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Notices

of the American Mathematical Society

March 2009 Volume 56, Number 3

TEX at 30: Going strong (see page 354)


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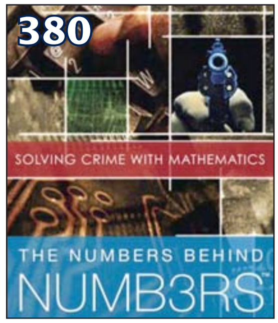
Notices

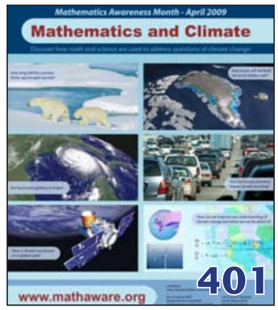
of the American Mathematical Society

March 2009

Communications

Commentary





Features

Notices
of the American Mathematical Society

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Departments

From the AMS Secretary

American Mathematical Society

JMM 2009 BESTSELLERS

Joint Mathematics Meetings
Washington, DC
January 5–8, 2009

What's Happening in the Mathematical Sciences

Dana Mackenzie

What's Happening in the Mathematical Sciences, Volume 7; 2009; 127 pages; Softcover; ISBN: 978-0-8218-4478-6; List US$19.95; AMS members US$15.95; Order code HAPPENING/7

Pioneering Women in American Mathematics

The Pre-1940 PhD's

Judy Green, *Marymount University, Arlington, VA*, and **Jeanne LaDuke**, *DePaul University, Chicago, IL*

Biographical information on the American women earning PhD's in mathematics before 1940, revealing insights into the mathematical community of their time

Co-published with the London Mathematical Society beginning with Volume 4. Members of the LMS may order directly from the AMS at the AMS member price. The LMS is registered with the Charity Commissioners.

History of Mathematics, Volume 34; 2009; 345 pages; Hardcover; ISBN: 978-0-8218-4376-5; List US$79; AMS members US$63; Order code HMATH/34

Lectures on Surfaces

(Almost) Everything You Wanted to Know about Them

Anatole Katok and **Vaughn Climenhaga**, *Pennsylvania State University, University Park, PA*

Student Mathematical Library, Volume 46; 2008; 286 pages; Softcover; ISBN: 978-0-8218-4679-7; List US$49; AMS members US$39; Order code STML/46

Five-Minute Mathematics

Ehrhard Behrends, *Freie Universität Berlin, Germany*

Translated by David Kramer

2008; 380 pages; Softcover; ISBN: 978-0-8218-4348-2; List US$35; AMS members US$28; Order code MBK/53

Mathematical Circles

Dmitri Fomin, *St. Petersburg State University, Russia*, **Sergey Genkin**, *Microsoft Corporation*, and **Ilia Itenberg**, *Institut de Recherche Mathématique de Rennes, France*

Mathematical World, Volume 7; 1996; 272 pages; Softcover; ISBN: 978-0-8218-0430-8; List US$38; AMS members US$30; Order code MAWRLD/7

A Decade of the Berkeley Math Circle

The American Experience, Volume I

Zvezdelina Stankova, *Mills College, Oakland, CA*, and *University of California, Berkeley, CA*, and **Tom Rike**, *Oakland High School, CA*, Editors

An engaging account of an American adaptation of mathematical circles designed to inspire a new generation of mathematical leaders

Titles in this series are co-published with the Mathematical Sciences Research Institute (MSRI).

MSRI Mathematical Circles Library, Volume 1; 2008; 326 pages; Softcover; ISBN: 978-0-8218-4683-4; List US$49; AMS members US$39; Order code MCL/1

Structure and Randomness

pages from year one of a mathematical blog

Terence Tao, *University of California, Los Angeles, CA*

Selections from a mathematical blog that offer rare insight into how a great mathematician thinks about his subject

2008; 298 pages; Softcover; ISBN: 978-0-8218-4695-7; List US$35; AMS members US$28; Order code MBK/59

Lessons in Geometry

COURSE ADOPTION

I. Plane Geometry

Jacques Hadamard

2008; 330 pages; Hardcover; ISBN: 978-0-8218-4367-3; List US$59; AMS members US$47; Order code MBK/57

Quantum Field Theory

A Tourist Guide for Mathematicians

Gerald B. Folland, *University of Washington, Seattle, WA*

Mathematical Surveys and Monographs, Volume 149; 2008; 325 pages; Hardcover; ISBN: 978-0-8218-4705-3; List US$89; AMS members US$71; Order code SURV/149

Quantum Mechanics for Mathematicians

COURSE ADOPTION

Leon A. Takhtajan, *Stony Brook University, NY*

Graduate Studies in Mathematics, Volume 95; 2008; 387 pages; Hardcover; ISBN: 978-0-8218-4630-8; List US$69; AMS members US$55; Order code GSM/95

Opinion

Global Crises from the Perspective of Complex Adaptive Systems

Mathematics of Global Problems:

Recently the whole world has faced a global food crisis (GFC). We propose to call such a problem an "emergent problem". An emergent problem is characterized by:

i) It has several reasons not just one.

ii) It cannot be solved locally (e.g., by one country) hence "collective efforts" are required.

iii) It needs a long time to be solved, hence evolutions in strategies and conditions have to be taken into consideration.

There are several problems that can be called emergent, e.g., GFC, climate change, water shortage problem, and global endemic diseases such as tuberculosis (TB). Such problems require that their mathematical models should have the following properties [2, 3, 6, 7]:

i) Models and optimization should be stochastic.

ii) Models should contain several time scales.

iii) Models should be non-autonomous.

iv) Control theory results based on short time data should not be applied on long time scale.

It is important to notice that we are not attempting long range predictions since it is known that these phenomena are chaotic. But what we are trying is to keep the system within certain limits (thresholds) to avoid crisis. We think that, despite chaos, this may be possible.

Some Guidelines for Local Governments:

Human societies are complex adaptive systems (CAS) which are known to be open [1], and optimization of such systems is multi-objective. This implies the following [4]:

i) Complete control of CAS is impossible. Hence the decisions should instead be guidelines. Detailed plans should be left to those executing them.

ii) Expect some failures. Hence continuous revision and updating are required.

iii) There is no single solution but multi-solutions that accommodate the different contradictory objectives.

iv) Diversity should be preserved and encouraged.

v) Transparency and trust have to exist.

vi) Decisions can result only after serious consultations with those executing them and those affected by them (bottom-up approach).

vii) Deserved decentralization should be encouraged.

Comments and Conclusions:

From the above we have the following comments:

- Collective efforts needed to solve emergent problems require large scale cooperation (c.f., prisoner's dilemma game). However it is known that for such cooperation to exist a feeling of imminent danger has to exist [5]. Therefore early preparations to deal with such problems are not expected to be as efficient as should be. This is particularly true for the expected water shortage problem, which is acute at certain places and unseen in other ones.

- The expected evolution of GFC is that countries will attempt to increase their production but at the same time increase their reserves. Moreover the feeding behavior of China and India populations is not likely to change. Hence a quick solution of this problem is not expected.

- The bottom-up approach is highly efficient in finding practical solutions and in making people more prepared to share the burden of the problems. But it requires a regime that has the trust of its people, a property that is rare in many third world countries.

We conclude: emergent problems, "messes", happen and will continue to happen. CAS is one of the approaches to attenuate their effects and make us better prepared for them.

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The American Mathematical Society

Math in Moscow

Scholarship Program

http://www.ams.org/employment/mimoscow.html

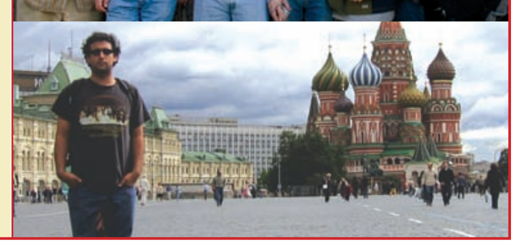
Study mathematics the Russian way in English

The American Mathematical Society (AMS) invites undergraduate mathematics and computer science majors in the U.S. to apply for a special scholarship to attend a semester in the Math in Moscow program, run by the Independent University of Moscow.

- Five scholarships in the amount of US$7,500 are available per semester.
- Scholarships are for U.S. undergraduate mathematics or computer science majors.
- Application deadlines for scholarships: September 30 for spring semesters and April 15 for fall semesters.
- Contact: Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA; telephone: 800-321-4267, ext. 4170; e-mail: student-serv@ams.org

Features of the Math in Moscow program:

- A 15-week long semester that offers foreign students the chance to spend a semester studying mathematics and computer science in Moscow with internationally recognized research mathematicians.
- Courses are taught in the Russian tradition of teaching mathematics, features of which include: small classes, emphasis on in-depth understanding of carefully selected material, one-on-one interaction with professors.
- Courses are taught in English.
- For more information about the Math in Moscow program and application instructions, visit **http://www.mccme.ru/mathinmoscow/**



Letters to the Editor

Math Circles

In their fascinating article "Cross-cultural analysis of students with exceptional talent in mathematical problem solving" (*Notices*, November 2008), the authors offer six proposals to stimulate national discussion re supporting young scholars with keen mathematical interests. May I add a seventh, namely, that of strongly encouraging the continued growth of math circles throughout this nation, through both increased student participation and increased involvement of mathematics professionals. Math circles provide sustained mathematical experiences for young scholars, a strong culture of support and encouragement of mathematical pursuit, exposure to higher level mathematical ideas and practices, freedom of mathematical creativity and ownership of ideas, and an experience of social acceptance from working with like-minded peers.

Since the publication of "Math circles and olympiads: MSRI asks is the U.S. coming of age?" (*Notices*, February 2006) and the continued work of MSRI, the MAA, and AIM [Mathematical Sciences Research Institute, Mathematical Association of America, American Institute of Mathematics]; of the AMS with its publication of *Circle in a Box*; and of very many individuals, math circles are becoming a solid part of the student mathematics educational landscape. They could benefit *all* students if adopted as part of the national culture (that is, to become "a way of life" as one colleague puts it), all the while continuing to provide a tremendous springboard for those keen to go further with their pursuits. The goals and practices of math circles address many of the issues raised in the November piece and their full support is very much worthy of a seventh call to action.

—James Tanton
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(Received November 25, 2008)

Evaluating Teaching in Interviews

In the "Letter from the Editor" that appeared in the December 2008 issue of the *Notices*, the one describing a videotaped lecture interview by a job candidate, one sentence stood out for me. Andy Magid wrote, "The presentation made it clear that the candidate should be an effective instructor." As I noted in my November 2007 *Notices* article, "Valuing and evaluating teaching in the mathematics faculty hiring process", using candidates' research talks to evaluate their teaching effectiveness is a worrisome practice. Although the survey I reported in my article indicated that 76 percent of search committees engage in this practice, there are important differences between talking about one's research to a group of experts and teaching undergraduate mathematics. In particular, research talks typically do not allow for demonstration of a candidate's approach to in-class formative assessment and active learning techniques, important components of undergraduate teaching effectiveness. Research talks delivered via video are even less able to convey a candidate's teaching effectiveness as these talks are essentially one-way conversations without any of the back-and-forth discussion that is often necessary for student learning. Although such talks can help search committees evaluate some components of a candidate's teaching effectiveness, I would hesitate to endorse their use as more than a secondary method for evaluating a candidate's potential in the classroom.

—Derek Bruff
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(Received November 24, 2008)

Corrections

The January 2009 issue of the *Notices* carried my article, "A Celebration of Women in Mathematics at MIT". A few errors have come to light since publication of the article. On page 44 the article stated that in 1968 Karen Uhlenbeck became the first woman C.L.E. Moore Instructor at MIT. I thank Robert Strichartz for pointing out that this distinction actually goes to Nancy Kopell, who started as a Moore Instructor in 1967. Uhlenbeck was a regular instructor during 1968-69. I also thank Dennis Porche for noting that, on page 45, the article did not make fully clear that, when Gigliola Staffilani was hired by MIT as an associate professor in *2002,* she was hired with tenure. Also on page 44 the name of former MIT dean Robert Birgeneau was misspelled. Finally, in Table 1 Susan Landau is listed as having earned her doctorate in 1996; the article's first paragraph correctly records the year as 1983.

—Margaret A. M. Murray

Submitting Letters to the Editor

The *Notices* invites readers to submit letters and opinion pieces on topics related to mathematics. Electronic submissions are preferred (`notices-letters@ams.org`); see the masthead for postal mail addresses. Opinion pieces are usually one printed page in length (about 800 words). Letters are normally less than one page long, and shorter letters are preferred.

The TeX Family in 2009

Jim Hefferon and Karl Berry

Mathematicians know TeX as a standard tool. Along with associated programs such as LaTeX and BibTeX it allows working professionals to produce documents of journal quality, without first having to become expert at the intricacies of typography.

We will highlight some of the exciting recent developments in the TeX family of programs. We will not aim the presentation towards TeX experts. Rather, as long as you are comfortable producing your own documents in TeX, or perhaps are a beginner interested in learning, you should find here some information that you can use. Our discussion will concentrate on things that are available today or are in a late stage of development.

You may know that TeX has been in some way frozen by its creator. How can there be big changes? Today's executable TeX programs can still give output conforming to the standard and can still process documents made years ago. The freeze was done in a way that allows developers to adapt TeX to changes in the world of document production. In addition, people in the TeX community have developed other programs of interest, such as graphical front-ends to make writing a document easier.

Jim Hefferon is professor and chair of mathematics at Saint Michael's College, Colchester, Vermont, as well as a maintainer of CTAN, the Comprehensive TeX Archive Network. His email address is `jhefferon@smcvt.edu`.

Karl Berry is currently the president of the TeX Users Group and chief maintainer of the TeX Live distribution. His email address is `karl@freefriends.org`.

Note. We've made all the links available in clickable form on this article's webpage, `http://tug.org/notices`.

History

Many *Notices* readers know the story but some may not: TeX began when Donald Knuth of Stanford University received the galleys for an edition of one of the books in his magnum opus *The Art of Computer Programming* and was so discouraged by how they looked that he resolved to write a system to do the job correctly. In 1978, he delivered the Gibbs lecture at the AMS annual meeting, outlining the basis of his work on both typography and fonts. This led the Society to adopt his as a standard format, which in turn led to its adoption by the mathematical community (and others), from large journals to individuals.

Theorem 1 (Central Limit Theorem). *Let $\{\mathbf{X}_k\}$ be a sequence of mutually independent random variables with a common distribution. Suppose that $\mu = \mathbf{E}(\mathbf{X}_k)$ and $\sigma^2 = \operatorname{Var}(\mathbf{X}_k)$ exist and $\mathbf{S}_n = \mathbf{X}_1 + \cdots + \mathbf{X}_n$. Then for every fixed β*

$$\mathbf{P}\left\{ \frac{\mathbf{S}_n - n\mu}{\sigma\sqrt{n}} < \beta \right\} \rightarrow \mathfrak{N}(\beta).$$

```
\documentclass{article}
\usepackage[paperwidth=2.75in,paperheight=1.5in,
   width=2.75in,height=1.5in,
   lmargin=0in,rmargin=0in]{geometry}
\usepackage{amssymb,amsmath,amsthm}
\DeclareMathOperator{\var}{Var}
\newtheorem{thm}{Theorem}
\newcommand{\rv}[1]{\mathbf{#1}}
\newcommand{\pr}[1]{\mathbf{#1}}
\newcommand{\ev}[1]{\mathbf{#1}}
\begin{document}
\begin{thm}[Central Limit Theorem]
Let $\{\rv{X}_k\}$ be a sequence of mutually
independent random variables with a common
distribution.
Suppose that $\mu=\ev{E}(\rv{X}_k)$ and
$\sigma^2=\var(\rv{X}_k)$ exist and
$\rv{S}_n=\rv{X}_1+\dots+\rv{X}_n$.
Then for every fixed $\beta$
\begin{equation*}
\pr{P}\left\lbrace
  \frac{\rv{S}_n-n\mu}{\sigma\sqrt{n}}<\beta
\right\rbrace \rightarrow \mathfrak{N}(\beta).
\end{equation*}\end{thm}
\end{document}
```

Figure 1. A sample of LaTeX output and the associated input (adapted from [6]**).**

A major factor in that adoption was that Knuth made the program freely available, including its source code. Soon, an informal community of users arose, porting TeX to many platforms, developing ancillary programs, etc. Following Knuth, this community typically makes its work freely available. A formal infrastructure also appeared, the TeX Users Group. This group continues to be active, with annual meetings, journals, and funds dedicated to further development. Other user groups are now active worldwide, working in many languages in addition to English.

Another factor in TeX's adoption was that Knuth designed the system so that any knowledgeable user could create extensions. Leslie Lamport used this capability to produce the LaTeX format. (A format is the overall set of commands that an author uses to write documents.) LaTeX was a major departure from Knuth's original `plain` format, providing many high-level facilities that authors need: it supports producing articles, reports, and books, including chapters and sections. It allows for floating figures and automatic generation or maintenance of cross-references, tables of contents, bibliographies, and indexes. It has a simple but powerful syntax for tables and strong capabilities with graphics and color. It also emphasized a philosophy that authors should describe the logical role of text rather than focus on its appearance. This means that you might start a chapter by typing `\chapter{Introduction}`, rather than directly specifying that the name appear in a larger font surrounded by additional vertical space.

LaTeX itself can also be extended. Many people have contributed packages of materials that adjust LaTeX's default behavior. One example is the AMS's class *amsart* for articles. Another is the AMS's *amsmath* style, which adds many options for presenting equations, mathematical symbols, arrays, etc. There are many smaller examples, such as the *fancyhdr* style that easily adjusts page headings and footings. (A LaTeX package is a class if it controls whole documents by setting margins, headers, type size, etc. If it is focused on more local aspects, such as adding facilities for including computer code listings, then it is a style.)

Formats other than LaTeX exist. These include Eplain, which adds some basic authoring features to `plain`, and ConTeXt, which is a comprehensive, modern system. However, LaTeX remains the most popular by far, in part because it has such a large library of useful additions. Below we will focus on solutions based on LaTeX, although much of our discussion holds for any TeX document.

What TeX Can Do

The steps for producing a TeX document are well-known to most *Notices* readers. If you are not familiar: the author creates a source file containing a mixture of text and commands, somewhat similar to a document in the webpage language HTML. The author then runs a program or sequence of programs to convert the source to typeset output. For instance, Figure 1 gives a sample of moderately complex output along with its complete input source. (*Aside:* This article is not about persuading you to adopt TeX but we cannot resist one suggestion: this input was done by a user who is not a wizard but is just reasonably competent. To judge the value added by TeX, we invite you to ask a reasonably-competent user of a word processing system to produce a version of this text and then compare the two on input effort as well as output comprehensibility and appearance.)

Increased Capabilities in the Engines: pdfTeX, XeTeX, and LuaTeX

The main executable TeX program that runs on your system is called the engine. The user community has ported the engine and other parts of the TeX suite to every computing platform that you are likely ever to use. In addition to porting it, developers have improved it. For instance, a modern TeX does not have the memory constraints of earlier systems. So the TeX engine that you are running is a descendant of Knuth's original.

The engine has changed in other ways. One has to do with output devices such as printers and computer screens. Rather than try to include in the engine the ability to work with every printer or screen on the market, Knuth designed the system to produce output in a format called DVI that is easily read by computers. Separate programs convert these DVI files for use on particular output devices. This approach is flexible but has the disadvantage that to share documents with colleagues, an author must distribute either the TeX source or the DVI file, and in either case the recipient must do further processing.

A step forward came when many printer vendors adopted the PostScript language for describing pages. Now an author could distribute work as a PostScript file and expect that colleagues could print or view it without further processing. Developers wrote a number of programs that convert DVI to PostScript; the most popular is `dvips` by Tomas Rokicki. It is still in widespread use today as part of the document production system of many individuals and publishers, including the production system at the AMS.

In recent years a descendant of the PostScript language, PDF, has become very popular. This language is designed for use on the Internet and Web browsers easily display these files. So now authors have a practical way to distribute their work online while retaining their fonts and formatting, something that is especially important with mathematical documents (the Web language HTML does not easily offer such control). In response to the emergence of PDF, which has become an open Internet standard, Hàn Thế Thành and others developed an extension of TeX's engine called pdfTeX. This directly outputs PDF so that the intermediate DVI step is no longer necessary. Many documents written with the original engine in mind can be output in PDF simply by processing it with the command `pdflatex myfile` instead of `latex myfile`.

Development of the engine continues. Another extended engine included in today's distributions is XeTeX. This allows you to move away from TeX-specific fonts, to easily use any font installed in your system. XeTeX also improves TeX's non-English language handling because it fully supports input in Unicode. (Unicode is a standard to provide a representation for every character in every human language. The AMS's Barbara Beeton, among many others, has been working to ensure that Unicode supports all mathematical symbols.)

On the horizon is LuaTeX, which connects the computer language Lua with the TeX engine. Since writing in TeX's standard extension language can be quite hard, while Lua is a scripting language, meaning that it is well-suited to this kind of work, this makes programming with TeX much easier. LuaTeX is being actively developed as of this writing.

Graphics

Knuth designed TeX to be able to use or import any sort of graphics.

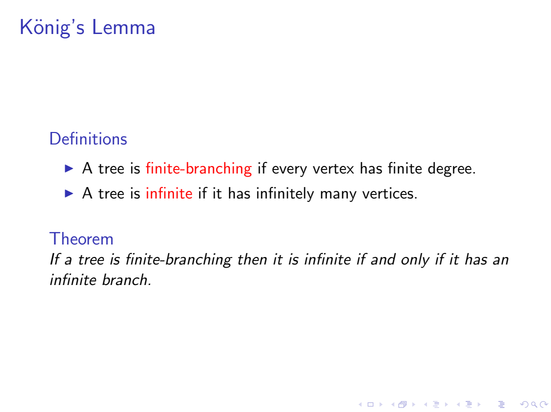
There are good ways to create graphics within a TeX source file, notably with the packages *PSTricks* and *TikZ*. This approach describes the figure with a graphics language. Another example of a graphics language that is good at making technical figures is MetaPost; with this language, the code is written outside of the TeX source.

Alternatively, you may prefer to produce graphics using a program such as Gnuplot, Excel, Matlab, or Illustrator. In addition, you may also want to use graphics that don't come from a program, such as photographs.

The typesetting engines in current distributions can incorporate all of the above. For instance, pdfTeX can directly import JPEG, PNG, and PDF format graphics. You can convert graphics in other formats to one of these three. An example is that you may have graphics in the EPS format (closely related to PostScript), and there are programs to convert EPS graphics to PDF; one that runs on all platforms is `epspdf`.

To insert and manipulate external graphics, LaTeX provides the package *graphicx* that is both powerful and straightforward. As an example, the command `\includegraphics[width=16pc]{lions.jpg}` appears in the source of this article to include the graphic on the first page. That command causes the *graphicx* package to examine the graphic file for its natural width and height. The package then puts the graphic

in the document and scales it to a width that works with the column size used by the *Notices*




```
\documentclass{beamer}
\usepackage{amsthm}
\theoremstyle{plain}
  \newtheorem{thm}{Theorem}
\theoremstyle{definition}
  \newtheorem{defs}{Definitions}

\begin{document}
\begin{frame}\frametitle{K\"onig's Lemma}
\begin{defs}
\begin{itemize}
  \item A tree is \alert{finite-branching} if
     every vertex has finite degree.
  \item A tree is \alert{infinite} if it has
     infinitely many vertices.
\end{itemize}
\end{defs}
\begin{thm}
  If a tree is finite-branching then it is infinite
  if and only if it has an infinite branch.
\end{thm}
\end{frame}
\end{document}
```

Figure 2. Using the beamer presentation package. The slide has been shrunk to fit this page (which is why the navigation elements in the lower right look tiny).

(16 `pc` is about 2.66 inches). This package can also do simple manipulations: in this paragraph, the picture from the first page has been clipped and shrunken by giving the `\includegraphics` command the optional arguments `width=5pc`, `viewport=120 300 360 590`, and `clip`. (The viewport unit is 1/72 inch. Also, we have wrapped the text around the image by using the LaTeX add-on package *wrapfig*.) We recommend an article [2] by Klaus Höppner for background and tips on working with graphics.

Hypertext

Web links, technically called URLs, didn't exist when TeX was first developed. They are a typesetting challenge because they tend to be long and hard to break across lines. They are also a challenge because readers expect document links to be clickable, and so the text in the source must be associated with the right target. The *url* package does a good job of handling the typesetting requirements. In particular, it handles the special characters that can appear in URLs, such as percent signs, that otherwise have a special meaning for TeX.

The LaTeX document style *hyperref* is even more ambitious: it tries to turn a paper-based document into a hyperlinked document without requiring any intervention by the author. For instance, suppose that you have an existing LaTeX document in which the input `\ref{th:LamesThm}` produces the output "Theorem 3". Adding `\usepackage{hyperref}` at the start of the document will produce that same text, but now it is also a link to the referenced spot. Similarly, entries in the table of contents become links to the chapters and sections, literal URLs become clickable, and so on.

Presentations

Another application that became widespread since TeX was developed is presentation software, of which Microsoft PowerPoint is an example.

Several packages bring TeX's ability with mathematical text to making presentations. These change the page size and orientation, produce navigation elements such as buttons for changing pages, and perhaps have a screen area showing an outline of the talk. They also allow the slides to appear in steps such as one bullet point at a time.

The *beamer* package is one of the most popular and well-documented; a sample is shown in Figure 2. The tutorial article by Andrew Mertz and William Slough [3] introduces it with a graduated sequence of examples.

Editing and Running TeX: TeXworks

Many users compose their TeX documents inside of a graphical user interface. Such a front end typically incorporates an editor that is specialized for writing TeX, along with a way to invoke commands; for instance, it may have a single button to compile the document and display the result. Everyone has a favorite. On Windows, both TeXnicCenter and WinEdt are among the most popular. In a Unix environment, including GNU/Linux, many people use the programming editor Emacs, perhaps with the AUCTeX add-on.

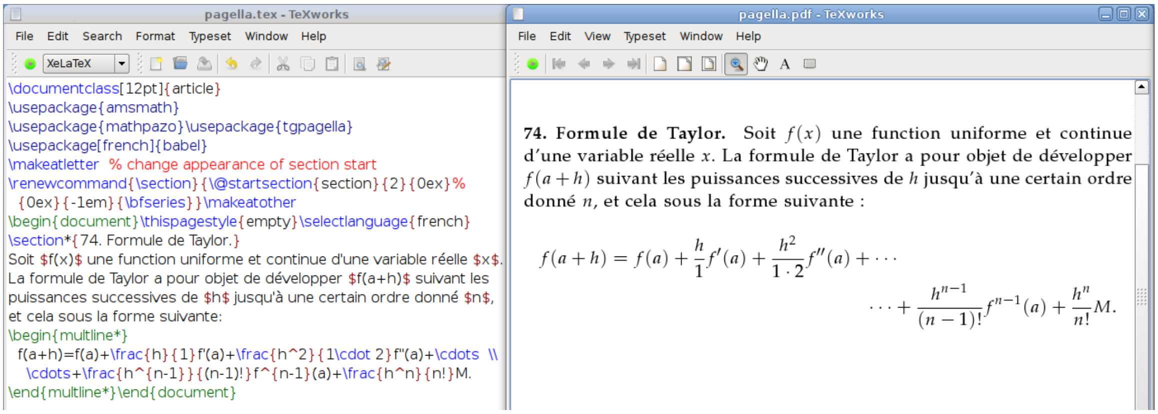


Figure 3. TEXworks screenshot with the edit and previewer windows (text from [5]).

One front end that has made a big splash in recent years is TEXShop by Richard Koch and others, for the Macintosh. It is a clean working environment directed at an average user. There are many useful features and an excellent help system (including videos). But there is one feature that users report makes the biggest difference in their productivity: source/preview synchronization. (Jérôme Laurens wrote the foundation work for this feature.) It allows you to use a mouse shortcut to switch back and forth between the TEX source and the output preview. That is, clicking in the output PDF sends you to the corresponding spot in the TEX input and, conversely, clicking in the input sends you to the corresponding spot in the output. This works even with multifile LATEX documents joined by `\include`.

TEXShop is Macintosh-specific. So the TEX user groups have sponsored the development of a new front end called TEXworks (by Jonathan Kew, also the author of XƎTEX). This has the same "keep it simple" attitude as TEXShop and is available for all of today's major systems: Windows, GNU/Linux and other X11-based systems, and Mac OS X. The editor works in Unicode so non-English text is not an issue. It will color TEX commands differently from regular text for easier reading. The default output is PDF so that you can share your files online or in email with recipients who do not have TEX. Finally, it includes an integrated PDF viewer that supports source/preview synchronization, so it brings that advantage of TEXShop to the other major computing platforms.

Figure 3 shows an example of TEXworks in action on a GNU/Linux system (it will look different on other platforms because it uses the window drawing system of the platform). It continues to develop but is very usable now. The TEXworks home page is `http://tug.org/texworks`.

Fonts: Latin Modern, TEX Gyre, and STIX

Computer fonts come in two types: a bitmap font has each character specified by an array of pixels, while a vector font has each character given by a set of parametric curves. Bitmap fonts are simpler but vector fonts scale smoothly to different sizes. Because of this advantage, vector fonts have come to dominate practical typesetting, originally in the form of PostScript Type 1 and TrueType fonts.

The recently developed OpenType font format standard was created and is supported by the major font vendors. It combines and extends the capabilities of TrueType and Type 1. The description earlier of the XƎTEX engine hints at its capability—it allows you to easily use any OpenType font. This means, for instance, that you can use a font that came with your system, or download one, without having to prepare it for use in TEX.

However, if you want to use the font in a document that contains mathematics then you still must supply a large number of parameters (for example, the spacing needed to position superscripts and subscripts). So fonts that have been prepared for mathematical text remain unusual and of special interest to the TEX community. A number of alternatives to Knuth's original font (Computer Modern) are currently available [1]. Here we will mention three recently developed vector font families that are well-suited for use with TEX documents. All three are freely available.

Latin Modern, by Bogusław Jackowski, Janusz M. Nowacki, and Marcin Wolínski of the Polish TEX users group, is based on Knuth's original Computer Modern fonts, but it is supplemented with a rich collection of diacritical marks such as accents or umlauts that can be added to letters, as well as letters that are precomposed with them. These supplements make for a better appearance and also improve hyphenation, since TEX's original mechanism for diacritical marks interferes with its hyphenation algorithm.

The TEX Gyre collection of fonts from the same group is based on the fonts commonly available in PostScript printers. Gyre adds to these fonts its own collection of diacritical marks for use in

European languages. Figure 3 shows one of these, Gyre Pagella (comparable to the Palatino font; its use with mathematics is not finalized so this example uses the package *mathpazo* to bring in a closely related font for math).

Finally, the STIX fonts are being developed by several leading scientific and technical publishers, including the AMS, and will provide a comprehensive set of mathematical symbols. When released, the fonts will have the look of the familiar Times Roman.

Obtaining TEX

A downloadable working TEX installation is called a distribution. Today there are two maintained distributions that are Free Software—both are free of cost and contain only materials with license conditions that allow for free redistribution. (Proprietary TEX distributions are also available.) These two, MiKTEX and TEX Live, are discussed below. Both support installation over the Internet or from a DVD and provide an install wizard to walk users through the steps. Both are large collections, with the programs, fonts, LATEX style files, etc., that users have come to expect. (To obtain these distributions, online or on DVD, see the `http://tug.org/notices` webpage.)

MiKTEX is the most popular distribution for the Windows platform (it is also being ported to GNU/Linux systems). It is best known for its package management and update programs, which are mature and very capable. For example, it can detect when a document being generated requires a package that is not installed and then download and install that package.

The other major distribution, TEX Live, also works on Windows but is most popular on Unix-like systems such as GNU/Linux. It has an active community of developers who have recently released a new package management and installation system.

Apple's Mac OS X is a Unix-like system, but for this platform we recommend the MacTEX distribution, which installs the complete TEX Live distribution along with a few extra Mac-specific features and programs.

In the TEX Community

After successfully installing, what's next?

Most TEX users choose LATEX as the core format for their documents. If you are new to TEX, we recommend it. One free manual that is enough to get you well under way in writing LATEX is *The Not So Short Introduction to LATEX2e* [4], available in many translations. Many other excellent documents and books have been written over the years; we have links on this article's webpage.

An advantage of using LATEX, and TEX in general, is that you are joining a community that has been active for a long time. Whatever issues you come across have very likely been tackled before. You can save yourself many struggles by looking for solutions that others have shared.

A great place to look for answers and to ask questions is the online discussion group `comp.text.tex`, which is one of the most active TEX forums. You can search through two decades of past questions. If you are still stuck then post one yourself.

The TEX community's largest resource for packages, programs, documentation, and more is the Comprehensive TEX Archive Network at `http://www.ctan.org`. This is a multi-gigabyte collection that contains far more than any TEX distribution. The solution to your TEX problem may have been already developed and made available here. Conversely, if you develop a package then please consider uploading it to CTAN. This not only gives your work greater visibility but it also gives it a stable Web address for years to come.

