris for a year. Laurie gave his lectures in French. Grammatically, his sentences were perfect; they had been carefully checked by his wife, Joan, who is fluent in French.
>
> At that time I never talked to Laurie, but after his lectures I often saw him from afar in one of the nearby cafés. There he loved to play pinball with two of the French students, Jacques Azéma and Daniel Revuz, who went on to become major figures in French probability. Much later Laurie told me that he had found another source of great joy in Paris, namely, the singing lessons he was taking from a well-known French teacher.
>
> The first time I actually spoke with Laurie Snell was in the spring of 1970, when I was an instructor at MIT. One day I received a phone call from Laurie, to my great surprise. He invited me to give a talk at Dartmouth College, and so I took a Greyhound bus up to New Hampshire. After the talk Laurie invited me for a beer on the porch of his house in Norwich. He was quite amused to hear that I had actually been a student in his class in Paris, and I was immediately taken in by his dry and self-deprecating New England sense of humor. So, when some weeks later I received an offer for an instructor position at Dartmouth, I accepted. The two years at Dartmouth turned out to be a great experience.
>
> At that time the atmosphere in probability at Dartmouth was very stimulating, thanks to Laurie Snell, John Lamperti, and Itrel Monroe; to some very bright students that included David Griffeath and David Kreps; and to visitors such as Joe Doob and Frank Spitzer. In the late 1960s R. L. Dobrushin and Y. Sinai had made a major breakthrough in understanding the probabilistic structure of phase transitions in statistical mechanics. Frank Spitzer had started to work on closely related problems for interacting particle systems. Laurie immediately recognized the importance of this new development and reacted with great and highly contagious enthusiasm. Laurie's main concern, however, was to make this new field accessible to a wider audience, including students at an early stage. This focus is reflected in his book with Ross Kindermann [5].
>
> I went back to Germany in 1972, but I always kept in touch with Laurie. The main reason was that Laurie was such a wonderful host and mentor, and in the end a close friend. For several years I returned to Dartmouth in the summer, and Laurie visited me in Bonn, Zürich, and Berlin. Over the years I was increasingly impressed to see how he maintained his youthful enthusiasm, especially for his ongoing project *Chance*. I will greatly miss these encounters, including his oft-repeated "Don't be silly."

Laurie's best-known book from that era (coauthored with Kemeny and Gerald Thompson) was *Introduction to Finite Mathematics* [4]. This was the first book to take seriously the applications of discrete mathematics in the social sciences. It eventually sold over 100,000 copies, and, in some sense, has never been matched as a textbook for mathematics in the social sciences. The review by D. Gale on MathSciNet says, "The book under review takes an entirely new tack. Instead of elementary analysis the mathematical subject matter is 'finite

mathematics' (actually certain branches of algebra). Instead of physical applications the book draws its illustrative material from the biological and social sciences…This book is more than original. It is unique."

The royalties from *Finite Mathematics* gave Laurie the ability to realize a lifelong dream of his: to create a performance space for amateur musicians and singers akin to Tanglewood, albeit on a smaller scale. "The Barn" on the property of the Snells' newly acquired house in Norwich, Vermont, was the center of local summer social life for several years. Faculty (including Laurie, singing), neighbors, visitors, and soon-to-be famous musicians all graced its stage. It was a visual and acoustic delight, the latter with the help of a team from New York's Metropolitan Opera that was at that time assisting in the construction of Dartmouth College's new Hopkins Center for the Arts. This was all for the pleasure of a local audience, seated in front of the stage in yellow captain's chairs, snacking on the wine and cheese that Laurie bought as part of his ritual preparations.

Chance

There are many people in the world who know Laurie only as the engine of *Chance News*, launched in 1992 and delivered at your electronic doorway approximately monthly until 2005, when Laurie finished the lengthy process of migrating the publication to Wiki form,[3] where it now lives, administered by his longtime friend and former student, Bill Peterson, professor of mathematics at Middlebury College. *Chance News* was in many ways a blog before there were blogs, at first providing extended abstracts of statistically interesting items from the news and evolving into a collection of more extended statistical and probabilistic investigations of news and other "real-life" stories, including many from Laurie's own life. The articles in *Chance News* provide terrific material for introductory probability and statistics courses. While friends and colleagues (most notably Bill Peterson, Jeanne Albert, Charles Grinstead, Peter Doyle, and Peter Kostelec) would from time to time share a story or help out on a problem, the vast majority of the work was done by Laurie. According to Tom Moore, during a Q&A period for one of the sessions at one of the Joint Statistical Meetings during the mid-1990s when the newsletter was just beginning to gain attention, a colleague from another institution got up to tell everyone about *Chance News* and what a wonderful resource it was. As detailed by Tom, the fellow described it clearly imagining a very large and impressive staff behind it, apparently unaware that it was being produced entirely by Laurie with a small support staff at Dartmouth and few regular contributors.

When it started, *Chance News* was a revolutionary use of the Web in terms of math pedagogy. Its continued relevance and importance are witnessed by a 2011 CAUSEweb Resource Award[4] presented to Bill Peterson, Jeanne Albert, and posthumously to Laurie. When *Chance News* started it was just Laurie's latest foray into using new technologies in teaching, a theme of his life that can be seen as far back as the significant use of BASIC in early editions of his *Introduction to Probability* (followed by his insistence that a second edition, published by the AMS [1], also be available for free on the Web). It continued in Laurie's pioneering work in integrating video and text for Web viewing (for the *Chance Lectures* that he and I organized in the late 1990s), and finally, in his last significant *Chance*-related work, when he migrated it into its current Wiki format. Had he been just a little younger or lived just a little longer, I'm sure that you'd be able to follow *Chance* on Twitter today.

Chance News was part of the larger *Chance* project that Laurie led [6], built around the idea of using real-world case studies to teach statistics. *Chance* courses were taught at Princeton, Dartmouth, and a host of other institutions and still live on today in many places. For these and other efforts, in 1996 Laurie was named a Fellow of the American Statistical Association.[5] Bill Peterson has this to say about the *Chance* years:

> After I began teaching at Middlebury College in 1989, I was reconnected with Laurie when he phoned our department to find out who was teaching statistics there. He was then nearing retirement and, as he described it, looking for a computing project in statistics that would parallel what he had done with probability and finite mathematics. We were intrigued by the success of a new Springer-Verlag magazine, *Chance* (now jointly published with the American Statistical Association), which had attracted leading statistics practitioners to describe their work in a form accessible to educated nonspecialists. This struck us as a promising model for a new course for liberal arts students that would introduce statistical topics in the context of real-world case studies, developing the necessary mathematical ideas only as needed.

[3] `http://www.causeweb.org/wiki/chance/index.php/Main_Page`

[4] *CAUSE is the Consortium for the Advancement of Undergraduate Statistics Education. The presentation was made at USCOTS 2011: United States Conference On Teaching Statistics in Raleigh-Durham, NC, on May 20, 2011.*

[5] *The official citation reads: "Laurie Snell, Benjamin Cheney Professor of Mathematics Emeritus, Dartmouth College: For an outstanding body of research in probability and its applications in the social sciences; for exemplary expository writing; and for curricular innovation and inspirational leadership as a teacher of probability and statistics extending over four decades."*

During the 1991–1992 academic year, the first *Chance* courses were offered. I taught a first-year seminar at Middlebury, following the case-study style we had originally planned. Meanwhile, Laurie was visiting Princeton University, where he cotaught a version of the course with Peter Doyle. Witnesses would later describe scenes of Peter and Laurie in the coffee room in the morning, poring over the day's news and selecting topics for discussion.

In fall 1992, Laurie produced the first issue of *Chance News* and also developed an NSF grant proposal to extend the *Chance* model to other institutions. With the additional funding, the project group expanded to include Joan Garfield from the University of Minnesota, Tom Moore from Grinnell College, and Nagambal Shah of Spelman College. Laurie became a traveling ambassador for the enterprise, coteaching *Chance* courses in a variety of formats at a variety of institutions.

Laurie officially retired from teaching in 1995, but his activities on the *Chance* project continued at full pace. He hosted a series of five-day summer workshops at Dartmouth for college faculty. Through a national application process, each of these drew about two dozen statistics educators interested in teaching their own versions of *Chance*. Laurie was a wonderfully generous host. He organized festive meals and after-workshop activities that included outdoor concerts and group hikes in the New Hampshire mountains. The participants appreciated these efforts, but above all they commented on how remarkable it was that such a well-known mathematician would take such a personal interest in their ideas and projects.

Final Thoughts

If you were to pick your mathematical specialization in order to maximize the number of people that you'd get to talk to about your work or the number of tales you'd be able to tell, probability and statistics would win. So, if Laurie was to be a mathematician, he had to be a probabilist, and *Chance* was the perfect capstone to his career. As his former colleague and student Claudia Henrion says, "Many people think of mathematics as something done alone, tucked away in an office with pen, paper, and now computer. But as Laurie Snell exemplified, it can also be a life filled with community, friendships, generosity and playfulness. These qualities all came together in his development of the *Chance* course, where he combined the theory of mathematics with people's everyday lives: events in the news, sports, gambling, and medicine."

As Laurie wound down his involvement with *Chance*, in his last few months he turned his attention to finally setting down as many of his stories as he could in one last volume, *Memory of Kemeny*. The last few weeks of his life were filled with visits by friends and several great dinners out and long stays with family. He played this last hand with his characteristic grace, humility, and good humor. To all of those whom he touched, Laurie was one in a million. Just by getting to know him, we all feel as though we've won the lottery.

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Kontsevich Awarded Shaw Prize

On May 29, 2012, the Shaw Foundation announced the awarding of the 2012 Shaw Prize in Mathematical Sciences to Maxim Kontsevich "for his pioneering works in algebra, geometry and mathematical physics, and in particular deformation quantization, motivic integration, and mirror symmetry." The prize carries a cash award of US$1 million. The Shaw Prize in Mathematical Sciences Committee made the following announcement: "Recently, some of the most profound advances in algebra and geometry have been inspired by ideas from physics. Maxim Kontsevich has led the way in a number of these developments.

"Beginning with Heisenberg's introduction of quantum mechanics, the mathematical process of quantization—that is, of passing from classical to quantum mechanics—has been a central theme. One version, known as deformation quantization, has for its natural setting classical spaces known as Poisson manifolds. Their exact quantization had been carried out in special cases, but in general this proved to be a formidable problem. It was resolved brilliantly by Kontsevich, who used ideas from quantum field theory.

"Kontsevich's invention of motivic integration, a striking new conceptual tool, allowed him and others to resolve some problems in algebraic geometry (the study of solutions to polynomial equations to several variables) that had previously seemed way out of reach.

"The discovery by string theorists of 'mirror symmetry' led to a series of unexpected mathematical predictions which assert that two apparently different geometries appearing in string theory—symplectic geometry, which is connected with classical mechanics, and algebraic geometry—are 'mirrors' to each other. Thanks to the contributions of many mathematicians, these assertions have gradually been proven. The modern understanding of mirror symmetry is framed by fundamental insights and advances. Many of these are due to Kontsevich, who, beginning with his 1994 'homological mirror symmetry conjecture', keeps revisiting the original formulation to provide clearer conceptual answers to the mathematical question 'What is mirror symmetry?'"

Maxim Kontsevich was born in 1964 in Khimki, Russia. He is currently a permanent professor at l'Institut des Hautes Études Scientifiques, a position he has held since 1995. He holds the AXA-IHES Chair for Mathematics. He received his Ph.D. in 1992 from the University of Bonn, Germany. From 1990 to 1994 he held visiting positions at the Max Planck Institute, Harvard University, and the Institute for Advanced Study. He was professor at the University of California, Berkeley, from 1993 to 1995. In 1999 he became a French citizen. He is a Fields Medalist (1998) and the recipient of the Henri Poincaré Prize (1997), the Prize of the International Congress of Mathematical Physics (1997), and the Crafoord Prize (2008). He is a member of the Academia Europaea and l'Institut de France.

The Shaw Prize is an international award established to honor individuals who are currently active in their respective fields and who have achieved distinguished and significant advances, who have made outstanding contributions in culture and the arts, or who have achieved excellence in other domains. The award is dedicated to furthering societal progress, enhancing quality of life, and enriching humanity's spiritual civilization. Preference is given to individuals whose significant work was recently achieved.

The Shaw Prize consists of three annual awards: the Prize in Astronomy, the Prize in Science and Medicine, and the Prize in Mathematical Sciences. Established under the auspices of Run Run Shaw in November 2002, the prize is managed and administered by the Shaw Prize Foundation based in Hong Kong.

Previous recipients of the Shaw Prize in Mathematical Sciences are Demetrios Christodoulou and Richard S. Hamilton (2011), Jean Bourgain (2010), Simon K. Donaldson and Clifford H. Taubes (2009), Vladimir Arnold and Ludwig Faddeev (2008), Robert Langlands and Richard Taylor (2007), David Mumford and Wen-Tsun Wu (2006), Andrew Wiles (2005), and Shiing-Shen Chern (2004).

— From Shaw Foundation announcements

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Annual Survey Doctoral Department Groupings

Richard Cleary and James Maxwell

Introduction: What's Changing

Since their inception in the late 1950s, the results of the annual AMS surveys of mathematics and statistics departments have been reported using *groupings* of departments. Such groupings need to be constant over long periods of time in order to allow trends in the data to be detected. On the other hand, groupings must be updated periodically to reflect longer-term changes. The Joint AMS-ASA-MAA-SIAM Data Committee is charged with managing and reporting the survey data, and the Committee will update the groupings used effective with the 2012 Annual Survey.

Since the most recent change in groupings was made after the release of the 1995 National Research Council ranking of doctoral programs,[1] the update of the NRC rankings in 2010[2] has prompted the Data Committee to reevaluate the groupings used in reporting the survey data. As many in the community are aware, the methodology used for the 2010 NRC rankings was very different from what had been used in 1995 (and for the previous ranking in 1982). In particular, no single number was reported in 2010 that could be used to linearly order departments and establish groupings. After considerable study and thought, the Joint Data Committee is hereby announcing a new grouping scheme based on the size of the departments and the type of institution rather than on a reputational ranking.

Starting with reports on the 2012 AMS-ASA-IMS-MAA-SIAM Annual Survey, doctorate-granting mathematics departments will first be grouped into those at public institutions and those at private institutions, constituting 130 and 51 departments, respectively, for the 2012 Annual Survey. These groups will then be further subdivided based on the average annual number of Ph.D.'s reported to the Annual Survey by the department between 2000 and 2010.[3] Departments which self-classify their Ph.D. program as being in applied mathematics will form their own group, as will departments in statistics and departments in biostatistics. The rest of this article describes the rationale behind the Data Committee's decision to adopt the new grouping scheme and the new groupings themselves in more detail, including a chart comparing old and new groupings.

The Rationale for Grouping Data by Institution Type and Size

Our professional societies formed the Data Committee to help members with questions about the state of the profession. The description of

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[1] *The 1995 report, "Research-Doctorate Programs in the United States: Continuity and Change", is available for purchase through the National Academies website* http://sites.nationalacademies.org/PGA/Resdoc/index.htm.

[2] *The 2010 report, "A Data-Based Assessment of Research-Doctorate Programs in the United States", is available through the National Academies website* http://sites.nationalacademies.org/PGA/Resdoc/index.htm.

An extract of the NRC data on Ph.D. programs in mathematics, applied mathematics and statistics, as revised in April 2011, has been posted to the AMS website and is accessible from http://www.ams.org/profession/data/annual-survey/groups_des.

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[3] *Individual departments will not be moved among size classifications until the next major revision of the groupings. Any new doctorate-granting departments that are added to the survey prior to that revision will be placed in the grouping which seems most likely to reflect their annual Ph.D. production.*

the Committee's responsibilities begins with this sentence: "The Committee is charged with gathering and disseminating data on matters of concern to the mathematical sciences community." Because any scheme for grouping departments is likely to be somewhat controversial, an important first question is to ask, "Why should we group institutions at all?" The answer is that without grouping, the variability in the size and nature of our various departments would typically overwhelm important information in the data.

Members of our societies use the reports on the Annual Survey in many ways. Members of the Data Committee often hear from colleagues who are using the data we provide to prepare reports or presentations for the administration of their college or university, for accrediting agencies, for funding agencies, and for other stakeholders. To be effective and useful benchmarking tools, this sort of data should allow a department to compare itself to others that are similar in size and mission.

In addition to use by individuals and departments, our data are frequently cited by other committees of the sponsoring societies. The "matters of concern" in our professional community would be much harder to study if our data were aggregated across all Ph.D.-granting departments. By providing information about the career trajectories of recent Ph.D.'s from groups of departments, we have been able to study trends about which groups have had the most success in the job market, which groups are granting Ph.D.'s to women at the highest rates, and the percentage of United States citizens receiving doctorates in various areas. The division of doctoral departments into groups also adds considerable value to the reports on faculty salaries. All of this information is potentially valuable to students as they choose careers, to departments as they advise students, and to the community as a whole as we make strategic decisions about managing our resources.

In moving to groups of doctoral departments formed by institutional control (public versus private) and size of doctoral program, we are explicitly making it clear that it is the business of the Data Committee to provide information about programs that are similar. We are not in the business of ranking programs, and indeed we never have been. The previous groups, formed as a reflection of the NRC rankings, implied such a ranking even if it was not the committee's intent. We hope that the new structure will make it clear that we are not claiming that departments in one group are in any way "better" than those in another group, but that they are indeed similar in ways that are self-reported and easily verifiable. The move to describing groups by their descriptive terms (e.g., Public Large) rather than by numerical titles (Group I, Group II, Group III), which suggested an order of quality, is meant to reinforce the notion that the groups no longer reflect subjective measures of quality.

A Brief History on Groupings of Ph.D.-Granting Mathematics Departments

The Conference Board of Associated Research Councils, a coalition with representatives from the American Council on Education, the American Council of Learned Societies, the National Research Council, and the Social Science Research Council, published an assessment of mathematical and physical sciences doctoral programs in 1982.[4] Soon after this, the AMS Data Committee replaced the groupings of doctoral mathematics departments in use at that time with new groupings based on the rating of "quality of graduate faculty" assigned each department in the new study. The committee used a rating of 3.0 or above to define Group I. This produced a Group I with 39 departments. Group II was defined as those departments whose doctoral program had an NRC rating below 3.0 but greater than or equal to 2.0. This produced a Group II with 43 departments. Group III was defined as the remaining mathematics departments whose doctoral program was rated below 1.0, together with those departments whose doctoral program was not rated in the assessment. (A doctoral program had to satisfy certain criteria before it was included in the study.) Rating information in the report was not used to further subdivide the much smaller groups in use for applied mathematics departments, Group V, nor for departments in statistics and biostatistics, Group IV.

Since 1996, Ph.D.-granting departments of mathematics have been grouped according to their rating of "scholarly quality of program faculty", as reported in the 1995 NRC assessment of doctoral programs mentioned earlier. This new assessment resulted in a revised Group I consisting of 48 departments: the 39 departments already in Group I plus the nine additional departments whose 1995 rating was greater than or equal to 3.0. In addition, Group I was subdivided into the 25 departments at public institutions, Group I Public, and the 23 departments at private institutions, Group I Private. The revised Group II contained 56 departments, and the revised Group III contained the remaining 65 doctoral departments in existence in 1996.

Description of the New Groupings

The new groupings of doctorate-granting departments of mathematics are based on the size of the Ph.D. program as reflected in the number of Ph.D.'s awarded during the ten years from

[4] *For further details on this assessment and a listing of related earlier assessments, see the April 1983 issue of* Notices of the American Mathematical Society, *pages 257–267. This article has been posted to the AMS's website and can be accessed from* `http://www.ams.org/profession/data/annual-survey/groups_des`.

July 1, 2000, through June 30, 2010. Since there are some departments that have not reported their Ph.D.'s for every Annual Survey during this time, the average annual number of Ph.D.'s awarded was used to compare the departments. In addition, the Data Committee feels that groupings that reflect the type of institution, public or private, will be most useful to the mathematical community. In the past we have done this only for Group I.

The Data Committee reviewed the list of 130 Ph.D.-granting mathematics departments at public institutions in 2010, sorted from highest to lowest based on their average annual number of Ph.D.'s awarded. The 20 percent at the top of this list forms the group labeled Public Large. This group contains 26 departments and accounts for 49 percent of the 6,148 Ph.D.'s produced by these 130 departments. The next 30 percent of the departments forms the group labeled Public Medium. This group consists of 40 departments and accounts for 32 percent of the Ph.D.'s produced by these 130 departments. The remaining 64 departments form the group labeled Public Small and account for the remaining 19 percent of the Ph.D.'s produced. The three groupings Public Large, Public Medium, and Public Small also account for 37 percent, 24 percent and 13 percent, respectively, of the 8,293 Ph.D.'s produced by all 180 departments over the ten years July 1, 2000, through June 30, 2010.

For the 50 Ph.D.-granting mathematics departments located at private institutions in 2010, the 24 departments with the highest annual number of Ph.D.'s awarded form the group labeled Private Large. This group accounts for 80 percent of the 2,145 Ph.D.'s awarded by these 50 departments during the ten years 2000–2010 and 21 percent of the Ph.D's awarded by all 180 departments. The remaining 26 departments form the group labeled Private Small.

Table A shows the mathematics departments currently in Groups I, II, and III (in 2010) cross-tabulated by their new grouping for 2012. Five of these mathematics departments are moving to applied mathematics. The 2010 NRC report, as revised in April of 2011, evaluated eleven Ph.D. programs from AMS's Groups I, II, and III mathematics departments solely within the NRC report's applied mathematics Ph.D. programs. The department chairs at these institutions were contacted and asked to decide if they wanted to be grouped with the other applied mathematics departments in the new Annual Survey groupings or remain grouped with the other mathematics departments. Four of these departments responded that they preferred to be grouped with applied mathematics departments. The new groupings reflect that preference. One program not reviewed by the NRC has also decided to move to the applied mathematics group with the 2012 survey cycle.

For the upcoming 2012 cycle of department surveys, there are 130 Ph.D.-granting mathematics departments at public institutions and 51 doctorate-granting mathematics departments at private institutions. There are also 30 Ph.D.-granting departments of applied mathematics, 58 Ph.D.-granting departments of statistics, and 34 Ph.D.-granting departments of biostatistics. Details on the new Annual Survey groupings, including listings of the departments in each group, are available on the AMS website `http://www.ams.org/profession/data/annual-survey/groups_des`.

The Data Committee recognizes that some of the most useful information in the Annual Survey reports comes from being able to identify trends within particular segments over time. Therefore we anticipate that the new groupings will be used for approximately ten years, at which time the sizes of departments can be reviewed to see if there would be substantial benefit in introducing revised groupings. The committee believes this long-term approach will not provide any incentive for departments to try to grow their doctoral program simply in order to move to a different group.

Table A: Realignment of Ph.D.-Granting Mathematics Departments [a]

	Current Group →				
New Group ↓	**Group I Public**	**Group I Private**	**Group II**	**Group III**	**Row Total**
Public Large	20	0	6	0	**26**
Public Medium	5	0	25	10	**40**
Public Small	0	0	13	50	**63**
Private Large	0	22	1	1	**24**
Private Small	0	0	11	15	**26**
Applied Math	0	1	0	4	**5**
Column Total	**25**	**23**	**56**	**80**	**184**

[a] Based on Groups I, II, and III during the 2010 Annual Survey.

Presidential Report Draws Criticism from Mathematicians

Allyn Jackson

In February 2012 the President's Council of Advisors on Science and Technology (PCAST) issued a report about the need to increase the number of college students majoring in scientific and technical areas. A rumble of consternation erupted among mathematicians, who were startled by the report's suggestion that college math instruction could be improved by having faculty from outside mathematics develop and teach mathematics courses. All of the major mathematics organizations in the United States, including the American Mathematical Society (AMS), have issued statements that, while praising many aspects of the report, take exception to some of its recommendations. Exactly what effect the report may ultimately have is unclear. One immediate result has been the initiation of dialogue between PCAST and the mathematical sciences community.

Controversial Recommendations

Titled *Engage to Excel*, the 106-page report argues that, over the coming decade, the nation needs to prepare a million more workers in science, technology, engineering, and mathematics—the so-called STEM areas—and makes specific recommendations for how the federal government can stimulate efforts toward this goal. Because many students leave pathways to STEM careers not long after secondary school, the report focuses on improving STEM instruction in the first two years of college. This is a time where students often fall into what the report calls the "math preparation gap": the gap between the math background students need for STEM majors and the math background they actually possess.

One of the report's five recommendations focuses on this gap, proposing "a national experiment in postsecondary mathematics education." The report suggests that the experiment include a variety of approaches and offers four specific possibilities, one of which is "college mathematics teaching and curricula developed and taught by faculty from mathematics-intensive disciplines other than mathematics, including physics, engineering, and computer science." To many mathematicians this sounded like a call for engineers and scientists to take over the first two years of college mathematics teaching. "What PCAST should have done is called for renewed efforts by mathematicians to reach out to other educators of students preparing for STEM careers in order to determine what is required by these students, what they are learning, and how to improve their performance," said AMS president Eric Friedlander of the University of Southern California. "For many reasons, mathematicians should play the central role in such efforts."

One of the other suggested approaches to the "national experiment" also struck many mathematicians as problematic: "a new pipeline for producing K–12 mathematics teachers from undergraduate and graduate programs in mathematics-intensive fields other than mathematics." Tara Holm of Cornell University, who chairs the AMS Committee on Education (CoE), said this idea struck her as "even less feasible and more outrageous" than the one about having nonmathematicians teach the first two years of college math. The question of what K–12 mathematics teachers need to know and how best to impart that knowledge to them is a difficult and subtle one that mathematicians and experts in mathematics education have struggled with—and fought over. Said Holm, "I don't see how PCAST could imagine that people outside of mathematics would have a sense of what K–12 math-specialist teachers would need."

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Lack of Awareness

Another drawback mathematicians found in the report is a lack of awareness of mathematicians' current activities in education reform. In this regard, the report's treatment of the laboratory sciences is quite different. In discussing its recommendation to replace traditional lab courses with "discovery-based research courses", *Engage to Excel* cites several studies showing that these kinds of courses increase students' understanding and enthusiasm and stimulate them to persist in STEM coursework. One of the appendices is devoted to highlighting two projects—one at the University of Texas at Austin, the other at the University of California at Davis—that have successfully used discovery-based science courses to attract and retain students in STEM majors. The general impression the reader gets is that, while there is plenty of room for improvement, there is also a degree of consensus about how lab courses should be revamped and that academic scientists are actively involved in improving collegiate science instruction.

By contrast, no examples of mathematicians' views about and activities in teaching reform appear in the report. No mention is made of, for instance, the Mathematical Association of America (MAA) Committee on the Undergraduate Program in Mathematics (CUPM), which, for more than half a century, has had a large influence on undergraduate mathematics teaching. The CUPM has a subcommittee called CRAFTY (Curriculum Renewal Across the First Two Years), which has held a series of workshops to stimulate conversations between mathematicians and faculty outside mathematics about how math courses can be made to better serve the needs of nonmath majors. William McCallum of the University of Arizona, former chair of the AMS Committee on Education, served on CRAFTY in the late 1990s and participated in some of those workshops. He noted that *Engage to Excel* repeats much of what mathematicians were saying about teaching reform at that time. In fact, he noted, "Conservative engineers and scientists often supported the fierce resistance to calculus reform from some mathematicians." CRAFTY's work continues; its latest report, *Partner Discipline Recommendations for Introductory College Mathematics and the Implications for College Algebra*, appeared in 2011 (see `http://maa.org/cupm/crafty`).

There are many other projects in the math community that aim to improve undergraduate math teaching. Examples are included in the mathematical sciences organizations' responses to the PCAST report, and the AMS has begun to build a webpage listing ongoing projects. Are these things difficult to find out about? "It's not so difficult," said MAA president Paul Zorn of St. Olaf College. "If [the report's authors] had consulted with people who are knowledgeable about what the math community is doing, they would have found these things out." MAA executive director Michael Pearson pointed out that one reason for the report's silence about activities in the mathematical community could be the way writings about such activities are published. They appear in, for example, the MAA's Notes and Reports series rather than in journals. "Other disciplines have created peer-reviewed channels for making discipline-based education efforts part of the record and thus more visible and readily accessible," he said.

Pearson noted that the report seems to overstate the existing shortcomings in mathematics instruction and to imply that students' lack of persistence in studying STEM areas is almost solely due to poor mathematics instruction. "The problem is much more complex than that," he said. "Improving mathematics instruction will require active engagement of mathematicians and a commitment of resources—for example, for teacher education and professional development, as well as for amelioration of gross economic inequity—at levels policymakers seem unwilling to make in the current political and fiscal environment."

Another drawback of the report is that it conflates two different issues, Friedlander noted. One is that many students leave high school with a mathematics background that is inadequate for tackling college-level mathematics courses. The other issue is the need to improve those courses to ensure that students majoring in STEM areas have the knowledge they need. As a result, he said, the report seems to set up an unrealistic expectation that colleges can "take students who are uncomfortable manipulating fractions, introduce them to the beauty and usefulness of mathematics, encourage them to engage in 'discovery', not burden them with tasks they view as onerous, and yet empower them to launch their STEM careers."

Agreement on the Big Picture

S. James Gates, a University of Maryland physicist and PCAST member, is one of the cochairs of the working group that produced *Engage to Excel*. When he was asked about the recommendation of having faculty outside of mathematics design and teach math courses, he conceded that the wording had unfortunately left room for misinterpretation. "Some thought that [this recommendation] meant we don't want mathematicians involved," he said. "That's not the case. We want to have mathematicians, who are the true masters of the field, engage with people who are consumers of mathematicians' output. We are working hard to get mathematicians involved." He said that the PCAST committee hopes to stimulate interaction between mathematicians and faculty in other disciplines to look carefully at what is needed in courses that sit at the boundary between mathematics and other fields.

When asked about the recommendation for new pathways for K–12 teachers, Gates emphasized that this is only one possible approach and acknowledged that the working group did not have a tidy solution for the complex problems of K–12 mathematics education. Nevertheless, "we wondered whether having people who are highly skilled in math but who are not necessarily aiming to become mathematicians might be closer to what is needed for K–12 math." He noted that math majors study areas of mathematics that are distant from K–12 mathematics and far more technical. "I can't put a metric on this," he said, "but the distance from that to teaching K–12 is bigger than for someone who, for example, studies quantum mechanics and learns the mathematics needed for that and then goes into K–12 teaching."

Gates said there would be plenty of opportunity to consider details of specific recommendations, but it is crucial to focus on the big picture. He noted that the United States has in recent decades lost millions of jobs that used to sustain the middle class. The future prosperity of the nation depends, he said, on the creation of a "STEM-capable workforce"—this includes not just scientific elites but also people who use knowledge of STEM areas in their jobs. Because mathematics is central to the training of such workers, the "mathematics preparation gap" is a major issue. "We recognize that this is a complex problem and that many in the mathematical community have tried to deal with it," said Gates.

Mathematics organizations' responses to *Engage to Excel* indicate that the mathematical sciences community basically agrees with this big-picture view. Friedlander comments that there are at least two fundamental problems that mathematicians are trying to address. The first is to raise the level of mathematics preparedness of students entering college; an important aspect is improving the education of K–12 mathematics teachers. The second is to inspire and retain students who might enter STEM careers while providing them with the necessary knowledge and skills. To do this, he said, mathematicians continue to reach out to colleagues in mathematics-intensive fields, both to ascertain what mathematics is useful in these fields and to supplement their teaching with relevant applications.

Zorn of the MAA noted that although there was plenty of "kvetching" over the report, "the main thrusts are very clearly ideas that we support and are working to promote." In particular, he agrees with the report's emphasis on "evidence-based" methods for improving teaching. "There are approaches to teaching science and mathematics that are known to be more effective for many teachers than the standard ways," he said. "We are not all still scratching our heads over this." For example, there is a research base of evidence showing that student-centered teaching methods are very effective. To understand and promulgate such methods is a task the mathematical sciences community is actively pursuing, he said. He also agreed with some parts of the report's proposal for a "national experiment" in postsecondary math education, in particular, the call for the federal government to support two hundred 5-year experiments at an average cost of US$500,000 each. Zorn called this "an excellent idea…. I hope it happens."

Math Organizations Issue Statements

All of the major mathematics organizations in the United States have come out with statements about the report: the AMS, the American Mathematical Association of Two-Year Colleges (AMATYC), the Association for Women in Mathematics (AWM), the MAA, and the Society for Industrial and Applied Mathematics (SIAM). All of the statements express agreement with the report's call to improve STEM education, and all pointedly criticize the report's treatment of mathematics. The AMS statement is posted on the Web (`http://www.ams.org/policy/govnews/pcast-statement`), and the "Opinion" column in this issue of the *Notices* presents a distillation of the views in that statement.

The reception the report has had in the mathematical sciences community seems to have been quite different from that in other areas of science. On the day the report was released, the American Physical Society (APS) and the American Chemical Society (ACS) issued news releases praising the report and aligning themselves with its recommendations. The APS release noted that one of its own programs is mentioned in the report.

In fall 2011, as preparation of *Engage to Excel* was entering the final stages, Gates made presentations before some mathematical sciences groups, including the AMS Committee on Education. Those presentations evidently did not prepare committee members for what the report would say about mathematics. After the report appeared, word about the controversial recommendations percolated through the mathematical sciences community. CoE chair Tara Holm said she first found out about them through the AWM Facebook posting that appeared about three weeks after the report's release. AWM president Jill Pipher of Brown University made the posting after hearing from Rebecca Goldin of George Mason University, who had found out about the report from a colleague. Goldin had a long discussion with PCAST executive director Deborah Stine and wound up at a PCAST meeting presenting testimony about the report on behalf of the AWM Policy and Advocacy Committee. Pearson of the MAA also gave testimony after the report's appearance.

After it became clear that the mathematical sciences community had serious reservations about how its subject is treated in the report, Gates began

reaching out to leaders in the community to hear their views. In April 2012 he met with the Joint Policy Board for Mathematics (JPBM), a collaborative group of leaders of the AMS, the MAA, the American Statistical Association, and SIAM. MAA president Zorn attended the JPBM meeting and said the discussions with Gates were cordial. "But there was this elephant in the room," said Zorn. "Why were all these things said in the report about mathematics and mathematics teaching without taking due account of the things that have been done and are being done by mathematicians?… Mathematicians were quite puzzled as to why we had so little impact on the report."

One probable reason is the lack of representation of mathematics on PCAST. Closest to the subject is PCAST cochair Eric Lander, a leading genomics researcher who founded the Broad Institute at the Massachusetts Institute of Technology. Lander received a Ph.D. in mathematics from Oxford in 1980 and soon thereafter moved into biology; he has fourteen publications in MathSciNet versus over four hundred in PubMed, the online citation index for biomedical literature. No mathematicians were appointed to the working group for *Engage to Excel*.

The report contains a list of "Experts Providing Input to PCAST", and on that list are some mathematicians: former AMS executive director John H. Ewing, who is now president of Math for America; Samuel M. Rankin III, director of the AMS Washington office; and MAA executive director Pearson. Ewing provided reactions to some early thoughts the working group had about how to approach mathematics in the report, and Rankin supplied some statistics from the Conference Board of the Mathematical Sciences. Pearson contacted PCAST on his own initiative to offer information and assistance from the MAA. He said that after reading the report it appeared his input had had no influence. Three others in mathematics education are also listed as experts consulted by the working group: Uri Treisman, director of the Charles A. Dana Center at the University of Texas at Austin; Joan Ferrini-Mundy, who heads the National Science Foundation's (NSF) Education and Human Resources directorate; and James Lightbourne, a senior adviser in that directorate.

What effect is the report likely to have? Certainly many PCAST reports have disappeared into desk drawers and had little impact. Whether *Engage to Excel* will meet a similar fate is unclear. It makes specific recommendations, with dollar amounts attached, for programs that the federal government could create. For its suggestion to support two hundred 5-year experiments to improve college mathematics teaching at an average of US$500,000 each, the report suggests the NSF and the Department of Education as possible funding sources. Three months after the report appeared, Ferrini-Mundy of the NSF issued a "Dear Colleague" letter calling for input on how to use US$60 million that is slated in the fiscal year 2013 federal budget for K–16 mathematics education programs at the NSF and the Department of Education. The letter did not specifically mention *Engage to Excel*, but given the timing of the report's appearance, it seems reasonable to expect that the report could influence the use of that US$60 million. "Certainly the report provides important perspectives on how to improve science, technology, engineering and mathematics education at the undergraduate level,'' said Ferrini-Mundy. "Undergraduate STEM education is an ongoing area of focus for us, and NSF is studying the report and its recommendations carefully. We are also continuing to review the many excellent suggestions we received from the community in response to the Dear Colleague letter.''

Meeting the Challenge

McCallum said he suspected that *Engage to Excel* might have been intentionally provocative to get the attention of mathematicians. It not only got their attention, he said, but it got a "full-throated tribal response". To achieve the goals of the report, what is needed is a powerful coalition of all faculty devoted to improving undergraduate education in STEM fields—a coalition that will be impossible to build "if the mathematicians and scientists are fighting it out." Said McCallum, "My feeling is that the correct response is to try to calm things down a bit, put out information about the extensive efforts by mathematicians at improving undergraduate mathematics education, admit with some humility that these efforts have not been as successful as we might like, and welcome the aid of people in other STEM fields."

Engage to Excel was written in a spirit that recognizes the beauty and importance of "the incomparable human language—mathematics," said Gates. "We regard our mathematician colleagues as a deep well of expertise, ability, and intellect, and we are making a call to apply their intellectual creativity to this problem…. We are not trying to be prescriptive. We don't know all the answers. We want people to work with us, because if we don't meet the challenge, then the United States will be a very different place from the one where we grew up."

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Does Algebraic Reasoning Enhance Reasoning in General? A Response to Dudley

Peter Johnson

I read with great interest the article "What is mathematics for?" by Underwood Dudley in the May 2010 *Notices*. Dudley makes a strong case that the importance of algebra in the future careers of most students is exaggerated and should not be used as an argument for the teaching of algebra. I have nothing to add to his argument on this point, but I would in fact take his argument one step further for postsecondary students. At the college level, algebra forms the core content of developmental mathematics courses, and passing a developmental mathematics course or gaining placement at a level beyond developmental mathematics is the usual prerequisite to taking quantitative courses and to graduate. However, for most non-STEM (Science, Technology, Engineering, and Mathematics) majors, the algebra in those developmental courses and placement examinations is not used in a meaningful way later on, even in subsequent mathematics courses they take at the college level. (See [6] for a case study on this point.)

Dudley makes the claims that the main reason to learn algebra is that "mathematics develops the power to reason" ([3], p. 612) and that while "it does not…always succeed," it is still "the best method that we have" ([3], p. 613). I thought that those readers who enjoyed Dudley's article might also want to know what the research on learning in educational psychology has to say on this point. What Dudley is ultimately claiming for algebra is transfer—that the kind of reasoning that algebra entails will enhance reasoning skills and that those reasoning skills will then transfer to other realms of thinking and understanding. In psychological research, Dudley's transfer would be termed "far transfer": that is, the understanding thus obtained from one domain (algebra) will transfer to another domain quite different in nature.

The study of transfer has a very long history in educational psychology, and the degree to which far transfer occurs has been a contentious issue for many decades, with many claiming that far transfer is rare or nonexistent (for example, see [2]). In order to attempt to bring some consensus to the debate on transfer, Barnett and Ceci [1] proposed a taxonomy for describing transfer. Their taxonomy includes six contexts, and it is interesting to note that the transfer of reasoning from algebra to "general reasoning skills" represents far transfer in five of their six contexts: knowledge domain (from algebra to other disciplines), physical context (mathematics classroom to reasoning in other places), temporal context (generalized reasoning done months or years later), academic context (mathematics to other academic and nonacademic contexts), and modality (the written/symbolic language of algebra to abstract thought).

In their review, Barnett and Ceci include a number of studies of transfer conducted over many decades. They also include a table representing a number of widely cited studies representing their place in the taxonomy using the constructs knowledge domain, physical context, and temporal context. In discussing this table they note that

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"[w]e simply did not find any well-controlled studies testing transfer to a far domain, in a far physical context, and in a far temporal context" ([1], p. 627). Thus there appears to be no research evidence that would support the notion that the reasoning skills obtained from learning algebra will transfer to reasoning in a general context.

Another related way to look at the value of algebraic reasoning would be to consider if algebra has an effect on problem solving or critical thinking. In their comprehensive review of problem solving and transfer, Mayer and Wittrock [8] point out that, in the early twentieth century, the prevailing view in education in the United States was "the doctrine of formal discipline—the idea that certain school subjects such as Latin and geometry improved students' minds by making their thinking more logical and disciplined" (p. 49). Dudley is making the identical claim for algebra.

Based on their review of the research literature, Mayer and Wittrock note that "the lack of documented success at promoting problem-solving transfer suggest that other views [than the doctrine of formal discipline] may be more fruitful" ([8], p. 59). In an updated review of the problem-solving literature ten years later, the same two authors posit three research-based principles of problem solving in their conclusion, two of which are relevant to transfer. Their "domain-specific principle" asserts that "[r]ather than attempting to teach general problem-solving heuristics, it is better to teach problem-solving skills within specific domains" ([9], p. 299). In addition, according to their "near-transfer principle", "[r]ather than expecting problem-solving skills to be applicable to a wide range of problems, it is better to expect that problem-solving skills will be largely restricted with respect to their range of applicability" ([9], p. 299). Their conclusions thus work against the hopes that Dudley has for algebra.

In order to determine what the research literature might say about the effects of algebra on either transfer or problem solving/critical thinking, I did two literature searches using the databases ERIC (for education) and PsycINFO (for psychology), using the descriptors "algebra" and "transfer", and then "algebra" and either "critical thinking", "reasoning", "logical thinking", or "problem solving". I did not locate a single study that investigated the transfer of algebraic thinking to other domains. There are some studies that investigate the effects of problem-solving strategies or critical thinking on performance in algebra, but virtually none that "go in the other direction" and investigate the effect of algebraic thinking on problem-solving or critical-thinking. One study that I did locate [5] compared two college algebra classes on their problem solving and critical-thinking skills, but with no comparison data to nonalgebra students, it is not possible to draw any conclusions about the effects of algebraic thinking on those domains. A second study I located from some time ago [4] found that low-achieving algebra students actually outperformed high-achieving students on some kinds of logical syllogisms. This was the complete set of studies on the effects of algebra I was thus able to locate. In addition, I note that the very extensive review of recent research literature on the learning of algebra by Kieran [7] does not contain any studies of the effects of algebra on either far transfer or on problem solving and critical thinking.

There appears to be no research whatsoever that would indicate that the kind of reasoning skills a student is expected to gain from learning algebra would transfer to other domains of thinking or to problem solving or critical thinking in general. The lack of such research evidence does not mean that such transfer does not occur or that algebraic reasoning might not have positive effects on problem solving and critical thinking. However, in light of the conclusions of Meyer and Wittrock [8], [9], until such effects are demonstrated through research, I shall remain a skeptic.

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Whither Journals?

Rob Kirby

Institutions and governments are increasingly promoting open access for papers in mathematics (and other disciplines). A number of universities, including Harvard,[1] Kansas,[2] MIT,[3] Duke,[4] and Princeton,[5] have established policies for their faculties, which are essentially this:

Each faculty member will grant to the university permission (i.e., a license) to make his or her scholarly article open access and to allow anyone else to do the same (provided that the article is not sold for a profit). The faculty member will provide to the university an electronic copy of the final version. The faculty member may opt out upon written request.

In November 2011, UC Berkeley announced that it would help make papers by its faculty open access in two cases. If the paper is published in an open-access journal, UCB will subsidize the cost to the author by up to US$3,000, with a US$6,000 limit per year. If the paper is published in a normal subscription-based open-access journal, UCB will pay up to US$1,500 to make the paper open access immediately.

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[1] *2008,* `osc.hul.harvard.edu/hfaspolicy`.

[2] *2008,* `kuscholarworks.ku.edu/dspace`.

[3] *2009,* `dspace.mit.edu`.

[4] *2010,* `library.duke.edu/dukespace/index.html`.

[5] *2011,* `princeton.edu/dof/policies/publ/fac/open-access-policy/`.

Members of the Editorial Board for Scripta Manent *are: Jon Borwein, Thierry Bouche, John Ewing, Andrew Odlyzko, Ann Okerson.*

DOI: http://dx.doi.org/10.1090/noti897

Berkeley is part of the Compact for Open-Access Publishing Equity,[6] which pledges that each of the undersigned universities commits to the timely establishment of durable mechanisms for underwriting reasonable publication charges for articles written by its faculty and published in fee-based open-access journals and for which other institutions would not be expected to provide funds. The signatories include Cornell, Dartmouth, Harvard, MIT, Ottawa, Columbia, Michigan, Barcelona, Duke, Calgary, and Simon Fraser. Not all have established a mechanism for underwriting yet, and not all will contribute to fees at a non-open-access journal.

These initiatives are important first steps in reclaiming more control over the dissemination of our published research.

Publication fees at open-access journals vary widely. The Public Library of Science (PLoS) charges over US$2,000 per article. The *Proceedings of the National Academy of Sciences* charges the authors (mathematicians are often not charged) US$70 per page, and this covers very roughly half the cost of the journal, the rest coming from subscriptions. Authors may choose to make the paper open access immediately upon publication for a surcharge of US$1,275.

Some subscription-based math journals will make a paper open access in return for a fee. For example, journals of the London Mathematical Society make their papers open access for the first six months after publication, and then the papers go behind a subscription wall. An author may make a paper open-access permanently for a fee of US$3,050. There also exist open access math journals with either no fees or low fees.

[6] `http://www.oacompact.org/`.

Mathematicians have been relatively quiet bystanders in this movement, which has been led by universities and broader agencies. Yet math, as always, is rather different from other subjects; e.g., we use TEX and often produce papers ready to be printed or posted at the arXiv.

This article will discuss the economics of publishing, both traditional and open access, and will suggest (at the end) a way in which mathematicians might help lead the transition to open-access journals.

A little-noticed fact is that the average professor at a top-fifty mathematics department in the U.S. publishes around twenty-five pages per year in math journals (not proceedings or books). The reader can determine, as I did, the number for his/her department by picking a year, say 2006, and counting pages in papers in that year that were reviewed on MathSciNet. Of course, this number can vary widely for different professors, from zero to hundreds.

It is reasonable to think that at least US$25,000 of a professor's salary goes to research (the rest to teaching and service to the department, the campus, and the math community). Thus his or her university spends US$1,000 per page to fund this research. As the goals of a university are to create and disseminate knowledge, it would seem reasonable for it to spend at the very least 5 percent to 10 percent of this money to make the research open access, freely available to the world. Indeed, Berkeley has offered to spend as much as US$6,000 for those twenty-five pages, which is 24 percent of the hypothesized US$25,000 for the research.

The amount that a U.S. library spends on math journals at a top-fifty school varies considerably by the size and wealth of the school, but US$300,000 at a large state university is not uncommon. If that money were spent instead on open access for, say, sixty research mathematicians, it would allow US$5,000 per person.

On the other hand, what should it cost to run an open-access e-only math journal? Existing journals have widely varying incomes, measured in dollars per page (calculated by dividing the subscription price by the average number of pages published in a given year). The AMS journals—JAMS, PAMS, TAMS—charge approximately twenty-five cents/page and have close to one thousand subscriptions, so their income per page is in the ballpark of US$250 per page.

A decade ago when bundles of journals were less common and data was easier to find, *Inventiones Mathematicae* charged over a dollar per page and had over six hundred subscriptions, for an income of over US$600/page. It seems likely that this income has not decreased over time. Some Springer journals make less than *Inventiones*, some more, but their average is still well above AMS journals. I believe that journals owned by other big commercial publishers are in the same range, although there are some exceptionably profitable commercial journals such as *Communications in Pure and Applied Mathematics*, a Wiley journal, whose income a decade ago was around US$900/page. Ulf Rehmann's website[7] contains a great deal of information about prices.

University-based nonprofit journals often have lower income. For example, *Annals of Math.* charges from ten to twenty cents per page depending on how many pages they publish in a given year; it has over nine hundred subscriptions, for income between US$90 and US$180 per page. The difference between *Annals* and the AMS journals is mostly due to overhead at AMS and perhaps a bit of profit to subsidize other AMS activities. Many other university-based math journals have income in the US$100 to US$200 range. Journals belonging to Mathematical Sciences Publishers (the author's (nonprofit) company) have incomes around US$40 per page and exist due to great efficiency and volunteer labor.

It appears then that a university-based (no overhead), e-only (no printing costs), open-access (no costs for maintaining subscriptions), nonprofit journal could exist on income well under US$100/page, perhaps even as low as US$50/page. Or perhaps even lower. An e-journal could arrange refereeing and establish a reputation for math quality (two very important aspects of a journal) and, with enough volunteer work, exist without any money changing hands. The *Electronic Journal of Combinatorics* is a good example. To save money on infrastructure, an e-journal could create some cover pages and become an overlay of the arXiv, which would host all versions, including the final version, of a paper.

Now let's look at papers from the reader's point of view. We like a paper with well-drawn figures, well-laid-out equations and diagrams, good line and page breaks, good internal and external linking, good spelling and grammar; most of all we want clear, understandable writing. Some authors submit a TEX file with all these characteristics, with little editing needed, but other submissions are a mess. The variation is huge.

Thus copy editing—the process for turning a mess into a clear, readable paper—can be very costly, and it is no surprise that many journals do rather little of it, while others are quite conscientious. It makes sense for a paper of high mathematical quality and wide readership to be very carefully copyedited, with attention paid to the clarity of the introduction and main theorems. Authors and referees should of course ensure correctness and some readability, but referees rarely

[7] `http://www.mathematik.uni-bielefeld.de/~rehmann/BIB/AMS/Price\_per\_page.html`.

engage in a back-and-forth dialog with the author to further improve the writing. Thus the absolute need for good copy editors.

As the quality of a paper and hence the number of readers declines, one would expect a concomitant decline in copy editing so as to reduce the cost of publication. Thus it is not the individual reader but rather the number of readers that indicates how much copy editing is economical for a given paper.

Times are tough at universities around the world, and it behooves us mathematicians to promote an efficient system whereby libraries pay publication costs directly and we publish in e-only open-access math journals, saving print and subscription costs and cutting out the profits to the big commercial publishers. But how do we transition to this model?

Existing journals can start by offering to make an article open access immediately at a modest cost per page of under US$50 to authors at institutions that subscribe (more otherwise) and, as subscriptions drop (and print runs drop), adjust the price per page so as to at least break even. But I believe that to really move forward, new open-access journals are needed. Here is a possible plan.

As the economists would say, a *signal* is needed, in the sense that a candidate for election needs to raise a significant amount of money in order to be taken seriously by the media and public. I would like to see a million-dollar endowment, with an income of US$30,000 per year. With that support, one would hope to recruit excellent editors (e.g., ICM speakers) for three journals called, let's say, *X, a Journal of Mathematics*, and similarly *Y, a Journal of Mathematics*, and *Z, a Journal of Mathematics*, i.e., XJM, YJM, and ZJM. XJM would be for papers of broadest interest, YJM less so, and ZJM more specialized. Or they might correspond to A+, A, and A– papers, which, as in a typical calculus course, would correspond to roughly the best 20 percent to 25 percent of papers in reputable math journals. (Papers "graded" C or lower could appear in journals in which no money changes hands and only volunteer work is done; B papers would fall somewhere in between.) The US$30,000 would go towards the website, editorial software, and a bit of marketing, with the remaining money subsidizing copy editing; it is the *signal* which I believe is most important.

I'd suggest that XJM be subdivided into the same sections as the ICM. Each section would have a chief editor and as many other editors as needed, so that no one editor has to handle more than, say, five papers per year in his/her specialty. There is always overlap between sections, and there should be editors who belong to "adjacent" sections. Furthermore, I would recommend a system such as that used at MSP journals, e.g., *Geometry and Topology*, where an editor gets a referee's report and then either recommends acceptance or rejection to the rest of the editors in that section. The other editors have a few weeks to weigh in, and two editors must second a paper for final acceptance (a recommendation to reject needs no further seconding). With this system, editors form a community to discuss papers and maintain uniformly high standards.[8]

I believe both the money and the editors are necessary. Who is willing to step up to the plate?!

Update: Since this article was written in fall 2011, Cambridge University Press has "stepped up to the plate," and announced a pair of open access journals, *Forum of Mathematics, Pi* (`http://journals.cambridge.org/FMP`) and *Forum of Mathematics, Sigma* (`http://journals.cambridge.org/FMS`). These are to be supported by publication charges, called "Article Processing Charges" or APCs, but CUP is going to subsidize the charges for three years. The journals are intended to act as proof of concept for high-quality, scalable, sustainable open-access publishing in mathematics. They are also intended to establish important basic principles. In particular, the editorial decisions on acceptance and rejection of a paper are to be completely independent of whether an author can arrange payment. I will be the managing editor of the journals.

—RK

[8] *This system has worked well at G&T for fifteen years, but it depends on having very high-quality papers so that editors and referees are relatively happy to deal with them.*

AMERICAN MATHEMATICAL SOCIETY

MSRI Mathematical Circles Library

This book series is designed as a resource for leaders and participants in mathematics clubs and mathematical circles. Books may also be of interest to parents and teachers.

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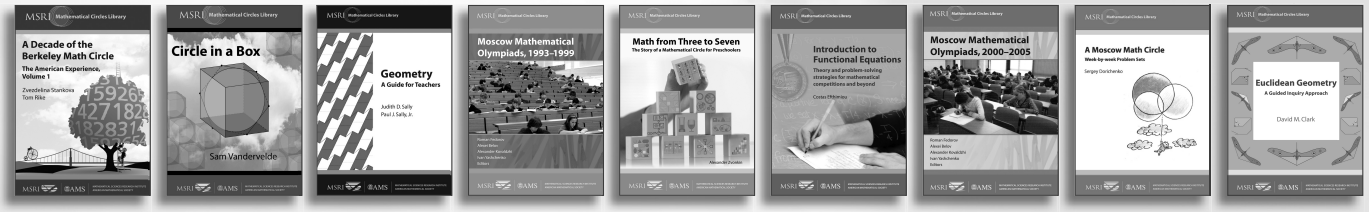

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Volume 1; 2008; 326 pages; Softcover; ISBN: 978-0-8218-4683-4; List US$39; AMS members US$31.20; Order code MCL/1

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Sam Vandervelde, *St. Lawrence University, Canton, NY*

A one-stop shopping guide to starting, funding, and maintaining a math circle

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Roman Fedorov, **Alexei Belov**, **Alexander Kovaldzhi**, and **Ivan Yashchenko**, Editors

A collection of problems from the 2000–2005 Moscow Mathematical Olympiads, including answers, hints, and detailed solutions

Volume 7; 2011; 176 pages; Softcover; ISBN: 978-0-8218-6906-2; List US$35; AMS members US$28; Order code MCL/7

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Describes in detail how to run math circles, choose problems, and handle any difficulties

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David M. Clark, *State University of New York, New Paltz, NY*

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Volume 9; 2012; 127 pages; Softcover; ISBN: 978-0-8218-8985-5; List US$39; AMS members US$31.20; Order code MCL/9

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Mathematics People

2012 Computer-Aided Verification Award Announced

Sam Owre, John Rushby, and Natarajan Shankar of SRI International have been named the recipients of the 2012 CAV (Computer-Aided Verification) Award "for developing PVS (Prototype Verification System), which, due to its early emphasis on integrated decision procedures and user-friendliness, significantly accelerated the application of proof assistants to real-world verification problems." The citation reads in part: "The design of automatic theorem provers has been one of the great challenges in computer science since its beginnings, with the hope that computers—by searching through infinite but well-defined spaces of formal proofs—would be able to determine whether a mathematical hypothesis is a theorem and, ultimately, discover interesting new mathematics. In parallel to the difficult task of finding entire proofs automatically, much focus has been on the more limited goal of building interactive proof assistants, which are programs that support a user in constructing formal arguments and point out gaps in the reasoning. Several such systems were already successful in the early 1990s, when Sam Owre, John Rushby, and Natarajan Shankar of SRI International built PVS (Prototype Verification System), a proof assistant that was specifically designed to be used in system verification. In verification, proofs demonstrate the absence of errors in a software or hardware system. …

"At a time when much research in computer-aided verification focused on semantic approaches such as model checking, Owre, Rushby, and Shankar made proof assistants fashionable in verification by building PVS around the following key elements: (1) an expressive, user-friendly, and well-documented system specification language; (2) programmable tactics for automatically exploring promising proof directions; and (3) decision procedures for common logical theories and their combination."

The CAV award is given annually in recognition of a specific fundamental contribution or a series of outstanding contributions to the field of computer-aided verification and includes a cash prize of US$10,000.

—Thomas Henzinger, Chair
CAV Award Committee

Toland Receives Sylvester Medal

John Toland of the University of Bath has been awarded the 2012 Sylvester Medal of the Royal Society of London "for his original theorems and remarkable discoveries in nonlinear partial differential equations, including applications to water waves." The Sylvester Medal is awarded biennially in even years "for the encouragement of mathematical research." It carries a cash award of £1,000 (approximately US$1,500).

—From a Royal Society announcement

SIAM Prizes Awarded

The Society for Industrial and Applied Mathematics (SIAM) has awarded a number of prizes for 2012.

John Ball of the University of Oxford has been named the John von Neumann Lecturer for 2012. The lectureship is awarded for outstanding and distinguished contributions to the field of applied mathematical sciences and for the effective communication of these ideas to the community. It carries a cash award of US$5,000.

Thomas Goldstein of Stanford University has been awarded the Richard C. DiPrima Prize. The prize is awarded every two years to a junior scientist who has done outstanding research in applied mathematics and who has completed his or her doctoral dissertation and all other requirements for his or her doctorate during the period from three years prior to the award date to one year prior to the award date.

Vojtěch Rödl of Emory University and Mathias Schacht of the University of Hamburg have been awarded the George Pólya Prize. The prize is given every two years alternately for a notable application of combinatorial theory or for a notable contribution in another area of interest to George Pólya, such as approximation theory, complex analysis, number theory, orthogonal polynomials, probability theory, or mathematical discovery and learning.

Ruth F. Curtain of the University of Groningen was awarded the W. T. and Idalia Reid Prize in Mathematics. This prize is awarded for research in or other contributions to the broadly defined areas of differential equations and control theory.

Robert Bridson of the University of British Columbia was named the I. E. Block Community Lecturer. The lectureship is intended to encourage public appreciation of the excitement and vitality of science.

Barbara Lee Keyfitz of Ohio State University has been awarded the SIAM Prize for Distinguished Service to the Profession. The prize is awarded to an applied mathematician who has made distinguished contributions to the furtherance of applied mathematics on the national level.

The SIAM Outstanding Paper Prizes have been awarded to the following researchers: Nir Ailon and Bernard Chazelle of Princeton University for "Approximate Nearest Neighbors and the Fast Johnson-Lindenstrauss Transform", *SIAM Journal on Computing*, vol. 39, issue 1 (2009), pp. 302–322; Matthew Finn of the University of South Adelaide and Jean-Luc Thiffeault of the University of Wisconsin, Madison, for "Topological Optimization of Rod-Stirring Devices", *SIAM Review*, vol. 53, issue 4 (2011), pp. 723–743; Bart Vandereycken of École Polytechnique Fédérale de Lausanne and Stefan Vandewalle of the Catholic University of Leuven for "A Riemannian Optimization Approach for Computing Low-Rank Solutions of Lyapunov Equations", *SIAM Journal on Matrix Analysis and Applications*, vol. 31, issue 5 (2010), pp. 2553–2579. The prizes are awarded annually to the authors of three outstanding papers published in SIAM journals in the preceding three calendar years.