Another way to contribute to the community is to join your local TEX user group—this helps support TEX development in all its facets. We provide a link on our webpage.

Best Practices with Publishers

For mathematicians, one area of special interest is working with professional publishers. Here are five points that publishers have passed on to us.

The biggest one is communication: you should communicate with the publisher's technical staff early on, particularly if you will need special packages or fonts.

The second point is to use LATEX; every serious mathematics publisher can use it. Some can use other formats, but don't count on it.

The third is to make sure that your source files are portable. The production staff at your publisher will greatly appreciate this. In addition, you may want to resubmit your work to a second publisher after a rejection, or otherwise reuse your mathematical work in different settings: books, class notes, grant applications, and so on. Having a portable source means that it will adapt to new situations with less effort.

How can you make your documents portable? The most important way is to take advantage of the structure inherent in LATEX. Use `\chapter` and `\section` and so on, rather than defining your own structure. In addition to portability, this makes your source file more organized. Be aware that if you define special theorem environments, or other special formatting commands, then your publisher may also define those and yours may be overridden. (Never redefine basic elements of TEX or LATEX such as `\par`.) In general, a light hand at doing your own formatting is best; accept the defaults.

About the Cover

TEX at 30: Going strong

We are very pleased that Duane Bibby agreed to do the cover for this month's issue. He is an illustrator well known to mathematicians through his illustrations of TEX manuals, starting with *The TEXBook* in 1986. The cover accompanies the article on TEX on the preceding pages in this issue by James Hefferon and Karl Berry (also illustrated by Bibby).

TEX was invented (discovered? developed?) roughly thirty years ago by Don Knuth, the "organist" portrayed in the cover picture. In terms of computer generations, as Berry and Hefferon point out, this makes it ancient, but it is still going strong. It seems now a miracle that Knuth took the time off from his normal insanely busy schedule to develop TEX, and to some of us even more of a miracle that he immersed himself in font design in order to make freely available at the same time his Computer Modern fonts and their cousins, still used by most of us.

There is an interesting interview with Duane Bibby on the TEX Users Group website:

`http://www.tug.org/interviews/interview-files/duane-bibby.html`

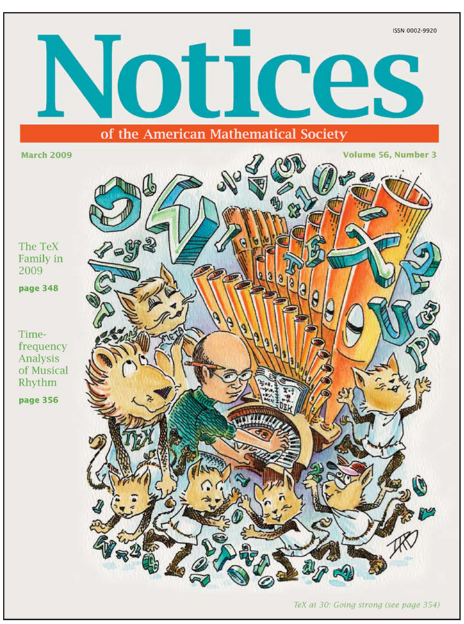
There you will find the answer to one question that has surely occurred to you:

Interviewer: "Do you ever get tired of drawing the TEX lions?"

DB: "No, not yet and I don't expect I will."

His own website is `http://duanebibby.com/`

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



In contrast with specifying your own commands for detailed spacing and fonts, a good portability practice is to create shorthands for frequent but cumbersome bits of code. For instance, in Figure 1 the random variables are not entered as `\mathbf{X}` but rather as `\rv{X}`, where `\rv` has been defined appropriately.

The fourth point is to be careful with graphics. Use standard programs and packages to create and include them. Find out what formats your publisher prefers for including graphics. (The AMS usually wants EPS files.) Be cautious about rescaling the size of the graphic via LATEX commands since this can blur differences in line thicknesses.

And, the fifth point, if you are writing a book then decide at the beginning whether you will have an index. If so, then use LATEX's indexing commands right from the start. Indexing is a painstaking job. If you do it as you compose the work then it is less tedious and the result will probably be more comprehensive.

Finally, you may find useful the AMS's list of frequently asked questions for authors: `http://www.ams.org/authors/author-faq.html`.

Closing

Despite its age—ancient in computer years—but because of its capabilities, TEX remains a standard. This includes publication platforms that didn't exist when TEX was written, such as the online preprint archive `arXiv`.

In recent years TEX has evolved rapidly, driven by the emergence of clear standards and by the effort of a development community that consciously keeps users in mind. The worldwide TEX user groups provide a framework and sponsorship for the activities.

We hope that you will find that taking advantage of these innovations helps you to be more productive.

References

[1] S. Hartke, A survey of free math fonts for TEX and LATEX, `http://ctan.org/tex-archive/info/Free_Math_Font_Survey`.

[2] K. Höppner, Strategies for including graphics in LATEX documents, *TUGboat* **26**(1), `http://tug.org/TUGboat/Articles/tb26-1/hoeppner.pdf`.

[3] A. Mertz and W. Slough, Beamer by example, *TUGboat* **26**(1), `http://tug.org/TUGboat/Articles/tb26-1/mertz.pdf`.

[4] T. Oetiker, et al., *The not so short introduction to LATEX2e*, `http://ctan.org/tex-archive/info/lshort`.

[5] C. de la Vallée Poussin, *Cours d'analyse*, Dover, 1938.

[6] W. Feller, *Probability*, Wiley, 1950.

Time-frequency Analysis of Musical Rhythm

Xiaowen Cheng, Jarod V. Hart, and James S. Walker

We shall use the mathematical techniques of Gabor transforms and continuous wavelet transforms to analyze the rhythmic structure of music and its interaction with melodic structure. This analysis reveals the hierarchical structure of rhythm. Hierarchical structure is common to rhythmic performances throughout the world's music. The work described here is interdisciplinary and experimental. We use mathematics to aid in the understanding of the structure of music, and have developed mathematical tools that (while not completely finished) have shown themselves to be useful for this musical analysis. We aim to explore ideas with this paper, to provoke thought, not to present completely finished work.

The paper is organized as follows. We first summarize the mathematical method of Gabor transforms (also known as short-time Fourier transforms, or spectrograms). Spectrograms provide a tool for visualizing the patterns of time-frequency structures within a musical passage. We then review the method of percussion scalograms, a new technique for analyzing rhythm introduced in [34]. After that, we show how percussion scalograms are used to analyze percussion passages and rhythm. We carry out four analyses of percussion passages from a variety of music styles (rock drumming, African drumming, and jazz drumming). We also explore three examples of the connection between rhythm and melody (a jazz piano piece, a Bach piano transcription, and a jazz orchestration). These examples provide empirical justification of our method. Finally, we explain how the parameters for percussion scalograms are chosen in order to provide a satisfactory display of the pulse trains that characterize a percussion passage (a key component of our method). A brief concluding section provides some ideas for future research.

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Gabor Transforms and Music

We briefly review the widely employed method of Gabor transforms [17], also known as short-time Fourier transforms, or spectrograms, or sonograms. The first comprehensive effort in employing spectrograms in musical analysis was Robert Cogan's masterpiece, *New Images of Musical Sound* [9]—a book that still deserves close study. In [12, 13], Dörfler describes the fundamental mathematical aspects of using Gabor transforms for musical analysis. Two other sources for applications of short-time Fourier transforms are [31, 25]. There is also considerable mathematical background in [15, 16, 19], with musical applications in [14]. Using sonograms or spectrograms for analyzing the music of bird song is described in [21, 30, 26]. The theory of Gabor transforms is discussed in complete detail in [15, 16, 19], with focus on its discrete aspects in [1, 34]. However, to fix our notations for subsequent work, we briefly describe this theory.

The sound signals that we analyze are all digital, hence discrete, so we assume that a sound signal has the form $\{f(t_k)\}$, for uniformly spaced

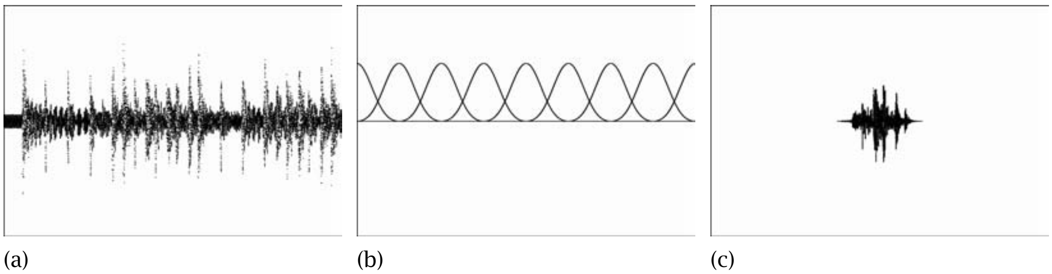


Figure 1. (a) Signal. (b) Succession of shifted window functions. (c) Signal multiplied by middle window in (b); an FFT can now be applied to this windowed signal.

values $t_k = k\Delta t$ in a finite interval $[0, T]$. A Gabor transform of f, with window function w, is defined as follows. First, multiply $\{f(t_k)\}$ by a sequence of shifted window functions $\{w(t_k - \tau_\ell)\}_{\ell=0}^{M}$, producing time localized subsignals, $\{f(t_k)w(t_k - \tau_\ell)\}_{\ell=0}^{M}$. Uniformly spaced time values, $\{\tau_\ell = t_{j\ell}\}_{\ell=0}^{M}$ are used for the shifts (j being a positive integer greater than 1). The windows $\{w(t_k - \tau_\ell)\}_{\ell=0}^{M}$ are all compactly supported and overlap each other. See Figure 1. The value of M is determined by the minimum number of windows needed to cover $[0, T]$, as illustrated in Figure 1(b).

Second, because w is compactly supported, we treat each subsignal $\{f(t_k)w(t_k - \tau_\ell)\}$ as a finite sequence and apply an FFT $\mathcal{F}$ to it. (A good, brief explanation of how FFTs are used for frequency analysis can be found in [1].) This yields the Gabor transform of $\{f(t_k)\}$:

$$\{\mathcal{F}\{f(t_k)w(t_k - \tau_\ell)\}\}_{\ell=0}^{M}. \tag{1}$$

Note that because the values t_k belong to the finite interval $[0, T]$, we always extend our signal values beyond the interval's endpoints by appending zeroes, hence the full supports of all windows are included.

The Gabor transform that we employ uses a *Blackman window* defined by

$$w(t) = \begin{cases} 0.42 + 0.5\cos(2\pi t/\lambda) + & \\ \qquad 0.08\cos(4\pi t/\lambda) & \text{for} \quad |t| \le \lambda/2 \\ 0 & \text{for} \quad |t| > \lambda/2 \end{cases}$$

for a positive parameter λ equaling the width of the window where the FFT is performed. The Fourier transform of the Blackman window is very nearly positive (negative values less than 10^{-4} in size), thus providing an effective substitute for a Gaussian function (which is well known to have minimum time-frequency support). See Figure 2. Further evidence of the advantages of Blackman-windowing is provided in [3, Table II]. In Figure 2(b) we illustrate that for each windowing by $w(t_k - \tau_m)$ we finely partition the frequency axis into thin rectangular bands lying above the support of the window. This provides a thin rectangular partition of the (slightly smeared) spectrum of f over the support of $w(t_k - \tau_m)$ for each m. The efficacy of these Gabor transforms is shown by how well they produce time-frequency portraits that accord well with our auditory perception, which is described in the vast literature on Gabor transforms that we briefly summarized above.

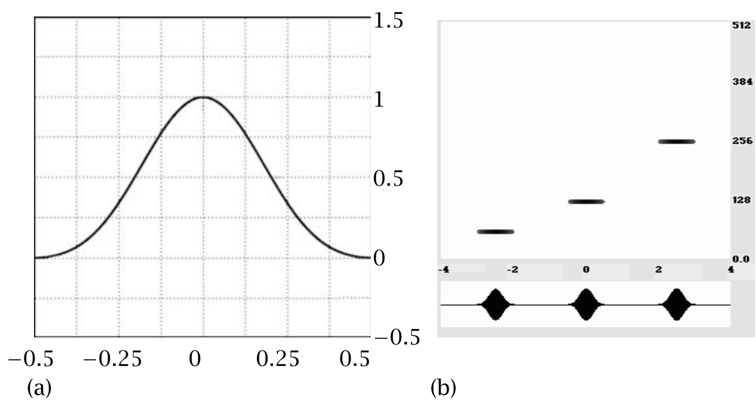
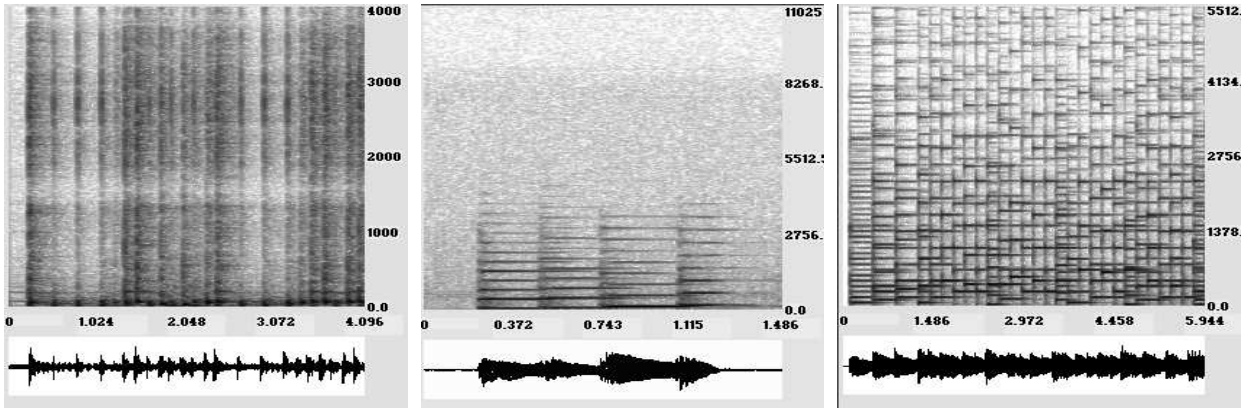


Figure 2. (a) Blackman window, $\lambda = 1$. Notice that it closely resembles the classic Gabor window—a bell curve described by a Gaussian exponential—but it has the advantage of compact support. (b) Time-frequency representation—the units along the horizontal are in seconds, along the vertical are in Hz—of three Blackman windows multiplied by the real part of the kernel $e^{i2\pi nk/N}$ of the FFT used in a Gabor transform, for three different frequency values n. Each horizontal bar accounts for 99.99% of the energy of the cosine-modulated Blackman window (Gabor atom) graphed below it.

It is interesting to listen to the sound created by the three Gabor atoms in Figure 2(b). You can watch a video of the spectrogram being traced out while the sound is played by going to the following webpage:

(2) `http://www.uwec.edu/walkerjs/TFAMRVideos/`

and selecting the video for *Gabor Atoms*. The sound of the atoms is of three successive pure



(a) Drum Clip (b) Piano scale notes (c) Bach melody

Figure 3. Three spectrograms. (a) Spectrogram of a drum solo from a rock song. (b) Notes along a piano scale. (c) Spectrogram of a piano solo from a Bach melody.

tones, on an ascending scale. The sound occurs precisely when the cursor crosses the thin dark bands in the spectrogram, and our aural perception of a constant pitch matches perfectly with the constant darkness of the thin bands. These Gabor atoms are, in fact, good examples of *individual notes.* Much better examples of notes, in fact, than the infinitely extending (both in past and future) sines and cosines used in classical Fourier analysis. Because they are good examples of pure tone notes, these Gabor atoms are excellent building blocks for music.

We shall provide some new examples that further illustrate the effectiveness of these Gabor transforms. For all of our examples, we used 1024 point FFTs, based on windows of support $\lesssim 1/8$ sec with a shift of $\Delta\tau \approx 0.008$ sec. These time-values are usually short enough to capture the essential features of musical frequency change.

In Figure 3 we show three basic examples of spectrograms of music. Part (a) of the figure shows a spectrogram of a clip from a rock drum solo. Notice that the spectrogram consists of dark vertical swatches; these swatches correspond to the striking of the drum, which can be verified by watching a video of the spectrogram (go to the website in (2) and select the video *Rock Drum Solo*). As the cursor traces over the spectrogram in the video, you will hear the sound of the drum strikes during the times when the cursor is crossing a vertical swatch. The reason why the spectrogram consists of these vertical swatches will be explained in the next section.

Part (b) of Figure 3 shows a spectrogram of a recording of four notes played on a piano scale. Here the spectrogram shows two features. Its main feature is a set of four sections consisting of groups of horizontal line segments placed vertically above each other. These vertical series of short horizontal segments are the fundamentals and overtones of the piano notes. There are also thin vertical swatches located at the beginning of each note. They are the percussive attacks of the notes (the piano is, in fact, classed as a percussive instrument).

Part (c) of Figure 3 shows a spectrogram of a clip from a piano version of a famous Bach melody. This spectrogram is much more complex, rhythmically and melodically, than the first two passages. Its melodic complexity consists in its *polyphonic* nature: the vertical series of horizontal segments are due to three-note *chords* being played on the treble scale and also individual notes played as counterpoint on the bass scale.[1] (This contrasts with the single notes in the *monophonic* passage in (b).) We will analyze the rhythm of this Bach melody in Example 5 below.

Scalograms, Percussion Scalograms, and Rhythm

In this section we briefly review the method of scalograms (continuous wavelet transforms) and then discuss the method of percussion scalograms.

Scalograms

The theory of continuous wavelet transforms is well-established [10, 8, 27]. A CWT differs from a spectrogram in that it does not use translations of a window of fixed width; instead it uses translations of differently sized dilations of a window. These dilations induce a logarithmic division of the frequency axis. The discrete calculation of a CWT that we use is described in [1, Section 4]. We shall only briefly review the definition of the CWT in

[1] *The chord structure and counterpoint can be determined either by careful listening or by examining the score* [2].

order to fix our notation. We then use it to analyze percussion.

Given a function Ψ, called the *wavelet*, the continuous wavelet transform $\mathcal{W}_\Psi[f]$ of a sound signal f is defined as

$$(3) \qquad \mathcal{W}_\Psi[f](\tau, s) = \frac{1}{\sqrt{s}} \int_{-\infty}^{\infty} f(t) \overline{\Psi\left(\frac{t-\tau}{s}\right)} \, dt$$

for *scale* $s > 0$ and *time-translation* τ. For the function Ψ in the integrand of (3), the variable s produces a dilation and the variable τ produces a translation.

We omit various technicalities concerning the types of functions Ψ that are suitable as wavelets; see [8, 10, 27]. In [8, 11], Equation (3) is derived from a simple analogy with the logarithmically structured response of our ear's basilar membrane to a sound stimulus f.

We now discretize Equation (3). First, we assume that the sound signal $f(t)$ is non-zero only over the time interval $[0, T]$. Hence (3) becomes

$$\mathcal{W}_\Psi[f](\tau, s) = \frac{1}{\sqrt{s}} \int_{0}^{T} f(t) \overline{\Psi\left(\frac{t-\tau}{s}\right)} \, dt.$$

We then make a Riemann sum approximation to this last integral using $t_m = m\Delta t$, with uniform spacing $\Delta t = T/N$, and discretize the time variable τ, using $\tau_k = k\Delta t$. This yields

(4)

$$\mathcal{W}_\Psi[f](\tau_k, s) \approx \frac{T}{N} \frac{1}{\sqrt{s}} \sum_{m=0}^{N-1} f(t_m) \overline{\Psi\left([t_m - \tau_k]s^{-1}\right)}.$$

The sum in (4) is a correlation of two discrete sequences. Given two N-point discrete sequences $\{f_k\}$ and $\{\Psi_k\}$, their *correlation* $\{(f : \Psi)_k\}$ is defined by

$$(5) \qquad (f : \Psi)_k = \sum_{m=0}^{N-1} f_m \overline{\Psi_{m-k}}.$$

(Note: For the sum in (5) to make sense, the sequence $\{\Psi_k\}$ is *periodically extended,* via $\Psi_{-k} := \Psi_{N-k}$.)

Thus, Equations (4) and (5) show that the CWT, at each scale s, is approximated by a multiple of a discrete correlation of $\{f_k = f(t_k)\}$ and $\{\Psi_k^s = s^{-1/2}\Psi(t_k s^{-1})\}$. These discrete correlations are computed over a range of discrete values of s, typically

$$(6) \qquad s = 2^{-r/J}, \quad r = 0, 1, 2, \dots, I \cdot J,$$

where the positive integer I is called the number of *octaves* and the positive integer J is called the number of *voices* per octave. For example, the choice of 6 octaves and 12 voices corresponds—based on the relationship between scales and frequencies described below—to the equal-tempered scale used for pianos.

The CWTs that we use are based on Gabor wavelets. A *Gabor wavelet,* with width parameter ω and frequency parameter ν, is defined as follows:

$$(7) \qquad \Psi(t) = \omega^{-1/2} e^{-\pi(t/\omega)^2} e^{i2\pi\nu t/\omega}.$$

Notice that the complex exponential $e^{i2\pi\nu t/\omega}$ has frequency ν/ω. We call ν/ω the *base frequency.* It corresponds to the largest scale $s = 1$. The bell-shaped factor $\omega^{-1/2}e^{-\pi(t/\omega)^2}$ in (7) damps down the oscillations of Ψ, so that their amplitude is significant only within a finite region centered at $t = 0$. See Figures 13 and 14. Since the scale parameter s is used in a reciprocal fashion in Equation (3), it follows that the reciprocal scale $1/s$ will control the frequency of oscillations of the function $s^{-1/2}\Psi(t/s)$ used in Equation (3). Thus, frequency is described in terms of the parameter $1/s$, which Equation (6) shows is logarithmically scaled. This point is carefully discussed in [1] and [34, Chap. 6], where Gabor scalograms are shown to provide a method of zooming in on selected regions of a spectrogram.

Pulse Trains and Percussion Scalograms

The method of using Gabor scalograms for analyzing percussion sequences was introduced by Smith in [32] and described empirically in considerable detail in [33]. The method described by Smith involved pulse trains generated from the sound signal itself. Our method is based on the spectrogram of the signal, which reduces the number of samples and hence speeds up the computation, making it fast enough for real-time applications. (An alternative method based on an FFT of the whole signal, the *phase vocoder,* is described in [31].)

Our discussion will focus on a particular percussion sequence. This sequence is a passage from the song, *Dance Around.* Go to the URL in (2) and select the video, *Dance Around percussion,* to hear this passage. Listening to this passage you will hear several groups of drum beats, along with some shifts in tempo. This passage illustrates the basic principles underlying our approach.

In Figure 4(a) we show the spectrogram of the *Dance Around* clip. This spectrogram is composed of a sequence of thick vertical segments, which we will call *vertical swatches.* Each vertical swatch corresponds to a percussive strike on a drum. These sharp strikes on drum heads excite a continuum of frequencies rather than a discrete tonal sequence of fundamentals and overtones. Because the rapid onset and decay of these sharp strikes produce approximate delta function pulses—and a delta function pulse has an FFT that consists of a constant value for all frequencies—it follows that these strike sounds produce vertical swatches in the time-frequency plane.

Our percussion scalogram method has the following two parts:

I. Pulse train generation. We generate a "pulse train", a sequence of subintervals of 1-values and 0-values (see the graph at

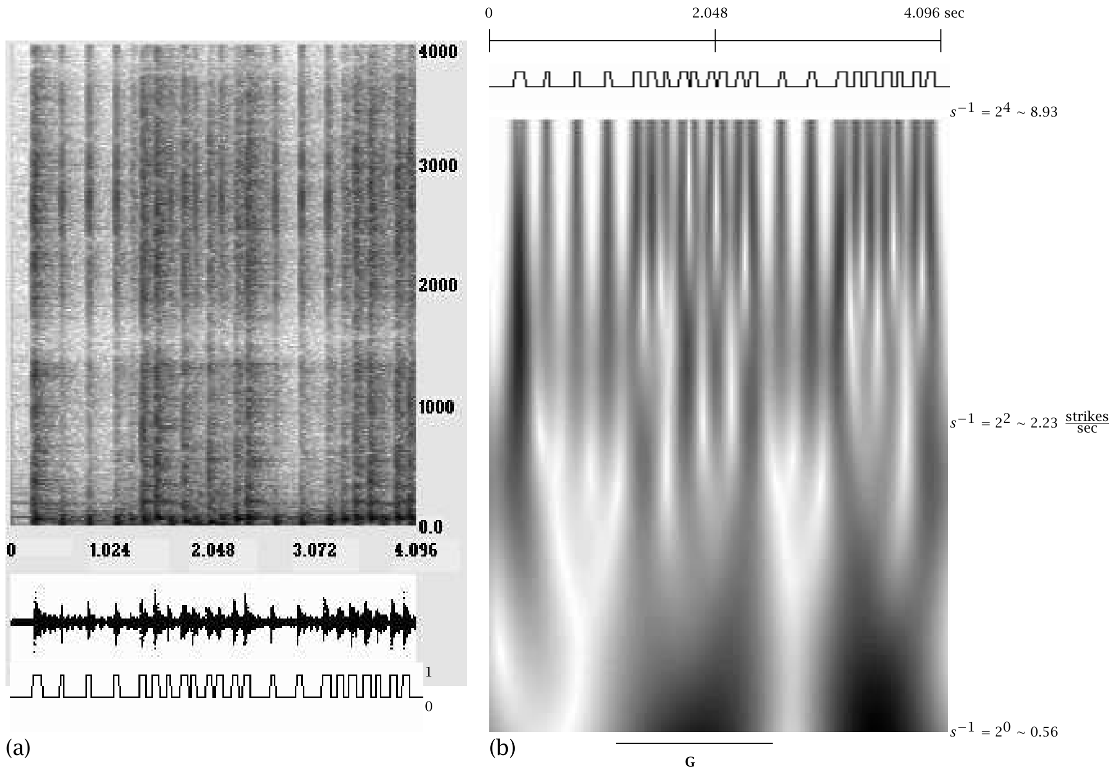


Figure 4. Calculating a percussion scalogram for the *Dance Around* sound clip. (a) Spectrogram of sound waveform with its pulse train graphed below it. (b) Percussion scalogram and the pulse train graphed above it. The dark region labeled by G corresponds to a collection of drum strikes that we hear as a group, and within that group are other subgroups over shorter time scales that are indicated by the splitting of group G into smaller dark blobs as one goes upwards in the percussion scalogram (those subgroups are also aurally perceptible). See Figure 5 for a better view of G.

the bottom of Figure 4(a)). The rectangular-shaped pulses in this pulse train correspond to sharp onset and decay of transient bursts in the percussion signal graphed just above the pulse train. The widths of these pulses are approximately equal to the widths of the vertical swatches shown in the spectrogram. Most importantly, the location and duration of the intervals of 1-values corresponds to our hearing of the drum strikes, while the location and duration of the intervals of 0-values corresponds to the silences between the strikes. In Step 1 of the method below we describe how this pulse train is generated.

II. Gabor CWT. We use a Gabor CWT to analyze the pulse train. This CWT calculation is performed in Step 2 of the method. The rationale for performing a CWT is that the pulse train is a step function analog of a sinusoidal of varying frequency. Because of this analogy between tempo of the pulses and frequency in sinusoidal curves, we employ a Gabor CWT for analysis. As an example, see the scalogram plotted in Figure 4(b). The thick vertical line segments at the top half of the scalogram correspond to the drum strikes, and these segments flow downward and connect together. Within the middle of the time-interval for the scalogram, these drum strike groups join together over four levels of hierarchy (see Figure 5). Listening to this passage, you can perceive each level of this hierarchy.

Now that we have outlined the basis for the percussion scalogram method, we can list it in detail. The percussion scalogram method for analyzing percussive rhythm consists of the following two steps.

Percussion Scalogram Method

Step 1. Let $\{g(\tau_m, y_k)\}$ be the spectrogram image, like in Figure 4(a). Calculate the average $\bar{g}$ over all frequencies at each time-value τ_m:

$$(8) \quad \bar{g}(\tau_m) = \frac{1}{P}\sum_{k=0}^{P-1} g(\tau_m, y_k),$$

(where P is the total number of frequencies y_k), and denote the average of $\bar{g}$ by A:

$$A = \frac{1}{M+1}\sum_{m=0}^{M} \bar{g}(\tau_m). \tag{9}$$

Then the pulse train $\{\mathcal{P}(\tau_m)\}$ is defined by

$$\mathcal{P}(\tau_m) = \mathbf{1}_{\{\tau_k : \bar{g}(\tau_k) > A\}}(\tau_m). \tag{10}$$

where $\mathbf{1}$ is the indicator function.[2] The values $\{\mathcal{P}(\tau_m)\}$ describe a pulse train whose intervals of 1-values mark off the position and duration of the vertical swatches (hence of the drum strikes). See Figure 6.

Step 2. *Compute a Gabor CWT of the pulse train signal* $\{\mathcal{P}(\tau_m)\}$ *from Step 1.* This Gabor CWT provides an objective picture of the varying rhythms within a percussion performance.

Remarks. (a) For the time intervals corresponding to vertical swatches, equations (8) and (9) produce values of $\bar{g}$ that lie above the average A (because A is pulled down by the intervals of silence). See Figure 6(a). For some signals, where the volume level is not relatively constant (louder passages interspersed with quieter passages) the total average A will be too high (the quieter passages will not contribute to the pulse train). We should instead be computing local averages over several (but not all) time-values. We leave this as a goal for subsequent research. In a large number of cases, such as those discussed in this article, we have found that the method described above is adequate. **(b)** For the *Dance Around* passage, the entire frequency range was used, as it consists entirely of vertical swatches corresponding to the percussive strikes. When analyzing other percussive passages, we may have to isolate a particular frequency range that contains just the vertical swatches of the drum strikes. We illustrate this later in the musical examples we describe (see the next section, "Examples of Rhythmic Analysis"). **(c)** We leave it as an exercise for the reader to show that the calculation of $\bar{g}(\tau_m)$ can actually be done in the time-domain using the data from the windowed signal values. (Hint: Use Parseval's theorem.) We chose to use the spectrogram values because of their ease of interpretation—especially when processing needs to be done, such as using only a particular frequency range. The spectrogram provides a lot of information to aid in the processing. **(d)** Some readers may wonder why we have computed a Gabor CWT in Step 2. Why not compute, say, a Haar CWT (which is based on a step function as wavelet)? We have found that a Haar CWT does provide essentially the same information as the *magnitudes* of the Gabor CWT (which is all we use in this article; using the phases of the complex-valued Gabor CWT is left for future research). However, the Haar CWT is more difficult to interpret, as shown in Figure 7.

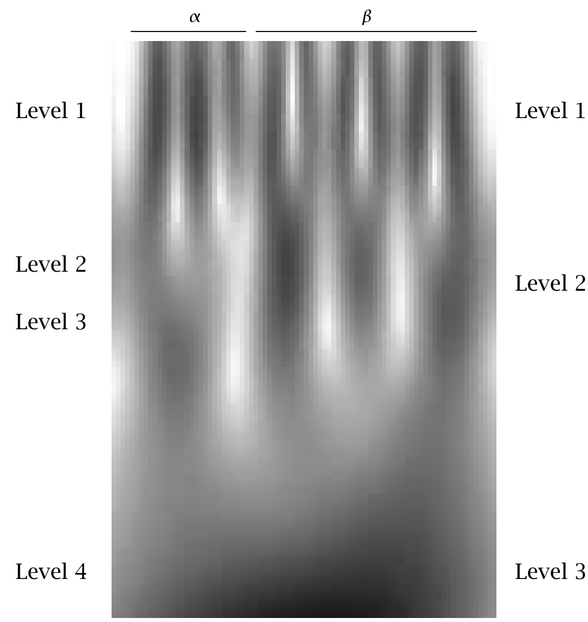


Figure 5. A rhythm hierarchy, obtained from the region corresponding to G in Figure 4. The hierarchy has two parts, labeled α and β. In each part the top level, Level 1, comprises the individual strikes. These strikes merge at Level 2 into regions which correspond to double strikes and which are aurally perceptible as groupings of double strikes. Notice that the Level 2 regions for β lie at positions of slightly increasing then decreasing strike-frequency as time proceeds; this is aurally perceptible when listening to the passage. There is also a Level 3 region for α that merges with the Level 2 regions for β to comprise the largest group G.

We have already discussed the percussion scalogram in Figure 4(b). We shall continue this discussion and provide several more examples of our method in the next section. In each case, we find that a percussion scalogram allows us to finely analyze the rhythmic structure of percussion sequences.

Examples of Rhythmic Analysis

As discussed in the previous section, a percussion scalogram allows us to perceive a hierarchal organization of the strikes in a percussion sequence. Hierarchical structures within music, especially within rhythmic passages and melodic contours, is a well-known phenomenon. For example, in an entertaining and thought-provoking book [24] with an excellent bibliography, *This Is Your Brain On Music,* Daniel Levitin says in regard to musical production (p. 154):

[2] *The indicator function $\mathbf{1}_S$ for a set S is defined by $\mathbf{1}_S(t) = 1$ when $t \in S$ and $\mathbf{1}_S(t) = 0$ when $t \notin S$.*

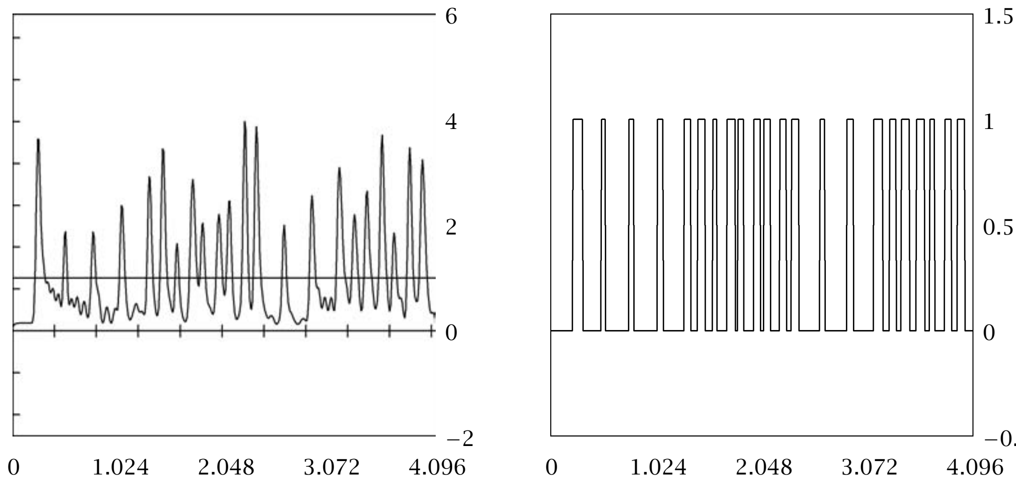


Figure 6. Creation of a pulse train. On the left we show the graph of $\bar{g}$ from equation (8) for the spectrogram of the *Dance Around* sound clip [see Figure 4(a)], which we have normalized to have an average of $A = 1$. The horizontal line is the graph of the constant function 1. The pulse train, shown on the right, is then created by assigning the value 1 when the graph of $\bar{g}$ is larger than A, and 0 otherwise.

> Our memory for music involves hierarchical encoding—not all words are equally salient, and not all parts of a musical piece hold equal status. We have certain entry points and exit points that correspond to specific phrases in the music…Experiments with musicians have confirmed this notion of hierarchical encoding in other ways. Most musicians cannot start playing a piece of music they know at any arbitrary location; musicians learn music according to a hierarchical phrase structure. Groups of notes form units of practice, these smaller units are combined into larger units, and ultimately into phrases; phrases are combined into structures such as verses and choruses of movements, and ultimately everything is strung together as a musical piece.

In a similar vein, related to musical theory, Steven Pinker summarizes the famous hierarchical theory of Jackendoff and Lerdahl [23, 22] in his fascinating book, *How The Mind Works* [28, pp. 532–533]:

> Jackendoff and Lerdahl show how melodies are formed by sequences of pitches that are organized in three different ways, all at the same time…The first representation is a grouping structure. The listener feels that groups of notes hang together in motifs, which in turn are grouped into lines or sections, which are grouped into stanzas, movements, and pieces. This hierarchical tree is similar to a phrase structure of a sentence, and when the music has lyrics the two partly line up...The second representation is a metrical structure, the repeating sequence of strong and weak beats that we count off as "ONE-two-THREE-four." The overall pattern is summed up in musical notation as the time signature…The third representation is a reductional structure. It dissects the melody into essential parts and ornaments. The ornaments are stripped off and the essential parts further dissected into even more essential parts and ornaments on them…we sense it when we recognize variations of a piece in classical music or jazz. The skeleton of the melody is conserved while the ornaments differ from variation to variation.

In regard to the strong and weak beats referred to by Pinker, we observe that these are reflected by the relative thickness and darkness of the vertical segments in a percussion scalogram. For example, when listening to the *Dance Around* passage, the darker groups of strikes in the percussion scalograms seem to correlate with loudness of the striking. This seems counterintuitive, since the pulse train consists only of 0's and 1's, which would not seem to reflect varying loudness. This phenomenon can be explained as follows. When a pulse is very long, that requires a more energetic striking of the drum, and this more energetic playing translates into a louder sound. The longer pulses correspond to darker spots lower down on the scalogram, and we hear these as louder sounds. (The other way that darker spots appear lower down is in grouping of several strikes. We do not hear them necessarily as louder individual sounds, but taken together they account for more energy than single, narrow pulses individually.)

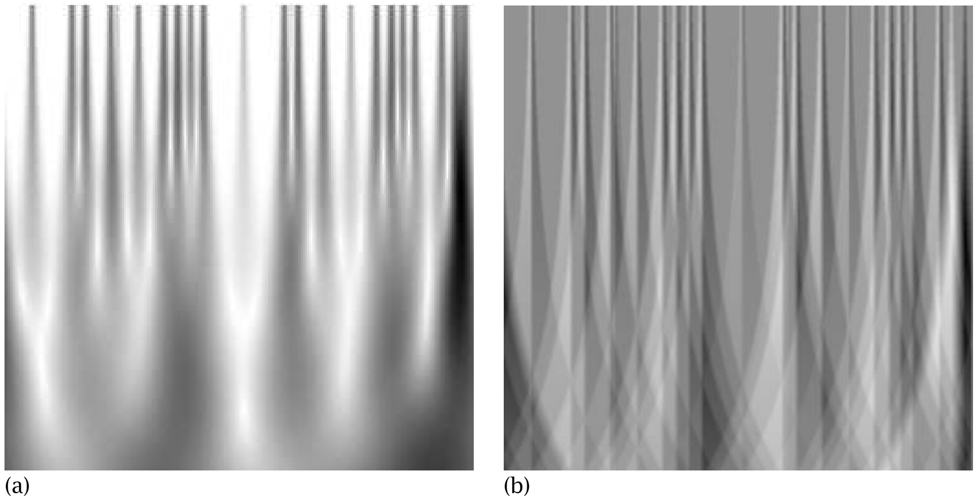


Figure 7. (a) Magnitudes of Gabor CWT of a pulse sequence. (b) Haar CWT of the same pulse sequence.

With these descriptions of the hierarchical structure of music in mind, we now turn to representations of them within four different percussion sequences.

Example 1: Rock Drumming

In Figure 8 we show a percussion scalogram for a clip from a rock drum solo, which we have partially analyzed in the previous section. Here we complete our analysis by describing the hierarchy shown in the scalogram in a more formal, mathematical way, and then introducing the notion of *production rules* for the performance of the percussion sequence.

We can see that there are five separate groupings of drum strikes in the scalogram in Figure 8:

A	B	C	B'	C'
(1-level)	(2-levels)	(4-levels)	(2-levels)	(4-levels)

The separate hierarchies within these groupings can be symbolized in the following way. We use the notation $\ast^{|}$ to symbolize a "whole note", a longer duration, more emphasized strike. And the notation $\ast^{\ulcorner}$ to symbolize a "half note", a shorter duration, less emphasized strike. This allows us to symbolize the different emphases in the rhythm. Furthermore, the underscore symbol _ will be used to denote a rest between strikes (notes). For example, $\ast^{\ulcorner}\_\ast^{|}$ symbolizes a half note followed by a rest followed by a whole note. Using this notation, the strikes in Figure 8 are symbolized by

$$\ast^{|}\_\ast^{|}\_\ast^{|}\_\ast^{|}\_\ast^{|}\ast^{|}\ast^{\ulcorner}\,\ast^{|}\ast^{\ulcorner}\,\ast^{|}\ast^{|}\ast^{|}\ast^{|}\_\ast^{|}\_\ast^{|}\_\ast^{|}\ast^{\ulcorner}\,\ast^{|}\ast^{|}\ast^{\ulcorner}\,\ast^{|}\ast^{|}$$

This notation is essentially equivalent to the standard notation for drumming used in musical scores (for examples of this notation, see [29] and [5]). We have thus shown that percussion scalograms can be used to read off a musical score for the drumming from its recorded sound. This is important because percussion playing is often extemporaneous, hence there is a need for notating particularly important extemporaneous passages as an aid to their repetition by other performers.

There is, however, much more information in a percussion scalogram. We can also use parentheses to mark off the groupings of the notes into their hierarchies, as follows:

$$\ast^{|}\_(\ast^{|}\_\ast^{|}\_\ast^{|})\_((\ast^{|}(\ast^{|}\ast^{\ulcorner}))(\ast^{|}\ast^{\ulcorner})(\ast^{|}\ast^{|})(\ast^{|}\ast^{|}))$$
$$\_(\ast^{|}\_\ast^{|})\_((\ast^{|}(\ast^{\ulcorner}\ast^{|})(\ast^{|}\ast^{\ulcorner}))(\ast^{|}\ast^{|}))$$

The advantage of this notation over the previous one is that the hierarchical groupings of notes is indicated. *We believe this enhanced notation, along with the videos that we create of sound with percussion scalograms, provide an important tool for analyzing the performance of percussion sequences. For example, they may be useful in teaching performance technique (recall Levitin's discussion of how musicians learn to play musical passages) by adding two adjuncts, notation plus video, to aid the ear in perceiving subtle differences in performance technique.*

In addition to this symbolic notation for percussion passages, there is an even deeper (and somewhat controversial) notion of *production rules* for the generation of these percussion sequences (analogous to Chomsky's notion of "deep structure" in linguistics that generates, via production rules, the syntactical hierarchy of sentences: [22, Section 11.4] and [7, Sections 5.2, 5.3]). Examples of these rules in music are described in [22, pp. 283–285, and p. 280]. Rather than giving a complete mathematical description at this time, we will

Figure 8. Percussion scalogram for rock drumming. The labels are explained in Example 1. To view a video of the percussion scalogram being traced out along with the drumming sound, go to the URL in (2) **and select the video for *Dance Around percussion.***

simply give a couple of examples. For instance, the grouping B' in the passage is produced from the grouping B, by clipping two strikes off the end:

$$B' \leftarrow \mathsf{End}(B)$$

As another example, if we look at the starting notes in the groups C and C' defined by

$$\mathsf{Start}(C) := \ast^{|}(\ast^{|}\ast^{\lceil}) \quad \text{and} \quad \mathsf{Start}(C') := \ast^{|}(\ast^{\lceil}\ast^{|})$$

then $\mathsf{Start}(C')$ is produced from $\mathsf{Start}(C)$ by a modulation of emphases:

$$\mathsf{Start}(C') \leftarrow \mathsf{Modulation}(\mathsf{Start}(C))$$

In this paper we are only giving these two examples of production rules, in order to give a flavor of the idea. A more complete discussion is a topic for a future paper.

Example 2: African Drumming

Our second example is a passage of African drumming, clipped from the beginning of the song *Welela* from an album by Miriam Makeba. In this case, the spectrogram of the passage, shown in Figure 9(a), has some horizontal banding at lower frequencies that adversely affect the percussion scalogram by raising the mean value of the spectrogram averages. Consequently, we used only values from the spectrogram that are above 1000 Hz to compute the percussion scalogram shown in Figure 9(b). By listening to the video referenced in the caption of Figure 9, you should find that this percussion scalogram does accurately capture the timing and grouping of the drum strikes in the passage.

This passage is quite interesting in that it is comprised of only 20 drum strikes, yet we shall see that it contains a wealth of complexity. First, we can see that there are seven separate groupings of drum strikes in the scalogram in Figure 9:

A	*B*	*C*	*A*	*B*	*C*	*D*
(1-level)	(3-level)	(3-level)	(1-level)	(3-level)	(3-level)	(2-level)

Notice the interweaving of different numbers of levels within this sequence of groups. Second, the drum strikes can be notated with hierarchical grouping as follows:

$$\ast^{\lceil}\,\_\_\_((\ast^{|}\ast^{|})\_(\ast^{|}\_\ast^{\lceil}))\_((\ast^{|}\ast^{|})(\ast^{\lceil})(\ast^{|}))$$

$$\_\_\_\ast^{\lceil}\,\_\_\_((\ast^{|}\ast^{|})\_(\ast^{|}\_\ast^{\lceil}))\_((\ast^{|}\ast^{|})(\ast^{\lceil})(\ast^{|}))\_(\ast^{|}\ast^{|})$$

This passage is interesting not only in terms of the complex hierarchical grouping of notes, but also because of the arrangement of the time intervals between notes. It is a well-known fact among musicians that the silences between notes are at least as important as the notes themselves. In this passage we have the following sequence of time-intervals between notes (1 representing a short rest, 2 representing a long rest, and 0 representing no rest):

2 0 1 1 1 0 0 0 2 2 0 1 1 1 0 0 0 1 0

which quantitatively describes the "staggered" sound of the drum passage. (The reader might find it interesting to compute the sequence of rests for Example 1, and verify that it is less staggered, with longer sequences of either 1's or 0's.)

Example 3: Jazz Drumming

In this example we consider a couple of cases of jazz drumming. In Figure 10(a) we show a percussion scalogram created from the drum solo at the beginning of the jazz classic, *Sing Sing Sing.* The tempo of this drumming is very fast. Our notation for this sequence was obtained from examining the percussion scalogram both as a picture and as the video sequence (referred to in the caption of the figure) is played. Here is the notated sequence:

Very fast

$$\ast^{|}\_\_\_\,\ast^{\lceil}\,\ast^{\lceil}\,\_\,\ast^{|}\,\_\,\ast^{\lceil}\,\_\,\ast^{|}\,\ast^{|}\_\,\ast^{|}\,\_\_\_\,\ast^{|}\,\_\_\_\,\ast^{|}\,\_\,\ast^{\lceil}\,\_$$

$$\ast^{|}\_\_\_\,\ast^{|}\,\_\,\ast^{|}\,\_\_\_\,\ast^{\lceil}\,\_\,\ast^{|}\,\_\,\ast^{\lceil}\,\ast^{\lceil}\,\ast^{\lceil}\,\_\,\ast^{|}\,\_\_\_\,\ast^{\lceil}\,\ast^{\lceil}\_\ast^{|}$$

Our notation differs considerably from the notation given for this beginning drum solo in the original score [29], the first several notes being:

Jungle Drum Swing

$$\ast^{|}\,\ast^{|}\,\ast^{\lceil}\,\ast^{\lceil}\,\ast^{\lceil}\,\ast^{\lceil}\,\ast^{|}\,\ast^{\lceil}\,\ast^{\lceil}$$

Setting aside its racist overtones, we observe that this tempo instruction is not terribly precise. We can see from comparing these two scores, that the drummer (Gene Krupa) is improvising the percussion (as is typical with jazz). Our percussion

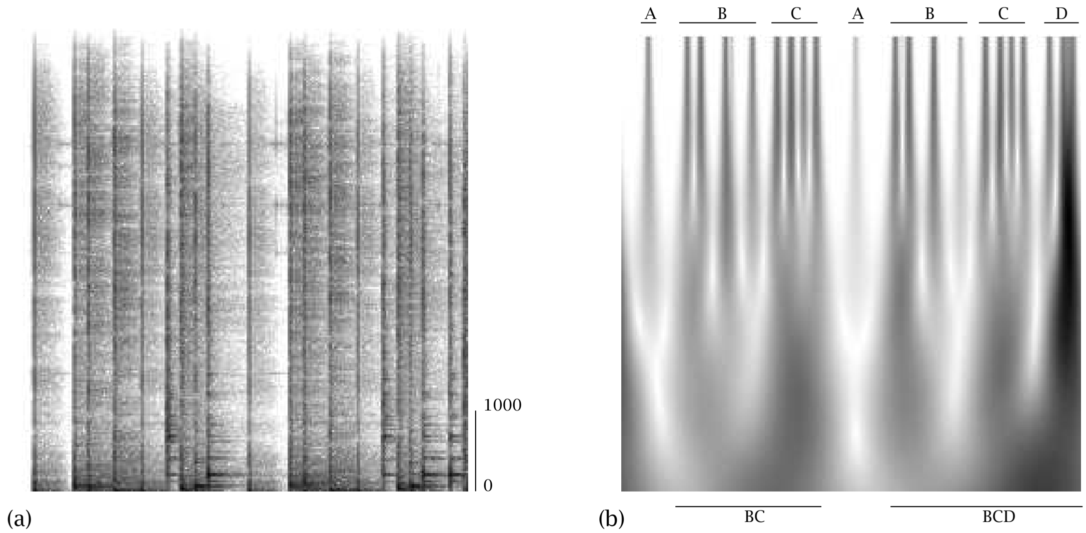


Figure 9. (a) Spectrogram for African drumming. Between 0 and 1000 Hz, as marked on the right side of (a), there are a considerable number of horizontal line segments. Those segments adversely affect the percussion scalogram. Consequently only frequencies above 1000 Hz are used to create the percussion scalogram. (b) Percussion scalogram for African drumming, using frequencies above 1000 Hz. The labels are explained in Example 2. To view a video of the percussion scalogram being traced out along with the drumming sound, go to the URL in (2) **and select the video for *Welela percussion.***

scalogram method allows us to derive a precise notation for Krupa's improvisation. We leave it as an exercise for the reader to notate the hierarchical structure of this drum passage, based on the percussion scalogram. From our notation above, we find that the pattern of rests in Krupa's playing has this structure:

2 0 1 1 1 0 1 2 2 1 1 2 1 2 1 1 0 0 0 1 2 0 1

Here, as with the African drumming, we see a staggered pattern of rests.

Our second example of jazz drumming is a clip of the beginning percussive passage from another jazz classic, *Unsquare Dance.* In the score for the piece [5], the following pattern of strikes (indicated as *hand clapping*)

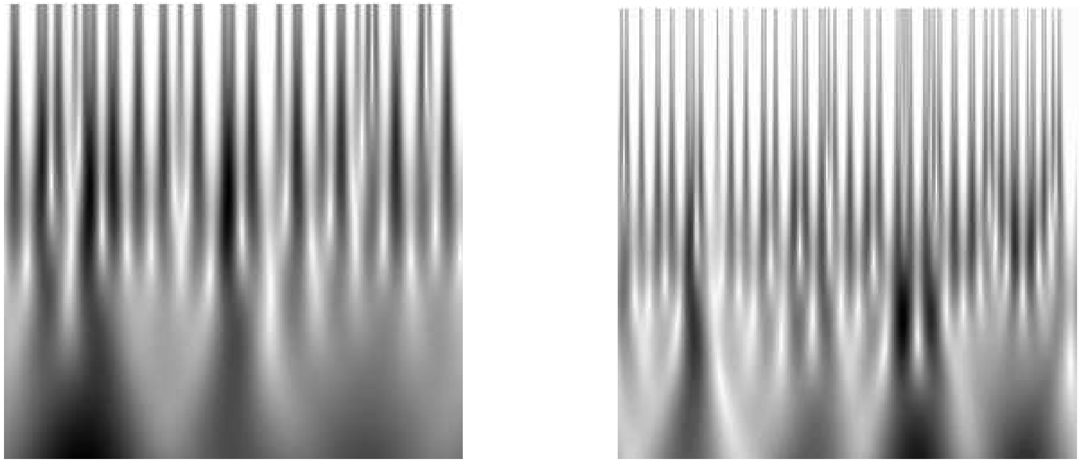
_ *| _ *| _ *| *|

is repeated in each measure (consistent with the 7/4 time signature). Listening to the passage as the video is played, we can hear this repeated series of "strikes" as groups of very fast individual strikings of drumsticks. The drummer (Joe Morello) is improvising on the notated score by replacing individual hand claps by these very rapid strikings of his drumsticks. It is noteworthy that, in many instances, the percussion scalogram is sensitive enough to record the timings of the individual drumstick strikings. The scalogram is thus able to reveal, in a visual representation, the double aspect to the rhythm: individual drum strikings within the larger groupings notated as hand claps in the original score.

These examples are meant to illustrate that the percussion scalogram method can provide useful musical analyses of drumming rhythms. Several more examples are given at the *Pictures of Music* website [6]. We now provide some examples of using both spectrograms and percussion scalograms to analyze both the melodic and rhythmic aspects of music. Because they are based on an assumption of intense pulsing in the musical signal due to percussion, which is only satisfied for some tonal instruments, percussion scalograms do not always provide accurate results for tonal instruments. However, when they do provide accurate results (a precise description of the timings of the notes), they reveal the rhythmic structure of the music (which is our goal). We now provide three examples of successful analyses of melody and rhythm.

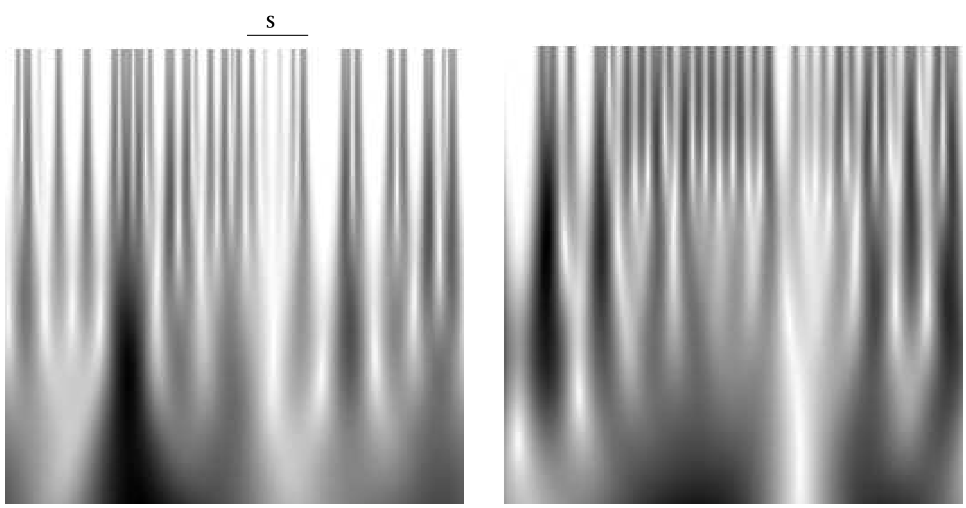
Example 4: A Jazz Piano Melody

In Figure 11(a) we show a percussion scalogram of a recording of a jazz piano improvisation by Erroll Garner. It was captured from a live recording [18]. Since this is an improvisation, there is no musical score for the passage. Several aspects of the scalogram are clearly evident. First, we can see a staggered spacing of rests as in the African drumming in Example 2 and the jazz drumming in the *Sing Sing Sing* passage in Example 3. There



(a) (b)

Figure 10. (a) Percussion scalogram for drum solo in *Sing Sing Sing* using frequencies above 1000 Hz. (b) Percussion scalogram for complex drum stick percussion in *Unsquare Dance* using frequencies above 2000 Hz. To view videos of these percussion scalograms being traced out along with the drumming sound, go to the URL in (2) **and select the videos for *Sing Sing Sing percussion* or *Unsquare Dance percussion.***



(a) (b)

Figure 11. (a) Percussion scalogram of a clip from an Erroll Garner jazz piano passage (using frequencies above 1800 Hz). To view a video of the percussion scalogram being traced out along with the piano playing, go to the URL in (2) **and select the video for *Erroll Garner piano recording.* The label S indicates a syncopation in the melody. (b) Percussion scalogram from a clip of a piano interpretation of a Bach melody (using frequencies above 3000 Hz). To view a video of the percussion scalogram being traced out along with the piano sound, go to the URL in** (2) **and select the video for *Bach piano piece (scalogram).***

is also a syncopation in the melody, indicated by the interval marked **S** in Figure 11(a). By syncopation we mean an altered rhythm, "ONE-two-three-FOUR," rather than the more common "ONE-two-THREE-four." The percussion scalogram provides us with a visual representation of these effects, which is an aid to our listening comprehension. Although the percussion scalogram does not perform perfectly here (for example the last note in the sequence marked **S** is split in two at the top; the scalogram has detected the attack and the decay of the note), when viewed as a video the percussion scalogram does enable us to quickly identify the timing and hierarchical grouping of the notes (which would be much more difficult using only our ears).

Example 5: A Bach Piano Transcription

As a simple contrast to the previous example, we briefly discuss the percussion scalogram shown in Figure 11(b), obtained from a piano interpretation of a Bach melody, *Jesu, Joy of Man's Desiring.* The sound recording used was created from a MIDI sequence. In contrast to the previous jazz piece, this classical piece shows no staggering of rests, and no syncopation. The hierarchy of groupings of notes is also more symmetrical than for the jazz piece. This hierarchy of notes, the rhythm of the passage, is easily discernable from this percussion scalogram, while it is not clearly evident from the score [2] (at least to untrained musicians).

Example 6: A Jazz Orchestral Passage

For our final example, we analyze the spectrogram and percussion scalogram shown in Figure 12. They were obtained from a passage from a recording of the jazz orchestral classic, *Harlem Air Shaft,* by Duke Ellington. This passage is quite interesting in that it is comprised of only about 15 notes, yet we shall see that it contains a wealth of complexity. (We saw this in the African drum passage as well; perhaps we have an aspect of aesthetic theory here.) We now describe some of the elements comprising the rhythm and melody within this passage. It should be noted that, although there is a score for *Harlem Air Shaft,* that score is a complex orchestration that requires a large amount of musical expertise to interpret. Our spectrogram/percussion scalogram approach provides a more easily studied description of the melody and rhythm, including visual depictions of length and intensity of notes from several instruments playing simultaneously. *Most importantly, the spectrogram provides an objective description of recorded performances. It can be used to compare different performances in an objective way. Our percussion scalograms facilitate the same kind of objective comparison of the rhythm in performances.*

(1) *Reflection of Notes.* The passage contains a sequence of high pitched notes played by a slide trombone (wielded by the legendary "Tricky Sam" Nanton). This sequence divides into two groups of three, enclosed in the rectangles labeled **T** and $\mathcal{R}$**T** in the spectrogram shown at the top of Figure 12. The three notes within **T** are located at frequencies of approximately 855, 855, and 845 Hz. They are then reflected about the frequency 850, indicated by the line segment $\mathcal{M}$ between the two rectangles, to produce the three notes within $\mathcal{R}$**T** at frequencies of approximately 845, 845, and 855 Hz. The operation of reflection $\mathcal{R}$ about a specific pitch is a common, group-theoretical, operation employed in classical music [20].

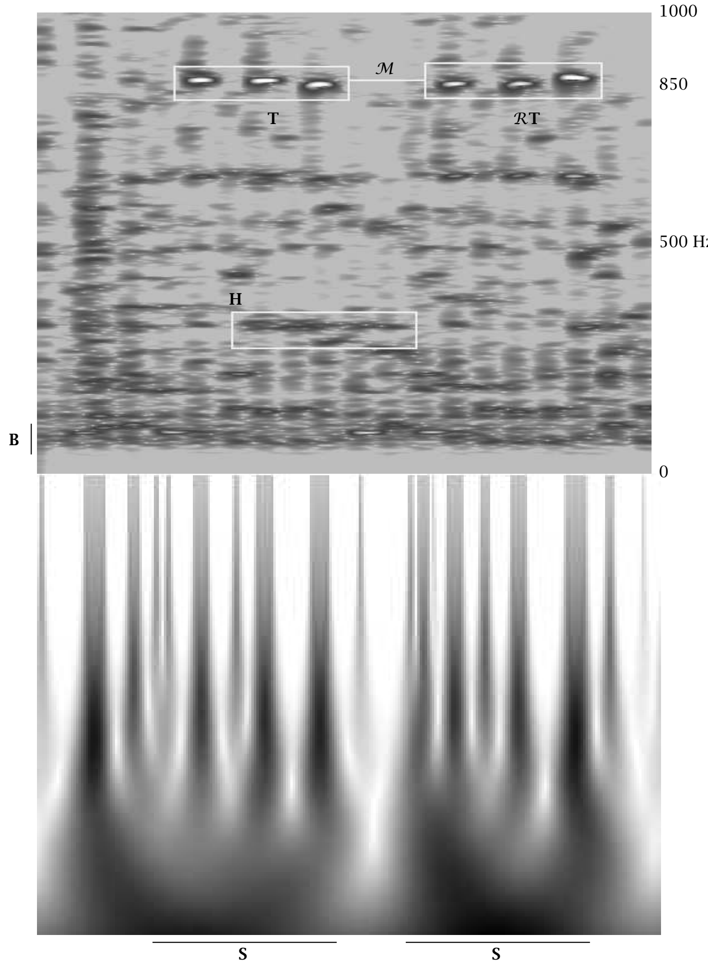


Figure 12. Top: Spectrogram of a passage from a recording of *Harlem Air Shaft.* Bottom: Percussion scalogram of the same passage (using all frequencies). The boxed regions and labels are explained in the text. To view videos of this spectrogram and scalogram, go to the URL in (2) **and select the links indicated by *Harlem Air Shaft.***

(2) *Micro-Tones.* The pitch interval described by going down in frequency from 855 to 845 Hz is

$$\log_2(855/845) = 0.017 \approx 1/48,$$

which is about 1/4 of the (logarithmic) half-tone change of 1/12 of an octave (on the 12-tone chromatic scale). Thus within **T** the pitch descends by an *eighth-tone.* Similarly, in $\mathcal{R}$**T** the pitch ascends at the end by an eighth-tone. These are *micro-tone* intervals, intervals that are not representable on the standard 12-tone scoring used in Western classical music. They are, in fact, half the interval of the quarter-tones that are a characteristic of jazz music (based on its roots in African tonal scales [4]). Here Ellington *synthesizes a melodic characteristic of jazz (micro-tones) with one of classical music (reflection about a pitch level).*

(3) *Staggered Syncopation.* Viewing the video of the percussion scalogram shown in Figure 12, we note that there is a staggering of rests between notes, and we also observe a syncopation. This syncopation occurs when the slide trombone slides into and between the emphasized notes in the structures **T** and $\mathcal{R}$**T**. The pattern lying above the segments marked **S** in the figure is

one – TWO – three – FOUR – (rest) – FIVE

an unusual, *staggered syncopation,* of rhythm. (One thing we observe when viewing the video is that the percussion scalogram does capture the timings of most of the note attacks, although it does not perfectly reflect some muted horn notes—because the attacks of those notes are obscured by the higher volume trombone notes. Nevertheless, the scalogram provides an adequate description of the driving rhythm of the trombone notes, and the muted trumpet notes at the end of the passage.)

(4) *Hierarchies of Melody.* Within the passage there are several different types of melody, over different length time-scales. First, we note that there is the hierarchy of **T** and $\mathcal{R}$**T** at one level along with their combination into one long passage, linked melodically by a sequence of muted horn notes **H**. Notice that the pitch levels in **H** exhibit, over a shorter time-scale, the pitch pattern shown in the notes within **T** together with $\mathcal{R}$**T**. That is a type of hierarchical organization of melodic contour. There is a further hierarchical level (in terms of a longer time-scale) exhibited by the melodic contour of the bass notes (shown as a long sinusoidal arc within the region marked by **B**). Here the bassist, Jimmy Blanton, is using the bass as a plucked melodic instrument as well as providing a regular tempo for the other players. This is one of his major innovations for the bass violin in jazz instrumentation.

We can see from this analysis that this passage within just 6 seconds reveals a wealth of structure, including many features that are unique to jazz. Such mastery illustrates why Duke Ellington was one of the greatest composers of the twentieth century.

Justification of the Percussion Scalogram Method

Choosing the Width and Frequency Parameters

In this section we discuss how the parameters are chosen to provide a satisfactory display of a scalogram for a pulse train, which is the second step of the percussion scalogram method. The term *satisfactory* means that both the average number of pulses/sec (beats/sec) are displayed and the individual beats are resolved.

To state our result we need to define several parameters. The number T will stand for the time duration of the signal, while B will denote the total number of pulses in the pulse train signal. We will use the positive parameter p to scale the width ω and frequency ν defined by

$$\omega = \frac{pT}{2B}, \quad \nu = \frac{B}{pT}. \tag{11}$$

Notice that ω and ν are in a reciprocal relationship; this is in line with the reciprocal relation between time-scale and frequency that is used in wavelet analysis. Notice also that the quantity B/T in ν is equal to the average number of pulses/sec. The best choice for the parameter p in these formulas will be described below. Two further parameters are the number of octaves I and voices M used in the percussion scalogram. We shall see that these two parameters will depend on the value of δ, the minimum length of a 0-interval (minimum space between two successive pulses).

Now that we have defined our parameters, we can state our main result:

Given the constraints of using positive integers for the octaves I and voices M and using 256 total correlations, satisfactory choices for the parameters of a percussion scalogram are:

$$\begin{aligned} &\omega = \frac{pT}{B}, \quad \nu = \frac{B}{pT}, \quad p = 4\sqrt{\pi} \\ &I = \left\lfloor \log_2\left(\frac{p^2T^2}{\delta B^2}\right) - \frac{3}{2} \right\rfloor, \quad M = \left\lfloor \frac{256}{I} \right\rfloor. \end{aligned} \tag{12}$$

The remainder of this section provides the rationale for this result (notice that the value of ω in (12) is twice the value given in (11); we shall explain why below). While this rationale may not be a completely rigorous proof, it does provide useful insights into how a Gabor CWT works with pulse trains, and it does provide us with the method used to produce the scalograms for the pulse trains shown in the section "Examples of Rhythmic Analysis" (and for the other examples given at the *Pictures of Music* website [6]). In fact, we have found that in every case, the method provides a satisfactory display of the scalogram for a pulse train from a musical passage (whether the pulse train is accurate is a separate question; we are still working on extending its capabilities as described previously).