The SIAM Awards in the Mathematical Contest in Modeling were awarded to Cheng Fu, Hangqi Zhao, and Danting Zhu of Zhejiang University for their work on the continuous problem "The secrets of leaves"; and to James Jones, Suraj Kannan, and Joshua Mitchell of the University of Louisville for their work on the discrete problem "C.A.R.S: Cellular Automaton Rafting Simulation". Each student member of the winning team receives a cash award of US$300.

The SIAM Student Paper Prizes were awarded to the following students: Brittany D. Froese, Simon Fraser University, "Convergent Finite Difference Solvers for Viscosity Solutions of the Elliptic Monge-Ampère Equation in Dimensions Two and Higher" (coauthored with Adam Oberman, Simon Fraser University); Stefanie Hollborn, Johannes Gutenberg University, Mainz, Germany, "Reconstructions from Backscatter Data in Electric Impedance Tomography"; and Marina Moraiti, University of Pittsburgh, "On the Quasistatic Approximation in the Stokes-Darcy Model of Groundwater-Surface Water Flows". A cash prize of US$1,000 is awarded for each paper.

—From a SIAM announcement

Prizes of the Canadian Mathematical Society

The Canadian Mathematical Society (CMS) has made a number of awards for 2011–2012.

Malgorzata Dubiel of Simon Fraser University was honored with the 2011 Adrien Pouliot Award. According to the prize citation, she is "a champion for what she believes in: success and joy in doing mathematics, for her students, for her colleagues and especially for women." She has served as president of the Canadian Math Education Study Group (CMESG) and was the cochair of the 2009 Canadian Mathematics Education Forum. She initiated the development of Connecting Women in Mathematics Across Canada (CWiMAC), a workshop for women graduate students in the mathematical sciences, and organized the "Changing the Culture" conference offered by the Pacific Institute for the Mathematical Sciences (PIMS). She is involved in many activities for youths, including math camps for both students and teachers. The Pouliot Award is for individuals or teams of individuals who have made significant and sustained contributions to mathematics education in Canada.

Veselin Jungic of Simon Fraser University is the recipient of the 2012 Excellence in Teaching Award. According to the prize citation, he "has a formidable reputation in the mathematics community for his effective teaching style, his innovative ideas, and the immense time and effort he puts into education initiatives. His dedication to students and his passion for the subject are truly inspiring." Much of his recent work has been with aboriginal students who did not complete secondary education; he has produced two short animated films in aboriginal storytelling format that have been translated into a number of native languages. The Excellence in Teaching Award recognizes sustained and distinguished contributions in teaching at the postsecondary undergraduate level at a Canadian institution.

Hugh Thomas of the University of New Brunswick and Alexander Yong of the University of Illinois at Urbana-Champaign received the 2011 G. de B. Robinson Award for their paper "Multiplicity-Free Schubert Calculus", published in the *Canadian Mathematical Bulletin*, vol. 53, issue 1 (2010), pp. 171–186. The award recognizes the publication of excellent papers in the *Canadian Journal of Mathematics* and the *Canadian Mathematical Bulletin*.

—From a CMS announcement

NSF Postdoctoral Fellowships Awarded

The Mathematical Sciences Postdoctoral Research Fellowship program of the Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) awards fellowships each year for postdoctoral research in pure mathematics, applied mathematics and operations research, and statistics. Following are the names of the fellowship recipients for 2012, together with their Ph.D. institutions (in parentheses) and the institutions at which they will use their fellowships.

Antonio Ache (University of Wisconsin), Princeton University; David Aulicino (University of Maryland), University of Chicago; Matthew Badger (University of Washington), Stony Brook University; Eric Baer (University of Texas), Massachusetts Institute of Technology; David Bland (University of Toronto), University of

California Berkeley; Ana Caraiani (Harvard University), University of Chicago; William Cavendish (Princeton University), University of Oxford; Melody Chan (University of California Berkeley), Harvard University; Elizabeth Chen (University of Michigan), Harvard University; Ameerah Chowdhury (University of California San Diego), University of California Los Angeles; Michael Cortez (Cornell University), Georgia Institute of Technology; Spencer Dowdall (University of Chicago), University of Illinois, Urbana-Champaign; Glenn Ford (Northwestern University), Stanford University; Rina Foygel (University of Chicago), Stanford University; James Freitag (University of Illinois, Chicago), University of California Berkeley; Sheel Ganatra (Massachusetts Institute of Technology), Stanford University; Noah Giansiracusa (Brown University), University of California Berkeley; Wushi Goldring (Harvard University), Princeton University; Owen Gwilliam (Northwestern University), University of California Berkeley; Kenneth Ho (Courant Institute, New York University), University of Texas; Jack Huizenga (Harvard University), University of Illinois, Chicago; Adam Jacob (Columbia University), Harvard University; Thomas Koberda (Harvard University), Yale University; Mark Lewko (University of Texas), University of California Los Angeles; Jonathan Luk (Princeton University), University of Pennsylvania; Keerthi Shyam Madapusi Sampath (University of Chicago), Harvard University; Johanna Mangahas (University of Michigan), Brown University; Andrew Marks (University of California Berkeley), California Institute of Technology; Jason Miller (Stanford University), Massachusetts Institute of Technology; Anatoly Preygel (Massachusetts Institute of Technology), University of California Berkeley; Douglas Rizzolo (University of California Berkeley), University of Washington; Ian Shipman (University of Chicago), University of Michigan; Steven Sivek (Massachusetts Institute of Technology), Harvard University; Susan Tolwinski-Ward (University of Arizona), National Center for Atmospheric Research; Rodrigo Trevino (University of Maryland), Cornell University; Vidya Venkateswaran (California Institute of Technology), Massachusetts Institute of Technology; Cynthia Vinzant (University of California Berkeley), University of Michigan; Alden Walker (California Institute of Technology), University of Chicago; Matthew Williams (University of Washington), Princeton University; Alexander Young (University of California San Diego), University of Washington; Elena Yudovina (University of Cambridge), University of Michigan; Inna Zakharevich (Massachusetts Institute of Technology), University of Chicago; Alexander Zupan (University of Iowa), University of Texas.

—NSF announcement

2012 International Mathematical Olympiad

Young mathematicians from one hundred countries competed in the fifty-third International Mathematical Olympiad (IMO), held in Mar del Plata, Argentina, July 4–16, 2012. The IMO is the preeminent mathematical competition for high-school-age students from around the world. The IMO consists of solving six extremely challenging mathematical problems in a nine-hour competition administered over two days.

The team from the Republic of Korea finished first in the 2012 IMO. China finished second, and the U.S. team finished third, one point behind China. Five members of the U.S. team won gold medals. In alphabetical order, the U.S. gold medal winners are: Ravi Jagadeesan, Phillips Exeter Academy, Exeter, New Hampshire; Mitchell Lee, homeschooled, Oakton, Virginia; Bobby Shen, Dulles High School, Sugar Land, Texas; Thomas Swayze, Canyon Crest Academy, San Diego, California; and David Yang, Phillips Exeter Academy, Exeter, New Hampshire. Xiaoyu He, Acton-Boxborough Regional High School, Acton, Massachusetts, received a silver medal. The team from Russia finished fourth, while Canada and Thailand tied for fifth. The 2013 IMO will take place in Santa Marta, Colombia, July 18–28.

—From an IMO announcement

Sanford Segal (1937–2010)

Sanford Segal, professor emeritus of mathematics at the University of Rochester, died on May 7, 2010.

In addition to studying pure mathematics, Segal had a keen interest in history and spent much of his later career researching, teaching, and writing about the history of mathematics. He received a grant from the Alexander von Humboldt Foundation to do research on the lives of mathematicians who stayed in Germany after Hitler came to power. This research eventually led to his book *Mathematicians under the Nazis*, which was published by Princeton University Press in 2003. That same year, Segal received a secondary appointment in the department of history at Rochester.

Segal's research area was classical analysis, particularly analytic number theory and complex function theory. He mentored five doctoral students and published more than 45 papers on mathematics, mathematics education, and the history of science. In 1982 he published the textbook *Nine Introductions in Complex Analysis*, now in its second edition. He also had a passion for pedagogy of mathematics and science.

Segal received his bachelor's degree from Wesleyan University in 1958 in mathematics and in classical civilization. He then spent a year as a Fulbright student in Mainz, Germany. He received his Ph.D. at the University of Colorado at Boulder in 1963, under the direction of Sarvadaman D. S. Chowla. Segal went to the University of Rochester as an instructor in 1963 and advanced to professor in 1970. He received a Fulbright Grant as a research fellow for 1965–1966 in Vienna, Austria, and also held visiting positions at the University of Nottingham and the Instituto de Matemática Pura e Aplicada in Rio de Janeiro.

—Allyn Jackson

Mathematics Opportunities

AMS-AAAS Mass Media Summer Fellowships

The American Mathematical Society provides support each year for a graduate student in the mathematical sciences to participate in the American Association for the Advancement of Science (AAAS) Mass Media Science and Engineering Fellows Program. This summer fellowship program pairs graduate students with major media outlets nationwide, where they will research, write, and report on science news and use their skills to bring technical subjects to the general public.

The principal goal of the program is to increase the public's understanding of science and technology by strengthening the connection between scientists and journalists to improve coverage of science-related issues in the media. Past AMS-sponsored fellows have held positions at *Scientific American*, Voice of America, KUNC-FM Radio, National Geographic Television, the *Oregonian*, *Popular Science*, the *Chicago Tribune*, the *Milwaukee Journal Sentinel*, and WOSU-AM Radio.

Fellows receive a weekly stipend of US$450, plus travel expenses, to work for ten weeks during the summer as reporters, researchers, and production assistants in newsrooms across the country. They observe and participate in the process by which events and ideas become news, improve their ability to communicate about complex technical subjects in a manner understandable to the public, and increase their understanding of editorial decision making and of how information is effectively disseminated. Each fellow attends an orientation and evaluation session in Washington, DC, and begins the internship in mid-June. Fellows submit interim and final reports to AAAS. A wrap-up session is held at the end of the summer.

Mathematical sciences faculty are urged to make their graduate students aware of this program. The deadline to apply for fellowships for the summer of 2013 is **January 15, 2013**. Further information about the fellowship program and application procedures is available online at `http://www.aaas.org/programs/education/MassMedia`; or applicants may contact Rahman Culver, Manager, Mass Media Program, AAAS Mass Media Science and Engineering Fellows Program, 1200 New York Avenue, NW, Washington, DC 20005; telephone 202-326-6645; fax 202-371-9849; email `raculver@aaas.org`. Further information is also available at `http://www.ams.org/programs/ams-fellowships/media-fellow/massmediafellow` and through the AMS Washington Office, 1527 Eighteenth Street, NW, Washington, DC 20036; telephone 202-588-1100; fax 202-588-1853; email `amsdc@ams.org`.

—AMS Washington Office

Call for Applications for Workshop "How to Run a Math Camp"

March 6–8, 2013, American Institute of Mathematics, Palo Alto, California

Organizers: Ellen J. Maycock, Max Warshauer

This workshop, sponsored by the American Institute of Mathematics (AIM), the American Mathematical Society (AMS), and the National Science Foundation (NSF), will bring together directors, organizers, and prospective organizers of summer programs or math camps in the United States. The main goals of this workshop are to provide advice and support for individuals who have recently started or are interested in starting a math camp, as well as to provide experienced directors of math camps an opportunity to share their experiences and knowledge with each other and with new directors. We invite applications from individuals or teams of up to two people. We especially encourage participation from those less experienced at running math camps and also from individuals who are thinking of starting a math camp.

Some of the topics to be covered at this workshop will include:

- Increasing diversity
- Obtaining funding: applying for grants (and metrics, quantifying outcomes from year to year)
- The basics of starting a math camp: advice for new programs
- The nuts and bolts of running a camp
- Curriculum development
- Serving different student populations

Along with the organizers of this workshop, an advisory board will provide additional help in deciding topics for the workshop and will participate in giving talks and running breakout sessions. Members of this advisory board are: Luis Cáceres, University of Puerto Rico, Mayagüez (PROTaSM); Wendy Hines, University of Nebraska-Lincoln (All Girls/All Math); Stephen Maurer, Swarthmore College

(MathPath); David Savitt, University of Arizona (Canada/USA Math Camp); Dan Shapiro, Ohio State University (Ross Mathematics Program); Glenn Stevens, Boston University (PROMYS).

Space and funding are available for a few more participants. If you would like to participate, please apply by filling out the online form no later than **November 6, 2012**.

Applications are open to all, and we especially encourage women, underrepresented minorities, junior mathematicians, and researchers from primarily undergraduate institutions to apply.

To view the workshop description and apply, visit `http://www.aimath.org/ARCC/workshops/mathcamp.html`. Before submitting an application, please read the description of the AIM style of workshop at `http://aimath.org/research/aimstyle.html`.

For more information, email `workshops@aimath.org`.

—Ellen Maycock
AMS Membership and Programs Department

NSF Program ADVANCE

The National Science Foundation (NSF) sponsors the ADVANCE Program in an effort to increase the representation and advancement of women in academic science and engineering careers.

In 2012 the program will support three types of projects. Partnerships for Adaptation, Implementation, and Dissemination (PAID) awards support analysis, adaptation, dissemination, and use of existing innovative materials and practices that have been demonstrated to be effective in increasing representation and participation of women in academic science and engineering careers. This category of award also supports scientific research designed to advance understanding of gender in academic science and engineering careers. The deadline for required letters of intent is **October 5, 2012**; the deadline for full proposals is **November 8, 2012**.

Institutional Transformation (IT) awards support academic institutional transformation to promote the increased participation and advancement of women scientists and engineers in academe. These awards support innovative and comprehensive programs for institution-wide change. The deadline for letters of intent for these awards is **October 4, 2013**; the full proposal deadline is **November 12, 2013**.

Institutional Transformation Catalyst (IT-Catalyst) awards are designed to support institutional self-assessment activities, such as basic data collection and analysis and policy review, in order to identify specific issues in the recruitment, retention, and promotion of women faculty in institutions of higher education. The deadline for letters of intent for these awards is **October 4, 2013**, and the full proposal deadline is **November 12, 2013**. Proposals are sought from both men and women for creative strategies to realize the goals of the ADVANCE Program. Members of underrepresented minority groups and individuals with disabilities are especially encouraged to apply. Proposals that address the participation and advancement of women with disabilities and women from underrepresented minority groups are encouraged. For more information see `http://www.nsf.gov/pubs/2012/nsf12584/nsf12584.htm?WT.mc_id=USNSF_36&WT.mc_ev=click`.

—From an NSF announcement

NSF Conferences and Workshops in the Mathematical Sciences

The National Science Foundation (NSF) supports conferences, workshops, and related events (including seasonal schools and international travel by groups). Proposals for conferences, workshops, or conference-like activities may request funding of any amount and for durations of up to three years. Proposals may be submitted only by universities and colleges and by nonprofit nonacademic institutions. For full information, including deadlines for each disciplinary program, see the website `http://www.nsf.gov/pubs/2010/nsf10578/nsf10578.htm?WT.mc_id=USNSF_25&WT.mc_ev=click`.

—From an NSF announcement

Clay Mathematics Institute Workshops

The Clay Mathematics Institute (CMI) is currently seeking proposals for funded workshops to be held in the Mathematical Institute in Oxford, United Kingdom. CMI intends to conduct a program of workshops of generally 10–20 persons, the aim of which is to bring a set of researchers together quickly outside the usual grant and application cycle when this is likely to result in significant progress. An application submitted **three months before the workshop** is sufficient. Funding for at least 10 people is available for each workshop. Proposals should be sent to Nick Woodhouse (`nwoodh@maths.ox.ac.uk`) and copied to Naomi Kraker (`kraker@maths.ox.ac.uk`).

—CMI announcement

MSRI Call for Proposals

The Mathematical Sciences Research Institute (MSRI) invites the submission of preproposals for full- or half-year programs to be held at MSRI. Planning of such programs is generally done about three years in advance. Except in extraordinary cases, a subject is the focus of a program not more than once in ten years.

A scientific program at MSRI generally consists of up to one year (ten months) of concentrated activity in a specific area of current research interest in the mathematical sciences. MSRI usually runs two programs simultaneously,

each with about thirty mathematicians in residence at any given time. The most common program lengths are one year and five months (typically in the form of a fall or spring semester program). Each program begins with a Connections for Women workshop, followed by an Introductory workshop. The purpose of both workshops is to introduce the subject to the broader mathematical community. The programs receive administrative and financial support from the Institute, allowing organizers to focus on the scientific aspects of the activities.

How to submit a program preproposal: The Scientific Advisory Committee (SAC) of the Institute meets in January and November each year to consider preproposals for programs. Successful proposals are usually developed from the preproposal in a collaborative process between the proposers, the directorate, and the SAC, and may be considered at more than one meeting of the SAC before selection.

The scientific planning and organization of each program are the responsibility of a committee of organizers (aided by a liaison of the directorate and the SAC). The organizers recommend participants in the program; they also plan workshops within the program, which many more participants may attend. Each program is allocated a budget for subsistence and travel expenses.

Please see our website for specific preproposal requirements and further information `https://www.msri.org/web/msri/scientific/request-for-proposals/propose-a-program`.

—MSRI Announcement

News from MSRI

The Mathematical Sciences Research Institute (MSRI) invites applications for two hundred Research Members and thirty semester-long Postdoctoral Fellows in the following programs: Mathematical General Relativity (August 19 to December 20, 2013), Optimal Transport: Geometry and Dynamics (August 19 to December 20, 2013), Algebraic Topology (January 20 to May 23, 2014), and Model Theory, Arithmetic Geometry and Number Theory (January 20 to May 23, 2014). Research Memberships are intended for researchers who will be making contributions to a program and who will be in residence for one or more months. Postdoctoral Fellowships are intended for recent Ph.D.'s. Interested individuals should carefully describe the purpose of their proposed visit and indicate why a residency at MSRI will advance their research program. To receive full consideration, an application must be submitted, including all letters of support, by **December 1, 2012**. It is the policy of MSRI to actively seek diversity in its programs and workshops. Thus a strong effort is made to remove barriers that hinder equal opportunity, particularly for those groups that have been historically underrepresented in the mathematical sciences. Application information: `http://www.msri.org/web/msri/scientific/member-application`.

—MSRI Announcement

THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department of Mathematics
Faculty Position(s)

The Department of Mathematics invites applications for tenure-track faculty position(s) at the rank of Assistant Professor in all areas of mathematics. Other things being equal, preference will be given to areas consistent with the Department's strategic planning.

Applicants should have a PhD degree and strong experience in research and teaching. Applicants with exceptionally strong qualifications and experience may be considered for position(s) above the Assistant Professor rank.

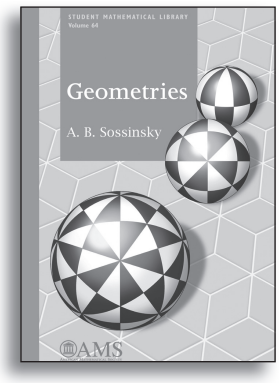
Starting rank and salary will depend on qualifications and experience. Fringe benefits include medical/dental benefits and annual leave. Housing will also be provided where applicable. Initial appointment will be on a three-year contract, renewable subject to mutual agreement. A gratuity will be payable upon successful completion of the contract.

Applications received on or before 31 December 2012 will be given full consideration for appointment in 2013. Applications received afterwards will be considered subject to the availability of position(s). Applicants should send their curriculum vitae together with at least three research references and one teaching reference to the Human Resources Office, HKUST, Clear Water Bay, Kowloon, Hong Kong. Applicants for position(s) above the Assistant Professor rank should send curriculum vitae and the names of at least three research referees to the Human Resources Office.

More information about the University is available on the University's homepage at http://www.ust.hk.

(Information provided by applicants will be used for recruitment and other employment-related purposes.)

AMERICAN MATHEMATICAL SOCIETY



Geometries

A. B. Sossinsky, *Independent University of Moscow, Russia*

An innovative modern exposition of geometry in which Felix Klein's Erlangen Program is systematically used as the basis for defining various geometries.

Student Mathematical Library, Volume 64; 2012; 301 pages; Softcover; ISBN: 978-0-8218-7571-1; List US$48; AMS members US$38.40; Order code STML/64

AMS AMERICAN MATHEMATICAL SOCIETY BOOKSTORE

www.ams.org/bookstore

For Your Information

"Transcending Tradition": Exhibition on Jewish Mathematicians in German States

"Transcending Tradition: Jewish Mathematicians in German-Speaking Academic Culture", an exhibition that showcases the technical and professional scope of the contributions made by Jewish mathematicians to the development of mathematical culture in the German states before 1933, is coming to the United States after having been on view in Israel in 2011 and early 2012. It is set to open October 4, 2012, at the Crerar Science Library at the University of Chicago.

For decades before their expulsion and extermination, Jewish mathematicians were an important part of the German-speaking mathematical world. Jewish mathematicians contributed to scientific research, to the professional institutions of mathematics, and to all layers of mathematical culture. But, from 1933 onward, Jewish mathematicians in Germany were forced to emigrate or faced concentration camps and death. Some of those who fled or who survived the camps were able to establish new careers in their host countries; however, others suffered greatly from losses caused by their forced exile.

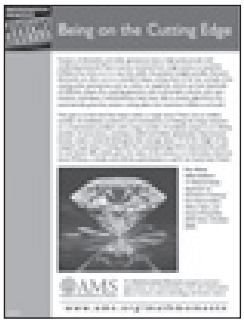
The exhibition focuses on the period between the legal and political emancipation of Jews in the nineteenth century and the rise of the Nazis, a time in which Jewish mathematicians in German-speaking countries achieved their most prominent successes. The exhibition highlights two points in particular. First, during the period in question, there was probably no part of the academic culture of mathematics in which Jewish mathematicians were not actively involved. In the Wilhelmine Empire and the Weimar Republic, Jewish mathematicians worked in research, teaching, and publishing. They were active in professional organizations such as the German Mathematical Society, and they participated in the public discourse on mathematics. They contributed to shaping the German-speaking mathematical culture of their time. Second, their activities were so varied and multifaceted that every stereotype of a "Jewish" style in mathematics is immediately refuted.

The exhibition was designed by a group of seven historians of mathematics in cooperation with the Jewish Museum Frankfurt and the German Mathematical Society. They are Moritz Epple, Frankfurt/Main University, head of the international project; Michael Korey, Staatliche Kunstsammlungen Dresden, curator of the U.S. presentation; Ruti Ungar, Frankfurt/Main University, project manager; Birgit Bergmann, Frankfurt/Main University; Walter Purkert, Bonn University; Volker Remmert, Wuppertal University; David E. Rowe, Mainz University; Erhard Scholz, Wuppertal University; and Annette Vogt, Max Planck Institute for the History of Science, Berlin. The partners in the exhibition are Wolfgang Lück, Director, Hausdorff Research Institute for Mathematics; Günter M. Ziegler, Free University of Berlin and head of the Media Office of the German Mathematical Society; Matthias Kreck, Mathematical Institute, Bonn University; Leo Corry, Tel Aviv University; Raphael Gross, Director, Jewish Museum Frankfurt/Main; and Fritz Backhaus, Codirector, Jewish Museum, Frankfurt/Main. The exhibition includes biographical and archival material, much of which has not appeared in English before. For more information, see the website `https://gj-math.uni-frankfurt.de/home/`.

—Elaine Kehoe

For Your Information

From the AMS Public Awareness Office



Mathematical Moments. The program now includes 100 topics. Some of the most recent Moments, which were sent to departments last month, are how math is used in gemstone cutting and the math involved in juggling. View and print all Mathematical Moments online at `http://www.ams.org/mathmoments/` or request the new packets by sending an email to `paoffice@ams.org` (subject line: Mathematical Moments).

Annual Report of the AMS, 2011–2012. The report is posted online: `http://www.ams.org/about-us/annual-reports/annual-reports`.

Mathematical Imagery. A *Fractal Pancakes* album is posted, and the images can be sent as e-postcards: `http://www.ams.org/mathimagery/`.

—Annette Emerson and Mike Breen
AMS Public Awareness Officers
`paoffice@ams.org`

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.wustl.edu` in the case of the editor and `smf@ams.org` in the case of the managing editor. The fax numbers are 314-935-6839 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Information for *Notices* Authors

The *Notices* welcomes unsolicited articles for consideration for publication, as well as proposals for such articles. The following provides general guidelines for writing *Notices* articles and preparing them for submission. Contact information for *Notices* editors and staff may be found on the *Notices* website, `http://www.ams.org/notices`.

Upcoming Deadlines

September 15, 2012: Nominations for Sloan Research Fellowships. See `http://www.sloan.org/fellowships` or write to: Sloan Research Fellowships, Alfred P. Sloan Foundation, 630 Fifth Avenue, Suite 2550, New York, New York 10111-0242.

September 15, 2012: Applications for spring 2013 semester of Math in Moscow. See `http://www.mccme.ru/mathinmoscow`, or write to: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax: +7095-291-65-01; email: `mim@mccme.ru`. Information and application forms for the AMS scholarships are available on the AMS website at `http://www.ams.org/programs/travel-grants/mimoscow`, or by writing to: Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence RI 02904-2294; email `student-serv@ams.org`.

September 17, 2012: Full proposals for DMS/NIGMS Initiative for Research in Biological and Mathematical Sciences. See `http://www.nsf.gov/pubs/2012/nsf12561/nsf12561.htm?WT.mc_id=USNSF_25&WT.mc_ev=click` or `http://tinyurl.com/7e2sk3c`.

Where to Find It

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

AMS Bylaws—*January 2012, p. 73*

AMS Email Addresses—*February 2012, p. 328*

AMS Ethical Guidelines—*June/July 2006, p. 701*

AMS Officers 2010 and 2011 Updates—*May 2012, p. 708*

AMS Officers and Committee Members—*October 2012, p. 1290*

Conference Board of the Mathematical Sciences—*September 2012, p. 1128*

IMU Executive Committee—*December 2011, p. 1606*

Information for *Notices* Authors—*June/July 2012, p. 851*

Mathematics Research Institutes Contact Information—*August 2012, p. 979*

National Science Board—*January 2012, p. 68*

NRC Board on Mathematical Sciences and Their Applications—*March 2012, p. 444*

NRC Mathematical Sciences Education Board—*April 2011, p. 619*

NSF Mathematical and Physical Sciences Advisory Committee—*May 2012, p. 697*

Program Officers for Federal Funding Agencies—*October 2012, p. 1284 (DoD, DoE); December 2011, p.1606 (NSF Mathematics Education)*

Program Officers for NSF Division of Mathematical Sciences—*November 2011, p. 1472*

September 21, 2012: Full proposals for NSF Focused Research Groups. See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5671.

October 1, 2012: Applications for AWM Travel Grants. See http://www.awm- math.org/travelgrants.html#standard; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030; 703-934-0163; awm@awm-math.org.

October 5, 2012: Letters of intent for NSF Program ADVANCE Partnerships for Adaptation, Implementation, and Dissemination (PAID). See "Mathematics Opportunities" in this issue.

October 15, 2012: Proposals for NSA Mathematical Sciences Program grants for research. See http://www.nsa.gov/research/math_research/index.shtml.

October 17, 2012: Applications for NSF Postdoctoral Research Fellowships. See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5301.

November 1, 2012: Proposals for AIM Workshops. See www.aimath.org.

November 1, 2012: Nominations for Clay Research Fellowships. See http://www.claymath.org/research_fellows.

November 1, 2012: Applications for National Academies Research Associateship Programs. See http://sites.nationalacademies.org/PGA/RAP/PGA_050491 or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334-2760; fax 202-334-2759; email rap@nas.edu.

November 6, 2012: Applications for AMS-AIM-NSF Math Camp Workshop. See "Mathematics Opportunities" in this issue.

November 8, 2012: Full proposals for NSF Program ADVANCE Partnerships for Adaptation, Implementation, and Dissemination (PAID). See "Mathematics Opportunities" in this issue.

November 15, 2012: Nominations for 2013 Vasil A. Popov Prize. See http://imi.cas.sc.edu/popov-prize-call-nominations/.

December 1, 2012: Applications for PIMS Postdoctoral Fellowships. See http://www.pims.math.ca/scientific/postdoctoral or contact: assistant.director@pims.math.ca.

December 1, 2012: Applications for AMS Centennial Fellowships. See http://www.ams.org/ams-fellowships/. For paper copies of the form, write to the Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; prof-serv@ams.org; 401-455-4105

December 3, 2012: Entries for Ferran Sunyer i Balaguer Prize. See http://ffsb.iec.cat.

December 31, 2012: Nominations for Otto Neugebauer Prize of the EMS. See the website http://www.euro-math-soc.eu/otto_neugebauer_prize.html.

February 1, 2013: Applications for AWM Travel Grants, Mathematics Education Research Travel Grants, Mathematics Mentoring Travel Grants, and Mathematics Education Research Mentoring Travel Grants. See https://sites.google.com/site/awmmath/programs/travel-grants; or telephone: 703-934-0163; email: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

April 15, 2013: Applications for fall 2013 semester of Math in Moscow. See http://www.mccme.ru/mathinmoscow, or write to: Math in Moscow, P.O. Box 524, Wynnewood, PA 19096; fax: +7095-291-65-01; email: mim@mccme.ru. Information and application forms for the AMS scholarships are available on the AMS website at http://www.ams.org/programs/travel-grants/mimoscow, or by writing to: Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence RI 02904-2294; email student-serv@ams.org.

May 1, 2013: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See https://sites.google.com/site/awmmath/programs/travel-grants; or telephone: 703-934-0163; email: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

October 1, 2013: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See https://sites.google.com/site/awmmath/programs/travel-grants; or telephone: 703-934-0163; email: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

October 4, 2013: Letters of intent for NSF Program ADVANCE Institutional Transformation and Institutional Transformation Catalyst awards. See "Mathematics Opportunities" in this issue.

November 12, 2013: Full proposals for NSF Program ADVANCE Institutional Transformation and Institutional Transformation Catalyst awards. See "Mathematics Opportunities" in this issue.

DoD Mathematics Staff

The following agencies of the Department of Defense and the Department of Energy fund research in the mathematical sciences. The names, addresses, and telephone numbers of the pertinent staff members are listed.

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http://www.arl.army.mil/www/default.cfm?Action=29&Page=216

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Attn: R1, Suite 6557

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Book List

The Book List highlights recent books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. Suggestions for books to include on the list may be sent to notices-booklist@ams.org.

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

Adventures in Group Theory: Rubik's Cube, Merlin's Machine, and Other Mathematical Toys, by David Joyner. Johns Hopkins University Press (second edition), December 2008. ISBN-13: 978-08018-9013-0.

**American Mathematicians as Educators, 1893–1923: Historical Roots of the "Math Wars"* by David Lindsay Roberts. Docent Press, July 2012, ISBN-13: 978-09837-004-49.

The Beginning of Infinity: Explanations That Transform the World, by David Deutsch. Viking Adult, July 2011. ISBN-13: 978-06700-227-55. (Reviewed April 2012.)

The Best Writing on Mathematics: 2010, edited by Mircea Pitici. Princeton University Press, December 2010. ISBN-13: 978-06911-484-10. (Reviewed November 2011.)

Bibliography of Raymond Clare Archibald by Scott Guthery. Docent Press, April 2012. ISBN-13: 978-0983700425.

The Big Questions: Mathematics, by Tony Crilly. Quercus, April 2011. ISBN: 978-18491-624-01. (Reviewed in this issue.)

Calculating Curves: The Mathematics, History, and Aesthetic Appeal of T. H. Gronwall's Nomographic Work, by Thomas Hakon Gronwall, with contributions by Ron Doerfler and Alan Gluchoff, translation by Paul Hamburg, and bibliography by Scott Guthery. Docent Press, April 2012. ISBN-13: 978-09837-004-32.

The Calculus of Selfishness, by Karl Sigmund. Princeton University Press, January 2010. ISBN-13: 978-06911-427-53. (Reviewed January 2012.)

Chasing Shadows: Mathematics, Astronomy, and the Early History of Eclipse Reckoning, by Clemency Montelle. Johns Hopkins University Press, April 2011. ISBN-13: 978-08018-969-10. (Reviewed March 2012.)

Classic Problems of Probability, by Prakash Gorroochurn. Wiley, May 2012. ISBN: 978-1-1180-6325-5.

The Crest of the Peacock: Non-European Roots of Mathematics, by George Gheverghese Joseph. Third edition. Princeton University Press, October 2010. ISBN-13: 978-0-691-13526-7.

The Crossing of Heaven: Memoirs of a Mathematician, by Karl Gustafson. Springer, January 2012. ISBN-13: 978-36422-255-74.

Divine Machines: Leibniz and the Sciences of Life, by Justin E. H. Smith. Princeton University Press, May 2011. ISBN-13: 978-06911-417-87.

Elegance with Substance, by Thomas Colignatus. Dutch University Press, 2009. ISBN-13: 978-90361-013-87.

Elliptic Tales: Curves, Counting, and Number Theory, by Avner Ash and Robert Gross. Princeton University Press, March 2012. ISBN-13: 978-06911-511-99.

Emmy Noether's Wonderful Theorem, by Dwight E. Neuenschwander. Johns Hopkins University Press, November 2010. ISBN-13: 978-08018-969-41.

Excursions in the History of Mathematics, by Israel Kleiner. Birkhäuser, 2012. ISBN-13: 978-08176-826-75.

Experimental and Computational Mathematics: Selected Writings, by Jonathan Borwein and Peter Borwein. PSIpress, 2011. ISBN-13: 978-19356-380-56.

Fascinating Mathematical People: Interviews and Memoirs, edited by Donald J. Albers and Gerald L. Alexanderson. Princeton University Press, October 2011. ISBN-13: 978-06911-482-98.

Galileo's Muse: Renaissance Mathematics and the Arts, by Mark Austin-Peterson. Harvard University Press, October 2011. ISBN-13: 978-06740-597-26.

Gösta Mittag-Leffler: A Man of Conviction, by Arild Stubhaug (translated by Tiina Nunnally). Springer, November 2010. ISBN-13: 978-36421-167-11.

Gottfried Wilhelm Leibniz: The Polymath Who Brought Us Calculus, by M. B. W. Tent. A K Peters/CRC Press, October 2011. ISBN-13: 978-14398-922-20.

In Pursuit of the Traveling Salesman: Mathematics at the Limits of Computation, by William J. Cook. Princeton University Press, December 2011. ISBN-13: 978-06911-527-07.

In Pursuit of the Unknown: 17 Equations That Changed the World, by Ian Stewart. Basic Books, March 2012. ISBN-13: 978-04650-297-30.

In Service to Mathematics: The Life and Work of Mina Rees, by Amy Shell-Gellasch. Docent Press, December 2010. ISBN-13: 978-0-9837004-1-8.

The Infinity Puzzle: Quantum Field Theory and the Hunt for an Orderly Universe, by Frank Close. Basic Books, November 2011. ISBN-13: 978-04650-214-44. (Reviewed September 2012.)

The Information: A History, a Theory, a Flood, by James Gleick. Pantheon, March 2011. ISBN-13: 978-03754-237-27.

The Irrationals: A Story of the Numbers You Can't Count On, by Julian Havil. Princeton University Press, June 2012. ISBN-13: 978-0691143422.

Knots Unravelled: From String to Mathematics, by Meike Akveld and Andrew Jobbings. Arbelos, October 2011. ISBN-13: 978-09555-477-20.

Late Style: Yuri I. Manin Looking Back on a Life in Mathematics. A DVD documentary by Agnes Handwerk and Harrie Willems. Springer, March 2012. ISBN NTSC: 978-3-642-24482-7; ISBN PAL: 978-3-642-24522-0.

Lemmata: A Short Mathematical Thriller, by Sam Peng. CreateSpace, December 2011. ISBN-13: 978-14681-442-39.

Lost in a Cave: Applying Graph Theory to Cave Exploration, by Richard L. Breisch. National Speleological Society, January 2012. ISBN-13: 978-1-879961-43-2.

The Lost Millennium: History's Timetables Under Siege, by Florin Diacu. Johns Hopkins University Press (second edition), November 2011. ISBN-13: 978-14214-028-88.

Magical Mathematics: The Mathematical Ideas That Animate Great Magic Tricks, by Persi Diaconis and Ron Graham. Princeton University Press, November 2011. ISBN-13: 978-06911-516-49. (Reviewed August 2012.)

The Man of Numbers: Fibonacci's Arithmetic Revolution, by Keith Devlin. Walker and Company, July 2011. ISBN-13: 978-08027-781-23. (Reviewed May 2012.)

Math Girls, by Hiroshi Yuki (translated from the Japanese by Tony Gonzalez). Bento Books, November 2011. ISBN-13: 978-09839-513-15. (Reviewed August 2012.)

Math is Murder, by Robert C. Brigham and James B. Reed. Universe, March 2012. ISBN-13: 978-14697-972-81.

A Mathematical Nature Walk, by John A. Adam. Princeton University Press, October 2011 (paperback edition). ISBN-13: 978-06911-526-53.

The Mathematical Writings of Évariste Galois, edited by Peter M. Neumann. European Mathematical Society, October 2011. ISBN-13: 978-3-03719-104-0.

**Mathematical Excursions to the World's Great Buildings*, by Alexander J. Hahn. Princeton University Press, July 2012. ISBN-13: 978-06911-452-04

A Mathematician Comes of Age, by Steven G. Krantz. Mathematical Association of America, December 2011. ISBN-13: 978-08838-557-82.

Mathematics in Popular Culture: Essays on Appearances in Film, Fiction, Games, Television and Other Media, edited by Jessica K. Sklar and Elizabeth S. Sklar. McFarland, February 2012. ISBN-13: 978-07864-497-81.

Mathematics in Victorian Britain, by Raymond Flood, Adrian Rice, and Robin Wilson. Oxford University Press, October 2011. ISBN-13: 978-019-960139-4.

The Mathematics of Life, by Ian Stewart. Basic Books, June 2011. ISBN-13: 978-04650-223-80. (Reviewed December 2011.)

Mathematics, Religion and Ethics: An Epistemological Study, by Salilesh Mukhopadhyay. Feasible Solution LLC, September 2010. ISBN-13: 978-1-4507-3558-2.

The Noether Theorems: Invariance and Conservation Laws in the Twentieth Century, by Yvette Kosmann-Schwarzbach. Springer, December 2010. ISBN-13: 978-03878-786-76.

**Nine Algorithms That Changed the Future: The Ingenious Ideas That Drive Today's Computers,* by John MacCormick. Princeton University Press, December 2011. ISBN-13: 978-06911-471-47.

Numbers: A Very Short Introduction, by Peter M. Higgins. Oxford University Press, February 2011. ISBN-13: 978-0-19-958405-5. (Reviewed January 2012.)

On the Formal Elements of the Absolute Algebra, by Ernst Schröder (translated and with additional material by Davide Bondoni; with German parallel text). LED Edizioni Universitarie, 2012. ISBN: 978-88-7916-516-7.

Our Days are Numbered: How Mathematics Orders Our Lives, by Jason Brown. Emblem Editions, April 2010. ISBN-13: 978-07710-169-74. (Reviewed in this issue.)

The Philosophy of Mathematical Practice, Paolo Mancosu, editor. Oxford University Press, December 2011. ISBN-13: 978-01996-401-02. (Reviewed March 2012.)

Pricing the Future: Finance, Physics, and the 300-Year Journey to the Black-Scholes Equation, by George G. Szpiro. Basic Books, November 2011. ISBN-13: 978-04650-224-89.

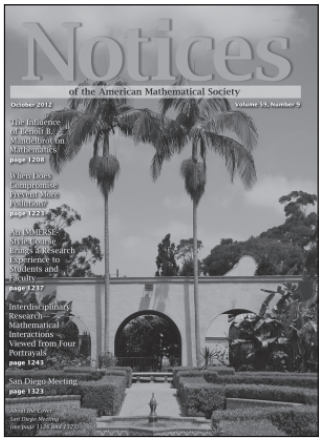
Proof and Other Dilemmas: Mathematics and Philosophy, edited by Bonnie Gold and Roger A. Simons. Mathematical Association of America,

About the Cover

San Diego Meeting

The cover shows part of the Alcazar Gardens in San Diego, California. The 2013 Joint Mathematics Meetings will be held in San Diego, January 9–12.

—Bill Casselman
Graphics Editor
(notices-covers@ams.org)



July 2008. ISBN-13: 978-08838-556-76. (Reviewed December 2011.)

The Proof Is in the Pudding: A Look at the Changing Nature of Mathematical Proof, by Steven G. Krantz. Springer, May 2011. ISBN-13: 978-03874-890-87.

Proving Darwin: Making Biology Mathematical, by Gregory Chaitin. Pantheon, May 2012. ISBN: 978-03754-231-47.

Scientific Reflections: Selected Multidisciplinary Works, by Richard Crandall. PSIpress, 2011. ISBN-13: 978-19356-380-87.

Six Gems of Geometry, by Thomas Reale. PSIpress, 2010. ISBN-13: 978-19356-380-25.

Sources in the Development of Mathematics: Series and Products from the Fifteenth to the Twenty-first Century, by Ranjan Roy. Cambridge University Press, June 2011. ISBN-13: 978-05211-147-07.

A Strange Wilderness: The Lives of the Great Mathematicians, by Amir D. Aczel. Sterling, October 2011.ISBN-13: 978-14027-858-49.

Taking Sudoku Seriously: The Math behind the World's Most Popular Pencil Puzzle, by Jason Rosenhouse and Laura Taalman. Oxford University Press, January 2012. ISBN-13: 978-01997-565-68.

The Theory That Would Not Die: How Bayes' Rule Cracked the Enigma Code, Hunted Down Russian Submarines, and Emerged Triumphant from Two Centuries of Controversy, by Sharon Bertsch McGrayne. Yale University Press, April 2011. ISBN-13: 978-03001-696-90. (Reviewed May 2012.)

Top Secret Rosies: The Female Computers of World War II. Video documentary, produced and directed by LeAnn Erickson. September 2010. Website: `http://www.topsecretrosies.com`. (Reviewed February 2012.)

Towards a Philosophy of Real Mathematics, by David Corfield. Oxford University Press, April 2003. ISBN-13: 0-521-81722-6. (Reviewed November 2011.)

**Transcending Tradition: Jewish Mathematicians in German Speaking Academic Culture,* edited by Birgit Bergmann, Moritz Epple, and Ruti Ungar. Springer, January 2012. ISBN: 978-3642224638.

Turbulent Times in Mathematics: The Life of J.C. Fields and the History of the Fields Medal, by Elaine McKinnon Riehm and Frances Hoffman. AMS, November 2011. ISBN-13: 978-08218-691-47.

Uneducated Guesses: Using Evidence to Uncover Misguided Education Policies, by Howard Wainer. Princeton University Press, August 2011. ISBN-13: 978-06911-492-88. (Reviewed June/July 2012.)

The Universe in Zero Words: The Story of Mathematics as Told through Equations, by Dana Mackenzie. Princeton University Press, April 2012. ISBN-13: 978-06911-528-20.

Vilim Feller, istaknuti hrvatsko-americki matematicar/William Feller, Distinguished Croatian-American Mathematician, by Darko Zubrinic. Bilingual Croatian-English edition, Graphis, 2011. ISBN-13: 978-953-279-016-0.

**A Wealth of Numbers: An Anthology of 500 Years of Popular Mathematics Writing,* edited by Benjamin Wardhaugh. Princeton University Press, April 2012. ISBN-13: 978-06911-477-58.

What's Luck Got to Do with It? The History, Mathematics and Psychology of the Gambler's Illusion, by Joseph Mazur. Princeton University Press, July 2010. ISBN-13: 978-0-691-13890-9. (Reviewed February 2012.)

Who's #1?: The Science of Rating and Ranking, by Amy N. Langville and Carl D. Meyer. Princeton University Press, February 2012. ISBN-13: 978-06911-542-20.

Why Beliefs Matter: Reflections on the Nature of Science, by E. Brian Davies. Oxford University Press, June 2010. ISBN-13: 978-01995-862-02. (Reviewed April 2012.)

Why Cats Land on Their Feet (and 76 Other Physical Paradoxes and Puzzles), by Mark Levi. Princeton University Press, May 2012. ISBN-13: 978-0691148540.

Statistics on Women Mathematicians Compiled by the AMS

At its August 1985 meeting the Council of the AMS approved a motion to regularly assemble and report in the *Notices* information on the relative numbers of men versus women in at least the following categories: membership in the AMS, invited hour addresses at AMS meetings, speakers at Special Sessions at AMS meetings, percentage of women speakers in AMS Special Sessions by gender of organizers, and members of editorial boards of AMS journals.

It was subsequently decided that this information would be gathered by determining the sex of the individuals in the above categories based on name identification if no other means was available and that additional information on the number of Ph.D.s granted to women would also be collected using the AMS-ASA-IMS-MAA-SIAM Annual Survey. Since name identification was used, the information for some categories necessitated the use of three classifications:

Male: names that were obviously male

Female: names that were obviously female

Unknown: names that could not be identified as clearly male or female (e.g., only initials given, non-gender-specific names, etc.)

The following is the twenty-sixth reporting of this information. Updated reports will appear annually in the *Notices*.

2011 Members of the AMS Residing in the U.S.

Male:	14,210	66%
Female:	3,749	18%
Unknown:	3,511	16%
Total:	21,515	

Invited Hour Address Speakers at AMS Meetings (2002–2011)

Male:	347	84%
Female:	68	16%
Unknown:	0	0%
Total:	415	

Speakers at Special Sessions at AMS Meetings (2007–2011)

Male:	10,976	78%
Female:	2,853	20%
Unknown:	181	1%
Total:	14,010	

Percentage of Women Speakers in AMS Special Sessions by Gender of Organizers (2011)

Special Sessions with at Least One Woman Organizer

Male:	906	72%
Female:	346	28%
Unknown:	4	<1%
Total:	1,256	

Special Sessions with No Women Organizers

Male:	1,409	82%
Female:	307	18%
Unknown:	12	1%
Total:	1,728	

Trustees and Council Members

	2008		2009		2010		2011	
Male:	26	66%	29	67%	28	67%	35	69%
Female:	14	37%	14	33%	14	33%	16	31%
Total:	41		43		42		51	

Members of AMS Editorial Committees

	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
Male:	195	85%	189	84%	180	84%	184	83%	193	84%	194	84%	168	83%	178	84%	176	82%	176	83%
Female:	35	15%	35	16%	34	16%	38	17%	36	16%	36	16%	35	17%	34	16%	39	18%	37	17%
Total:	230		224		214		222		229		230		203		212		215		213	

Ph.D.s Granted to U.S. Citizens

	2002		2003		2004		2005		2006		2007		2008		2009		2010		2011	
Male:	291	70%	341	68%	347	68%	355	72%	399	72%	396	69%	431	69%	515	69%	564	71%	274	72%
Female:	127	30%	158	32%	166	32%	141	28%	153	28%	180	31%	191	31%	227	31%	225	28%	228	28%
Total:	418		499		513		496		552		576		622		742		790		802	

Officers and Committee Members

Numbers to the left of headings are used as points of reference in an index to AMS committees which follows this listing. Primary and secondary headings are:

1. Officers
   1.1. Liaison Committee
2. Council
   2.1. Executive Committee of the Council
3. Board of Trustees
4. Committees
   4.1. Committees of the Council
   4.2. Editorial Committees
   4.3. Committees of the Board of Trustees
   4.4. Committees of the Executive Committee and Board of Trustees
   4.5. Internal Organization of the AMS
   4.6. Program and Meetings
   4.7. Status of the Profession
   4.8. Prizes and Awards
   4.9. Institutes and Symposia
   4.10. Joint Committees
5. Representatives
6. Index

Terms of members expire on January 31 following the year given unless otherwise specified.

1. Officers

President	Eric M. Friedlander	2012
President Elect	David A. Vogan, Jr.	2012
Vice Presidents	Sylvain Cappell	2012
	Barbara Lee Keyfitz	2013
	Andrew M. Odlyzko	2014
Secretary	Robert J. Daverman	2012
Associate Secretaries	Georgia Benkart	2013
	Michel L. Lapidus	2013
	Steven Weintraub	2012
		2012
Treasurer	Jane M. Hawkins	2012
Associate Treasurer	Zbigniew Nitecki	2013

1.1. Liaison Committee

All members of this committee serve *ex officio*.

	Robert J. Daverman
Chair	Eric M. Friedlander
	Jane M. Hawkins
	Ronald J. Stern

2. Council

2.0.1. Officers of the AMS

President	Eric M. Friedlander	2012
President Elect	David A. Vogan, Jr.	2012
Vice Presidents	Sylvain Cappell	2012
	Barbara Lee Keyfitz	2013
	Andrew M. Odlyzko	2014
Secretary	Robert J. Daverman	2012
Associate Secretaries*	Georgia Benkart	2013
	Michel L. Lapidus	2013
	Steven Weintraub	2012
		2012
Treasurer	Jane M. Hawkins	2012
Associate Treasurer	Zbigniew Nitecki	2013

2.0.2. Representatives of Committees

Term of Bulletin representative begins on January 1 and ends on December 31 of the year listed.

Bulletin	Susan J. Friedlander	2014
Colloquium	Peter Sarnak	2013
Executive Committee	Joseph H. Silverman	2012
Journal of the AMS	Karl Rubin	2013
Mathematical Reviews	Ronald M. Solomon	2012
Mathematical Surveys and Monographs	Ralph L. Cohen	2012
Mathematics of Computation	Susanne C. Brenner	2015
Proceedings	Ken Ono	2013
Transactions and Memoirs	Robert Guralnick	2012

2.0.3. Members at Large

Dan Abramovich	2014	Patricia Hersh	2013
Alejandro Adem	2012	Tara S. Holm	2013
Matthew Ando	2013	Victoria Powers	2014
Hélène Barcelo	2014	Jennifer Schultens	2012
Estelle Basor	2013	T. Christine Stevens	2013
Arthur Benjamin	2014	Janet Talvacchia	2012
James Carlson	2014	Christoph Thiele	2012
Richard Hain	2012		

* Only one Associate Secretary at a time is a voting member of the Council, namely the cognizant Associate Secretary for the scientific sessions.

2.1. Executive Committee of the Council

	Hélène Barcelo	2015
	Ralph L. Cohen	2014
	Robert J. Daverman	*ex officio*
	Eric M. Friedlander	*ex officio*
	Bryna Kra	2013
	Joseph H. Silverman	2012
	David A. Vogan, Jr.	*ex officio*

3. Board of Trustees

	Ruth Charney	2016
	Eric M. Friedlander	*ex officio*
	Mark L. Green	2014
	Jane M. Hawkins	*ex officio*
	William H. Jaco	2015
Secretary	Zbigniew H. Nitecki	*ex officio*
Chair	Ronald J. Stern	2013
	Karen Vogtmann	2012

4. Committees

4.1. Committees of the Council

Standing Committees

4.1.1. Editorial Boards

	Robert J. Daverman	*ex officio*
	Sergei Gelfand	*ex officio*
	Ralph Greenberg	2014
	Jonathan I. Hall	2012
Chair	Anatoly S. Libgober	2012
	Dana Randall	2014
	John R. Stembridge	2013
	Sergei K. Suslov	2013

4.1.2. Nominating Committee

Terms begin on January 1 and expire on December 31 of the year listed.

	William Beckner	2012
Chair	Richard A. Brualdi	2013
	Frederick R. Cohen	2014
	Richard T. Durrett	2012
	Susan J. Friedlander	2014
	Fan Chung Graham	2014
	Donal O'Shea	2013
	Carla D. Savage	2012
	Gunther Uhlmann	2013

Special Committee

4.1.3. Initial Fellows Selection Committee

Chair	George F. Andrews	2012
	Douglas N. Arnold	2012
	Idris Assani	2012
	Georgia Benkart	2012
	Andrea L. Bertozzi	2012
	Fan Chung Graham	2012
	Frank Morgan	2012
	Wilfried Schmid	2012
	Philippe M. Tondeur	2012
	Alejandro Uribe	2012

4.2. Editorial Committees

4.2.1. Abstracts Editorial Committee

All members of this committee serve *ex officio*.

	Georgia Benkart
Chair	Robert J. Daverman
	Michel L. Lapidus
	Steven Weintraub

4.2.2. Bulletin (New Series)

Terms begin on January 1 and expire on December 31 of the year listed.

Consultant	Gerald L. Alexanderson	2014
Chief Editor	Susan J. Friedlander	2014
Consultant	Jane Kister	2014
Book Reviews Editor	Peter Kuchment	2014

Associate Editors for Bulletin Articles

David J. Benson	2014	Barry Mazur	2014
Daniel S. Freed	2014	Paul H. Rabinowitz	2014
Edward Frenkel	2014	Andrew Ranicki	2014
Mark Goresky	2014	Christoph Thiele	2014
Andrew J. Granville	2014	Yuri Tschinkel	2014
Bryna Kra	2014	Michael Wolf	2014
Gregory Lawler	2014		

Associate Editors for Book Reviews

Jonathan L. Alperin	2014	Steven G. Krantz	2014
Evans M. Harrell II	2014	Ken Ono	2014
Lisa Jeffrey	2014	Philip E. Protter	2014

4.2.3. Collected Works

Chair	Dusa McDuff	2012
	Elias M. Stein	2012
	William A. Veech	2015

4.2.4. Colloquium

	Lawrence Craig Evans	2015
	Yuri Manin	2013
Chair	Peter Sarnak	2013

4.2.5. Contemporary Mathematics

Chair	Dennis DeTurck	2015
	Michael P. Loss	2015
	Kailash C. Misra	2015
	Martin Strauss	2015

4.2.6. Graduate Studies in Mathematics

Chair	David A. Cox	2012
	Daniel S. Freed	2015
	Rafe Mazzeo	2015
	Gigliola Staffilani	2013

4.2.7. Journal of the AMS

	Weinan E	2013
	Sergey Fomin	2012
	Gregory Lawler	2012
	Elon Lindenstrauss	2015
	Tom Mrowka	2013
Chair	Karl Rubin	2013

Associate Editors

Noga Alon	2015	Jacob Lurie	2012
Roman Bezrukavnikov	2015	Haynes R. Miller	2012
Alexei Borodin	2015	William P. Minicozzi II	2015
Emanuel Candes	2015	Maryam Mirzakhani	2015
Sun-Yung Alice Chang	2013	Assaf Naor	2015
Henry Lee Cohn	2015	Sorin T. Popa	2015
Brian Conrad	2013	Thomas Scanlon	2012
Christopher Hacon	2012	Freydoon Shahidi	2012
Mikhail Khovanov	2015	Karen Vogtmann	2013
Peter Kronheimer	2012	Avi Wigderson	2012

4.2.8. Mathematical Reviews

AMS staff contact: Graeme Fairweather

	Cameron Gordon	2015
	Barbara Lee Keyfitz	2013
	Peter Maass	2012
	Shigefumi Mori	2013
Chair	Ronald M. Solomon	2012
	Trevor D. Wooley	2012

4.2.9. Mathematical Surveys and Monographs

Chair	Ralph L. Cohen	2012
	Michael Singer	2013
	Benjamin Sudakov	2015
	Michael Weinstein	2013

4.2.10. Mathematics of Computation

Chair	Susanne C. Brenner	2015
	Ronald F. Cools	2015
	Igor Shparlinski	2015
	Chi-Wang Shu	2015

Associate Editors

Rémi Abgrall	2013	Gilles Pagès	2013
Daniela Calvetti	2015	Cheryl Praeger	2012
Zhiming Chen	2013	Renate Scheidler	2013
Ricardo G. Duran	2013	Christoph Schwab	2015
Viviette Girault	2012	Jie Shen	2015
Douglas Hardin	2015	Zuowei Shen	2014
Fred J. Hickernell	2015	Chris J. Smyth	2013
Gregor Kemper	2012	Michael Stillman	2012
Boris N. Khoromskij	2015	Daniel B. Szyld	2013
Christian Lubich	2015	Tao Tang	2012
Gunter Malle	2015	Hans W. Volkmer	2015
Michael J. Mossinghoff	2013	Ya-Xiang Yuan	2013
Stanley Osher	2015	Zhimin Zhang	2012

4.2.11. Notices Editorial Board

Terms begin on January 1 and expire on December 31 of the year listed.

Editor	Steven G. Krantz	2012

Associate Editors

Krishnaswami Alladi	2012	Robion C. Kirby	2012
David H. Bailey	2012	Rafe Mazzeo	2012
Jonathan M. Borwein	2012	Harold R. Parks	2012
Susanne C. Brenner	2012	Peter C. Sarnak	2012
William Casselman	2012	Mark E. Saul	2012
Robert J. Daverman	*ex officio*	Edward L. Spitznagel	2012
Lisette de Pillis	2012	John R. Swallow	2012
Susan J. Friedlander	2012		

4.2.12. Proceedings

	Lev Borisov	2013
	Kathrin Bringmann	2013
	James E. Colliander	2014
Coordinating	Walter Craig	2012
	Harm Derksen	2013
	Franc Forstneric	2012
	James Haglund	2013
	Michael Hitrik	2014
Coordinating	Birge Huisgen-Zimmermann	2013
	Alexander Iosevich	2015
	Marius Junge	2014
	Julia Knight	2012
	David Levin	2015
	Mark M. Meerschaert	2014
	Kailash C. Misra	2014
	Lei Ni	2013
Chair	Ken Ono	2013
	Matthew Papanikolas	2013
	Irena Peeva	2013
	Richard H. Rochberg	2013
Coordinating	Daniel Ruberman	2013
	Thomas B. Schlumprecht	2013
	Nimish Shah	2015
Coordinating	Mei-Chi Shaw	2012
	Brooke E. Shipley	2012
	Sergei K. Suslov	2014
Coordinating	Chuu-Lian Terng	2013
	Pham Huu Tiep	2014
	Tatiana Toro	2014
	Jeremy Tyson	2015
	Walter Van Assche	2012
	Mathai Varghese	2015
	Kevin Whyte	2015
	Michael Wolf	2013
	Yingfei Yi	2012

4.2.13. Proceedings of Symposia in Applied Mathematics

Chair	Mary C. Pugh	2013
	Daniel Rockmore	2015
	Lenya Ryzhik	2015

4.2.14. Transactions and Memoirs

	Dan Abramovich	2014
	Alejandro Adem	2012
	Luchezar L. Avramov	2012
	Nathanial Brown	2014
	Daniel Willis Bump	2015
	Mark Feighn	2015
	Patrick J. Fitzsimmons	2015
Chair	Robert Guralnick	2012
	Yunping Jiang	2015
	Alexander Kleshchev	2012
	William P. Minicozzi II	2014
	Antonio Montalban	2015
	Peter Polacik	2014
	Gustavo Alberto Ponce	2013
	Malabika Pramanik	2014
	Wilhelm Schlag	2014
	Shankar Sen	2012
	John R. Stembridge	2013
	Erik P. Van Den Ban	2013
	Christopher Woodward	2012

4.2.15. Translation from Chinese

	Sun-Yung Alice Chang	
	S.-Y. Cheng	
Chair	Tsit-Yuen Lam	
	Tai-Ping Liu	
	Chung-Chun Yang	

4.2.16. Translation from Japanese

Chair	Shoshichi Kobayashi	
	Masamichi Takesaki	

Standing Committees

4.2.17. Conformal Geometry and Dynamics

	Francois Berteloot	2013
	Mario Bonk	2013
	Ursula Hamenstadt	2014
	Pekka Koskela	2012
Chair	Gaven Martin	2012
	Caroline Series	2012
	Nageswari Shanmugalingam	2015

4.2.18. History of Mathematics

	Peter L. Duren	2013
	Robin Hartshorne	2012
Chair	Karen H. Parshall	2012
	Adrian Clifford Rice	2015

4.2.19. Pure and Applied Undergraduate Texts

Chair	Paul J. Sally, Jr.	2012
	Joseph H. Silverman	2012
	Francis Edward Su	2012
	Susan Tolman	2012

4.2.20. Representation Theory

	Jens Carsten Jantzen	2012
	Nicolai Reshetikhin	2012
Chair	Henrik Schlichtkrull	2012
	Freydoon Shahidi	2012
	Peter E. Trapa	2012
	David A. Vogan	2013

4.2.21. Student Mathematics Library

	Satyan L. Devadoss	2015
Chair	Gerald B. Folland	2013
	John Stillwell	2013
	Sergei Tabachnikov	2015

4.2.22. University Lecture Series

	Jordan S. Ellenberg	2014
Chair	William P. Minicozzi II	2013
	Benjamin Sudakov	2012
	Tatiana Toro	2013

4.3. Committees of the Board of Trustees

4.3.1. Agenda and Budget

All members of this committee serve *ex officio*.
AMS staff contact: Ellen H. Heiser

	Robert J. Daverman
Chair	Eric M. Friedlander
	Jane M. Hawkins
	Zbigniew Nitecki
	Ronald J. Stern

4.3.2. Audit

All members of this committee serve *ex officio*.
AMS staff contact: Emily D. Riley.