We shall denote a given pulse train by $\{\mathcal{P}(t_m)\}$. (Here we use $\{t_m = \tau_m\}$ as the time-values; this notational change is clarified by looking at equation (16).) This signal satisfies $\mathcal{P}(t_m) = 1$ during the duration of a beat and $\mathcal{P}(t_m) = 0$ when there is no beat. We use the Gabor wavelet in (7) to analyze the pulse signal. Since we are using the complex Gabor wavelet, we have both a real and imaginary part:

$$\Psi_{\Re}(t) = \omega^{-\frac{1}{2}} e^{-\pi(t/\omega)^2} \cos \frac{2\pi\nu t}{\omega} \tag{13}$$

$$\Psi_{\Im}(t) = \omega^{-\frac{1}{2}} e^{-\pi(t/\omega)^2} \sin \frac{2\pi\nu t}{\omega}. \tag{14}$$

These real and imaginary parts have the same envelope function:

$$\Psi_E(t) = \omega^{-\frac{1}{2}} e^{-\pi(t/\omega)^2}. \tag{15}$$

The width parameter ω controls how quickly Ψ_E is dampened. For smaller values of ω the function dampens more quickly. Also, ω controls the magnitude of the wavelet function at $t = 0$. In fact, we have $\Psi(0) = \omega^{-1/2}$. The width parameter also affects the frequency of oscillations of the wavelet. As ω is increased, the frequency of oscillations of the wavelet is decreased. See Figure 13.

The frequency parameter ν is used to control the frequency of the wavelet within the envelope function. This parameter has no effect on the envelope function, as shown in Equation (15). As ν is increased, the Gabor wavelet oscillates much more quickly. See Figure 14.

When using the Gabor wavelet to analyze music, correlations are computed using the Gabor wavelet with a scaling parameter s. For our pulse train $\mathcal{P}$ these correlations are denoted $(\mathcal{P} : \Psi_s)$ for $s = 2^{-r/M}$, $r = 0, 1, \ldots, IM$, and are defined by

$$(\mathcal{P} : \Psi_s)(\tau_k) = \sum_{m=0}^{M} \mathcal{P}(t_m)\overline{s^{-1/2}\Psi\left([t_m - \tau_k]s^{-1}\right)}. \tag{16}$$

Since $\{\mathcal{P}(t_m)\}$ is a binary signal, the terms of this sum will equal $\overline{s^{-1/2}\Psi\left([t_m - \tau_k]s^{-1}\right)}$ if $\mathcal{P}(t_m) = 1$, and 0 if $\mathcal{P}(t_m) = 0$. The values of τ_k represent the center of the Gabor wavelet being translated along the time axis. So for values of t_m closer to τ_k, $\overline{s^{-1/2}\Psi\left([t_m - \tau_k]s^{-1}\right)}$ will be larger in magnitude. Then, at values for t_m where $\mathcal{P}(t_m) = 1$ and $t_m = \tau_k$, the corresponding term in the correlation sum will be

$$\begin{aligned}\mathcal{P}(t_m)\overline{s^{-1/2}\Psi\left([t_m - \tau_k]s^{-1}\right)} &= \overline{s^{-1/2}\Psi(0)} \\ &= \frac{1}{\sqrt{s}}\sqrt{\frac{2B}{pT}}\end{aligned}$$

which will represent the striking of an instrument. So as s reaches its smallest values, near $s = 2^{-I}$, the correlations will have large magnitude values only near τ_k, and where $\mathcal{P}(t_m) = 1$, i.e., at the beat of the instrument. This happens because small values of s result in the function

$$\overline{s^{-1/2}\Psi\left([t_m - \tau_k]s^{-1}\right)}$$

being dampened very quickly, so very little other than the actual beats are detected by the Gabor CWT.

Detection of the rhythm and grouping of the percussion signal is accomplished by the larger values of s that result in a slowly dampened Gabor wavelet. As the correlation sum moves to values such that $t_m \neq \tau_k$, the function $\overline{s^{-1/2}\Psi\left([t_m - \tau_k]s^{-1}\right)}$ is being dampened. But with the wavelet being dampened more slowly now, the values of $\overline{s^{-1/2}\Psi\left([t_m - \tau_k]s^{-1}\right)}$ are larger near $t_m = \tau_k$ than they were before. Hence the t_m values where $\mathcal{P}(t_m) = 1$ will result in summing more values of the wavelet that are significantly large. Therefore, any beat that is close to another beat will result in larger correlation values for larger values of s. Notice also that those values of t_m where $\mathcal{P}(t_m) = 0$ that are close to t_m values where $\mathcal{P}(t_m) = 1$ will result in summing across the lesser dampened Gabor wavelet values—our scalogram will thus be registering the grouping of closely spaced beats.

Now we need to choose the parameters ω and ν based on $\{\mathcal{P}(t_m)\}$ to obtain the desired shape for the Gabor wavelet. To choose these parameters for a specific percussion signal we will use B/T as our measure of the average beats per second. The average time between beats will then be the reciprocal of the average beats per second: T/B. Then we let the width parameter ω and the frequency parameter ν be defined by (11), with parameter $p > 0$ used as a scaling factor. With these width and frequency parameters, the Gabor wavelet is

$$\Psi(t) = \sqrt{\frac{2B}{pT}}\, e^{-\pi(2Bt/pT)^2} e^{i4\pi B^2/(p^2T^2)}. \tag{17}$$

We want to detect beats that are within T/B, the average time between beats, of each other. Likewise, we want separation of the beats that are not within T/B of each other. We accomplish this by inspecting the envelope function evaluated at $t = T/B$,

$$\Psi_E\left(\frac{T}{B}\right) = \sqrt{\frac{2B}{pT}}\, e^{-4\pi/p^2}. \tag{18}$$

The value of the enveloping function $\Psi_E(T/B)$ can be written as a function of the parameter p, call it $M(p)$:

$$M(p) = \sqrt{\frac{2B}{pT}}\, e^{-4\pi/p^2}. \tag{19}$$

Remembering that T and B are constants determined by the percussion sound signal, the maximization of the magnitude of the wavelet

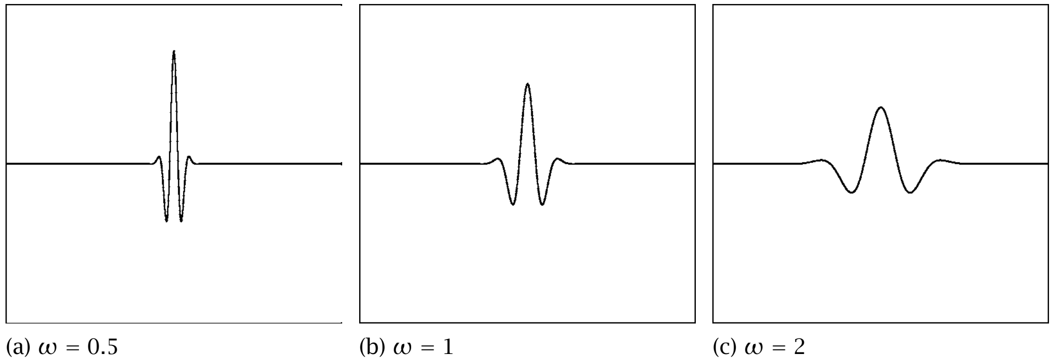


Figure 13. Real parts of Gabor wavelet with frequency parameter $\nu = 1$ and width parameter $\omega = 0.5$, 1, and 2. For each graph, the horizontal range is $[-5, 5]$ and the vertical range is $[-2, 2]$.

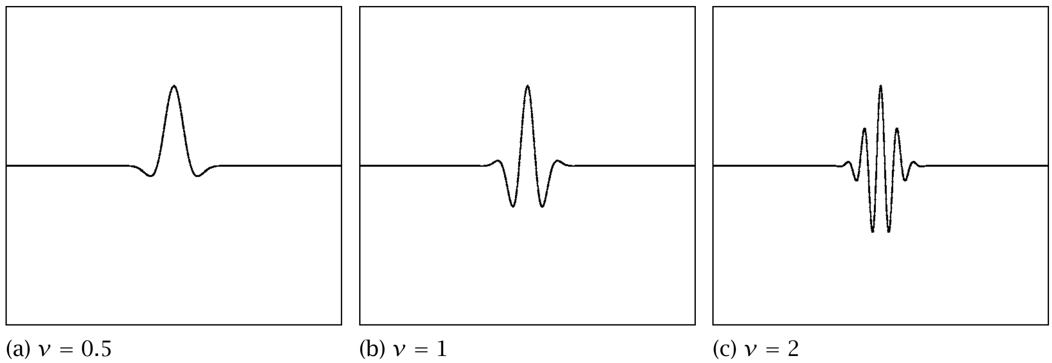


Figure 14. Real parts of Gabor wavelet with width parameter $\omega = 1$ and frequency parameter $\nu = 0.5$, 1, and 2. For each graph, the horizontal range is $[-5, 5]$ and the vertical range is $[-2, 2]$.

at $t = T/B$ becomes a simple one variable optimization problem. The first derivative of $M(p)$ is

$$M'(p) = \frac{16\pi - p^2}{2p^3 e^{4\pi/p^2}\sqrt{pT/2B}}.$$

Hence $p = 4\sqrt{\pi}$ maximizes the value of the envelope function of the wavelet at $t = T/B$, thus allowing us to detect beats within T/B of each other.

With the wavelet function dampened sufficiently slowly, we know that the envelope function is sufficiently wide. But the correlations are computed by taking the magnitude of the sum of the complex Gabor wavelet samples. Since the real and imaginary parts involve products with sines and cosines, there are intervals where the functions are negative. It is these adjacent negative regions, on each side of the main lobe of $\Psi_{\Re}$, that allow for the separation of beats that are greater than T/B apart but less than $2T/B$ apart (if they are more than $2T/B$ apart, the dampening of Ψ_E produces low-magnitude correlations).

Width and Frequency for Better Display

There is one wrinkle to the analysis above. If the width and frequency parameters are set according to Equation (11), then at the lowest reciprocal-scale value $1/s = 1$ the display of the percussion scalogram cuts off at the bottom, and it is difficult to perceive the scalogram's features at this scale. To remedy that defect, when we display a percussion scalogram we double the width in order to push down the lowest reciprocal-scale by one octave. Hence we use the following formulas

$$\omega = \frac{pT}{B}, \quad \nu = \frac{B}{pT}, \quad p = 4\sqrt{\pi} \tag{20}$$

for displaying our percussion scalograms.

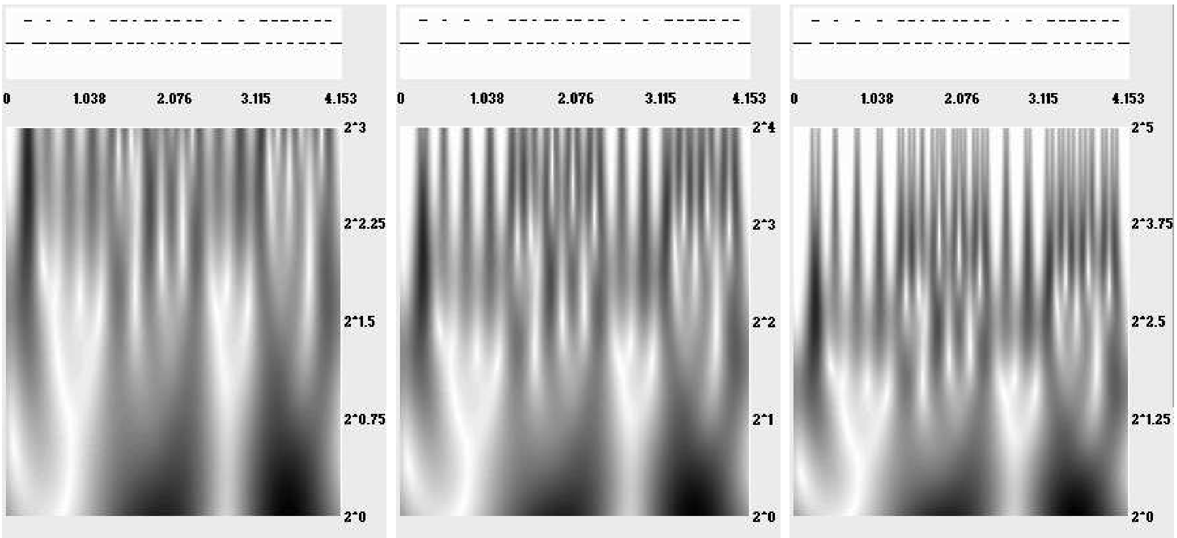
Choosing Octaves and Voices

The variable $1/s$ along the vertical axis of a percussion scalogram (see Figure 4(b), for example) is related to frequency, but on a logarithmic scale. *To find the actual frequency at any point along the vertical axis we compute the base frequency ν/ω multiplied by the value of $1/s$.* The value of I determines the range of the vertical axis in a scalogram, i.e., how large $1/s$ is, and the value of M determines how many correlations per octave we are computing for our scalogram.

In order to have a satisfactory percussion scalogram, we need the maximum wavelet frequency equal to the maximum pulse frequency. The scale variable s satisfies $s = 2^{-k/M}$, where $k = 0, 1, \ldots, IM$. Hence the maximum $1/s$ we can use is calculated as follows:

$$\frac{1}{s} = 2^{IM/M} = 2^I.$$

Now let δ be the minimum distances between pulses on a pulse train. By analogy of our pulse trains with sinusoidal curves, we postulate that the



(a) $I = 3$ (b) $I = 4$ (c) $I = 5$

Figure 15. Examples of percussion scalograms using different values of I, the number of octaves, for the *Dance Around* percussion passage. Graph (b) uses the value of $I = 4$ calculated from Equation (23)**.**

maximum pulse frequency should be one-half of $1/\delta$. Setting this maximum pulse frequency equal to the maximum wavelet frequency, we have

$$\frac{1}{2\delta} = \frac{\nu}{\omega}\, 2^I. \tag{21}$$

Notice that both sides of (21) have units of beats/sec.

Using the equations for ν and ω in (20), we rewrite Equation (21) as

$$\begin{aligned}\frac{1}{2\delta} &= \frac{\nu}{\omega}\, 2^I \\ &= \left(\frac{B}{pT}\right)^2 2^I.\end{aligned}$$

Solving for I yields

$$I = \log_2\left(\frac{p^2T^2}{\delta B^2}\right) - 1. \tag{22}$$

Because I is required to be a positive integer, we shall round down this exact value for I. Thus we set

$$I = \left\lfloor \log_2\left(\frac{p^2T^2}{\delta B^2}\right) - \frac{3}{2} \right\rfloor. \tag{23}$$

To illustrate the value of selecting I per Equation (23), in Figure 15 we show three different scalograms for the *Dance Around* percussion sequence. For this example, Equation (23) yields the value $I = 4$. Using this value, we find that the scalogram plotted in Figure 15(b) is able to detect the individual drum strikes and their groupings. If, however, we set I too low, say $I = 3$ in Figure 15(a), then the scalogram does not display the timings of the individual drum beats very well. On the other hand, if I is set too high, say $I = 5$ in Figure 15(c), then the scalogram is too finely resolved. In particular, at the top of the scalogram, for $1/s = 2^5$, we find that the scalogram is detecting the beginning and ending of each drum strike as *separate events,* which overestimates by a factor of 2 the number of strikes.

Having set the value of I, the value for M can then be expressed as a simple inverse proportion, depending on the program's capacity. For example, with Fawav [35] the number of correlations used in a scalogram is constrained to be no more than 256, in which case we set

$$M = \left\lfloor \frac{256}{I} \right\rfloor \tag{24}$$

and that concludes our rationale for satisfactorily choosing the parameters for percussion scalograms.

Conclusion

In this paper we have described the way in which spectrograms and percussion scalograms can be used for analyzing musical rhythm and melody. While percussion scalograms work fairly effectively on brief percussion passages, more research is needed to improve their performance on a wider variety of music (especially when the volume is highly variable). We only briefly introduced the use of spectrograms for analyzing melody and its hierarchical structure; more examples are discussed in [34] and at the website [6]. Our discussion showed how percussion scalograms could be used to distinguish some styles of drumming, but much more work remains to be done. Further research is also needed on using local averages, instead of the global average A that we employed, and on determining what additional information can be gleaned from the phases of the Gabor CWTs.

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W H A T   I S . . .

Lehmer's Number?

Eriko Hironaka

Lehmer's number, $\lambda \approx 1.17628$, is the largest real root of the polynomial

$$f_\lambda(x) = x^{10} + x^9 - x^7 - x^6 - x^5 - x^4 - x^3 + x + 1.$$

This number appears in various contexts in number theory and topology as the (sometimes conjectural) answer to natural questions involving notions of "minimality" and "small complexity".

Its story begins within number theory. Lehmer's number λ is the conjectural answer to

What is the smallest size of an algebraic integer greater than one?

Since two algebraic integers are algebraically conjugate if they are roots of the same minimal polynomial, any natural notion of the size of an algebraic integer should be constant on conjugacy classes. Given an irreducible monic integer polynomial f, the Mahler measure of f, or $M(f)$, is the absolute value of the product of roots with norm greater than one. By size of an algebraic integer α we mean the Mahler measure of the minimal polynomial of α. The Mahler measure of α is one if and only if α is a root of unity. Since Lehmer's number λ is the only root of f_λ outside the unit circle, λ is its own Mahler measure.

A related notion of size is the maximal norm of algebraic integers conjugate to α, which we will call the length of α. By this definition, the length of an algebraic integer can be arbitrarily close to one (e.g., consider $\sqrt[n]{2}$ for n large). It is not known whether the same is true for Mahler measures. Lehmer in [1] formulated the problem in this way:

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Given any $\delta > 0$, is there an algebraic integer whose Mahler measure is strictly between 1 and $1 + \delta$?

Algebraic integers with small Mahler measure were important to Lehmer in his study of prime number-generating functions. Using computing machines he built himself, he found the smallest Mahler measures for even degrees up to 10. Recent computer searches by D. Boyd, M. Mossinghoff, and G. Rhin verify that Lehmer's number λ is the smallest Mahler measure greater than one for all degrees up to 40 (see Mossinghoff's website [2]).

Lehmer's number λ has special number-theoretic properties. First, the coefficients of its minimal polynomial f_λ are the same when read from the left or from the right. We call such a polynomial reciprocal, since this implies that the set of algebraic conjugates of λ contains all its reciprocals. Second, Lehmer's number λ is the only one of its algebraic conjugates that lies outside the unit circle. Such an algebraic integer is called either a Salem number (reciprocal case) or a Pisot number (nonreciprocal case).

What is known about Lehmer's question restricted to Salem and Pisot numbers is similar to what is known for more general Mahler measures. For nonreciprocal polynomials f, C. Smyth showed in 1970 that

$$M(f) \geq M(x^3 - x - 1) = \theta(\approx 1.32472) > \lambda.$$

This generalizes A. Siegel's result that θ is the smallest Pisot number and shows that θ is also the smallest Mahler measure of nonreciprocal polynomials, reducing Lehmer's question to the reciprocal case. Similarly, Lehmer's number is both the smallest known Salem number and the smallest known Mahler measure greater than one.

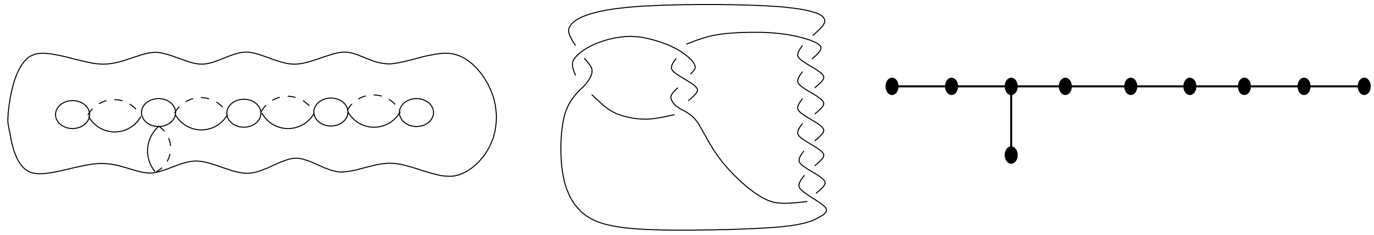

Figure 1. Manifestations of Lehmer's number as mapping class, pretzel knot, and Coxeter graph.

Lehmer's question is equivalent to asking whether an algebraic integer with small length must have a correspondingly large number of algebraic conjugates outside the unit circle. The number of exterior conjugates can be thought of as the complexity of α.

Lehmer's question and its offshoots have natural analogs in geometry and topology. For example, D. Lind, K. Schmidt, T. Ward, and others have studied the logarithm of a multivariable version of Mahler measure as the topological entropy of an associated dynamical system on the n-dimensional torus. D. Silver and S. Williams showed that the Mahler measure of the Alexander polynomial of a knot or link complement is the growth rate of its classical torsion numbers.

There is evidence for the minimality of Lehmer's number among Mahler measures in the contexts of mapping classes, fibered links, and Coxeter systems. Lehmer's number itself can be found in the cross-section of these fields of study.

An irreducible mapping class is an isotopy class of homeomorphisms of a compact oriented surface to itself so that no power preserves a nontrivial subsurface. By the Thurston-Nielsen classification, irreducible mapping classes are either periodic (analogous to roots of unity) or are of a type called pseudo-Anosov. There is a natural notion of length greater than one for pseudo-Anosov mapping classes: if ϕ is pseudo-Anosov, the surface has a local Euclidean structure (with singularities) so that ϕ expands by a real number $\alpha > 1$ in one direction and contracts by α^{-1} in another. The number α is called the (geometric) dilatation of ϕ.

The dilatations α are special algebraic integers, called Perron numbers, and are roots of reciprocal monic integer polynomials. The logarithm of α is the length of a geodesic determined by ϕ in Teichmüller space. As with lengths of algebraic integers, the dilatations of mapping classes on surfaces of genus g can be made arbitrarily close to one as g grows large. More precisely, R. Penner showed that the minimal dilatation α_g for a genus g surface satisfies the asymptotic relation $\log(\alpha_g) \asymp \frac{1}{g}$.

One source of mapping classes comes from fibered knots and links. A knot or link K in S^3 is fibered if its complement is the mapping torus for a mapping class ϕ defined on a surface S that spans K in S^3. The Alexander polynomial of K is the characteristic polynomial of the action of ϕ on the first homology of S. Its largest root, the homological dilatation of ϕ, is bounded above by the geometric dilatation. By a theorem of T. Kanenobu, any reciprocal monic integer polynomial is the Alexander polynomial of a fibered link. In particular, Lehmer's number λ is the homological dilatation of the (-2,3,7)-pretzel knot (shown in Figure 1, center) and is the Mahler measure of its Alexander polynomial.

One can also associate mapping classes to simply laced Coxeter systems. Given a simple graph Γ with ordered vertices, there is an associated linear transformation called the Coxeter element of Γ. From bipartite graphs Γ that are neither spherical nor affine, W. Thurston constructed an associated pseudo-Anosov mapping class so that the homological and geometric dilatations are both equal to the spectral radius of the Coxeter element. The monodromy ϕ of the (-2,3,7)-pretzel knot is the mapping class associated to the Coxeter graph E_{10} (Figure 1, right) and is the product of positive Dehn twists along simple closed curves dual to E_{10} on a genus 5 surface (Figure 1, left). Thus, Lehmer's number is the geometric dilatation of ϕ and the spectral radius of the Coxeter element of E_{10}.

Results from graph theory imply that to find Coxeter elements with small spectral radius it suffices to look at simple extensions of spherical and affine Coxeter graphs. C. McMullen showed further that the spectral radius of any element of a Coxeter group is either one or greater than Lehmer's number λ. This answers Lehmer's question not only for Coxeter systems but also for the corresponding subclasses of mapping classes and fibered links.

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The Best of All Possible Worlds: Mathematics and Destiny

Reviewed by Hector Sussmann

The Best of All Possible Worlds: Mathematics and Destiny
Ivar Ekeland
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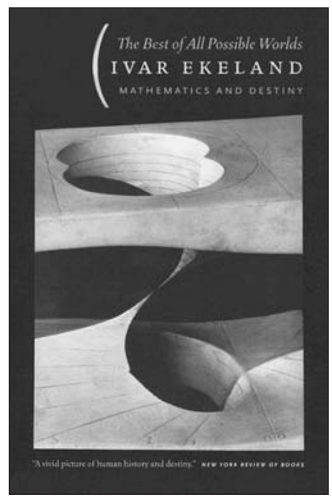
Leibniz held that we are living in the best of all possible worlds. Maupertuis stated the least action principle, according to which "the quantity of action necessary to cause any change in Nature always is the smallest possible", and then went on to claim, in his 1752 *Essay in Cosmology*, that he had "discovered a principle underlying all the laws of motion, which applies to hard bodies as well as elastic ones, from which all motions of all corporeal substances depend.... Our principle...leaves the world in its natural need of the Creator's power, and follows naturally from the use of that power". In Ivar Ekeland's words, Maupertuis claimed "a grand unification of his own, the unification of physics with metaphysics, and even with morals. In later work, he claims that a certain quantity of good (or bad) is attached to each of our actions, and that God has ordained the world so that, adding up all the good and subtracting all the bad, the balance will be found to be the greatest possible. In other words, this is the best of all possible worlds." These ideas would become known to future generations through Voltaire's ferociously satirical novel *Candide*, in which the optimistic Doctor Pangloss perseveres in concluding, in the midst of terrible disasters and catastrophes, that "all is well that ends well in the best of all possible worlds."



Ekeland sets the tone of his beautifully written and enormously enjoyable book with its opening sentence:[1] "The optimist believes that this is the best of all possible worlds, and the pessimist fears that this might be the case." In the book, he tells us about Leibniz's "much ridiculed idea", and about Maupertuis's "eventful life", which was "full of impressive achievements" (such as holding "the honor of being the first scientist ever to have stated the idea that animal and plant species are not immutable"), as well as his "exasperating arrogance, which did little to make him popular among his peers". The reader is given a clear and precise explanation of what Leibniz meant by the assertion that from the infinity of all possible worlds God must have chosen "the best", and of how he attempted to establish that this was true. (In the *Monadology*, Leibniz writes that "the existence of the best, which is disclosed to God by His wisdom, determines His choice by His goodness, and is produced by His

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[1] *The sources found by my own Google search attribute these words to the writer James Branch Cabell (1879–1958).*

power." To explain what Leibniz meant by "the best", Ekeland rephrases Leibniz's statements in his own words: "perfection consists of two things: variety on the one hand, that is the inexhaustible profusion of natural phenomena, and order on the other, that is the interrelatedness of all things and the basic simplicity of natural laws." And, later, "Leibniz belongs to this category of philosophers who claim that happiness lies in contemplating the wonders of God in His creation, an idea that is certainly far away from the everyday concerns of most humans beings. All in all, to say that this world is the best of all possible worlds does not imply that it is a pleasant one to live in." In other words, the great philosopher did indeed say that ours is the best of all possible worlds, but what he meant by this was "far from the crude philosophy 'All's well that ends well' incorrectly attributed to Leibniz.") He discusses Maupertuis's principle of least action, the controversy between Maupertuis and Koenig about whether Leibniz had discovered the principle before Maupertuis did, and the way Euler, Lagrange, Hamilton, and Jacobi formulated "Maupertuis's idea in a precise and workable way". He sketches a clear, plausible explanation of how the least action principle—which in reality is a principle of stationary action, namely, the assertion that the motion follows a path which is a critical point of the action—may come about. (The explanation—which, of course, is nonrigorous—is based on quantum mechanics: the quantum mechanical amplitude of a transition from point x at time t to point y at time s is given by the Feynman path integral of $e^{\frac{2\pi i}{h}S}$ over all paths that go from x at time t to y at time s, where S is the action, and the method of stationary phase suggests that, in the classical limit as $h \to 0$, the leading term in the asymptotic behavior of the integral is the sum of the contributions of the critical points of S.) And he does not forget to tell us about Voltaire's hostility toward Maupertuis. ("When Maupertuis came back from his northern expedition [to Lapland in 1736–1737], and all of Paris sang his praises, Voltaire chimed in with these verses: You have gone to confirm in places far and lonesome\\What Newton always knew without leaving his desk." And later: "[Voltaire's] book *Story of Doctor Akakia and the Native of Saint-Malo* is a collection of pamphlets against Maupertuis, the general theme being that such a mass of nonsense had been published under the name of the respected president of the Berlin Academy of Sciences that it is simply not possible that they were authentic: they had to be the work of a young impersonator, whom Voltaire proceeds to unmask.")

But the book is not just about Leibniz, Maupertuis, Voltaire, and the least action principle. Ekeland—himself a distinguished mathematician, well known for his important contributions to variational analysis and optimization theory—is the author of several nontechnical volumes, such as *The Broken Dice and other Mathematical Tales of Chance*, *Mathematics and the Unexpected*, and *The Cat in Numberland*, in which he has developed a unique style for turning stories about mathematics into engaging narratives filled with interesting details and explanations of fundamental concepts that are understandable as well as accurate. And in this book he uses his unique approach to scientific storytelling to offer us a guided tour through the successes and failures, during four centuries of modern science, of efforts by scientists and philosophers to understand the world by means of extremal principles. (In this review, I use "extremal principles" to refer to optimization as well as critical point principles.) The result is a book that provides much information about the ideas of optimization and critical points and is full of details about a large cast of characters, such as Galileo, Huygens, Descartes, Newton, Fermat, Leibniz, Maupertuis, and Voltaire, to name just a few.

Optimizing behavior can be that of an intelligent optimizer, such as the creator God who chose to make the best of all possible worlds, or a rational utility-maximizing human being, or an engineer seeking to build a device or to design a plant so as to minimize some cost functional, or the management of an airline looking for a schedule that minimizes cost subject to a large number of constraints, or a social planner maximizing society's welfare. Or it can arise from a natural process, as in the maximization of fitness of a species by natural selection (which is really an ascent process, famously described by R. Dawkins as "climbing Mount Improbable"), in which a fitness function that can vary in time due to changes in the environment (including changes in other species) is required to increase steadily, but may get stuck at a local maximum, and need not even attain a local maximum at all. Stationarity principles occur as basic physical laws, such as the least action principle and Fermat's minimum time principle in geometrical optics, both of which assert that a physical system follows a path that is a critical point of some functional, such as action or travel time.

All the above types of extremal principles are described by Ekeland in the various chapters of the book. Furthermore, as the guided tour proceeds and the extremal principles are presented, other topics naturally appear, and the author spends time on them, always elegantly working his way from secondary topic to secondary topic and eventually back to the main theme in a continuous narrative. For example, he opens Chapter 3 on the least action principle with the condemnation of Galileo by the Inquisition on June 22, 1633. He then makes the transition from Galileo to Descartes by telling us that Galileo's condemnation "was a lesson for others as well", and that Descartes learned of it in

November of 1633, and "immediately decided not to publish his magnum opus, the *Treatise of the World, or of Light*". The stage is thus set for a brief description of Descartes's treatises on philosophy, mathematics, and physics. Ekeland regrets that, with the separate publication of these works, "An essential part of [Descartes's] message has…been lost, for unity is central to his way of thinking." (This unity is that of reasoning rather than experimentation. "Descartes…believed that science rests on eternal truths. As a consequence, he held experimental results in low esteem…and less trustworthy than sound argumentation.") From here he moves on to the work of Snell, Descartes, and Fermat on the law of refraction of light and the minimum time principle, including a discussion of the conflict between two basic approaches to the formulation of physical laws, namely, that of extremal principles—which seems to involve final causes, since a system obeying the least action principle or a light ray that follows Fermat's minimum time principle appears to know that they want to go from point A to point B of configuration space and then choose their path to be extremal—and the equally widely used causal approach in which initial conditions determine the future by means of dynamical laws, such as ordinary differential equations. He illustrates this conflict with a discussion of the criticism of Fermat in 1662–1665 by the followers of Descartes (who had died in 1650) about the law of refraction of light. Descartes and Fermat derived the same law of refraction starting from mutually contradictory assumptions. Descartes compared "light traveling from air to water to a tennis ball which is accelerated in the vertical direction as it crosses the surface, the horizontal speed being unaffected". Fermat believed that the speed of light in air is larger than that in water, and that a light ray will travel from a point A in the air to a point B in the water by following a minimum-time path. Remarkably, both assumptions lead to exactly the same path, determined by Snell's law of refraction $\sin i = n \sin r$, where i and r are the angles of incidence and of refraction, and n is the index of refraction. "[Descartes and Fermat] both agreed on the value of … n, namely, 1.33 for the water-air interface, but they did not agree on its meaning. For Descartes that number meant that light travels 1.33 times faster in water than in air, and for Fermat it meant that it travels that much slower." Descartes's model is clearly causal—i.e., such that the past determines the future—whereas Fermat's approach involves, or at least appears to involve, final causes, as the light ray uses time minimization to choose which path to follow from all the paths that lead to the desired target point. Fermat was criticized by Descartes's disciple Clerselier for the seemingly teleological nature of his minimum-time principle, to which he gave the "very modern" reply that "light propagates *as if* it had both [the desire to travel fast] and [the means to compute the quickest path], and while the mathematical problem may not be an accurate description of what happens at some deeper level of reality, it is good enough to make predictions which turn out to be in agreement with experiments." Ekeland explains that Fermat was eventually proven right by the measurement of the speed of light in water by Foucault and Fizeau in 1850 and does not miss the opportunity to relate this early discussion of determinism vs. extremal principles to the later arguments by Mach and the controversy between Bohr and Einstein about the foundations of quantum mechanics. He then returns to the theme of the critique of Fermat by the Cartesians, by telling us that this was the "opening battle" of the "long, drawn-out struggle" of the Cartesians against Newtonian physics, and then turning his attention to the closing battle, which was Maupertuis's expedition to Lapland. "Newton, working on the idea that the Earth is a liquid ball that had solidified, had predicted that it would be flattened at the poles, because its rotation when it was fluid would have created a bulge around the equator. Cassini, the French astronomer royal, a loyal Cartesian, believed the opposite: the Earth should be elongated at the poles, like a lemon." The measurements that Maupertuis brought, of the arc of meridian in the far North, "compared with the arc of meridian at the latitude of Paris, showed that Newton was right and made Maupertuis a hero overnight". After entering Ekeland's book in this triumphant way, Maupertuis finally gets to occupy center stage, to which he is justly entitled in a book on "the best of all possible worlds". Thus Ekeland introduces the central theme of the book and turns to the least action principle.