	Mark L. Green
Chair	Jane M. Hawkins
	Zbigniew Nitecki
	Ronald J. Stern

4.3.3. Investment

AMS staff contact: Emily D. Riley.

Chair	Jane M. Hawkins	*ex officio*
	Zbigniew Nitecki	*ex officio*
	Ronald J. Stern	*ex officio*
	Rob Taylor	2012

4.3.4. Retirement Plan Investment

AMS staff contact: Emily Riley

	Zbigniew H. Nitecki	*ex officio*
	Emily Riley	2014
	Karen Vogtmann	*ex officio*
Chair	Tammy Walsh	2014

4.3.5. Salary

All members of this committee serve *ex officio*.
AMS staff contact: Donald E. McClure.

Chair	Jane M. Hawkins
	Zbigniew Nitecki
	Ronald J. Stern

4.4. Committees of the Executive Committee and Board of Trustees

4.4.1. AMS Development

All members of this committee serve *ex officio*.

	Robert J. Daverman
	Eric M. Friedlander
	Jane M. Hawkins
	Donald E. McClure
	Ronald J. Stern

4.4.2. Long Range Planning

All members of this committee serve *ex officio*.
AMS staff contact: Ellen H. Heiser.

	Ralph L. Cohen
	Robert J. Daverman
Chair	Eric M. Friedlander
	Jane M. Hawkins
	Bryna Kra
	Donald E. McClure
	Ronald J. Stern

4.4.3. Nominating

All members of this committee serve *ex officio*.

	Richard A. Brualdi
Chair	Mark L. Green
	Bryna Kra

Special Committee

4.4.4. Southeastern Section Associate Secretary Search Committee

	Ruth M. Charney
	Robert J. Daverman
	Carla D. Savage
	Joseph H. Silverman

4.5. Internal Organization of the American Mathematical Society

Standing Committees

4.5.1. Archives

	Peter L. Duren	2014
	Jonathan I. Hall	2013
	Thomas W. Hawkins	2012

4.5.2. Books and Journal Donations Steering Committee

	Alfonso Castro	2014
Chair	Toka Diagana	2012
	Jet Foncannon	2013
	Wilfrid Gangbo	2016

4.5.3. Committee on Committees

Chair	Alejandro Adem	2012
	Asuman G. Aksoy	2012
	Daniel Bates	2012
	Carlos Castillo-Chavez	2012
	Robert J. Daverman	*ex officio*
	Eric M. Friedlander	*ex officio*
	Rebecca F. Goldin	2012
	Susan R. Loepp	2012
	Russell D. Lyons	2012
	William A. Massey	2012
	Daniel Ken Nakano	2012
	Nataša Pavlović	2012
	Natasa Sesum	2012
	David A. Vogan, Jr.	*ex officio*

4.5.4. Employment Services, Advisory Board on

	Patrick Barry Eberlein	2012
	Jesse Johnson	2014
	Karl Peterson	2013

4.5.5. Library

Co-chair	Cunera Buys	2013
	Kristine K. Fowler	2013
	Parker Ladwig	2014
	Robert E. Noel	2014
	Peter A. Perry	2014
Co-chair	Joseph Rosenblatt	2012
	Andrew V. Sills	2013
	Smilka Zdravkovska	2012

4.5.6. Publications

AMS staff contact: Erin Buck.

Chair	Matthew Ando	2013
	Luchezar L. Avramov	2014
	Hélène Barcelo	2014
	Steven R. Bell	2014
	Richard Brualdi	2012
	Robert J. Daverman	*ex officio*
	Eric M. Friedlander	*ex officio*
	Sergei Gelfand	*ex officio*
	Richard M. Hain	2012
	Jonathan I. Hall	2012
	Krystyna M. Kuperberg	2013
	David Marker	2014
	Donald E. McClure	*ex officio*
	Karen Vogtmann	2012

Special Committees

4.5.7. AMS Web Editorial Group

Chair	John Baez	2013
	Robert Ghrist	2013
	Frank Morgan	2013
	Ravi D. Vakil	2013

4.5.8. Graduate Working Group

	Daniel James Bates	2012
	Kareem Carr	2012
	Diana Davis	2012
	Eric M. Friedlander	2012
	Douglas Lind	2012
	Ellen J. Maycock	2012
	Frank Morgan	2012
	Ken Ono	2012
Chair	Joseph H. Silverman	2012

4.6. Program and Meetings

Standing Committees

4.6.1. Mathematics Research Communities Advisory Board

	Steven Benjamin Damelin	2013
	Robert J. Daverman	2012
Chair	David Eisenbud	2013
	William M. Goldman	2012
	Ken Ono	2012
	Kim Ruane	2013
	Henry K. Schenck	2013
	Alejandero Uribe	2012
	Kevin Wortman	2013
	Steven M. Zelditch	2013

4.6.2. Meetings and Conferences

AMS staff contact: Ellen J. Maycock

	Estelle Basor	2013
	Robert J. Daverman	*ex officio*
	Laura De Carli	2013
	Benson S. Farb	2013
Chair	David W. Farmer	2012
	Eric M. Friedlander	*ex officio*
	William H. Jaco	2012
	Anna L. Mazzucato	2014
	Robert J. McCann	2014
	Donald E. McClure	*ex officio*
	Paul Muhly	2013
	Victoria Ann Powers	2014
	Janet Talvacchia	2012

4.6.3. Program Committee for National Meetings

	Georgia Benkart	*ex officio*
Chair	J. P. Buhler	2012
	Robert J. Daverman	*ex officio*
	Christopher Jones	2014
	Thomas M. Liggett	2014
	Wilfried Schmid	2013
	Kannan Soundararajan	2012
	Amie Wilkinson	2013

4.6.4. Short Course Subcommittee

	Lisette de Pillis	2014
	Robert W. Ghrist	2012
Chair	Charles M. Grinstead	2012
	Jon McCammond	2013
	Ezra N. Miller	2014
	Sivaram Narayan	2013
	John Sylvester	2012

4.6.5. Central Section Program Committee

	Georgia Benkart	*ex officio*
	David Ben-Zvi	2013
Chair	Dick Canary	2012
	Alex Kiselev	2013
	Jared Wunsch	2012

4.6.6. Eastern Section Program Committee

	Mikhail Kapranov	2013
	Kavita Ramanan	2013
	Igor Rodnianski	2012
Chair	Laurent Saloff-Coste	2012
	Jennifer Taback	2013
	Steven Weintraub	*ex officio*

4.6.7. Southeastern Section Program Committee

	Ricardo Cortez	2013
	Scott McCullough	2012
	Ezra N. Miller	2013
Chair	Daniel Ken Nakano	2012
	———	*ex officio*

4.6.8. Western Section Program Committee

Chair	Asüman G. Aksoy	2012
	Daniel Dugger	2013
	Ko Honda	2012
	Sandor J. Kovacs	2013
	Michel L. Lapidus	*ex officio*

4.6.9. Arnold Ross Lecture Series

	Jonathan M. Kane	2012
	John M. (Jack) Lee	2013
	Donald A. Outing	2014
Chair	David Pollack	2012

4.6.10. Colloquium Lecture

	Ingrid Daubechies	2013
Chair	Barry Mazur	2014
	Efim I. Zelmanov	2012

4.6.11. Gibbs Lecturer for 2013 and 2014, Committee to Select

	Michael Aizenman	2013
	Douglas Arnold	2013
Chair	Robert V. Kohn	2013

4.6.12. Joint Mathematics Meetings Travel Grants

	Noel Brady	2012
Chair	Irina Mitrea	2013
	Jian Song	2014

4.6.13. Sectional Meetings Travel Grants

	Michael C. Reed	2013
	Jonathan Wahl	2014
Chair	Sarah Witherspoon	2013

4.7. Status of the Profession

Standing Committees

4.7.1. Academic Freedom, Tenure, and Employment Security

Chair	John B. Garnett	2012
	Ross Geoghegan	2013
	Carolyn S. Gordon	2013
	Lance L. Littlejohn	2013
	Margaret M. Robinson	2012
	Julianna Tymoczko	2014
	Joseph C. Watkins	2014

4.7.2. Education

AMS staff contact: Samuel M. Rankin III.

	Arthur T. Benjamin	2014
	Susan Jane Colley	2014
	Robert J. Daverman	*ex officio*
	Eric M. Friedlander	*ex officio*
	Kenneth M. Golden	2012
	Mark L. Green	2012
	Kenneth I. Gross	2012
Chair	Tara S. Holm	2013
	Irwin Kra	2013
	Donald E. McClure	*ex officio*
	Harriett S. Pollatsek	2012
	Catherine Roberts	2012
	Christoph Thiele	2012
	Hung-Hsi Wu	2013

4.7.3. Fan Fund

	Zhihong Jeff Xia	2013
	Paul C. Yang	2014
Chair	Tonghai Yang	2012

4.7.4. Human Rights of Mathematicians

	Mark Alber	2012
	Augustin Banyaga	2012
	Alexander A. Beilinson	2014
	Toka Diagana	2013
	Jan Minac	2014
Chair	Mel Nathanson	2013
	Yakov B. Pesin	2013
	Tony Shaska	2012
	Edriss Saleh Titi	2014

4.7.5. Profession

AMS staff contact: Ellen J. Maycock.

	Dan Abramovich	2014
	Robert J. Daverman	*ex officio*
	James F. Davis	2014
	Rachelle C. DeCoste	2013
	Ron Y. Donagi	2012
	Eric M. Friedlander	*ex officio*
	William Mark Goldman	2014
	Patricia Hersh	2013
	Lorelei Koss	2012
	Peter DesBarres March	2014
	Donald E. McClure	*ex officio*
	Jennifer Schultens	2012
	Ronald J. Stern	2012
Chair	Abigail A. Thompson	2013
	Jeffrey Vaaler	2012

4.7.6. Professional Ethics

	Miklos Bona	2012
	Petra Bonfert-Taylor	2012
	Priscilla E. Greenwood	2014
	Daniel Pollack	2013
Chair	John Roe	2012
	Margaret Fife Symington	2013

4.7.7. Science Policy

AMS staff contact: Samuel M. Rankin III.

	Alejandro Adem	2012
	Alexander Berkovich	2013
	James W. Carlson	2014
	Ruth M. Charney	2012
	Robert J. Daverman	*ex officio*
	Maarten V. deHoop	2013
	Eric M. Friedlander	*ex officio*
Chair	Kenneth M. Golden	2012
	Tara S. Holm	2012
	David C. Manderscheid	2012
	Donald E. McClure	*ex officio*
	Claudia M. Neuhauser	2013
	Joshua Marc Sabloff	2014
	T. Christine Stevens	2013
	Richard A. Tapia	2014
	David A. Vogan, Jr.	*ex officio*

4.7.8. Women in Mathematics

	Susan Hermiller	2013
	Ellen Kirkman	2015
	Linda Preiss Rothschild	2012
	Carol S. Wood	2015

4.7.9. Young Scholars Awards

Terms expire on June 30.

	Brian R. Hunt	2013
	Douglas Norton	2015
	Cornelius Pillen	2015
Chair	Zvezdelina E. Stankova	2013

4.8. Prizes and Awards

Standing Committees

4.8.1. AMS Public Policy Award Selection Committee

	Eric M. Friedlander	2012
	Kenneth M. Golden	2012
	David A. Vogan, Jr.	2012

4.8.2. Award for Distinguished Public Service, Committee to Select the Winner of the

	Richard A. Askey	2013
	C. Herbert Clemens	2013
	Roger E. Howe	2015
	Sylvia M. Wiegand	2015

4.8.3. The Stefan Bergman Trust Fund

	Harold P. Boas	2013
	Carlos Kenig	2012
	Alexander Nagel	2014

4.8.4. Centennial Fellowships

Terms expire on June 30.

	Paul Frank Baum	2014
	Bjorn E. Engquist	2013
Chair	Ronald A. Fintushel	2013
	Trachette Jackson	2014
	Monica Vazirani	2013
	Daniel T. Wise	2014
	Guoliang Yu	2014

4.8.5. Conant Prize, Committee to Select the Winner of the

	Thomas F. Banchoff	2014
Chair	Jerry Bona	2012
	J. Brian Conrey	2013

4.8.6. Joseph L. Doob Prize

	Harold Boas	2015
	Andrew J. Granville	2012
	Robin C. Hartshorne	2012
	Neal I. Koblitz	2015
	John H. McCleary	2015

4.8.7. Exemplary Program or Achievement by a Mathematics Department, Committee to Select the Winner of the Prize for

	Carlos Castillo-Chavez	2012
	Annalisa Crannell	2012
Chair	Phil Kutzko	2012
	Suzanne M. Lenhart	2013
	Francis Edward Su	2013

4.8.8. Menger Prize, Committee to Select the Winner of the

Terms expire on May 31.

Chair	Jonathan King	2013
	John Milton	2014
	Mihai Stoiciu	2015

4.8.9. E. H. Moore Research Article Prize, Committee to Select the Winner of the

	Sergiu Klainerman	2014
	Howard Masur	2017
	Bjorn Poonen	2017
Chair	Kenneth A. Ribet	2014
	Ulrike Tillmann	2017

4.8.10. National Awards and Public Representation

	James G. Arthur	2012
	Robert L. Bryant	2012
	Luis A. Caffarelli	2013
	Robert J. Daverman	*ex officio*
Chair	Eric M. Friedlander	*ex officio*
	David A. Vogan, Jr.	*ex officio*

4.8.11. David P. Robbins Prize

	Daniel J. Allcock	2013
	Joseph P. Buhler	2013
	Maria Chudnovsky	2013
	Bernd Strumfels	2013
Chair	Benny Sudakov	2013

4.8.12. Satter Prize, Committee to Select the Winner of the

Chair	Victor Guillemin	2013
	Svetlana Jitomirskaya	2015
	Raman Parimala	2015

4.8.13. Steele Prizes

Chair	Yakov Eliashberg	2012
	John Erik Fornaess	2012
	Irene Martinez Gamba	2013
	Barbara Lee Keyfitz	2012
	Tom Mrowka	2014
	Gang Tian	2014
	Akshay Venkatesh	2012
	Lai-Sang Young	2013
	Efim I. Zelmanov	2014

4.8.14. Veblen Prize

	Tobias Colding	2013
	William G. Dwyer	2013
Chair	Michael Hopkins	2013

Special Committee

4.8.15. Math in Moscow Progam—Travel Support

Terms expire on June 30.

	Sergey Bolotin	2014
Chair	Arkady Vaintrob	2014
	Alexander Varchenko	2013

4.9. Institutes and Symposia

Standing Committees

4.9.1. Liaison Committee with AAAS

	Edward F. Aboufadel	*ex officio*
	Robert Calderbank	*ex officio*
Chair	John Ewing	*ex officio*
	Lawrence Firman Gray	*ex officio*
	James M. Hyman	2013
	Jill P. Mesirov	*ex officio*
	Juan C. Meza	*ex officio*
	Konstantin Mischaikow	2013
	Lior Pachter	2012
	Fadil Santosa	2013

4.10. Joint Committees

4.10.1. AMS-ASA-AWM-IMS-MAA-NCTM-SIAM Committee on Women in the Mathematical Sciences

	Indrani Basak (ASA)	2012
	Janet A. Best (SIAM)	2014
	Marty Carr (NCTM)	2013
	K. Renee Fister (SIAM)	2012
	Christine M. Guenther (AMS)	2014
	Patricia Hale (MAA)	2013
	Susan M. Hermiller (AMS)	2012
	Terrell Hodge (AWM)	2012
Co-chair	Tanya Leise (MAA)	2014
Co-chair	Maura Mast (AWM)	2012
	Gerald Porter (MAA)	2014
	Amber Puha (IMS)	2013
	Paula Roberson (ASA)	2013
	Svetlana Roudenko (AMS)	2013
	S. Lynne Stokes (ASA)	2014
	Jane-Ling Wang (IMS)	2013

4.10.2. AMS-ASA-MAA-SIAM Data Committee

AMS staff contact: James W. Maxwell.

	Pam Arroway (ASA)	2012
Chair	Richard J. Cleary (MAA)	2014
	Steven R. Dunbar (AMS)	2012
	Susan Geller (MAA)	2014
	Boris Hasselblatt (AMS)	2012
	Ellen Kirkman (MAA)	2013
	Peter March (AMS)	2013
	James W. Maxwell (AMS)	*ex officio*
	David Morrison (AMS)	2013
	Bart S. Ng (SIAM)	2012
	William Yslas Velez (AMS)	2014

4.10.3. AMS-ASA-MAA-SIAM Joint Policy Board for Mathematics

ASA and SIAM members' terms expire December 31 of the year given.

	James Crowley (SIAM)	2012
	Robert J. Daverman (AMS)	2012
	Barbara T. Faires (MAA)	2014
	Eric M. Friedlander (AMS)	2012
	Reinhard Laubenbacher (SIAM)	2012
	Donald E. McClure (AMS)	2013
	Michael Pearson (MAA)	2012
	Steve Pierson (ASA)	2013
	Robert N. Rodriguez (ASA)	2012
	L. Nick Trefethen (SIAM)	2012
	Ronald Wasserstein (ASA)	2012
	Paul Zorn (MAA)	2012

4.10.4. AMS-ASL-IMS-SIAM Committee on Translations from Russian and Other Slavic Languages

Chair	James D. Stasheff (AMS)

AMS Subcommittee Members

Consultant	V. I. Arnol′d	
	Luchezar Avramov	
	Igor Dolgachev	
Consultant	S. G. Gindikin	
Consultant	Askol′d Georgievič Khovanskiĭ	
	Robert D. MacPherson	
	Grigorii A. Margulis	
Consultant	N. K. Nikol′skiĭ	
Chair	James D. Stasheff	

ASL Subcommittee Members

Chair	Veronica Becher	
	Max Dickmann	
	Andrei Morozov	
	Hiroakira Ono	2014
	Kai Wehmeier	
	Feng Ye	

IMS Subcommittee Members

Chair	M. I. Freidlin
	B. Pittel
	A. Rukhin
	W. J. Studden

4.10.5. AMS-MAA Committee on Cooperation

All members of this committee serve *ex officio*.

Robert J. Daverman (AMS)
Robert L. Devaney (MAA)
Barbara T. Faires (MAA)
Eric M. Friedlander (AMS)
Donald E. McClure (AMS)
Michael Pearson (MAA)
David A. Vogan, Jr. (AMS)
Paul Zorn (MAA)

4.10.6. AMS-MAA Committee on Mathematicians with Disabilities

	Bradford Chin (MAA)	2012
Chair	Michael Filaseta (AMS)	2013
	David M. James (MAA)	2014
	Mitchell B. Luskin (AMS)	2013
	Judith Miller (MAA)	2011
	James Michael Turner (AMS)	2014

4.10.7. AMS-MAA Committee on Teaching Assistants and Part-time Instructors (TA/PTI)

	Morton Brown (MAA)	2013
	David C. Carothers (MAA)	2013
	Mary Glaser (AMS)	2013
Chair	Delaram Kahrobaei (AMS)	2012
	Angela K. Kubena (AMS)	2013
	Janet McShane (MAA)	2014
	James Sellers (AMS)	2012
	George T. Yates (MAA)	2013

4.10.8. AMS-MAA Joint Archives Committee

	Amy K. Ackerberg-Hastings (MAA)	2014
	Peter L. Duren (AMS)	2014
	Jonathan I. Hall (AMS)	2013
	Thomas W. Hawkins (AMS)	2012
Chair	James J. Tattersall (MAA)	2013
	David Zitarelli (MAA)	2012

4.10.9. AMS-MAA Joint Meetings Committee

All members of this committee serve *ex officio*.

Chair	Robert J. Daverman
	Donald E. McClure
	Michael Pearson
Consultant	Penny Pina
	Gerard Venema

4.10.10. AMS-MAA Exhibits Advisory Subcommittee

	Carol Baxter
	Robert J. Daverman
	Christine Davis
	Nicole DeFazio
	Rebecca Elmo
	Robert Fathauer
	Norma Flores
	Elizabeth Huber
	Linda Lorusso
	Ivars Peterson
Chair	Penny Pina
	Kady Safar
	Mary L. Simons
	Inez van Korlaar
	Gerard Venema

4.10.11. AMS-MAA Joint Program Committee for the San Diego Meeting January 9–12, 2013

	Michael John Dorff (MAA)
	Darren A. Narayan (MAA)
	Kannan Soundararajan (AMS)
Chair	Tatiana Toro (AMS)

4.10.12. AMS-MAA Mathfest Program Committee

Terms for MAA members expire August 15 of the year given. The term of the chair expires August 15, 2013.

	Donna L. Beers (MAA)	2013
	Robert W. Ghrist (AMS)	2012
Chair	Ami Radunskaya (AMS)	2013
	Francis Edward Su (MAA)	2013

4.10.13. AMS-MAA Task Forms on Art Prizes

	William A. Casselman (AMS)	2012
	Annalisa Crannell (AMS)	2012
	Frank Farris (MAA)	2012
	Reza Sarhangi (MAA)	2012

4.10.14. AMS-MAA-SIAM Joint Committee on Employment Opportunities

AMS staff contact: Ellen J. Maycock.

	Sharon Arroyo (SIAM)	2014
	Leslie Button (SIAM)	2013
	Sharon Garthwaite (AMS)	2013
	Sue Geller (MAA)	2014
	Ellen J. Maycock (AMS)	*ex officio*
	Michael Pearson (MAA)	*ex officio*
Chair	Margaret Robinson (MAA)	2012
	Ivelisse M. Rubio (AMS)	2014
	Sarah Ann Stewart (AMS)	2012
	Linda Thiel (SIAM)	*ex officio*
	Gerard Venema (MAA)	2013

4.10.15. AMS-MAA-SIAM Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student

	Colin C. Adams (AMS)	2013
Chair	Jill Dietz (MAA)	2013
	Kathleen Fowler (SIAM)	2013
	Reza Malek-Madani (SIAM)	2014
	Kannan Soundararjan (MAA)	2012
	Sergei Tabachnikov (AMS)	2012

4.10.16. AMS-SIAM Committee to Select the Winner of the Wiener Prize

	Jerry Bona
	Roger Temam
Chair	Horn-Tzer Yau

4.10.17. AMS-Simons Travel Grants

	Vitaly Bergelson	2014
	Clint Dawson	2012
	Bruce K. Driver	2014
	Donald J. Estep	2012
	Malay Ghosh	2012
Chair	Paul G. Goerss	2012
	Carolyn S. Gordon	2014
	James Haglund	2012
	Ko Honda	2014
	Richard Kenyon	2013
	Irina A. Kogan	2014
	Anna L. Mazzucato	2013
	Jon McCammond	2013
	Roman Shvydkoy	2013
	Christopher D. Sogge	2014
	Michael Zieve	2013

Special Committees

4.10.18. AMS-Romanian Mathematical Society Joint Program Committee, June 27–30, 2013

Ioana Dumitriu
Daniel I. Tataru
Yuri Tschinkel
Steven H. Weintraub

4.10.19. AMS-Israel Mathematical Society Joint Program Committee, June 16–19, 2014

Daniel S. Freed
Robert M. Guralnick
Sergiu Klainerman
Michel Lapidus

5. Representatives

5.0.1. American Association for the Advancement of Science

Terms expire on February 21.

Section A	Robert Calderbank	2013
Section Q	Lawrence Firman Gray	2013

5.0.2. Canadian Mathematical Society

Alejandro Adem	2012

5.0.3. Conference Board of the Mathematical Sciences

Eric M. Friedlander	2012

5.0.4. Delbert Ray Fulkerson Prize Selection Committee

Richard P. Stanley	2011

5.0.5. MAA Committee on the American Mathematics Competition

Term expires on June 30.

David Benko	2015

5.0.6. AMS-MAA-SIAM Committee on the Porter Public Lecture

David Eisenbud (AMS)	2011

5.0.7. MAA Committee on Undergraduate Program in Mathematics (CUPM)

Dennis DeTurck	2014
Mike O'Neill	2014

5.0.8. Mathematical Congress of the Americas Steering Committee

Susan J. Friedlander	2013

5.0.9. Professionals in Science and Technology, Commission on

Sam Rankin	2012

5.0.10. U.S. National Committee on Theoretical and Applied Mechanics

Term expires on October 31.

Russel Caflisch	2012

6. Index

ABC Committee 4.3.1
AMS Development 4.4.1
AMS Public Policy Award Selection Committee 4.8.1
AMS Web Editorial Group 4.5.7
AMS-ASA-AWM-IMS-MAA-NCTM-SIAM Committee on Women in the Mathematical Sciences 4.10.1
AMS-ASA-MAA-SIAM Data Committee 4.10.2
AMS-ASA-MAA-SIAM Joint Policy Board for Mathematics 4.10.3
AMS-ASL-IMS-SIAM Committee on Translations from Russian and Other Slavic Languages 4.10.4
AMS-Israel Mathematical Society Joint Program Committee, June 16–19, 2014 . . . . . 4.10.19
AMS-MAA Committee on Cooperation 4.10.5
AMS-MAA Committee on Mathematicians with Disabilities 4.10.6
AMS-MAA Committee on Teaching Assistants and Part-time Instructors (TA/PTI) 4.10.7
AMS-MAA Exhibits Advisory Subcommittee 4.10.10
AMS-MAA Joint Archives Committee 4.10.8
AMS-MAA Joint Meetings Committee 4.10.9
AMS-MAA Joint Program Committee for the San Diego Meeting January 9–12, 2013 . . . . . 4.10.11
AMS-MAA Mathfest Program Committee 4.10.12
AMS-MAA Task Forms on Art Prizes 4.10.13
AMS-MAA-SIAM Committee on the Porter Public Lecture 5.0.6
AMS-MAA-SIAM Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student 4.10.15
AMS-MAA-SIAM Joint Committee on Employment Opportunities 4.10.14
AMS-Romanian Mathematical Society Joint Program Committee, June 27–30, 2013 . . . . . 4.10.18
AMS-SIAM Committee to Select the Winner of the Wiener Prize 4.10.16
AMS-Simons Travel Grants 4.10.17
Abstracts Editorial Committee 4.2.1
Academic Freedom, Tenure, and Employment Security . 4.7.1
Agenda and Budget 4.3.1
American Association for the Advancement of Science . 5.0.1
American Mathematics Competition, Committee on . . . 5.0.5
Archives 4.5.1
Arnold Ross Lecture Series 4.6.9
Audit 4.3.2
Award for Distinguished Public Service, Committee to Select the Winner of the 4.8.2
Board of Trustees 3
Books and Journal Donations Steering Committee 4.5.2
Bulletin 4.2.2
Bulletin (New Series) 4.2.2
CBMS 5.0.3
COE 4.7.2
CPUB 4.5.6
CSP 4.7.7
Canadian Mathematical Society 5.0.2
Centennial Fellowships 4.8.4
Central Section Program Committee 4.6.5
Chinese, Translation from 4.2.15
Collected Works 4.2.3
Colloquium 4.2.4
Colloquium Lecture 4.6.10
Committee on Committees 4.5.3
Committees 4
Committees of the Board of Trustees 4.3
Committees of the Council 4.1
Committees of the Executive Committee and Board of Trustees 4.4
Conant Prize, Committee to Select the Winner of the . . 4.8.5
Conference Board of the Mathematical Sciences 5.0.3
Conformal Geometry and Dynamics 4.2.17
Contemporary Mathematics 4.2.5
Council 2
Data Committee 4.10.2
David P. Robbins Prize 4.8.11
Delbert Ray Fulkerson Prize Selection Committee 5.0.4
E. H. Moore Research Article Prize, Committee to Select the Winner of the 4.8.9
EC 2.1
Eastern Section Program Committee 4.6.6
Editorial Boards 4.1.1
Editorial Committees 4.2
Education 4.7.2
Employment Opportunities 4.10.14
Employment Services, Advisory Board on 4.5.4
Ethics 4.7.6
Executive Committee of the Council 2.1
Exemplary Program or Achievement by a Mathematics Department, Committee to Select the Winner of the Prize for 4.8.7
Fan Fund 4.7.3

Gibbs Lecturer for 2013 and 2014, Committee to Select 4.6.11
Graduate Studies in Mathematics 4.2.6
Graduate Working Group 4.5.7
Graduate Working Group 4.5.8
Graduate Working Group 4.5.8
History of Mathematics 4.2.18
Human Rights of Mathematicians 4.7.4
Initial Fellows Selection Committee 4.1.3
Institutes and Symposia 4.9
Internal Organization of the American Mathematical Society 4.5
Investment 4.3.3
JCEO 4.10.14
JPBM 4.10.3
Japanese, Translation from 4.2.16
Joint Archives Committee 4.10.8
Joint Committees 4.10
Joint Mathematics Meetings Travel Grants 4.6.12
Joint Meetings Committee 4.10.9
Joint Policy Board 4.10.3
Joseph L. Doob Prize 4.8.6
Journal of the AMS 4.2.7
LRP 4.4.2
Liaison Committee 1.1
Liaison Committee with AAAS 4.9.1
Library 4.5.5
Long Range Planning 4.4.2
MAA Committee on Undergraduate Program in Mathematics (CUPM) 5.0.7
MAA Committee on the American Mathematics Competition 5.0.5
Math in Moscow Progam—Travel Support 4.8.15
Mathematical Congress of the Americas Steering Committee 5.0.8
Mathematical Congress of the Americas Steering Committee 5.0.8
Mathematical Reviews 4.2.8
Mathematical Surveys and Monographs 4.2.9
Mathematics Research Communities Advisory Board . . 4.6.1
Mathematics of Computation 4.2.10
Meetings and Conferences 4.6.2
Members at Large 2.0.3
Memoirs 4.2.14
Menger Prize, Committee to Select the Winner of the . . 4.8.8
Monographs 4.2.9
Morgan Prize Committee for Outstanding Research in Mathematics by an Undergraduate Student, AMS-MAA-SIAM Committee on 4.10.15
National Awards and Public Representation 4.8.10
National Meetings 4.6.3
Nominating 4.4.3
Nominating Committee 4.1.2
Nominating Committee of the ECBT 4.4.3
Notices Editorial Board 4.2.11
Officers 1
Officers of the AMS 2.0.1
PSAM 4.2.13
Porter Public Lecture, AMS-MAA-SIAM Committee on . . 5.0.6
Prizes and Awards 4.8
Proceedings 4.2.12
Proceedings of Symposia in Applied Mathematics 4.2.13
Profession 4.7.5
Professional Ethics 4.7.6
Professionals in Science and Technology, Commission on 5.0.9
Professionals in Science and Technology, Commission on 5.0.9
Programs Committees
Central 4.6.5
Eastern 4.6.6
National Meetings 4.6.3
Southeastern 4.6.7
Western 4.6.8
Program and Meetings 4.6
Publications 4.5.6
Pure and Applied Undergraduate Texts 4.2.19
Representation Theory 4.2.20
Representatives 5
Representatives of Committees 2.0.2
Retirement Plan Investment 4.3.4
Retirement Plan Investment 4.3.4
Russian and Other Slavic Languages, Translations from 4.10.4
Salary 4.3.5
Satter Prize, Committee to Select the Winner of the . . . 4.8.12
Science Policy 4.7.7
Sectional Meetings Travel Grants 4.6.13
Short Course Subcommittee 4.6.4
Southeastern Section Associate Secretary Search Committee 4.4.4
Southeastern Section Program Committee 4.6.7
Staff Salaries 4.3.5
Status of the Profession 4.7
Steele Prizes 4.8.13
Student Mathematics Library 4.2.21
TA/PTI 4.10.7
The Stefan Bergman Trust Fund 4.8.3
Theoretical and Applied Mechanics 5.0.10
Transactions and Memoirs 4.2.14
Translations:
Chinese 4.2.15
Japanese 4.2.16
Russian and Other Slavic Languages 4.10.4
Trustees 3
U.S. National Committee on Theoretical and Applied Mechanics 5.0.10
Undergraduate Program in Mathematics, MAA Committee on 5.0.7
University Lecture Series 4.2.22
Veblen Prize 4.8.14
Western Section Program Committee 4.6.8
Women in Mathematics 4.7.8
Women in the Mathematical Sciences 4.10.1
Young Scholars Awards 4.7.9

Mathematics Calendar

Please submit conference information for the Mathematics Calendar through the Mathematics Calendar submission form at `http://www.ams.org/cgi-bin/mathcal-submit.pl`. The most comprehensive and up-to-date Mathematics Calendar information is available on the AMS website at `http://www.ams.org/mathcal/`.

October 2012

* 4–6 **The Ninth Mississippi State—UAB Conference on Differential Equations & Computational Simulations**, Mississippi State University, Starkville, Mississippi.
Description: This interdisciplinary conference will provide a joint forum where mathematicians, scientists and engineers from industries, federal laboratories and academia can exchange research and development ideas. An overall goal of this conference is to promote research and education in mathematical and computational analysis of theoretical and applied differential equations. In addition to the ten principal lectures, there will be sessions for twenty-minute contributed talks. This conference will also be dedicated to Alfonso Castro in celebration of his 62nd birthday and his outstanding contributions to differential equations. Conference participants are encouraged to submit full length manuscripts after the conference. Reviewed manuscripts will be published as a special issue of the *Electronic Journal of Differential Equations*.
Deadlines: Pre-registration deadline is August 31, 2012. Abstracts for contributed papers should be submitted electronically no later than August 31, 2012.
Information: `http://www.ccs.msstate.edu/deconf/de2012/`.

* 12–14 **Istanbul Workshop on Teichmüller Theory**, Galatasaray University, Istanbul, Turkey.
Description: This is a workshop on Teichmüller theory. Sessions are devoted to talks by researchers.
Aim: The aim of the event is to share new results around the geometry of various Teichmüller spaces.
Information: `http://math.gsu.edu.tr/2012iwtt.html`.

November 2012

* 1–December 23 **Optimization: Computation, Theory and Modeling**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Description: The field of optimization has found numerous applications in science, engineering, economics, finance, and risk management. The optimization research has achieved much progress recently in theory, algorithms and applications. Yet, exciting new developments continue to emerge at a speed that has never been seen in the history of optimization.
Activities: Workshop I–Large scale conic optimization: Nov. 19–23, 2012. Tutorials on conic optimization: Nov. 19, 2012. Workshop II–Optimization under uncertainty: Dec. 10–14, 2012. Workshop III–Complementarity and its extensions: Dec. 17–21, 2012.
Information: `http://ims.nus.edu.sg/Programs/012opti/index.php`.

* 13–17 **DIMACOS '12: International Conference on Discrete Mathematics and Computer Science**, Lebanese University, Faculty of Science I, EDST, Beirut, Lebanon.

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 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. 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 **eight 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/July, 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/`.

Description: DIMACOS'12 will witness in addition to discrete mathematics and its various titles, a new wider scope in some aspects of applied mathematics.
Information: http://www.lmh-lb.net/dimacos12/index.htm.

* 21–24 **International Conference on History and Development of Mathematical Sciences and Symposium on Nonlinear Analysis ICHDMS-2012: Events to commemorate 125th Birth Year of Srinivasa Ramanujan**, Department of Mathematics, Maharshi Dayanand University, Rohtak-124001 Haryana, India.
Description: ICHDMS-2012 is intended to provide a common platform for researchers, scientists, engineers and other interested professionals throughout the world to present their latest findings, ideas, developments and applications covering aspects of the History and Development of Mathematical Sciences including Mathematics, Statistics, Operations Research and Computer Science. The academic sessions will consist of invited plenary talks and contributed paper presentations. Open Session Dedicated to the Great Mathematician Srinivasa Ramanujan
Information: http://www.mdurohtak.ac.in/international_conference/.

December 2012

* 6–8 **Thailand-Japan Joint Conference on Computational Geometry and Graphs TJJCCGG2012**, Department of Mathematics, Srinakharinwirot University, Bangkok, Thailand.
Description: Call for Papers TJJCCGG 2012 is mainly intended to provide a forum for researchers working in computational geometry, graph theory/algorithms and their applications. Original research papers in these areas and their applications are sought. Applied and experimental papers are expected to show convincingly the usefulness and efficiency of algorithms discussed in a practical setting.
Topics: Include but are not limited to: Computational geometry, discrete geometry, graph algorithms, graph theory and their applications. Following the style of past conferences, the post-conference proceedings of TJJCCGG2012 will be published by Springer as a volume of the series Lecture Notes in Computer Science.
Plenary Speakers: Janos Pach (NYU, USA) Saad El-Zanati (ISU, USA) Jorge Urrutia (UNAM, Mexico), Erik Demaine (MIT, USA), Toshinori Sakai (Tokai University, Japan), Mikio Kano (Ibaraki, Japan).
Information: http://www.tjjccgg2012.com/index.htm.

* 17–22 **The Legacy of Srinivasa Ramanujan–An International Conference**, University of Delhi, Delhi, India.
Description: An International Conference in mathematics being organized by the University of Delhi as a commemoration of the National Mathematics Year in India.
Information: http://www.legacyoframanujan.com.

January 2013

* 14–February 1 **Winter School on Mathematical Physics**, Universidad Nacional Autonoma de Mexico, Mexico City, Mexico.
Description: The aim of the school is to give introductory lectures on recent trends and methods in mathematical physics. There will be mini-courses on spectral theory of operators, quantum optics and quantum information theory. The Winter School on Mathematical Physics will be held from January 14–February 1, 2013 on the premises of the Instituto de Inventigaciones en Matemáticas Aplicadas y en Sistemas (IIMAS); http://www.iimas.unam.mx/, located in the main campus of the Universidad Nacional Autónoma de México (UNAM); http://www.unam.mx/.
Invited Lecturers: Robert Alicki, University of Gdańsk (Poland), Marc Bienert, Universität des Saarlandes (Germany), César R. De Oliveira, Universidade Federal de São Carlos (Brazil), Jan Janas, Instytut Matematyczny Polskiej Akademii Nauk (Poland).
Organizers: Ricardo Weder (Chairman), Pablo Barberis, Rafael del Rio, Juan Manuel García-Islas. Luis O. Silva of the school is to give introductory lectures on recent trends and methods in mathematical physics.
Registration: To attend the Winter School is open.
Information: http://leibniz.iimas.unam.mx/~wsmph/index.html.

February 2013

* 4–March 15 **Doc-course on Complex Analysis and Related Areas**, Universities of Seville and Málaga, Spain.
Description: This is a six-week intensive school (what we call a Doc-course) on complex analysis and related areas. The aim of the program is to provide to the participant students (30 maximum) background and research skills in several areas of analysis of current interest. Our intention is to facilitate a quick transition from basic concepts to open problems in the areas of interplay between complex and harmonic analysis, operator theory, geometric function theory and mathematical physics. The Doc-course will start on February 4, 2013: four weeks of courses in Seville (one week of introductory courses and three weeks for the six main courses) and a workshop (at the end) in Málaga where the participants will have the opportunity to report on the work made during the whole course.
Speakers: The main courses will be delivered by A. Aleman, W. Bergweiler, E. Saksman, X. Tolsa, A. Vasiliev, and D. Vukotic.
Funding: There will be a number of grants available; we hope to fund at least 15 students.
Information: http://www.imus.us.es/CARA13/.

* 11–17 (NEW DATE) **Representation Theory, Homological Algebra, and Free Resolutions**, Mathematical Sciences Research Institute, Berkeley, California.
Description: The workshop will focus on recent breakthroughs in understanding and applications of free resolutions and on interactions of commutative algebra and representation theory, where algebraic geometry often appears as a third player. A specific goal is to stimulate further interaction between these fields.
Information: http://www.msri.org/web/msri/|scientific/workshops/all-workshops/show/-/event/Wm8999

March 2013

* 4–8 **Forty-Fourth Southeastern International Conference on Combinatorics, Graph Theory and Computing**, Florida Atlantic University, Boca Raton, Florida.
Description: Celebrating its 44th year, the Conference continues in the spirit of earlier conferences in Baton Rouge and Boca Raton. It brings together mathematicians and others interested in combinatorics, graph theory and computing, and their interactions. The Conference lectures and contributed papers, as well as the opportunities for informal conversations, have proved to be of great interest to other scientists and analysts employing these mathematical sciences in their professional work.
Confirmed speakers: For our 44th Conference, we shall have a program of exceptional invited speakers: Ronald Gould, Ivelisse Rubio, Bruce Sagan, and Douglas West.
Organizers: The organizing committee cordially invites participation in our Conference by interested persons in the academic community as well as business, industry and government. The 44th Conference is partially supported by the National Security Agency.
Information: http://www.math.fau.edu.

April 2013

* 26 **Philosophy of Information: The Value of Information**, American University, Washington, DC.
Description: The overall objective of this workshop is to study some of the open questions within philosophy of information with an emphasis on the study of the value of information and the philosophy of information processing.

Information: http://www.american.edu/cas/economics/info-metrics/workshop/workshop-2013-spring.cfm.

June 2013

* 3–July 12 **Nonlinear expectations, stochastic calculus under Knightian uncertainty, and related topics**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Description: This program will be focusing on, but not limited to, the following two areas: 1) Nonlinear expectations, backward stochastic differential equations and path-dependent PDE; 2) Nonlinear-expectations, risk measures and robust controls. These areas form the substance of 3 workshops in the 6-weeks-long program. There will also be a series of tutorial lectures and ample opportunities for discussions. The program is intended for leading researchers working in these areas to exchange ideas and hopefully to inspire new mathematical concepts and results. It is also intended to bring young researchers and investment banking practitioners in the related quantitative areas to the frontier of this fascinating area. Activities 1. Workshop on Knightian uncertainty and backward stochastic differential equations: June 10–14, 2013. 2. Workshop on quantitative finance: June 20–21, 2013. 3. Workshop on Knightian uncertainty and risk measures: July 1–5, 2013.
Information: http://ims.nus.edu.sg/Programs/013wnlinear/index.php.

* 22–29 **Physics and Mathematics of Nonlinear Phenomena 2013**, Hotel Le Sirene, Gallipoli, South of Italy.
Description: The conference, organized by members of the Dipartimento di Matematica e Fisica "E. De Giorgi", follows the long established tradition of the Nonlinear Physics meetings organized by the research group on Integrable Systems of Universita' del Salento and held in Gallipoli (Lecce, Italy).
Topics: Continuous and discrete, classical and quantum integrable systems; Hamiltonian, critical and geometrical structures of nonlinear integrable equations of mathematical physics; Integrable systems in quantum field theory and matrix models; Mathematical models of nonlinear phenomena in physics; applications of nonlinear integrable systems in physics.
Scientific Committee: F. Calogero, B. Dubrovin, Y. Kodama, F. Magri, V. Zakharov.
Organizing Committee: M. Beccaria, B. Konopelchenko, G. Landolfi, L. Martina, R. Vitolo.
Information: http://pmnp2013.dmf.unisalento.it/.

July 2013

* 1–4 **2nd IMA Conference on Dense Granular Flows**, Isaac Newton Institute of Mathematical Sciences, Cambridge, United Kingdom.
Description: Themes will include dense granular flow, biological systems, self-propelled particles and geological flows, exploring new developments in theoretical analysis and experimental techniques. All attendees will be provided with an opportunity to present recent work and there will be substantial time for discussion, both during the workshop and during the evening! Postgraduate and Ph.D. students are particularly welcomed and oral presentations will reflect the breadth of the field.
Information: http://www.ima.org.uk/conferences/conferences_calendar/dense_granular_flows.cfm.

* 1–5 **Preconditioning of Iterative Methods—Theory and Applications 2013 (PIM 2013)**, Faculty of Civil Engineering, Czech Technical University in Prague, Czech Republic.
Description: The conference is in honor of Ivo Marek, a distinguished scientist interested mainly in numerical and functional analysis, on the occasion of his 80th birthday.
Themes: The main themes of the conference are (i) preconditioning of sparse matrix problems, symmetric or non-symmetric, arising in large-scale real applications; (ii) multilevel preconditioning techniques, including multigrid, algebraic multilevel, and domain decomposition methods for partial differential equations; (iii) multilevel solution of characteristics of Markov chains. The aim of this conference is to bring together specialists from these different fields of numerical analysis with complementary views and to stimulate interaction.
Information: http://pim13.fsv.cvut.cz.

The following new announcements will not be repeated until the criteria in the next to the last paragraph at the bottom of the first page of this section are met.

December 2013

* 28–30 **3rd International Conference on Mathematics & Information Science (ICMIS 2013)**, Luxor, Egypt.
Description: The conference will feature advances in mathematical science and technology presented by leading African and international researchers. The conference will provide the opportunity to showcase research in mathematics, theoretical physics and information science and technology to engender dialogue and collaboration between Egyptian and international researchers. The conference is part of a series of conferences dedicated to bringing top scientists and technologists to Egypt thereby helping to raise Egyptian science and technology to the highest international standard, raise awareness of governments and industry in Egypt of the importance and excitement of new research and development in technologies, and engender collaborations and research exchanges.
Grants: Some grants for young and early stage researchers are available.
Information: http://conf.naturalspublishing.com/.

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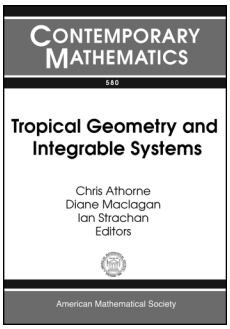
Algebra and Algebraic Geometry



Tropical Geometry and Integrable Systems

Chris Athorne, *University of Glasgow, United Kingdom*, **Diane Maclagan**, *University of Warwick, United Kingdom*, and **Ian Strachan**, *University of Glasgow, United Kingdom*, Editors

This volume contains the proceedings of the conference on tropical geometry and integrable systems, held July 3–8, 2011, at the University of Glasgow, United Kingdom.

One of the aims of this conference was to bring together researchers in the field of tropical geometry and its applications, from apparently disparate ends of the spectrum, to foster a mutual understanding and establish a common language which will encourage further developments of the area. This aim is reflected in these articles, which cover areas from automata, through cluster algebras, to enumerative geometry. In addition, two survey articles are included which introduce ideas from researchers on one end of this spectrum to researchers on the other.

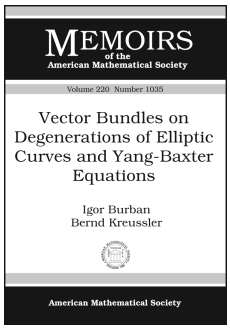
This book is intended for graduate students and researchers interested in tropical geometry and integrable systems and the developing links between these two areas.

This item will also be of interest to those working in analysis.

Contents: D. Maclagan, Introduction to tropical algebraic geometry; **R. Inoue** and **S. Iwao**, Tropical curves and integrable piecewise linear maps; **F. Block**, Counting algebraic curves with tropical geometry; **P. Johnson**, Hurwitz numbers, ribbon graphs, and tropicalization; **T. Maeno** and **Y. Numata**, Sperner property, matroids and finite-dimensional Gorenstein algebras; **L. Chekhov** and **M. Mazzocco**, Block triangular bilinear forms and braid group action; **T. Nakanishi**, Tropicalization method in cluster algebras; **S. Sergeev**, An application of the max-plus spectral theory to an ultradiscrete analogue of the Lax pair; **R. Willox**, **A. Ramani**, **J. Satsuma**, and **B. Grammaticos**, A KdV cellular automaton without integers.

Contemporary Mathematics, Volume 580

November 2012, 155 pages, Softcover, ISBN: 978-0-8218-7553-7, 2010 *Mathematics Subject Classification:* 14T05, 14H70, 14N10, 37K10, 37K20, **AMS members US$49.60**, List US$62, Order code CONM/580



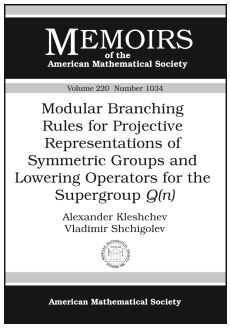
Vector Bundles on Degenerations of Elliptic Curves and Yang-Baxter Equations

Igor Burban, *Universität Bonn, Germany*, and **Bernd Kreussler**, *Mary Immaculate College, Limerick, Ireland*

Contents: Introduction; Yang–Baxter equations; Massey products and AYBE—a single curve; Massey products and AYBE—families of curves; Explicit calculations—smooth curves; Explicit calculations—singular curves; Summary; Bibliography.

Memoirs of the American Mathematical Society, Volume 220, Number 1035

October 2012, 131 pages, Softcover, ISBN: 978-0-8218-7292-5, 2010 *Mathematics Subject Classification:* 14F05, 14H60, 14H70, 16T25, **Individual member US$42.60**, List US$71, Institutional member US$56.80, Order code MEMO/220/1035



Modular Branching Rules for Projective Representations of Symmetric Groups and Lowering Operators for the Supergroup $Q(n)$

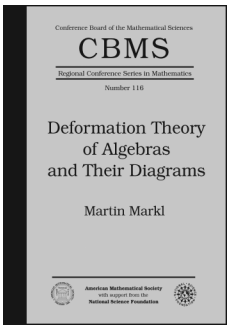
Alexander Kleshchev, *University of Oregon, Eugene, OR*, and **Vladimir Shchigolev**, *Lomonosov Moscow State University, Russia*

Contents: Preliminaries; Lowering operators; Some polynomials; Raising coefficients; Combinatorics of signature sequences;

Constructing $U(n-1)$-primitive vectors; Main results on $U(n)$; Main results on projective representations of symmetric groups; Bibliography.

Memoirs of the American Mathematical Society, Volume 220, Number 1034

October 2012, 123 pages, Softcover, ISBN: 978-0-8218-7431-8, 2010 *Mathematics Subject Classification:* 20C30; 20C25, 20C20, 17B10, **Individual member US$42.60**, List US$71, Institutional member US$56.80, Order code MEMO/220/1034



Deformation Theory of Algebras and Their Diagrams

Martin Markl, *Academy of Sciences of the Czech Republic, Praha, Czech Republic*

This book brings together both the classical and current aspects of deformation theory. The presentation is mostly self-contained, assuming only basic knowledge of commutative algebra, homological algebra and category theory. In the interest of readability, some technically complicated proofs have been omitted when a suitable reference was available. The relation between the uniform continuity of algebraic maps and topologized tensor products is explained in detail, however, as this subject does not seem to be commonly known and the literature is scarce.

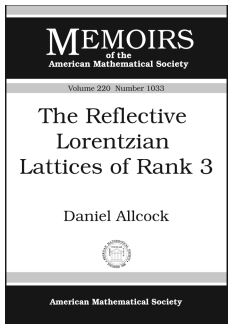
The exposition begins by recalling Gerstenhaber's classical theory for associative algebras. The focus then shifts to a homotopy-invariant setup of Maurer-Cartan moduli spaces. As an application, Kontsevich's approach to deformation quantization of Poisson manifolds is reviewed. Then, after a brief introduction to operads, a strongly homotopy Lie algebra governing deformations of (diagrams of) algebras of a given type is described, followed by examples and generalizations.

Contents: Basic notions; Deformations and cohomology; Finer structures of cohomology; The gauge group; The simplicial Maurer-Cartan space; Strongly homotopy Lie algebras; Homotopy invariance and quantization; Brief introduction to operads; L_∞-algebras governing deformations; Examples; Index; Bibliography.

CBMS Regional Conference Series in Mathematics, Number 116

October 2012, 129 pages, Softcover, ISBN: 978-0-8218-8979-4, 2010 *Mathematics Subject Classification:* 13D10, 14D15; 53D55, 55N35, **AMS members US$28**, **All Individuals US$28**, List US$35, Order code CBMS/116

Analysis



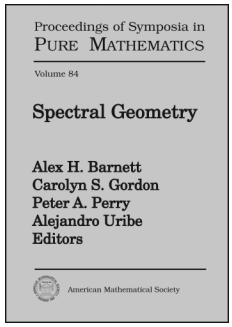
The Reflective Lorentzian Lattices of Rank 3

Daniel Allcock, *University of Texas at Austin, TX*

Contents: Background; The classification theorem; The reflective lattices; Bibliography.

Memoirs of the American Mathematical Society, Volume 220, Number 1033

October 2012, 108 pages, Softcover, ISBN: 978-0-8218-6911-6, 2010 *Mathematics Subject Classification:* 11H56; 20F55, 22E40, **Individual member US$42**, List US$70, Institutional member US$56, Order code MEMO/220/1033



Spectral Geometry

Alex H. Barnett, *Dartmouth College, Hanover, NH*, **Carolyn S. Gordon**, *Dartmouth College, NH*, **Peter A. Perry**, *University of Kentucky, Lexington, KY*, and **Alejandro Uribe**, *University of Michigan, Ann Arbor, MI*, Editors

This volume contains the proceedings of the International Conference on Spectral Geometry, held July 19–23, 2010, at Dartmouth College, Dartmouth, New Hampshire.

Eigenvalue problems involving the Laplace operator on manifolds have proven to be a consistently fertile area of geometric analysis with deep connections to number theory, physics, and applied mathematics. Key questions include the measures to which eigenfunctions of the Laplacian on a Riemannian manifold condense in the limit of large eigenvalue, and the extent to which the eigenvalues and eigenfunctions of a manifold encode its geometry.

In this volume, research and expository articles, including those of the plenary speakers Peter Sarnak and Victor Guillemin, address the flurry of recent progress in such areas as quantum unique ergodicity, isospectrality, semiclassical measures, the geometry of nodal lines of eigenfunctions, methods of numerical computation, and spectra of quantum graphs. This volume also contains mini-courses on spectral theory for hyperbolic surfaces, semiclassical analysis, and orbifold spectral geometry that prepared the participants, especially graduate students and young researchers, for conference lectures.

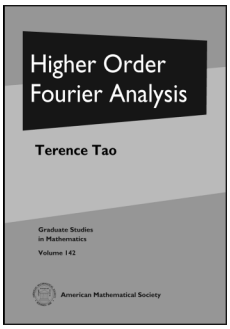
This item will also be of interest to those working in geometry and topology.

Contents: *Expository lectures:* **D. Borthwick**, Introduction to spectral theory on hyperbolic surfaces; **C. Gordon**, Orbifolds and their spectra; **A. Uribe** and **Z. Wang**, A brief introduction to semiclassical analysis; *Invited papers:* **N. Anantharaman** and **F. Macià**, The dynamics of the Schrödinger flow from the point of view of semiclassical measures; **G. Berkolaiko** and **P. Kuchment**, Dependence of the spectrum of a quantum graph on vertex conditions and edge lengths;

J. D. Bouas, **S. A. Fulling**, **F. D. Mera**, **K. Thapa**, **C. S. Trendafilova**, and **J. Wagner**, Investigating the spectral geometry of a soft wall; **E. B. Dryden**, **V. Guillemin**, and **R. Sena-Dias**, Equivariant inverse spectral problems; **C. Gordon**, **W. Kirwin**, **D. Schueth**, and **D. Webb**, Classical equivalence and quantum equivalence of magnetic fields on flat tori; **V. Guillemin**, **A. Uribe**, and **Z. Wang**, A semiclassical heat trace expansion for the perturbed harmonic oscillator; **A. Hassell** and **A. Barnett**, Estimates on Neumann eigenfunctions at the boundary, and the "method of particular solutions" for computing them; **H. Hezari** and **Z. Wang**, Lower bounds for volumes of nodal sets: An improvement of a result of Sogge-Zelditch; **C. Judge**, The nodal set of a finite sum of Maass cusp forms is a graph; **T. Kappeler**, **B. Schaad**, and **P. Topalov**, Asymptotics of spectral quantities of Schrödinger operators; **P. Sarnak**, Recent progress on the quantum unique ergodicity conjecture; **I. Wigman**, On the nodal lines of random and deterministic Laplace eigenfunctions; **S. Zelditch**, Pluri-potential theory on Grauert tubes of real analytic Riemannian manifolds, I.

Proceedings of Symposia in Pure Mathematics, Volume 84

November 2012, approximately 337 pages, Hardcover, ISBN: 978-0-8218-5319-1, 2010 *Mathematics Subject Classification:* 58J53, 58J50, 58J51, 65N25, 35P15, 11F72, 53C20, 34L15, 34E05, 57R18, **AMS members US$64**, List US$80, Order code PSPUM/84



Higher Order Fourier Analysis

Terence Tao, *University of California, Los Angeles, CA*

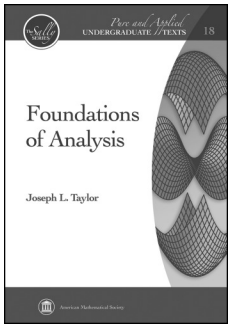
Traditional Fourier analysis, which has been remarkably effective in many contexts, uses linear phase functions to study functions. Some questions, such as problems involving arithmetic progressions, naturally lead to the use of quadratic or higher order phases. Higher order Fourier analysis is a subject that has become very active only recently. Gowers, in groundbreaking work, developed many of the basic concepts of this theory in order to give a new, quantitative proof of Szemerédi's theorem on arithmetic progressions. However, there are also precursors to this theory in Weyl's classical theory of equidistribution, as well as in Furstenberg's structural theory of dynamical systems.

This book, which is the first monograph in this area, aims to cover all of these topics in a unified manner, as well as to survey some of the most recent developments, such as the application of the theory to count linear patterns in primes. The book serves as an introduction to the field, giving the beginning graduate student in the subject a high-level overview of the field. The text focuses on the simplest illustrative examples of key results, serving as a companion to the existing literature on the subject. There are numerous exercises with which to test one's knowledge.

Contents: Higher order Fourier analysis; Related articles; Bibliography; Index.

Graduate Studies in Mathematics, Volume 142

November 2012, 187 pages, Hardcover, ISBN: 978-0-8218-8986-2, 2010 *Mathematics Subject Classification:* 11B30, 37A45, 11U07, 11L07, **AMS members US$43.20**, List US$54, Order code GSM/142



Foundations of Analysis

Joseph L. Taylor, *University of Utah, Salt Lake City, UT*

Analysis plays a crucial role in the undergraduate curriculum. Building upon the familiar notions of calculus, analysis introduces the depth and rigor characteristic of higher mathematics courses. *Foundations of Analysis* has two main goals. The first is to develop in students the mathematical maturity and sophistication they will need as they move through the upper division curriculum. The second is to present a rigorous development of both single and several variable calculus, beginning with a study of the properties of the real number system.

The presentation is both thorough and concise, with simple, straightforward explanations. The exercises differ widely in level of abstraction and level of difficulty. They vary from the simple to the quite difficult and from the computational to the theoretical. Each section contains a number of examples designed to illustrate the material in the section and to teach students how to approach the exercises for that section.

The list of topics covered is rather standard, although the treatment of some of them is not. The several variable material makes full use of the power of linear algebra, particularly in the treatment of the differential of a function as the best affine approximation to the function at a given point. The text includes a review of several linear algebra topics in preparation for this material. In the final chapter, vector calculus is presented from a modern point of view, using differential forms to give a unified treatment of the major theorems relating derivatives and integrals: Green's, Gauss's, and Stokes's Theorems.

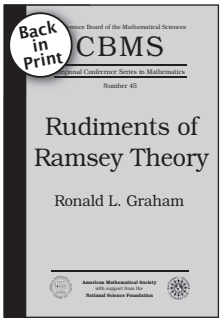
At appropriate points, abstract metric spaces, topological spaces, inner product spaces, and normed linear spaces are introduced, but only as asides. That is, the course is grounded in the concrete world of Euclidean space, but the students are made aware that there are more exotic worlds in which the concepts they are learning may be studied.

Contents: The real numbers; Sequences; Continuous functions; The derivative; The integral; Infinite series; Convergence in Euclidean space; Functions on Euclidean space; Differentiation in several variables; Integration in several variables; Vector calculus; Degrees of infinity; Bibliography; Index.

Pure and Applied Undergraduate Texts, Volume 18

November 2012, approximately 401 pages, Hardcover, ISBN: 978-0-8218-8984-8, 2010 *Mathematics Subject Classification:* 26-01, 26Axx, 26Bxx, 26Dxx, 03Exx, **AMS members US$59.20**, List US$74, Order code AMSTEXT/18

Discrete Mathematics and Combinatorics



Rudiments of Ramsey Theory

Ronald L. Graham

The survey is not only very readable in terms of mathematical exposition, it is highly entertaining.

—***N. Hindman, Mathematical Reviews***

This book is back in print from the AMS:

It is no exaggeration to say that over the past several decades there has been a veritable explosion of activity in the general field of combinatorics. Ramsey theory, in particular, has shown remarkable growth. This book gives a picture of the state of the art of Ramsey theory at the time of Graham's CBMS lectures. In keeping with the style of the lectures, the exposition is informal. However, complete proofs are given for most of the basic results presented. In addition, many useful results may be found in the exercises and problems.

Loosely speaking, Ramsey theory is the branch of combinatorics that deals with structures that are preserved under partitions. Typically, one looks at the following kind of question: If a particular structure (e.g., algebraic, combinatorial or geometric) is arbitrarily partitioned into finitely many classes, what kinds of substructures must always remain intact in at least one of the classes?

At the time of these lectures, a number of spectacular advances had been made in the field of Ramsey theory. These include: the work of Szemerédi and Furstenberg settling the venerable conjecture of Erdös and Turán, the Nesetril-Rödl theorems on induced Ramsey properties, the results of Paris and Harrington on "large" Ramsey numbers and undecidability in first-order Peano arithmetic, Deuber's solution to the old partition regularity conjecture of Rado, Hindman's surprising generalization of Schur's theorem, and the resolution of Rota's conjecture on Ramsey's theorem for vector spaces by Graham, Leeb and Rothschild. It has also become apparent that the ideas and techniques of Ramsey theory span a rather broad range of mathematical areas, interacting in essential ways with parts of set theory, graph theory, combinatorial number theory, probability theory, analysis and even theoretical computer science. These lecture notes lay out the foundation on which much of this work is based.

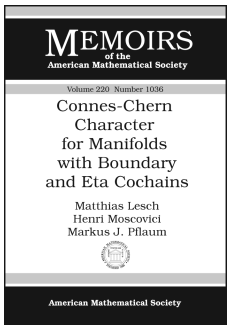
Relatively little specialized mathematical background is required for this book. It should be accessible to upper division students.

Contents: Three views of Ramsey theory; Ramsey's theorem; van der Waerden's theorem; The Hales-Jewett theorem; Szemerédi's theorem; Graph Ramsey theory; Euclidean Ramsey theory; A general Ramsey product theorem; The theorems of Schur, Folkman, and Hindman; Rado's theorem; Current trends; References.

CBMS Regional Conference Series in Mathematics, Number 45

December 1981, 65 pages, Softcover, ISBN: 978-0-8218-1696-7, LC 80-29667, 2010 *Mathematics Subject Classification:* 05-XX, **AMS members US$14.40**, **All Individuals US$14.40**, List US$18, Order code CBMS/45

Geometry and Topology



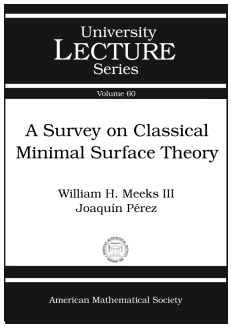
Connes-Chern Character for Manifolds with Boundary and Eta Cochains

Matthias Lesch, *Universität Bonn, Germany*, **Henri Moscovici**, *Ohio State University, Columbus, OH*, and **Markus J. Pflaum**, *University of Colorado, Boulder, CO*

Contents: Introduction; Preliminaries; The b-analogue of the entire Chern character; Heat kernel and resolvent estimates; The main results; Bibliography; Subject index; Notation index.

Memoirs of the American Mathematical Society, Volume 220, Number 1036

October 2012, 92 pages, Softcover, ISBN: 978-0-8218-7296-3, 2010 *Mathematics Subject Classification:* 58Jxx, 46L80; 58B34, 46L87, **Individual member US$40.20**, List US$67, Institutional member US$53.60, Order code MEMO/220/1036



A Survey on Classical Minimal Surface Theory

William H. Meeks III, *University of Massachusetts, Amherst, MA*, and **Joaquín Pérez**, *Universidad de Granada, Spain*

Meeks and Pérez present a survey of recent spectacular successes in classical minimal surface theory. The classification of minimal planar domains in three-dimensional Euclidean space provides the focus of the account. The proof of the classification depends on the work of many currently active leading mathematicians, thus making contact with much of the most important results in the field. Through the telling of the story of the classification of minimal planar domains, the general mathematician may catch a glimpse of the intrinsic beauty of this theory and the authors' perspective of what is happening at this historical moment in a very classical subject.

This book includes an updated tour through some of the recent advances in the theory, such as Colding–Minicozzi theory, minimal laminations, the ordering theorem for the space of ends, conformal structure of minimal surfaces, minimal annular ends with infinite total curvature, the embedded Calabi–Yau problem, local pictures on the scale of curvature and topology, the local removable singularity theorem, embedded minimal surfaces of finite genus, topological classification of minimal surfaces, uniqueness of Scherk

singly periodic minimal surfaces, and outstanding problems and conjectures.

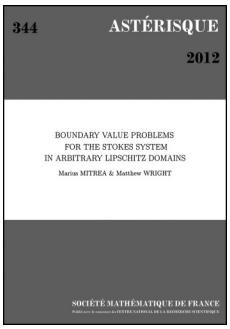
Contents: Introduction; Basic results in classical minimal surface theory; Minimal surfaces with finite topology and more than one end; Limits of embedded minimal surfaces without local area or curvature bounds; The structure of minimal laminations of $\mathbb{R}^3$; The Ordering Theorem for the space of ends; Conformal structure of minimal surfaces; Uniqueness of the helicoid I: proper case; Embedded minimal annular ends with infinite total curvature; The embedded Calabi–Yau problem; Local pictures, local removable singularities and dynamics; Embedded minimal surfaces of finite genus; Topological aspects of minimal surfaces; Partial results on the Liouville conjecture; The Scherk uniqueness theorem; Calabi–Yau problems; Outstanding problems and conjectures; Bibliography.

University Lecture Series, Volume 60

November 2012, approximately 197 pages, Softcover, ISBN: 978-0-8218-6912-3, 2010 *Mathematics Subject Classification:* 53A10; 49Q05, 53C42, **AMS members US$38.40**, List US$48, Order code ULECT/60

New AMS-Distributed Publications

Differential Equations



Boundary Value Problems for the Stokes System in Arbitrary Lipschitz Domains

Marius Mitrea, *University of Missouri at Columbia, MO*, and **Matthew Wright**, *Missouri State University, Springfield, MO*

The goal of this work is to treat the following main boundary value problems for the Stokes system: (1) the Dirichlet problem with L^p-data and nontangential maximal function estimates, (2) the Neumann problem with L^p-data and nontangential maximal function estimates, (3) the Regularity problem with L^p_1-data and nontangential maximal function estimates, (4) the transmission problem with L^p-data and nontangential maximal function estimates, (5) the Poisson problem with Dirichlet condition in Besov-Triebel-Lizorkin spaces, and (6) the Poisson problem with Neumann condition in Besov-Triebel-Lizorkin spaces, in Lipschitz domains of arbitrary topology in $\mathbb{R}^n$, for each $n \geq 2$.

The authors' approach relies on boundary integral methods and yields constructive solutions to the aforementioned problems.

This item will also be of interest to those working in analysis.

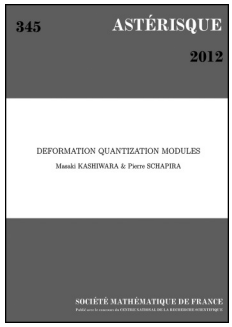
A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Smoothness spaces and Lipschitz domains; Rellich identities for divergence form, second-order systems; The Stokes system and hydrostatic potentials; The L^p transmission problem with p near 2; Local L^2 estimates; The transmission problem in two and three dimensions; Higher dimensions; Boundary value problems in bounded Lipschitz domains; The Poisson problem for the Stokes system; Appendix; Bibliography.

Astérisque, Number 344

July 2012, 241 pages, Softcover, ISBN: 978-2-85629-343-0, 2010 *Mathematics Subject Classification:* 35J25, 42B20, 46E35, 35J05, 45B05, 31B10, **Individual member US$67.50**, List US$75, Order code AST/344

Geometry and Topology



Deformation Quantization Modules

Masaki Kashiwara, *Kyoto University, Japan*, and **Pierre Schapira**, *Université Paris VI, France*

On a complex manifold $(X, \mathcal{O}_X)$, a DQ-module is a module (in the derived sense) over an algebroid stack locally equivalent to the sheaf $\mathcal{O}_X[[\hbar]]$ endowed with a star-product. The book treats relative finiteness, duality and index theorems for DQ-modules, showing in particular the functoriality of the Hochschild class in this framework and studying in detail holonomic modules in the symplectic case.

Hence, these notes could be considered both as an introduction to noncommutative complex analytic geometry and to the study of microdifferential systems on complex Poisson manifolds.

This item will also be of interest to those working in differential equations.

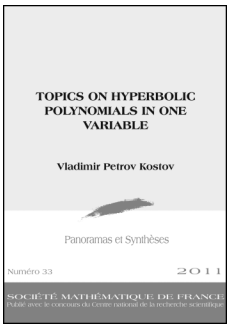
A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Modules over formal deformations; DQ-algebroids; Kernels; Hochschild classes; The commutative case; Symplectic case and $\mathcal{D}$-modules; Holonomic DQ-modules; Notation index; Terminological index; Bibliography.

Astérisque, Number 345

June 2012, 147 pages, Softcover, ISBN: 978-2-85629-345-4, 2010 *Mathematics Subject Classification:* 53D55, 35A27, 19L10, 32C38, **Individual member US$54**, List US$60, Order code AST/345

Number Theory



Topics on Hyperbolic Polynomials in One Variable

Vladimir Petrov Kostov,
Université de Nice, France

This book exposes recent results about hyperbolic polynomials in one real variable, i.e. having all their roots real. It contains a study of the stratification and the geometric properties of the domain in $\mathbb{R}^n$ of the values of the coefficients a_j for which the polynomial $P := x^n + a_1x^{n-1} + \cdots + a_n$ is hyperbolic. Similar studies are performed w.r.t. very hyperbolic polynomials, i.e. hyperbolic and having hyperbolic primitives of any order, and w.r.t. stably hyperbolic ones, i.e. real polynomials of degree n which become hyperbolic after multiplication by x^k and addition of a suitable polynomial of degree $k-1$.

New results are presented concerning the Schur-Szegő composition of polynomials, in particular of hyperbolic ones, and of certain entire functions. The question about the arrangement of the $n(n+1)/2$ roots of the polynomials $P, P^{(1)}, \ldots, P^{(n-1)}$ is studied for $n \leq 5$ with the help of the discriminant sets $\mathrm{Res}(P^{(i)}, P^{(j)}) = 0$.

This item will also be of interest to those working in analysis.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; The hyperbolicity domain; Very hyperbolic and stably hyperbolic polynomials; The Schur–Szegö composition and the mapping Φ; Root arrangements and the Rolle theorem; Testing hyperbolicity; Bibliography.

Panoramas et Synthèses, Number 33

June 2012, 152 pages, Softcover, ISBN: 978-2-85629-346-1, 2010 *Mathematics Subject Classification:* 12D10, 26C10, 30C15, **Individual member US$40.50**, List US$45, Order code PASY/33

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****

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Eligibility: Open to persons who have recently received their doctorates in mathematics.

Deadline: January 1, 2013.

Application information: Please apply online at `mathjobs.org`. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship.

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Eligibility: Offered to a candidate within six years of having received the Ph.D. who shows strong research promise in one of the areas in which Caltech's mathematics faculty is currently active

Deadline: January 1, 2013.

Application information: Please apply online at `mathjobs.org`. To avoid duplication of paperwork, your application will also be considered for an Olga Taussky and John Todd Instructorship and a Harry Bateman Research Instructorship.

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CALIFORNIA INSTITUTE OF TECHNOLOGY
Olga Taussky and John Todd Instructorships in Mathematics

Description: Appointments are for three years. There are three terms in the Caltech academic year, and instructors are expected to teach one course in all but two terms of the total appointment. These two terms will be devoted to research. During the summer months there are no duties except research.

Eligibility: Offered to persons within three years of having received the Ph.D. who show strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.

Deadline: January 1, 2013.

Application information: Please apply online at `mathjobs.org`. To avoid duplication of paperwork, your application will also be considered for a Harry Bateman Research Instructorship.

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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 2012 rate is $3.50 per word with a minimum two-line headline. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified ads.

Upcoming deadlines for classified advertising are as follows: November 2012 issue–August 30, 2012; December 2012 issue–October 1, 2012; January 2013 issue–October 29, 2012; February 2013 issue–November 28, 2012; March 2013 issue–January 2, 2013; April 2013 issue–January 30, 2013.

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 email to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

CALIFORNIA INSTITUTE OF TECHNOLOGY
The Division of Physics, Mathematics, and Astronomy

The Division of Physics, Mathematics, and Astronomy at the California Institute of Technology invites applications for a possible tenure-track position in Mathematics at the assistant professor level. We are particularly interested in the following research areas: Algebraic Geometry/Number Theory, Analysis/Dynamics, Combinatorics, Finite and Algebraic Groups, Geometry/Topology, Logic/Set Theory, and Mathematical Physics, but other fields may be considered. The term of the initial appointment is normally four years for a tenure-track assistant professor (with a possible extension to as much as seven years). Appointment is contingent upon completion of the Ph.D. Exceptional candidates may also be considered at the associate or full professor level. We are seeking highly qualified applicants who are committed to a career in research and teaching. Applicants should apply online at `mathjobs.org`.

Caltech is an Affirmative Action/Equal Opportunity Employer. Women and minorities are encouraged to apply.

000047

UNIVERSITY OF CALIFORNIA, SAN DIEGO
Division of Physical Sciences

The Division of Physical Sciences at the University of California, San Diego, invites applications for up to two tenure-track faculty positions in a research area of interest to any of the three divisional departments: Chemistry & Biochemistry, Mathematics, and Physics (`http://physicalsciences.ucsd.edu/about/index.html`). Successful candidates must have a Ph.D. in the relevant discipline and demonstrated potential for a recognized program of excellence in both teaching and research. Preferred candidates will have the potential for leadership in areas contributing to diversity, equity, and inclusion and will have a desire to play a future role in helping to shape and expand the University's diversity initiatives (`http://diversity.ucsd.edu/`). We especially welcome candidates who have experience with and wish to contribute to programs that increase the access to mathematics and the sciences for underrepresented students and faculty and their success in these fields.

Salary is commensurate with qualifications and based on University of California pay scale.

Applications should be submitted to `http://www.mathjobs.org` and should include the following items: 3 reference letters (writers should upload their reference letter to `mathjobs.org` and at least one letter should address teaching experience in some depth), curriculum vitae with a list of publications, research statement to include a summary of research plans, teaching statement, and a separate statement that addresses past and/or potential contributions to diversity, equity and inclusion (see `http://facultyequity.ucsd.edu/Faculty-Applicant-C2D-Info.asp`). Review of applications will commence on November 1, 2012, and will continue until the position is filled.

UCSD is an Affirmative Action/Equal Opportunity Employer with a strong institutional commitment to excellence through diversity.

000066

UNIVERSITY OF CALIFORNIA, SAN DIEGO
Faculty Positions in the Department of Mathematics 2012-2013

The Department of Mathematics, within the Division of Physical Sciences at the University of California, San Diego, (`http://www.math.ucsd.edu`) invites applications for TWO tenure-track positions from outstanding candidates. The department's priorities this year are to hire one person in representation theory or number theory and one person in applied mathematics with potential interdisciplinary implications. The positions are expected to be filled at the Assistant Professor level.

The University is committed to an excellent and diverse student body. Successful candidates will be evaluated on research and teaching accomplishments, as well as on potential for leadership in areas contributing to diversity, equity and inclusion. Candidates must receive their Ph.D. prior to their first quarter of teaching. Salary is commensurate with qualifications and based on UC pay scales. The starting date for the positions, pending funding approval, will be July 1, 2013. To receive full consideration, applications should be submitted online through `http://www.mathjobs.org/` by November 1, 2012. For instructions on the application procedure, see `http://math.ucsd.edu/about/employment/faculty/`.

In compliance with the Immigration Reform and Control Act of 1986, individuals offered employment by the University of California will be required to show documentation to prove identity and authorization to work in the United States before hiring can occur. For applicants interested in spousal/partner employment, please visit the UCSD Partner Opportunities Program at `http://academicaffairs.ucsd.edu/offices/partneropp/`. UCSD is an Equal Opportunity/Affirmative Action Employer with a strong institutional commitment to excellence and diversity (`http://diversity.ucsd.edu/`).

000063

CONNECTICUT

FAIRFIELD UNIVERSITY
Assistant Professor
Tenure-Track in Mathematics

The Department of Mathematics and Computer Science at Fairfield University invites applications for one tenure-track position in mathematics, at the rank of assistant professor, to begin in September 2013. We seek a highly qualified candidate with a commitment to and demonstrated excellence in teaching, and strong evidence of research potential. A doctorate in mathematics, statistics, or a related field is required. The teaching load is 3 courses/9 credit hours per semester and consists primarily of courses at the undergraduate level. The successful candidate will be expected to teach a wide variety of courses from elementary calculus and statistics to senior electives; in particular, Fairfield University's core curriculum includes two semesters of mathematics for all undergraduates and the department enjoys a good number of majors and minors in mathematics. The successful candidate also will be able to teach graduate courses, if she or he desires.

Specifically, we are looking for someone in statistics, biostatistics, stochastic processes, or in an applied area with a good background in statistics, in order to help us to address curricular needs in statistics.

Fairfield University is a Catholic and Jesuit comprehensive university with about 3,200 undergraduates, 1,000 graduate students, and a strong emphasis on liberal arts education. The department has an active faculty of 15 full-time tenured or tenure-track members. We offer a BS and an MS in mathematics, as well as a BS in computer science. The MS program is an evening program and attracts students from various walks of life, secondary school teachers, eventual Ph.D. candidates, and people working in industry or business, among others.

Fairfield offers competitive salaries and compensation benefits. The picturesque campus is located on Long Island Sound in southwestern Connecticut, about 50 miles from New York City. Fairfield University is an Equal Opportunity/Affirmative Action employer, committed to excellence through diversity and, in this spirit, particularly welcomes applications from women, persons of color, and members of historically underrepresented groups.

How to Apply: Applicants are required to apply electronically through `http://www.mathjobs.org`. Applications must include the following: a cover letter, a curriculum vitae, teaching and research statements, and three letters of recommendation commenting on the applicant's experience and promise as a teacher and scholar. Reference letter writers should be asked to submit their letters online through `MathJobs.org`. If they are unable

to do so, they may send their letters to the following address: Matt Coleman, Chair of the Department of Mathematics and Computer Science, Fairfield University, 1073 N. Benson Rd., Fairfield CT 06824-5195. Full consideration will be given to complete applications received by Tuesday, November 27, 2012. We will be interviewing at the Joint Mathematics Meetings in San Diego, January 9-12, 2013. Please let us know if you will be attending.

000062

MARYLAND

JOHNS HOPKINS UNIVERSITY
Department of Mathematics
J. J. Sylvester Assistant Professor

Subject to availability of resources and administrative approval, the Department of Mathematics invites applications for non-tenure-track two-year Assistant Professor positions beginning July 1, 2013. The J.J. Sylvester Assistant Professorship is a position offered to recent Ph.D.'s with outstanding research potential. Candidates in all areas of pure mathematics are encouraged to apply. The teaching load is three courses per academic year. To submit your application, go to `http://www.mathjobs.org/jobs/jhu`. Submit the AMS cover sheet, your curriculum vitae, and research and teaching statements, and ensure that at least four letters of recommendation, one of which addresses teaching, are submitted by the reference writers. If you are unable to apply online, you may send application materials to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218. If you have questions concerning this position, please write to: `cpoole@jhu.edu`. Preference will be given to applications received by December 1, 2012. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

000050

JOHNS HOPKINS UNIVERSITY
Department of Mathematics
Tenure-Track Assistant Professor

The Department of Mathematics invites applications for two positions at the tenure-track Assistant Professor level beginning July 1, 2013. A Ph.D. degree or its equivalent and demonstrated promise in research and commitment to teaching are required. Candidates in all areas of pure mathematics are encouraged to apply. To submit your application, go to: `www.mathjobs.org/jobs/jhu`. Submit the AMS cover sheet, your curriculum vitae, list of publications, and research and teaching statements, and ensure that at least four letters of recommendation, one of which addresses teaching, are submitted by the reference writers. If you are unable to apply online or do not wish to do so, you may send application materials to: Appointments Committee, Department of Mathematics, Johns Hopkins University, 404 Krieger Hall, Baltimore, MD 21218. If you have questions concerning this position, please write to: `cpoole@jhu.edu`. Preference will be given to applications received by October 15, 2012. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer. Minorities and women candidates are encouraged to apply.

000051

MASSACHUSETTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Mathematics

The Mathematics Department at MIT is seeking to fill positions in Pure and Applied Mathematics, and Statistics at the level of Instructor, Assistant Professor or higher beginning September 2013. The department also seeks candidates for the Schramm Postdoctoral Fellowship. Appointments are based primarily on exceptional research qualifications. Appointees will be expected to fulfill teaching duties and to pursue their own research program. Ph.D. required by employment start date.

For more information and to apply, please visit `www.mathjobs.org`. To receive full consideration, submit applications by December 1, 2012. MIT is an Equal Opportunity, Affirmative Action Employer.

000060

WILLIAMS COLLEGE
Department of Mathematics and Statistics

Williams College invites applications for one tenure-track position in mathematics, beginning fall 2013, at the rank of assistant professor (in an exceptional case, a more advanced appointment may be considered). We are seeking a highly qualified candidate who has demonstrated excellence in teaching, who will establish an active and successful research program, and who will have a Ph.D. by the time of appointment. Williams College is a private, coeducational, residential, highly selective liberal arts college with an undergraduate enrollment of approximately 2,000 students. The teaching load is two courses per 12-week semester and a winter term course every other January. Applicants are encouraged to apply electronically at: `http://mathjobs.org` or send a vita and have three letters of recommendation on teaching and research sent to Satyan Devadoss, Chair of the Hiring Committee, Department of Mathematics and Statistics, Williams College, 18 Hoxsey Street, Williamstown, MA 01267. Teaching and research statements are also welcome. Evaluations of applications will begin on or after November 15 and will continue until the position is filled. All offers of employment are contingent upon completion of a background check. Further information is available upon request. For more information on the Department of Mathematics and Statistics, visit: `http://math.williams.edu/`. Williams College is a coeducational liberal arts institution located in the Berkshire Hills of western Massachusetts with easy access to the culturally rich cities of Albany, Boston, and New York City. The college is committed to building and supporting a diverse population of students, and to fostering an inclusive faculty, staff, and curriculum. Williams has built its reputation on outstanding teaching and scholarship and on the academic excellence of its students. Please visit the Williams College website `http://www.williams.edu/`. Beyond meeting fully its legal obligations for non-discrimination, Williams College is committed to building a diverse and inclusive community where members from all backgrounds can live, learn, and thrive.

000041

NEW JERSEY

INSTITUTE FOR ADVANCED STUDY
School of Mathematics

The School of Mathematics has a limited number of memberships with financial support for research in mathematics and computer science at the Institute during the 2013-14 academic year.

The school frequently sponsors special programs. However, these programs comprise no more than one-third of the membership so that each year a wide range of mathematics is supported.

"Non-equilibrium Dynamics and Random Matrices" will be the topic of the special program during 2013-14. Horng-Tzer Yau of Harvard and Thomas Spencer of the Institute will lead the program. Juerg Froehlich of ETH and Herbert Spohn of Zentrum Mathematik will be among the senior participants attending.

For more information about the special program for the year, please see the school's homepage.

Several years ago the school established the von Neumann Fellowships. Up to eight of these fellowships will be available for each academic year. To be eligible for the von Neumann Fellowships, applicants should be at least five, but no more than fifteen, years following the receipt of their Ph.D.

The Veblen Research Instructorship is a three-year position which was established in partnership with the Department of Mathematics at Princeton University in

1998. Three-year instructorships will be offered each year to candidates in pure and applied mathematics who have received their Ph.D. within the last three years. Usually the first and third year of the instructorship will be spent at Princeton University and will carry regular teaching responsibilities. The second year is spent at the Institute and dedicated to independent research of the instructor's choice.

Candidates must have given evidence of ability in research comparable at least with that expected for the Ph.D. degree.

Application materials may be requested from Applications, School of Mathematics, Institute for Advanced Study, Einstein Drive, Princeton, NJ 08540; email: `applications@math.ias.edu`.

Postdoctoral computer science and discrete mathematics applicants may be interested in applying for a joint (2-year) position with one of the following: The Department of Computer Science at Princeton University, `http://www.cs.princeton.edu`; DIMACS at Rutgers, The State University of New Jersey, `http://www.dimacs.rutgers.edu`; or the Intractability Center, `http://intractability.princeton.edu`. For a joint appointment, applicants should apply to the School of Mathematics as well as to the above noting their interest in a joint appointment.

Applications may be found online at: `https://applications.ias.edu`.

The deadline for all applications is December 1.

The Institute for Advanced Study is committed to diversity and strongly encourages applications from women and minorities.

000049

NEW YORK

CORNELL UNIVERSITY
Tenure or Tenure-Track Positions

The Department of Mathematics at Cornell University invites applications for three tenure-track Assistant Professor positions, or higher rank, pending administrative approval, starting July 1, 2013. The searches are open to all areas of mathematics with an emphasis on the areas of probability; algebra, in particular, number theory; analysis, in particular, PDE; and topology. The department actively encourages applications from women and minority candidates.

Applicants must apply electronically at: `http://www.mathjobs.org`.

For information about our positions and application instructions, see: `http://www.math.cornell.edu/Positions/positions.html`. Applicants will be automatically considered for all eligible positions. Deadline November 1, 2012. Early applications will be regarded favorably. Cornell University is an Affirmative Action/Equal Opportunity Employer and Educator.

000054

CORNELL UNIVERSITY
Department of Mathematics
H.C. Wang Assistant Professor

The Department of Mathematics at Cornell University invites applications for one H.C. Wang Assistant Professor, non-renewable, 3-year position beginning July 1, 2013. Successful candidates are expected to pursue independent research at Cornell and teach three courses per year. A Ph.D. in mathematics is required. The department actively encourages applications from women and minority candidates.

Applicants must apply electronically at: `http://www.mathjobs.org`.

For information about our positions and application instructions, see: `http://www.math.cornell.edu/Positions/positions.html`.

Applicants will be automatically considered for all eligible positions. Deadline December 1, 2012. Early applications will be regarded favorably. Cornell University is an Affirmative Action/Equal Opportunity Employer and Educator.

000055

OHIO

THE OHIO STATE UNIVERSITY
Position Title: Mathematics Professor, Rank Open

Description: The Department of Mathematics in the College of Arts and Sciences at The Ohio State University anticipates having four positions available; rank open, effective Autumn Semester 2013. These positions are intended to support the College's strategic initiative in "Cyber-enabled Discovery" research facilitated in an essential way by modeling, algorithms and computation. To be considered for any of these positions candidates should have a significant computational aspect in their work. Two searches are expected to lead to joint appointments: one in Probability (joint with the Department of Statistics) and one in Computational Science (joint with the Department of Computer Science and Engineering). Two searches are open to all areas of mathematics, with preference given to the areas of harmonic analysis, topology, probability, and number theory. In all cases, significant use of computational methods is a necessary qualification of a successful candidate. Applications will be considered on a continuing basis, but the annual review process begins October 15, 2012.

REQUIRED: Candidates are expected to have a Ph.D. in mathematics (or related area) and to present evidence of excellence in teaching and research.

Application Instructions: Applications should be submitted online at `http://www.mathjobs.org`. If you cannot apply online, please contact `facultysearch@math.ohio-state.edu` or write to: Hiring Committee, Department of Mathematics, The Ohio State University, 231 W. 18th Avenue, Columbus, OH 43210. Application Deadline: 12/31/2012.

EEO Statement: To build a diverse workforce Ohio State encourages applications from individuals with disabilities, veterans and women. EEO/AA employer.

000067

PENNSYLVANIA

PENN STATE UNIVERSITY
Department of Mathematics
Faculty Positions, Department of Mathematics

Subject to availability of funding, the Penn State Mathematics Department will seek to fill openings for S. Chowla Research Assistant Professors and for tenure and tenure-track faculty positions.

S. Chowla Research Assistant Professor. Successful candidates will be new or recent Ph.D.'s with exceptional research potential and a commitment to excellence in teaching. These non-tenure-track appointments are for three years. Starting salary is $51,500 for the nine-month academic year. The Chowla program is designed to maximize the professional development of its participants and provides a research stipend. The department may in addition make other postdoctoral appointments. Applicants for the Chowla position will automatically be considered for these appointments also. Initial offers will be made in January 2013.

Tenure or Tenure Track Faculty Position. Candidates from all areas of mathematics will be considered. A Ph.D. degree or its equivalent is required. One position has been budgeted for candidates with actuarial credentials. Online application via `www.mathjobs.org` is strongly preferred. Review of applications will begin November 15, 2012, and will continue until positions are filled. Required application materials include:

- Online application
- At least three reference letters, one of which should address in detail the candidate's abilities as a teacher
- Curriculum Vitae
- Publication List
- Research Statement
- Teaching Statement

Persons who are unable to apply using the `mathjobs.org` website or who do

not wish to do so may send application materials to:

Search Committee
Department of Mathematics
Penn State University
107 McAllister Building
University Park, PA 16802

We encourage applications from individuals of diverse backgrounds. Penn State is committed to affirmative action, equal opportunity and the diversity of its workforce.

000041

RHODE ISLAND

BROWN UNIVERSITY
Department of Mathematics

J. D. Tamarkin Assistant Professorship: One three-year non-tenured non-renewable appointment, beginning July 1, 2013. The teaching load is one course one semester, and two courses the other semester and consists of courses of more than routine interest. Candidates are required to have received a Ph.D. degree or equivalent by the start of their appointment, and they may have up to three years of prior academic and/or postdoctoral research experience.

Applicants should have strong research potential and a commitment to teaching. Field of research should be consonant with the current research interests of the department.

For full consideration, applicants must submit a curriculum vit, an AMS Standard Cover Sheet and three letters of recommendation by December 1, 2012. Please submit all application materials online at: `http://www.mathjobs.org`. Email inquiries should be addressed to: `juniorsearch@math.brown.edu`.

Brown University is an Equal Opportunity/Affirmative Action Employer and encourages applications from women and minorities.

000053

SOUTH CAROLINA

UNIVERSITY OF SOUTH CAROLINA
Department of Mathematics
Algebraic Geometry
Tenure-track Assistant Professor

Applications are invited for a tenure-track Assistant Professor position in the area of algebraic geometry. Areas of particular interest include algebraic geometry and allied fields, such as algebraic and geometric combinatorics, algebraic number theory, algebraic topology, commutative algebra, non-commutative algebra, representation theory, and symbolic computation.

Candidates must have a Ph.D. in mathematics, an outstanding research program, a commitment to effective teaching at the undergraduate and graduate levels, and a demonstrated potential for excellence in both research and teaching.

Applicants must apply electronically at `http://www.mathjobs.org`. A completed application should contain a cover letter, standard AMS cover sheet, curriculum vitae, description of research plans, statement of teaching philosophy, and four letters of recommendation. One of the letters should appraise the candidate's teaching ability.

The beginning date for the position will be August 16, 2013. Review of applications will begin on December 1, 2012, and continue until the position is filled. To ensure consideration, applications should be received by January 8, 2013. Please address inquiries to: `hiring@math.sc.edu`.

The Mathematics Department, located in the heart of the historic campus, currently has 32 tenured and tenure-track faculty, 5 instructors, 48 graduate students, over 250 majors, and 40 minors. Faculty research interests include algebra, analysis, applied and computational math, biomath, discrete math, geometry, logic, and number theory.

The University of South Carolina's main campus is located in the state capital, close to mountains and coast. The Carnegie Foundation for the Advancement of Teaching has designated the University of South Carolina as one of only 73 public and 32 private academic institutions with very high research activity. The Carnegie Foundation also lists USC as having strong community engagement. The university has over 29,500 students on the main campus (and over 44,500 students system-wide), more than 350 degree programs, and a nationally-ranked library system that includes one of the nation's largest public film archives. Columbia, the capital of South Carolina, is the center of an increasingly sophisticated greater metropolitan area with a population over 750,000.

The University of South Carolina is an Affirmative Action, Equal Opportunity Employer. Minorities and women are encouraged to apply. The University of South Carolina does not discriminate in educational or employment opportunities or decisions for qualified persons on the basis of race, color, religion, sex, national origin, age, disability, sexual orientation, or veteran status.

000059

UNIVERSITY OF SOUTH CAROLINA
Department of Mathematics
Bio-Mathematics Assistant,
Associate or Full Professor
Tenure-Track or Tenured

Applications are invited for an open rank tenure-track or tenured position in bio-mathematics for research related to modeling and computation of tissue and organ fabrication. Candidates should have a Ph.D. in mathematics or a related field, and have sufficient background in mathematical modeling, mathematical/numerical analysis, simulation, and/or visualization of biological systems to direct a vigorous interdisciplinary research program in mathematical biology. The successful candidate is expected to interact effectively with researchers in the College of Engineering and Computing and the College of Medicine at the University of South Carolina, and at the Medical University of South Carolina.

Applicants must apply electronically at `http://www.mathjobs.org`. A complete application should contain a cover letter, standard AMS cover sheet, curriculum vitae, description of research plans, statement of teaching philosophy, and four letters of recommendation. One of the letters should appraise the candidate's teaching ability.

The beginning date for the position will be August 16, 2013. Review of applications will begin on November 15, 2012, and continue until the position is filled. To ensure consideration, applications should be received by December 15, 2012. Please address inquiries to: `hiring@math.sc.edu`.

The Mathematics Department, located in the heart of the historic campus, currently has 32 tenured and tenure-track faculty, 5 instructors, 48 graduate students, over 250 majors, and 40 minors. Faculty research interests include algebra, analysis, applied and computational math, biomath, discrete math, geometry, logic, and number theory.

The University of South Carolina's main campus is located in the state capital, close to mountains and coast. The Carnegie Foundation for the Advancement of Teaching has designated the University of South Carolina as one of only 73 public and 32 private academic institutions with very high research activity. The Carnegie Foundation also lists USC as having strong community engagement. The University has over 29,500 students on the main campus (and over 44,500 students system-wide), more than 350 degree programs, and a nationally-ranked library system that includes one of the nation's largest public film archives. Columbia, the capital of South Carolina, is the center of an increasingly sophisticated greater metropolitan area with a population over 750,000.

The University of South Carolina is an Affirmative Action, Equal Opportunity Employer. Minorities and women are encouraged to apply. The University of South Carolina does not discriminate in educational or employment opportunities or decisions for qualified persons on the basis of race, color, religion, sex, national origin, age, disability, sexual orientation, or veteran status.

000064

TEXAS

TEXAS TECH UNIVERSITY
Department of Mathematics and Statistics

The Department of Mathematics and Statistics at Texas Tech University (M&S) invites applications for three tenure-track assistant professor positions beginning fall 2013. A Ph.D. degree at the time of appointment is required. M&S has active research groups in both pure and applied mathematics (see `http://www.math.ttu.edu/FacultyStaff/research.shtml`). The department fosters a spirit of interdisciplinary collaboration across areas of mathematics as well as with engineering and the physical and biological sciences. M&S is seeking candidates who will be engaged in nationally visible scholarship, establish externally-funded research programs, interact with the existing research groups in the department, involve graduate students in their research, and show excellence in teaching at the undergraduate and graduate levels.

It is anticipated that one of the positions will be in statistics, one in numerical analysis, and one in another area compatible with the department's existing research programs. Candidates with very strong records who will bring externally sponsored research to Texas Tech will be considered for associate or full professor ranks.

Please apply for position numbers T96800 for Statistics, T96232 for Numerical Analysis, and T96376 for all other areas, at `http://jobs.texastech.edu`. Include a completed AMS standard cover sheet and a vita.

Three letters of reference plus any material in addition to that completed online should be sent to:

Alex Wang, Hiring Committee Chair, Department of Mathematics and Statistics, Texas Tech University, Lubbock, TX 79409-1042.

Review of applications will begin immediately.

Texas Tech University is committed to diversity among its faculty. We strongly encourage applications from women, minorities, persons with disabilities, and veterans, and we consider the needs of dual career couples.

Texas Tech University is an Affirmative Action/Equal Opportunity Employer.

000048

WASHINGTON

UNIVERSITY OF WASHINGTON
Department of Mathematics

Applications are invited for a full-time tenure-track Assistant or Associate Professor position at the Department of Mathematics of the University of Washington, to begin in September 2013. Applicants are required to have a Ph.D., and a research record in mathematics. Duties include undergraduate and graduate teaching, independent research, and service.

Applications should include the American Mathematical Society's Cover Sheet for Academic Employment, a curriculum vitae, statements of research and teaching interests, and three letters of recommendation. We prefer applications and supporting materials to be submitted electronically via `www.mathjobs.org`. Application materials may also be mailed to: Appointments Committee Chair (AP position), Department of Mathematics, Box 354350, University of Washington, Seattle, WA 98195-4350. Priority will be given to applicants whose complete applications, including recommendations, are received by December 15, 2012.

The University of Washington is building a culturally diverse faculty and strongly encourages applications from female and minority candidates. The university is an Equal Opportunity/Affirmative Action Employer.

000056

UNIVERSITY OF WASHINGTON
Department of Mathematics

Applications are invited for a non-tenure-track Acting Assistant Professor position. The appointment is for a period of up to three years to begin in September 2013. Applicants are required to have a Ph.D. by the starting date, and to be highly qualified for undergraduate and graduate teaching and independent research.

Applications should include the American Mathematical Society's Cover Sheet for Academic Employment, a curriculum vitae, statements of research and teaching interests, and three letters of recommendation. We prefer applications and supporting materials to be submitted electronically via `www.mathjobs.org`. Application materials may also be mailed to: Appointments Committee Chair (AAP position), Department of Mathematics, Box 354350, University of Washington, Seattle, WA 98195-4350. Priority will be given to applicants whose complete applications, including recommendations, are received by December 15, 2012.

The University of Washington is building a culturally diverse faculty and strongly encourages applications from female and minority candidates. The university is an Equal Opportunity/Affirmative Action Employer.

000057

UNIVERSITY OF WASHINGTON
Department of Mathematics

Applications are invited for a full-time Lecturer position at the Department of Mathematics of the University of Washington, to begin in September 2013. The successful candidate will be expected to teach two or three undergraduate courses per quarter, for a total of six or nine class hours per week, and to engage in related department activities such as course coordination and supervision of teaching assistants. The department is committed to excellence in teaching, and offers precalculus and calculus tracks serving science and engineering and business students. Applicants should have a Ph.D., as well as an excellent record of teaching undergraduate mathematics. The initial appointment is for three years, with the possibility of renewal.

Applications should include the American Mathematical Society's Cover Sheet for Academic Employment, a curriculum vitae, a statement of teaching interests, and three letters of recommendation. We prefer applications and supporting materials to be submitted electronically via `www.mathjobs.org`. Application materials may also be mailed to: Appointments Committee Chair (Lecturer position), Department of Mathematics, Box 354350, University of Washington, Seattle, WA 98195-4350. Priority will be given to applicants whose complete applications, including recommendations, are received by December 15, 2012

The University of Washington is building a culturally diverse faculty and strongly encourages applications from female and minority candidates. The university is an Equal Opportunity/Affirmative Action Employer.

000058

WISCONSIN

UNIVERSITY OF WISCONSIN-MADISON
Department of Mathematics

The Department of Mathematics is accepting applications for an assistant professor (tenure-track) position beginning August 26, 2013, contingent upon budgetary approval by the College of Letters and Science. Applications are invited in all areas of mathematics. Candidates should exhibit evidence of outstanding research potential, normally including significant contributions beyond the doctoral dissertation. A strong commitment to excellence in instruction is also expected. Additional departmental information is available on our website: `http://www.math.wisc.edu`. An application packet should include a completed AMS Standard Cover Sheet, a curriculum vitae which includes a publication list, and brief descriptions of research and teaching. Application packets should be submitted electronically to `http://www.mathjobs.org`. Applicants should also arrange to have sent, to the above URL address, three to four letters of recommendation, at least one of which must discuss the applicant's teaching experiences and capabilities and potential. To ensure full consideration, application packets must be received by November 15,

2012. Applications will be accepted until the position is filled.

The Department of Mathematics is committed to increasing the number of women and minority faculty. The University of Wisconsin-Madison is an Affirmative Action, Equal Opportunity Employer and encourages applications from women and minorities. Unless confidentiality is requested in writing, information regarding the applicants must be released upon request. Finalists cannot be guaranteed confidentiality. A background check will be required prior to employment.

000061

HONG KONG

THE UNIVERSITY OF HONG KONG
Tenure-Track Associate Professor/ Assistant Professor in the Department of Mathematics (Ref.: 201200445)

Applications are invited for a tenure-track appointment as Associate Professor/ Assistant Professor in the Department of Mathematics, from July 1, 2013, or as soon as possible thereafter. The position will initially be made on a three-year term basis, with the possibility of renewal and with consideration for tenure during the second three-year contract.

The position is to be held by an academic in Pure Mathematics. Special consideration will be given to candidates whose expertise overlaps with Algebraic Geometry, Arithmetic Geometry and/or Complex Geometry, but applications from candidates in any area of Pure Mathematics will also be considered. The appointee, who will be a regular professoriate member of the department, will be associated with the Institute of Mathematical Research (IMR) (`http://www.hku.hk/math/imr`), a centre of the University of Hong Kong attached to the department. He/She is expected to actively participate in research activities of the IMR and to take part in the organization of these activities such as research seminars, workshops, and conferences. The appointee will share teaching duties as other regular professoriate members of the department, but efforts will be made by the department so that part of those duties will be fulfilled through the teaching of graduate level and advanced undergraduate level courses. For enquiries about the existing research activities and the specific job requirements, please write to Professor J. Lu, Head of the Department of Mathematics (email: `jhlu@maths.hku.hk`).

A globally competitive remuneration package commensurate with the appointee's qualifications and experience will be offered. At current rates, salaries tax does not exceed 15% of gross income. The appointment will attract a contract-end gratuity and university contribution to a retirement benefits scheme, totalling up to 15% of basic salary, as well as leave, and medical benefits. Housing benefits will be provided as applicable.

Applicants should send a completed application form, together with a C.V. containing information on educational experience, professional experience, a complete list of publications, a survey of past research and teaching experience, a research plan for the next few years, and a statement on teaching philosophy by email to: `scmath@hku.hk`. They should also arrange for submission, to the same email address as stated above, three reference letters from senior academics. One of these senior academics should be asked to comment on the applicant's ability in teaching, or the applicant should arrange to have an additional reference letter on his/her teaching sent to the same email address as stated above. Please indicate clearly "Ref.: 201200445" and which level the candidate is being considered for (Tenure-Track Associate Professor/ Assistant Professor in the Department of Mathematics) in the subject of the email. Application forms (341/1111) can be obtained at: `http://www.hku.hk/apptunit/form-ext.doc`. Further particulars can be obtained at `http://jobs.hku.hk/`. Closes November 30, 2012.

The university thanks applicants for their interest, but advises that only shortlisted applicants will be notified of the application result.

The University is an Equal Opportunity Employer and is committed to a No-Smoking policy.

000042

KOREA

KOREA INSTITUTE FOR ADVANCED STUDY (KIAS)
Postdoctoral Research Fellowships in Pure and Applied Mathematics

The School of Mathematics at the Korea Institute for Advanced Study (KIAS) invites applicants for the positions at the level of postdoctoral research fellows in pure and applied mathematics. KIAS, founded in 1996, is committed to the excellence of research in basic sciences (mathematics, theoretical physics, and computational sciences) through high-quality research programs and a strong faculty body consisting of distinguished scientists and visiting scholars. Applicants are expected to have demonstrated exceptional research potential, through the doctoral dissertation and beyond. The annual salary ranges from 42,000,000 Korean won–70,000,000 Korean won (equivalent to approximately US$36,500–US$61,000 at current exchange rate). In addition, research fund in the amount of 10,000,000 Korean won–15,000,000 Korean won (equivalent to approximately US$8,700–US$13,000 at current exchange rate) is provided each year. The initial appointment will be for two years with a possibility of renewal for two to three additional years, depending on your research performance and the needs of the research program at KIAS. Applicants should send a cover letter specifying the research area, a curriculum vitae with a list of publications, and a summary of research plan, and arrange three recommendation letters to be sent to:

Mr. Kang Won Lee (`kwlee@kias.re.kr`)
School of Mathematics
Korea Institute for Advanced Study (KIAS)
85 Hoegiro (Cheongnyangni-dong 207-43), Dongdaemun-gu,
Seoul 130-722, Republic of Korea

Email applications are strongly encouraged. We review the applications twice a year; the deadlines are June 30 and December 31.

000052

Mathematical Sciences Employment Center

San Diego Convention Center, San Diego, California
January 9–12, 2012

The Employment Center offers a convenient, safe, and practical meeting place for employers and applicants attending the Joint Meetings. The focus of the Employment Center is on Ph.D.-level mathematical scientists and those that seek to hire them from academia, business, and government.

Employment Center Web Services

Employment Center registration information will be accessed through the `Mathjobs.org` system. For those who do not have existing `Mathjobs.org` accounts, it will be possible to set up special Employment Center accounts on `Mathjobs.org`. The website and all information will be available beginning in early September 2012 and will remain accessible through the period of the Employment Center. While some schools may delay appointment setting until late December, virtually all scheduling will be done before travel takes place, so applicants should expect few or no further appointments after arrival. Registering on site, for applicants, serves no real purpose.

No Admittance Without a JMM Badge

All applicants and employers planning to enter the Employment Center—even just for one interview must present a 2013 Joint Meetings Registration badge or they will be denied admittance. Meeting badges are obtained by registering for the Joint Mathematics Meetings and paying a meeting registration fee. See the JMM website at: `http://jointmathematicsmeetings.org/jmm` for registration instructions and rates.

Employers: Choose a Table

There are two table types available for employers, based on the number of interviewers who will be present at any one time:

- one or two interviewers per table in the "Quiet Area"(US$310), additional table (US$125).
- three to six interviewers per table in the "Committee Table" area (US$385), additional table (US$135).
- Electricity is available to employers (US$50 per table).

All Employment Center forms are now housed on the Mathjobs.org site. An existing account can be used for accessing Employment Center services and paying appropriate fees, or if no account exists, participants can start an account solely for Employment Center use.

Employers are expected to create their own interview schedules as far in advance as possible, using the assisted-email system in `Mathjobs.org` or using other means of communication.

Please mark appointments as confirmed in your `Mathjobs.org` account which will allow the appointments to display in the applicants' schedules. At the time of interview, meet the applicant in the waiting area on site and escort him or her to your table.

Employers: How to Register

- Registration runs from early September 2012 through January 9, 2013, at the following website: `www.mathjobs.org`.

2013 Employment Center Schedule:

December 17, 2012–Advance registration deadline for JMM. Meeting badge will be required for admittance. After this date, meeting registration fees go up and meeting registration may only happen on site in San Diego.

OPEN HOURS (NO access before opening time):

Wednesday, January 9, 2013–8:00 a.m.–6:00 p.m.

Thursday, January 10, 2013–8:00 a.m.–6:00 p.m.

Friday, January 11, 2013–8:00 a.m.–6:00 p.m.

Saturday, January 12, 2013–9:00 a.m.–12:00 noon.

Location: Exhibit Hall A, San Diego Convention Center, 111 West Harbor Drive, San Diego

Do not schedule an interview to begin until 15 minutes after opening.

• Use your existing Mathjobs.org account or create a new Employer account at www.mathjobs.org. Once a table is reserved, the ad can be placed at any time (or never) and will run until late January.

• To register, go to www.mathjobs.org. Log into your existing account if you have one. Purchase a table by clicking the "EmpCent" logo in the menus along the top tool bar. Use the "buy tables" link. Then post a job using the NewJob link or attach an existing job to your table. By default, applicants may request interviews. You can change this setting.

• Each person who will need to enter the Employment Center area must have a meeting badge (obtained by registering for the JMM and paying a meeting registration fee).

To display an ad on site, and use no Employment Center services at all, submit your one page paper ad on site in San Diego to the Employment Center staff. There is no fee for this service.

For complete information, visit http://www.ams.org/emp-reg/.

Applicants: Making the Decision to Attend

• The Employment Center offers no guarantees of interviews or jobs. Hiring decisions are not made during or immediately following interviews. In the current job market, the ratio of applicants to employers is about 10:1, and many applicants go completely unnoticed.

• There will ordinarily be no research-oriented postdoctoral positions listed or discussed at the Employment Center.

• Interviews will go to applicants who applied to jobs during the fall and are now being sought out by the institutions for in-person meetings during the JMM.

• There will be no opportunity to speak to employers without a pre-arranged interview, and no walk-up job information tables. Scheduling of interviews is complete prior to the JMM.

In the current job market, the majority of Employment Center employers are academic departments of mathematical sciences seeking to meet a short list of applicants who applied for their open positions during the fall. Each year, a few government or industry employers are present. Often, they are seeking U.S. citizens only due to existing contracts.

All job postings and interview request arrangements are available on the website in advance, and now that this electronic service is in place, there is no other messaging conducted on paper.

Past attendees have pointed out that all interviews are arranged in advance, and there is no opportunity to make connections on site if it has not happened before the meeting. In a recent survey, fifty percent of applicants responding reported being invited for at least one on-campus visit to an employer they had interviewed with at the Employment Center. Please visit the Employment Center website for further advice, information and program updates at www.ams.org/emp-reg/.

Applicants: How to Register

• Early registration is vital since most employers will finalize schedules before arriving in San Diego.

• To register, applicants should log into their Mathjobs.org accounts or create a new account, look for the EmpCent icon and mark that they will be attending. Then upload documents, request interviews, and check email for replies.

There are no Employment Center fees for applicants; however, admission to the Employment Center room requires a 2013 JMM badge, obtainable by registering (and paying a fee) for the Joint Mathematics Meetings. To register for the meeting, go to http://jointmathematicsmeetings.org/jmm.

It is possible to attend one or more privately arranged interviews without official Employment Center registration, however, a meeting badge is required to access the interview room.

Applicants should keep track of their interview schedules and note their busy times in their accounts. If invited for an interview at a conflicting time, please ask the employer to offer a new time or suggest one.

For complete information, visit http://www.ams.org/emp-reg/.

Questions about the Employment Center registration and participation can be directed to Steve Ferrucci, AMS Membership and Programs Department, at 800-321-4267, ext. 4113 or by email to emp-info@ams.org.

AMS Short Course in San Diego, CA

2013 AMS Short Course

The 2013 Short Course on **Random Matrices** is organized by **Van Vu**, Yale University.

The theory of random matrices is a rich topic in mathematics. Beside being interesting in its own right, random matrices play fundamental roles in various areas such as statistics, mathematical physics, combinatorics, theoretical computer science, number theory, and numerical analysis, to mention a few. A famous example here is the study of physicist E. Wigner, who used the spectrum of random matrices as a model in nuclear physics, and consequently discovered the fundamental semicircle law which describes the limiting distribution of the eigenvalues of a random hermitian matrix.

Special random matrices models where the entries are iid complex or real Gaussian random variables (GUE, GOE or Wishart) have been studied in detail. However, much less was known about general models, as the above-mentioned study relies very heavily on properties of the Gaussian distribution. In the last ten years or so we have witnessed considerable progress on several fundamental problems concerning general models, such as the Circular law conjecture or the Wigner-Dyson-Mehta conjecture. More importantly, these new results are proved using novel approaches which seem to be applicable to many other problems. The main goal of this Short Course is to introduce to a general audience these new results and methods, along with the several beautiful and surprising connections between the theory of random matrices with other areas of mathematics. We hope this will provide the audience a broad picture about this fascinating and rapidly developing field and encourage young researchers to participate in its study.

Each talk will be accessible to a general audience and will contain several open questions and/or suggestions for new directions of research. The methods presented in the first two talks, combined with earlier results by many researchers, have led to a complete solution of one of the most important conjectures in the field, the Wigner-Dyson-Mehta conjecture on the universality of the k-correlation functions of the eigenvalues. Both speakers will discuss this conjecture from different points of view.

Monday's Lectures

(1) **Terence Tao**, University of California Los Angeles, *Random matrices: The universality phenomenon for the Wigner ensemble*. We survey recent progress on rigorously establishing the universality of various spectral statistics of Wigner Hermitian random matrix ensembles, focusing on the Four Moment theorem and its applications, including the universality of the sine-kernel and Central Limit theorem for various parameters.

(2) **Laszlo Erdös**, Ludwig-Maximilians Universität, *Universality of random matrices and Dyson Brownian motion*. By proving an old conjecture of Dyson, we demonstrate that the strong local ergodicity of the Dyson Brownian motion is the the intrinsic mechanism behind universality for both invariant and noninvariant ensembles.

(3) **Alice Guionnet**, Massachusetts Institute of Technology, *Free probability and random matrices*. We will introduce the theory of free probability and give some applications of this theory to random matrix theory and operator algebra.

Tuesday's Lectures

(4) **Alan Edelman**, Massachusetts Institute of Technology, *Random matrices, numerical computation, and remarkable applications*. In this talk requiring no special prerequisites, we will introduce the interplay of numerical computation with Random Matrix Theory. Two overarching themes will emerge: 1) computation is not a side show to the mathematics, but rather the math and computation go together and 2) The applications of Random Matrix Theory continue to surprise all of us.

(5) **Mark Rudelson,** University of Michigan, *Nonasymptotic theory of random matrices*. We will discuss recent developments in the study of the spectral properties of random matrices of a large fixed size, concentrating on the extreme singular values. Bounds for the extreme singular values were crucial in establishing several limit laws of random matrix theory. Besides the random matrix theory itself, these bounds have applications in geometric functional analysis and computer science.

(6) **Djalil Chafai**, Université Paris-Est Marne-la-Valleé, *Around the circular law.* We will present in an accessible way various stochastic models connected to the circular law phenomenon, including models of random matrices, random graphs, and random polynomials, investigated in recent years. We will also discuss some open problems.

(7) **Van Vu,** *Random Matrices: The universality phenomenon for nonhermitian random matrices*. We discuss a very recent universality result for local statistics of eigenvalues of nonhermitian random matrices. As an application, we determine the number of real eigenvalues of a random matrix with iid (non-gaussian) real entries.

Registration

Advance registration fees for members of the AMS or MAA, US$104; nonmembers are US$150; and students/unemployed or emeritus members are US$52. These fees are in effect until December 17. If you choose to register on site, the fees for members of the AMS or MAA are US$138; nonmembers are US$180; and students/unemployed or emeritus members are US$73. Advance registration starts on September 1, 2012. Onsite registration will take place on Monday, January 7, outside Room 4, San Diego Conventions Center upper level.

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/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

Rochester, New York

Rochester Institute of Technology

September 22–23, 2012

Saturday – Sunday

Meeting #1082

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June/July 2012
Program first available on AMS website: July 19, 2012
Program issue of electronic *Notices*: September 2012
Issue of *Abstracts*: Volume 33, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Steve Gonek, University of Rochester, *Whither the Riemann zeta function?*

James P. Keener, University of Utah, *The mathematics of life—decisions, decisions.*

Dusa McDuff, Barnard College, Columbia University, *Embedding questions in symplectic geometry.*

Peter Winkler, Dartmouth College, *Edge-cover by random walk.*

Special Sessions

Analytic Number Theory, **Steve Gonek**, University of Rochester, and **Angel Kumchev**, Towson University.

Applied and Computational Mathematics, **Ludwig Kohaupt**, Beuth University of Technology, and **Yan Wu**, Georgia Southern University.

Continuum Theory, **Likin C. Simon Romero**, Rochester Institute of Technology.

Difference Equations and Applications, **Michael Radin**, Rochester Institute of Technology.

Financial Mathematics, **Tim Siu-Tang Leung**, Columbia University.

Frontiers in Applied and Industrial Mathematics, **Kara L. Maki** and **David S. Ross**, Rochester Institute of Technology.

Geometric Evolution Equations, **Mihai Bailesteanu**, University of Rochester, and **Mao-Pei Tsui**, University of Toledo.

Geometric, Categorical and Combinatorial Methods in Representation Theory, **David Hemmer** and **Yiqiang Li**, State University of New York at Buffalo.

Inverse Problems and Nonsmooth Optimization: Celebrating Zuhair Nashed's 75th Birthday, **Patricia Clark**, **Baasansuren Jadama**, and **Akhtar A. Khan**, Rochester Institute of Technology, and **Hulin Wu**, University of Rochester.

Mathematical Image Processing, **Nathan Cahill**, Rochester Institute of Technology, and **Lixin Shen** and **Yuesheng Xu**, Syracuse University.

Microlocal Analysis and Nonlinear Evolution Equations, **Raluca Felea**, Rochester Institute of Technology, and **Dan-Andrei Geba**, University of Rochester.

Modern Relativity, **Manuela Campanelli** and **Yosef Zlochower**, Rochester Institute of Technology.

New Advances in Graph Theory, **Jobby Jacob**, Rochester Institute of Technology, and **Paul Wenger**, University of Colorado Denver.

Nonlinear Dynamics of Excitable Media, **Elizabeth Cherry**, Rochester Institute of Technology.

Nonlinear Partial Differential Equations in the Physical and Biological Sciences, **Tony Harkin**, Rochester Institute of Technology, and **Doug Wright**, Drexel University.

Operator Theory and Function Spaces, **Gabriel T. Prajitura** and **Ruhan Zhao**, State University of New York at Brockport.

Permutations Patterns, Algorithms, and Enumerative Combinatorics, **Howard Skogman** and **Rebecca Smith**, State University of New York at Brockport.

Probability and Statistical Physics, **Wenbo Li**, University of Delaware, and **Carl Mueller** and **Shannon Starr**, University of Rochester.

Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, **Bernard Brooks**, **Darren Narayan**, and **Tamas Wiandt**, Rochester Institute of Technology.

Symplectic and Contact Topology, **Dusa McDuff**, Barnard College, and **Vera Vertesi**, Massachusetts Institute of Technology.

Wavelet and Frame Theoretic Methods in Harmonic Analysis and Partial Differential Equations in Memory of Daryl Geller, **Alex Iosevich**, University of Rochester, and **Azita Mayeli**, City University of New York.