"… All in all, to say that this world is the best of all possible worlds does not imply that it is a pleasant one to live in."

The same narrative technique of making continuous transitions to take us from topic to topic and from character to character, always finding a smooth way to return to the main theme, is displayed throughout the book. We are treated to side trips to such subjects as the measurement of time and clock making: from Galileo's ideas about the pendulum to Huygens's achievement as "the founder of modern chronometry", to John Harrison, to the overturning of Galileo's "idea of the whole universe at a given instant" by Einstein's theory on the relativity of simultaneity. We learn of the unification of algebra and geometry by Descartes, Euler's analysis of the free motion of rigid bodies, the integrable cases discovered by Lagrange and Kowalewska of the motion of a rigid body subject to gravity, and the unpredictability of the behavior of nonintegrable systems (including a detailed discussion of billiard balls and how the shape of the table determines whether the ball's motion is integrable or not, with tables that are elliptic or close to elliptic leading to integrable behavior, while chaos occurs for tables that are far away from being elliptic). Ekeland describes some of "many attempts toward a scientific theory of history, comparable to the theory of evolution" (especially the account by Thucydides of the Peloponnesian War, and that of Guicciardini of the wars in Italy between 1492 and 1534, in both of which Ekeland discerns "an echo of chaos theory", as in Guicciardini's statement that "small events that would hardly be noticed are often responsible for great ruins and successes"). We learn about the Condorcet three-voters paradox and equilibria (that is, Nash equilibria) in game theory, and are treated to a discussion of whether future global catastrophes, such as global warming or a nuclear war, are avoidable, and of the possible dangers of cloning and altering our genes ("history and mythology hand down stern warnings against tampering with such things.…Are such warnings valid for the modern world? We do not know.…Possible worlds are now crowding our doorstep.…For instance, one very real possibility is a warmer world, a planet where the environment has been profoundly altered by the greenhouse effect.…We have to shape a new world, and do it now. What a change since the time of Leibniz! In his view the choice between all possible worlds had been made once and for all, by God Himself, at the time of creation. Now this choice is ours to make").

The book can be savored in bits and pieces, by reading individual chapters, or portions of chapters dealing with particular topics such as the measurement of time or the mathematical problems posed by collective decision-making. But the reader who just chooses to start on page one and keep going will almost certainly find it impossible to put the book down, because it is densely packed with delightful items of information and is as entertaining as a fast-moving thriller.

The Numbers Behind *NUMB3RS*: Solving Crime with Mathematics

Reviewed by Brent Deschamp

The Numbers Behind *NUMB3RS*: Solving Crime with Mathematics
Keith Devlin and Gary Lorden
Plume, 2007
US$15.00, 256 pages
ISBN-13: 978-0-452-28857-7

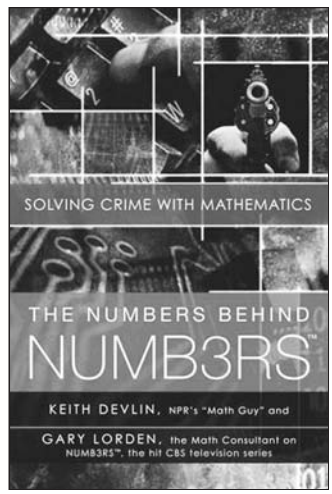
Since reading *The Numbers Behind* NUMB3RS*: Solving Crime with Mathematics*, I've started watching the television show *NUMB3RS* again. I've always found crime dramas predictable and repetitive, and nothing much has changed. Still, I've tuned in a few times out of a morbid curiosity spawned from this book.

As many readers know, *NUMB3RS* focuses on FBI agent Don Eppes, who solves crime with the help of his younger brother Charlie, a mathematician.

The question I've been asking myself since I finished the book is: why was this book written?

The authors, Keith Devlin and Gary Lorden, offer a reason in the opening line of the appendix. They write, "'Is the math in *NUMB3RS* real?' Both of us are asked this question a lot." The two are certainly qualified to answer. Both hold doctorates in mathematics, Devlin works at Stanford, and Lorden works at Caltech. Both are also reasonable people to ask. Devlin is known for his work promoting mathematics on National Public Radio, and Lorden is the mathematical consultant to *NUMB3RS*.

From this question one infers the book was written to show how the math in *NUMB3RS* is real, but I'm not entirely comfortable with that response. This is not really a book about mathematics;



it deals too much with the television show to merit that description.

Thus, I keep asking, is this book selling math, or is it selling the television show? Why was it written?

To be sure, this book contains math, and it is good math. In thirteen chapters the authors cover the following topics: geographic profiling, statistics, data mining, link analysis, geometric clustering, machine learning, neural networks, facial recognition software, change-point detection, Bayesian inference, DNA profiling, cryptography, fingerprints, networks, risk analysis, and math in casinos. It's interesting, and for the most part it's well written.

But then the book ends with an appendix providing an episode guide for the first three seasons of the television show. Why is that important, and what does it have to do with the math involved in crime solving? Most of the entries read like a slightly more intelligent version of the kind of entries logged on a fan's website. Yes, vague descriptions of the math used in each episode are mentioned, but they are just that: vague.

If this 256-page book is meant to explore the use of math in crime solving, then why is nearly fifteen percent of the book solely devoted to the television show?

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Based on what has been written thus far, it may seem as if my opinion of this book is rather poor. Certainly, parts of the book are rather disappointing, but other parts are fascinating. I learned a lot from this book. I'll focus on the two chapters I found most intriguing.

The chapter on DNA profiling was an eye-opener for me. Like most people I have a rough understanding of how DNA matches are done, but until reading this book I had little idea of what truly goes into performing a DNA comparison. Only certain loci on the DNA strand are used in the comparison, thirteen locations in all, and even then the exact sequence is not recorded, but instead a count of the various base pairs is recorded. A DNA profile, to me, now feels more like a hash function.

What was more surprising, though, was the authors' discussion of the FBI CODIS system that houses DNA profiles. If evidence points to a suspect, then obtaining a DNA sample and comparing it to DNA evidence found at the scene has a very low probability of showing an incorrect match. If instead the authorities run a search of CODIS looking for a DNA match, a "cold hit", then the odds of finding an incorrect match rise dramatically. The authors end the chapter with calculations based on the Arizona state database. With 65,000 entries they show the probability of finding two matches that agree on nine of thirteen loci during a search for cold hits is about five percent.

Is this book a product tie-in for the show, …or is it a book about mathematics?

These sorts of discussions are fascinating for two reasons. First, it's nice to see math in action. The science is well presented, and the book discusses the differences inherent in the two viewpoints of having a suspect and searching for a suspect. By the end of the chapter an argument has been made that is based on sound mathematical principles and shown in direct calculation.

Second, it points out a common misconception. I've seen my fair share of crime dramas, and I can recall many instances where a DNA sample was run through the system and a cold hit was found. Inevitably, the name on the screen turned out to be the killer. On television, DNA enjoys an aura of infallibility, and discussions like these point out that methodology is just as important as facts.

The discussion is also paired with an actual court case and reports from the forensic community about DNA profiling. In this way the facts become more than an academic enterprise. The chapter has a reality to it that sells the material.

Another chapter that revolves around an actual court case is the discussion of image enhancement. The case involves the beating of Reginald Denny in 1992 during the Los Angeles riots following the Rodney King trial. Damian Williams stood trial for his participation in the beating, and the defense used image enhancement of news footage to show the attacker in the film had the same rose tattoo as Williams.

Since the book is aimed at a general audience, the process of image enhancement is not described in detail. An additional section offers a brief glimpse of deeper math using functions and derivatives, and the readers are told they can skip this section if they don't have the requisite background. It is a nice inclusion, but at a single page it could have been more detailed. Still, the discussion is clear and informative, and readers should have a better understanding of how image enhancement works.

In terms of detail this book is rather light. The chapter on geographic profiling has a wonderful discussion of how each piece of a given equation relates to the rationale used in geographic profiling. The discussion of DNA profiling is just as detailed. The chapters on change-point detection and graph theory both have adequate discussions, but some chapters are woefully vague.

For example, in the chapter on data mining, many forms of data mining are discussed, but none is explained in any depth. This is an area I know nothing about, and so I had hoped I would walk away with a better understanding of neural networks and other forms of data mining. Instead I learned just enough to realize that I still knew nothing. Why not devote a few pages to providing some additional detail, as in the chapter on image enhancement? If twenty-five pages can be used to provide episode summaries, why can't a few pages be used to better explain data mining?

My frustration with this book is that when it succeeds, it provides great insight, but most of the time it falls short.

My other frustration has to do with the continual inclusion of material from the television show. Only four out of thirteen chapters are motivated by real-world cases in which mathematics played a vital role. The remaining chapters begin with a plot synopsis of some episode as motivation for the discussion. The topic is explored, but eventually we find ourselves once again reading about how Don and Charlie get the bad guys using math.

Why?

Is this book a product tie-in for the show, a marketing ploy, or is this a book about mathematics?

I get the impression the authors can't decide. If mathematics is as useful as this book claims, then shouldn't there be plenty of actual cases where math played a role? Why should the authors have to resort to using television fiction to make their case? In fact, they answer this question by presenting numerous cases where math played a role. So, the fiction isn't needed, but it overwhelmingly overshadows the real world in this book. Couple that with the episode guide in the appendix, and the entire book feels less like a book about math and more like something concocted in a marketing meeting.

Some people will argue that Charlie Eppes and *NUMB3RS* provide a way to reach people about the power of math. I cannot argue that point. It is nice having a figure in popular entertainment who puts an accessible and interesting face on a subject that is often disliked. Those same people could also argue that using Charlie in a book like this does much the same thing. People who would not ordinarily read a book about math might just pick this one up because the presentation is accessible: Charlie, a fictional character, provides the link to the applications of math.

But I disagree. The discussion of real-world cases riveted me. The chapter on statistics involved a discussion of a nurse nicknamed the "Angel of Death". Statistics led to her indictment but wasn't used in her trial. The chapter provided a wonderful look at the power and limitations of math in crime solving. If instead a fictional television episode were used as the basis for that discussion, then such an approach merely brings us back to the first line of the appendix: Is any of this real? Does it take a team of writers and mathematical consultants to come up with bizarre scenarios where math might actually be of use? When every chapter relies on fiction, then yes, it begins to feel that way. On the other hand, point to enough real cases and suddenly math is being used every day in a tangible way.

This leads to the efficacy of having a character like Charlie. *NUMB3RS* is entering its fifth season, but does public perception about math remain the same? Does having a mathematician on television increase the number of math majors? Has Charlie helped in any way?

The problem is that *NUMB3RS* is ultimately a crime drama, and Charlie is its gimmick. Most crime dramas have a gimmick. *CSI* has its forensic technicians, *Bones* has its anthropologist, *Criminal Minds* has its profilers, and the new drama *The Mentalist* proudly displays its gimmick in the title. *NUMB3RS* isn't really about mathematics; it's about selling a crime drama in a market crowded with similar shows. The math is used as a gimmick, so the mathematics will always be secondary. A similar approach is taken in *The Numbers Behind NUMB3RS,* so the mathematics in the book suffers a similar fate.

Strangely, if someone came to me wanting to know if math was ever really used in the real world, I would probably point them to this book. It's inoffensive, accessible, and filled with enough information that they would probably finish the book with the sense that math is out there being used. Devlin and Lorden have brought together interesting and insightful information about certain areas of math and crime solving, and I appreciate their effort.

But, and I want to emphasize the following caveat, I am disappointed with this book. Yes, the book is interesting, but only when the authors take the time to delve into the subject matter. Too much of this book feels like the commercials that punctuate the television show—short snippets of vague descriptions designed to titillate but not educate. My feeling is this approach will do nothing to help the public perception of math, will gain few converts, and will ultimately be forgotten like so many thirty-second ads.

Finally, we should have enough confidence in our chosen field to feel comfortable writing a book about mathematics that does not need gimmicks. *The Numbers Behind NUMB3RS* shows us a glimmer of how this could be done. I just wish the authors had chosen to put their faith in the power of math to make its own case instead of giving in to what seems like marketing pressure.

That said, I also cannot deny the results of clever marketing—it got me watching again.

Presidential Views: Interview with George Andrews

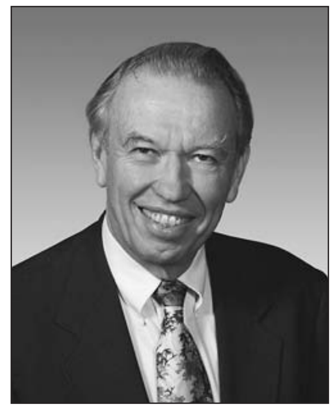
Every other year, when a new AMS president takes office, the *Notices* publishes interviews with the outgoing and incoming presidents. What follows is an edited version of an interview with George E. Andrews, whose two-year term as president begins on February 1, 2009. Andrews is the Evan Pugh Professor in the Department of Mathematics at Pennsylvania State University. The interview was conducted in fall 2008 by *Notices* senior writer and deputy editor Allyn Jackson.

An interview with past-president James G. Glimm appeared in the February 2009 issue of the *Notices*.

Notices: *The AMS is a large organization with many activities: publishing, meetings, public awareness work, science policy work, etc. How do you see the role of the AMS president in this large, diverse enterprise?*

Andrews: Obviously the president plays a role as the public face of the AMS, both to the members of the AMS as well as to the rest of society. So I will be following in the footsteps of my predecessors, presiding at a variety of meetings, assisting with our office in Washington in making presentations to Congress, and attending various policy committee meetings that occur throughout the year. Those are the standard items that involve any president.

When I was first asked to run for the presidency, it came as a great surprise to me, because it was not something I had ever thought of doing. But once I decided to run for the office, I wrote my candidate's statement listing a few things that seemed to me important and that I might concentrate on in the brief period of two years. One of the most important is: How can we better fund the research of younger mathematicians? Now with the economy in such dire straits, this is even more important. In the candidate's statement I mentioned the way research money is awarded by the NSERC [National Science and Engineering Research Council] in Canada; their program seems to be working very well. Unfortunately the National Science Foundation [NSF] does not see the NSERC model as one that they want to follow. I am trying to figure out ways that we in the AMS could approach funding agencies with the universal recognition that it's terribly important to nurture and develop young mathematicians, and concomitantly, there are funding problems that are probably going to get worse rather than better. Something really serious has to be done, including a careful husbanding of money, in order to keep more young people coming into the profession. The funding issue and expanding employment opportunities are most important.



George Andrews

The issues involving mathematics education, stretching from K–12 through undergraduate and graduate school, are things that I also mentioned in my statement. My main interest here is to promote programs that would provide current and future teachers with the mathematics that they need to understand in order to do a good job in the classroom. I would also cast a skeptical eye on a variety of curricular reforms that seem to me very far from the mark in achieving anything and that, just by the confusion that they create, actually turn out to be counterproductive.

Notices: *Going back to the matter of research support, it has often been proposed to the NSF that it could move to the NSERC model of giving smaller grants to more people. However, NSF has not been receptive to this idea and has stuck with giving large grants to a smaller elite of researchers. Is there a new or different way to approach the NSF on this question?*

Andrews: I'm working on that. From my conversations with people at the NSF, I believe they truly appreciate that we are not funding younger mathematicians nearly as much as we should. That was my motivation in bringing up the NSERC grants. The NSF is also deeply concerned about new researchers; so hopefully some new or creative way can be found to improve matters. In other words, I am not wedded to any particular proposal. I am perfectly willing to entertain other ideas—perhaps some sort of large block grant, or a new way of designing an institute, that could be used to obtain the desired results. Obviously it's something that requires a fair amount of talking and negotiation. The conversations I have had so far make it clear that one cannot just go to the NSF and say, "Let's be like NSERC", because there is an institutional view that that's the wrong thing to do.

Notices: *What do you see as the impact on young mathematicians of the lack of research funding?*

Andrews: What is the point of funding? For administrators, grants produce overhead and cushion the salaries of star researchers. But for a young person who's really dedicated to mathematics, salary is not nearly as important as things like money for computers and computer use, money to bring in visitors, money for travel, money for various peripheral things like books, etc. These items require small amounts of money, and yet they can have a really dramatic impact on one's career.

Notices: *Do you think federal funding of mathematics has emphasized applied areas, at the expense of funding the field more broadly?*

Andrews: I think the NSF has been fairly well balanced. My problem is that the funding is focused on big grants, and a number of good young mathematicians are not getting grants.

I do want to say one thing about pure and applied mathematics. Surprisingly, all the presidents-elect of the three major organizations are either current or former Penn State-ers. Doug Arnold, president of SIAM [Society for Industrial and Applied Mathematics], David Bressoud, president of the MAA [Mathematical Association of America], and I all taught at Penn State in the early 1990s. The three of us are talking over ways in which we might introduce or at least tentatively begin some sort of reciprocity arrangement that would lower dues for people who are members of 2 or 3 of the organizations—something like, but not exactly like, the way reciprocity arrangements work with foreign math societies. The object would be to encourage a greater intersection of the members of the three societies. This is another way to make sure that there is interaction amongst the various aspects of mathematics.

The problem of course is the finances. If you lower your dues, then you hope that more people who are only in one society will join two or three societies. You could make up your losses if you increase your membership. It is guaranteed that your current joint members will be paying lower dues, but it is not guaranteed that people who are only in one society will think, "Maybe I should join another one, or maybe all three." Such concerns make you fearful, and in straitened economic times, fear is something we have to deal with.

Notices: *I am not sure what the intersection of the membership is.*

Andrews: It's not that high between SIAM and AMS, and consequently the reciprocity discussions there seem easier than with MAA. The AMS dues support a much smaller portion of the overall AMS budget than the dues at MAA—and consequently the MAA's concerns about financial problems are understandably much more serious than those for the other two organizations.

Notices: *You mentioned education as a major concern of yours. The problems here are big, extensive, and multi-faceted. What can the AMS do to help solve them?*

Andrews: Efforts undertaken—not necessarily by the AMS, but perhaps with AMS support—that are designed primarily to assist teachers in enhancing their mathematical knowledge relevant to what they are teaching, are central. It's widely known that I have been extremely critical of many of the curricular reforms that have been proposed and sometimes implemented over the last fifteen years. This is primarily because I do not believe that curriculum is the real problem. I think the curriculum is not close to the main difficulty. It is fairly easy to figure out what a reasonable curriculum should be for K–12. What is needed are people who are really well versed in the mathematics that they are teaching and who are comfortable with it. What one wants to avoid is a curricular fix where technology plays a substantial role. There are huge dangers in introducing technology too soon. The idea that students won't have access to technology is ridiculous. Computers are ubiquitous. What we need to do is to concentrate on students' actual skills in and understanding of mathematics. Technology contributes very little to that whole process, especially in pre-college education.

Notices: *Can you say more specifically where you see a role for the AMS in this?*

Andrews: Obviously the AMS has research as its primary focus. The MAA is devoted to teaching, and SIAM is devoted to applied mathematics. Of course this oversimplified splitting up of the three organizations is unfortunate. We all have great interests in pure and applied math, and we are all teachers. However the activities of the MAA and the AMATYC [the American Mathematical Association of Two-Year Colleges] are much more closely focused on the problems of teaching mathematics. I hope to look at what these organizations are doing, and what we can do to support them. Subsequently if there is something that is neglected, then the AMS might step up. My hope is that we will be able, at least for things outside collegiate mathematics, to support efforts that make good sense. The NCTM [National Council of Teachers of Mathematics], for example, is amplifying its "focus points" brought out a couple of years ago. These are much more sensible suggestions concerning mathematics education in the early grades than any of the NCTM documents that appeared in the 1990s. It is my hope that this trend will continue. If the NCTM continues to concentrate on core mathematics and the actual skills necessary to do and understand mathematics, that's obviously something we should support.

Notices: *Do you think public understanding and awareness of mathematics have improved in recent years? What more can the AMS do in this area?*

Andrews: The Public Awareness Office of the AMS seems to me to have done a number of interesting things that are about as effective as they can be. The fact that we live in a computer age means that in some real sense mathematics is everywhere. But I don't think that means the public is aware of mathematics. I do believe that the diminution of the average citizen's mathematical facility works against whatever public awareness program is put forward. Any sort of mathematical content at all is difficult to communicate to people lacking facility with mathematics. Overall I am pleased with our public awareness efforts. I believe that in order for them to have a wider audience, we must improve mathematics education.

Notices: *But mathematics is certainly more visible in the popular culture, in the public eye. It has been a theme in movies, television, plays, and novels.*

Andrews: Two or three years ago, Penn State invited John Nash to give a series of lectures. The person who was to be his host had a family crisis, and as a result I was host of John Nash for three days and spent a lot of time with him. The thing that I remember most vividly about this charming gentleman is that after he gave a talk on relativity that must have been way over the heads of the 1,300 undergraduates in the audience, there was a line that snaked all the way around the auditorium. The students in line were holding their VHS tapes of *A Beautiful Mind* that they wanted him to sign. That dear sweet man sat there and signed every single one of them. I loved that movie as did the students, but the problem in making a movie about mathematics is that oftentimes what's focused on is not the mathematics, but the dramatic lives of the mathematicians who are being portrayed. Is the public more aware of mathematics? Or is the public is more aware of the fact that some mathematicians have led eccentric lives? I suspect the latter.

Notices: *One last question, not related to the AMS. You were the first person to realize the importance of what is now called Ramanujan's "Lost Notebook", and you have spent decades studying it. What is the mathematical personality that emerges from those pages?*

Andrews: That's an interesting question, because certainly the "Lost Notebook" is a perplexing collection. It was written during the last year of Ramanujan's life, when he was dying, and it was probably his personal notes—not at all something that he thought of publishing. Consequently, there are very few words, there are pages that are just chaotic, there are pages with formula after formula—sometimes the formulas are related to one another, and sometimes they aren't. Sometimes two or three on a page are related and then there is a fourth one that is completely unrelated. So in terms of gaining a sense of personality, what it might call to mind is the dramatized picture that Eric Temple Bell portrayed of Galois on the night before he was to die in a duel, scribbling his thoughts in a very hurried and chaotic way. With Ramanujan, it was a year rather than a night. But he was lying ill in India for a year at the end of his life, and according to interviews with his widow he was always doing his mathematics because it helped him to forget the pain. So I do get the feeling of hurriedness.

Penetrating how he actually thought about things is something that I still have not managed. Ramanujan is what Mark Kac would have called a "magical genius". Kac described the world as having two types of geniuses. There are the geniuses who are just ten times smarter than I am, and if I had had more time and a few more points in my IQ, I'd have been able to do what they do. Then there are others who do things that make you think: "Wow, where did he come up with that? This is just beyond belief!" And that's the way I feel about much of what Ramanujan did. Bruce Berndt and I are bringing out our edited version of the "Lost Notebook" in four volumes—we have one out, one in press, and two more volumes to do to fully give proofs of everything in the "Lost Notebook". But just because we can prove something does not mean at all that we understand Ramanujan's motivation or how he came up with these things.

Notices: *So they seemed to come out of nowhere. It's hard to tell what was going through his head.*

Andrews: Obviously lots was going on in his head; I just don't know what it was. F. H. Jackson, one of the British amateur mathematicians who was around at the time of Ramanujan, sent one of his reprints to Ramanujan. I once saw another copy of this reprint in which Jackson had written to someone else, "In 1920, I wrote to Ramanujan three weeks before his death (I did not know of his illness) pointing out that there was some connection with his theorems. He wrote me a long letter in reply showing how he came to guess his theorems." That letter would be the only document where Ramanujan explained how he found something out, and we have no idea where that letter is or if it still exists.

Donald McClure Named AMS Executive Director

Allyn Jackson

Photograph by John Abramowski, Brown University.

Donald McClure

In January 2009, the AMS Council approved the appointment of Donald E. McClure of Brown University as executive director of the Society. He succeeds John H. Ewing, who has held the post for the past thirteen years and who is now president of Math for America, a program that aims to attract mathematically talented young people to teach in the nation's schools.

McClure's background and experience make him an ideal candidate for the executive director position. He has a deep commitment to service on behalf of the mathematics community—a commitment that has led to him play a variety of roles in Society leadership, from hands-on tasks for the Data Committee and the Board of Trustees, to high-level work on policy committees. He has an impressive research background as well as experience in academic administration, including helping to run a distributed mathematics institute for more than a decade. He also has developed considerable business savvy, having founded and run a consulting business with a colleague at Brown University. On top of all this, he is geographically a good fit, for the AMS headquarters office is located in Brown's home city of Providence, RI. As McClure put it, "Here's a tremendous professional opportunity within walking distance of my house."

The main emphasis of McClure's AMS service over the years has been on professional issues. During the 1980s and early 1990s, he served as an AMS representative on the Data Committee, a joint committee of several mathematics organizations that each year produces the Annual Survey of Mathematical Sciences. As chair of this committee from 1991 to 1993, McClure led the computerization of the data analysis, ushering in the use of statistical software that greatly expanded the kinds of analysis that could be done with the survey data. Also in the early 1990s, he served on the Task Force for Employment, and he designed a targeted survey to examine the difficulties young mathematicians were having in finding jobs. The recommendations of the task force influenced many universities to expand the number of postdoctoral positions available to young mathematicians. These positions not only eased the immediate employment problem, but, after the job outlook improved, they helped provide more secure career paths for young people. McClure also served on the Committee on the Profession from the time that committee was started in 1993 until 2002 and served two years as chair. He was also a member of the Task Force on Excellence, which produced the 1999 AMS report *Towards Excellence*.

McClure was elected to the AMS Board of Trustees in 1995 and served on the board until 2000. His service included stints as chair of the board and as liaison to the AMS Publications Division. From 2003 until his appointment as executive director, McClure was AMS associate treasurer. Through serving on the board and in the treasurer position, he has come to understand many of the practical aspects of running the AMS and has a sense of the scope of its programs and publishing business. One of his main goals is to keep the business side running strong. "The AMS has for years been a very successful publishing business, and I want to assure that it stays that way," he said. In particular, he noted, it is important to continue investment in the Society's most important product, MathSciNet. "I want to continue to find ways to make MathSciNet the very best database it can be to serve the community," he said. The book program, which has expanded in the last several years, could be vulnerable to the recent economic downturn, he noted, and so the AMS might face challenges in this area.

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One immediate challenge McClure sees on the horizon for the mathematical community stems from the pressure the current economic climate is putting on college and university budgets, which in turn affects the mathematics job market. "We are going to see a difficult time for new Ph.D.'s again," he said. "We don't have data yet to back this up, but the forces that affected the condition of the market in the early 1990s are all being applied in the same direction that they were then—reduction of tax revenues for states and great pressure to reduce state budgets. I think this is going to have an impact on higher education, and colleges and universities are figuring out ways to cut their budgets." Drawing on its experience with the job market difficulties of the 1990s, the AMS can consider various ways to help ease the situation, such as doing a targeted survey of new doctorates and facilitating the advertising of positions that open up late in the hiring season.

McClure received his bachelor's degree in 1966 from the University of California, Berkeley, and his Ph.D. in applied mathematics in 1970 from Brown University, where his advisor was Ulf Grenander. McClure has spent his entire career at Brown, starting as an instructor in 1969 and rising to the rank of professor in 1982. He has advised fifteen Ph.D. students. McClure's research concerns the formulation of probabilistic models for images and the design of algorithms based on those models and classical statistical principles. The research is motivated by the areas of image processing and computer vision, ill-posed inverse problems, and analysis of image sequences such as those occurring in film or progressive video. In early work in nonlinear approximation theory, he developed characterizations and very sharp asymptotic results for convergence of optimal approximations by variable knot splines. In the area of ill-posed inverse problems, McClure and his Brown colleague Stuart Geman were the first to propose and analyze Bayesian methods for computed tomography. There is now a vast literature in this area.

In 1986 McClure was part of a group that applied for and received a major grant through the University Research Initiative of the Department of Defense to launch a distributed mathematics institute, the Center for Intelligent Control Systems. The center ran for fifteen years and involved twenty-five to thirty faculty members at Brown, Harvard University, and the Massachussetts Institute of Technology, as well as many graduate students and postdoctoral researchers. As associate director of the center, McClure ran the center's node at Brown, which was concerned primarily with computational vision and control theory. The center received three grants from the DoD and was phased out when the last one ended in 2001.

In 1981, together with Geman, McClure founded a consulting company, which initially focused on design of statistical methods for large-scale clinical trials. The company later expanded its work to algorithm development for vision software for semiconductor manufacturing equipment. In 1993 the company received a grant through the Advanced Technology Program of the National Institute of Standards and Technology and moved into automation of methods to remove damage and restore digital film and video. This is the main focus today of the company, which has about twenty employees and offices in Providence and Hollywood. "[Geman and I] still get involved in thinking about how to formulate the problems and design algorithms for them, but we don't sit down and write the code!", McClure remarked. "We have a great group of software developers" who understand both the mathematical and the programming sides.

With his research accomplishments, experience in both business and academic administration, and extensive knowledge of issues facing the mathematics profession, McClure brings a wealth of assets to the executive director position. "I am really excited about the new position," he remarked. "My responsibilities and efforts will be guided by the Society's mission to further mathematics research and scholarship. The AMS has a very positive impact on mathematics worldwide. I look forward to working with the staff and leadership to continue and expand the AMS contributions."

2008 Annual Survey of the Mathematical Sciences

(First Report, Part II)

Report on the 2008–2009 Faculty Salaries

Polly Phipps, James W. Maxwell, and Colleen A. Rose

This report of the 2008 Annual Survey provides information on the distribution of 2008-2009 academic-year salaries for tenured and tenure-track faculty at four-year mathematical sciences departments in the U.S. The information is gathered from departments using a questionnaire initially distributed in June of 2008. This year's salary report includes, for the second time, separate reporting on the salaries of newly appointed tenure-track assistant professors. This report has traditionally appeared as part of the First Report of the Annual Survey, published in recent years in the February issue of *Notices* of the American Mathematical Society.

The Annual Survey series begun in 1957 by the American Mathematical Society is currently under the direction of the Data Committee, a joint committee of the American Mathematical Society, the American Statistical Association, the Institute of Mathematical Statistics, the Mathematical Association of America, and the Society of Industrial and Applied Mathematics. The current members of this committee are Richard Cleary, Richard M. Dudley, John W. Hagood, Abbe H. Herzig, Ellen Kirkman, David J. Lutzer, Joanna Mitro, James W. Maxwell (ex officio), Bart Ng, Polly Phipps (chair), Douglas Ravenel, Jianguo (Tony) Sun, and Marie Vitulli. The committee is assisted by AMS survey analyst Colleen A. Rose. Comments or suggestions regarding this Survey Report may be directed to the committee.

Polly Phipps is a senior research statistician with the Bureau of Labor Statistics. James W. Maxwell is AMS associate executive director for special projects. Colleen A. Rose is AMS survey analyst.

Faculty Salary Survey

The charts on the following pages describe the distribution of academic-year salaries for tenured and tenure-track faculty in each of the departmental groupings used in the Annual Survey. Salaries are described separately by rank, and for the second time, salaries for newly appointed (tenure-track) assistant professors are profiled separately. Salaries are reported in current dollars (at time of data collection). Results reported here are based on the departments which responded to the survey with no adjustment for non-response.