New Orleans, Louisiana

Tulane University

October 13–14, 2012

Saturday – Sunday

Meeting #1083

Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: June/July 2012
Program first available on AMS website: September 6, 2012
Program issue of electronic *Notices*: October 2012
Issue of *Abstracts*: Volume 33, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Anita Layton, Duke University, *Mathematical modeling of renal hemodynamics: Feedback dynamics and coupled oscillators*.

Lenhard Ng, Duke University, *From holomorphic curves to knot invariants via the cotangent bundle*.

Henry K. Schenck, University of Illinois at Urbana-Champaign, *From approximation theory to algebraic geometry: The ubiquity of splines*.

Milen Yakimov, Louisiana State University, *The Andruskiewitsch-Dumas Conjecture*.

Special Sessions

Algebraic Combinatorics: Rook Theory and Applications, **Mahir Bilen Can** and **Michael Joyce**, Tulane University, and **Jeff Remmel**, University of California at San Diego.

Algebraic Structures over Commutative Rings, **Lee Klingler**, Florida Atlantic University, **Aihua Li**, Montclair State University, and **Ralph Tucci**, Loyola University New Orleans.

Algebraic and Topological Combinatorics, **Alexander Engstrom** and **Matthew Stamps**, Aalto University.

Analysis of Pattern Formation in Partial Differential Equations, **Xuefeng Wang**, Tulane University.

Application of Functional Analytic Techniques to Nonlinear Boundary Value Problems, **John R. Graef** and **Lingju Kong**, University of Tennessee at Chattanooga, and **Bo Yang**, Kennesaw State University.

Approximation Theory, Geometric Modelling, and Algebraic Geometry, **Henry Schenck**, University of Illinois at Urbana-Champaign.

Biological Fluid Dynamics: Modeling, Computations, and Applications, **Anita T. Layton**, Duke University, and **Sarah D. Olson**, Worcester Polytechnic Institute.

Combinatorial Commutative Algebra, **Chris Francisco**, Oklahoma State University, **Tai Huy Ha**, Tulane University, and **Adam Van Tuyl**, Lakehead University.

Combinatorial Methods in Knot Theory, **Heather Russell**, University of Southern California, and **Oliver Dasbach**, Louisiana State University.

Diffusion Processes in Biology, **Gustavo Didier**, Tulane University, and **Greg Forest**, University of North Carolina, Charlotte.

Geometric and Algebraic Aspects of Representation Theory, **Pramod N. Achar**, Louisiana State University, and **Dijana Jakelić**, University of North Carolina at Wilmington.

Interactions of Geometry and Topology in Low Dimensions, **John Etnyre**, Georgia Tech, **Rafal Komendarczyk**, Tulane University, and **Lenhard Ng**, Duke University.

Quantum Groups and Noncommutative Algebraic Geometry, **Kailash C. Misra**, North Carolina State University, and **Milen Yakimov**, Louisiana State University.

Stochastic Analysis: Current Directions and Applications, **Hui-Hsiung Kuo**, **Ambar Sengupta**, and **P. Sundar**, Louisiana State University.

Akron, Ohio

University of Akron

October 20–21, 2012

Saturday – Sunday

Meeting #1084

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2012
Program first available on AMS website: September 27, 2012
Program issue of electronic *Notices*: October 2012
Issue of *Abstracts*: Volume 33, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Tanya Christiansen, University of Missouri, *Title to be announced*.

Tim Cochran, Rice University, *Title to be announced*.

Ronald Solomon, Ohio State University, *Title to be announced*.

Ben Weinkove, University of California San Diego, *Title to be announced*.

Special Sessions

A Survey of Lattice-Valued Mathematics and its Applications, **Austin Melton**, Kent State University, and **Stephen E. Rodabaugh**, Youngstown State University.

Additive and Combinatorial Number Theory, **Tsz Ho Chan**, University of Memphis, **Kevin O'Bryant**, City University of New York, and **Gang Yu**, Kent State University.

Applied Topology, **Peter Bubenik**, Cleveland State University, and **Matthew Kahle**, Ohio State University.

Cayley Graph Computations and Challenges for Permutation Puzzle Groups, **Morley Davidson**, Kent State University, and **Tomas Rokicki**, Radical Eye Software.

Commutative Algebra, **Livia Hummel**, University of Indianapolis, and **Sean Sather-Wagstaff**, North Dakota State University.

Complex Analysis and its Broader Impacts, **Mehmet Celik**, University of North Texas, Dallas, **Alexander Izzo**, Bowling Green State University, and **Sonmez Sahutoglu**, University of Toledo.

Complex Geometry and Partial Differential Equations, **Gabor Szekelyhidi**, University of Notre Dame, **Valentino Tosatti**, Columbia University, and **Ben Weinkove**, University of California San Diego.

Extremal Graph Theory, **Arthur Busch**, University of Dayton, and **Michael Ferrara**, University of Colorado Denver.

Geometry of Algebraic Varieties, **Ana-Marie Castravet**, **Emanuele Macrí**, and **Hsian-Hua Tseng**, The Ohio State University.

Graphs and Polytopes in Algebraic Combinatorics, **Stefan Forcey**, University of Akron, and **Forest Fisher**, NOVA-Manassas.

Groups, Representations, and Characters, **Mark Lewis**, Kent State University, **Adriana Nenciu**, Otterbein University, and **Ronald Solomon**, Ohio State University.

Harmonic Analysis and Convexity, **Benjamin Jaye**, **Dmitry Ryabogin**, and **Artem Zvavitch**, Kent State University.

Interactions Between Geometry and Topology, **Dan Farley**, Miami University, **Jean-Francois Lafont**, Ohio State University, and **Ivonne J. Ortiz**, Miami University.

Issues in the Preparation of Secondary Teachers of Mathematics, **Laurie A. Dunlap** and **Antonio R. Quesada**, University of Akron.

Knot Theory and 4-Manifolds, **Tim Cochran** and **Christopher Davis**, Rice University, and **Kent Orr**, Indiana University.

Noncommutative Ring Theory, **S. K. Jain**, Ohio University, and **Greg Marks** and **Ashish Srivastava**, St. Louis University.

Nonlinear Partial Differential Equations and Harmonic Analysis, **Diego Maldonado**, Kansas State University, **Truyen Nguyen**, University of Akron, and **Nguyen Cong Phuc**, Louisiana State University.

Nonlinear Waves and Patterns, **Anna Ghazaryan** and **Vahagn Manukian**, Miami University.

Separate versus Joint Continuity—a Tribute to I. Namioka, **Zbigniew Piotrowski** and **Eric J. Wingler**, Youngstown State University.

Spectral, Scattering, and Inverse Scattering Theory, **Tanya Christiansen**, University of Missouri, and **Peter Hislop** and **Peter Perry**, University of Kentucky.

Statistical Genetics and Applications, **Omar De La Cruz**, Case Western Reserve University.

Stochastic Processes and Applications, **Oana Mocioalca**, Kent State University.

Toric Algebraic Geometry and Beyond, **Kiumars Kaveh**, University of Pittsburgh, **Benjamin Nill**, Case Western Reserve University, and **Ivan Soprunov**, Cleveland State University.

Tucson, Arizona

University of Arizona

October 27–28, 2012

Saturday – Sunday

Meeting #1085

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2012
Program first available on AMS website: October 4, 2012
Program issue of electronic *Notices*: October 2012
Issue of *Abstracts*: Volume 33, Issue 4

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michael Hutchings, University of California Berkeley, *Quantitative invariants in four-dimensional symplectic geometry*.

Kenneth McLaughlin, University of Arizona, Tucson, *Random matrices, integrable systems, asymptotic analysis, combinatorics*.

Ken Ono, Emory University, *Adding and counting* (Erdős Memorial Lecture).

Jacob Sterbenz, University of California San Diego, *Regularity of hypberbolic gauge field equations*.

Goufang Wei, University of California, Santa Barbara, *Comparison results for Ricci curvature*.

Special Sessions

Analytical and Numerical Approaches in Nonlinear Systems: Collapses, Turbulence, Nonlinear Waves in Mathematics, Physics, and Biology, **Alexander Korotkevich** and **Pavel Lushnikov**, University of New Mexico.

Asymptotic Analysis of Random Matrices, Integrable Systems, and Applications, **Ken McLaughlin** and **Nick Ercolani**, University of Arizona.

Biomathematics, **Jim M. Cushing** and **Joseph Watkins**, University of Arizona.

Differential Equations and Biological Systems, **Patrick Shipman**, Colorado State University, and **Zoi Rapti**, University of Illinois at Urbana-Champaign.

Dispersion in Heterogeneous and/or Random Environments, **Rabi Bhattacharya**, Oregon State University, Corvallis, and **Edward Waymire**, University of Arizona.

Geometric Analysis and Riemannian Geometry, **David Glickenstein**, University of Arizona, **Guofang Wei**, University of California Santa Barbara, and **Andrea Young**, Ripon College.

Geometrical Methods in Mechanical and Dynamical Systems, **Akif Ibragimov**, Texas Tech University, **Vakhtang Putkaradze**, Colorado State University, and **Magdalena Toda**, Texas Tech University.

Harmonic Maass Forms and q-Series, **Ken Ono**, Emory University, **Amanda Folsom**, Yale University, and **Zachary Kent**, Emory University.

Hyperbolic Geometry, **Julien Paupert**, Arizona State University, and **Domingo Toledo**, University of Utah.

Inverse Problems and Wave Propagation, **Leonid Kunyansky**, University of Arizona.

Mathematical Fluid Dynamics and its Application in Geosciences, **Bin Cheng**, Arizona State University, and **Nathan Glatt-Holtz**, Indiana University.

Mathematical Physics: Spectral and Dynamical Properties of Quantum Systems, **Bruno Nachtergaele**, University of California, Davis, **Robert Sims**, University of Arizona, and **Günter Stolz**, University of Alabama, Birmingham.

Mathematics of Optical Pulse Propagation: Modeling, Analysis, and Simulations, **Jason Fleischer**, Princeton University, and **Moysey Brio**, **Karl Glasner**, and **Shankar Venkataramani**, University of Arizona.

Motives, Algebraic Cycles, and K-theory, **Deepam Patel**, Indiana University, Bloomington, and **Ravindra Girivaru**, University of Missouri, St. Louis.

Representations of Groups and Algebras, **Klaus Lux** and **Pham Huu Tiep**, University of Arizona.

Special Functions, Combinatorics, and Analysis, **Diego Dominici**, SUNY New Paltz, **Tim Huber**, University of Texas-Pan American, and **Robert Maier**, University of Arizona.

Spectral Theory and Global Analysis, **Lennie Friedlander**, University of Arizona, and **Klaus Kirsten**, Baylor University.

The B.S. Degree in Mathematics in Industry, **William Velez**, University of Arizona.

The Ubiquitous Laplacian: Theory, Applications, and Computations, **Bin Dong** and **Lotfi Hermi**, University of Arizona.

Topics in Commutative Algebra, **Kristen Beck** and **Silvia Saccon**, University of Arizona.

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 9–12, 2013

Wednesday – Saturday

Meeting #1086

Joint Mathematics Meetings, including the 119th Annual Meeting of the AMS, 96th Annual Meeting of the Mathematical Association of America, 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),

with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2012
Program first available on AMS website: November 1, 2012
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 34, Issue 1

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: September 25, 2012

The challenges facing our planet and our civilization are multidisciplinary and mulitfaceted, and the mathematical sciences play a central role in the scientific effort to understand and to deal with these challenges. Dozens of scientific societies, universities, research institutes, and foundations all over the world have banded together to dedicate 2013 as a special year for the Mathematics of Planet Earth. The Joint Mathematics Meetings is pleased to be a part of this initiative and the first of many events throughout 2013 that will showcase ongoing efforts to raise awareness and focus attention on identifying and solving fundamental questions about planet earth. Sessions that contribute directly to the mission of the 2013 initiative are identified with the Mathematics of Planet Earth logo.

The scientific information listed below may be dated. For the latest information, see `http://jointmathematicsmeetings.org/jmm`.

Joint Invited Addresses

Kenneth Golden, University of Utah, *Mathematics and the melting polar ice caps.*; 3:00 p.m. on Saturday. (MAA-AMS-SIAM Gerald and Judith Porter Public Lecture)

Robin Pemantle, David Rittenhouse Laboratories, *Zeros of polynomials and their importance in combinatorics and probability*; 11:10 a.m. on Friday.

Emily Shuckburgh, Cambridge University, Title to be announced; 11:10 a.m. on Wednesday.

Joint Prize Session

Prize Session and Reception: In order to showcase the achievements of the recipients of various prizes, the AMS and MAA are cosponsoring this event at 4:25 p.m. on Thursday. A cash bar reception will immediately follow. All participants are invited to attend. The AMS, MAA, and SIAM will award the Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student. The AMS will announce the winners of the Levi L. Conant Prize, E. H. Moore Research Article Prize, Frank and Brennie Morgan Prize for Outstanding Research by an Undergraduate Student, David P. Robbins Prize, Ruth Lyttle Satter Prize in Mathematics, Leroy P. Steele Prizes, Oswald Veblen Prize in Goemetry, and Norbert Wiener Prize in Applied Mathematics. The MAA will award the Chauvenet Prize; Euler Book Prize; Yueh-Gin Gung and Dr. Charles Y. Hu Award for Distinguished Service to Mathematics; Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching of Mathematics; David P. Robbins Prize in Algebra, Combinatorics, and Discrete Mathematics; and Certificates of Meritorious Service. The AWM will present the Alice T. Schafer Prize for Excellence in Mathematics by an Undergraduate Woman, the Louise Hay Award for Contributions to Mathematics Education, and the Gweneth Humphreys Award for Mentorship of Undergraduate Women in Mathematics.

This session will also be the venue for the announcement of the Joint Policy Board for Mathematics Communication Award.

119th Meeting of the AMS

AMS Invited Addresses

Gerard Ben Arous, Courant Institute-NYU, *Title to be announced*; 10:05 a.m. on Wednesday.

Jean Bourgain, Institute for Advanced Study, *Diophantine applications of the theory of expansion and spectral gaps in thin groups*; 3:20 p.m. on Thursday.

Laura DeMarco, University of Illinois at Chicago, *Critically-finite maps in the moduli space of polynomials*; 2:15 p.m. on Thursday.

Jordan Ellenberg, University of Wisconsin, *How to count with topology*.

Alice Guionnet, Ecole Normale Supérieure de Lyon, *Free probability and random matrices* (AMS Colloquium Lectures); 1:00 p.m. Wednesday–Friday.

Robert Guralnick, University of Southern California, *Generators and relations for finite groups*; 9:00 a.m. on Saturday.

Cedric Villani, Institut Henri Poincaré, *Title to be announced* (AMS Josiah Willard Gibbs Lecture); 8:30 p.m. on Wednesday.

AMS Special Sessions

Some sessions are cosponsored with other organizations. These are noted within the parenthesis at the end of each listing, where applicable.

Advances in General Optimization and Global Optimality Conditions for Multiobjective Fractional Programming Based on Generalized Invexity (Code: SS 18A), **Roland Glowinski**, University of Houston, **R. N. Mohapatra**, University of Central Florida, **Ram U. Verma**, International Publications USA, and **Alexander J. Zaslavski**, Technion-Israel Institute of Technology.

Algebraic Combinatorics and Representation Theory (Code: SS 38A), **Julie Beier**, Mercer University, and **Gizem Karaali**, Pomona College.

Algorithmic Problems of Group Theory and Their Complexity (Code: SS 9A), **Delaram Kahrobaei**, CUNY Graduate Center and New York College of Technology, City University of New York, and **Vladimir Shpilrain**, City College of New York and CUNY Graduate Center, City University of New York.

Arithmetic Statistics, I (a Mathematics Research Communities session) (Code: SS 74A), **Kevin McGown**, Ursinus College, **Jennifer Balakrishnan**, Harvard University, and **Ethan Smith**, Liberty University.

Arithmetic Theory of Quadratic Forms and Lattices (Code: SS 7A), **Wai Kiu Chan**, Wesleyan University, and **Lenny Fukshansky**, Claremont McKenna College.

Arithmetic and Ideal Theory of Integral Domains and Monoids (Code: SS 27A), **Scott T. Chapman**, Sam Houston State University, and **Vadim Ponomarenko**, San Diego State University.

Brauer Group in Algebra and Geometry (Code: SS 24A), **Asher Auel**, Emory University, **Kelly McKinnie**, University of Montana, and **V. Suresh**, Emory University (AMS-AWM).

Celestial Mechanics (Code: SS 43A), **Gareth Roberts**, College of the Holy Cross, and **Zhifu Xie**, Virginia State University.

Challenges in Data Assimilation and the Mathematics of Planet Earth and Its Climate (Code: SS 56A), **Lewis Mitchell**, University of Vermont, and **Thomas Bellsky**, Arizona State University.

Commutative Algebra and Algebraic Geometry (Code: SS 54A), **Kuei-Nan Lin**, University of California, Riverside, and **Tai Ha**, Tulane University.

Complex Dynamics (Code: SS 30A), **Laura DeMarco**, University of Illinois, Chicago, and **Rodrigo Perez** and **Roland Roeder**, Indiana University-Purdue University Indianapolis.

Computational Algebraic and Analytic Geometry for Low-dimensional Varieties (Code: SS 36A), **Mike Seppala**, Florida State University, and **Emil Volcheck**, National Security Agency.

Continued Fractions (Code: SS 44A), **James McLaughlin**, West Chester University, and **Nancy J. Wyshinski**, Trinity College.

Coverings of the Integers (Code: SS 53A), **Carrie E. Finch**, Washington and Lee University, and **Lenny Jones**, Shippenburg University.

Creating a Professional Community of Math Teachers K–20 (Code: SS 61A), **Patrick Callahan**, University of California Los Angeles, **William McCallum**, University of Arizona, and **Kristin Umland**, University of New Mexico.

Difference Equations and Applications (Code: SS 11A), **Michael Radin**, Rochester Institute of Technology.

Dirac and Laplace Operators in Global Analysis and Geometry (Code: SS 8A), **Ken Richardson** and **Igor Prokhorenkov**, Texas Christian University.

Discrete Geometry and Algebraic Combinatorics (Code: SS 67A), **Alexander Barg**, University of Maryland, and **Oleg Musin**, University of Texas, Brownsville.

Discrete and Computational Geometry, I (a Mathematics Research Communities session) (Code: SS 71A), **Emilie Hogan**, Pacific Northwest National Laboratory, **Elizabeth Munch**, Duke University, **Louis Theran**, Freie Universität, and **Russ Thompson**, Texas A&M University.

Effective Algebra and Model Theory (Code: SS 29A), **Sam Buss**, **Mia Minnes**, and **Jeff Remmel**, University of California, San Diego (AMS-ASL).

Environmental Mathematics: Evaluate the Past Climate Changes and Model the Future Climate Variations (Code: SS 70A), **Phillip Arkin**, University of Maryland, **Samuel Shen**, San Diego State University, **Thomas Smith**, University of Maryland, and **Guang Zhang**, Scripps Institute of Oceanography, University of California, San Diego.

Financial Mathematics (Code: SS 37A), **Maxim Bichuch**, Princeton University, and **Tim Siu-Tang Leung**, Columbia University.

Finite Element Exterior Calculus and Applications (Code: SS 50A), **Douglas Arnold**, University of Minnesota, and **Andrew Gillette** and **Michael Holst**, University of California, San Diego.

Fractional, Hybrid, and Stochastic Dynamic Systems with Applications (Code: SS 13A), **John Graef**, University of Tennessee at Chattanooga, **Gangaram S. Ladde**, University of South Florida, and **Aghalaya Vatsala**, University of Louisiana at Lafayette.

Frontiers in Geomathematics (Code: SS 69A), **Willi Freeden**, University of Kaiserlautern, **Volker Michel**, University of Siegen, and **M. Zuhair Nashed**, University of Central Florida.

Generalized Symmetric Spaces (Code: SS 51A), **Catherine Buell**, Bates College, and **Aloysius G. Helminck**, North Carolina State University.

Geometric Complexity Theory, I (a Mathematics Research Communities session) (Code: SS 73A), **Christian Ikenmeyer**, Texas A&M University, and **Ryan Kinser**, Northeastern University.

Geometric and Analytic Methods in Teichmüller Theory and Hyperbolic Geometry (Code: SS 3A), **Ren Guo**, Oregon State University, and **Zheng Huang** and **Marcello Lucia**, City University of New York, Staten Island.

Graph Theory (Code: SS 57A), **Andre Kundgen**, California State University, San Marcos, **Michael Pelsmajer**, Illinois Institute of Technology, and **Douglas West**, University of Illinois, Urbana-Champaign.

Groups, Representations, and Applications (Code: SS 33A), **Robert Guralnick**, University of Southern California, and **Pham Huu Tiep**, University of Arizona.

Harmonic Analysis, Partial Differential Equations, and Geometric Measure Theory (Code: SS 72A), **Theresa Anderson**, Brown University, **Matthew Badger**, Stony Brook University, **Nathan Pennington**, Kansas State University, and **Eric Stachura**, Temple University.

History of Mathematics (Code: SS 16A), **Patti Hunter**, Westmont College, **Deborah Kent**, Drake University, and **Adrian Rice**, Randolph-Macon College (AMS-MAA).

Homotopy Theory and Commutative Algebra (Code: SS 19A), **Julia Bergner**, **Philip Hackney**, and **Inês Henriques**, University of California, Riverside.

Influence of Ramanujan on his 125th Birthday (Code: SS 1A), **George Andrews**, Pennsylvania State University, **Bruce Berndt**, University of Illinois Urbana-Champaign, and **Ae Ja Yee**, Pennsylvania State University.

Interplays Between Feynman Operational Calculus, Wiener and Feynman Integrals, Physics, and Analysis on Wiener Space (Code: SS 41A), **Tepper Gill**, Howard University, **Lance Nielsen**, Creighton University, and **Ian Pierce**, St. Olaf College.

Knots, Links, and Three-manifolds (Code: SS 48A), **Christopher Herald**, **Stanislav Jabuka**, and **Swatee Naik**, University of Nevada, Reno.

L-Functions and Arithmetic Geometry (Code: SS 59A), **Alina Bucur** and **Kiran Kedlaya**, University of California, San Diego.

Lie Algebras, Algebraic Transformation Groups, and Representation Theory (Code: SS 6A), **Andrew Douglas**, City University of New York, **Alistair Savage**, University of Ottawa, and **Bart Van Steirteghem**, City University of New York.

Manifolds with Special Holonomy and Generalized Geometries (Code: SS 60A), **Sema Salur**, University of Rochester, and **Albert James Todd**, University of California, Riverside.

Mathematical Underpinnings of Multivariate Complexity Theory and Algorithm Design, and Its Frontiers and the Field of Incrementalization (Code: SS 28A), **Rodney Downey**, Victoria University of Wellington, New Zealand, **Michael Fellows**, Charles Darwin University, Australia, and **Anil Nerode**, Cornell University.

Mathematical and Numerical Analysis of Nonlocal Problems (Code: SS 23A), **Qiang Du** and **Tadele Mengesha**, Pennsylvania State University.

Mathematics and Education Reform (Code: SS 64A), **William Barker**, Bowdoin College, **Cathy Kessel**, Berkeley, California, **William McCallum**, University of Arizona, and **Bonnie Saunders**, University of Illinois, Chicago (AMS-MAA).

Mathematics and Social Interactions (Code: SS 32A), **Jeff Suzuki**, Brooklyn College.

Mathematics of Computation: Algebra and Number Theory (Code: SS 46A), **Michael Mossinghoff**, Davidson College, **Cheryl Praeger**, University of Western Australia, and **Igor Shparlinksi**, Macquarie University.

Mathematics of Computation: Differential Equations, Linear Algebra, and Applications (Code: SS 47A), **Susanne C. Brenner**, Louisiana State University, and **Chi-Wang Shu**, Brown University.

Mathematics of Decisions, Elections, and Games (Code: SS 52A), **Karl-Dieter Crisman**, Gordon College, **Michael A. Jones**, Mathematical Reviews, and **Michael Orrison**, Harvey Mudd College.

Mathematics of Natural Resource Modeling (Code: SS 40A), **Shandelle Henson**, Andrews University, and **Catherine A. Roberts**, College of the Holy Cross.

Mathematics Teacher Education Partner- ship and the Common Core Standards (Code: SS 17A), **W. Gary Martin**, Auburn University, and **Michael Mays**, West Virginia University.

Nonlinear Evolution Equations and Integrable Systems (Code: SS 10A), **Jennifer Gorsky**, University of San Diego, and **Alex Himonas**, University of Notre Dame.

Nonstandard Finite-Difference Discretizations and Nonlinear Oscillations (In Honor of Ronald Mickens' 70th Birthday) (Code: SS 45A), **Ron Buckmire**, Occidental College, **Abba Gumel**, University of Manitoba, and **Talitha Washington**, Howard University.

Number Theory and Geometry (Code: SS 34A), **Jordan Ellenberg**, University of Wisconsin, Madison, and **Akshay Venkatesh**, Stanford University.

Patterns in Permutations and Words (Code: SS 35A), **Jeffrey Liese**, California State Polytechnic University, San Luis Obispo, **Brian K. Miceli**, Trinity University, and **Jeffrey Remmel**, University of California, San Diego.

Progress in Free Probability and Free Analysis (Code: SS 20A), **Ken Dykema**, Texas A&M University, and **Scott McCullough**, University of Florida.

q-series in Mathematical Physics and Combinatorics (Code: SS 2A), **Mourad Ismail**, University of Central Florida.

Quantum Walks and Related Topics (Code: SS 5A), **Yusuke Ide**, Kanagawa University, **Chaobin Liu** and **Nelson Petulante**, Bowie State University, and **Salvador E. Venegas-Andraca**, Tecnológico de Monterrey, Campus Estado de México.

Recent Advances and New Challenges in Applied Analysis (Code: SS 55A), **Marian Bocea**, Loyola University, Chicago.

Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs (Code: SS 12A), **Bernard Brooks** and **Jobby Jacob**, Rochester Institute of Technology, **Jacqueline Jensen**, Sam Houston State University, and **Darren Narayan** and **Tamas Wiandt**, Rochester Institute of Technology (AMS-MAA-SIAM).

Set-Valued Optimization and Variational Problems with Applications (Code: SS 68A), **Andreas H. Hamel**, Yeshiva University, **Akhtar Khan**, Rochester Institute of Technology, **Miguel Sama**, Universidad Nacional de Educacin a Distancia, and **Christiane Tammer**, Martin Luther University of Halle-Wittenberg.

Several Complex Variables Techniques in Operator Theory (Code: SS 4A), **Zeljko Cuckovic** and **Sonmez Sahutoglu**, University of Toledo.

Several Complex Variables and Multivariable Operator Theory (Code: SS 14A), **Joseph Ball**, Virginia Tech University, and **Ronald Douglas**, Texas A&M University.

Singularities in Geometry and Algebra (Code: SS 49A), **John Brevik**, California State University, Long Beach, and **Scott Nollet**, Texas Christian University.

Stochastic Analysis of Stochastic Differential Equations and Stochastic Partial Differential Equations (Code: SS 22A), **Edward Allen**, Texas Tech University, **Armando Arciniega**, The University of Texas at San Antonio, **Gangaram Ladde**, University of South Florida, and **Sivapragasam Sathananthan**, Tennessee State University.

Stochastic and Functional Analysis (Code: SS 63A), **Mark Burgin**, University of California Los Angles, and **Alan Krinik** and **Randall Swift**, California State Polytechnic University, Pomona.

The Present and Future of Mathematics on the Web (Code: SS 62A), **Douglas Meade**, University of South Carolina, and **Philip Yasskin**, Texas A&M University.

Theory and Applications of Differential Equations on Graphs (Code: SS 25A), **Sergei Avdonin**, University of Alaska, Fairbanks, and **Jonathan Bell**, University of Maryland, Baltimore County.

Theory and Interdisciplinary Applications of Dynamical Systems (Code: SS 42A), **Sukanya Basu**, Grand Valley State University.

Topics and Issues in Electronic Publishing (Code: SS 21A), **Klaus Kaiser**, University of Houston, **Steven Krantz**, Washington University in St. Louis, and **Elizabeth Loew**, Springer.

Topological Combinatorics (Code: SS 58A), **Thomas Engstrom**, Aalto University, **Steven Klee**, University of California, Davis, and **Matthew Stamps**, Aalto University.

Tropical Geometry (Code: SS 66A), **Florian Block**, University of Warwick, and **Melody Chan**, University of California, Berkeley.

Understanding Planet Earth via Reaction Diffusion Equations (Code: SS 26A), **Jerome Goddard, II**, Auburn University, Montgomery, **Eun Kyung Lee**, Pusan National University, Korea, **Junping Shi**, College of William and Mary, and **Ratnasingham Shivaji**, University of North Carolina, Greensboro.

Water Waves, Tsunamis, and Extreme Waves (Code: SS 31A), **Walter Craig**, McMaster University, Canada, **Philippe Guyenne**, University of Delaware, and **David Nicholls**, University of Illinois, Chicago.

Witt Vectors, Descent and Lifting (Code: SS 39A), **James Borger**, Australia National University, **Alexandru Buium** and **Taylor Dupuy**, University of New Mexico, and **Lance Miller**, University of Utah.

AMS Contributed Paper Sessions

There will be sessions of ten-minute contributed talks. Although an individual may present only one contributed paper at a meeting, any combination of joint authorship may be accepted, provided no individual speaks more than once on the program. Contributed papers will be grouped together by related subject classifications into sessions.

Submission of Abstracts for AMS Sessions

Authors must submit abstracts of talks through `http://jointmathematicsmeetings.org/meetings/abstracts/abstract.pl?type=jmm`. Indicate the number of authors for the paper, click on the "submit" button, and you will be taken to the submission form. Simply follow the step-by-step instructions (read them carefully) until you receive your unique abstract number. No submission is complete until you receive your abstract receipt number. **The deadline for all submissions is September 25, 2012**. Late papers cannot be accommodated. Please email `abs-coord@ams.org` if you have questions. If you make an inquiry about your specific abstract, please include your abstract number.

Other AMS Sessions

Getting Started as a Research Mathematician, Wednesday, 4:30 p.m.–6:00 p.m. Sponsored by the Committee on the Profession.

Who Wants to Be a Mathematician—National Contest, organized by **Michael A. Breen**, AMS, and **William T. Butterworth**, DePaul University; Thursday, 9:30 a.m.–11:00 a.m. See ten of the nation's best high school students compete for a US$5,000 first prize for themselves and US$5,000 for their school's math department. Semifinals are at 9:30 a.m. and finals at 10:30 a.m. You are invited to come and take part in this educational and fun presentation.

How Will Mathematical Research be Published in the 21st Century?, organized by **Kenneth M. Golden,** University of Utah; Thursday, 2:30 p.m.–4:00 p.m. Sponsored by the Committee on Science Policy.

Taking the Long View: The Life of Shiing-Shen Chern, 6:00 p.m. on Thursday. **George Csicsery**, director of many films about mathematicians including "N is a Number", about Paul Erdős will present his recent film about Chern, a poetic document that examines the life of this remarkable mathematician whose scientific achievements were matched by an approach and vision that helped build bridges between China and the West. The film follows Chern through some of the dramatic events of the 20th century, portraying a man who dedicated his life to pure mathematics with the style of a classical Chinese sage. (A short version was shown at the ICM in Hyderabad.)

Csicsery will also present excerpts from films he has made for the Simons Foundation "Science Lives" project, and answer questions about his work. Sponsored by the AMS and the MAA.

Grad School Fair, Friday, 8:30 a.m.–10:30 a.m. Here is the opportunity for undergrads to meet representatives from mathematical sciences graduate programs from universities all over the country. January is a great time for juniors to learn more, and college seniors may still be able to refine their search. This is your chance for one-stop shopping in the graduate school market. At last year's meeting about 300 students met with representatives from 50 graduate programs. If your school has a graduate program and you are interested in participating, a table will be provided for your posters and printed materials for US$70 (registration for this event must be made by a person already registered for the JMM), and you are welcome to personally speak to interested students. Complimentary coffee will be served. Cosponsored by the AMS and MAA.

Conversation on Nonacademic Employment, Friday, 9:30 a.m.–11:00 a.m. This session will concentrate on how to find nonacademic positions, types of jobs, the interview process, work environments, and advancement opportunities. The discussion will be led by a panel of mathematical scientists working in government and industry.

Current Events Bulletin, organized by **David Eisenbud**, University of California, Berkeley; Friday, 1:00 p.m.–5:00 p.m. Speakers in this session follow the model of the Bourbaki Seminars in that mathematicians with strong expository skills speak on work not their own. Written versions of the talks will be distributed at the meeting and also be available on line at `www.ams.org/ams/current-events-bulletin.html` after the conclusion of the meeting.

Congressional Fellowship Session, organized by **Samuel M. Rankin III**, AMS; Friday, 4:30 p.m.–6:30 p.m. This fellowship provides a public policy learning experience, demonstrates the value of science-government interaction, and brings a technical background and external perspective to the decision-making process in Congress. Learn more about this program and speak with current and former

AMS Fellows. The application deadline for the 2013–14 AMS Congressional Fellowship is February 15, 2013.

Darwin's Extra Sense, Friday, 6:30 p.m. Charles Darwin famously wrote that he wished he had worked harder at mathematics, so as to possess the "extra sense" he believed mathematicians had in approaching the problems of science. In this 40-minute film, filmmakers Wendy Conquest and Bob Drake and mathematician Dan Rockmore show just how right Darwin was as they survey some of the ways in which mathematics is making possible many of the great new discoveries in the life sciences. Through an engaging style and informative animations, augmented by interviews with a diverse set of working mathematicians and scientists, "Darwin's Extra Sense" communicates the excitement and possibilities of twenty-first century applied mathematics. Sponsored by the AMS and the MAA.

Mathematics Serving Students in other Disciplines, Saturday, 8:30 a.m.–10:00 a.m. The February 2012 President's Council of Advisors on Science and Technology (PCAST) Report identifies college-level mathematics as foundational in the education of science, technology, and engineering majors and of future mathematics teachers. Mathematicians have implemented a wide array of innovations to enhance the learning of these students. Join the panelists for a discussion of the success and challenges we face in this diverse range of classroom settings. Sponsored by the Committee on Education.

Other AMS Events

Council: Tuesday, 1:30 p.m.

Business Meeting: Saturday, 11:45 a.m. The secretary notes the following resolution of the Council: Each person who attends a business meeting of the Society shall be willing and able to identify himself as a member of the Society. In further explanation, it is noted that each person who is to vote at a meeting is thereby identifying himself as and claiming to be a member of the American Mathematical Society. The Society has a Committee on the Agenda for Business Meetings. The purpose is to make business meetings orderly and effective. The committee does not have legal or administrative power. It is intended that the committee consider what may be called "quasipolitical" motions. The committee has several possible courses of action on a proposed motion, including but not restricted to:

(a) doing nothing,

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

(c) recommending and planning a format for debate to suggest to a business meeting,

(d) recommending referral to a committee, and

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

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

In order that a motion for this business meeting receive the service offered by the committee in the most effective manner, it should be in the hands of the AMS Secretary by **December 12, 2012**.

AMS Short Course on Random Matrices

This two-day course will take place on Monday and Tuesday before the meeting actually begins. It is organized by **Van Vu**, Yale University. Speakers include **Terence Tao**, University of California Los Angeles, *Random matrices: The universality phenomenon for the Wigner ensemble*; **Laszlo Erdős**, Ludwig-Maximilians Universität, *Universality of random matrices and Dyson Brownian Motion*; **Alice Guionnet**, Massachusetts Institute of Technology, *Free probability and random matrices*; **Alan Edelman**, Massachusetts Institute of Technology, *Random matrices, numerical computation, and remarkable applications*; **Mark Rudelson,** University of Michigan, *Nonasymptotic theory of random matrices;* **Djalil Chafai**, Université Paris-Est Marne-la-Valleé, *Around the circular law*; and **Van Vu,** *Random Matrices: The universality phenomenon for nonhermitian random matrices*.

There are separate registration fees to participate in these courses. See the complete article beginning on page 1319 of this issue or at `http://www.ams.org/meetings/short-courses/short-course-general`.

NSF-EHR Grant Proposal Writing Workshop

The goals of this workshop held on Monday, 3:00 p.m.–6:00 p.m., two days before the Joint Meetings actually begin, are to familiarize participants with current direction/priorities in the NSF's Directorate for Education and Human Resources (EHR); familiarize participants with key EHR education research and development programs; consider common issues of competitive proposals; and prepare participants to write a competitive proposal. There is no registration fee for this workshop, but attendees must register separately in advance. Please contact the AMS Washington Office at 202-588-1100 or `amsdc@ams.org` for further information.

Department Chairs Workshop

This annual one-day workshop for department chairs and leaders of mathematical sciences will be held a day before the start of the Joint Meetings on Tuesday, 8:00 a.m.–6:30 p.m. It is designed to stimulate discussion on a wide range of issues facing departments today, including personnel issues (staff and faculty), long-range planning, hiring, promotion and tenure, budget management, assessments, outreach, stewardship, junior faculty development, communication, and departmental leadership. There is a separate registration fee to participate. Interested attendees should also consider attending the NSF-EHR Grant Proposal Writing Workshop to be held on Monday afternoon. For further information please contact the AMS Washington Office at 202-588-1100 or `amsdc@ams.org`.

96th Meeting of the MAA

MAA Invited Addresses

Timothy Chartier, Davidson College, *Thinking linearly about data*, 9:00 a.m. on Thursday.

Tony DeRose, Pixar Animation Studios, *How mathematics has changed Hollywood*, 3:20 p.m. on Wednesday.

Chris Rasmussen, San Diego State University, *Who chooses not to persist in calculus and why?*, 10:05 a.m. on Saturday.

Suzanne Weekes, Worcester Polytechnic Institute, *Industrial strength mathematics in academia*, 2:15 p.m. on Wednesday.

Paul Zorn, St. Olaf College, *Communicating mathematics,* 9:00 a.m. on Friday. (Retiring Presidential Address)

Presentations by Teaching Award Recipients

Friday, 2:30 p.m.–3:50 p.m., organized by MAA Secretary **Barbara J. Faires**, Westminster College, and MAA President, **Paul Zorn**, St. Olaf College. Winners of the Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching will give presentations on the secrets of their success.

MAA Invited Paper Sessions

Beauty and Power of Number Theory, organized by **Shannon Lockard**, Bridgewater State University, and **Tim Flowers**, Indiana University of Pennsylvania. The tentative list of speakers includes **Michael Bennett**, University of British Columbia; **Chantal David**, Concordia University; **Richard Guy**, University of Calgary; and **Alice Silverberg**, University of California Irvine; Wednesday morning.

Mathematics in Industry, organized by **Suzanne Weekes**, Worcester Polytechnic Institute. The tentative list of speakers includes **Burt Tilley**, Worcester Polytechnic Institute; **Erica Klampfl,** Ford Motor Company; **Stephen Keeler**, The Boeing Company; **Catherine O'Neill**, Intent Media;**Tamara Kolda**, Sandia National Laboratories; and **Helen Moore**, Pharsight Corporation; Thursday morning.

Mathematics, Computer Graphics, and Film Production, organized by **Tony DeRose**, Pixar Animation Studios, and **Michael Dorff**, Brigham Young University. The tentative list of speakers includes **Dan Goldman**, Adobe Systems; **Tim Chartier**, Davidson College; **Doug Roble**, Digital Domain; **Ravi Ramamoorthi**, University of California Berkeley; and **Rasmus Tamstorf**, Walt Disney Studios; Thursday afternoon.

Energy, Population, and Sustainability, organized by **Ben Fusaro**, Florida State University, and **Fred Roberts**, Center for Discrete Mathematics and Theoretical Computer Science, Rutgers University. The tentative list of speakers includes **Paul Ehrlich**, Center of Conservation Biology, Stanford University; **Irene Fonseca**, Carnegie Mellon University; **Ben Fusaro**, Florida State University; **Roland Lamberson**, Humboldt State University; **Fred S. Roberts**; **Steve Sain**, National Center for Atmospheric Research (NCAR); **Abdul-Aziz Yakubu**, Howard University; and **Mary Lou Zeeman**, Bowdoin College; Thursday morning and afternoon. Cosponsored by the AMS, SIAM, SIGMAA EM.

Thinking Linearly about Data in Research and Teaching, organized by **Tim Chartier,** Davidson College. The tentative list of speakers includes **Michael Berry**, University of Tennessee, Knoxville; **Van Emden Henson**, Lawrence Livermore National Laboratory; **Amy Langville**, College of Charleston; **Ken Massey**, Carson-Newman College; and **Charles Wessell**, Gettysburg College; Friday morning.

Where Have All the Zeros Gone? organized by **Stephanie Edwards**, Hope College. The tentative list of speakers includes **Matthew Boelkins**, Grand Valley State University; **Jessalyn Bolkema**, University of Nebraska-Lincoln; **Stephanie Edwards**; and **Alexander Vandenberg-Rodes**, University of California Irvine; Friday afternoon.

Writing, Talking, and Sharing Mathematics, organized by **Paul Zorn,** St. Olaf College; speakers to be announced; Saturday morning.

MAA Minicourses

MAA Minicourses are open only to persons who register for the Joint Meetings and pay the Joint Meetings registration fee in addition to the appropriate minicourse fee. The MAA reserves the right to cancel any minicourse that is undersubscribed. Participants in minicourses 4, 6, 7, and 15 are required to bring their own laptop computer equipped with appropriate software. Instructions on how to download any data files needed for those courses will be provided by the organizers. The enrollment in each minicourse is limited to 50; the cost of a minicourse is US$80.

Minicourse #1: *Heavenly mathematics: The forgotten art of spherical trigonometry*, presenterd by **Glen Van Brummelen**, Quest University, and **Joel Silverberg**, Roger Williams University. Part A, Thursday, 9:00 a.m.–11:00 a.m.; Part B, Saturday, 9:00 a.m.–11:00 a.m. Trigonometry came into being at the birth of science itself: merging Greek geometric models of the motions of celestial bodies with the desire to predict where the planets will go. With the sky as the arena, spherical trigonometry was the "big brother" to the ordinary plane trigonometry our children learn in school. We shall explore the surprisingly elegant theory that emerges, as well as its appropriation into mathematical geography motivated by the needs of Muslim religious ritual. The beautiful modern theory of spherical trigonometry (including the pentagramma mirificum), developed by John Napier along with his logarithms, leads eventually to an astonishing alternate path to the subject using stereographic projection discovered only in the early 20th century. We conclude with a consideration of some of the ingenious techniques developed by navigators in the 19th century to find their locations, using as data only a couple of observations of stellar altitudes.

Minicourse #2: *A Game Theory path to quantitative literacy*, presented by **David Housman**, Goshen College; Part A, Thursday, 1:00 p.m.–3:00 p.m.; Part B, Saturday, 1:00 p.m.–3:00 p.m. Game Theory, defined in the broadest sense, can be used to model many real world scenarios of decision making in situations involving conflict and cooperation. Further, mastering the basic concepts and tools of game theory require only an understanding of basic algebra, probability, and formal reasoning. These two features of Game Theory make it an ideal path to developing

habits of quantitative literacy among our students. This audience participation minicourse develops some of the material used by the presenter in general education and math major courses on Game Theory and encourages participants to develop their own, similar, courses.

Minicourse #3: *How to run a successful math circle*, presented by **Sam Vandervelde**, St. Lawrence University; **Japheth Wood**, Bard College; and **Amanda Katharine Serenevy**, Riverbend Community Math Center; Part A, Wednesday, 4:45–6:45 p.m.; Part B, Friday, 3:30–5:30 p.m. A math circle brings together secondary school students and professional mathematicians on a regular basis to explore engaging topics. This course will focus on the logistics involved in organizing and sustaining a math circle as well as the fine art of conducting lively sessions. Facilitators will discuss how to adapt a promising topic for math circle use, provide tips for keeping a circle running smoothly, and address issues such as publicity and funding. Participants will craft a math circle lesson plan and take away a variety of materials including sample topics and a list of book and Web resources.

Minicourse #4. *Experiments in circle packing*, presented by **Ken Stephenson**, University of Tennessee, and **G. Brock Williams**, Texas Tech University. Part A, Wednesday, 2:15–4:15 p.m.; Part B, 1:00–3:00 p.m. Friday. Circle packing concerns configurations of circles with specified patterns of tangency. They were introduced in 1985 by Bill Thurston and provide as thorough and pleasing a blend of theory, computation, application, and visualization as you will find in all of mathematics. Moreover, their concrete visual nature make them uniquely accessible. This minicourse will give participants direct exposure to this topic through the creation, manipulation, display, and analysis of circle packings on their own laptops. We will use the open source software "CirclePack" with a variety of prepared "scripts" that will guide participants from the basics in Euclidean, hyperbolic, and spherical geometry, through selected advanced topics such as conformal mapping and Riemann surfaces, to opportunities for open-ended experiments and applications in areas from graph embedding to random triangulations.

The goal of the minicourse is to expose the participants to this fascinating new topic with tools that they can use to initiate their own explorations or to share with students and colleagues: "CirclePack" provides an experimental test bench for addressing problems from the undergraduate project to the research paper level.

The minicourse will assume no background in circle packing nor any but routine computer skills. A taste of the topic can be found in "Circle Packing: A Mathematical Tale", (*Notices* of the AMS, 2003). (In particular, note that "sphere packing" is a mathematically distinct topic.) Deeper background material can be found in "Introduction to Circle Packing: the Theory of Discrete Analytic Functions" (Cambridge, 2005) and "Exploring Complex Analysis", (MAA ebooks, due in 2012, Chapter 6).

Minicourse #5. *Visualizing projective geometry through photographs and perspective drawings*, presented by **Annalisa Crannell**, Franklin & Marshall College; **Marc Frantz**, Indiana University Bloomington; and **Fumiko Futamura**, Southwestern University. Part A, Wednesday, 9:00–11:00 a.m.; Part B, Friday, 9:00–11:00 a.m. Projective geometry is the study of properties invariant under projective transformations, often taught as an upper level course. Although projective geometry was born out of the ideas of Renaissance artists, it is often taught without any reference to perspective drawing or photography. This minicourse seeks to re-establish the link between mathematics and art, motivating several important concepts in projective geometry, including Desargues' Theorem, Casey's Theorem and its applications, and Eves' Theorem. This minicourse will consist of hands-on activities, but no artistic experience is required.

Minicourse #6. *Using randomization methods to build conceptual understanding of statistical inference*, presented by **Robin H. Lock**, St. Lawrence University. Part A, Wednesday, 9:00 a.m.–11:00 a.m.; Part B, Friday, 9:00 a.m.–11:00 a.m. The goal of this minicourse is to demonstrate how computer simulation techniques, such as bootstrap confidence intervals and randomization tests, can be used to introduce students to fundamental concepts of statistical inference in an introductory statistics course. Simulation methods are becoming increasingly important in statistics, and can be effective tools for building student understanding of inference. Through easy to use online tools and class activities, participants will see how to engage students and make these methods readily accessible.

Minicourse #7. *Teaching and assessing writing and presentations: Collaborative development of pedagogy*, presented by **Susan Ruff**, Massachusetts Institute of Technology; **Mia Minnes**, University of California, San Diego; and **Joel Lewis**, University of Minnesota. Part A, Wednesday, 4:45 p.m.–6:45 p.m.; Part B, Friday, 3:30 p.m.-5:30 p.m. In the first session we break into groups to characterize "good" math writing and "good" math presentations and to create sample materials for assessing student work. The second session is about how to teach students to communicate math effectively and will focus on participants' specific interests. Existing resources will be presented from the mathematical communication pages of the MAA's MathDL website, and open questions will be discussed in small groups. The session concludes with the optional formation of working groups to address open questions using available tools for collaborative development of pedagogy.

Participants will leave this highly interactive minicourse with a strategy for grading math writing and speaking, a clearer understanding of their own priorities for teaching math communication as well as the diverse priorities of other math educators, awareness of the wealth of resources for teaching mathematical communication available through MAA's MathDL and, if desired, collaborators and a plan for addressing open questions in how to teach mathematical communication.

Minicourse #8. *Getting students involved in undergraduate research*, presented by **Aparna Higgins**, University of Dayton, and **Joseph Gallian**, University of Minnesota Duluth. Part A, Thursday, 9:00 a.m.–11:00 a.m.; Part B, Saturday, 9:00-11:00 a.m. This minicourse will cover

many aspects of facilitating research by undergraduates, such as getting students involved in research, finding appropriate problems, deciding how much help to provide, and presenting and publishing the results. It is designed for faculty who are beginners at directing undergraduate research. Similarities and differences between research conducted during summer programs and research that can be conducted during the academic year will be discussed. Although the examples used will be primarily in the area of discrete mathematics, the strategies discussed can be applied to any area of mathematics.

Minicourse #9. *Shortest, quickest, or best: An introduction to the calculus of variations*, presented by **Jeffrey Ehme**, Spelman College. Part A, Thursday, 1:00–3:00 p.m.; Part B, Saturday, 1:00–3:00 p.m. The calculus of variations is a nice blend of calculus, real analysis, and differential equations with many applications in physics, engineering, and mathematics. These techniques give an easy proof that the shortest distance between two points is a straight line and determine the path of quickest descent between two points among other results. This introductory minicourse will begin by introducing the topic and providing some historical background. Next, we will derive a necessary condition for extremals, the Euler-Lagrange equation, and apply it to several concrete problems. We also consider generalizations to higher order problems, problems with more dimensions, problems with constraints, least action formalizations, and the relationship between Hamilton's principle and Newton's laws. Lastly, we consider differential calculus in general Banach spaces and discuss possible student projects.

Minicourse #10. *The mathematics of the Common Core*, presented by **William McCallum**, **Cody L. Patterson**, and **Ellen Whitesides**, University of Arizona; and **Kristin Umland**, University of New Mexico. Part A, Wednesday, 9:00 a.m.–11:00 a.m.; Part B, Friday, 9:00 a.m.–11:00 a.m. The Common Core State Standards in Mathematics were designed to present mathematics to K–12 students in a progression that reveals the coherence of mathematics and encourages mathematical reasoning. This minicourse will dig into the details of both the content standards and the standards for mathematical practice and will provide resources for mathematicians interested in supporting the implementation of the Standards. Possible roles for mathematicians in professional development, in review of curriculum materials, and in writing assessments (for example) will be considered.

Minicourse #11. *Teaching differential equations with modeling*, presented by **Darryl Yong**, Harvey Mudd College; **Ami Radunskaya**, Pomona College; **Tom LoFaro**, Gustavus Adolphus College; **Dan Flath**, Macalester College; and **Michael Huber**, Muhlenberg College. Part A, Wednesday, 4:45 p.m.–6:45 p.m.; Part B, Friday, 3:30 p.m.–5:30 p.m. Participants will learn about incorporating modeling into their differential equations courses and will do some modeling themselves using technology. The workshop will have three segments: (1) a short overview of curricular goals, what is modeling and why it is important, how modeling benefits student learning in differential equations; (2) activities and discussions in small groups on specific projects, to include modeling the dynamics of flight, population growth/interaction models, modeling infectious disease outbreaks, deflection in steel beams, applications to physics, and others; and (3) a wrap-up with references, sharing of best practices, and online resources that are available to instructors and students. The bulk of the minicourse will involve participants modifying existing modeling projects or creating new modeling projects for use in their own classes. To take full advantage of the course, participants: (a) should bring their own laptops and (b) are encouraged to bring applications to model.

Minicourse #12. *Teaching an applied topology course*, presented by **Colin Adams**, Williams College, and **Robert Franzosa**, University of Maine. Part A, Wednesday, 2:15 p.m.–4:15 p.m. Part B, Friday, 1:00 p.m.–3:00 p.m. Applications of topology have proliferated in recent years. It is now possible to teach a course in topology, still covering much of the same material that would appear in a traditional topology course, but motivated entirely by applications. Typically, offering an "applied" topology course immediately doubles the enrollments. Applications include areas such as geographic information systems, robotics, chaos, fixed point theory in economics, knots in DNA and synthetic chemistry, and the topology of the spatial universe. Through the applications, students become engaged with the material. In this minicourse we will introduce the various applications, and provide participants with the background necessary to design and teach their own applied topology course.

Minicourse #13. *Problem-based courses for teachers, future teachers, and math majors*, presented by **Gail Burrill**, Michigan State University; **Darryl Yong**, Harvey Mudd College; **Bowen Kerins**, Education Development Center; and **James King**, University of Washington. Part A, Thursday, 9:00–11:00 a.m.; Part B, Saturday, 9:00–11:00 a.m. A math course can simultaneously engage a broad range of students and enlarge their understanding of what it means to do math. This minicourse—based on a decade of experience at the Park City Mathematics Institute—will illustrate a problem-based approach for doing just that. Participants will spend most of the time in an interactive, collaborative environment, working on problems connecting algebra, number theory and geometry and involving content such as Pythagorean triples, Gaussian integers, lattice geometry, polynomials with special properties, and complex numbers. We will discuss the issues of teaching such a course, originally developed for teachers at the Park City Mathematics Institute, for undergraduate majors, prospective teachers, or as part of continuing education programs for experienced teachers.

Minicourse #14. *Teaching introductory statistics (for instructors new to teaching intro stats)*, presented by **Michael Posner**, Villanova University, and **Carolyn Cuff**, Westminster College. Part A, Wednesday, 2:15 p.m.–4:15 p.m.; Part B, Friday, 1:00 p.m.–3:00 p.m. This minicourse, intended for instructors new to teaching statistics, exposes participants to the big ideas of statistics and the ASA-endorsed Guidelines for Assessment and Instruction in Statistics Education (GAISE) report. It considers ways to engage students in statistical literacy and thinking, and

contrast conceptual and procedural understanding in the first statistics course. Participants will engage in many of the classic activities that all statistics instructors should know. Internet sources of real data, activities, and best practices articles will be examined. Participants will find out how they can continue to learn about the best practices for the first course in statistics by becoming involved in statistics education related conferences, newsletters, and groups.

Minicourse #15. *WeBWorK: An open source alternative for generating and delivering online homework problems*, presented by **John Travis**, Mississippi College, and **Jason Aubrey**, University of Missouri. Part A, Thursday, 1:00 p.m.–3:00 p.m.; Part B, Saturday, 1:00–3:00 p.m. This minicourse introduces participants to the WeBWorK online homework system. Supported by grants from NSF, WeBWorK has been adopted by well over 500 colleges, universities, and secondary schools and is a popular open-source alternative to commercial products. WeBWorK can handle problems in college algebra, calculus, linear algebra, ODEs and more and comes with an extensive library of nearly 30,000 problems across the mathematics curriculum. WeBWorK recognizes a multitude of mathematical objects and allows for elegant solution checking. This minicourse will introduce participants to WeBWorK and equip participants with the knowledge and skills to use WeBWorK in the classroom.

MAA Contributed Papers

The MAA Committee on Contributed Paper Sessions solicits contributed papers pertinent to the sessions listed below. Contributed Paper Session presentations are limited to fifteen minutes, except in the general session, where they are limited to ten minutes. You may give at most two talks in the "topical" sessions. If your paper cannot be accommodated in the session in which it is submitted, it will automatically be considered for the general session. You may give at most one talk in the general session, and the general session is open only to those who are not already speaking in one of the topical contributed paper sessions.

Please note that the dates and times scheduled for these sessions remain tentative. Full descriptions of these sessions may be found at `http://jointmathematicsmeetings.org/meetings/national/jmm2013/2141_maacall`.

Contributed Paper Sessions with Themes

Actuarial Education, organized by **Robert Buck**, Slippery Rock University, and **Thomas Wakefield**, Youngstown State University; Friday afternoon. Sponsored by PRIMUS: Problems, Resources, and Issues in Undergraduate Mathematics Studies. Papers from the session may be considered for a special issue of PRIMUS on actuarial education.

Adding Modern Ideas to an Introductory Statistics Course, organized by **Brian T. Gill**, Seattle Pacific University; **Scott Alberts,** Truman State University; and **Andrew Zieffler**, University of Minnesota; Friday afternoon. Sponsored by the SIGMAA on Statistics Education. Presenters will be considered for the Dex Whittinghill Award for Best Contributed Paper.

Assessing the Effectiveness of Online Homework, organized by **Jason Aubrey**, University of Missouri; **John Travis**, Mississippi College; and **Joanne Peeples**, El Paso Community College; Saturday morning. Sponsored by the MAA Committee on Technologies in Mathematics Education (CTME), MAA Committee on Two-Year Colleges (CTYC), and the SIGMAA on Mathematics Instruction Using the Web.

Bridging the Gap: Designing an Introduction to Proofs Course, organized by **Sarah L. Mabrouk**, Framingham State University; Thursday afternoon.

Communicating Mathematics, organized by **Brian Katz**, Augustana College, and **Elizabeth Thoren**, University of California Santa Barbara; Saturday afternoon.

Computational Modeling in the Undergraduate Curriculum, organized by **Kurt Matthew Bryan**, **Joseph Eichholz**, and **Jeffery Leader**, Rose-Hulman Institute of Technology; Wednesday morning.

Developmental Mathematics Education, organized by **J. Winston Crawley**, and **Kimberly J. Presser**, Shippensburg University; Saturday morning.

Effective Strategies and Programs for Mentoring Women and Minorities in Mathematics, organized by **Jenna Price Carpenter**, Louisiana Tech University; **Jessica M. Deshler**, West Virginia University; and **Elizabeth A. Burroughs**, Montana State University; Thursday afternoon.

Fostering Mathematical Habits of Mind, organized by **Kien H. Lim**, University of Texas at El Paso; **Ayse A. Sahin**, DePaul University; and **Holly Hirst**, Appalachian State University; Friday afternoon. Sponsored by the MAA Committee on the Mathematical Education of Teachers (COMET).

The History of Geometry, Its Applications, and Their Uses in the Classroom, organized by **Amy Shell-Gellasch**, Hood College, and **Glen Van Brummelen**, Quest University; Saturday afternoon. Sponsored by the SIGMAA on the History of Mathematics.

How Assessment Results Changed Our Program, organized by **Miriam Harris-Botzum**, Lehigh Carbon Community College, and **Bonnie Gold**, Monmouth University; Wednesday morning. Sponsored by the MAA Committee on Assessment.

Innovative and Effective Ways to Teach Linear Algebra, organized by **David M. Strong**, Pepperdine University; Friday morning.

Innovative Ideas for Courses in the First Two Years, organized by **Andrew Granville Bennett**, Kansas State University; Wednesday afternoon. Sponsored by the MAA Committee on Calculus Reform and the First Two Years (CRAFTY).

Integrating the Mathematics of Planet Earth 2013 in the College Mathematics Curriculum, organized by Ben Galluzzo, Shippensburg University; Wednesday afternoon. Accepted papers will be published on the SIGMAA EM website to increase awareness and encourage conversation about theme-related topics throughout the year. Sponsored by the SIGMAA on Environmental Mathematics.

Learning Centers: Problems and Creative Solutions, organized by **James M. Sobota**, **Karoline Auby**, and **Maighread McHugh**, University of Wisconsin–La Crosse; Thursday morning.

Mathematics and the Arts: Practice, Pedagogy, and Discovery, organized by **Douglas Norton**, Villanova University; Thursday morning. Sponsored by SIGMAA on Mathematics and the Arts.

Mathematics Experiences in Business, Industry, and Government, organized by **Carla D. Martin**, James Madison University; **Phil Gustafson**, Mesa State College; and **Michael Monticino**, University of North Texas; Saturday morning. Sponsored by the SIGMAA on Business, Industry, and Government.

Mathematics and Sports, organized by **R. Drew Pasteur**, College of Wooster; Thursday afternoon.

Mentoring Graduate Students: Pathways to Success, organized by **Jenna Price Carpenter**, Louisiana Tech University, and **Molly Fenn**, North Carolina State University; Friday afternoon. Sponsored by the MAA Professional Development Committee.