Table 1 provides the departmental response rates for the 2008 Faculty Salary Survey. Departments were asked to report for each rank the number of tenured and tenure-track faculty whose

Table 1: Faculty Salary Response Rates

Department	Number	Percent
Group I (Public)	21 of 25	84
Group I (Private)	15 of 23	65
Group II	45 of 56	80
Group III	60 of 73	82
Group IV (Statistics)	37 of 57	65
Group IV (Biostatistics)	15 of 31	48
Group Va	10 of 17*	59
Group M	93 of 190	49
Group B	308 of 1031	30

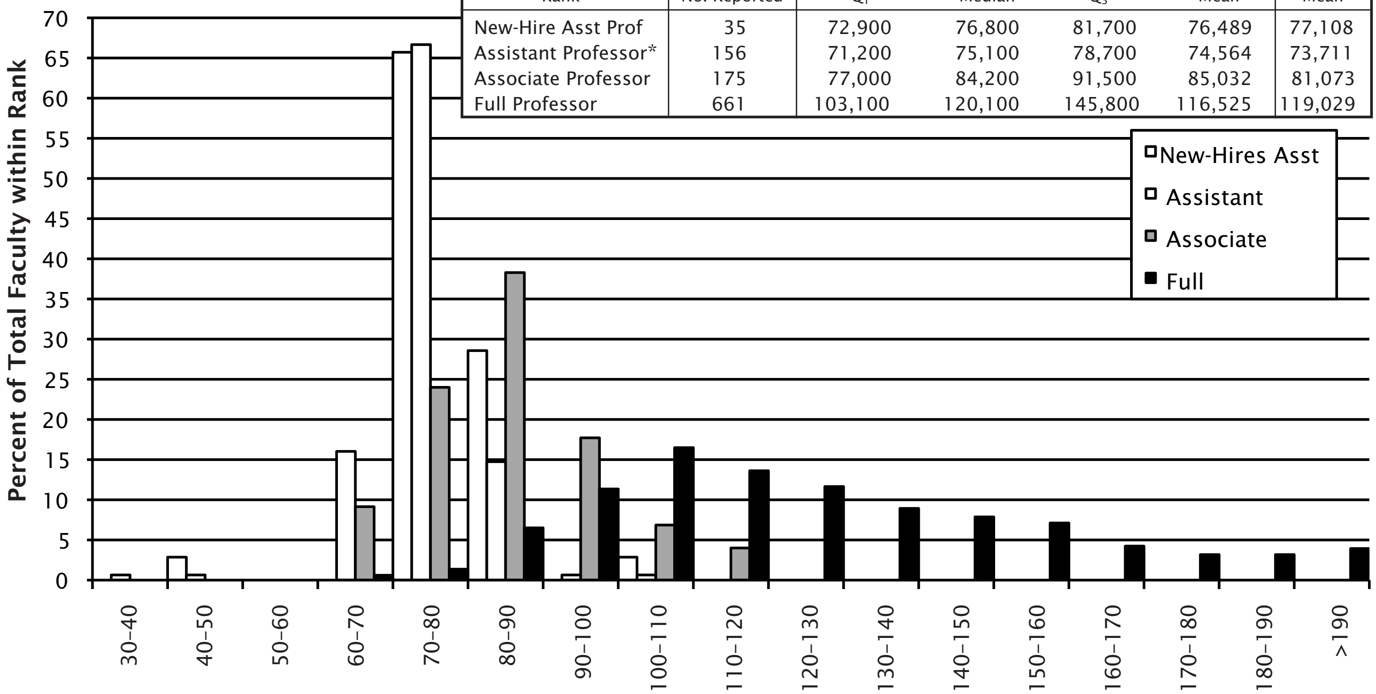
* The population for Group Va is slightly less than for the Doctorates Granted Survey, because two programs do not formally "house" faculty and their salaries.

Group I (Public) Faculty Salaries

Doctoral degree-granting departments of mathematics

21 responses out of 25 departments (84%)

	2008–09					2007–08
Rank	No. Reported	Q_1	Median	Q_3	Mean	Mean
New-Hire Asst Prof	35	72,900	76,800	81,700	76,489	77,108
Assistant Professor*	156	71,200	75,100	78,700	74,564	73,711
Associate Professor	175	77,000	84,200	91,500	85,032	81,073
Full Professor	661	103,100	120,100	145,800	116,525	119,029

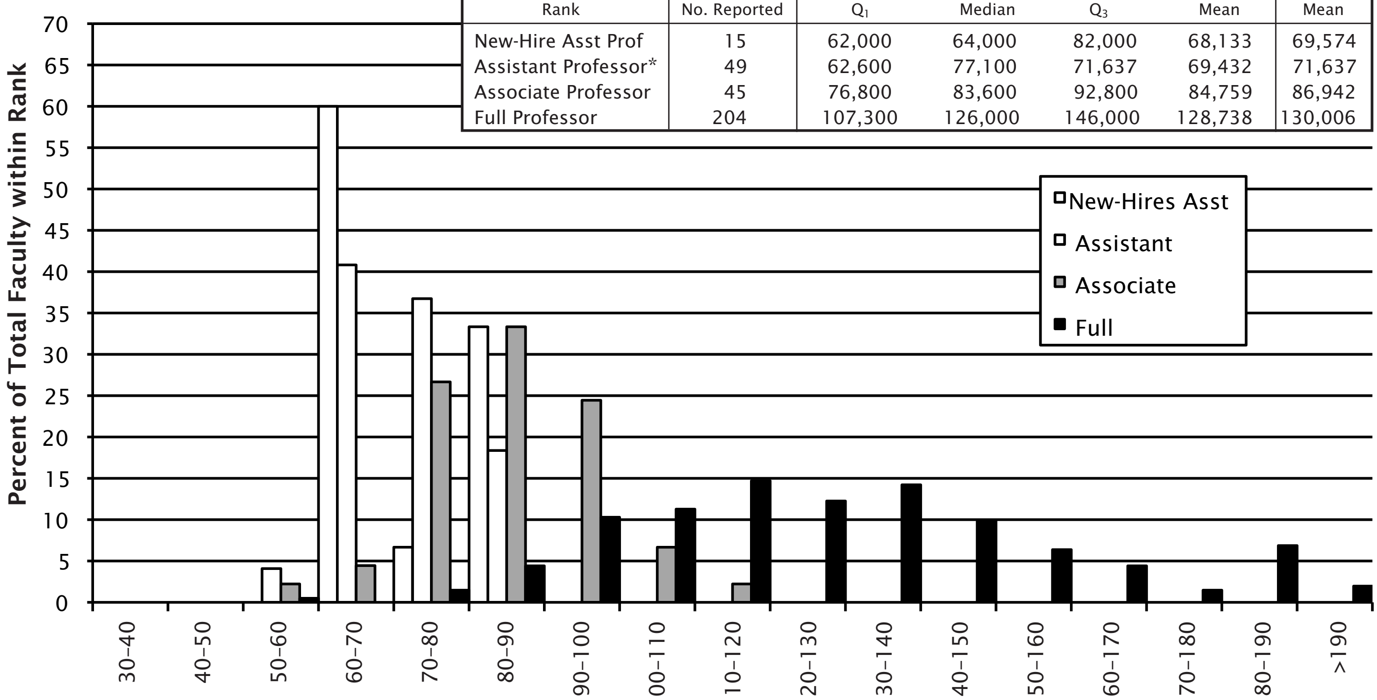


Group I (Private) Faculty Salaries

Doctoral degree-granting departments of mathematics

15 responses out of 23 departments (65%)

	2008–09					2007–08
Rank	No. Reported	Q_1	Median	Q_3	Mean	Mean
New-Hire Asst Prof	15	62,000	64,000	82,000	68,133	69,574
Assistant Professor*	49	62,600	77,100	71,637	69,432	71,637
Associate Professor	45	76,800	83,600	92,800	84,759	86,942
Full Professor	204	107,300	126,000	146,000	128,738	130,006



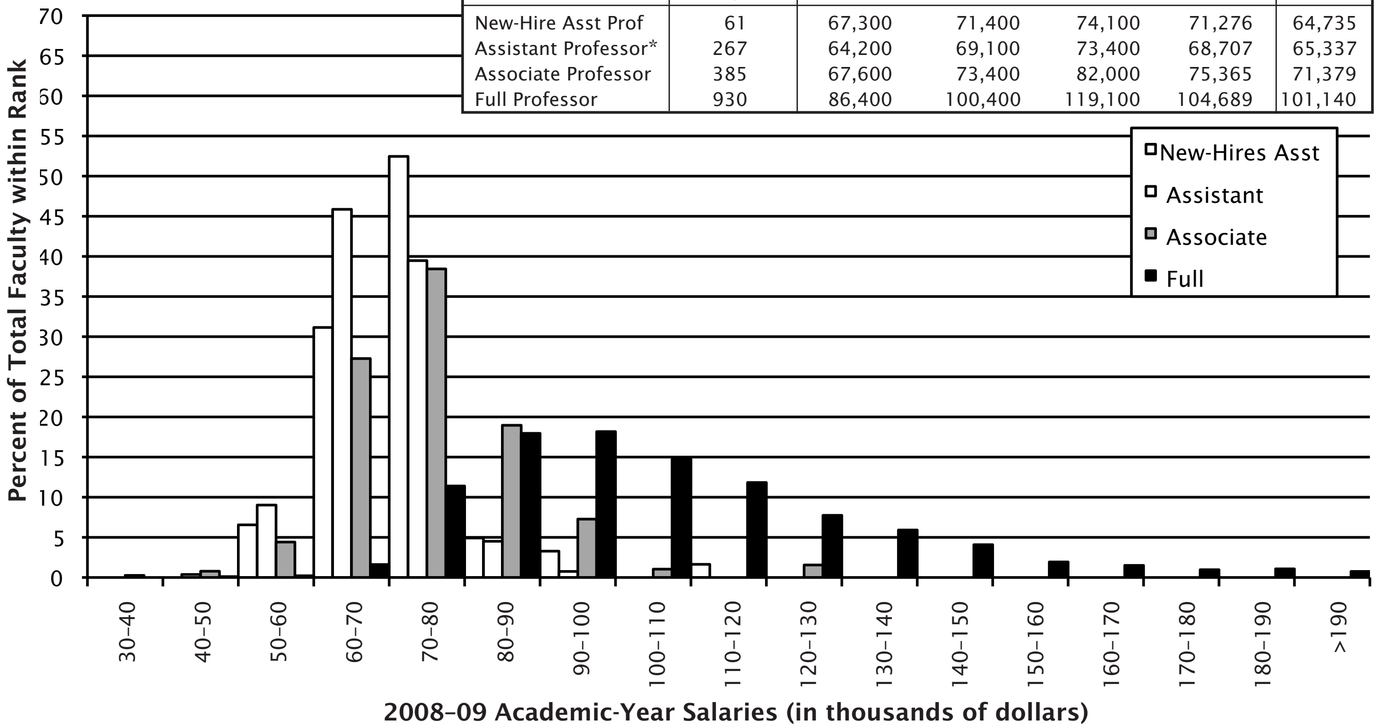
*Includes new hires and is comparable to previous years' figures.

Group II Faculty Salaries

Doctoral degree-granting departments of mathematics

45 responses out of 56 departments (80%)

Rank	2008–09					2007–08
	No. Reported	Q_1	Median	Q_3	Mean	Mean
New-Hire Asst Prof	61	67,300	71,400	74,100	71,276	64,735
Assistant Professor*	267	64,200	69,100	73,400	68,707	65,337
Associate Professor	385	67,600	73,400	82,000	75,365	71,379
Full Professor	930	86,400	100,400	119,100	104,689	101,140

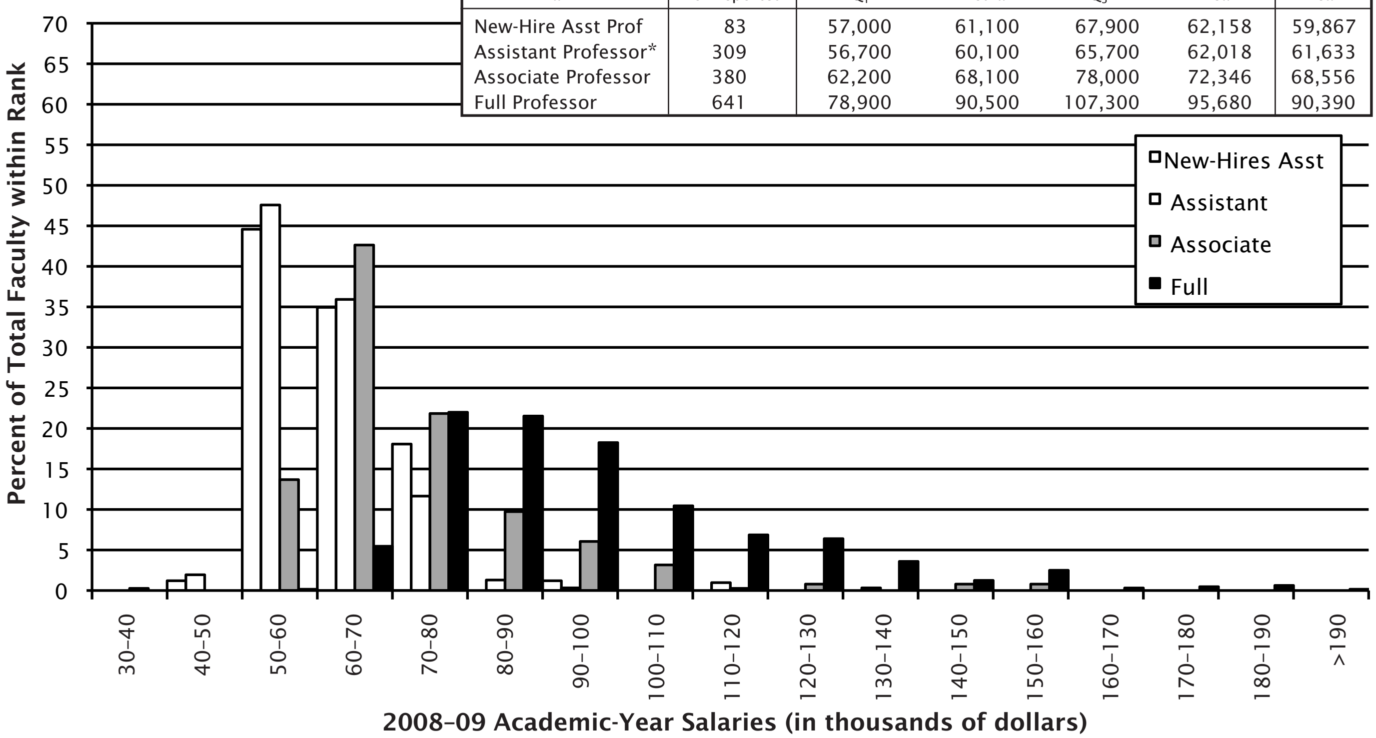


Group III Faculty Salaries

Doctoral degree-granting departments of mathematics

60 responses out of 73 departments (82%)

Rank	2008–09					2007–08
	No. Reported	Q_1	Median	Q_3	Mean	Mean
New-Hire Asst Prof	83	57,000	61,100	67,900	62,158	59,867
Assistant Professor*	309	56,700	60,100	65,700	62,018	61,633
Associate Professor	380	62,200	68,100	78,000	72,346	68,556
Full Professor	641	78,900	90,500	107,300	95,680	90,390



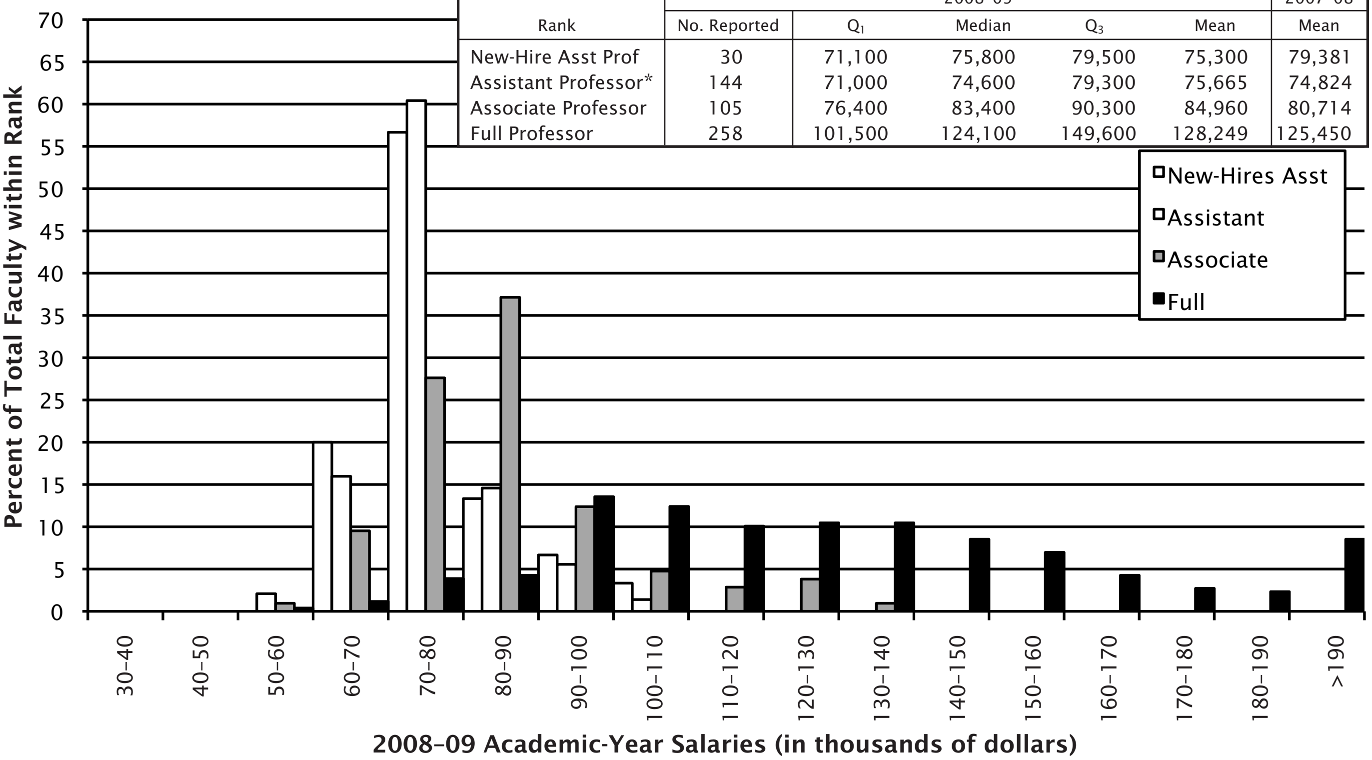
*Includes new hires and is comparable to previous years' figures.

Group IV Statistics Faculty Salaries

Doctoral degree-granting departments of statistics

37 responses out of 57 departments (65%)

Rank	2008–09					2007–08
	No. Reported	Q_1	Median	Q_3	Mean	Mean
New-Hire Asst Prof	30	71,100	75,800	79,500	75,300	79,381
Assistant Professor*	144	71,000	74,600	79,300	75,665	74,824
Associate Professor	105	76,400	83,400	90,300	84,960	80,714
Full Professor	258	101,500	124,100	149,600	128,249	125,450

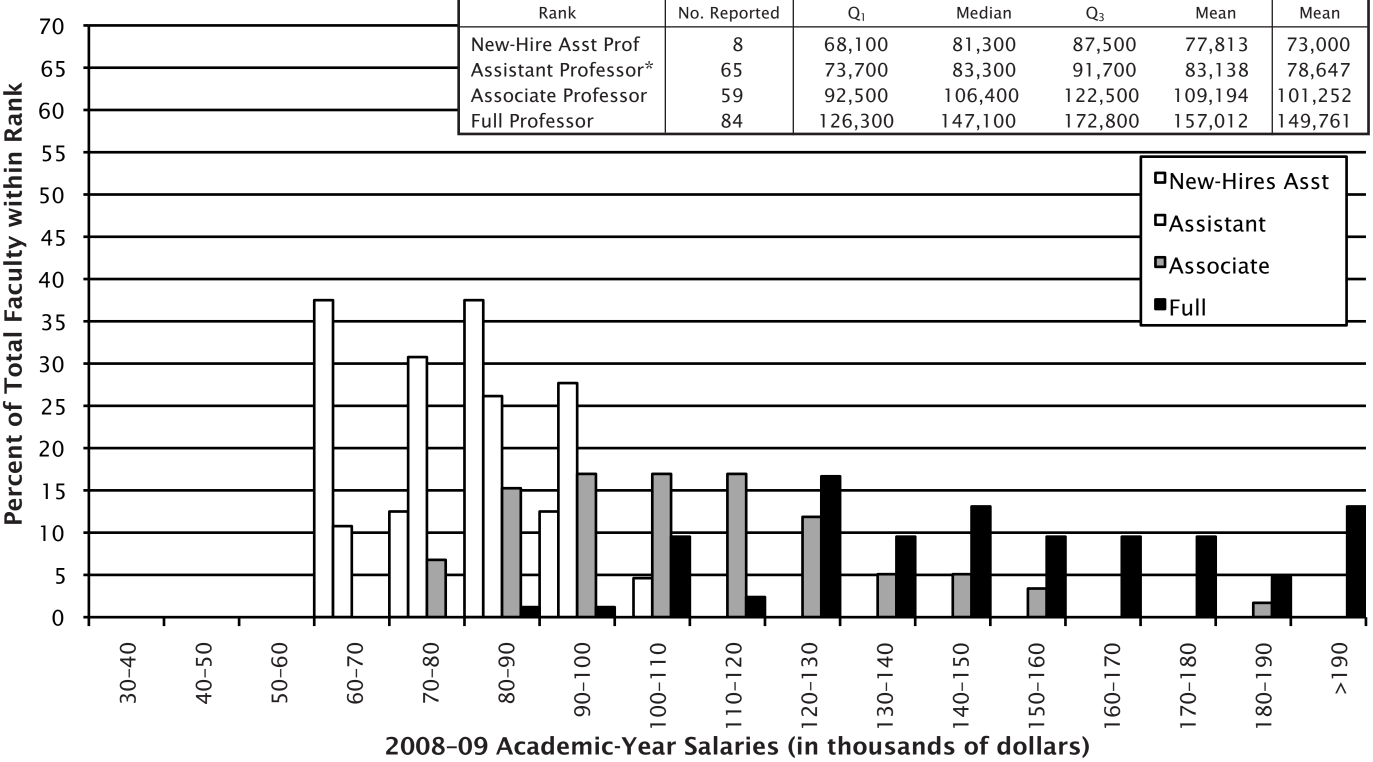


Group IV Biostatistics Faculty Salaries

Doctoral degree-granting departments of biostatistics

15 responses out of 31 departments (48%)

Rank	2008–09					2007–08
	No. Reported	Q_1	Median	Q_3	Mean	Mean
New-Hire Asst Prof	8	68,100	81,300	87,500	77,813	73,000
Assistant Professor*	65	73,700	83,300	91,700	83,138	78,647
Associate Professor	59	92,500	106,400	122,500	109,194	101,252
Full Professor	84	126,300	147,100	172,800	157,012	149,761



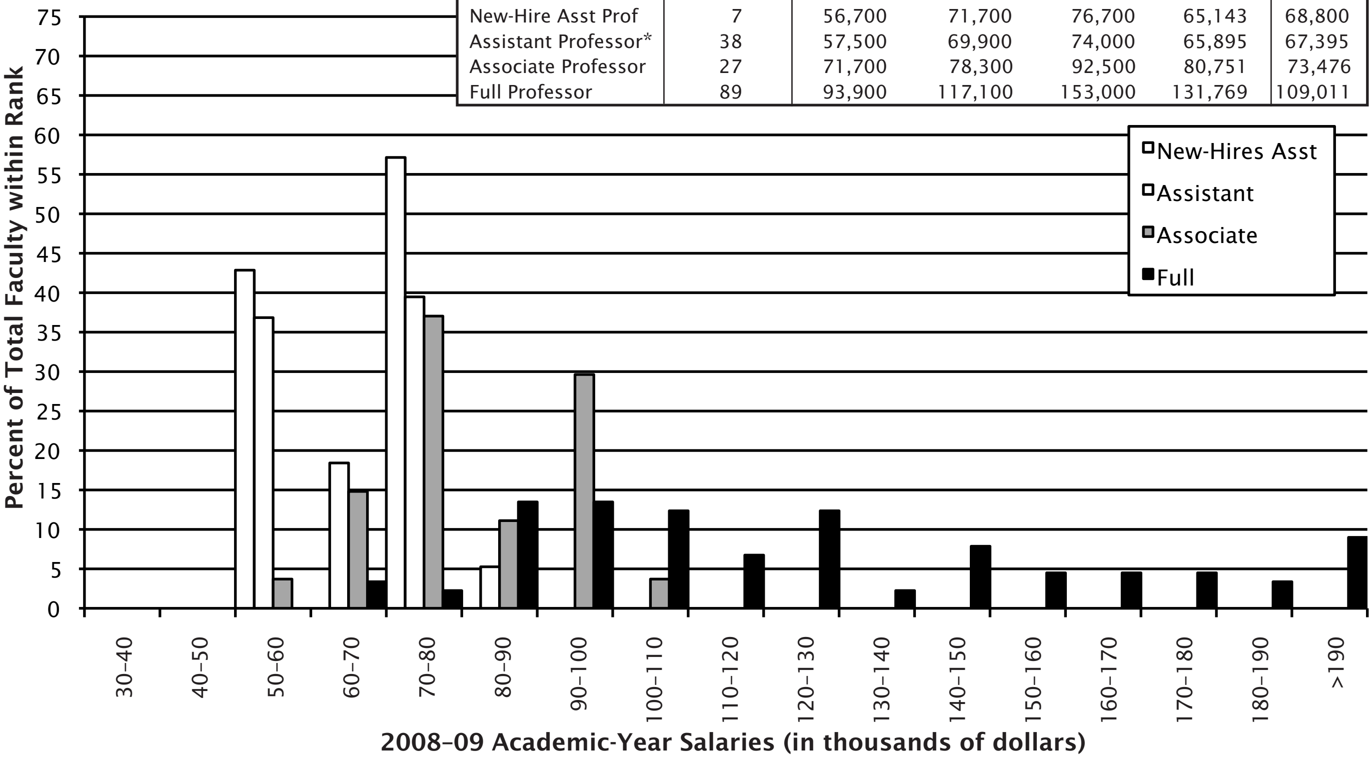
*Includes new hires and is comparable to previous years' figures.

Group Va Faculty Salaries

Doctoral degree-granting departments of applied mathematics

10 responses out of 17 departments (59%)

	2008–09					2007–08
Rank	No. Reported	Q_1	Median	Q_3	Mean	Mean
New-Hire Asst Prof	7	56,700	71,700	76,700	65,143	68,800
Assistant Professor*	38	57,500	69,900	74,000	65,895	67,395
Associate Professor	27	71,700	78,300	92,500	80,751	73,476
Full Professor	89	93,900	117,100	153,000	131,769	109,011



*Includes new hires and is comparable to previous years' figures.

2008–09 academic-year salaries fell within given salary intervals (the survey form is available at `www.ams.org/employment/surveyforms.html`). Reporting salary data in this fashion eliminates some of the concerns about confidentiality but does not permit determination of actual quartiles. Although the actual quartiles cannot be determined from the data gathered, these quartiles have been estimated assuming that the density over each interval is uniform.

When comparing current and prior year figures, one should keep in mind that differences in the set of responding departments may be a significant factor in the change in the reported mean salaries.

Previous Annual Survey Reports

The 2007 First, Second, and Third Annual Survey Reports were published in the *Notices* of the AMS in the February, August, and November 2008 issues respectively. These reports and earlier reports, as well as a wealth of other information from these surveys, are available on the AMS website at `www.ams.org/employment/surveyreports.html`.

Acknowledgments

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

Other Data Sources

American Association of University Professors, *The Annual Report on the Economic Status of the Profession 2007–08*, Academe: Bull. AAUP (March–April 2008), Washington, DC.

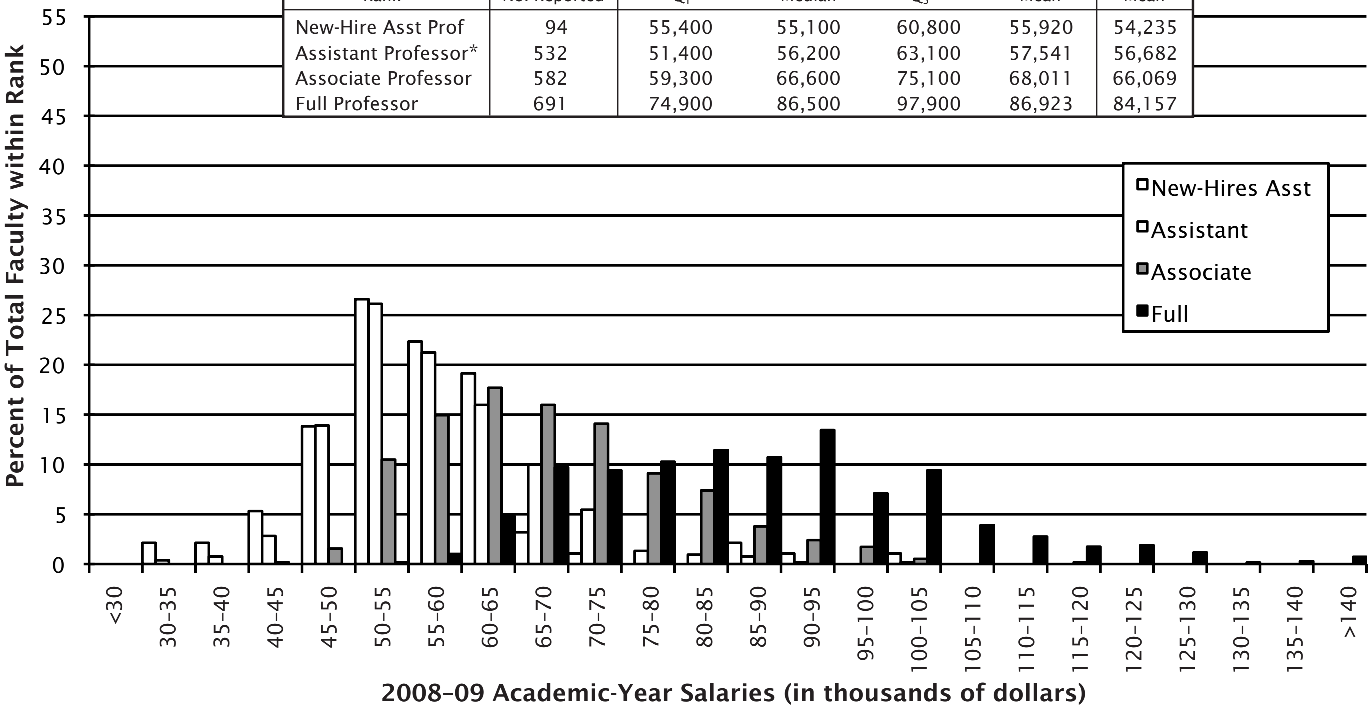
American Statistical Association, *Business, Industry, and Government 2007 Salary Survey.* [`http://www.`

Group M Faculty Salaries

Master's degree-granting departments of mathematics

93 responses out of 190 departments (49%)

	2008–09					2007–08
Rank	No. Reported	Q_1	Median	Q_3	Mean	Mean
New-Hire Asst Prof	94	55,400	55,100	60,800	55,920	54,235
Assistant Professor*	532	51,400	56,200	63,100	57,541	56,682
Associate Professor	582	59,300	66,600	75,100	68,011	66,069
Full Professor	691	74,900	86,500	97,900	86,923	84,157

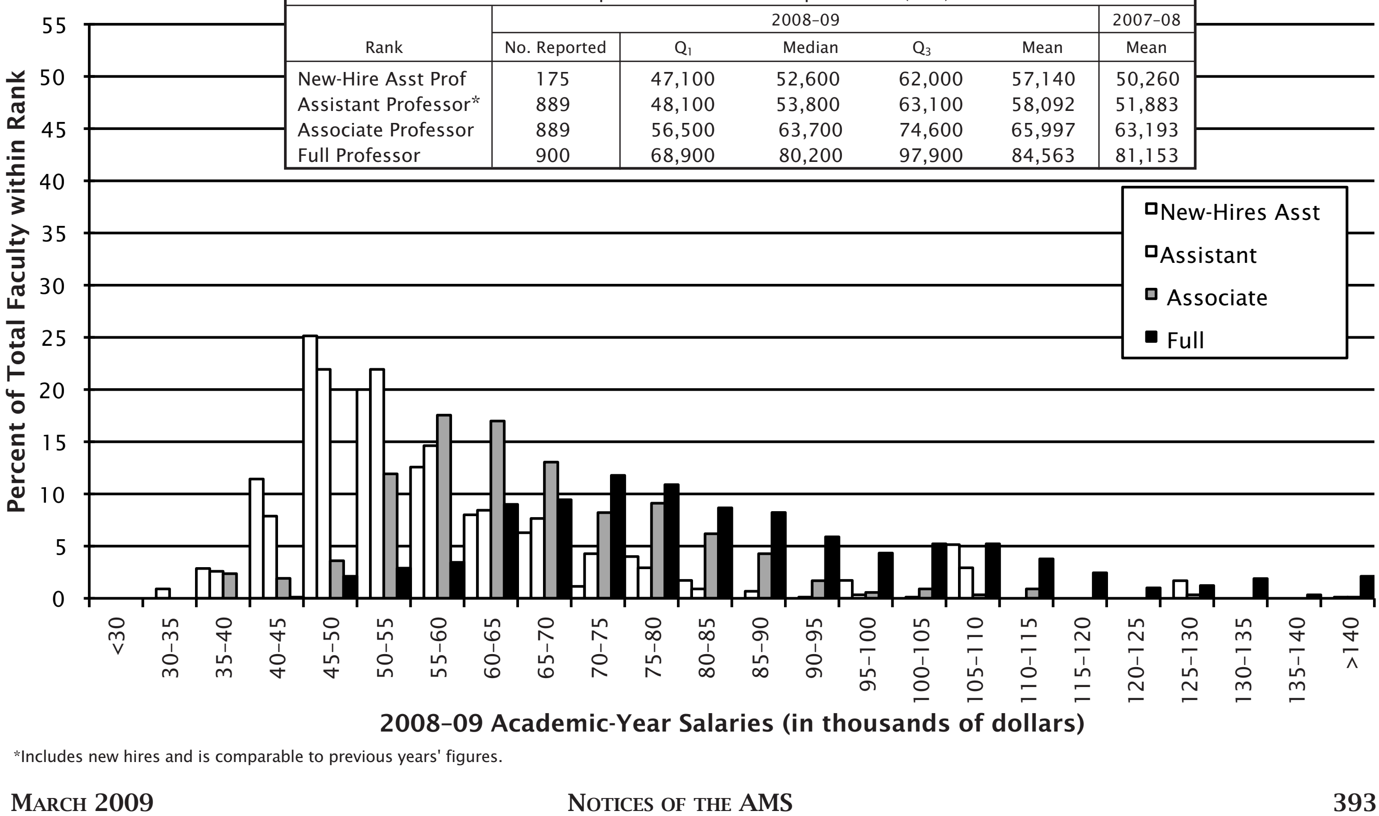


Group B Faculty Salaries

Bachelor's degree-granting departments of mathematics

308 responses out of 1031 departments (30%)

	2008–09					2007–08
Rank	No. Reported	Q_1	Median	Q_3	Mean	Mean
New-Hire Asst Prof	175	47,100	52,600	62,000	57,140	50,260
Assistant Professor*	889	48,100	53,800	63,100	58,092	51,883
Associate Professor	889	56,500	63,700	74,600	65,997	63,193
Full Professor	900	68,900	80,200	97,900	84,563	81,153



*Includes new hires and is comparable to previous years' figures.