Philosophy, Mathematics, and Progress, organized by **Thomas Drucker**, University of Wisconsin Whitewater, and **Dan Sloughter**, Furman University; Friday afternoon. Sponsored by the SIGMAA on the Philosophy of Mathematics.

Preparing Elementary School Mathematics Specialists, organized by **Steve Morics**, University of Redlands, and **Klay T. Kruczek**, Southern Connecticut State University; Saturday afternoon. Sponsored by the MAA Committee on the Mathematical Education of Teachers (COMET).

Projects, Demonstrations, and Activities That Engage Liberal Arts Mathematics Students, organized by **Sarah L. Mabrouk**, Framingham State University; Thursday morning.

Research on the Teaching and Learning of Undergraduate Mathematics, organized by **Kyeong Hah Roh**, Arizona State University; **Stacy Brown**, Pitzer College; and **Mike Oehrtman**, University of Northern Colorado; Thursday morning. Sponsored by the SIGMAA on Research in Undergraduate Mathematics Education.

The Scholarship of Teaching and Learning in Collegiate Mathematics, organized by **Jacqueline Dewar**, Loyola Marymount University; **Thomas Banchoff,** Brown University; **Curtis Bennett**, Loyola Marymount University; **Pam Crawford**, Jacksonville University; and **Edwin Herman**, University of Wisconsin–Stevens Point; Friday morning.

Student Success in Quantative Reasoning, organized by **Ray Collings**, Georgia Perimeter College; Thursday afternoon. Sponsored by the MAA Committee on Two-Year Colleges (CTYC), and the SIGMAA on Quantative Literacy.

Touch It, Feel It, Learn It: Tactile Learning Activities in the Undergraduate Mathematics Classroom, organized by **Jessica M. Libertini,** University of Rhode Island, and **Julie Barnes**, Western Carolina University; Friday morning.

Transition from High School to College: Alternative Pathways, organized by **Gail Burrill**, Michigan State University; Saturday afternoon. Sponsored by the MAA/NCTM Committee on Mutual Concerns and the MAA Committee on Articulation and Placement.

Trends in Undergraduate Mathematical Biology Education, organized by **Timothy D. Comar**, Benedictine University; Saturday morning. Sponsored by the SIGMAA on Mathematical and Computational Biology.

Using Inquiry-Based Learning in Mathematics for Liberal Arts Courses, organized by **Julian F. Fleron**, **Volker Ecke**, **Philip K. Hotchkiss**, and **Christine von Renesse**, Westfield State University; Friday morning. Sponsored by PRIMUS: Problems, Resources, and Issues in Undergraduate Mathematics Studies. Papers from the session may be considered for a special issue of PRIMUS on Inquiry-Based Learning in Mathematics for Liberal Arts Courses.

Using Mobile Communication Devices for Mathematics Education, organized by **Lawrence Moore**, Duke University, and **Lila Roberts**, Clayton State University; Friday afternoon. Depending on the number of papers submitted, all or some of the contributors will be asked to demonstrate their projects at an informal reception organized by the WEB SIGMAA. Sponsored by the Committee on Technologies in Mathematics Education (CTME) and the SIGMAA on Mathematics Instruction Using the Web.

Writing the History of the MAA, organized by **Victor J. Katz**, University of the District of Columbia; **Amy Shell-Gellasch**, Hood College; and **Janet Beery**, Redlands University; Wednesday morning. This session is sponsored by the History Subcommittee of the Centennial Committee and is a follow up to the contributed paper session of the same name at the 2012 JMM. Sponsored by the History Subcommittee of the MAA Centennial Planning Committee.

General Contributed Paper Sessions

These are organized by **Stephen Davis**, Davidson College; **Gizem Karaali,** Pomona College; and **Douglas Norton**, Villanova University; Wednesday, Thursday, Friday, and Saturday mornings and afternoons. These sessions accept contributions in all areas of mathematics, curriculum, and pedagogy. When you submit your abstract you will be asked to classify it into one of the following areas: *Assessment and Outreach, Calculus, History and Philosophy of Mathematics, Interdisciplinary Topics, Mathematics Education, Mathematics and Technology, Modeling and Applications of Mathematics, Probability and Statistics, Research in Algebra and Topology, Research in Analysis, Research in Applied Mathematics, Research in Geometry and Linear Algebra, Research in Graph Theory and Combinatorics, Research in Number Theory, Teaching Introductory Mathematics, Teaching Mathematics beyond the Calculus Sequence, Assorted Other Topics* (does not fit into one of the stated topical general sessions).

Submission Procedures for MAA Contributed Paper Abstracts

Abstracts must be submitted electronically at `http://jointmathematicsmeetings.org/meetings/abstracts/abstract.pl?type=jmm`. Simply fill in the number of authors, click "New Abstract", and then follow the step-by-step instructions. **The final deadline for abstracts is Tuesday, September 25, 2012**; it is highly advised that you **submit your abstract well before the final deadline.**

Each session room is equipped with a computer projector, an overhead projector, and a screen.

N.B. Laptops are not provided; speakers should bring their own, or contact your organizer.

The organizer(s) of your session will automatically receive a copy of the abstract, so it is not necessary for you to send it directly to the organizer. All accepted abstracts are published in a book that is available to registered participants at the meeting. Questions concerning the submission of abstracts should be addressed to `abs-coord@ams.org`.

MAA Panels, Posters, Workshops, and Other Sessions

National Science Foundation Programs Supporting Learning, Teaching and the Future Workforce in the Mathematical Sciences, organized by **Jennifer Slimowitz Pearl**, Division of Mathematical Sciences, National Science Foundation; **Richard Alo**, **Ron Buckmire**, and **Lee Zia**, Division of Undergraduate Education, National Science Foundation; Wednesday, 9:00 a.m.–10:20 a.m. A number of NSF divisions offer a variety of grant programs that support innovations in learning and teaching in the mathematical sciences. These programs will be discussed by the organizers along with examples of successful projects. Anticipated budget highlights and other new initiatives for the next fiscal year will also be presented. Cosponsored by the National Science Foundation.

A Survey of Quantitative Literacy Teaching Resources, organized by **Caren Diefenderfer**, Hollins University; **Semra Kilic-Bahi**, Colby-Sawyer College; **Maura Mast**, University of Massachusetts Boston; and **Eric Gaze**, Bowdoin College; Wednesday, 9:00–10:20 a.m. Over the past decade or so, as more colleges and universities are offering QL courses, a number of new and different approaches to QL instruction have emerged in the textbook market. In particular a number of new texts are written specifically for the QL classroom, including texts on game theory, QL and the environment, and QL in the media. Panelists **Jeff Bennett**, Boulder, CO; **Kay Somers**, Moravian College; **Eric Gaze**; **Andrew Miller**, Belmont University; **Bernie Madison,** University of Arkansas; **Judith Moran**, Trinity College; and **Maura Mast** will focus on these different approaches, with discussion addressing the roles of technology, collaborative learning, and writing in QL courses along with the different instructional resources that are now available. Panelists will address issues of adapting material to diverse student populations and institutions, supporting professional development for faculty, conducting assessment of student learning, and navigating the growing market of QL textbooks and resources. Sponsored by the SIGMAA QL

Mathematicians Supporting the Implementation of Common Core State Standards for Mathematics, organized by **Elizabeth Burroughs**, Montana State University, and **James King**, University of Washington; Wednesday, 2:15–3:35 p.m. Mathematicians have been active in projects that support state-level implementation of the Common Core State Standards for Mathematics (CCSSM). Panelists **James King**; **Brynja Kohler**, Utah State University; **W. Gary Martin**, Auburn University; **William McCallum**, University of Arizona; and **Kristin Umland**, University of New Mexico; will identify examples of such projects and highlight the role of mathematicians in each. The projects are varied, including projects aimed at restructuring undergraduate mathematics to better prepare mathematics teachers, projects focused on the professional development of practicing teachers, and projects designed to engage mathematicians and teachers in developing resources that support the implementation of the standards. Panelists will provide opportunities for discussion about how mathematicians can engage in the implementation of CCSSM.Sponsored by the MAA Committee on the Mathematical Education of Teachers (COMET)

Reporting Progress: Projects from the NSF Course, Curriculum, and Laboratory Improvement/Transforming Undergraduate Education in STEM Program, organized by **Richard Alo**, **Ron Buckmire**, and **Lee Zia**, Division of Undergraduate Education, National Science Foundation; Wednesday, 2:15–3:35 p.m. In this session selected projects from the NSF Division of Undergraduate Education's Course, Curriculum, and Laboratory Improvement/Transforming Undergraduate Education in STEM Program will provide project updates and present major outcomes. A moderated discussion of common development and implementation issues among Principal Investigators from selected CCLI/TUES projects will follow with an emphasis on scaling up impact. Sponsored by the National Science Foundation.

What Every Student Should Know About the JMM, organized by **Jacqueline Jensen-Vallin**, Slippery Rock University, and **Lisa Marano**, West Chester University of Pennsylvania; Wednesday, 2:15–3:35 p.m. Navigating a large conference can be overwhelming, even for those who have previously attended such an event. Panelists, including **Robert Vallin**, Slippery Rock University, and others, will provide guidance for students attending the Joint Mathematics Meetings, including answers to the following questions: How do I get the most out of the program? What sessions are especially for students? What other events should I be on the lookout for? Will I understand any of the invited addresses or should I not bother attending them? If I am presenting a poster, where do I go to set it up? How can I get some cool, free math stuff? Students and their faculty mentors are encouraged to attend. Sponsored by the MAA Committee on Undergraduate Student Activities and Chapters.

The Paul R. Halmos Photograph Collection of the Archives of American Mathematics, organized by **Amy Shell-Gellasch**, Hood College; Wednesday, 2:15 p.m.–3:45. In 2011, several thousand photographs taken by Paul Halmos were donated to the Archives of American Mathematics at the University of Texas at Austin by his widow, Virginia Halmos. With funding from the History of Mathematics Special Interest Group of the MAA and Virginia Halmos, these photos have been digitally captured and now reside on the MAA's Convergence online journal for the history of mathematics.

Please join us for a sampling of photos, some fun and games, and a discussion on the Halmos Collection and

the AAM by archivist **Carol Mead**. Sponsored by the HOM SIGMAA

YMN/Project NExT Poster Session, organized by **Mike Axtell**, University of St. Thomas, and **Kim Roth**, Juniata College; Wednesday, 2:15 p.m.–4:15 p.m. Abstract submissions, both mathematical and pedagogical, are invited for this poster session intended to highlight the research activities of recent or future Ph.D.s in mathematics and related fields. The organizers seek to provide an open venue for people who are near completion, or have finished their graduate degrees in the last five years, to present their work and make connections with other same-stage professionals, in much the same spirit as YMN and Project NExT. To apply, send a poster abstract, when and where you have or will receive your Ph.D., and your current college or university affiliation to the organizers, Mike Axtell (`maxtell@stthomas.edu`) or Kim Roth (`roth@juniata.edu`). Sponsored by the Young Mathematicians Network and Project NExT

Placement Testing and the Common Core Curriculum, organized by **Sheldon P. Gordon**, Farmingdale State College; Wednesday, 3:50 p.m.–5:10 p.m. The new Common Core Curriculum, which has been adopted by at least 45 states, calls for some major changes in what mathematics will be emphasized in the secondary schools. These changes have significant implications for collegiate mathematics, including both the algebra through precalculus/calculus track and for statistics. One of the major issues we face is how placement testing will measure what students have learned under the new curriculum and how it meshes with college offerings. Too often, rather than being the bridge to a smooth transition from secondary to collegiate mathematics, placement tests tend to push large numbers of students into a remedial abyss from which vanishingly few ever emerge. The Common Core provides the opportunity for faculty and placement test makers to rethink the issues and so establish a new and better transition. Panelists include people working on the new generation of placement tests as well as mathematics and statistics educators familiar with the new curriculum: **Zalman Usiskin**, University of Chicago; **William McCallum**, University of Arizona; **Roxy Peck**, California Polytechnic State University, San Luis Obispo; **Jonell Sanchez**, The College Board (AccuPlacer); and **Lavonne Mohn**, ACT Test Development. The panel will be moderated by **Bernard Madison**, University of Arkansas. Sponsored by the MAA Committee on Articulation and Placement (CAP) and the Joint NCTM-MAA Committee on Mutual Concerns.

Published or Perished: Life After the Tenure Decision, organized by **Michael Posner,** Villanova University; Wednesday, 3:50 p.m.–5:10 p.m. Tenure is an important foundation of today's academy that has come under much scrutiny in the public media. But what does life after tenure look like? There are a number of potential career trajectories, depending on the tenure decision and professional interests. Panelists **Gary Towsley,** SUNY Geneseo; **Tevian Dray**, Oregon State University; **Curtis Bennett**, Loyola Marymount University; **Dexter Whittinghill**, Rowan University; and **Rebecca Goldin**, George Mason University; all from colleges and research universities with a variety of career paths—one with a "two body problem", one who was denied tenure, an associate dean, and a nationally recognized teacher—will share their insights and stories on how to build a successful career after the tenure decision.

Bring your Lab to Work: Projects that Incorporate Instrumented Laboratory Devices into Mathematics Courses, organized by **Ron Buckmire** and **Lee Zia**, Division of Undergraduate Education, National Science Foundation; Wednesday, 3:50 p.m.–5:10 p.m. In this session principal investigators from selected NSF/DUE projects supported over the years by the NSF Division of Undergraduate Education will describe their work in bringing laboratory equipment usually found in physics and engineering courses into a variety of applied mathematics courses. A moderated discussion of common development and implementation issues will follow. Sponsored by the National Science Foundation

Career Options for Undergraduate Mathematics Majors, organized by **Nyles Breecher**, Hamline University, and **Allison Oldham**, William and Mary University; Thursday, 9:00 a.m.–10:20 a.m. There are a vast number of options available for students in today's global market. A degree in mathematics continues to be a desirable asset, yet a common question for students to ask is "What options are available for someone with a math degree?" Panelist **Michael Dorff,** Brigham Young University, along with representatives from other industries will showcase several options for career paths for students with an undergraduate degree in mathematics. These panelists will speak on their own experiences of finding a job and answer questions from the audience. Sponsored by the Young Mathematicians Network.

Session for Chairs: Transition from High School to College Mathematics, organized by **Daniel Maki**, Indiana University, and **Catherine M. Murphy**, Purdue University Calumet; Thursday, 9:00 a.m.–10:20 a.m. For the success of incoming students correct placement into mathematics courses is essential. Two specific issues are 1) methods of placement including placement tests, and 2) especially for STEM majors, calculus courses which meet the needs of today's students. Two nationally known experts, **David Bressoud** from Macalester College and **Bernie Madison** from the University of Arkansas, will present findings on these issues from their research. Bernie Madison will address the broad issue of placement methods. David Bressoud will talk about the transition to college calculus and will include results from his current work as PI of the NSF grant Characteristics of Successful Programs in College Calculus. The Session for Chairs is a great social networking experience. Participate by attending and contributing your ideas and experiences to the conversation.

Benefits of Research with Undergraduates for Faculty, organized by **Steven Schlicker**, Grand Valley State University, and **Zsuzsanna Szaniszlo**, Valparaiso University; Thursday, 9:00 a.m.–10:20 a.m. Research with undergraduate students offers several benefits to the students, but faculty members might wonder what advantages it may hold for them. In this discussion, panelists will describe some of the benefits that research with undergraduates provides for faculty, including creating an intellectually

stimulating department and campus environment, enhancing mentoring and teaching, invigorating or reinvigorating a research program, increasing job satisfaction, enhancing personal and professional development, and building a legacy for the future. Panelists will include mathematicians who have had several years' experience mentoring undergraduate researchers and who are working as regular faculty or as administrators. Sponsored by the MAA Subcommittee on Research by Undergraduates.

Mathematical Outreach Programs Poster Session, organized by **Elizabeth Yanik**, Emporia State University; Thursday, 9:00 a.m.–11:00 a.m. This session is designed to highlight special programs that have been developed to encourage students to maintain an interest in and commitment to succeeding in mathematics. These programs might include such activities as after school clubs, weekend activities, one-day conferences, mentoring opportunities, summer camps, etc. This poster session encompasses a wide variety of outreach efforts for a variety of age groups. For example, programs might be designed to reach out to underrepresented groups. The projects supported by MAA Tensor and Summa grants will find this an ideal venue in which to share the progress of their funded projects. Another possible type of outreach might involve mathematical enrichment programs. For example, recipients of Dolciani Mathematics Enrichment Grants might wish to highlight their programs. Other examples might include innovative programs to motivate undergraduates to study mathematics. We encourage everyone involved with offering mathematical outreach activities to consider submitting an abstract to the session organizer, Betsy Yanik, `eyanik@emporia.edu`. Sponsored by the MAA Committee on the Participation of Women

On-Campus Interview Survival Guide, organized by **Nick Scoville**, Ursinus College, and **Jacob White**, Arizona State University, Thursday, 10:35 a.m.–11:55 a.m. Your job applications are in and soon invitations for on-campus interviews will follow. Make the most of these opportunities by doing your homework. How do you prepare differently for an interview at a liberal arts school than for an interview at a research university? Panelists **Sheldon Axler**, San Francisco State University; **Jeremy Martin**, University of Kansas; **Kristine Roinestad**, Georgetown College; and **Francis Su**, Harvey Mudd College; who represent schools that recently conducted job searches, will share what they look for in a candidate and discuss the differences in how to interview at primarily a teaching school versus primarily a research school. They will also discuss how to score well during an on-campus interview, and how to aim job talks at various audiences. Also on the agenda will be the types of questions one should ask during an on-campus interview, and "what not to do, but what many applicants do anyway." Sponsored by the Young Mathematicians Network.

Proposal Writing Workshop for Grant Applications to the NSF Division of Undergraduate Education, presented by **Michael Jacobson**, **Ron Buckmire**, and **Lee Zia**, Division of Undergraduate Education, National Science Foundation; Thursday, 10:35 a.m.–11:55 a.m. The general NSF grant proposal process will be described as well as what are considered to be particular details relevant to programs in the Division of Undergraduate Education. This interactive session will feature a mock panel review using a series of short excerpts from sample proposals. Sponsored by the National Science Foundation.

Creating and Growing an Applied Statistics Minor Program, organized by **K. Scott Alberts**, Truman State University; Thursday, 10:35 a.m.–11:55 a.m. A statistics minor is an attractive option for some students majoring in statistically-driven fields including psychology, business, economics, and life sciences. Many of these students will be required to have a first course in statistics, and may have taken a discipline-specific methodology course as well. Panelists **Scott Alberts**, Truman State University; **Robin Lock**, St. Lawrence University; **Daniel Kaplan**, Macalester College; and **David Nelson**, Mercer University; will address these and other questions: How can we design courses for a minor to be attractive to a variety of these students? How can we work with our colleagues in these programs to ensure that we serve them well? What courses from those programs count for the minor? Is this minor possible with limited resources (can it make a "profit")? How does it overlap with other math/stat program offerings? Sponsored by the SIGMAA Stat Ed.

Graduate School: Choosing One, Getting In, Staying In, organized by **Timothy Goldberg**, Lenoir-Rhyne University, and **Kristine Roinestad**, Georgetown College; Thursday, 1:00 p.m.–2:20 p.m. You've made the decision to apply to graduate school. Now you must sift through all the available information, match schools to your academic and research interests, narrow down your list to a handful of schools, and submit outstanding applications. How do you accomplish all this and hopefully increase the likelihood of getting into your first- or second-choice program? Then, once accepted, how do you successfully complete the program and earn your degree? Panelists **Richard A. Levine**, San Diego State University; **William Y. Velez**, University of Arizona; **Annalisa Crannell**, Franklin & Marshall College; and **Cynthia J. Wyels**, California State University, Channel Islands; will discuss these and other important issues for those considering graduate school, transferring to a different graduate school, or switching graduate programs. Sponsored by the Young Mathematicians Network.

PRAXIS Mathematics Exams for Prospective Teachers: Responsibilities of and Reflections on Mathematics Departments, organized by **William Martin**, North Dakota State University, and **Myron Rigsby**, University of Arkansas Fort Smith; Thursday, 1:00 p.m.–2:20 p.m. Prospective school teachers are required to take and pass a variety of national or state exams prior to obtaining a teacher license. This session will provide information about the mathematics tests that are used by many states. One of the widely used suite of tests is the PRAXIS series produced by the Educational Testing Service (ETS). The specific requirements and tests are set by each state. Mathematics departments teach the mathematics and statistics content courses that provide preparation for the tests, so mathematics faculty need familiarity with the requirements. Conversely, results by program graduates provide departments with assessment data directly comparable to

state and national norms. Panelists **Barbara Weren**, Educational Testing Service; **Karen King**, National Council of Teachers of Mathematics; **William Martin**, North Dakota State University; **Angela Hodge**, University of Nebraska at Omaha; and **Jack L. Jackson**, University of Arkansas Fort Smith; have expertise in mathematics content testing and accreditation requirements for mathematics majors in teacher preparation programs. Sponsorsed by the MAA Assessment Committee and the MAA Committee on the Mathematical Education of Teachers.

An Introduction to Inquiry-Based Learning, organizers/presenters are **Stan Yoshinobu**, California Polytechnic State University, San Luis Obispo; **Matthew Jones**, California State University Dominguez Hills; and **Carol Schumacher**, Kenyon College; Thursday, 1:00 p.m.–2:20 p.m. Inquiry-based learning in mathematics is a method of instruction that asks students to engage deeply in rich mathematical tasks without being given prescribed solutions or answers. Students are also required to collaborate (in some form) with one another to determine the correctness of other students' presented solutions. Research suggests that students in IBL courses have better learning and attitudinal outcomes compared to peers in equivalent non-IBL courses.

Despite the benefits of IBL courses, implementing one, especially for the first time, can be a challenge, due to the initial startup work required to learn IBL teaching skills and concepts. This workshop addresses some of the main challenges of "getting started with IBL." Specifically, participants will (a) investigate real-time video data from an upper-level IBL course, (b) discuss the core components of an IBL course, and (c) develop sample IBL tasks for a target course.

Poster Session of Projects Supported by the NSF Division of Undergraduate Education, organized by **Jon Scott**, Montgomery College; Thursday, 2:00 p.m.–4:00 p.m. This session will feature principal investigators (PIs) presenting progress and outcomes from various NSF-funded projects in the Division of Undergraduate Education. The poster session format will permit ample opportunity for attendees to engage in small group discussions with the PIs and to network with each other. Information about presenters and their projects will appear in the program.

You Published Your Dissertation, Now What?, organized by **Ralucca Gera**, Naval Postgraduate School, and **Rachel Esselstein**, California State University Monterey Bay; Thursday; 2:40 p.m.– 4:00 p.m. Junior faculty members tend to struggle starting a new postdoctoral professional life. Panelists **Chris Storm**, Adelphi University; **Nick Scoville**, Ursinus College; **Joyati Debnath**, Winona State University; and **Allison Henrich**, Seattle University; will speak on their own experiences and address some of the issues a fresh Ph.D. encounters as he starts his tenure-track position, including finding a direction for future research projects, establishing new research relationships, and guidance in finding grants. Sponsored by the Young Mathematicians Network.

Taking the Long View: The Life of Shiing-Shen Chern, 6:00 p.m. on Thursday. **George Csicsery**, director of many films about mathematicians including "N is a Number", about Paul Erdős will present his recent film about Chern, a poetic document that examines the life of this remarkable mathematician whose scientific achievements were matched by an approach and vision that helped build bridges between China and the West. The film follows Chern through some of the dramatic events of the 20th century, portraying a man who dedicated his life to pure mathematics with the style of a classical Chinese sage. (A short version was shown at the ICM in Hyderabad.)

Csicsery will also present excerpts from films he has made for the Simons Foundation "Science Lives" project, and answer questions about his work. Sponsored by the MAA and the AMS.

The Invigorating Experience of Mathematical Positions Abroad, organized by **Deane Arganbright**, Divine Word University, Papua New Guinea; **Donald York**, Pennsylvania College of Technology; **Erich Neuwirth**, University of Vienna; and **Carol Shubin**, California State University, Northridge; Friday, 9:00 a.m.–10:20 a.m. The organizers will provide a unique opportunity for members of both the U.S. and international mathematical communities to share insights obtained from their professional mathematical experiences in countries other than their own. Such experiences include regular full-time and limited-term academic positions, visiting and Fulbright appointments, faculty exchanges, research and industrial assignments, and others. They will illustrate how working in other countries allows mathematicians to obtain fresh understandings into teaching, research, and interdisciplinary collaboration, as well as how to interact and teach effectively in diverse cultures. They will inform those attending of the broad range of international opportunities that exist and how these can be discovered. They will also show how these involvements contribute to both host and home institutions. Audience participation through questions and briefly sharing from their own experiences will be encouraged.

Using Mathematical Archives and Special Collections for Research and Teaching, organized by **Amy Shell-Gellasch**, Hood College, and **Janet Beery**, University of Redlands; Friday, 9:00 a.m.–10:55 a.m. This panel presentation will introduce the audience to several special collections and archives available to the scholar and teacher of mathematics and its history. Panelists **Carol Mead**, American Archives of Mathematics; **Fred Rickey**, United States Military Academy; **Dominic Klyve**, Central Washington University; **Victor Katz**, University of District of Columbia; **Peggy Kidwell**, Smithsonian Museum of American History; and **Shirley Gray**, California State University Los Angeles; will introduce us to their collection or archive, explain how to access it, share ideas on how to use it in research and/or teaching, and answer questions from the audience. Sponsored by the HOM SIGMAA.

Training and Professional Development of Teaching Assistants, organized by **David Carothers**, James Madison University, and **Delaram Kahrobaei**, CUNY Graduate Center; Friday, 9:00 a.m.–10:20 a.m. This session will consider best practices for the preparation of graduate teaching assistants (GTAs) and for their ongoing support. Panelists **Solomon Friedberg**, Boston College; **Karen Rhea**, University of Michigan; **Nathan Ritchey**, Youngstown State

University; and **James Sellers**, Pennsylvania State University; will consider the diverse needs of GTAs in a variety of programs and at differing institutions. Information about some model programs will be offered. The goals of the session are to provide participants with resources for design of their own programs and to continue and encourage an ongoing discussion in the mathematical community on how to best support current mathematics instruction while encouraging future members of the profession. A majority of graduate programs in the mathematical sciences have introduced orientation and training programs for GTAs. Nonetheless, the transition from student to teacher continues to be stressful for many graduate students, especially those with little or no background/preparation for teaching. Directors of graduate programs also feel time and resource constraints for support of GTAs while facing a shifting university budget. Sponsored by the AMS-MAA Joint Committee on Teaching Assistants and Part-Time Instructors.

Reporting Progress: Mathematical Modeling Across the K–16 Curriculum, organized by **Richard Alo**, **Ron Buckmire**, and **Lee Zia**, Division of Undergraduate Education, National Science Foundation; and **Peter Turner**, Clarkson University and SIAM; Friday, 1:00 p.m.–2:20 p.m. In this session we will report on initiatives being taken to incorporate more mathematical modeling in K–16 curricula at schools, colleges, and universities. Specifically, panelists **Ron Buckmire**; **Katherine Socha**, Math for America; **Jeffrey Humpherys**, Brigham Young University; and **Rachel Levy**, Harvey Mudd College; will discuss the following: a Modeling Across the Curriculum workshop held at NSF in 2012, the impact of the Common Core State Standards in Mathematics (CCSSM) on inclusion of mathematical modeling in K–12 curricula, the development of a multidisciplinary STEM undergraduate degree, and the incorporation of modeling in preservice and in-service teacher education. Sponsored by the National Science Foundation and the Society for Industrial and Applied Mathematics.

Parental and Family Leave for Graduate Students and Post-docs: Policies and Experiences, organized by **Patricia Hale**, California State Polytechnic University Pomona; **Cathy Kessel**, Berkeley, California; and **Tanya Leise**, Amherst College; Friday, 1:00 p.m.–2:20 p.m. Graduate school and postdoctoral work often occurs during family formation, yet policies that could enable women and men to balance family and career are often nonexistent or poorly understood, as noted in the 2012 report "A Forgotten Class of Scientists: Examining the Parental and Family Benefits Available to Research Trainees". Changing departmental and institutional culture through mentoring, providing clear guidelines about how things work in the department, and implementing family-responsive policies can improve the climate, allowing departments to attract and retain students and faculty. Panelists **Cathy Kessel**; **Sonja Mitchell**, University of California, Santa Barbara; **Kathryn Murphy**, University of California, San Diego; **Mary Radcliffe**, University of California, San Diego; **Ami Radunskaya**, Pomona College; and **Ruth Haas,** Smith College; will discuss institutional policies and individual experiences of parental and family leave. The panelists include graduate students who have taken family leave, the co-director of the EDGE Program for Women, the director of the Smith Post-bac Center for Women, and an administrator from UC San Diego (where family-friendly policies are based on Mary Ann Mason's pioneering work at Berkeley). Sponsored by the MAA Committee on the Participation of Women in Mathematics and the Joint Committee on the Participation of Women in the Mathematical Sciences.

Math Circle Poster and Activity Session, organized by **Philip B. Yasskin**, Texas A&M University; **Sam Vandervelde**, St. Lawrence University; **Tatiana Shubin**, San Jose State University; and **James Tanton**, St. Mark's School; Friday, 1:00 p.m.–4:00 p.m. Come join us for the chance to experience a math circle firsthand. Math circles vary widely in format and frequency, but they all bring groups of interested students or teachers together with professional mathematicians to investigate and discover mathematics. About ten math circles from around the country will display a poster describing that circle along with a live activity to try out. These activities are intended to provide ideas for lessons to use at your own circle or school. Activities will be designed to either restart every 30 minutes or run continuously.

Potential presenters should send the organizers (`yasskin@math.tamu.edu`) an electronic file (or files) of the sample lesson plan and handouts for their activity. The SIGMAA MCST will post those which are accepted at its website. Those that are not accepted will be automatically considered for future meetings. Sponsored by the SIGMAA on Math Circles for Students and Teachers.

Using Technology to Develop Mathematical Understanding, organized by **Gail Burrill**, Michigan State University; Friday, 2:40 p.m.–4:00 p.m. Although technology is often used as a powerful tool for doing mathematics—creating graphs and crunching numbers—it can also be a powerful tool for developing understanding of mathematical concepts. Interactive dynamic algebra or geometry software can play a central role in helping students grapple with ideas in courses from introductory algebra and remedial courses at community colleges, to calculus, introductory statistics, linear algebra, and differential equations. CAS technology offers the potential for students to explore sophisticated and subtle mathematics concepts as well as providing opportunities for students to make and test conjectures that set up mathematics. Panelists **Tom Dick**, Oregon State University; **Wade Ellis**, West Valley Community College; **Al Cuoco**, Educational Development Center; and **Gail Burrill**; will share examples from a variety of content areas, discuss the affordances and limitations of technology and offer suggestions from research about how technology can be used effectively. The discussion will focus on interactive dynamic technologies but will also include a broader perspective on technologies available for use in teaching.

Current Issues in Actuarial Science Education, organized by **Robert Buck**, Slippery Rock University; **Bettye Anne Case**, Florida State University; **Steve Paris**, Lebanon Valley College; and **Kevin Charlwood**, Washburn University; Friday, 5:00 p.m.–7:00 p.m. Panelists **Robert Buck**; **Kevin Charlwood**; and **Jim Daniel**, University of Texas Austin;

are a diverse group of actuaries, publishers, and actuarial educators. The pace of change in actuarial science is faster than in most academic areas, and this session aims to help faculty adjust curriculum and activities to meet student needs and expectations. CUPM is forming a Program Area Study Group concentrating on undergraduate programs in actuarial science. This will be one of the topics for discussion.

Poetry Reading, organized by **Gizem Karaali**, Pomona College; **Mark Huber**, Claremont McKenna College; and **Sue VanHattum**, Contra Costa College; Friday, 5:00 p.m.–7:00 p.m. All mathematical poets and those interested in mathematical poetry are invited. Share your poetry or simply enjoy the company of like-minded poetic-math people! The reading is sponsored by the *Journal of Humanistic Mathematics* (`http://scholarship.claremont.edu/jhm`) and will be hosted by the organizers. Though we also encourage interested meeting participants to simply come to the reading and share as they like, those who wish to contact the organizers ahead of time to inquire about the session or to add their name to the program can email Gizem Karaali (`gizem.karaali@pomona.edu`).

Mathematically Bent Theater, presented by **Colin Adams** and the **Mobiusbandaid Players**; Friday, 6:00 p.m.– 7:00 p.m. This event includes a small collection of humorous short mathematical pieces that ask questions like, "How did Pythagoras discover his famous theorem?", "What happens when a 19th century mathematician is thrust into the 21st century?" and "What would you see if you looked in 'The Book'?"

Darwin's Extra Sense, Friday, 6:30 p.m. Charles Darwin famously wrote that he wished he had worked harder at mathematics, so as to possess the "extra sense" he believed mathematicians had in approaching the problems of science. In this 40-minute film, filmmakers Wendy Conquest and Bob Drake and mathematician Dan Rockmore show just how right Darwin was as they survey some of the ways in which mathematics is making possible many of the great new discoveries in the life sciences. Through an engaging style and informative animations, augmented by interviews with a diverse set of working mathematicians and scientists, "Darwin's Extra Sense" communicates the excitement and possibilities of twenty-first century applied mathematics. Sponsored by the MAA and the AMS.

Randomization and Bootstrap Methods in the Introductory Statistics Course, organized by **Andrew Zieffler**, University of Minnesota; Saturday, 9:00 a.m.–10:20 a.m. George Cobb (2007), in a landmark paper based on his 2005 plenary talk at the United States Conference on Teaching Statistics, argued for a 21st century approach to teaching introductory statistics. He advocated for the instruction of statistical inference through the use of randomization and simulation methods, rather than the traditional formula-based approach using methods such as the t-test and ANOVA. Since that time, several grants have been written and funded to develop, implement, and evaluate these computational approaches to teaching statistics. In addition, more and more textbooks at the introductory level are being written that include randomization and bootstrap methods.

Panelists **George Cobb**, Mount Holyoke College; **Jeff Hamrick**, Rhodes College; **John Holcomb**, Cleveland State University; **Kari Lock Morgan**, Duke University; **Rachel Dunwell**, Rhodes College; **Robert delMas**, University of Minnesota; **Robin Lock**, St. Lawrence University; **Soma Roy**, California Polytechnic State University, San Luis Obispo; and **Laura Ziegler**, University of Minnesota; will give an overview of randomization and bootstrap methods, discuss how they fit into the current introductory statistics curriculum, how the curriculum might change to accommodate these methods, and describe the knowledge needed by the future K–12 teachers who will be teaching using these methods. Sponsoed by the SIGMAA on Statistics Education.

Active Learning in Mathematics, organized by **David Taylor**, Roanoke College; **Lorena Bociu**, North Carolina State University; and **Robert Allen**, University of Wisconsin La Crosse; Saturday, 9:00 a.m.–10:20 a.m. Active learning is the process whereby students engage in activities such as reading, writing or problem solving that encourage analysis, synthesis and evaluation of class content. It has been well known that active learning strategies increase student learning and have long time effects on student success (Braxton et al 2008). The goal of this panel is to promote and provide useful strategies for implementing active learning while teaching mathematics. Panelists **Alina Duca** and **Susan Hermiller**, University of Nebraska Lincoln; **Michael Smith**, Lycoming College; **John Zweck**, University of Maryland Baltimore; **Robin Lock**, St. Lawrence University; and **Jennifer Kosiak**, University of Wisconsin La Crosse; will focus on active learning techniques used specifically in math classes, at both undergraduate and graduate levels. We will bring together a group of people who are acknowledged promoters of active learning in mathematics. They will share their experiences and thus provide different useful tips on overcoming obstacles to active learning and successful strategies that they implement in their classrooms. We will close with an opportunity for the audience to ask questions of the panelists so that the active learning ideas promoted can be discussed and tailored for audience members' individual needs.

How a Placement Program Can Increase Success Rates in Preparatory Courses and the Calculus Sequence, organized by **Alison Ahlgren,** University of Illinois, and **Marc Harper**, UCLA; Saturday, 1:00 p.m.–2:20 p.m. An effective placement program can reduce failure rates in calculus and prerequisite courses. Colleges and universities often experience DWF rates of 40% or higher in Calculus I at great expense to the student and the institution. Prerequisite coursework and college entrance exams are generally available but often an insufficient indicator of success in Precalculus and Calculus. An effective placement program is based on accurate and comprehensive assessments paired with consistent enforcement and policy. In this session panelists **Alison Ahlgren**; **Karen Rhea**, University of Michigan; **Pavel Sikorskii**, Michigan State University; and **Andrew Tonge**, Kent State University; will discuss what additional measures may be necessary and the role of a placement program (particularly with the rapid increase of

AP calculus) to increase student success rates. The panel will be moderated by **Marc Harper.**

Special Interest Groups of the MAA (SIGMAAs)

SIGMAAs are Special Interest Groups of the MAA. SIGMAAs will be hosting a number of activities, sessions, and guest lectures. There are currently twelve such focus groups in the MAA offering members opportunities to interact, not only at meetings, but throughout the year, via newsletters and email-based communications. For more information visit `http://www.maa.org/sigmaa/`.

SIGMAA Officers Meeting: Thursday, 10:30 a.m., chaired by **Amy Shell-Gellasch**, Hood College.

Mathematics and the Arts: SIGMAA ARTS

Mathematics and the Arts: Practice, Pedagogy, and Discovery, Thursday morning. (see MAA Contributed Paper Sessions)

Mathematical and Computational Biology: BIO SIGMAA

Trends in Undergraduate Mathematical Biology Education, Saturday morning. (see MAA Contributed Paper Sessions)

Reception and Business Meeting, Friday, 6:00 p.m.–7:00 p.m.

Guest Lecture, Friday, 7:00 p.m.–8:00 p.m. by **Joseph M. Mahaffy**, San Diego State University, *Modeling and calculus for the life sciences with WeBWorK computer labs.*

Mathematicians in Business, Industry and Government: BIG SIGMAA

Mathematics Experiences in Business, Industry, and Government, Saturday morning. (see MAA Contributed Paper Sessions)

Business Meeting, Friday, 5:00 p.m.–5:45 p.m.

Guest Lecture, Friday, 6:00 p.m.–7:00 p.m. by **Mario Livio**, Space Telescope Science Institute, *Is God a mathematician?*

Reception, Friday, 7:15 p.m.–8:00 p.m.

History of Mathematics: HOM SIGMAA

The History of Geometry, its Applications, and their Uses in the Classroom, Thursday afternoon. (see MAA Contributed Paper Sessions)

The Paul R. Halmos Photograph Collection of the Archives of American Mathematics, Wednesday, 2:15 p.m.–3:45. (See MAA Panels, etc.)

Reception and Business Meeting, Wednesday 5:30 p.m.–6:30 p.m.

Guest Lecture, Wednesday, 6:30 p.m.–7:30 p.m. by **Keith Devlin**, Stanford University, *Leonardo Fibonacci, Liber abbaci, and the rise of the modern commercial world.*

Using Mathematical Archives and Special Collections for Research and Teaching, Friday, 9:00 a.m.–10:55 a.m.(See MAA Panels, etc.)

Math Circles for Students and Teachers: SIGMAA MCST

Math Circle Poster and Activity Session, Friday, 1:00 p.m.– 4:00 p.m. (see MAA Panels, etc.)

Demonstration Math Circles: Session for Mathematicians, Saturday, 9:00 a.m.–9:55 a.m., and Session for Students, Saturday, 10:00 a.m.–10:55 a.m. (see MAA Panels, etc.)

Math Wrangle, Saturday, 1:30 p.m.–2:30 p.m. (see MAA Panels, etc.)

Philosophy of Mathematics: POM SIGMAA

Philosophy, Mathematics, and Progress, Friday afternoon. (see MAA Contributed Paper Sessions)

Reception, Friday, 5:30 p.m.–6:00 p.m.

Business Meeting, Friday, 6:00 p.m.–6:30 p.m.

Guest Lecture, Friday, 6:30 p.m.–7:30 p.m., by **Mark Balaguer**, California State University at Los Angeles, *A Guide for the Perplexed: What Mathematicians Need to Know to Understand Philosophers of Mathematics.*

Quantitative Literacy: SIGMAA QL

Student Success in Quantitative Reasoning, Thursday afternoon. (see MAA Contributed Paper Sessions)

A Survey of Quantitative Literacy Teaching Resources, Wednesday, 9:00 a.m.–10:20 a.m. (See MAA Panels, etc.)

Business Meeting, Wednesday, 5:00 p.m.–6:00 p.m.

Research in Undergraduate Mathematics Education: SIGMAA RUME

Research on the Teaching and Learning of Undergraduate Mathematics, Thursday morning. (see MAA Contributed Paper Sessions)

Business Meeting, Thursday, 5:30 p.m.–7:30 p.m.

Statistics Education: SIGMAA STAT-ED

Adding Modern Ideas to an Introductory Statistics Course, Friday afternoon. (see MAA Contributed Paper Sessions)

Creating and Growing an Applied Statistics Minor Program. Thursday, 10:35 a.m.–11:55 a.m. (see MAA Panels, etc.)

Randomization and Bootstrap Methods in the Introductory Statistics Course, Saturday, 9:00 a.m.–10:20 a.m. (see MAA Panels, etc.)

Reception, Thursday, 5:45 p.m.–6:45 p.m.

Business Meeting, Thursday, 6:45 p.m.–7:45 p.m.

Mathematics Instruction Using the Web: WEB SIGMAA

Using Mobile Communication Devices for Mathematics Education, Friday afternoon. (see MAA Contributed Paper Sessions)

Assessing the Effectiveness of Online Homework, Saturday morning. (see MAA Contributed Paper Sessions)

Business Meeting and Reception, Friday, 5:00 p.m.–5:30 p.m.

Guest Lecture, Friday, 5:30 p.m.–6:30 p.m., **Davide Cervone**, Union College, *MathJax: The Present and the Future.*

Environmental Mathematics: SIGMAA EM

Energy, Population, and Sustainability, Thursday morning and afternoon. (see MAA Invited Paper Sessions)

Integrating The Mathematics of Planet Earth 2013 in the College Mathematics Curriculum, Wednesday afternoon, (see MAA Contributed Paper Sessions)

Business Meeting, Wednesday, 5:00 p.m.– 6:00 p.m.

MAA Sessions for Students

Grad School Fair, Friday, 8:30 a.m.–10:30 a.m. Here is the opportunity for undergrads to meet representatives from mathematical sciences graduate programs from universities all over the country. January is a great time for juniors to learn more, and college seniors may still be able to refine their search. This is your chance for one-stop shopping in the graduate school market. At last year's meeting about 300 students met with representatives from 50 graduate programs. If your school has a graduate program and you are interested in participating, a table will be provided for your posters and printed materials for US$70 (registration for this event must be made by a person already registered for the JMM), and you are welcome to personally speak to interested students. Complimentary coffee will be served. Cosponsored by the AMS and MAA.

MAA Lecture for Students, Friday, 1:00 p.m.–1:50 p.m., will be given by **Judith Covington**, Louisiana State University Shreveport, on *The game of SET and geometry*.

Undergraduate Student Poster Session, Friday, 3:30 p.m.–5:30 p.m., organized by **Joyati Debnath**, Winona State University. The session is reserved to undergraduates and first-year graduate students submitting posters on work done while undergraduates. Abstracts are accepted on a first-come basis. Space is limited and students are encouraged to apply early. See `http://www.maa.org/students/undergrad/jmmposterindex.html` for pertinent details, including a link to the abstracts submission form. Examples of poster topics include a new result, a different proof of a known theorem, an innovative solution of a Putnam problem, a new mathematical model, or method of solution of an applied problem. Purely expository posters cannot be accepted. Prizes will be awarded to the top-rated posters with money provided by the AMS, MAA, AWM, CUR, PME, the Educational Advancement Foundation, and the MAA Committee on Undergraduate Student Activities and Chapters (CUSAC). Participants must be available for setting up their posters from noon to 1:00 p.m. and then from 2:30 p.m. to 4:00 p.m. to answer questions from the judges. The general public will be allowed in from 3:30 p.m. to 5:30 p.m. Questions regarding this session should be directed to the session organizer at `jdebnath@winona.edu`. The deadline for proposals is **October 28, 2011**.

Some more advanced students might be interested in these sessions where full descriptions are listed in the MAA Panels, etc. section: **What Every Student Should Know About the JMM**, Wednesday at 2:15 p.m.; **YMN/Project NExT Poster Session**, Wednesday at 2:15 p.m.; **Career Options for Undergraduate Mathematics Majors**, Thursday at 9:00 a.m.; **On-Campus Interview Survival Guide**, Thursday at 10:35 a.m.; **Graduate School: Choosing One, Getting In, Staying In**, Thursday at 1:00 p.m.; **Career Options for Undergraduate Mathematics Majors**, Thursday at 1:00 p.m.; **You Published Your Dissertation, Now What?**, Thursday at 2:40 p.m.; **Parental and Family Leave for Graduate Students and Post-docs: Policies and Experiences**, Friday at 1:00 p.m. You may also be interested in the **AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs** on Friday and Saturday afternoons, listed in the "AMS Special Sessions" section.

Also see the "Social Events" section for the open hours of the **Student Hospitality Center**, **Reception for Undergraduates**, and **Reception for Graduate Students and First-Time Participants**.

MAA Short Course

This two-day Short course on *Conceptual Climate Models* is organized by **Anna Barry**, Institute for Mathematics and Its Applications; **Hans Kaper**, Georgetown University; **Richard McGehee**, University of Minnesota; **Samantha Oestreicher**, University of Minnesota; **Esther Widiasih**, University of Arizona; and **Mary Lou Zeeman**, Bowdoin College. The presenters will introduce various conceptual models of the Earth's climate system. The first day will be devoted to Energy Balance Models (EBMs)—differential equations that express the physical law of energy conservation in mathematical terms. It will be shown how the models can be modified to include the effects of greenhouse gases and the ice-albedo feedback mechanism. The second day will be devoted to paleoclimate studies. It will be shown how observational data from the paleoclimate record and computational data from simulations of the Earth's orbit during the Pliocene and Pleistocene can be incorporated into EBMs.

During this course, participants will have the opportunity to conduct hands-on simulations with models to explore the interplay between energy balance, ice-albedo feedback, Milankovitch cycles in Earth's orbit, and other feedback mechanisms. This will build insight into which features of the paleoclimate record can be explained by the dynamics of low-dimensional conceptual models. Modules for bringing the material into a range of core undergraduate mathematics classes will be provided.

For more details, see the Joint Mathematics Meetings website at `http://jointmathematicsmeetings.org/`. There are separate registration fees to participate in this Short Course. See the fee schedule on the registration form at the back of this issue or visit `http://jointmathematicsmeetings.org/meetings/national/jmm2013/2141_regfees.html`.

Other MAA Events

Board of Governors, Tuesday, 9:00 a.m.–5:00 p.m.

Section Officers, chaired by **Rick Gillman**, Valparaiso University; Wednesday, 4:00 p.m.–5:00 p.m.

Business Meeting, Saturday, 11:10 a.m.–11:40 a.m., chaired by MAA President **Paul Zorn**, Saint Olaf College.

Department Liaisons Meeting, Wednesday, 9:30 a.m.–11:00 a.m.

Minority Chairs Meeting, Saturday, 7:30 a.m.

See the listings for various receptions in the Social Events section.

MAA Ancillary Workshops

These workshops have been scheduled for Tuesday, January 8, the day before the Joint Meetings actually begins, cosponsored by the MAA and the Consortium for the Advancement of Undergraduate Statistics Education (CAUSE).

Space in each workshop is limited. Please note there are no registration fees but you must register in advance and that **walk-ins will not be accommodated**. All participants will receive notification of acceptance, or, whether the course is full. Participants are responsible for their own transportation, lodging, and parking expenses.

Functions, Parameters, and Fitting for Teaching Calculus, presented by **Daniel Kaplan**, Macalester College, **Randall Pruim**, Calvin College; Tuesday, 9:00 a.m.–4:00 p.m. This one-day workshop is designed to help instructors move toward teaching introductory calculus in a modeling- and data-oriented way. The parameters of basic functions are often treated casually in introductory calculus, as if they were a nuisance or merely fodder for the chain rule. In the first half of the workshop, we'll show how to interpret them physically, how to relate them to data, and how to use them for model building. The second half emphasizes polynomial approximation, the relationship between Taylor series and model fitting, and model building using information about derivatives. A small, general purpose mathematical toolkit suffices to build and interpret compelling models in a very wide range of settings spanning economics, biology, physics, etc. We'll provide in-class activities, assignments, student project topics, and example exam questions. Both paper-and-pencil as well as computer-oriented approaches (using R, Sage, or Mathematica) will be featured, drawing on the materials developed through the NSF-supported Project MOSAIC, which aims to construct strong connections in teaching modeling, calculus, statistics, and computation. The workshop is an outreach activity of Project MOSAIC (NSF DUE-0920350) as well as CAUSE—the Consortium for the Advancement of Undergraduate Statistics.

Participants are strongly encouraged to bring a laptop. If you don't currently use software for teaching calculus, we'll set you up with the free R system running through a web browser. Lunch will be provided. Space is limited and advance registration is required through `http://www.causeweb.org/workshop/jmm13_mosaic/`.

Identifying and Addressing Difficult Concepts for Students in the Introductory Statistics Course, presented by **Marjorie Bond**, Monmouth College; Tuesday, 8:30 a.m.–4:30 p.m. We know that students have difficulty with certain topics in statistics, and it can be difficult to determine the best approach to take to help our students work through these topics. In this workshop, we take a selection of difficult concepts, zoom in on exactly what the problems are from the student's point of view, and examine where, when, and how to address them in our course. Along the way, we will examine these difficult statistical concepts in detail, and look for common threads that may even lead us back to issues from Chapter 1. The workshop will also discuss the Guidelines for Assessment and Instruction in Statistics Education (GAISE) objectives for a statistically educated citizen. The workshop is particularly geared toward instructors at two-year colleges. Instructors new to teaching statistics as well those who have been teaching for a while will find the workshop beneficial. Supported by NSF DUE #0942924 & 0942456. The workshop is an outreach activity of CAUSE—the Consortium for the Advancement of Undergraduate Statistics.

Advance registration is required through `http://www.causeweb.org/workshop/jmm13_concepts/`. Space is limited. Workshop participants are encouraged to bring their own fully charged laptops for this workshop. Lunch will be provided.

Playing Games with a Purpose: A New Approach to Teaching and Learning Statistics, presented by **Shonda Kuiper**, Grinnell College, and **Rod Sturdivant**, U.S. Military Academy; Tuesday, 9:00 a.m.–4:00 p.m. This one-day workshop is designed to help instructors and students bridge the gap between short, traditional homework questions towards the open-ended nature of a real-world problem. Web-based games and other materials will be demonstrated that introduce undergraduates to statistical methods from a variety of disciplines. The materials demonstrated in this workshop encourage students early in their undergraduate studies to experience the role of a research scientist and to understand how statistics help advance scientific knowledge. By making students grapple with intriguing real-world problems that demonstrate the intellectual content and broad applicability of statistics as a discipline, these materials encourage students to incorporate statistical thinking into any career. This workshop will provide materials that can be used as projects in an introductory statistics course, synthesize key elements learned throughout a second statistics course, form the basis of an individual research project, or used to help students and researchers in other disciplines better understand how statisticians approach the scientific process. These materials were developed through the NSF-supported grants (NSF DUE #0510392 and NSF DUE #1043814). The workshop is an outreach activity of CAUSE—the Consortium for the Advancement of Undergraduate Statistics.

Participants should bring their own fully-charged laptops for this workshop. Space is limited. Advance registration is required through `http://www.causeweb.org/workshop/jmm13_games/`.

Activities of Other Organizations

This section includes scientific sessions. Several organizations or special groups are having receptions or other social events. Please see the "Social Events" section of this announcement for details.

Association for Symbolic Logic (ASL)

This-two day program on Friday and Saturday will include sessions of contributed papers as well as Invited Addresses by **Bradd Hart**, McMaster University; **Philipp Hieronymi**, University of Illinois at Urbana-Champaign; **Peter Koellner**, Harvard University; **Colin McLarty**, Case Western Reserve University; **Justin Moore**, Cornell

University; **Itay Neeman**, University of California Los Angeles; and **Christian Rosendal**, University of Illinois at Chicago.

See also the session cosponsored by the ASL, *Effective Algebra and Model Theory,* on Wednesday and Thursday in the "AMS Special Sessions" listings.

Association for Women in Mathematics (AWM)

Thirty-Fourth Annual Noether Lecture, Thursday, 10:05 a.m., will be given by **Raman Parimala**, Emory University, *A Hasse principle for quadratic forms over function fields.*

Also see the session on **The Brauer Group in Algebra and Geometry**, jointly sponsored by the AWM, in the "AMS Special Sessions" listings.

The Retention of Women in Mathematics, organized by **Ami Radunskaya**, Pomona College, and **Christina Sormani**, City University of New York; Wednesday, 2:15 p.m.–3:40 p.m. This panel is being organized in response to an article in *Science* entitled "Survival Analysis of Faculty Retention in Science and Engineering by Gender", in which it was reported that the survival rate for women assistant professors in mathematics is only 4.45 years. Panelists **Julie Bergner**, University of California, Riverside; **Andrea Bertozzi**, University of California, Los Angeles; **Estela Gavosto**, University of Kansas; **Douglas Haynes**, University of California, Irvine; **Lisette de Pillis**, Harvey Mudd College; and **Chuu-Lian Terng**, University of California, San Diego; are all from departments and universities which have successfully attracted and supported women through the tenure process. They will describe the methods that worked for them. Audience members are welcome to bring in suggestions of their own. The panel will have an online component located at `https://sites.google.com/site/awmpanel2013/` where all suggestions will be posted. The panel will be moderated by **Cheryl Geisler**, Simon Fraser University. The online moderator is **Christina Sormani**.

Business Meeting, Wednesday, 3:45 p.m.–4:15 p.m.

Workshop Poster Presentations and Reception, Friday, 6:00 p.m. - 7:15 p.m. With funding from the National Security Agency, AWM will conduct its workshop poster presentations by women graduate students.

Workshop on Number Theory, Saturday, 8:00 a.m.–5:50 p.m. With funding from the National Security Agency, AWM will conduct its workshop with presentations by senior and junior women researchers; all talks will be listed in the meeting program. Graduate student posters from Friday's AWM Poster Presentation will also be on display. All mathematicians (female and male) are invited to attend the entire program. Departments are urged to help graduate students and recent Ph.D.s who do not receive funding to obtain some institutional support to attend the workshop and other meeting sessions. Updated information about the workshop is available at `www.awm-math.org/workshops.html`. AWM seeks volunteers to serve as mentors for workshop participants. If you are interested, please contact the AWM office; inquiries regarding future workshops may be made to the office at `awm@awm-math.org`.

Reception, Wednesday, 9:30 p.m.–11:00 p.m. See the listing in the "Social Events," section of the announcement.

National Association of Mathematicians (NAM)

Granville-Brown-Haynes Session of Presentations by Recent Doctorial Recipients in the Mathematical Sciences, Friday, 1:00 p.m.–4:00 p.m.

Cox-Talbot Address, to be given Friday after the banquet, speaker and title to be announced.

Panel Discussion, Saturday, 9:00 a.m.-9:50 a.m., title to be announced.

Business Meeting, Saturday, 10:00 a.m.-10:50 a.m.

Claytor-Woodward Lecture, Saturday, 1:00 p.m., speaker and title to be announced.

See details about the banquet on Friday in the "Social Events" section.

National Science Foundation (NSF)

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

Pi Mu Epsilon (PME)

Council Meeting, Friday, 8:00 a.m.–11:00 a.m.

Rocky Mountain Mathematics Consortium (RMMC)

Board of Directors Meeting, Friday, 2:15 p.m.–4:10 p.m.

Society for Industrial and Applied Mathematics (SIAM)

This program consists of an Invited Address at 11:10 a.m. on Thursday given by **Adrian Nachman**, University of Toronto, *Inverse problems with minimal interior measurements,* and a series of Minisymposia on these topics:

Applied, Computational, and Discrete Mathematics at National Laboratories and Federal Research Agencies, **Rick Chartand**, Los Alamos National Lab; **Gary Hewer**, Naval Air Warfare Center Weapons Division, China Lake; **Zuhair Nashed**, University of Central Florida; and **Luminita Vese**, University of California Los Angeles, Friday afternoon.

Hybrid Inverse Problems in Medical Imaging, **Adrian Nachman**, University of Toronto; Thursday afternoon.

Integer Programming and Combinatorial Optimization, **Jesus De Loera**, University of California, Davis; Saturday morning.

Inverse Problems and Signal Processing, **Zuhair Nashed**, University of Central Florida, Friday morning.

Mathematical Models and Fast Algorithms in Imaging Sciences, **Yonggang Shi**, University of California Los Angeles; **Xue-Cheng Tai**, University of Bergen; **Luminita Vese**, University of California Los Angeles, Wednesday morning.

Modeling Across the Curriculum: Bringing Relevance to Middle, High School, and Early Undergraduate Math Experiences, **Kate Fowler**, Clarkson University; **Suzanne Lenhart**, University of Tennesee, Knoxville; and **Peter Turner**, Clarkson University; Thursday morning.

Perspectives from Industry, **Luminita Vese**, University of California Los Angeles, Saturday afternoon.

Vistas in Applied, Computational, and Discrete Mathematics, **Zuhair Nashed**, University of Central Florida, and **Luminita Vese**, University of California Los Angeles, Wednesday afternoon.

Young Mathematicians Network (YMN)

Open Forum, Thursday, 7:30 p.m.–8:30 p.m., organized by **Josh Laison**, Willamette University; **Elizabeth Moseman**, National Institute of Standards and Technology; and **Thomas Wakefield**, Youngstown State University. All meeting participants, especially undergraduates and graduate students, and early career mathematicians are invited to discuss topics and issues affecting young mathematicians.

Also see details about other sessions cosponsored by the YMN in the MAA Panels, etc. section: *Project NExT-YMN Poster Session,* Wednesday, 2:15 p.m.; *Published or Perished: Life After the Tenure Decision*, Wednesday, 3:50 p.m.; *Career Options for Undergraduate Mathematics Majors*, Thursday, 9:00 a.m.; *On-Campus Interview Survival Guide*, Thursday, 10:35 a.m.; *Graduate School: Choosing One, Getting In, Staying In*, Thursday, 1:00 p.m.; and *You Published Your Dissertation, Now What?*, Thursday, 2:40 p.m.

Others

Mathematical Art Exhibition, organized by **Robert Fathauer**, Tessellations Company; **Nathaniel A. Friedman**, ISAMA and SUNY Albany, **Anne Burns**, Long Island University C. W. Post University, **Reza Sarhangi**, Towson University, and **Nathan Selikoff**, Digital Awakening Studios. A popular feature at the Joint Mathematics Meetings, this exhibition provides a break in your day. On display are works in various media by artists who are inspired by mathematics and by mathematicians who use visual art to express their findings. Topology, fractals, polyhedra, and tiling are some of the ideas at play here. Don't miss this unique opportunity for a different perspective on mathematics. The exhibition will be located inside the Joint Mathematics Exhibits and open during the same exhibit hours.

Summer Program for Women in Mathematics (SPWM) Reunion, organized by **Murli M. Gupta**, George Washington University, Thursday, 9:00 a.m.–noon. This is a reunion of the participants from our past 18 years who are in various states in their mathematical careers: some are students (undergraduate or graduate), others are in various jobs, both in academia as well as government and industry. The participants will describe their experiences relating to all aspects of their careers, and a few will give talks on the research areas they are exploring. See `http://www.gwu.edu/~spwm`.

You Are Promoted! Great, What Is Next?, moderated by **K. Renee Fister**, Murray State University; Thursday, 1:00 p.m.–2:30 p.m. Panelists **Christina Sormani**, Lehman College; **Catherine Roberts**, College of the Holy Cross; **Suzanne Lenhart**, University of Tennessee, Knoxville; and **Michael Dorff**, Brigham Young University; will focus on viable options that women and men can examine in the mid-career phases of their academic and industrial jobs. Panelists and audience members have the opportunity to share perspectives and lessons learned. There exist many instances in which people have moved forward into administration and/or other managerial opportunities. As this may not be the best option for many, this panel will discuss strategies to help target those next steps for one's career.

The session will involve a panel discussion and then a group break-out session in which each group focuses on a general question relating to this topic. Discussion will involve how tenured women and men in academia and managers in industrial settings can become active in mentoring their junior colleagues and how recently promoted people can seek out mentors from senior colleagues for assistance. Another discussion topic will relate to the pressures to which tenured women and women in industrial leadership roles are encouraged to sculpt out time for additional administrative responsibilities that may inhibit further promotions. Sponsored by the Joint Committee on Women in the Mathematical Sciences.

The Mathematical Sciences in 2025, presented by **Tom Everhart**, California Institute of Technology, and **Mark Green**, University of California, Los Angeles, Thursday, 3:00 p.m.–4:00 p.m . The National Academies undertook a study assessing the current state of the mathematical sciences and of emerging trends that will affect the discipline and its stakeholders as they look ahead to the quarter century mark. Specifically, the study addressed the following topics: 1) the vitality of research in the mathematical sciences, looking at such aspects as the unity and coherence of research, significance of recent developments, rate of progress at the frontiers, and emerging trends; 2) the impact of research and training in the mathematical sciences on science and engineering; on industry and technology; on innovation and economic competitiveness; on national security; and other areas of national interest. The study will make recommendations to NSF's Division of Mathematical Sciences on how to adjust its portfolio of activities to improve the vitality and impact of the discipline. The presenters will discuss the major results, key findings, and recommendations of their study and answer questions. Sponsored by the Board on Mathematical Sciences and Their Applications.

Social Events

All events listed are open to all registered participants. It is strongly recommended that for any event requiring a ticket, tickets should be purchased through advance registration. Only a very limited number of tickets, if any, will be available for sale on site. If you must cancel your participation in a ticketed event, you may request a 50% refund by returning your tickets to the Mathematics Meetings Service Bureau (MMSB) by **December 27**. After that date no refunds can be made. Special meals are available at banquets upon advance request, but this must be indicated on the Advanced Registration/Housing Form.

AMS 125th Anniversary Gala: In 2013, the American Mathematical Society celebrates its 125th Anniversary. To launch the year-long festivities, the AMS invites its members

and friends to a celebratory dinner. Gourmet food stations and musical accompaniment will complement the special program. The Gala will be held this year in place of the traditional banquet on Saturday evening at 7:30 p.m. Tickets are US$62 including tax and gratuity. The Gala will be preceded by a reception at 6:30 p.m.

Association of Christians in the Mathematical Sciences (ACMS) Reception and Guest Lecture, Thursday, 5:30 p.m.–7:30 p.m. The reception will take place between 5:30 p.m. and 6:30 p.m. and will be followed by a talk at 6:30 p.m. from **Mike Orrison**, Harvey Mudd College, on *Community, complexity, and contradiction,* and students are especially encouraged to attend. An opportunity will be provided afterwards for delegates to go to dinner at local restaurants in small groups.

Annual Association of Lesbian, Gay, Bisexual, and Transgendered Mathematicians Reception, Thursday, 6:00 p.m.–8:00 p.m. All are welcome to attend this open reception affiliated with NOGLSTP, the National Organization of Gay and Lesbian Scientists and Technical Professionals, Inc.

AWM Reception: This open reception takes place on Wednesday at 9:30 p.m. after the AMS Gibbs Lecture and has been a popular, well-attended event in the past. AWM will recognize all of the honorees of the Alice T. Schaffer Prize for Excellence in Mathematics by an Undergraduate Woman. Note that formal prizewinner announcements are made at the Joint Prize Session on Thursday afternoon. Reception attendees are invited to participate in a networking activity based on the game SET which will provide opportunities to meet new people and have added fun at the reception.

Budapest Semesters in Mathematics Annual Alumni Reunion, Thursday, 5:30 p.m.–7:00 p.m. All alumni, family, and spouses are welcome to attend.

Reception for Graduate Students and First-Time Participants, Wednesday, 5:30 p.m.–6:30 p.m. The AMS and MAA cosponsor this social hour. Graduate students and first-timers are especially encouraged to come and meet some old-timers to pick up a few tips on how to survive the environment of a large meeting. Light refreshments will be served.

University of Illinois at Urbana-Champaign, Department of Mathematics Alumni Reception, Friday, 5:30 p.m.–7:30 p.m. Everyone ever connected with the department is encouraged to get together for conversation and to hear about mathematics at the University of Illinois.

Knitting Circle, Thursday, 8:15 p.m.–9:45 p.m. Bring a project (knitting/crochet/tatting/beading/etc.) and chat with other mathematical crafters!

MAA/Project NExT Reception, Friday, 8:30 p.m.–10:30 p.m.; organized by **Julia Barnes**, Western Carolina University Shreveport; **Judith Covington**, Louisiana State University; **Matthew DeLong**, Taylor University; and **Aparna W. Higgins**, University of Dayton; and. All Project NExT Fellows, consultants, and other friends of Project NExT are invited.

MAA Two-Year College Reception, Wednesday, 5:45 p.m.–7:00 p.m., is open to all meeting participants, particularly two-year faculty members. This is a great opportunity to meet old friends and make some new ones. There will be hot and cold refreshments and a cash bar.

***Mathematical Reviews* Reception**, Friday, 6:00 p.m.–7:00 p.m. All friends of the *Mathematical Reviews* (MR) are invited to join reviewers and MR editors and staff (past and present) for a reception in honor of all of the efforts that go into the creation and publication of the *Mathematical Reviews* database. Refreshments will be served.

Mathematical Institutes Open House, Wednesday, 5:30 p.m.–8:00 p.m. Participants are warmly invited to attend this open house which is co-sponsored by several of the mathematical science institutes in North America. This reception precedes the Gibbs Lecture. Come find out about the latest activities and programs at each of the institutes that may be suited to your own research.

MER/IME Banquet, Thursday, 6:30 p.m.–9:30 p.m. The Mathematicians and Education Reform (MER) Forum and the Institute for Mathematics and Education (IME) welcome all mathematicians who are interested in precollege, undergraduate, and/or graduate educational issues to attend the MER/IME banquet on Thursday evening. This is an opportunity to make or renew contacts with other mathematicians who are involved in education projects and to engage in lively conversation about educational issues. The after-dinner discussion is an open forum for participants to voice their impressions, observations, and analyses of the current education scene. There will be a cash bar beginning at 6:30 p.m.; dinner will be served at 7:30 p.m. Tickets are US$65 each, including tax and gratuity.

National Association of Mathematicians Banquet, Friday, 6:00 p.m.–8:40 p.m. A cash bar reception will be held at 6:00 p.m., and dinner will be served at 6:30 p.m. Tickets are US$62 each, including tax and gratuity. The Cox-Talbot Invited Address will be given after the dinner.

NSA Women in Mathematics Society Networking Session, Thursday, 6:00 p.m.–8:00 p.m. All participants are welcome to this annual event. Please stop by the NSA booth in the exhibit hall for the exact location.

Pennsylvania State University Mathematics Alumni Reception, Wednesday, 6:30 p.m.–8:15 p.m. Please join us for hors d'oeuvres and beverages and mingle with math alumni, faculty, and College of Science representatives.

Student Hospitality Center, Wednesday–Friday, 9:00 a.m.–5:00 p.m., and Saturday, 9:00 a.m.–3:00 p.m., organized by **Richard** and **Araceli Neal**, American Society for the Communication of Mathematics.

Reception for Undergraduates, Wednesday, 4:00 p.m.–5:00 p.m.

Other Events of Interest

AMS Information Booth: All meetings participants are invited to visit the AMS Information Booth during the meetings. A special gift will be available for participants, compliments of the AMS. AMS staff will be at the booth to answer questions about AMS programs and membership.

Book Sales and Exhibits: All participants are encouraged to visit the book, education media, and software exhibits from 12:15 p.m.–5:30 p.m. on Wednesday, 9:30

a.m.–5:30 p.m. on Thursday and Friday, and 9:00 a.m.–noon on Saturday. Books published by the AMS and MAA will be sold at discounted prices somewhat below the cost for the same books purchased by mail. These discounts will be available only to registered participants wearing the official meetings badge. Participants visiting the exhibits are required to display their meetings badge in order to enter the exhibit area.

The MAA and the AMS cordially invite all registered participants to enjoy complimentary tea and coffee while perusing the associations' booths.

Mathematical Sciences Employment Center: Those wishing to participate in the Mathematical Sciences Employment Center should read carefully the important article about the center beginning on page 1317 in this issue of *Notices* or at `http://www.ams.org/emp-reg/`. Employers should pay the appropriate fees; there are no fees for applicants to participate, except that all Employment Center participants must also register for the Joint Mathematics Meetings (JMM). Official meeting badges are required to enter the Employment Center.

Networking Opportunities: There are many opportunities to meet new friends and greet old acquaintances in addition to the vast array of scientific sessions offered at these meetings. These opportunities are listed on the networking page at `jointmathematicsmeetings.org/2141_newcomers.html`.

First-Time Participants: A special welcome is extended to all new participants of these meetings. For your convenience tips on how to navigate the meetings are found at the newcomers' page at `jointmathematicsmeetings/2141_newcomers.html`. You may want to investigate the many receptions listed in the "Social Events" section, the Student Hospitality Center, and the Employment Center. On site you will find a Networking Center featuring casual seating, and lists of registered participants sorted by school and math subject classification will be available for your perusal. This is a great place to relax between sessions and forge new friendships.

Registering in Advance

The importance of advance registration cannot be overemphasized. Advance registration fees are considerably lower than onsite registration fees. The AMS and the MAA encourage all participants to register for the meeting. When you pay the registration fee, you are helping to support a wide range of activities associated with planning, organizing, and execution of the meetings. Participants who register by **November 19** may receive their badges, programs, and tickets (where applicable) in advance by U.S. mail approximately three weeks before the meetings. Those who do not want their materials mailed should check the appropriate box on the Advance Registration/Housing (ARH) Form. However, materials will not be mailed to Canada or overseas due to delays. These participants must pick up their materials at Registration Assistance Desk at the meetings. Please note that a US$5 replacement fee will be charged for programs and badges that were mailed but not taken to San Diego.

Acknowledgments of registrations will be sent by email to the email addresses given on the ARH Form. If you do not wish your registration acknowledged by email, please mark the appropriate box on the ARH form.

Advance registration forms accompanied by insufficient payment will be returned and a US$5 charge will be assessed if an invoice must be prepared to collect the delinquent amount. Overpayments of less than US$5 will not be refunded.

For each invalid check or credit card transaction that results in an insufficient payment for registration or housing, a US$5 charge will be assessed. Participants should check with their tax preparers for applicable deductions for education expenses as they pertain to these meetings.

If you wish to be included in a list of individuals sorted by mathematical interest, please provide the one mathematics subject classification number of your major area of interest on the ARH Form. (A list of these numbers is available by sending an empty email message to `abs-submit@ams.org`; include the number 1086 as the subject of the message.) Copies of this list will be available in the Networking Center at the meetings. If you do not wish to be included in any mailing list used for promotional purposes, check the appropriate box on the ARH Form.

Online Advance Registration: This service is available for advance registration and hotel reservations at `https://www.jointmathematicsmeetings.org/meetreg?meetnum=2141`. VISA, MasterCard, Discover, and American Express are the only methods of payment which are accepted for online advance registrations, and charges to credit cards will be made in U.S. funds. All online advance registrants will receive acknowledgment of payment upon submission of this completed form.

Paper Form Registration: For your convenience, a copy of the form is available in pdf format at `http://jointmathematicsmeetings.org/meetings/national/jmm2013/jmm13_regform.pdf`. Forms must be mailed or faxed to the MMSB at MMSB, P. O. Box 6887, Providence, RI 02940 or 401-455-4004. For your security, we do not accept credit card numbers by email or fax. If you are registering by paper form and wish to pay for your registration or guarantee your hotel reservation by credit card, please indicate on the form and someone from the MMSB will contact you by phone.

Cancellation Policy: Participants who cancel their advance registration for the meetings, minicourses, or short courses by **January 4, 2013**, will be eligible to receive a 50% refund of fees paid. Participants who cancel their banquet tickets by **December 27** will receive a 50% refund of monies paid. No refunds will be issued after these dates.

Joint Mathematics Meetings Registration Fees

	by Dec. 17	at meeting
Member of AMS, ASL, CMS, MAA, SIAM	US$235	US$309
Nonmember	367	476
Graduate Student Member of AMS, MAA	52	62
Graduate Student Nonmember	80	91
Undergraduate Student	52	62
Temporarily Employed	191	220

Emeritus Member of AMS, MAA; Unemployed; High School Teacher; Developing Countries; Librarian	52	62
High School Student	5	10
One-Day Member of AMS, ASL, CMS, MAA, SIAM	N/A	168
One-Day Nonmember	N/A	263
Nonmathematician Guest	15	15
MAA Minicourses *if space is available	US$80	US$80*
Grad School Fair Table (table/posterboard/electricity)	US$70	US$70
AMS Short Course		
Member of AMS or MAA	US$104	US$138
Nonmember	150	180
Student/Unemployed/Emeritus	52	73
MAA Short Course		
MAA or AMS Member	US$156	US$166
Nonmember	225	235
Student/Unemployed/Emeritus	78	88

Full-Time Students: Any person who is currently working toward a degree or diploma. Students are asked to determine whether their status can be described as graduate (working toward a degree beyond the bachelor's), undergraduate (working toward a bachelor's degree), or high school (working toward a high school diploma) and to mark the Advance Registration/Housing Form accordingly.

Graduate Student: Any graduate student who is a member of the AMS or MAA. These students should check with their department administrator to check their membership status.

Emeritus: Any person who has been a member of the AMS or MAA for twenty years or more and who retired because of age or long-term disability from his or her latest position.

Librarian: Any librarian who is not a professional mathematician.

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

Developing Country Participant: Any person employed in developing countries where salary levels are radically noncommensurate with those in the U.S.

Temporarily Employed: Any person currently employed but who will become unemployed by June 1, 2013, and who is actively seeking employment.

Nonmathematician Guest: Any family member or friend who is not a mathematician and who is accompanied by a participant in the meetings. These official guests will receive a badge and may accompany a mathematician to a session or talk.

Participants who are not members of the AMS or MAA and register for the meetings as a nonmember will receive mailings after the meetings with special membership offers.

All mathematicians who wish to attend sessions are expected to register and should be prepared to show their badges if so requested. Badges are required to enter the Exhibits and the Employment Center, to obtain discounts at the AMS and MAA Book Sales, and to cash a check with the Joint Meetings cashier.

Advance Registration Deadlines

There are three separate advance registration deadlines, each with its own benefits.

EARLY meetings advance registration (room drawing)	**November 5**
ORDINARY meetings advance registration (hotel reservations, materials mailed)	**November 19**
FINAL meetings advance registration (advance registration, short courses, minicourses, and banquets)	**December 17**

Early Advance Registration: Those who register by the early deadline of **November 5** will be included in a random drawing to select winners of complimentary hotel rooms in San Diego. Multiple occupancy is permissible. The location of rooms to be used in this drawing will be based on the number of complimentary rooms available in the various hotels. Therefore, the free room may not necessarily be in the winner's first-choice hotel. The winners will be notified by mail prior to **December 17**, so register early!

Ordinary Advance Registration: Those who register after **November 5** and by the ordinary deadline of **November 19** may use the housing services offered by the MMSB but are not eligible for the room drawing. You may also elect to receive your badge and program by mail in advance of the meetings.

Final Advance Registration: Those who register after November 19 and by the final deadline of **December 17** must pick up their badges, programs, and any tickets for social events at the meetings. Unfortunately it is sometimes not possible to provide final advance registrants with housing, so registrants are strongly urged to make their hotel reservations by **November 18**. Please note that the **December 17** deadline is firm; any forms received after that date will be returned and full refunds issued. To pick up your materials, please come to the Meetings Registration Desk located inside Exhibit Hall B of the San Diego Convention Center.

Hotel Reservations

The AMS and MAA contract only with facilities who are working toward being in compliance with the public accommodations requirements of ADA. Participants requiring hotel reservations should read the instructions on the following hotel pages.

How to Obtain Hotel Accommodations – 2013 Joint Mathematics Meetings

Importance of Staying in an Official JMM Hotel

The importance of reserving a hotel room at one of the official JMM hotels cannot be stressed enough. The AMS and the MAA make every effort to keep participant expenses at meetings, registration fees, and hotel rooms for the meetings as low as possible. They work hard to negotiate the best hotel rates and to make the best use of your registration dollars to keep the meetings affordable. The AMS and the MAA encourage all participants to register for the meeting. When you pay the registration fee and reserve a room with an official JMM hotel, you are helping to support not only the 2013 JMM, but also future meetings.

General

Participants must register in advance in order to obtain hotel accommodations through the Mathematics Meetings Service Bureau (MMSB). Special rates have been negotiated exclusively for this meeting at the following hotels: San Diego Marquis & Marina, Omni San Diego Hotel, Embassy Suites Hotel San Diego Bay Downtown, Horton Grand Hotel, Residence Inn by Marriott Gaslamp District, Hard Rock Hotel, Best Western Bayside, Residence Inn by Marriott Downtown, Four Points by Sheraton Downtown (formerly Holiday Inn Downtown), Holiday Inn San Diego–On the Bay, and Hampton Inn San Diego Downtown. **Reservations for these hotels must be made through the MMSB to receive JMM rates.** The hotels will not be able to accept reservations directly until after **December 19**. At that time, rooms and rates will be based on availability. Higher rates may be applied to any rooms reserved directly with the hotels before **December 19.**

To reserve a room, please complete the housing section of the Advanced Registration/Housing (ARH) Form by **November 19**. All reservations must be guaranteed by either credit card or check deposit in the total amount of your first night stay. If you use the online form, a credit card number will be required for guarantee. If you use the paper form, a credit card number or check may be given for guarantee. For your security, credit card numbers will not be accepted by postal mail, email, or fax. If you wish to guarantee your room by credit card and are submitting a paper form, the MMSB will call you at the number you provided. The online form is located at **https://www.jointmathematicsmeetings.org/meetreg?meetnum=2141**. The paper form is located at the back of this announcement. Participants interested in suites should contact the MMSB at mmsb@ams.org or 1-800-321-4267 ext. 4137 or ext. 4144 for further information. **Sorry, reservations cannot be taken over the phone.**

Participants should be aware that most hotels are starting to charge a penalty fee to guests for departure changes made before or after guests have checked into their rooms. These hotels are indicated on the next two pages and also at **jointmathematicsmeetings.org/2141_hotelpage.** Participants should also inquire about this at check-in and make their final plans accordingly.

Participants should also be aware that it is general hotel practice in most cities to hold an unguaranteed reservation until 6:00 p.m. only. A hotel reservation is guaranteed by either paying a deposit equivalent to one-night stay or by submitting a credit card number in advance; however, the hotel will usually honor this reservation until checkout time the following day. If the individual holding the reservation has not checked in by that time, the room is then released, and the hotel retains the deposit or applies a room charge to the credit card number submitted which is also equivalent to a one-night stay.

Deadlines

- Complimentary Room Drawing: **November 5**
- Reservations through MMSB: **November 19**
- Changes/Cancellations through MMSB: **December 10**

Complimentary Room Drawing

All participants who register and reserve a room at any of the official JMM hotels by **November 5, 2012**, will automatically be included in a random drawing to select a winner of free room nights in that hotel. The number of drawings is based on the number of complimentary room nights available in the various hotels. Multiple occupancy is permissible. The winners will be drawn at random from the hotel reservation lists and notified by email or phone prior to December 17, 2012. Good luck!

Looking for a Roommate?

For your convenience, a search board has been set up at **http://bboards.jointmathematicsmeetings.org** to help you find a roommate.

Confirmations

All hotels will be sending email confirmations if an email address is provided. Please contact the MMSB after **December 19** if you did not receive a confirmation number.

ADA Accessibility

We strive to take the appropriate steps required to ensure that no individual with a disability is excluded, denied services, segregated or otherwise treated differently. Please tell us what you require to help make your participation more enjoyable and meaningful. If you require special assistance, auxiliary aids or other reasonable accommodations to fully participate in this meeting, please check off the appropriate box on the ARH Form or email the MMSB at mmsb@ams.org. All requests for special accommodations under the Americans with Disabilities Act of 1990 (ADA) must be made allowing enough time for evaluation and appropriate action by the AMS and MAA. Any information obtained about a disability will remain confidential.

Environmental Policies

Most of the hotels have successful "green" programs in place. The Marriott is the recipient of more ENERGY STAR labels than any other hotel company since 2004.

Rates

- All rates are subject to applicable local and state taxes in effect at the time of check-in; currently 10.5% state tax and 2% occupancy tax.
- Only certified students or unemployed mathematicians qualify for student rates.
- See the ARH Form for a detailed breakdown of rates for each hotel.

Cancellation Policies

- Four Points by Sheraton Downtown has a 24-hour cancellation policy prior to check-in. All of the other hotels have a 72-hour cancellation policy prior to check-in.

Guarantee Requirements

- One night deposit by check, or
- Credit cards (online only): Visa, MC, AMEX, Diners, and Discover. For your security, we do not accept credit card numbers by postal mail, email or fax. If you reserve a room by paper form and want to guarantee by credit card, the MMSB will contact you at the phone number you provided.

Check-in/Check-out

Check-in at the San Diego Marriott Marquis & Marina, Embassy Suites, the Marriott Residence Inn Gaslamp District, and the Hard Rock Hotel is 4:00 p.m. Check-in at the other seven hotels is 3:00 p.m. Check-out at each hotel is noon.

Internet Access/Wireless	San Diego Marriott Marquis & Marina (Headquarters)	Omni San Diego Hotel
• **San Diego Marriott Marquis & Marina:** Complimentary wireless available in the lobby and public areas; wired and wireless in guest rooms for a daily rate of US$12.95 • **Omni San Diego Hotel**: Complimentary wireless available in the lobby and public areas; wired and wireless in the guest rooms for a daily rate of US$9.95 • **Embassy Suites Hotel San Diego Bay Downtown**: Complimentary wireless available in the lobby and public areas; wired in guest rooms for a daily rate of US$12.95 • **Horton Grand Hotel**: Wired and wireless available in the guest rooms for a daily rate of US$9.95 • **All other hotels listed on these pages:** Complimentary wired and wireless for all registered guests in all sleeping rooms and all public space.	**.25 miles, connected to the San Diego Convention Center** 333 West Harbor Drive San Diego, CA 92101 Single/Double Rate (City Side): US$184 Single/Double Rate (Bay Side): US$199 Student Single/Double Rate: US$147, City Side Only Smoke-free hotel. Restaurants: Marina Kitchen, The Exchange, Roy's Hawaiian Fusion Cuisine, Tequila Bar & Grille, and Starbucks Coffee; Fitness center; Outdoor heated pool; UPS Store; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Windows open in some guest rooms; Children under 15 free in room with an adult; Cribs available upon request at no charge; Rollaways $20 one time fee; Pets allowed; Valet parking US$36 per day with in/out privileges; Self-parking US$26 per day with in/out privileges, tax included in both parking rates. See the travel section of this announcement for other parking options. **Confirmations sent by email only.**	**1 block from the San Diego Convention Center** 675 L Street San Diego, CA 92101 Single Rate: US$171 Double Rate: US$194 Student Single Rate: US$154 Student Double Rate: US$174 Smoke-free hotel. Restaurants: Morsel's and McCormick & Schmick's; Fitness center; Outdoor heated pool; Business center; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Windows open; Children under 18 free in room with an adult; Cribs available upon request at no charge; Rollaways no charge; Pets allowed (under 40 pounds only); Valet parking ONLY- US$35 per day with in/out privileges, tax included in the parking rate. See the travel section of this announcement for other parking options. **Confirmations sent by email only.**
Embassy Suites Hotel San Diego Bay, Downtown	**Horton Grand Hotel**	**Residence Inn by Marriott Gaslamp District**
4 blocks from the San Diego Convention Center 601 Pacific Highway San Diego, CA 92101 Single/Double Rate: US$155 Student Single/Double Rate: US$135 Smoke-free hotel. Restaurants: Pacific Fish Company Bar & Grill and Starbucks; Business center; Full amenities in guest rooms; Safety deposit boxes available at front desk; Windows open in all rooms, including suites; No pets allowed; Children under 18 free in room with an adult; Cribs available upon request at no charge; Valet parking ONLY- US$29 per day with in/out privileges, no additional tax on parking rate. See the travel section of this announcement for other parking options. **Confirmations sent by email only.**	**8 blocks from the San Diego Convention Center** 311 Island Avenue San Diego, CA 92101 Single/Double Rate: US$155 Student Single/Double Rate: US$145 Smoke-free hotel. No restaurants on property; Room service ONLY- available 5:00 a.m. to 11:00 a.m.; Full amenities in guest rooms; Safety deposit boxes available at the front desk; Windows open in all rooms; Children under 12 free in room with an adult; Cribs available upon request at no charge; Rollaways are not available; No pets allowed; Valet Parking ONLY - US$25 per day with in/out privileges, no additional tax on parking rate. See the travel section of this announcement for other parking options. **Confirmations sent by email only**.	**3 blocks from the San Diego Convention Center** 356 6th Avenue San Diego, CA 92101 Single/Double Rate: US$152 Student Single/Double Rate: US$145 Smoke-free hotel. Restaurant: Bar Vie; Fitness center; Business center; Fully-equipped kitchens in guest rooms; Lock boxes at the front desk; Windows do not open; Children under 18 free in room with an adult; Cribs available upon request at no charge; Rollaways are not available; Small pets allowed; Valet Parking ONLY - US$38 per day with in/out privileges, no additional tax on parking rate. See the travel section of this announcement for other parking options. **Confirmations sent by email only.**

Hard Rock Hotel	Best Western Plus Bayside Inn	Residence Inn by Marriott Downtown
3 blocks from the San Diego Convention Center 207 Fifth Avenue San Diego, CA 92101 Single/Double Rate: US$149 Student Single/Double Rate: US$129 Smoke-free hotel. Restaurants: Float, 207, Mary Jane's, and Nobu; Spa services; Business center; Full amenities in guest rooms; Laptop-size safe in every guest rooms; Windows open in all rooms; Pets allowed; Children under 18 free in room with an adult; Cribs available upon request at no charge; Rollaways not available; Valet parking ONLY - US$37 per day with in/out privileges, no additional tax on parking rate. See the travel section of this announcement for other parking options. **Confirmations sent by email only.**	**10 blocks from the San Diego Convention Center** 555 West Ash Street San Diego, CA 92101 Single/Double Rate: US$129 Student Single/Double Rate: US$119 Smoking rooms available. Restaurant: Bayside Bar & Grill; Full amenities in guest rooms; All rooms have balconies; Laptop-sized safes in guest rooms; Children under 12 free in room with an adult; Cribs available upon request at no charge; Rollaways are limited and are US$10 per day; No pets allowed; Discounted access to local fitness center; Self-parking ONLY - US$14 day with in/out privileges, no additional tax on parking rate. See the travel section of this announcement for other parking options. **Confirmations sent by email only.**	**8 blocks from the San Diego Convention Center** 1747 Pacific Highway San Diego, CA 92101 Single/Double Rate: US$129 Student Single/Double Rate: US$119 Smoke-free hotel. No restaurant on property; Fitness center; Business center; Outdoor pool; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Windows open in all rooms; Children under 12 free in room with an adult; Cribs available upon request at no charge; Rollaways not available; Pets allowed; Self-parking ONLY - US$14 per day with in/out privileges, no additional tax on parking rate. See the travel section of this announcement for other parking options. **Confirmations sent by email only.**
Four Points by Sheraton Downtown (formerly Holiday Inn Downtown)	**Holiday Inn San Diego – On the Bay**	**Hampton Inn San Diego Downtown**
6 blocks from the San Diego Convention Center 1617 First Avenue San Diego, CA 92101 Single/Double Rate: US$125 Student Single/Double Rate: US$115 Smoke-free hotel. Restaurant: First Avenue Grille; Fitness center; Business center; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Windows do not open; Children under 15 free in room with an adult; Cribs available upon request at no charge; Rollaways no charge; Pets are not allowed; Self-parking ONLY - US$17 per day with in/out privileges, no additional tax on parking rate. See the travel section of this announcement for other parking options. **Confirmations sent by email only.**	**1.1 miles from the San Diego Convention Center** 1355 North Harbor Drive San Diego, CA 92101 Single/Double Rate: US$124 Student Single/Double Rate: US$114 Smoke-free hotel. Restaurant: Hazelwood's Bayside Deli, Elephant and Castle Pub, and Ruth's Chris Steakhouse; Fitness center; Outdoor heated pool; Full amenities in guest rooms; Laptop-sized safes located at the front desk; Windows open in all rooms, including suites; Children under 18 free in room with an adult; Cribs available upon request at no charge; Rollaways available for US$10 per night; Pets allowed; Self-parking for US$22 + tax per day with in/out privileges; Valet parking US$28 + tax per day with in/out privileges. See the travel section of this announcement for other parking options. **Confirmations sent by email only.**	**8 blocks from the San Diego Convention Center** 1531 Pacific Highway San Diego, CA 92101 Single/Double Rate: US$109 Student Single/Double Rate: US$99 Smoke-free hotel. Fitness center; Outdoor pool; Business center; Full amenities in guest rooms; No in-room safes; Windows open in all rooms, including suites; Children under 15 free in room with an adult; Cribs available upon request at no charge; Rollaways not available; Pets allowed; Self-parking ONLY - US$12 per day with in/out privileges, no additional tax on parking rate. See the travel section of this announcement for other parking options. **Confirmations sent by email only.**

SAN DIEGO Convention Center

Joint Mathematics Meetings

Jan 9, 2012 to Jun 12, 2012

Hotel

Downtown San Diego

1. San Diego Marriott Marquis & Marina (HQT)
2. Best Western Plus Bayside Inn
3. Embassy Suites Hotel San Diego Bay - Downtown
4. Hampton Inn by Hilton San Diego Downtown
5. Hard Rock Hotel San Diego
6. Holiday Inn San Diego on the Bay
7. Four Points by Sheraton Downtown (formerly Holiday Inn San Diego Downtown)
8. Horton Grand Hotel
9. Omni San Diego Hotel
10. Residence Inn by Marriott San Diego Downtown
11. Residence Inn San Diego Downtown/Gaslamp Quarter

Miscellaneous Information

Audio-Visual Equipment: Standard equipment in all session rooms is one overhead projector and screen. Invited 50-minute speakers are automatically provided with an ELMO visual presenter (document camera/projector), one overhead projector, and a laptop projector; AMS Special Sessions and Contributed Papers, and MAA Invited and Contributed Paper Sessions, are provided with the standard equipment and a laptop projector. Blackboards are not available, nor are Internet hookups in session rooms. Any request for additional equipment should be sent to `meet@ams.org` and **received by November 1**.

Equipment requests made at the meetings most likely will not be granted because of budgetary restrictions. Unfortunately no audio-visual equipment can be provided for committee meetings or other meetings or gatherings not on the scientific program.

Childcare: The AMS and the MAA will again offer childcare services for the Joint Mathematics Meetings to registered participants.

The childcare will be offered through KiddieCorp Children's Program. KiddieCorp is an organization that has been providing high-quality programs for children of all ages at meetings throughout the United States and Canada since 1986. Read all about them at `www.kiddiecorp.com/`.

The childcare services provided at the JMM are for children ages 6 months through 12 years old. Space per day will be limited and is on a space available basis. The dates and times for the program are January 9–12, 2013, 8:00 a.m.–5:00 p.m. each day. It will be located at the Marriott Marina San Diego. If you would like to know how many children will be in the same age group as your child's, please call KiddieCorp. Parents are encouraged to bring snacks and beverages for their children but items such as juice boxes, Cheerios, and crackers will be provided. KiddieCorp can arrange meals for children at cost plus 15% or parents can be responsible for meals for their children. Parents who have questions about specific programs that will be offered or special requests, rules, or needs for their children must call KiddieCorp ahead of time.

Registration starts on **September 1**. The registration fee is US$30 per family (nonrefundable). Additional cost will be US$14 per hour per child or US$10 per hour per child for graduate students. These reduced child care rates are made possible to the meetings participants by the MAA and the AMS, who heavily subsidize the cost of this service, thus keeping this program affordable for families. Parents must be registered for the JMM to participate. Full payment is due at the time of registration with KiddieCorp. Deadline for registering is **December 12, 2012**.

If parents do not pick up their children at the time scheduled or by the end of the day (no later than 5:00 p.m.), they will be charged a late fee of US$5 per child for every 15 minutes thereafter.

Cancellations must be made to KiddieCorp prior to December 12, 2012, for a full refund. Cancellations made after that date will be subject to a 50% cancellation fee. Once the program has begun, no refunds will be issued.

To register, go to `https://www.kiddiecorp.com/jmmkids.htm` or `jointmathematicsmeetings.org/2141_daycare.html`, or call KiddieCorp at 858-455-1718 to request a form.

Email Services: Limited email access for all Joint Meetings participants will be available in an email center located outside Hall B, San Diego Convention Center. The hours of operation will be published in the program. Participants should be aware that **complimentary Internet access** will be available in several (tba) areas of the San Diego Convention Center.

Information Distribution: Tables are set up in the exhibit area for dissemination of general information of possible interest to the members and for the dissemination of information of a mathematical nature not promoting a product or program for sale. Information must be approved by the director of meetings prior to being placed on these tables.

If a person or group wishes to display information of a mathematical nature promoting a product or program for sale, they may do so in the exhibit area at the Joint Books, Journals, and Promotional Materials exhibit for a fee of US$50 (posters are slightly higher) per item. Please contact the exhibits manager, MMSB, P.O. Box 6887, Providence, RI 02940, or by email at `cpd@ams.org` for further details.

The administration of these tables is in the hands of the AMS-MAA Joint Meetings Committee, as are all arrangements for Joint Mathematics Meetings.

Local Information: For information about the city see `www.sandiego.org.`

Petition Table: At the request of the AMS Committee on Human Rights of Mathematicians, a table will be made available in the exhibit area at which petitions on behalf of named individual mathematicians suffering from human rights violations may be displayed and signed by meetings participants acting in their individual capacities. For details contact the director of meetings in the Providence office at 401-455-4145 or by email at `pop@ams.org`.

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

Any material that is not a petition (e.g., advertisements, résumés) will be removed by the staff. At the end of the exhibits on Saturday, any material on the table will be discarded, so individuals placing petitions on the table should be sure to remove them prior to the close of exhibits.

Telephone Messages: It will be possible to leave a message for any registered participant at the meetings registration desk from January 9 through 12 during the hours that the desk is open. These messages will be posted on the Mathematics Meetings Message Board; however,

staff at the desk will try to locate a participant in the event of a bona fide emergency. The telephone number will be published in the program and daily newsletter.

Travel/Transportation

Airline: San Diego is on Pacific Standard Time. The **San Diego International Airport** (SAN, www.san.org) is served by all major airlines and is slightly over three miles from the downtown area and the Convention Center. For reference, the terminal maps of the airport can be seen at www.san.org/sdia/at_the_airport/maps.aspx.

The **official airline** for this meeting is **Delta Airlines**. Participants are encouraged to book their flights for the meeting, where possible, with Delta and receive special pricing (in most cases a 5% discount) on scheduled service to San Diego. Discounts are applicable to U.S./Canada originating passengers. The discount is not valid with other discounts, certificates, coupons or promotional offers. To make a reservation, go to www.Delta.com, and click on the words "Planning Tools". Under "Planning Tools", choose "Book a Flight". On the reservation screen, please enter the Meeting Event Code **NME5G**. It will be to the right of "Number of Passengers". Please note that reservations can also be made by calling Delta at 1-800-329-1111 and giving the meeting ticket designation file number of **NME5G**. However, a US$25 ticketing fee will be levied for not booking online.

Airport Shuttles: Please note that the **Holiday Inn San Diego on the Bay**, the **Residence Inn by Marriott Downtown**, and the **Hampton Inn San Diego Downtown** provide complimentary airport shuttles. Reservations should be made in advance by calling the hotels. Please call the hotel after retrieving your luggage and identify yourself as a person who has a hotel reservation. You will be given a pickup location and an estimated time of arrival.

Shuttle service is available from the airport to the downtown hotels for approximately US$8–11 per person one way and US$16–22 per person round trip from several shuttle companies. Shuttle service is available at the Transportation Plazas across from Terminals 1 and 2, and curbside at the Commuter Terminal. From Terminal 1, cross the skybridge, and take either the escalators or the elevators to street level. From Terminal 2, use the pedestrian crosswalk located outside the baggage claim area to access the Transportation Plaza. A Transportation Coordinator will place you with the first available shuttle, unless you specify a particular shuttle company. There is a list of shuttle companies available at www.san.org/sdia/transportation/default.aspx. Two of the companies are **Advanced Shuttle**, www.advancedshuttle.com, 800-719-3499; and **Cloud 9 Shuttle/Super Shuttle**, www.cloud9shuttle.com/ 800-9-SHUTTLE (619-974-8885). The concierge services at many of the hotels will assist you with a return shuttle.

Car Rental: **Hertz** is the official car rental company for the meeting. To access the JMM special meeting rates at www.hertz.com, please click the box that says "I have a discount" on the reservation screen and type in the JMM convention number (CV): **04N30003**. Reservations can also be made by calling Hertz directly at 800-654-2240 (U.S. and Canada) or 1-405-749-4434. Meeting rates include unlimited mileage and are subject to availability. Advance reservations are recommended and blackout dates may apply. Government surcharges, taxes, tax reimbursement, airport-related fees, vehicle licensing fees and optional items are extra. Standard rental conditions and qualifications apply. Minimum rental age is 20 (age differential charge for 20-24 applies). Vehicles can be returned to most Southern California locations.

The following meeting rates are available for pickups January 2–19, 2013, from all Southern California corporate locations (except Palm Springs):

Car Class	Daily (per day)	Weekend (per day)	Weekly (5-7 days)
A Economy	US$39	US$19	US$169
B Compact	42	21	179
C Midsize	45	23	189
D Standard	50	25	199
F Fullsize 4DR	55	26	209
Q4 Midsize SUV	59	59	249
G Premium	69	69	289
I Luxury	89	89	329
(L, R, U) Standard SUV, Minivan or Convertible	70	70	269
T Large SUV	89	89	489
T6 X-Capacity SUV	99	99	499

Car rental reservation boards are located near the baggage claim areas of Terminals 1 and 2 of the San Diego airport. The courtesy phones there may be used to request shuttle transport to the car rental agencies. Car rental shuttles, however, regularly operate at the Terminal 1 center traffic aisle and at the traffic island at the far west end of Terminal 2 and usually there is no need to call. The free Airport Loop Shuttle service can provide transportation to Terminal 1 or 2 if you arrive at the Commuter Terminal.

Driving Directions from the Airport to the Convention Center: The San Diego Convention Center is located at 111 W. Harbor Drive, San Diego, CA 92101. Upon leaving the airport, drive out of parking lot, and follow signs to Interstate 5/Downtown. The ramp will put you on Harbor Drive going south. Follow signage to the parking entrance for the San Diego Convention Center. For driving directions from other points, see www.visitsandiego.com/maps/. For driving directions to specific hotels, check the hotel map on the Joint Meetings website.

Parking: On-site private vehicle parking is available at the San Diego Convention Center's 1,950-vehicle underground garage which is located below the building. The entrance to the parking garage is on Harbor Drive between First Avenue and Fifth Avenue. The current daily rate is US$11. Parking rates may range from US$11 to US$21 on days when there is special event activity at PETCO Park or other downtown events. Payment is due upon entry and there are no in and out privileges. No overnight or RV parking is permitted. There is a 2,000-space parking structure located directly across the street from the Convention Center on the corner of Harbor and 8th Avenue. Off-site parking is available at numerous nearby parking

lots and garages in downtown San Diego. Many are within walking distance. San Diego's off-street parking map is located at www.ccdc.com/images/stories/downloads/programs/downtown-parking/downtown-off-street-parking.pdf. Helpful local parking information may also be found on the nearby Gaslamp District's website at www.gaslamplocal.com/menu/217/Park.html#PARKING.

Public Transportation: The Metropolitan Transit System Bus Route No. 992 (Airport via Harbor Drive/Cruise Ship Terminal) stops at airport Terminals 1 and 2 and the Commuter Terminal and travels to downtown San Diego. It runs every 15 minutes between 5:00 a.m. and 11:30 p.m. on weekdays and every 30 minutes on weekends. Maps, schedules and a helpful online trip planner (www.sdmts.com/Tripplanner.asp) are available at www.sdmts.com, the website of the San Diego Metropolitan Transit System.

To go to the Convention Center, take the 992 to Broadway and Kettner Boulevard and walk one tenth of a mile to the America Plaza Bus/Trolley Station. Take the Orange Line (Downtown/Conv Ctr) trolley and get off at the Convention Center stop. It is also possible to exit at other stops, such as the one at Broadway and 4th Street near the Gaslamp District, and walk to the Convention Center. For alternate routes and destinations, please check the trip planner. The price is currently US$2.25 one way, exact fare is appreciated. A regional day pass is US$5.

Taxicabs: From the baggage claim area, follow the signs leading to the ground Transportation Plazas, and a Transportation Coordinator will place you with the first available taxi. Taxi fare to the downtown area is approximately US$15 one way.

Train: The San Diego station, Santa Fe Depot (also called Union Station), is located at 1050 Kettner Boulevard. For additional information on Amtrak service to San Diego, call 1-800-USA-RAIL, or visit Amtrak (www.amtrak.com) or Amtrak California (www.amtrakcalifornia.com).

Oxford, Mississippi

University of Mississippi

March 1–3, 2013

Friday – Sunday

Meeting #1087

Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: December 2012
Program first available on AMS website: December 13, 2012
Program issue of electronic *Notices*: March 2013
Issue of *Abstracts*: Volume 34, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: October 16, 2012
For abstracts: December 4, 2012

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Patricia Hersh, North Carolina State University, *Title to be announced.*

Daniel Krashen, University of Georgia, *Title to be announced.*

Washington Mio, Florida State University, *Title to be announced.*

Slawomir Solecki, University of Illinois at Urbana-Champaign, *Title to be announced.*

Special Sessions

Algebraic Combinatorics (Code: SS 1A), **Patricia Hersh**, North Carolina State University, and **Dennis Stanton**, University of Minnesota.

Approximation Theory and Orthogonal Polynomials (Code: SS 5A), **David Benko**, University of South Alabama, **Erwin Mina-Diaz**, University of Mississippi, and **Edward Saff**, Vanderbilt University.

Banach Spaces and Operators on Them (Code: SS 4A), **Qingying Bu** and **Gerard Buskes**, University of Mississippi, and **William B. Johnson** and **Thomas Schlumprecht**, Texas A&M University.

Commutative Algebra (Code: SS 3A), **Sean Sather-Wagstaff**, North Dakota State University, and **Sandra M. Spiroff**, University of Mississippi.

Fractal Geometry and Ergodic Theory (Code: SS 2A), **Manav Das**, University of Louisville, and **Mrinal Kanti Roychowdhury**, University of Texas-Pan American.

Chestnut Hill, Massachusetts

Boston College

April 6–7, 2013

Saturday – Sunday

Meeting #1088

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2013
Program first available on AMS website: February 21, 2013
Program issue of electronic *Notices*: April 2013
Issue of *Abstracts*: Volume 34, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 18, 2012
For abstracts: February 12, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Roman Bezrukavnikov, Massachusetts Institute of Technology, *Title to be announced.*

Marston Conder, University of Auckland, *Title to be announced.*

Alice Guionnet, Ecole Normale Supérieure de Lyon, *Title to be announced.*

Yanir Rubinstein, Stanford University, *Title to be announced.*

Special Sessions

Algebraic and Geometric Structures of 3-manifolds (Code: SS 3A), **Ian Biringer**, Yale University, and **Tao Li** and **Robert Meyerhoff**, Boston College.

Complex Geometry and Microlocal Analysis (Code: SS 2A), **Victor W. Guillemin** and **Richard B. Melrose**, Massachusetts Institute of Technology, and **Yanir A. Rubinstein**, Stanford University.

Homological Invariants in Low-dimensional Topology. (Code: SS 1A), **John Baldwin**, **Joshua Greene**, and **Eli Grigsby**, Boston College.

Moduli Spaces in Algebraic Geometry (Code: SS 4A), **Dawei Chen** and **Maksym Fedorchuk**, Boston College, and **Joe Harris** and **Yu-Jong Tzeng**, Harvard University.

Boulder, Colorado

University of Colorado Boulder

April 13–14, 2013

Saturday – Sunday

Meeting #1089

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: January 2013
Program first available on AMS website: February 28, 2013
Program issue of electronic *Notices*: April 2013
Issue of *Abstracts*: Volume 34, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 26, 2012
For abstracts: February 19, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Gunnar Carlsson, Stanford University, *Title to be announced.*

Jesus A. De Loera, University of California, Davis, *Title to be announced.*

Brendan Hassett, Rice University, *Title to be announced.*

Raphael Rouquier, University of California Los Angeles, *Title to be announced.*

Special Sessions

Algebras, Lattices and Varieties (Code: SS 5A), **Keith A. Kearnes** and **Ágnes Szendrei**, University of Colorado, Boulder.

Associative Rings and Their Modules (Code: SS 1A), **Greg Oman** and **Zak Mesyan**, University of Colorado, Colorado Springs.

Dynamics and Arithmetic Geometry (Code: SS 2A), **Suion Ih**, University of Colorado at Boulder, and **Thomas J. Tucker**, University of Rochester.

Extremal Graph Theory (Code: SS 3A), **Michael Ferrara**, University of Colorado Denver, **Stephen Hartke**, University of Nebraska-Lincoln, and **Michael Jacobson**, University of Colorado Denver.

Themes in Applied Mathematics: From Data Analysis through Fluid Flows and Biology to Topology (Code: SS 4A), **Hanna Makaruk**, Los Alamos National Laboratory, and **Robert Owczarek**, University of New Mexico, and Enfitek, Inc..

Ames, Iowa

Iowa State University

April 27–28, 2013

Saturday – Sunday

Meeting #1090

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: February 2013
Program first available on AMS website: March 14, 2013
Program issue of electronic *Notices*: April 2013
Issue of *Abstracts*: Volume 34, Issue 2

Deadlines

For organizers: September 27, 2012
For consideration of contributed papers in Special Sessions: January 18, 2013
For abstracts: March 5, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Kevin Costello, Northwestern University, *Title to be announced.*

Marianne Csornyei, University of Chicago, *Title to be announced.*

Vladimir Markovic, California Institute of Technology, *Title to be announced.*

Eitan Tadmor, University of Maryland, *Title to be announced.*

Special Sessions

Algebraic and Geometric Combinatorics (Code: SS 4A), **Sung Y. Song**, Iowa State University, and **Paul Terwilliger**, University of Wisconsin-Madison.

Commutative Algebra and its Environs (Code: SS 6A), **Olgur Celikbas** and **Greg Piepmeyer**, University of Missouri, Columbia.

Commutative Ring Theory (Code: SS 8A), **Michael Axtell**, University of St. Thomas, and **Joe Stickles**, Millikin University.

Computability and Complexity in Discrete and Continuous Worlds (Code: SS 11A), **Jack Lutz** and **Tim McNicholl**, Iowa State University.

Extremal Combinatorics (Code: SS 7A), **Steve Butler** and **Ryan Martin**, Iowa State University.

Generalizations of Nonnegative Matrices and Their Sign Patterns (Code: SS 3A), **Minerva Catral**, Xavier University, **Shaun Fallat**, University of Regina, and **Pauline van den Driessche**, University of Victoria.

Logic and Algebraic Logic (Code: SS 9A), **Jeremy Alm**, Illinois College, and **Andrew Ylvisaker**, Iowa State University.

Operator Algebras and Topological Dynamics (Code: SS 1A), **Benton L. Duncan**, North Dakota State University, and **Justin R. Peters**, Iowa State University.

Stochastic Processes with Applications to Physics and Control (Code: SS 10A), **Jim Evans** and **Arka Ghosh**, Iowa State University, **Jon Peterson**, Purdue University, and **Alexander Roitershtein**, Iowa State University.

Zero Forcing, Maximum Nullity/Minimum Rank, and Colin de Verdiere Graph Parameters (Code: SS 2A), **Leslie Hogben**, Iowa State University and American Institute of Mathematics, and **Bryan Shader**, University of Wyoming.

Alba Iulia, Romania

June 27–30, 2013

Thursday – Sunday

Meeting #1091

First Joint International Meeting of the AMS and the Romanian Mathematical Society, in partnership with the "Simion Stoilow" Institute of Mathematics of the Romanian Academy.

Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2013
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

Invited Addresses

Viorel Barbu, Universitatea Cuza, *Title to be announced.*

Sergiu Klainerman, Princeton University, *Title to be announced.*

George Lusztig, Massachusetts Institute of Technology, *Title to be announced.*

Stefan Papadima, Institute of Mathematicsof the Romanian Academy of Sciences, *Title to be announced.*

Dan Timotin, Institute of Mathematics of the Romanian Academy of Sciences, *Title to be announced.*

Srinivasa Varadhan, New York University, *Title to be announced.*

Louisville, Kentucky

University of Louisville

October 5–6, 2013

Saturday – Sunday

Meeting #1092

Southeastern Section
Associate secretary: Robert J. Daverman
Announcement issue of *Notices*: June 2013
Program first available on AMS website: August 22, 2013
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 33, Issue 3

Deadlines

For organizers: March 5, 2013
For consideration of contributed papers in Special Sessions: June 18, 2013
For abstracts: August 13, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michael Hill, University of Virginia, *Title to be announced.*

Suzanne Lenhart, University of Tennessee, *Title to be announced.*

Ralph McKenzie, Vanderbilt University, *Title to be announced.*

Victor Moll, Tulane University, *Title to be announced.*

Special Sessions

Set Theory and Its Applications (Code: SS 1A), **Paul Larson**, Miami University, **Justin Moore**, Cornell University, and **Grigor Sargsyan**, Rutgers University.

Philadelphia, Pennsylvania

Temple University

October 12–13, 2013

Saturday – Sunday

Meeting #1093

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June 2013
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 33, Issue 3

Deadlines

For organizers: March 12, 2013
For consideration of contributed papers in Special Sessions: June 25, 2013
For abstracts: August 20, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Barry Mazur, Harvard University, *Title to be announced* (Erdős Memorial Lecture).

Special Sessions

Geometric and Spectral Analysis (Code: SS 3A), **Thomas Krainer**, Pennsylvania State Altoona, and **Gerardo A. Mendoza**, Temple University.

Higher Structures in Algebra, Geometry and Physics (Code: SS 2A), **Jonathan Block**, University of Pennsylvania, **Vasily Dolgushev**, Temple University, and **Tony Pantev**, University of Pennsylvania.

History of Mathematics in America (Code: SS 4A), **Thomas L. Bartlow**, Villanova University, **Paul R. Wolfson**, West Chester University, and **David E. Zitarelli**, Temple University.

Recent Advances in Harmonic Analysis and Partial Differential Equations (Code: SS 1A), **Cristian Gutiérrez** and **Irina Mitrea**, Temple University.

St. Louis, Missouri

Washington University

October 18–20, 2013

Friday – Sunday

Meeting #1094

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2013
Program first available on AMS website: September 5, 2013
Program issue of electronic *Notices*: October 2013
Issue of *Abstracts*: Volume 33, Issue 4

Deadlines

For organizers: March 20, 2013
For consideration of contributed papers in Special Sessions: July 2, 2013
For abstracts: August 27, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Ronny Hadani, University of Texas at Austin, *Title to be announced.*

Effie Kalfagianni, Michigan State University, *Title to be announced.*

Jon Kleinberg, Cornell University, *Title to be announced.*

Vladimir Sverak, University of Minnesota, *Title to be announced.*

Special Sessions

Algebraic and Combinatorial Invariants of Knots (Code: SS 1A), **Heather Dye**, McKendree University, **Allison Henrich**, Seattle University, and **Louis Kauffman**, University of Illinois.

Riverside, California

University of California Riverside

November 2–3, 2013

Saturday – Sunday

Meeting #1095

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2013
Program first available on AMS website: September 19, 2013
Program issue of electronic *Notices*: November 2013
Issue of *Abstracts*: Volume 33, Issue 4

Deadlines

For organizers: April 2, 2013
For consideration of contributed papers in Special Sessions: July 15, 2013
For abstracts: September 10, 2013

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michael Christ, University of California, Berkeley, *Title to be announced.*

Mark Gross, University of California, San Diego, *Title to be announced.*

Matilde Marcolli, California Institute of Technology, *Title to be announced.*

Paul Vojta, California Institute of Technology, *Title to be announced.*

Baltimore, Maryland

Baltimore Convention Center, Baltimore Hilton, and Marriott Inner Harbor

January 15–18, 2014

Wednesday – Saturday
Joint Mathematics Meetings, including the 120th Annual Meeting of the AMS, 97th Annual Meeting of the Mathematical Association of America, 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, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2013
Program first available on AMS website: November 1, 2013
Program issue of electronic *Notices*: January 2013
Issue of *Abstracts*: Volume 35, Issue 1

Deadlines

For organizers: April 1, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Knoxville, Tennessee

University of Tennessee, Knoxville

March 21–23, 2014

Friday – Sunday
Southeastern Section
Associate secretary: Robert J. Daverman
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 21, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Albuquerque, New Mexico

University of New Mexico

April 5–6, 2014

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: April 2014
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 5, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: February 11, 2014

Lubbock, Texas

Texas Tech University

April 11–13, 2014

Friday – Sunday
Central Section
Associate secretary: Georgia Benkart
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 18, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Tel Aviv, Israel

Bar-Ilan University, Ramat-Gan and Tel-Aviv University, Ramat-Aviv

June 16–19, 2014

Monday – Thursday
The 2nd Joint International Meeting between the AMS and the Israel Mathematical Union.
Associate secretary: Michel L. Lapidus
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: To be announced

For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/internmtgs.html`.

AMS Special Sessions

Mirror Symmetry and Representation Theory, **David Kazhdan**, Hebrew University, and **Roman Bezrukavnikov**, Massachusetts Institute of Technology.

Nonlinear Analysis and Optimization, **Boris Mordukhovich**, Wayne State University, and **Simeon Reich** and **Alexander Zaslavski**, The Technion-Israel Institute of Technology.

Qualitative and Analytic Theory of ODE's, **Yosef Yomdin**, Weizmann Institute.

Eau Claire, Wisconsin

University of Wisconsin-Eau Claire

September 20–21, 2014

Saturday – Sunday
Central Section
Associate secretary: Georgia Benkart
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: February 20, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: August 5, 2014

San Francisco, California

San Francisco State University

October 25–26, 2014

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: October 2014
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 25, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: September 3, 2014

San Antonio, Texas

Henry B. Gonzalez Convention Center and Grand Hyatt San Antonio

January 10–13, 2015

Saturday – Tuesday
Joint Mathematics Meetings, including the 121st Annual Meeting of the AMS, 98th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: October 2014
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2015
Issue of *Abstracts*: Volume 36, Issue 1

Deadlines

For organizers: April 1, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Porto, Portugal

University of Porto

June 11–14, 2015

Thursday – Sunday
Associate secretary: Georgia Benkart
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*: Not applicable

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Seattle, Washington

Washington State Convention Center and the Sheraton Seattle Hotel

January 6–9, 2016

Wednesday – Saturday
Joint Mathematics Meetings, including the 122nd Annual Meeting of the AMS, 99th Annual Meeting of the Mathematical Association of America, annual meetings of the

Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2016
Issue of *Abstracts*: Volume 37, Issue 1

Deadlines

For organizers: April 1, 2015
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Hyatt Regency Atlanta and Marriott Atlanta Marquis

January 4–7, 2017

Wednesday – Saturday
Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2016
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2017
Issue of *Abstracts*: Volume 38, Issue 1

Deadlines

For organizers: April 1, 2016
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 10–13, 2018

Wednesday – Saturday
Joint Mathematics Meetings, including the 124th Annual Meeting of the AMS, 101st Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2017
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 1, 2017
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

AMERICAN MATHEMATICAL SOCIETY

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Program at a Glance

This document provides a thumbnail sketch of all scientific and social events so you can easily see which events may overlap and better plan your time.