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National Science Board, *Science and Engineering Indicators—2008.* Two volumes. (volume 1, NSB 08-01; volume 2, NSB 08-01A), National Science Foundation, Arlington, VA, 2008.

Definitions of the Groups

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

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

Brief descriptions of the groupings are as follows:

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

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

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

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

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

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

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

Listings of the actual departments which compose these groups are available on the AMS website at www.ams.org/employment/groups_des.html.

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

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

Mathematics People

Barlow Receives 2009 CRM-Fields-PIMS Prize

Martin Barlow of the University of British Columbia has been awarded the 2009 CRM-Fields-PIMS Prize. The prize, awarded annually by the Centre de Recherches Mathématiques (CRM), the Fields Institute, and the Pacific Institute for the Mathematical Sciences (PIMS), recognizes exceptional contributions by a mathematician working in Canada. The prize carries a cash award of CA$10,000 (approximately US$8,000) and an invitation to give a lecture at each institute.

According to the prize citation, Barlow "is a leading figure in probability and the leading international expert in diffusion on fractals and other disordered media". He has made important contributions in the fields of partial differential equations (including major progress on the De Giorgi conjecture), stochastic differential equations, the mathematical finance of electricity pricing, filtration enlargement, and branching measure diffusions.

Barlow received his undergraduate degree from Cambridge University in 1975 and his Ph.D. from University College of Swansea, Wales, in 1978. He held a Royal Society University Research Fellowship at Cambridge University from 1985 to 1992, when he joined the mathematics department at the University of British Columbia. He has held a number of visiting professorships at leading universities, including the University of Tokyo; Cornell University; Imperial College, London; and the Université de Paris. In 2008 he received the Jeffery-Williams Prize of the Canadian Mathematical Society. He has also been the recipient of the Rollo Davidson Prize and the Junior Whitehead Prize of the London Mathematical Society. He is a fellow of the Institute of Mathematical Statistics, the Royal Society of Canada, and the Royal Society of London.

The CRM and the Fields Institute established the CRM-Fields Prize in 1994 to recognize exceptional research in the mathematical sciences. In 2005, PIMS became an equal partner, and the name was changed to the CRM-Fields-PIMS Prize. Previous recipients of the prize are H. S. M. (Donald) Coxeter, George A. Elliott, James Arthur, Robert V. Moody, Stephen A. Cook, Israel Michael Sigal, William T. Tutte, John B. Friedlander, John McKay, Edwin Perkins, Donald A. Dawson, David Boyd, Nicole Tomczak-Jaegermann, Joel S. Feldman, and Allan Borodin.

—From a Fields Institute announcement

Wilking and Zirnbauer Awarded Leibniz Prizes

Two mathematicians are among eleven recipients of the 2009 Gottfried Wilhelm Leibniz Prizes awarded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation). Burkhard Wilking of the University of Münster was awarded the prize in differential geometry. Martin R. Zirnbauer of the University of Cologne was awarded the prize in mathematical physics.

Wilking is a leader in the field of differential geometry. According to the prize citation, "his work has had a decisive influence, in particular on what is known as 'Riemannian geometry'." He has achieved "spectacular breakthroughs" both in the classification of Riemannian manifolds of positive sectional curvature and in the convergence of the Ricci flow. He "takes a very original approach to algebraic methods using geometric intuition, which enables him to achieve a deep understanding of the geometric properties of manifolds."

Zirnbauer is "one of the world's leading mathematical physicists". His research interests focus primarily on condensed matter and in particular on mesoscopic electronic systems, which exhibit chaos due to disorder or a lack of geometric symmetry. He has done research on color-flavor transformation and on the generalization of the three Wigner-Dyson universality classes of random matrices for the "tenfold way". He is adept at translating physics questions into modern mathematical language, thus stimulating successful cooperation between mathematics and physics.

As part of the Leibniz Prize, Wilking and Zirnbauer have each received a cash award of 2.5 million euros (approximately US$3.6 million), which they may use as they like for their own research over a period of up to seven years.

—From a Leibniz Prize announcement

Prizes of the Mathematical Society of Japan

The Mathematical Society of Japan (MSJ) awarded several prizes in autumn 2008.

Masanao Ozawa of Nagoya University has been awarded the Autumn Prize for his contributions to the mathematical foundations of quantum information. He showed that Heisenberg's uncertainty principle is not physically correct, and he proposed and proved the inequality that replaces the principle. He has quantitatively generalized the Wigner-Araki-Yanase theorem and shown severe theoretical restrictions for the construction of quantum computers, has succeeded in characterizing all physically possible observables as a measure with the values in the completely positive operators, and finally solved Hilbert's sixth problem. The Autumn Prize is awarded to an individual who has made outstanding contributions within the preceding five years to mathematics in the highest and broadest sense.

The Analysis Prizes have been awarded to Ken-iti Sato of Nagoya University, Hideo Tamura of Okayama University, and Nakao Hayahi of Osaka University in recognition of their outstanding contributions to analysis. Sato was honored for his contributions to developments in the theory of Levy processes and in particular for his work on stochastic integrals with respect to Levy processes and infinitely divisible distributions. Tamura was selected for his contributions to the asymptotic analysis of the spectrum arising from quantum physics and in particular for his results on the Aharanov-Bohm effect in scattering theory and the sharp error estimate to the Trotter-Kato product formula. Hayahi was recognized for his work on various nonlinear dispersive equations and in particular for his construction of modified wave operators for general equations of KdV type and construction of modified scattering operators for nonlinear Schrödinger equations and nonlinear Klein-Gordon equations.

—From a Mathematical Society of Japan announcement

Naor Receives Packard Fellowship

Assaf Naor, a mathematician at New York University, has been awarded a Fellowship for Science and Engineering from the David and Lucile Packard Foundation for the year 2008. He works in analysis and geometry, investigating "the extent to which abstract geometries with an intrinsic notion of distance (metric spaces) can be faithfully represented as points in a better understood geometry, such as Euclidean space". His work concentrates on the development of a structure theory for metric spaces and the applications of geometry and analysis to the theory of computing.

The Packard Fellowships are awarded to researchers in mathematics, natural sciences, computer science, and engineering who are in the first three years of a faculty appointment.

—From a Packard Foundation announcement

Rhodes Scholarships Awarded

Two students in the mathematical sciences are among the thirty-two American men and women chosen as Rhodes Scholars by the Rhodes Scholarship Trust. The Rhodes Scholars were chosen from among 769 applicants who were endorsed by 207 different colleges and universities in a nationwide competition. The names and brief biographies of the mathematics scholars follow.

Joshua A. Lospinoso of Sparta, New Jersey, is a senior at the United States Military Academy with a double major in economics and operations research. He has done pioneering theoretical and applied research on social network analysis, has done top-secret-level signals intelligence work at the National Security Agency, and has many publications in network analysis. He is a Regimental Operations Officer at West Point and has competed three years in the Sandhurst competition. Joshua plans to study for an M.Sc. in applied statistics at Oxford.

Anna Yermakova of Buffalo Grove, Illinois, is a senior at Northwestern University, where she majors in biochemistry, piano, and history and philosophy of science and logic. Anna immigrated to the United States from Russia when she was eleven years old. Since then she has won national awards for piano and French, has done research in chemical engineering and nanotechnology at the University of Washington and in neuroscience and biomedical engineering at Northwestern, and has composed and choreographed works in ballroom dance and flamenco. She will study for a doctorate in mathematical biology at Oxford.

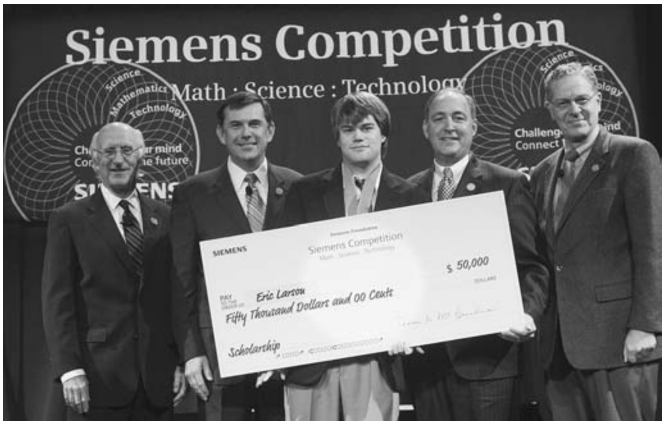
Rhodes Scholarships provide two or three years of study at the University of Oxford in England. The value of the Rhodes Scholarship varies depending on the academic field and the degree (bachelor's, master's, doctoral) and Oxford college chosen. The Rhodes Trust pays all college and university fees and provides a stipend to cover students' necessary expenses while they are in residence in Oxford, as well as during vacations, and transportation to and from England. The total value averages approximately US$50,000 per year.

—From a Rhodes Scholarship Trust announcement

Siemens Competition Prizes Announced

Several students whose work involves the mathematical sciences have won prizes in the Siemens Competition in Math, Science, and Technology.

Eric K. Larson of South Eugene High School, Eugene, Oregon, received a US$50,000 scholarship for his project, "The Classification of Certain Fusion Categories". Larson is a senior who conducted mathematics research that looked to classify certain types of fusion categories. Fusion categories are a recently discovered type of algebraic structure with applications to various areas of theoretical physics, computer science, and mathematics, such as string theory, quantum computation, and knot theory. These extremely complex structures are a far-reaching generalization of groups, which are the algebraic structure traditionally used in mathematics to model symmetries. The main result of this project identifies and completely classifies a new class of fusion categories which, for the



Eric K. Larson (center) wins the US$50,000 scholarship in the 2008 Siemens Competition. ***Photograph courtesy of the Siemens Foundation.***

first time, contains non-group-theoretic examples. He was mentored by Pavel Etingof of the Massachusetts Institute of Technology and Victor Ostrik of the University of Oregon. Larson is an avid piano player, a four-time winner of the Oregon Junior Bach Festival; he has been invited to perform in master classes sponsored by the Eugene Symphony. He was awarded a silver medal at the Forty-eighth International Mathematical Olympiad. He is also involved in his high school's math, chemistry, and programming clubs.

Ashok Cutkosky, a senior at David Henry Hickman High School, Columbia, Missouri, was awarded a US$20,000 scholarship for his project, "Associated Primes of the Square of the Alexander Dual of Hypergraphs". Cutkosky's research uncovered new information about the intrinsic structure of hypergraphs; these results have potential applications in such problems as sharing of resources. He took an algebraic approach to study hypergraphs and worked to restate geometric properties of multivariable polynomials. He was mentored by Christopher Francisco of Oklahoma State University. Cutkosky is the captain of his school's math team and a member of the Mu Alpha Theta Math Honor Society. He placed first and second at the Great Plains Math League State Competition and received a silver medal at the USA Mathematical Talent Search in 2007.

Hayden C. Metsky, a senior at Millburn High School, Millburn, New Jersey, received a US$10,000 scholarship for his project, "Improving Statistical Machine Translation Through Template-based Phrase-table Extensions". His research proposed a novel method to improve the quality of machine translation from one language to another. His approach addressed a critical problem in machine translation, that of producing good results for phrases that the system has not seen before, which will yield performance improvements to automatic translators through virtual extension of a given sample. He was mentored by Nizar Habash of Columbia University and Paul Citrin, a science teacher and advisor in Millburn High School's Science Research Program. Metsky has been named the New Jersey Governor's School of Engineering and Technology Scholar and has won the George Washington University School of Engineering and Applied Science medal. He enjoys independent software development and has developed a "Word of the Day" widget that drew the attention of a notable online dictionary website. He is the front-page news section editor of his school newspaper. Metsky enjoys mentoring other students in math, running cross-country, and playing cello in the school orchestra. He hopes to conduct research in a computer science-related field after completing his undergraduate education.

Raphael-Joel Lim of the Indiana Academy for Science, Math, and Humanities in Muncie, Indiana, and Mark Zhang of William P. Clements High School, Sugar Land, Texas, received a US$20,000 scholarship for their team project, "Previously Unknown Parts of the Greene-Kleitman Partition for the Tamari Lattice". Their research answered a question about the thickness of a fundamental mathematical structure, the Tamari lattice. The team met at the Texas Mathworks Honors Summer Math Camp, where they worked closely with Max Warshauer, founder and director of the camp. The team's mentor was Edward Early of St. Edward's University. Lim, a senior, likes reading novels, tackling tough math problems, and playing competitive video games. He spent last summer as a counselor at the Texas Mathworks Honors Summer Math Camp and works as a math tutor. Zhang, also a senior, was a Siemens Competition Regional Finalist in 2007. He is a member of both the Mu Alpha Theta Math Club and the Junior Engineering Technical Society and regularly competes in a variety of math, science, and computer science competitions. In addition, he also enjoys playing the piano, reading and writing fantasy novels, programming games, sketching, playing DDR, and volunteering.

Erika DeBenedictis of the Albuquerque Academy, Albuquerque, New Mexico, and Duanni (Tony) Huang of La Cueva High School, Albuquerque, received a US$40,000 scholarship for their team project, "Optimizing the Direct Simulation Monte Carlo Algorithm for Multi-core Processors". The goal of the team's project was to create a physically realistic direct simulation Monte Carlo (DSMC) model and optimize its performance on multicore processors, making intricate simulation available on desktop computers versus a "supercomputer" that may cost tens of millions of dollars. The research could open doors to simpler methods of simulation of physical systems; such systems include the weather, reentry of space vehicles (which this project studied), auto collisions, and even modeling of complex biological processes such as molecular docking. DeBenedictis, a junior, enjoys physics and independent research projects. She competes in her school science fair and on the New Mexico Supercomputing Challenge as part of a team each year. She sings with the Girls Ensemble and her school's audition choir and plays piano. Huang, a senior, has participated in many science competitions through the years and has won honors at the Science Olympiads, Science Bowl/Quiz Bowls, and MATHCOUNTS, for which he is an assistant coach. He is a member of the National Honor Society and is actively involved in a mentorship at the Center for High Tech Materials.

—From a Siemens Competition announcement

Mathematics Opportunities

Mathematics Research Communities 2009

The American Mathematical Society (AMS) invites mathematicians just beginning their research careers to become part of Mathematics Research Communities (MRC), a new program to develop and sustain long-lasting cohorts for collaborative research projects in many areas of mathematics. Women and underrepresented minorities are especially encouraged to participate. The AMS will provide a structured program to engage and guide all participants as they start their careers. The program will include: a one-week summer conference for each topic, special sessions at the national meeting, discussion networks by research topic, ongoing mentoring, and a longitudinal study of early career mathematicians.

The summer conferences of the Mathematics Research Communities will be held in the breathtaking mountain setting of the Snowbird Resort, Utah, where participants can enjoy the natural beauty and a collegial atmosphere. The application deadline for summer 2009 is **March 2, 2009**. This program is supported by a grant from the National Science Foundation.

The topics, dates, and organizers of the 2009 conferences follow.

Mathematical Challenges of Relativity, June 13–19, 2009, Mihalis Dafermos (University of Cambridge), Alexandru Ionescu (University of Wisconsin, Madison), Sergiu Klainerman (Princeton University, chair), and Richard Schoen (Stanford University).

Inverse Problems, June 20–26, 2009, Guillaume Bal (Columbia University), Allan Greenleaf (University of Rochester), Todd Quinto (Tufts University), and Gunther Uhlmann (University of Washington, chair).

Modern Markov Chains and Their Statistical Applications, June 27–July 3, 2009, Persi Diaconis (Stanford University, chair), Jim Hobert (University of Florida), and Susan Holmes (Stanford University).

Harmonic Analysis, June 27–July 3, 2009, Ciprian Demeter (Indiana University), Michael Lacey (Georgia Institute of Technology), and Christoph Thiele (University of California, Los Angeles, chair).

Situated in a beautiful mountain setting, Snowbird Resort provides an extraordinary environment for the MRC. The atmosphere is comparable to the collegial gatherings at Oberwolfach and other conferences that combine peaceful natural ambience with stimulating meetings.

MRC participants have access to a range of activities, such as a tram ride to the top of the mountain, guided hikes, swimming, mountain bike tours, rock climbing, plus heated outdoor pools. More than a dozen walking and hiking trails head deep into the surrounding mountains. Participants also enjoy the simpler pleasures of convening on the patios at the resort to read, work, and socialize.

In the evenings colleagues enjoy informal gatherings to network and continue discussion of the day's sessions over refreshments. Within a half hour of the University of Utah, Snowbird is easily accessible from the Salt Lake City International Airport. For more information about Snowbird Resort, see `http://www.snowbird.com`.

A report about the 2008 MRC conferences appeared in the February issue of the *Notices,* pages 224–225. For information on applying for the 2009 program, please visit the website `http://www.ams.org/amsmtgs/mrc-09.html`. For further information about the MRC program, please contact AMS Associate Executive Director Ellen Maycock at `ejm@ams.org`.

—AMS announcement

NSF Collaboration in Mathematical Geosciences

The Division of Mathematical Sciences (DMS) within the Directorate for Mathematical and Physical Sciences (MPS), the Directorate for Geosciences (GEO), and the Office of Polar Programs of the National Science Foundation (NSF) expect to make a number of awards in fiscal year 2009 that will support the activities of groups of investigators working at the frontiers of mathematical geosciences. Proposals should bring together scientists from both the mathematics and geosciences communities in a truly collaborative effort. Proposals in three broad thematic areas are solicited in this competition: mathematical and statistical modeling of complex geosystems, understanding and quantifying uncertainty in geosystems, and analyzing large/complex geoscience data sets. The window for submission is **February 24–March 10, 2009**. See `http://www.nsf.gov/pubs/2009/nsf09520/nsf09520.htm?govDel=USNSF_25` for more information.

—From an NSF announcement

NSF Integrative Graduate Education and Research Training

The Integrative Graduate Education and Research Training (IGERT) program was initiated by the National Science Foundation (NSF) to meet the challenges of educating Ph.D. scientists and engineers with the interdisciplinary backgrounds and the technical, professional, and personal skills needed for the career demands of the future. The program is intended to catalyze a cultural change in graduate education for students, faculty, and universities by establishing innovative models for graduate education in a fertile environment for collaborative research that transcends traditional disciplinary boundaries. It is also intended to facilitate greater diversity in student participation and to contribute to the development of a diverse, globally aware science and engineering workforce. Supported projects must be based on a multidisciplinary research theme and administered by a diverse group of investigators from U.S. Ph.D.-granting institutions with appropriate research and teaching interests and expertise.

The preliminary proposal deadline for the 2009 IGERT competition is **March 13, 2009**. The deadline for full proposals is **September 14, 2009**. Further information may be found at the website `http://www.nsf.gov/pubs/2009/nsf09519/nsf09519.htm?govDel=USNSF_25`.

—From an NSF announcement

For Your Information

Program Director Positions at NSF

The Division of Mathematical Sciences (DMS) announces a nationwide search for a number of program director positions at the National Science Foundation (NSF).

NSF program directors bear the primary responsibility for carrying out the NSF's overall mission: to support innovative and merit-reviewed activities in basic research and education that contribute to the nation's technical strength, security, and welfare. To discharge this responsibility requires not only knowledge in the appropriate disciplines but also a commitment to high standards, a considerable breadth of interest and receptivity to new ideas, a strong sense of fairness, good judgment, and a high degree of personal integrity.

Applicants should have a Ph.D. or equivalent training in a field of the mathematical sciences, a broad knowledge of one of the relevant disciplinary areas of the DMS, some administrative experience, a knowledge of the general scientific community, skill in written communication and preparation of technical reports, an ability to communicate orally, and several years of successful independent research normally expected of the academic rank of associate professor or higher. Skills in multidisciplinary research are highly desirable.

Qualified individuals who are women, ethnic/racial minorities, and/or persons with disabilities are strongly urged to apply. No person shall be discriminated against on the basis of race, color, religion, sex, national origin, age, or disability in hiring by the National Science Foundation.

Program director positions recruited under this announcement may be filled under one of the following appointment options:

Visiting Scientist Appointment: Appointment to this position will be made under the Excepted Authority of the NSF Act. Visiting scientists are on unpaid leave status from their home institutions and appointed to NSF's payroll as federal employees. NSF withholds Social Security taxes and pays the home institution's contributions to maintain retirement and fringe benefits (i.e., health benefits and life insurance) either directly to the home institution or to the carrier. Appointments are usually made for up to one year and may be extended for an additional year by mutual agreement.

Intergovernmental Personnel Act (IPA) Assignment: Individuals eligible for an IPA assignment with a federal agency include employees of state and local government agencies or institutions of higher education, Indian tribal governments, and other eligible organizations in instances in which such assignments would be of mutual benefit to the organizations involved. Initial assignments under IPA provisions may be made for a period of up to two years, with a possible extension for up to an additional two-year period. The individual remains an employee of the home institution, and NSF provides funding toward the assignee's salary and benefits. Initial IPA assignments are made for a one-year period and may be extended by mutual agreement.

Temporary Excepted Service Appointment: Appointment to this position will be made under the Excepted Authority of the NSF Act. Candidates who do not have civil service status or reinstatement eligibility will not obtain civil service status if selected. Candidates currently in the competitive service will be required to waive competitive civil service rights if selected. Usual civil service benefits (retirement, health benefits, life insurance) are applicable for appointments of more than one year. Temporary appointments may not exceed three years.

For additional information on NSF's rotational programs, see "Programs for Scientists, Engineers and Educators" on the NSF website at `http://www.nsf.gov/about/career_opps`.

Applicants should send a letter of interest and vita (preferably via email) to Deborah F. Lockhart, Executive Officer, Division of Mathematical Sciences, National Science Foundation, 4201 Wilson Boulevard, Suite 1025, Arlington, Virginia 22230; phone: 703-292-4858; fax: 703-292-9032; email: `dlockhar@nsf.gov`.

NSF is an Equal Opportunity Employer committed to employing a highly qualified staff that reflects the diversity of our nation. This announcement can also be found at `http://www.nsf.gov/publications/pub_summ.jsp?ods_key=dms0601`.

—DMS announcement

Everett Pitcher Lectures

The next series of Everett Pitcher Lectures will be held March 16–18, 2009, on the campus of Lehigh University in Bethlehem, Pennsylvania. The speaker will be Maria Chudnovsky of Columbia University. The lectures, which are open to the public, are held in honor of Everett Pitcher, who was secretary of the AMS from 1967 until 1988. Pitcher served in the mathematics department at Lehigh University from 1938 until 1978, when he retired as Distinguished Professor of Mathematics. He passed away in December 2006 at the age of ninety-four. For further information, contact the Everett Pitcher Lecture Series, Department of Mathematics, Lehigh University, Bethlehem, PA, 18015; telephone 610-758-3788; or see the website `http://www.lehigh.edu/~math/pitcher.html`.

—From a Lehigh University announcement

Inside the AMS

Mathematics Awareness Month, April 2009: "Mathematics and Climate"

The AMS, the American Statistical Association, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics announce that the theme for Mathematics Awareness Month, April 2009, is **Mathematics and Climate**. One of the most important challenges of our time is modeling global climate. Some of the fundamental questions researchers are currently addressing are:

- How long will the summer Arctic Sea ice pack survive?
- Are hurricanes and other severe weather events getting stronger?
- How much will sea level rise as ice sheets melt?
- How do human activities affect climate change?
- How is global climate monitored?

Calculus, differential equations, numerical analysis, probability, and statistics are just some of the areas of mathematics used to understand the oceans, atmosphere, polar ice caps, and the complex interactions among these vast systems. Indeed, analyzing feedback effects is a crucial component of global climate modeling and often a significant factor in long-term predictions. For example, warmer temperatures cause ice to melt, exposing more land and water, so that more sunlight is absorbed instead of being reflected, in turn leading to more warming.

Mathematics, computer science, and other sciences are inextricably linked, and each is required to begin to solve the fundamental questions about Earth's climate, particularly those concerning global warming. Moreover, math and science are central to the development of both traditional and alternative energy sources and to the evolution of other strategies for mitigating the effects of climate change.

Mathematics departments can find a sample press release that can be adapted for public awareness activities on the Mathematics Awareness Month website, `http://www.mathaware.org`.

Each year the Joint Policy Board for Mathematics sponsors Mathematics Awareness Month to recognize the importance of mathematics through written materials and an accompanying poster that highlight mathematical developments and applications in one particular area.

—JPBM announcement from the AMS Public Awareness Office

Deaths of AMS Members

G. C. Byers, from Hancock, MI, died on January 19, 1996. Born on June 18, 1918, he was a member of the Society for 45 years.

Charles Christenson, from Moscow, ID, died on September 20, 2008. Born on September 17, 1936, he was a member of the Society for 43 years.

H. Cornet, from The Hague, Netherlands, died in November 2008. Born on June 21, 1923, he was a member of the Society for 35 years.

Michael Herschorn, from Westmount, Quebec, Canada, died on March 2, 2008. Born on April 21, 1933, he was a member of the Society for 52 years.

Jack Ohm, from Pensacola Beach, FL, died on May 24, 2008. Born on September 23, 1932, he was a member of the Society for 51 years.

Nicholas Reingold, from Somerville, MA, died on July 3, 2008. Born in July 1960, he was a member of the Society for 25 years.

John Robert Stallings, from Berkeley, CA, died on November 24, 2008. Born on July 22, 1935, he was a member of the Society for 36 years.

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.ou.edu` in the case of the editor and `notices@ams.org` in the case of the managing editor. The fax numbers are 405-325-7484 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Upcoming Deadlines

February 24, 2009: Full proposals for NSF Project ADVANCE Partnerships for Adaptation, Implementation, and Dissemination (PAID) awards. See `http://www.nsf.gov/pubs/2009/nsf09504/nsf09504.htm?govDel=USNSF_25`.

February 24–March 10, 2009: Proposals for NSF Collaboration in Mathematical Geosciences (CMG). See "Mathematics Opportunities" in this issue.

February 26, 2009: Preliminary proposals for NSF Partnerships for International Research and Education (PIRE). See `http://www.nsf.gov/pubs/2009/nsf09505/nsf09505.htm?govDel=USNSF_25#awd_info`.

Where to Find It

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

February 27, 2009: Applications for 2009 Summer Program for Women in Mathematics (SPWM2009). Contact the director, Murli M. Gupta, email: mmg@gwu.edu; telephone: 202-994-4857; or see the website http://www.gwu.edu/~spwm/.

February 27, 2009: Submissions for Association for Women in Mathematics (AWM) essay contest. See http://www.awm-math.org/biographies/contest.html.

February 27, 2009: Proposals for DMS New Institute Competition. See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5302.

March 1, 2009: Applications for the June program of the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program of the National Academies. See http://www7.nationalacademies.org/policyfellows; or contact The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 Fifth Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667; email: policyfellows@nas.edu.

March 2, 2009: Applications for EDGE Summer Program. See http://www.edgeforwomen.org/?page_id=5.

March 31, 2009: Submissions for *Plus* Magazine New Writers Award. See the website http://plus.maths.org/competition/.

April 15, 2009: Applications for fall 2009 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. For information on AMS scholarships see http://www.ams.org/outreach/mimoscow.html or write 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 8, 2009: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; email: awm@awm-math.edu. The postal address is: Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

May 15, 2009: Applications for National Academies Research Associateship Programs. See http://www7.nationalacademies.org/rap/ 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.

June 1, 2009: Applications for the September program of the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program of the National Academies. See http://www7.nationalacademies.org/policyfellows; or contact The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 Fifth Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667; email: policyfellows@nas.edu.

June 1, 2009: Applications for the Math for America Foundation (MfA) Fellowship Program in San Diego. See http://www.mathforamerica.org/.

June 2, 2009: Proposals for NSF's Enhancing the Mathematical Sciences Workforce in the Twenty-First Century program. See http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf05595.

June 30, 2009: Applications for Fermat Prize for Mathematics Research. Contact Prix Fermat de Recherche en Mathématiques, Service Relations Publiques, Université Paul Sabatier, 31062 Toulouse Cedex 9, France, or see the website http://www.math.ups-tlse.fr/Fermat/.

August 4, 2009: Letters of intent for NSF Project ADVANCE Institutional Transformation (IT) and Institutional Transformation Catalyst (IT-Catalyst) awards. See http://www.nsf.gov/pubs/2009/nsf09504/nsf09504.htm?govDel=USNSF_25.

August 4, 2009: Full proposals (by invitation only) for NSF Partnerships for International Research and Education (PIRE). See http://www.nsf.gov/pubs/2009/nsf09505/nsf09505.htm?govDel=USNSF_25#awd_info.

August 15, 2009: Applications for National Academies Research Associateship Programs. See http://www7.nationalacademies.org/rap/ 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.

September 14, 2009: Full proposals for NSF Integrative Graduate Education and Research Training (IGERT). See "Mathematics Opportunities" in this issue.

October 1, 2009: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html; telephone: 703-934-0163; email: awm@awm-math.edu. The postal address is: Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

November 1, 2009: Applications for the January program of the Christine Mirzayan Science and Technology Policy Graduate Fellowship Program of the National Academies. See http://www7.nationalacademies.org/policyfellows; or contact The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 Fifth Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202-334-1667; email: policyfellows@nas.edu.

November 12, 2009: Full proposals for NSF Project ADVANCE Institutional Transformation (IT) and Institutional Transformation Catalyst (IT-Catalyst) awards. See http://www.nsf.gov/pubs/2009/nsf09504/nsf09504.htm?govDel=USNSF_25.

November 15, 2009: Applications for National Academies Research Associateship Programs. See http://www7.nationalacademies.org/rap/ 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.

Board on Mathematical Sciences and Their Applications, National Research Council

The Board on Mathematical Sciences and Their Applications (BMSA) was established in November 1984 to lead activities in the mathematical sciences at the National Research Council (NRC). The mission of BMSA is to support and promote the quality and health of the mathematical sciences and their benefits to the nation. Following are the current BMSA members.

Massoud Amin, University of Minnesota

Tanya Styblo Beder, SB Consulting Corporation

Marsha Berger, New York University

Philip Bernstein, Microsoft Corporation

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Charles M. Lucas, American International Companies

Donald Saari, University of California at Irvine

J. B. Silvers, Case Western Reserve University

George Sugihara, University of California, San Diego

The postal address for BMSA is: Board on Mathematical Sciences and Their Applications, National Academy of Sciences, Room K974, 500 Fifth Street, NW, Washington, DC 20001; telephone: 202-334-2421; fax: 202-334-2422/2101; email: `bms@nas.edu`; website: `http://www7.nationalacademies.org/bms/BMSA_Members.html`.

Book List

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

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

An Abundance of Katherines, by John Green. Dutton Juvenile Books, September 2006. ISBN-13:978-0-5254-7688-7. (Reviewed October 2008.)