JOINT MATHEMATICS MEETINGS
SAN DIEGO • JAN 9-12, 2013
AMERICAN MATHEMATICAL SOCIETY
MATHEMATICAL ASSOCIATION OF AMERICA

Monday, January 07

8:00 a.m.–5:00 p.m.	**MAA SHORT COURSE ON CONCEPTUAL CLIMATE MODELS, PART I**
9:00 a.m.–5:00 p.m.	**AMS SHORT COURSE ON RANDOM MATRICES, PART I**

Tuesday, January 08

8:30 a.m.–4:30 p.m.	**MAA ANCILLARY WORKSHOP ON IDENTIFYING AND ADDRESSING DIFFICULT CONCEPTS FOR STUDENTS IN THE INTRODUCTORY STATISTICS COURSE**
8:30 a.m.–5:00 p.m.	**MAA BOARD OF GOVERNORS**
9:00 a.m.–5:00 p.m.	**AMS SHORT COURSE ON RANDOM MATRICES, PART II**
9:00 a.m.–5:00 p.m.	**MAA SHORT COURSE ON CONCEPTUAL CLIMATE MODELS, PART II**
9:00 a.m.–4:00 p.m.	**MAA ANCILLARY WORKSHOP ON FUNCTIONS, PARAMETERS, AND FITTING FOR TEACHING CALCULUS**
9:00 a.m.–4:00 p.m.	**MAA ANCILLARY WORKSHOP ON PLAYING GAMES WITH A PURPOSE: A NEW APPROACH TO TEACHING AND LEARNING STATISTICS**
1:30 p.m.–10:00 p.m.	**AMS COUNCIL**
3:00 p.m.–7:00 p.m.	**JOINT MEETINGS REGISTRATION**, Exhibit Hall B1, Ground Level, San Diego Convention Center

Wednesday, January 09

7:30 a.m.–6:00 p.m.	**JOINT MEETINGS REGISTRATION**, Exhibit Hall B1, Ground Level, San Diego Convention Center
	AMS SPECIAL SESSIONS
8:00 a.m.–10:50 a.m.	*Effective Algebra and Model Theory, I (AMS-ASL)*
8:00 a.m.–10:50 a.m.	*Nonlinear Evolution Equations and Integrable Systems, I*
8:00 a.m.–10:50 a.m.	*Difference Equations and Applications, I*
8:00 a.m.–10:50 a.m.	*The Mathematics Teacher Education Partnership and the Common Core Standards, I*
8:00 a.m.–10:50 a.m.	*Topics and Issues in Electronic Publishing, I*
8:00 a.m.–10:50 a.m.	*Stochastic Analysis of Stochastic Differential Equations and Stochastic Partial Differential Equations, I*
8:00 a.m.–10:50 a.m.	*Mathematical and Numerical Analysis of Nonlocal Problems, I*
8:00 a.m.–10:50 a.m.	*Arithmetic and Ideal Theory of Integral Domains and Monoids, I*
8:00 a.m.–10:50 a.m.	*Complex Dynamics, I*
8:00 a.m.–10:50 a.m.	*Mathematics and Social Interactions, I*
8:00 a.m.–10:50 a.m.	*Number Theory and Geometry, I*
8:00 a.m.–10:50 a.m.	*Interplays Between Feynman Operational Calculus, Wiener and Feynman Integrals, Physics, and Analysis on Wiener Space, I*

8:00 a.m.–10:50 a.m.	*Theory and Interdisciplinary Applications of Dynamical Systems, I*
8:00 a.m.–10:50 a.m.	*Celestial Mechanics, I*
8:00 a.m.–10:50 a.m.	*Commutative Algebra and Algebraic Geometry, I*
8:00 a.m.–10:50 a.m.	*Recent Advances and New Challenges in Applied Analysis, I*
8:00 a.m.–10:50 a.m.	*Graph Theory, I*
8:00 a.m.–10:50 a.m.	*Manifolds with Special Holonomy and Generalized Geometries, I*
8:00 a.m.–10:50 a.m.	*Tropical Geometry, I*
	MAA INVITED PAPER SESSION
8:00 a.m.–10:55 a.m.	*The Beauty and Power of Number Theory*
	MAA CONTRIBUTED PAPER SESSIONS
8:00 a.m.–11:00 a.m.	*Computational Modeling in the Undergraduate Curriculum*
8:00 a.m.–11:00 a.m.	*How Assessment Results Changed Our Program*
8:00 a.m.–11:00 a.m.	*Writing the History of the MAA*
8:00 a.m.–10:55 a.m.	*General Contributed Paper Sessions*
8:00 a.m.–10:55 a.m.	**SIAM MINISYMPOSIUM ON INTEGER PROGRAMMING AND COMBINATORIAL OPTIMIZATION**
8:00 a.m.–10:55 a.m.	**AMS CONTRIBUTED PAPER SESSIONS**
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #10: PART A** *The mathematics of the Common Core.*
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #5: PART A** *Visualizing projective geometry through photographs and perspective drawings.*
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #6: PART A** *Using randomization methods to build conceptual understanding of statistical inference.*
9:00 a.m.–10:20 a.m.	**MAA-NSF PANEL DISCUSSION** *National Science Foundation programs supporting learning, teaching, and the future workforce in the mathematical sciences.*
9:00 a.m.–10:20 a.m.	**SIGMAA ON QUANTITATIVE LITERACY PANEL DISCUSSION** *A survey of quantitative literacy teaching resources.*
8:00 a.m.–6:00 p.m.	**EMPLOYMENT CENTER**
9:00 a.m.–5:00 p.m.	**STUDENT HOSPITALITY/INFORMATION CENTER**
9:30 a.m.–11:00 a.m.	**MAA DEPARTMENT LIAISONS MEETING**
10:05 a.m.–10:55 a.m.	**AMS INVITED ADDRESS** *Title to be announced.* **Gerard Ben Arous**
11:10 a.m.–12:00 p.m.	**AMS-MAA INVITED ADDRESS** *Title to be announced.* **Emily Shuckburgh**
12:15 p.m.–5:30 p.m.	**EXHIBITS AND BOOK SALES** *Come to the Grand Opening at 12:15 p.m.!*
1:00 p.m.–2:00 p.m.	**AMS COLLOQUIUM LECTURES: LECTURE I** *Free probability and random matrices, I.* **Alice Guionnet**
2:15 p.m.–3:05 p.m.	**MAA INVITED ADDRESS** *Industrial strength mathematics in academia.* **Suzanne Weekes**
	AMS SPECIAL SESSIONS
2:15 p.m.–6:05 p.m.	*Nonlinear Evolution Equations and Integrable Systems, II*
2:15 p.m.–6:05 p.m.	*The Mathematics Teacher Education Partnership and the Common Core Standards, II*
2:15 p.m.–6:05 p.m.	*Stochastic Analysis of Stochastic Differential Equations and Stochastic Partial Differential Equations, II*
2:15 p.m.–6:05 p.m.	*Mathematical and Numerical Analysis of Nonlocal Problems, II*
2:15 p.m.–6:05 p.m.	*Complex Dynamics, II*
2:15 p.m.–6:05 p.m.	*Water Waves, Tsunamis, and Extreme Waves, I*
2:15 p.m.–6:05 p.m.	*Mathematics and Social Interactions, II*
2:15 p.m.–6:05 p.m.	*Number Theory and Geometry, II*
2:15 p.m.–6:05 p.m.	*Interplays Between Feynman Operational Calculus, Wiener and Feynman Integrals, Physics, and Analysis on Wiener Space, II*
2:15 p.m.–6:05 p.m.	*Celestial Mechanics, II*
2:15 p.m.–6:05 p.m.	*Nonstandard Finite-Difference Discretizations and Nonlinear Oscillations (in honor of Ronald Mickens' 70th Birthday), I*

2:15 p.m.–6:05 p.m.	*The Mathematics of Computation: Differential Equations, Linear Algebra, and Applications, I*
2:15 p.m.–6:05 p.m.	*Commutative Algebra and Algebraic Geometry, II*
2:15 p.m.–6:05 p.m.	*Graph Theory, II*
2:15 p.m.–6:05 p.m.	*Manifolds with Special Holonomy and Generalized Geometries, II*
2:15 p.m.–6:05 p.m.	*Tropical Geometry, II*
2:15 p.m.–6:05 p.m.	*Lie Algebras, Algebraic Transformation Groups, and Representation Theory, I*
2:15 p.m.–6:05 p.m.	*Algorithmic Problems of Group Theory and Their Complexity, I*
2:15 p.m.–4:15 p.m.	**MAA MINICOURSE #12: PART A** *Teaching an applied topology course.*
2:15 p.m.–4:15 p.m.	**MAA MINICOURSE #14: PART A** *Teaching introductory statistics (for instructors new to teaching intro stats).*
2:15 p.m.–4:15 p.m.	**MAA MINICOURSE #4: PART A** *Experiments in circle packing.*
	MAA CONTRIBUTED PAPER SESSIONS
2:15 p.m.–6:00 p.m.	*Innovative Ideas for Courses in the First Two Years*
2:15 p.m.–6:00 p.m.	*Integrating the Mathematics of Planet Earth 2013 in the College Mathematics Curriculum*
2:15 p.m.–6:00 p.m.	*General Contributed Paper Sessions*
2:15 p.m.–6:05 p.m.	**SIAM MINISYMPOSIUM ON VISTAS IN APPLIED, COMPUTATIONAL,AND DISCRETE MATHEMATICS**
2:15 p.m.–5:55 p.m.	**AMS CONTRIBUTED PAPER SESSIONS**
2:15 p.m.–3:45 p.m.	**SIGMAA ON THE HISTORY OF MATHEMATICS SPECIAL PRESENTATION** *The Paul R. Halmos photograph collection of the Archives of American Mathematics.*
2:15 p.m.–3:35 p.m.	**MAA-NSF PANEL DISCUSSION** *Reporting progress: A minisymposium of projects from the NSF Course, Curriculum, and Laboratory Improvement/Transforming Undergraduate Education in STEM program.*
2:15 p.m.–3:35 p.m.	**MAA COMMITTEE ON THE MATHEMATICAL EDUCATION OF TEACHERS PANEL DISCUSSION** *Mathematicians supporting the implementation of Common Core State Standards for Mathematics.*
2:15 p.m.–3:35 p.m.	**MAA COMMITTEE ON UNDERGRADUATE STUDENT ACTIVITIES AND CHAPTERS PANEL DISCUSSION** *What every student should know about the Joint Mathematics Meetings.*
2:15 p.m.–4:15 p.m.	**YMN/PROJECT NEXT POSTER SESSION**
2:15 p.m.–3:40 p.m.	**AWM PANEL DISCUSSION** *The retention of women in mathematics.*
3:20 p.m.–4:10 p.m.	**MAA INVITED ADDRESS** *How mathematics has changed Hollywood.* **Tony DeRose**
3:45 p.m.–4:15 p.m.	**AWM BUSINESS MEETING**
3:50 p.m.–5:10 p.m.	**MAA COMMITTEE ON ARTICULATION AND PLACEMENT/NCTM-MAA COMMITTEE ON MUTUAL CONCERNS PANEL DISCUSSION** *Placement testing and the Common Core Curriculum.*
3:50 p.m.–5:10 p.m.	**MAA PANEL DISCUSSION** *Published or perished: Life after the tenure decision.*
3:50 p.m.–5:10 p.m.	**MAA-NSF PANEL DISCUSSION** *Bring your lab to work: A minisymposium of projects that incorporate instrumented laboratory devices into mathematics courses.*
4:00 p.m.–5:00 p.m.	**MAA SECTION OFFICERS**
4:00 p.m.–5:00 p.m.	**RECEPTION FOR UNDERGRADUATE STUDENTS**
4:30 p.m.–6:00 p.m.	**AMS COMMITTEE ON THE PROFESSION PANEL DISCUSSION** *Getting started as a research mathematician.*
4:45 p.m.–6:45 p.m.	**MAA MINICOURSE #11: PART A** *Teaching differential equations with modeling.*
4:45 p.m.–6:45 p.m.	**MAA MINICOURSE #3: PART A** *How to run a successful Math Circle.*
4:45 p.m.–6:45 p.m.	**MAA MINICOURSE #7: PART A** *Teaching and assessing writing and presentations: Collaborative development of pedagogy.*
5:30 p.m.–7:30 p.m.	**SIGMAA ON THE HISTORY OF MATHEMATICS RECEPTION, BUSINESS MEETING, AND GUEST LECTURE**
5:30 p.m.–6:30 p.m.	**RECEPTION FOR GRADUATE STUDENTS AND FIRST-TIME PARTICIPANTS**

5:30 p.m.–8:00 p.m.	**MATHEMATICAL INSTITUTES OPEN HOUSE**
8:30 p.m.–9:30 p.m.	**AMS JOSIAH WILLARD GIBBS LECTURE** *Title to be announced.* **Cedric Villani**
9:30 p.m.–11:00 p.m.	**AWM RECEPTION**

Thursday, January 10

7:30 a.m.–4:00 p.m.	**JOINT MEETINGS REGISTRATION**, Exhibit Hall B1, Ground Level, San Diego Convention Center
	AMS SPECIAL SESSIONS
8:00 a.m.–11:50 a.m.	*Effective Algebra and Model Theory, II (AMS-ASL)*
8:00 a.m.–11:50 a.m.	*Several Complex Variables and Multivariable Operator Theory, I*
8:00 a.m.–11:50 a.m.	*Homotopy Theory and Commutative Algebra, I*
8:00 a.m.–11:50 a.m.	*The Influence of Ramanujan on his 125th Birthday, I*
8:00 a.m.–11:50 a.m.	*Arithmetic and Ideal Theory of Integral Domains and Monoids, II*
8:00 a.m.–11:50 a.m.	*Witt Vectors, Descent, and Lifting, I*
8:00 a.m.–11:50 a.m.	*The Mathematics of Natural Resource Modeling, I*
8:00 a.m.–11:50 a.m.	*The Mathematics of Computation: Differential Equations, Linear Algebra, and Applications, II*
8:00 a.m.–11:50 a.m.	*L-Functions and Arithmetic Geometry, I*
8:00 a.m.–11:50 a.m.	*Quantum Walks and Related Topics, I*
8:00 a.m.–11:50 a.m.	*Creating a Professional Community of Math Teachers K–20, I*
8:00 a.m.–11:50 a.m.	*Lie Algebras, Algebraic Transformation Groups, and Representation Theory, II*
8:00 a.m.–11:50 a.m.	*Environmental Mathematics: Evaluate the Past Climate Changes and Model the Future Climate Variations, I*
8:00 a.m.–11:50 a.m.	*Discrete and Computational Geometry, I (a Mathematics Research Communities session)*
8:00 a.m.–11:50 a.m.	*Harmonic Analysis, Partial Differential Equations, and Geometric Measure Theory, I*
8:00 a.m.–11:50 a.m.	*Geometric Complexity Theory, I (a Mathematics Research Communities session)*
8:00 a.m.–11:50 a.m.	*Arithmetic Statistics, I (a Mathematics Research Communities session)*
8:00 a.m.–11:50 a.m.	*Arithmetic Theory of Quadratic Forms and Lattices, I*
	MAA INVITED PAPER SESSIONS
8:00 a.m.–11:55 a.m.	*Energy, Population, and Sustainability, I (MAA-AMS-SIAM)*
8:00 a.m.–11:55 a.m.	*Mathematics in Industry*
	MAA CONTRIBUTED PAPER SESSIONS
8:00 a.m.–12:00 p.m.	*Projects, Demonstrations, and Activities that Engage Liberal Arts Mathematics Students*
8:00 a.m.–12:00 p.m.	*Mathematics and the Arts: Practice, Pedagogy, and Discovery*
8:00 a.m.–12:00 p.m.	*Research on the Teaching and Learning of Undergraduate Mathematics*
8:00 a.m.–12:00 p.m.	*Learning Centers: Problems and Creative Solutions*
8:00 a.m.–12:00 p.m.	*General Contributed Paper Sessions*
8:00 a.m.–10:50 a.m.	**SIAM MINISYMPOSIUM ON MODELING ACROSS THE CURRICULUM, BRINGING RELEVANCE TO MIDDLE, HIGH SCHOOL, AND EARLY UNDERGRADUATE MATH EXPERIENCES**
8:00 a.m.–11:55 a.m.	**AMS CONTRIBUTED PAPER SESSIONS**
8:00 a.m.–6:00 p.m.	**EMPLOYMENT CENTER**
9:00 a.m.–9:50 a.m.	**MAA INVITED ADDRESS** *Thinking linearly about data.* **Timothy Chartier**
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #13: PART A** *Problem-based courses for teachers, future teachers, and math majors.*
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #1: PART A** *Heavenly mathematics: The forgotten art of spherical trigonometry.*
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #8: PART A** *Getting students involved in undergraduate research.*
9:00 a.m.–10:20 a.m.	**MAA-YMN PANEL DISCUSSION** *Career options for undergraduate mathematics majors.*
9:00 a.m.–10:20 a.m.	**MAA SESSION FOR CHAIRS** *The transition from high school to college mathematics.*

9:00 a.m.–10:20 a.m.	**MAA SUBCOMMITTEE ON RESEARCH BY UNDERGRADUATES PANEL DISCUSSION** *The benefits of research with undergraduates for faculty.*
9:00 a.m.–11:00 a.m.	**MAA COMMITTEE ON THE PARTICIPATION OF WOMEN POSTER SESSION** *Mathematical outreach programs.*
9:00 a.m.–5:00 p.m.	**STUDENT HOSPITALITY/INFORMATION CENTER**
9:30 a.m.–11:00 a.m.	**AMS SPECIAL PRESENTATION** *Who wants to be a mathematician—National contest.*
9:30 a.m.–5:30 p.m.	**EXHIBITS AND BOOK SALES**
10:05 a.m.–10:55 a.m.	**AWM NOETHER LECTURE** *A Hasse principle for quadratic forms over function fields.* **Raman Parimala**
10:30 a.m.–12:00 p.m.	**SIGMAA OFFICERS MEETING**
10:35 a.m.–11:55 a.m.	**MAA WORKSHOP** *Proposal writing for grant applications to the NSF Division of Undergraduate Education.*
10:35 a.m.–11:55 a.m.	**SIGMAA ON STATISTICS EDUCATION PANEL DISCUSSION** *Creating and growing an applied statistics minor program.*
10:35 a.m.–11:55 a.m.	**MAA-YMN PANEL DISCUSSION** *The on-campus interview survival guide.*
11:10 a.m.–12:00 p.m.	**SIAM INVITED ADDRESS** *Inverse problems with minimal interior measurements.* **Adrian Nachman**
1:00 p.m.–2:00 p.m.	**AMS COLLOQUIUM LECTURES: LECTURE II** *Free probability and random matrices, II.* **Alice Guionnet**
	AMS SPECIAL SESSIONS
1:00 p.m.–3:50 p.m.	*Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, I (AMS-MAA-SIAM)*
1:00 p.m.–3:50 p.m.	*Mathematics and Education Reform, I (AMS-MAA)*
1:00 p.m.–3:50 p.m.	*Difference Equations and Applications, II*
1:00 p.m.–3:50 p.m.	*Several Complex Variables and Multivariable Operator Theory, II*
1:00 p.m.–3:50 p.m.	*Topics and Issues in Electronic Publishing, II*
1:00 p.m.–3:50 p.m.	*Witt Vectors, Descent, and Lifting, II*
1:00 p.m.–3:50 p.m.	*Geometric and Analytic Methods in Teichmüller Theory and Hyperbolic Geometry, I*
1:00 p.m.–3:50 p.m.	*Theory and Interdisciplinary Applications of Dynamical Systems, II*
1:00 p.m.–3:50 p.m.	*Continued Fractions, I*
1:00 p.m.–3:50 p.m.	*Nonstandard Finite-Difference Discretizations and Nonlinear Oscillations (in honor of Ronald Mickens' 70th Birthday), II*
1:00 p.m.–3:50 p.m.	*Finite Element Exterior Calculus and Applications, I*
1:00 p.m.–3:50 p.m.	*Recent Advances and New Challenges in Applied Analysis, II*
1:00 p.m.–3:50 p.m.	*L-Functions and Arithmetic Geometry, II*
1:00 p.m.–3:50 p.m.	*Quantum Walks and Related topics, II*
1:00 p.m.–3:50 p.m.	*Discrete and Computational Geometry, II (a Mathematics Research Communities session)*
1:00 p.m.–3:50 p.m.	*Harmonic Analysis, Partial Differential Equations, and Geometric Measure Theory, II (a Mathematics Research Communities session)*
1:00 p.m.–3:50 p.m.	*Geometric Complexity Theory, II (a Mathematics Research Communities session)*
1:00 p.m.–3:50 p.m.	*Arithmetic Statistics, II (a Mathematics Research Communities session)*
1:00 p.m.–3:50 p.m.	*Arithmetic Theory of Quadratic Forms and Lattices, II*
1:00 p.m.–3:50 p.m.	*Algorithmic Problems of Group Theory and Their Complexity, II*
	MAA INVITED PAPER SESSIONS
1:00 p.m.–4:00 p.m.	*Energy, Population, and Sustainability, II (MAA-AMS-SIAM)*
1:00 p.m.–4:00 p.m.	*Mathematics, Computer Graphics, and Film Production*
1:00 p.m.–3:00 p.m.	**MAA MINICOURSE #15: PART A** *WeBWorK: An open source alternative for generating and delivering online homework problems.*
1:00 p.m.–3:00 p.m.	**MAA MINICOURSE #2: PART A** *A game theory path to quantitative literacy.*
1:00 p.m.–3:00 p.m.	**MAA MINICOURSE #9: PART A** *Shortest, quickest, or best: An introduction to the calculus of variations.*

	MAA CONTRIBUTED PAPER SESSIONS
1:00 p.m.–4:15 p.m.	*Effective Strategies and Programs for Mentoring Women and Minorities in Mathematics*
1:00 p.m.–4:00 p.m.	*Student Success in Quantitative Reasoning*
1:00 p.m.–4:00 p.m.	*Bridging the Gap: Designing an Introduction to Proofs Course*
1:00 p.m.–4:00 p.m.	*Mathematics and Sports*
1:00 p.m.–4:15 p.m.	*The History of Geometry, Its Applications, and Their Uses in the Classroom*
1:00 p.m.–4:15 p.m.	*General Contributed Paper Sessions*
1:00 p.m.–3:50 p.m.	**SIAM MINISYMPOSIUM ON HYBRID INVERSE PROBLEMS IN MEDICAL IMAGING**
1:00 p.m.–4:10 p.m.	**AMS CONTRIBUTED PAPER SESSIONS**
1:00 p.m.–2:20 p.m.	**MAA WORKSHOP** *An introduction to inquiry-based learning.*
1:00 p.m.–2:20 p.m.	**MAA-YMN PANEL DISCUSSION** *Graduate school: Choosing one, getting in, staying in.*
1:00 p.m.–2:20 p.m.	**MAA ASSESSMENT COMMITTEE-MAA COMMITTEE ON THE MATHEMATICAL EDUCATION OF TEACHERS PANEL DISCUSSION** *PRAXIS mathematics exams for prospective teachers: Responsibilities of and reflections on mathematics departments.*
1:00 p.m.–2:30 p.m.	**JOINT COMMITTEE ON WOMEN IN THE MATHEMATICAL SCIENCES PANEL DISCUSSION** *You are promoted! Great, what is next?*
2:00 p.m.–4:00 p.m.	**MAA POSTER SESSION OF PROJECTS SUPPORTED BY THE NSF DIVISION OF UNDERGRADUATE EDUCATION**
2:15 p.m.–3:05 p.m.	**AMS INVITED ADDRESS** *Critically-finite maps in the moduli space of polynomials.* **Laura DeMarco**
2:40 p.m.–4:00 p.m.	**MAA-YMN PANEL DISCUSSION** *You published your dissertation; now what?*
3:00 p.m.–4:00 p.m.	**BOARD ON MATHEMATICAL SCIENCES AND THEIR APPLICATIONS SPECIAL PRESENTATION** *The Mathematical Sciences in 2025 Study: Key findings and recommendations.*
3:20 p.m.–4:10 p.m.	**AMS INVITED ADDRESS** *Diophantine applications of the theory of expansion and spectral gaps in thin groups.* **Jean Bourgain**
4:25 p.m.–5:25 p.m.	**JOINT PRIZE SESSION**
5:30 p.m.–4:00 p.m.	**JOINT PRIZE SESSION RECEPTION**
5:30 p.m.–7:30 p.m.	**ASSOCIATION OF CHRISTIANS IN THE MATHEMATICAL SCIENCES ANNUAL RECEPTION AND LECTURE**
5:45 p.m.–7:00 p.m.	**MAA TWO-YEAR COLLEGE RECEPTION**
6:00 p.m.–8:00 p.m.	**ASSOCIATION OF LESBIAN, GAY, BISEXUAL, AND TRANSGENDERED MATHEMATICIANS RECEPTION**
6:30 p.m.–9:30 p.m.	**MER/IME BANQUET**
7:30 p.m.–8:30 p.m.	**YOUNG MATHEMATICIANS' NETWORK OPEN FORUM**

Friday, January 11

7:30 a.m.–4:00 p.m.	**JOINT MEETINGS REGISTRATION**, Exhibit Hall B1, Ground Level, San Diego Convention Center
	AMS SPECIAL SESSIONS
8:00 a.m.–10:50 a.m.	*Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, II (AMS-MAA-SIAM)*
8:00 a.m.–10:50 a.m.	*Mathematics and Education Reform, II (AMS-MAA)*
8:00 a.m.–10:50 a.m.	*Fractional, Hybrid, and Stochastic Dynamic Systems with Applications, I*
8:00 a.m.–10:50 a.m.	*Homotopy Theory and Commutative Algebra, II*
8:00 a.m.–10:50 a.m.	*The Progress in Free Probability and Free Analysis, I*
8:00 a.m.–10:50 a.m.	*Mathematical Underpinnings of Multivariate Complexity Theory and Algorithm Design, and Its Frontiers and the Field of Incrementalization, I*
8:00 a.m.–10:50 a.m.	*Water Waves, Tsunamis, and Extreme Waves, II*

8:00 a.m.–10:50 a.m.	*Groups, Representations, and Applications, I*
8:00 a.m.–10:50 a.m.	*Algebraic Combinatorics and Representation Theory, I*
8:00 a.m.–10:50 a.m.	*Continued Fractions, II*
8:00 a.m.–10:50 a.m.	*Mathematics of Computation: Algebra and Number Theory, I*
8:00 a.m.–10:50 a.m.	*Knots, Links, and Three-manifolds, I*
8:00 a.m.–10:50 a.m.	*Singularities in Geometry and Algebra, I*
8:00 a.m.–10:50 a.m.	*Several Complex Variables Techniques in Operator Theory, I*
8:00 a.m.–10:50 a.m.	*Generalized Symmetric Spaces, I*
8:00 a.m.–10:50 a.m.	*The Mathematics of Decisions, Elections, and Games, I*
8:00 a.m.–10:50 a.m.	*Discrete Geometry and Algebraic Combinatorics, I*
8:00 a.m.–10:50 a.m.	*Frontiers in Geomathematics, I*
	MAA CONTRIBUTED PAPER SESSIONS
8:00 a.m.–11:00 a.m.	*The Scholarship of Teaching and Learning in Collegiate Mathematics*
8:00 a.m.–11:00 a.m.	*Using Inquiry-Based Learning in Mathematics for Liberal Arts Courses*
8:00 a.m.–11:00 a.m.	*Touch It, Feel It, Learn It: Tactile Learning Activities in the Undergraduate Mathematics Classroom*
8:00 a.m.–11:00 a.m.	*Innovative and Effective Ways to Teach Linear Algebra*
8:00 a.m.–11:00 a.m.	*General Contributed Paper Sessions*
8:00 a.m.–10:50 a.m.	**SIAM MINISYMPOSIUM ON INVERSE PROBLEMS**
8:00 a.m.–10:55 a.m.	**AMS CONTRIBUTED PAPER SESSIONS**
8:00 a.m.–5:00 p.m.	**ASL INVITED ADDRESSES AND CONTRIBUTED PAPER SESSIONS**
8:00 a.m.–6:00 p.m.	**EMPLOYMENT CENTER**
8:00 a.m.–11:00 a.m.	**PME COUNCIL MEETING**
	MAA INVITED PAPER SESSION
8:30 a.m.–10:55 a.m.	*Thinking Linearly about Data in Research and Teaching*
8:30 a.m.–10:30 a.m.	**AMS-MAA GRADUATE STUDENT FAIR** *Undergrads! Take this opportunity to meet representatives from mathematical science graduate programs.*
9:00 a.m.–9:50 a.m.	**MAA RETIRING PRESIDENTIAL ADDRESS** *Communicating mathematics.* **Paul Zorn**
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #10: PART B** *The mathematics of the Common Core.*
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #5: PART B** *Visualizing projective geometry through photographs and perspective drawings.*
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #6: PART B** *Using randomization methods to build conceptual understanding of statistical inference.*
9:00 a.m.–10:20 a.m.	**MAA PANEL DISCUSSION** *The invigorating experience of mathematical positions abroad.*
9:00 a.m.–10:20 a.m.	**AMS-MAA JOINT COMMITTEE ON TEACHING ASSISTANTS AND PART-TIME INSTRUCTORS PANEL DISCUSSION** *Training and professional development of teaching assistants.*
9:00 a.m.–10:55 a.m.	**SIGMAA ON THE HISTORY OF MATHEMATICS PANEL DISCUSSION** *Using mathematical archives and special collections for research and teaching.*
9:00 a.m.–5:00 p.m.	**STUDENT HOSPITALITY/INFORMATION CENTER**
9:30 a.m.–5:30 p.m.	**EXHIBITS AND BOOK SALES**
10:05 a.m.–10:55 a.m.	**AMS INVITED ADDRESS** *How to count with topology.* **Jordan Ellenberg**
11:10 a.m.–12:00 p.m.	**AMS-MAA INVITED ADDRESS** *Zeros of polynomials and their importance in combinatorics and probability.* **Robin Pemantle**
1:00 p.m.–2:00 p.m.	**AMS COLLOQUIUM LECTURES: LECTURE III** *Free probability and random matrices, III.* **Alice Guionnet**
1:00 p.m.–1:50 p.m.	**MAA LECTURE FOR STUDENTS** *The game of SET and geometry.* **Judith Covington**
1:00 p.m.–6:00 p.m.	**AMS CURRENT EVENTS BULLETIN**

AMS SPECIAL SESSIONS

1:00 p.m.–5:50 p.m.	*The History of Mathematics, I (AMS-MAA)*
1:00 p.m.–5:50 p.m.	*The Brauer Group in Algebra and Geometry, I (AMS-AWM)*
1:00 p.m.–5:50 p.m.	*Advances in General Optimization and Global Optimality Conditions for Multiobjective Fractional Programming Based on Generalized Invexity*
1:00 p.m.–5:50 p.m.	*The Influence of Ramanujan on his 125th Birthday, II*
1:00 p.m.–5:50 p.m.	*The Progress in Free Probability and Free Analysis, II*
1:00 p.m.–5:50 p.m.	*Groups, Representations, and Applications, II*
1:00 p.m.–5:50 p.m.	*Algebraic Combinatorics and Representation Theory, II*
1:00 p.m.–5:50 p.m.	*Geometric and Analytic Methods in Teichmüller Theory and Hyperbolic Geometry, II*
1:00 p.m.–5:50 p.m.	*Mathematics of Computation: Algebra and Number Theory, II*
1:00 p.m.–5:50 p.m.	*Singularities in Geometry and Algebra, II*
1:00 p.m.–5:50 p.m.	*Several Complex Variables Techniques in Operator Theory, II*
1:00 p.m.–5:50 p.m.	*Finite Element Exterior Calculus and Applications, II*
1:00 p.m.–5:50 p.m.	*The Coverings of the Integers*
1:00 p.m.–5:50 p.m.	*Challenges in Data Assimilation and the Mathematics of Planet Earth and Its Climate*
1:00 p.m.–5:50 p.m.	*Discrete Geometry and Algebraic Combinatorics, II*
1:00 p.m.–5:50 p.m.	*Set-Valued Optimization and Variational Problems with Applications*
1:00 p.m.–5:50 p.m.	*Frontiers in Geomathematics, II*
1:00 p.m.–3:00 p.m.	**MAA MINICOURSE #12: PART B** *Teaching an applied topology course.*
1:00 p.m.–3:00 p.m.	**MAA MINICOURSE #14: PART B** *Teaching introductory statistics (for instructors new to teaching intro stats).*
1:00 p.m.–3:00 p.m.	**MAA MINICOURSE #4: PART B** *Experiments in circle packing.*

MAA CONTRIBUTED PAPER SESSIONS

1:00 p.m.–4:00 p.m.	*Actuarial Education*
1:00 p.m.–6:00 p.m.	*Mentoring Graduate Students: Pathways to Success*
1:00 p.m.–5:00 p.m.	*Philosophy, Mathematics, and Progress*
1:00 p.m.–6:00 p.m.	*Adding Modern Ideas to an Introductory Statistics Course*
1:00 p.m.–4:00 p.m.	*Fostering Mathematical Habits of Mind*
1:00 p.m.–4:45 p.m.	*Using Mobile Communication Devices for Mathematics Education*
1:00 p.m.–5:55 p.m.	*General Contributed Paper Sessions*
1:00 p.m.–5:00 p.m.	**SIAM MINISYMPOSIUM ON APPLIED, COMPUTATIONAL, AND DISCRETE MATHEMATICS AT NATIONAL LABORATORIES AND FEDERAL RESEARCH AGENCIES**
1:00 p.m.–4:00 p.m.	**NAM GRANVILLE-BROWN-HAYNES SESSION OF PRESENTATIONS BY RECENT DOCTORAL RECIPIENTS IN THE MATHEMATICAL SCIENCES**
1:00 p.m.–5:55 p.m.	**AMS CONTRIBUTED PAPER SESSIONS**
1:00 p.m.–4:00 p.m.	**SIGMAA ON MATH CIRCLES FOR STUDENTS AND TEACHERS POSTER AND ACTIVITY SESSION** *Come join us for the chance to experience a math circle firsthand.*
1:00 p.m.–2:20 p.m.	**MAA-NSF-SIAM PANEL DISCUSSION** *Reporting progress: A minisymposium on mathematical modeling across the K–16 curriculum.*
1:00 p.m.–2:20 p.m.	**MAA COMMITTEE ON THE PARTICIPATION OF WOMEN IN MATHEMATICS-JOINT COMMITTEE ON THE PARTICIPATION OF WOMEN IN THE MATHEMATICAL SCIENCES** *Parental and family leave for graduate students and post docs: Policies and experiences.*

MAA INVITED PAPER SESSION

2:00 p.m.–4:00 p.m.	*Where Have All the Zeros Gone?*
2:15 p.m.–4:00 p.m.	**ROCKY MOUNTAIN MATHEMATICS CONSORTIUM BOARD OF DIRECTORS MEETING**
2:30 p.m.–3:50 p.m.	**PRESENTATIONS BY MAA TEACHING AWARD RECIPIENTS**
2:30 p.m.–4:00 p.m.	**AMS COMMITTEE ON SCIENCE POLICY SESSION** *How will mathematical research be published in the 21st century?*

2:40 p.m.–4:00 p.m.	**MAA PANEL DISCUSSION** *Using technology to develop mathematical understanding.*
3:30 p.m.–5:30 p.m.	**MAA MINICOURSE #11: PART B** *Teaching differential equations with modeling.*
3:30 p.m.–5:30 p.m.	**MAA MINICOURSE #3: PART B** *How to run a successful Math Circle.*
3:30 p.m.–5:30 p.m.	**MAA MINICOURSE #7: PART B** *Teaching and assessing writing and presentations: Collaborative development of pedagogy.*
3:30 p.m.–5:30 p.m.	**MAA UNDERGRADUATE POSTER SESSION**
5:00 p.m.–8:00 p.m.	**SIGMAA FOR MATHEMATICIANS IN BUSINESS, INDUSTRY, AND GOVERNMENT BUSINESS MEETING, GUEST LECTURE, AND RECEPTION**
5:00 p.m.–6:30 p.m.	**SIGMAA ON MATHEMATICS INSTRUCTION USING THE WEB BUSINESS MEETING, RECEPTION, AND GUEST LECTURE**
5:00 p.m.–7:00 p.m.	**MAA SPECIAL PRESENTATION: POETRY READING** *All mathematical poets and those interested in mathematical poetry are invited.*
5:00 p.m.–7:00 p.m.	**MAA PANEL DISCUSSION** *Current issues in actuarial science education.*
5:30 p.m.–7:30 p.m.	**SIGMAA ON THE PHILOSOPHY OF MATHEMATICS RECEPTION, BUSINESS MEETINGS, AND GUEST LECTURE**
5:30 p.m.–7:30 p.m.	**UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN RECEPTION**
6:00 p.m.–8:00 p.m.	**SIGMAA ON MATHEMATICAL AND COMPUTATIONAL BIOLOGY RECEPTION, BUSINESS MEETING, AND GUEST LECTURE**
6:00 p.m.–7:00 p.m.	**MAA DRAMATIC PRESENTATION** *Mathematically Bent Theater.*
6:00 p.m.–7:00 p.m.	**AMS *MATHEMATICAL REVIEWS* RECEPTION**
6:00 p.m.–9:00 p.m.	**NAM RECEPTION AND BANQUET**
7:45 p.m.–8:30 p.m.	**NAM COX-TALBOT ADDRESS** *Speaker and title to be announced*
8:30 p.m.–10:00 p.m.	**MAA-PROJECT NEXT RECEPTION** *All Project NExT Fellows, consultants, and other friends of Project NExT are invited.*

Saturday, January 12

7:30 a.m.–2:00 p.m.	**JOINT MEETINGS REGISTRATION**, Exhibit Hall B1, Ground Level, San Diego Convention Center
	AMS SPECIAL SESSIONS
8:00 a.m.–10:50 a.m.	*Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, III (AMS-MAA-SIAM)*
8:00 a.m.–10:50 a.m.	*The Brauer Group in Algebra and Geometry, II (AMS-AWM)*
8:00 a.m.–10:50 a.m.	*Fractional, Hybrid, and Stochastic Dynamic Systems with Applications, II*
8:00 a.m.–10:50 a.m.	*The Theory and Applications of Differential Equations on Graphs, I*
8:00 a.m.–10:50 a.m.	*Understanding Planet Earth via Reaction Diffusion Equations, I*
8:00 a.m.–10:50 a.m.	*q-series in Mathematical Physics and Combinatorics, I*
8:00 a.m.–10:50 a.m.	*Patterns in Permutations and Words, I*
8:00 a.m.–10:50 a.m.	*Computational Algebraic and Analytic Geometry for Low-dimensional Varieties, I*
8:00 a.m.–10:50 a.m.	*Financial Mathematics, I*
8:00 a.m.–10:50 a.m.	*The Mathematics of Natural Resource Modeling, II*
8:00 a.m.–10:50 a.m.	*Topological Combinatorics, I*
8:00 a.m.–10:50 a.m.	*Creating a Professional Community of Math Teachers K–20, II*
8:00 a.m.–10:50 a.m.	*Stochastic and Functional Analysis, I*
8:00 a.m.–10:50 a.m.	*Environmental Mathematics: Evaluate the Past Climate Changes and Model the Future Climate Variations, II*
8:00 a.m.–10:50 a.m.	*Dirac and Laplace Operators in Global Analysis and Geometry, I*
	MAA INVITED PAPER SESSION
8:00 a.m.–10:55 a.m.	*Writing, Talking, and Sharing Mathematics*

	MAA CONTRIBUTED PAPER SESSIONS
8:00 a.m.–11:00 a.m.	*Assessing the Effectiveness of Online Homework*
8:00 a.m.–11:00 a.m.	*Trends in Undergraduate Mathematical Biology Education*
8:00 a.m.–11:00 a.m.	*Developmental Mathematics Education*
8:00 a.m.–11:00 a.m.	*Mathematics Experiences in Business, Industry, and Government*
8:00 a.m.–11:00 a.m.	*General Contributed Paper Sessions*
8:00 a.m.–10:50 a.m.	**SIAM MINISYMPOSIUM ON MATHEMATICAL MODELS AND FAST ALGORITHMS IN IMAGING SCIENCES**
8:00 a.m.–5:50 p.m.	**AWM WORKSHOP ON NUMBER THEORY**
8:00 a.m.–10:55 a.m.	**AMS CONTRIBUTED PAPER SESSIONS**
8:00 a.m.–5:00 p.m.	**ASL INVITED ADDRESSES AND CONTRIBUTED PAPER SESSIONS**
8:00 a.m.–12:00 p.m.	**EMPLOYMENT CENTER**
8:30 a.m.–10:00 a.m.	**AMS COMMITTEE ON EDUCATION PANEL DISCUSSION** *Mathematics serving students in other disciplines.*
9:00 a.m.–9:50 a.m.	**AMS INVITED ADDRESS** *Generators and relations for finite groups.* **Robert Guralnick**
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #13: PART B** *Problem-based courses for teachers, future teachers, and math majors.*
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #1: PART B** *Heavenly mathematics: The forgotten art of spherical trigonometry.*
9:00 a.m.–11:00 a.m.	**MAA MINICOURSE #8: PART B** *Getting students involved in undergraduate research.*
9:00 a.m.–9:55 a.m.	**SIGMAA ON MATH CIRCLES FOR STUDENTS AND TEACHERS: DEMONSTRATION FOR MATHEMATICIANS** *Come learn about and participate in this Math Circles experience.*
9:00 a.m.–10:20 a.m.	**MAA PANEL DISCUSSION** *Active learning in mathematics.*
9:00 a.m.–10:20 a.m.	**SIGMAA ON STATISTICS EDUCATION PANEL DISCUSSION** *Randomization and bootstrap methods in the introductory statistics course.*
9:00 a.m.–3:00 p.m.	**STUDENT HOSPITALITY/INFORMATION CENTER**
9:00 a.m.–9:50 a.m.	**NAM PANEL DISCUSSION**
9:00 a.m.–12:00 p.m.	**EXHIBITS AND BOOK SALES**
10:00 a.m.–10:55 a.m.	**SIGMAA ON MATH CIRCLES FOR STUDENTS AND TEACHERS: DEMONSTRATION FOR STUDENTS** *Come learn about and participate in this Math Circles experience.*
10:00 a.m.–10:50 a.m.	**NAM BUSINESS MEETING**
10:05 a.m.–10:55 a.m.	**MAA INVITED ADDRESS** *Who chooses not to persist in calculus and why?* **Chris Rasmussen**
11:10 a.m.–11:40 a.m.	**MAA BUSINESS MEETING**
11:45 a.m.–12:15 p.m.	**AMS BUSINESS MEETING**
1:00 p.m.–1:50 p.m.	**NAM CLAYTOR-WOODARD LECTURE** *Speaker and title to be announced.*
	AMS SPECIAL SESSIONS
1:00 p.m.–5:50 p.m.	*Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, IV (AMS-MAA-SIAM)*
1:00 p.m.–5:50 p.m.	*The History of Mathematics, II (AMS-MAA)*
1:00 p.m.–5:50 p.m.	*Mathematics and Education Reform, III (AMS-MAA)*
1:00 p.m.–5:50 p.m.	*The Theory and Applications of Differential Equations on Graphs, II*
1:00 p.m.–5:50 p.m.	*Understanding Planet Earth via Reaction Diffusion Equations, II*
1:00 p.m.–5:50 p.m.	*Mathematical Underpinnings of Multivariate Complexity Theory and Algorithm Design, and Its Frontiers and the Field of Incrementalization, II*
1:00 p.m.–5:50 p.m.	*q-series in Mathematical Physics and Combinatorics, II*
1:00 p.m.–5:50 p.m.	*Patterns in Permutations and Words, II*
1:00 p.m.–5:50 p.m.	*Computational Algebraic and Analytic Geometry for Low-dimensional Varieties, II*
1:00 p.m.–5:50 p.m.	*Financial Mathematics, II*
1:00 p.m.–5:50 p.m.	*Knots, Links, and Three-manifolds, II*
1:00 p.m.–5:50 p.m.	*Generalized Symmetric Spaces, II*

1:00 p.m.–5:50 p.m.	*The Mathematics of Decisions, Elections, and Games, II*
1:00 p.m.–5:50 p.m.	*Topological Combinatorics, II*
1:00 p.m.–5:50 p.m.	*The Present and Future of Mathematics on the Web*
1:00 p.m.–5:50 p.m.	*Stochastic and Functional Analysis, II*
1:00 p.m.–5:50 p.m.	*Dirac and Laplace Operators in Global Analysis and Geometry, II*
1:00 p.m.–3:00 p.m.	**MAA MINICOURSE #15: PART B** *WeBWorK: An open source alternative for generating and delivering online homework problems.*
1:00 p.m.–3:00 p.m.	**MAA MINICOURSE #2: PART B** *A game theory path to quantitative literacy.*
1:00 p.m.–3:00 p.m.	**MAA MINICOURSE #9: PART B** *Shortest, quickest, or best: An introduction to the calculus of variations.*
	MAA CONTRIBUTED PAPER SESSIONS
1:00 p.m.–6:00 p.m.	*Transition from High School to College: Alternative Pathways*
1:00 p.m.–6:00 p.m.	*Communicating Mathematics*
1:00 p.m.–6:00 p.m.	*Preparing Elementary School Mathematics Specialists*
1:00 p.m.–5:55 p.m.	*General Contributed Paper Sessions*
1:00 p.m.–5:50 p.m.	**SIAM MINISYMPOSIUM ON PERSPECTIVES FROM INDUSTRY**
1:00 p.m.–5:55 p.m.	**AMS CONTRIBUTED PAPER SESSIONS**
1:00 p.m.–2:20 p.m.	**MAA PANEL DISCUSSION** *How a placement program can increase success rates in preparatory courses and the calculus sequence.*
1:30 p.m.–2:30 p.m.	**SIGMAA ON MATH CIRCLES FOR STUDENTS AND TEACHERS MATH WRANGLE DEMONSTRATION** *Come see how everyone can get involved in this exciting combination of mathematical problem solving, public speaking, strategy, and rebuttal.*
3:00 p.m.–4:00 p.m.	**MAA-AMS-SIAM GERALD AND JUDITH PORTER PUBLIC LECTURE** *Mathematics and the melting polar ice caps.* **Kenneth Golden**
6:30 p.m.–7:30 p.m.	**AMS 125TH GALA RECEPTION**
7:30 p.m.–10:00 p.m.	**AMS 125TH GALA**

2013 Joint Mathematics Meetings Advance Registration/Housing Form

JOINT MATHEMATICS MEETINGS
SAN DIEGO • JAN 9-12, 2013
AMERICAN MATHEMATICAL SOCIETY
MATHEMATICAL ASSOCIATION OF AMERICA

Name _____
(please write name as you would like it to appear on your badge)

Mailing Address _____

_____

Telephone _____ Fax: _____

In case of emergency (for you) at the meeting, call: Day #_____ Evening #:_____

Email Address _____

Acknowledgment of this registration and any hotel reservations will be sent to the email address given here, unless you check this box: *Send by U.S. Mail* ☐

Affiliation for badge _____ (company/university) Nonmathematician guest badge name: _____ (Note fee of US$15)

☐ **I DO NOT want my program and badge to be mailed to me on 12/07/12. (Materials will be mailed to the address listed above unless you check this box.)**

Registration Fees

Membership please ✓ that apply. First row is eligible to register as a JMM member.
☐ AMS ☐ MAA ☐ ASL ☐ CMS ☐ SIAM
☐ ASA ☐ AWM ☐ NAM ☐ YMN

Joint Meetings	**by Dec 17**	**at mtg**	**Subtotal**
☐ Member AMS, MAA, ASL, CMS, SIAM	US$ 235	US$ 309	
☐ Nonmember	US$ 367	US$ 476	
☐ Graduate Student (Mem. of AMS or MAA)	US$ 52	US$ 62	
☐ Graduate Student (Nonmember)	US$ 80	US$ 91	
☐ Undergraduate Student	US$ 52	US$ 62	
☐ High School Student	US$ 5	US$ 10	
☐ Unemployed	US$ 52	US$ 62	
☐ Temporarily Employed	US$ 191	US$ 220	
☐ Developing Countries Special Rate	US$ 52	US$ 62	
☐ Emeritus Member of AMS or MAA	US$ 52	US$ 62	
☐ High School Teacher	US$ 52	US$ 62	
☐ Librarian	US$ 52	US$ 62	
☐ Press	US$ 0	US$ 0	
☐ Nonmathematician Guest	US$ 15	US$ 15	
			$_____
AMS Short Course: *Random Matrices (1/7–1/8)*			
☐ Member of AMS or MAA	US$ 104	US$ 138	
☐ Nonmember	US$ 150	US$ 180	
☐ Student, Unemployed, Emeritus	US$ 52	US$ 73	
			$_____
MAA Short Course: *Conceptual Climate Models (1/7–1/8)*			
☐ Member of MAA or AMS	US$ 156	US$ 166	
☐ Nonmember	US$ 225	US$ 235	
☐ Student, Unemployed, Emeritus	US$ 78	US$ 88	
			$_____

MAA Minicourses (see listing in text)
I would like to attend: ☐ One Minicourse ☐ Two Minicourses
Please enroll me in MAA Minicourse(s) #_____ and/or #_____
In order of preference, my alternatives are: #_____ and/or #_____
Price: US$80 for each minicourse.
(For more than 2 minicourses call or email the MMSB.) $_____

Graduate School Fair
☐ Graduate Program Table US$ 70 US$ 70
(includes table, posterboard & electricity)
$_____

Employment Center *Please go to http://ams.org/profession/employment-services/employment-center/employment-center to register.*
For further information, contact Steve Ferrucci at emp-info@ams.org.

Events with Tickets
☐ Graduate Student/First Time Attendee Reception (1/9) (no charge)
☐ MER/IME Banquet (1/10) US$ 65 # ___Chicken #___Fish
#___Kosher #___Vegan
☐ NAM Banquet (1/11) US$ 62 #___Chicken #___Fish
#___Kosher #___Vegan
☐ AMS 125th Anniversary Gala (1/12) US$ 62 #____
(Additional fees may apply for Kosher meals.) $_____

Total for Registrations and Events $_____

Registration for the Joint Meetings is not required for the short courses but it is required for the minicourses and the Employment Center.

Payment

Registration & Event Total (total from column on left) $ _____
Hotel Deposit (only if paying by check) $ _____

Total Amount To Be Paid **$** _____
(Note: A US$5 processing fee will be charged for each returned check or invalid credit card. Debit cards cannot be accepted.)

Method of Payment
☐ **Check**. Make checks payable to the AMS. Checks drawn on foreign banks must be in equivalent foreign currency at current exchange rates. For all check payments, please keep a copy of this form for your records.

☐ **Credit Card**. All major credit cards accepted. For your security, we do not accept credit card numbers by postal mail, email or fax. If the MMSB receives your registration form by fax or postal mail, we will contact you at the phone number provided on this form. For questions, contact the MMSB at mmsb@ams.org.

Signature: _____

☐ **Purchase Order #** _____(please enclose copy)

Other Information

Mathematical Reviews field of interest # _____
How did you hear about this meeting? Check one:
☐ Colleague(s) ☐ Internet ☐ *Notices* ☐ *Focus* ☐ Other _____
☐ This is my first Joint Mathematics Meetings.
☐ I am a mathematics department chair.
☐ For planning purposes for the MAA Two-year College Reception, please check if you are a faculty member at a two-year college.
☐ I would like to receive promotions for future JMM meetings.
☐ Please do not include my name on any promotional mailing lists.
☐ Please do not include my name on any list of participants distributed or displayed at the meeting.
☐ Please ✓ this box if you have a disability requiring special services.

Mailing Address/Contact:

Mathematics Meetings Service Bureau (MMSB)
P. O. Box 6887
Providence, RI 02940-6887 Fax: 401-455-4004; **Email:** mmsb@ams.org
Telephone: 401-455-4143 or 1-800-321-4267 x4143 or x4144

Deadlines

To be eligible for the complimentary room drawing:	**Nov. 5, 2012**
For housing reservations, badges/programs mailed:	**Nov. 19, 2012**
For housing changes/cancellations through MMSB:	**Dec. 10, 2012**
For advance registration for the Joint Meetings, short courses, minicourses, and tickets:	**Dec. 17, 2012**
For 50% refund on banquets, cancel by:	**Dec. 27, 2012***
For 50% refund on advance registration, minicourses & short courses, cancel by:	**Jan. 04, 2013***

***no refunds issued after this date**

2013 Joint Mathematics Meetings Hotel Reservations – San Diego, CA

(Please see the hotel page in the announcement or on the web for detailed information on each hotel.) To ensure accurate assignments, please rank hotels in order of preference by writing 1, 2, 3, etc. in the column on the left and by circling the requested room type and rate. If the rate or the hotel requested is no longer available, you will be assigned a room at the next available comparable rate. Please call the MMSB for details on suite configurations, sizes, availability, etc. All reservations, including suite reservations, must be made through the MMSB to receive the JMM rates. Reservations made directly with the hotels before **December 19** may be changed to a higher rate. All rates are subject to a 12.5% sales/occupancy tax. **Guarantee requirements: First night deposit by check (add to payment on reverse of form) or a credit card guarantee.**

☐ **Deposit enclosed (see front of form)** ☐ **Hold with my credit card. For your security, we do not accept credit card numbers by postal mail, email or fax.** If the MMSB receives your registration form by postal mail or fax, we will contact you at the phone number provided on the reverse of this form.

Date and Time of Arrival _____ **Date and Time of Departure** _____

Name of Other Room Occupant _____ **Arrival Date** _____ **Departure Date** _____ **Child (give age(s)** _____

Order of choice	Hotel	Single	Double 1 bed	Double 2 beds	Triple 2 beds	Triple 2 beds w/cot	Triple - king or queen w/cot	Quad 2 beds	Quad 2 beds w/cot	Suites Starting rates
	San Diego Marriott Hotel & Marina (hdqtrs)									
	City View	US$ 184	US$ 184	US$ 184	US$ 204	US$204*	US$ 204*	US$ 224	US$ 224*	US$ 750
	Bay View	US$ 199	US$ 199	US$ 199	US$ 219	US$219*	US$ 219*	US$ 239	US$ 239*	N/A
	Student Rate (City View)	US$ 147	US$ 147	US$ 147	US$ 167	US$167*	US$ 167*	US$ 187	US$ 187*	N/A
	Omni San Diego	US$ 171	US$ 194	US$ 194	US$ 214	N/A	N/A	US$ 234	N/A	US$ 350
	Student Rate	US$ 154	US$ 174	US$ 174	US$ 194	N/A	N/A	US$ 214	N/A	N/A
	Embassy Suites San Diego Bay	US$ 155	US$ 155	US$ 155	US$ 175	N/A	N/A	US$ 195	N/A	(all suites)
	Student Rate	US$ 135	US$ 135	US$ 135	US $145	N/A	N/A	US$ 155	N/A	(all suites)
	Horton Grand Hotel	US$ 155	US$ 155	US$ 155	N/A	N/A	N/A	N/A	N/A	US$ 259
	Student Rate	US$ 145	US$ 145	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Residence Inn by Marriott Gaslamp District	US$ 152	US$ 152	US$ 152	N/A	N/A	N/A	N/A	N/A	(all suites)
	Student Rate	US$ 145	US$ 145	US$ 145	N/A	N/A	N/A	N/A	N/A	N/A
	Hard Rock Hotel San Diego	US$ 149	US$ 149	US$ 149	US$169	N/A	N/A	US$189	N/A	US$ 199
	Student Rate	US$ 129	US$ 129	US$ 129	US$149	N/A	N/A	US$ 169	N/A	N/A
	Best Western Plus Bayside Inn	US$ 129	US$ 129	US$ 129	US$ 139	US$ 149	US$ 149	US$ 139	US$ 149	N/A
	Student Rate	US$ 119	US$ 119	US$ 119	US$ 129	US$ 139	US$ 139	US$ 129	US$ 139	N/A
	Residence Inn by Marriott Downtown (1-bedroom studio suites. Bedroom has 1 queen bed. Living room has a single sofa sleeper)	US$ 129	US$ 129	US$ 129 **	N/A	N/A	US$144 **	N/A	N/A	(all suites)
	Student Rate (1 bed. studio suite)	US$ 119	US$ 119	US$ 119 **	N/A	N/A	US$134 **	N/A	N/A	(all suites)
	Residence Inn by Marriott Downtown (2-bedroom suites. Each bedroom has 1 queen bed. Living room has a single sofa sleeper.) Limited quantity.	N/A	N/A	US $239	US$ 254	US$ 254 **	N/A	US$ 269	US$ 269 **	(all suites)
	Four Points by Sheraton Downtown	US$ 125	US$ 125	US$ 125	US$ 135	N/A	US$ 145	US$ 145	N/A	N/A
	Student Rate	US$ 115	US$ 115	US$ 115	US$ 125	N/A	US$ 135	US$ 135	N/A	N/A
	Holiday Inn on the Bay	US$ 124	US$ 124	US$ 124	US$ 139	N/A	US$ 149	US$ 154	N/A	US$ 274
	Student Rate	US$ 114	US$ 114	US$ 114	US$ 129	N/A	US$ 139	US$ 144	N/A	N/A
	Hampton Inn San Diego Downtown	US$ 109	US$ 109	US$ 109	US$ 119	N/A	N/A	US $139	N/A	N/A
	Student Rate	US$ 99	US$ 99	US$ 99	US$ 119	N/A	N/A	US $129	N/A	N/A

* The San Diego Marriott has a one-time fee of US$ 20 for a rollaway cot. Rooms with 2 beds are limited. A king with a sleeper sofa may be substituted for the second bed.

** The sleeper sofa is the additional bed. Rollaway cots are not available.

Special Housing Requests:.

☐ I have disabilities as defined by the ADA that require a sleeping room that is accessible to the physically challenged. My needs are:_____

_____

☐ Other requests:_____

☐ I am a member of a hotel frequent-travel club and would like to receive appropriate credit.
The hotel chain and card number are:_____

Only email confirmations will be sent by the hotels, if an email address is provided.

If you are not making a reservation, please check one of the following:

☐ I plan to make a reservation at a later date.

☐ I will be making my own reservations at a hotel not listed. Name of hotel:_____

☐ I live in the area or will be staying privately with family or friends.

☐ I plan to share a room with_____, who is making the reservations.

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

Central Section: **Georgia Benkart**, University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706-1388; e-mail: benkart@math.wisc.edu; telephone: 608-263-4283.

Eastern Section: **Steven H. Weintraub**, Department of Mathematics, Lehigh University, Bethlehem, PA 18105-3174; e-mail: steve.weintraub@lehigh.edu; telephone: 610-758-3717.

Southeastern Section: **Robert J. Daverman,** Department of Mathematics, University of Tennessee, Knoxville, TN 37996-6900, e-mail: daverman@math.utk.edu; telephone: 865-974-6900.

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 can be found at** www.ams.org/meetings/.

Meetings:

2012

September 22–23	Rochester, New York	p. 1320
October 13–14	New Orleans, Louisiana	p. 1321
October 20–21	Akron, Ohio	p. 1322
October 27–28	Tucson, Arizona	p. 1323

2013

January 9–12	San Diego, California Annual Meeting	p. 1323
March 1–3	Oxford, Mississippi	p. 1354
April 6–7	Chestnut Hill, Massachusetts	p. 1354
April 13–14	Boulder, Colorado	p. 1355
April 27–28	Ames, Iowa	p. 1355
June 27–30	Alba Iulia, Romania	p. 1356
October 5–6	Louisville, Kentucky	p. 1356
October 12–13	Philadelphia, Pennsylvania	p. 1357
October 18–20	St. Louis, Missouri	p. 1357
November 2–3	Riverside, California	p. 1357

2014

January 15–18	Baltimore, Maryland Annual Meeting	p. 1358
March 21–23	Knoxville, Tennessee	p. 1358
April 5–6	Albuquerque, New Mexico	p. 1358
April 11–13	Lubbock, Texas	p. 1358
June 16–19	Tel Aviv, Israel	p. 1358
September 20–21	Eau Claire, Wisconsin	p. 1359
October 25–26	San Francisco, California	p. 1359

2015

January 10–13	San Antonio, Texas Annual Meeting	p. 1359
June 11–14	Porto, Portugal	p. 1359

2016

January 6–9	Seattle, Washington	p. 1359

2017

January 4–7	Atlanta, Georgia Annual Meeting	p. 1360

2018

January 10–13	San Diego, California Annual Meeting	p. 1360

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 111 in the the January 2012 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the 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, and all math displays and similarily coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. 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.)

October 3–8, 2012: International Conference on Group Theory, Combinatorics, and Computing, at Florida Atlantic University, Boca Raton, FL (held in cooperation with the AMS). Please see http://www.math.fau.edu/ for more information.

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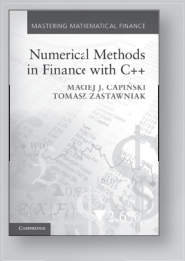

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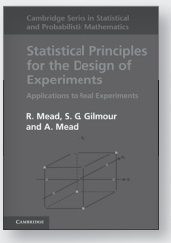

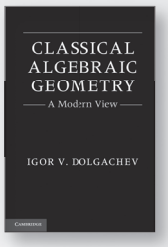

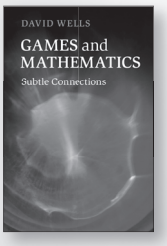

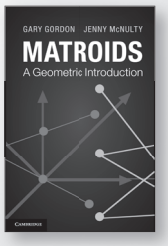

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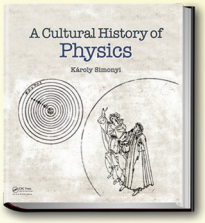

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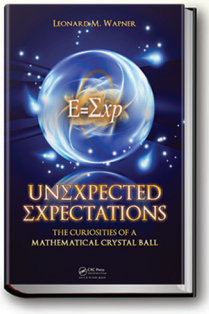

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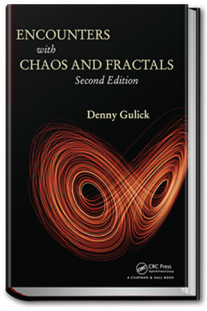

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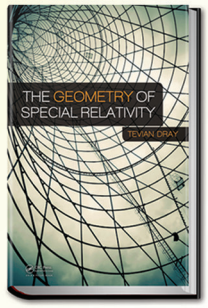

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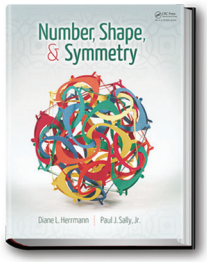

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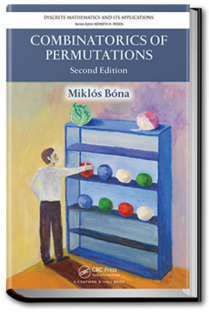

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