Amongst Mathematicians: Teaching and Learning Mathematics at University Level, by Elena Nardi. Springer, November 2007. ISBN-13: 978-0-387-37141-2.

The Annotated Turing: A Guided Tour Through Alan Turing's Historic Paper on Computability and the Turing Machine, by Charles Petzold. Wiley, June 2008. ISBN-13: 978-04702-290-57.

The Archimedes Codex, by Reviel Netz and William Noel. Weidenfeld and Nicolson, May 2007. ISBN-13: 978-0-29764-547-4. (Reviewed September 2008.)

**The Best of All Possible Worlds: Mathematics and Destiny*, by Ivar Ekeland. University Of Chicago Press, October 2006. ISBN-13: 978-0-226-19994-8. (Reviewed in this issue.)

The Book of Numbers: The Secret of Numbers and How They Changed the World, by Peter J. Bentley. Firefly Books, February 2008. ISBN-13: 978-15540-736-10.

The Cat in Numberland, by Ivar Ekeland. Cricket Books, April 2006. ISBN-13: 978-0-812-62744-2. (Reviewed January 2009.)

**Crossing the Equal Sign*, by Marion D. Cohen. Plain View Press, January 2007. ISBN-13: 978-18913-866-95.

Digital Dice, by Paul J. Nahin. Princeton University Press, March 2008. ISBN-13: 978-06911-269-82.

Dimensions, by Jos Leys, Etienne Ghys, and Aurélien Alvarez. DVD, 117 minutes. Available at `http://www.dimensions-math.org`.

Discovering Patterns in Mathematics and Poetry, by Marcia Birken and Anne C. Coon. Rodopi, February 2008. ISBN-13: 978-9-0420-2370-3.

**The Drunkard's Walk: How Randomness Rules Our Lives*, by Leonard Mlodinow. Pantheon, May 2008. ISBN-13: 978-03754-240-45.

Einstein's Mistakes: The Human Failings of Genius, by Hans C. Ohanian. W. W. Norton, September 2008. ISBN-13: 978-0393062939.

Emmy Noether: The Mother of Modern Algebra, by M. B. W. Tent. A K Peters, October 2008. ISBN-13: 978-15688-143-08.

Euclidean and Non-Euclidean Geometries: Development and History, fourth revised and expanded edition, by Marvin Jay Greenberg. W. H. Freeman, September 2007. ISBN-13: 978-0-7167-9948-1.

Euler's Gem: The Polyhedron Formula and the Birth of Topology, by David S. Richeson. Princeton University Press, September 2008. ISBN-13: 97-80691-1267-77.

Fifty Mathematical Ideas You Really Need to Know, by Tony Crilly. Quercus, 2007. ISBN-13: 978-18472-400-88.

Fighting Terror Online: The Convergence of Security, Technology and the Law, by Martin Charles Golumbic. Springer, 2008. ISBN: 978-0-387-73577-1.

Five-Minute Mathematics, by Ehrhard Behrends (translated by David Kramer). AMS, May 2008. ISBN-13: 978-08218-434-82.

Fly Me to the Moon: An Insider's Guide to the New Science of Space Travel, by Edward Belbruno. Princeton University Press, January 2007. ISBN-13: 978-0-6911-2822-1. (Reviewed April 2008.)

Geekspeak: How Life + Mathematics = Happiness, by Graham Tattersall. Collins, September 2008. ISBN-13: 978-00616-292-42.

Geometric Folding Algorithms: Linkages, Origami, Polyhedra, by Erik D. Demaine and Joseph O'Rourke. Cambridge University Press, July 2007. ISBN-13: 978-05218-57574.

**Geometric Origami*, by Robert Geretschläger. Arbelos, October 2008. ISBN-13: 978-09555-477-13.

The Golden Section: Nature's Greatest Secret (Wooden Books), by Scott Olsen. Walker and Company, October 2006. ISBN-13: 978-08027-153-95.

Group Theory in the Bedroom, and Other Mathematical Diversions, by Brian Hayes. Hill and Wang, April 2008. ISBN-13: 978-08090-521-96. (Reviewed February 2009.)

Guesstimation: Solving the World's Problems on the Back of a Cocktail Napkin, by Lawrence Weinstein and John A. Adam. Princeton University Press, April 2008. ISBN-13: 978-0-6911-2949-5.

Hexaflexagons, Probability Paradoxes, and the Tower of Hanoi: Martin Gardner's First Book of Mathematical Puzzles and Games, by Martin Gardner. Cambridge University Press, September 2008. ISBN-13: 978-0-521-73525-4.

**How Math Explains the World: A Guide to the Power of Numbers, from Car Repair to Modern Physics*, by James D. Stein. Collins, April 2008. ISBN-13: 978-00612-417-65.

How Round Is Your Circle, by John Bryant and Chris Sangwin. Princeton University Press, January 2008. ISBN-13: 978-0-6911-3118-4.

Impossible?: Surprising Solutions to Counterintuitive Conundrums, by Julian Havil. Princeton University Press, April 2008. ISBN-13: 978-0-6911-3131-3.

The Indian Clerk, by David Leavitt. Bloomsbury USA, September 2007. ISBN-13: 978-15969-1040-9. (Reviewed September 2008.)

Irreligion: A Mathematician Explains Why the Arguments for God Just Don't Add Up, by John Allen Paulos. Hill and Wang, December 2007. ISBN-13: 978-0-8090-591-95. (Reviewed August 2008.)

Is God a Mathematician? by Mario Livio. Simon & Schuster, January 2009. ISBN-13: 978-07432-940-58.

Kiss My Math: Showing Pre-Algebra Who's Boss, by Danica McKellar. Hudson Street Press, August 2008. ISBN-13: 978-1594630491.

The Last Theorem, by Arthur C. Clarke and Frederik Pohl. Del Rey, August 2008. ISBN-13: 978-0345470218.

Logic's Lost Genius: The Life of Gerhard Gentzen, by Eckart Menzler-Trott, Craig Smorynski (translator), Edward R. Griffor (translator). AMS-LMS, November 2007. ISBN-13: 978-0-8218-3550-0.

Making Mathematics Work with Needlework: Ten Papers and Ten Projects, edited by Sarah-Marie Belcastro and Carolyn Yackel. A K Peters, September 2007. ISBN-13: 978-1-5688-1331-8.

The Map of My Life, by Goro Shimura. Springer, September 2008. ISBN-13: 978-03877-971-44.

Mathematical Omnibus: Thirty Lectures on Classic Mathematics, by Dmitry Fuchs and Serge Tabachnikov. AMS, October 2007. ISBN-13: 978-08218-431-61. (Reviewed December 2008).

The Mathematician's Brain, by David Ruelle. Princeton University Press, July 2007. ISBN-13 978-0-691-12982-2. (Reviewed November 2008.)

Mathematics and the Aesthetic: New Approaches to an Ancient Affinity, edited by Nathalie Sinclair, David Pimm, and William Higginson. Springer, November 2006. ISBN-13: 978-03873-052-64. (Reviewed February 2009.)

Mathematics and Democracy: Designing Better Voting and Fair-Division Procedures, by Steven J. Brams. Princeton University Press, December 2007. ISBN-13: 978-0691-1332-01.

Mathematics at Berkeley: A History, by Calvin C. Moore. A K Peters, February 2007. ISBN-13: 978-1-5688-1302-8. (Reviewed November 2008.)

Mathematics in Ancient Iraq: A Social History, by Eleanor Robson. Princeton University Press, August 2008. ISBN13: 978-06910-918-22.

The Mathematics of Egypt, Mesopotamia, China, India, and Islam: A Sourcebook, by Victor J. Katz et al. Princeton University Press, July 2007. ISBN-13: 978-0-6911-2745-3.

Measuring the World, by Daniel Kehlmann. Pantheon, November 2006. ISBN 0-375-42446-6. (Reviewed June/July 2008.)

More Mathematical Astronomy Morsels, by Jean Meeus. Willmann-Bell, 2002. ISBN 0-943396743.

More Sex Is Safer Sex: The Unconventional Wisdom of Economics, by Steven E. Landsburg. Free Press, April 2007. ISBN-13: 978-1-416-53221-7. (Reviewed June/July 2008.)

Number and Numbers, by Alain Badiou. Polity, June 2008. ISBN-13: 978-07456-387-82.

Number Story: From Counting to Cryptography, by Peter M. Higgins. Springer, February 2008. ISBN-13: 978-1-8480-0000-1.

**The Numbers Behind NUMB3RS: Solving Crime with Mathematics*, by Keith Devlin and Gary Lorden. Plume, August 2007. ISBN-13: 978-04522-8857-7. (Reviewed in this issue.)

The Numerati, by Stephen Baker. Houghton Mifflin, August 2008. ISBN-13: 978-06187-846-08.

One to Nine: The Inner Life of Numbers, by Andrew Hodges. W. W. Norton, May 2008. ISBN-13: 978-03930-664-18.

Origami, Eleusis, and the Soma Cube: Martin Gardner's Mathematical Diversions, by Martin Gardner. Cambridge University Press, September 2008. ISBN-13: 978-0-521-73524-7.

**Our Days Are Numbered: How Mathematics Orders Our Lives*, by Jason Brown. McClelland and Stewart, to appear April 2009. ISBN-13: 978-07710-169-67.

A Passion for Discovery, by Peter Freund. World Scientific, August 2007. ISBN-13: 978-9-8127-7214-5.

Plato's Ghost: The Modernist Transformation of Mathematics, by Jeremy Gray. Princeton University Press, September 2008. ISBN-13: 978-06911-361-03.

The Presidential Election Game, by Steven J. Brams. A K Peters, December 2007. ISBN-13: 978-1-5688-1348-6.

The Princeton Companion of Mathematics, edited by Timothy Gowers (June Barrow-Green and Imre Leader, associate editors). Princeton University Press, November 2008. ISBN-13: 978-06911-188-02.

Professor Stewart's Cabinet of Mathematical Curiosities, by Ian Stewart. Basic Books, December 2008. ISBN-13: 978-0-465-01302-9.

Pursuit of Genius: Flexner, Einstein, and the Early Faculty at the Institute *for Advanced Study*, by Steve Batterson. A K Peters, June 2006. ISBN 1-56881-259-0. (Reviewed August 2008.)

Pythagorean Crimes, by Tefcros Michalides. Parmenides Publishing, September 2008. ISBN-13: 978-19309-722-78. (Reviewed January 2009.)

Random Curves: Journeys of a Mathematician, by Neal Koblitz. Springer, December 2007. ISBN-13: 978-3-5407-4077-3.

Reminiscences of a Statistician: The Company I Kept, by Erich Lehmann. Springer, November 2007. ISBN-13: 978-0-387-71596-4.

**Rock, Paper, Scissors: Game Theory in Everyday Life*, by Len Fisher. Basic Books, November 2008. ISBN-13: 978-04650-093-81.

Roots to Research: A Vertical Development of Mathematical Problems, by Judith D. Sally and Paul J. Sally Jr. AMS, November 2007. ISBN-13: 978-08218-440-38. (Reviewed December 2008.)

Sacred Mathematics: Japanese Temple Geometry, by Fukagawa Hidetoshi and Tony Rothman. Princeton University Press, July 2008. ISBN-13: 978-0-6911-2745-3.

The Shape of Content: An Anthology of Creative Writing in Mathematics and Science, edited by Chandler Davis, Marjorie Wikler Senechal, and Jan Zwicky. A K Peters, November 2008. ISBN-13: 978-15688-144-45.

Souvenirs sur Sofia Kovalevskaya (French), by Michèle Audin. Calvage et Mounet, October 2008. ISBN-13: 978-29163-520-53.

Strange Attractors: Poems of Love and Mathematics, edited by Sarah Glaz and JoAnne Growney. A K Peters, November 2008. ISBN-13: 978-15688-134-17.

Super Crunchers: Why Thinking-by-Numbers Is the New Way to Be Smart, by Ian Ayres. Bantam, August 2007. ISBN-13: 978-0-5538-0540-6.

The Symmetries of Things, by John H. Conway, Heidi Burgiel, and Chaim Goodman-Strauss. A K Peters, May 2008. ISBN-13: 978-1-5688-1220-5.

Symmetry: A Journey into the Patterns of Nature, by Marcus du Sautoy. Harper, March 2008. ISBN-13: 978-0-0607-8940-4.

Symmetry: The Ordering Principle (Wooden Books), by David Wade. Walker and Company, October 2006. ISBN-13: 978-08027-153-88.

Tools of American Math Teaching, 1800–2000, by Peggy Aldrich Kidwell, Amy Ackerberg-Hastings, and David Lindsay Roberts. Johns Hopkins University Press, July 2008. ISBN-13: 978-0801888144.

The Unfinished Game: Pascal, Fermat, and the Seventeenth-Century Letter That Made the World Modern, by Keith Devlin. Basic Books, September 2008. ISBN-13: 978-0-4650-0910-7.

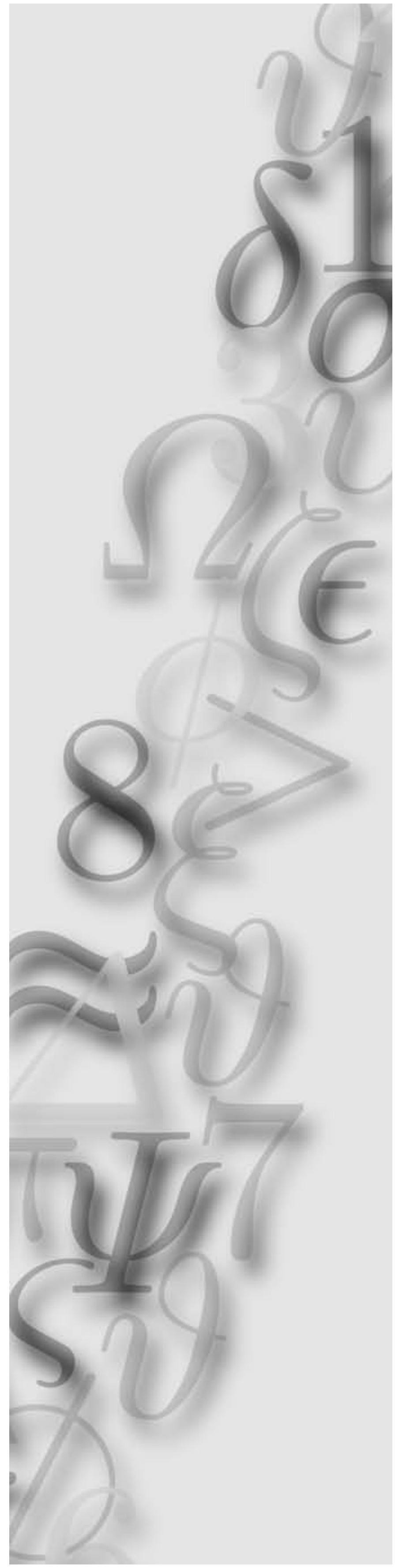
The Unimaginable Mathematics of Borges' Library of Babel, by William Goldbloom Bloch. Oxford University Press, August 2008. ISBN-13: 978-01953-345-79.

Unknown Quantity: A Real and Imaginary History of Algebra, by John Derbyshire. Joseph Henry Press, May 2006. ISBN 0-309-09657-X. (Reviewed May 2008.)

Useless Arithmetic: Why Environmental Scientists Can't Predict the Future, by Orrin Pilkey and Linda Pilkey-Jarvis. Columbia University Press, February 2007. ISBN 0-231-13212-3. (Reviewed April 2008.)

The Wraparound Universe, by Jean-Pierre Luminet. A K Peters, March 2008. ISBN 978-15688-130-97. (Reviewed December 2008.)

Zeno's Paradox: Unraveling the Ancient Mystery behind the Science of Space and Time, by Joseph Mazur. Plume, March 2008 (reprint edition). ISBN-13: 978-0-4522-8917-8.



AMERICAN MATHEMATICAL SOCIETY

AMS Award for Mathematics Programs *That Make a Difference*

Deadline: August 15, 2009

This award was established in 2005 in response to a recommendation from the AMS's Committee on the Profession that the AMS compile and publish a series of profiles of programs that:

1. aim to bring more persons from underrepresented minority backgrounds into some portion of the pipeline beginning at the undergraduate level and leading to advanced degrees in mathematics and professional success, or retain them once in the pipeline;
2. have achieved documentable success in doing so; and
3. are replicable models.

Two programs are highlighted annually.

Nomination process: Letters of nomination may be submitted by one or more individuals. Nomination of the writer's own institution is permitted. The letter should describe the specific program(s) for which the department is being nominated as well as the achievements that make the program(s) an outstanding success, and may include any ancillary documents which support the success of the program. The letter of nomination should not exceed two pages, with supporting documentation not to exceed three more pages. Up to three supporting letters may be included in addition to these five pages.

Send nominations to:
Programs That Make a Difference
c/o Ellen Maycock
American Mathematical Society
201 Charles Street
Providence, RI 02904
or via email to eim@ams.org

Previous Winners:
2008: Summer Undergraduate Mathematical Science Research Institute (SUMSRI), Miami University (Ohio); Mathematics Summer Program in Research and Learning (Math SPIRAL), University of Maryland, College Park.

2007: Enhancing Diversity in Graduate Education (EDGE), Bryn Mawr College and Spelman College; and Mathematical Theoretical Biology Institute (MTBI), Arizona State University.

2006: Summer Institute in Mathematics for Undergraduates (SIMU), Universidad de Puerto Rico, Humacao; and Graduate Program, Department of Mathematics, University of Iowa.

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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/.`

March 2009

* 2–6 **IMA Workshop: Coherence, control, and dissipation**, Institute for Mathematics and its Applications (IMA), University of Minnesota Minneapolis, Minnesota.
Description: This workshop will focus on the interplay between mathematical and physical aspects on the three complementary subjects of quantum coherence, control, and dissipative dynamics, with a special emphasis on the dynamics of time-dependent systems driven by external electromagnetic fields and interacting with a medium. These fields have benefited from many ideas and techniques coming from the mathematical and engineering worlds, and have many applications to chemistry and physics.
Information: `http://www.ima.umn.edu/2008-2009/W3.2-6.09/.`

2–6 **SIAM Conference on Computational Science and Engineering (CSE09)**, Miami Hilton Downtown, Miami, Florida. (Feb. 2009, p. 307)

6–8 **2nd Bluegrass Algebra Conference**, University of Kentucky, Lexington, Kentucky. (Feb. 2009, p. 307)

7–11 **The Spring Topology and Dynamics Conference and the Ulam Centennial Conference**, University of Florida, Gainesville, Florida. (Feb. 2009, p. 308)

9–June 12 **Quantum and Kinetic Transport: Analysis, Computations, and New Applications**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Apr. 2008, p. 526)

10–13 **IPAM/Quantum and Kinetic Transport Equations: Tutorials**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2008, p. 1447)

14 **Statistical Methods for Complex Data: A conference in honor of the 60th birthday of Raymond J. Carroll**, Texas A& M University, Department of Statistics, College Station, Texas. (Sept. 2008, p. 1030)

15–17 **Frontier Probability Days 2009**, University of Utah, Salt Lake City, Utah. (Dec. 2008, p. 1447)

15–20 **ALGORITMY 2009 Conference on Scientific Computing**, Hotel Permon, Podbanske, High Tatra Mountains, Slovak Republic. (Jun./Jul. 2008, p. 741)

15–21 **Spring School on Index Theory, Lie Groupoids and Boundary Value Problems**, University of Regensburg, Germany. (Feb. 2009, p. 308)

* 16–20 **Entropy and the Quantum**, University of Arizona, Tucson, Arizona.
Description: This school aims at introducing junior mathematicians to analytic inequalities and several of their applications. It will consist of four main lectures: "Quantum Physics from Zero" by Jan Wehr (University of Arizona); "Trace Inequalities and Quantum Entropy" by Eric Carlen (Rutgers University); "Quantum Entropy in Condensed Matter and Information Theory" by Bruno Nachtergaele (University of California, Davis); "Inequalities for Schroedinger Operators and Applications" by Robert Seiringer (Princeton University). In addition, many participants will contribute research talks.
Information: `http://www.ueltschi.org/AZschool/.`

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/.`

18–20 **IAENG International Conference on Scientific Computing ICSC 2009**, Regal Kowloon Hotel, Kowloon, Hong Kong. (Aug. 2008, p. 871)

20–22 **Southern Regional Algebra Conference 2009**, University of South Alabama, Mobile, Alabama. (Feb. 2009, p. 308)

20–23 **Cincinnati Symposium on Probability Theory and Applications 2009**, University of Cincinnati, Cincinnati, Ohio. (Feb. 2009, p. 308)

22–26 **SETIT 2009: The Fifth International Conference Sciences of Electronic, Technologies of Information and Telecommunications**, Hammamet, Tunisia. (Nov. 2008, p. 1319)

22–28 **Talbot Workshop 2009: Fukaya Categories**, Nags Head, North Carolina. (Jan. 2009, p. 70)

* 23–26 **IMA Hot Topics Workshop: Higher Order Geometric Evolution Equations: Theory and Applications from Microfluidics to Image Understanding**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.
Description: This workshop will bring together analysts, numerical analysts, and domain scientists in the challenging area of research.
Information: `http://www.ima.umn.edu/2008-2009/SW3.23-26.09/`.

23–27 **Combinatorial, Enumerative and Toric Geometry**, Mathematical Sciences Research Institute, Berkeley, California. (Aug. 2008, p. 871)

* 24–26 **Workshop on CR and Sasakian Geometry**, University of Luxembourg, Luxembourg.
Description: Recent developments in the theory of Cauchy-Riemann and Sasakian manifolds, and related topics.
Information: `http://math.uni.lu/CRSasaki`.

25–26 **Illinois Number Theory Celebration**, University of Illinois at Urbana-Champaign, Urbana, Illinois. (Jan. 2009, p. 70)

27 **Illinois/Missouri Applied Harmonic Analysis Seminar**, University of Illinois, Urbana, Illinois. (Feb. 2009, p. 308)

27–28 **35th Annual New York State Regional Graduate Mathematics Conference**, Syracuse University, Syracuse, New York. (Dec. 2008, p. 1447)

27–29 **AMS Central Section Meeting**, University of Illinois at Urbana-Champaign, Urbana, Illinois. (Aug. 2008, p. 871)

27–29 **GSCC09: Fifth Annual Graduate Student Combinatorics Conference**, University of Kentucky, Lexington, Kentucky. (Oct. 2008, p. 1134)

* 27–30 **The Fifth International Conference on Number Theory and Smarandache Notions**, Shangluo College, Shangluo, Shaanxi, People's Republic of China.
Description: This conference is organized by the Mathematics Institute of Northwest University and Shangluo College. Papers on number theory and Smarandache notions should be sent to the organizer by March 15, 2009.

30–April 3 **Quantum and Kinetic Transport: Computational Kinetic Transport and Hybrid Methods**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2008, p. 1447)

April 2009

* 1–3 **100 Years of Queueing — The Erlang Centennial**, Technical University of Denmark, Copenhagen.
Description: In 1909 A.K. Erlang published the paper "The theory of probabilities and telephone conversations" (Nyt Tidsskrift for Matematik B, Vol. 20. pp. 33-39), which may be considered to be the first publication in queueing theory. To celebrate the centennial of queueing theory, a conference "100 years of queueing — The Erlang Centennial" will be organized in Copenhagen, on April 1-3, 2009. The number of participants is restricted. The journal *Queueing Systems* will devote a special issue to the papers that will be presented. The editors of the special issue are Søren Asmussen and Onno Boxma. There will be invited talks by Francois Baccelli, Sem Borst, Serguei Foss, Peter Glynn, Frank Kelly, John Kingman, Sean Meyn, Peter Taylor, Ward Whitt.
Information: `http://www.erlang100.dk`.

* 1–4 **Harmonic Analysis & Partial Differential Equations**, Marrakech, Morocco.
Mini-Courses: M. Englis (Czech Republic), V. V. Kisil (England), T. Koorwinder (Netherland), T. Nomura (Japan).
Conferences: A. Boussejra (Morocco), S. Echterhoff (Germany), Y. Hantout (France), A. Intissar (France), M. Kolountzakis (Greece), K. Koufany (France), E. Ouhabaz (France), M. Sifi (Tunisia), K. Stempak (Poland), A. Zinoun (France).
Information: email: `ahgsmaroc@gmail.com`; `http://groups.google.com/group/ahgsMorocco`.

* 2–4 **Career Options for Women in Mathematical Sciences**, University of Minnesota Institute for Mathematics and its Applications, Twin Cities Campus, Minneapolis, Minnesota.
Description: This workshop aims to familiarize women in the mathematical sciences with professional opportunities in industry and government labs and to help them thrive in these fields. The audience is graduate students and Ph.D.'s in the early stages of their post-graduate careers. Researchers at any stage of their careers will also find it valuable. Speakers, panelists, and discussion leaders are women in research and management positions in industry and government labs as well as women in academia who have strong ties with industry. Participants are encouraged to present a poster on their research. Sponsored by the Institute of Mathematics and its Applications (IMA) at the University of Minnesota and the Association for Women in Mathematics (AWM).
Information: For more information and a tentative schedule, visit: `http://www.ima.umn.edu/2008-2009/SW4.2-4.09` or contact Cheri Shakiban at `Shakiban@ima.umn.edu`. The IMA's mission is to foster interdisciplinary research to address important problems arising in science, technology, and society.

2–4 **International Conference on Multimedia Computing and Systems (ICMCS'09)**, Polydisciplinary Faculty of Ouarzazate, Morocco. (Jan. 2009, p. 71)

4–5 **AMS Southeastern Section Meeting**, North Carolina State University, Raleigh, North Carolina. (Aug. 2008, p. 871)

6–9 **BMC 2009/IMS. This is a joint meeting of the 61st British Mathematical Colloquium and the 22nd annual meeting of the Irish Mathematical Society**, National University of Ireland, Galway, Ireland. (Jan. 2009, p. 71)

6–10 **The 3D Euler and 2D surface quasi-geostrophic equations**, American Institute of Mathematics, Palo Alto, California. (May 2008, p. 636)

* 14–17 **3rd International Workshop on Elementary Operators and their Applications (ElOp2009)**, Queen's University Belfast, Belfast, Northern Ireland.
Description: The third international workshop on elementary operators and applications will be held in the Pure Mathematics Research Centre of Queen's University, Belfast, between April 14–17, 2009, as a satellite to the BMC2009, which is held jointly with the annual meeting of the Irish Mathematical Society at NUI Galway in the week before Easter. The workshop is organised by Dr. Martin Mathieu and supported by the London Mathematical Society and the Irish Mathematical Society.
Information: All information, including the list of invited speakers, can be found on the conference website: `http://elop2009.awardspace.co.uk/`; email: `elop2009@qub.ac.uk`.

15–17 **Quantum and Kinetic Transport: The Boltzmann Equation — DiPerna-Lions Plus 20 Years**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2008, p. 1447)

* 16 **NSV-II: Second International Workshop on Numerical Software Verification. Verification of Cyber-Physical Software Systems**, Parc Hotel 55, San Francisco, California.
Description: The focus of the workshop for 2009 will be on the verification of software for Cyber-Physical Systems (CPS). CPS refers to the class of systems that integrate physical systems with computational and communication systems. Examples of CPS range from small scale systems, such as implanted medical devices or autonomous robots, to medium scale, such as automobiles and aircrafts, to large scale

systems, for example, a power grid. A key component of every CPS is the underlying software that controls a system or a system of systems. Numerical and logical errors in the software can have catastrophic results on the physical system. Many well-known CPSs failures have been attributed to the existence of numerical errors and bugs in the software. NSV-II aims to initiate and catalyze work along such research directions by bringing together people from the hybrid systems, control and software verification communities. A secondary goal will be to create a benchmark problems library.
Information: `http://theory.stanford.edu/~srirams/nsv2/`.

16–18 **New Results on the Discrepancy Function, and Related Results, University of Arkansas Spring Lecture Series**, University of Arkansas, Fayetteville, Arkansas. (Dec. 2008, p. 1448)

17–18 **2009 Barrett Lectures**, University of Tennessee, Knoxville, Tennessee. (Feb. 2009, p. 308)

19–25 **Spring School on Variational Analysis and its Applications**, Paseky nad Jizerou, Czech Republic. (Feb. 2009, p. 308)

19–May 2 **Spring School on Fluid Mechanics and Geophysics of Environmental Hazards**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Jan. 2009, p. 71)

20–22 **Geometry and Physics: Atiyah80**, Edinburgh, Scotland, United Kingdom. (Dec. 2008, p. 1448)

23–25 **Twelfth New Mexico Analysis Seminar**, University of New Mexico, Albuquerque, New Mexico. (Feb. 2009, p. 308)

25–26 **AMS Eastern Section Meeting**, Worcester Polytechnic Institute, Worcester, Massachusetts. (Aug. 2008, p. 871)

25–26 **AMS Western Section Meeting**, San Francisco State University, San Francisco, California. (Aug. 2008, p. 872)

27–May 1 **Combinatorial Challenges in Toric Varieties**, American Institute of Mathematics, Palo Alto, California. (Jun./Jul. 2008, p. 741)

27–May 1 **Quantum and Kinetic Transport: Flows and Networks in Complex Media**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2008, p. 1448)

28–30 **CMIS2009 5th Contact Mechanics International Symposium**, Technical University of Crete, Chania, Crete, Greece. (Jan. 2009, p. 71)

30–May 2 **SIAM International Conference on Data Mining**, John Ascuaga's Nugget, Sparks, Nevada. (Dec. 2008, p. 1448)

May 2009

* 1–3 **3rd Annual Graduate Student Probability Conference**, UNC-Chapel Hill, Chapel Hill, North Carolina.
Description: This conference is co-hosted by the Statistics and Operations Research Department at UNC-Chapel Hill and the Mathematics Department at Duke University. It provides graduate students and post-docs from across the country with the opportunity to speak on an area of interest within probability. Participants will have the opportunity to deliver and attend talks on a variety of topics within probability. With an audience composed primarily of students, the friendly and informal atmosphere fosters constructive discussions and promotes innovative research. In addition to the student talks, there will be keynote speaker addresses delivered by Professors David Aldous (UC-Berkeley), Russell Lyons (Indiana University) and Daniel Stroock (MIT).
Information: `http://www.unc.edu/~crbaek/gscp`.

1–June 20 **INdAM Intensive Period "Geometric Properties of Nonlinear Local and Nonlocal Problems"**, Department of Mathematics "F. Brioschi", Politecnico di Milano, Milan, Italy; Department of Mathematics "F. Casorati", University of Pavia, Pavia, Italy. (Dec. 2008, p. 1448)

* 2–July 30 **Geometric Flows and Geometric Operators**, Center "Ennio De Giorgi", Pisa, Italy.
Description: Intensive research period at the Ennio De Giorgi Center in Pisa about "Geometric Flows and Geometric Operators" in May/June/July 2009. The main program will consist of a series of lectures delivered by Mauro Carfora, Klaus Ecker, Matthew Gursky, Andrea Malchiodi, Jeff Viaclovsky and a couple of meetings: "Geometric Flows in Mathematical and Theoretical Physics" 22/25 of June 2009 and "GFO in Pisa" –June 29/July 3, 2009. Moreover, we plan to organize during all the trimester daily seminars given by the participants. For more detailed info and abstracts, the website of the trimester is: `http://cvgmt.sns.it/GFO`. If you are interested in participating, please register there. Financial support is available for young students. Interested people must fill the form at the link above BEFORE February 15, 2009. There is a mailing list for participants or interested people to get up-to-date info on the trimester. To be put on or removed from the list, see: `http://cvgmt.sns.it/gfopisa`.
Information: `http://cvgmt.sns.it/GFO`

* 4–8 **Combinatorics, Randomization, Algorithms and Probability**, Centre de recherches mathématiques, Montréal, Québec.
Description: The ties between combinatorics and probability run so deep that for many deep and interesting problems, it is nonsensical to try to assign one category or the other. The subject of this workshop is these sorts of problems, many of which in fact come from the theoretical computer science and statistical physics communities. Most of the speakers straddle two or several of these areas in their research. We expect the workshop to both expose participants to cutting edge research in combinatorics and probability, and, importantly, to lead to fruitful discussions and the opening of new avenues of research.
Information: `http://www.crm.umontreal.ca/CARP09/index.php`.

* 4–8 **IMA Special Workshop: MOLCAS**, Institute for Mathematics and its Applications (IMA), University of Minnesota, Minneapolis, Minnesota.
Description: This 5-day workshop is an hands-on training on MOLCAS, a quantum chemistry software package. MOLCAS is a research tool for scientists, and was developed by the Lund quantum chemistry group. The basic philosophy behind MOLCAS is to develop methods that will allow an accurate ab initio treatment of very general electronic structure in small molecules in both ground and excited states, to more versatile procedures applied to systems of large size. The workshop is aimed at users and potential users of the MOLCAS suite. The workshop will consist of 8 hours of lectures and 17 hours of practical sessions. Participants are encouraged to bring their own problems to solve. Researchers interested in using MOLCAS as a platform to implement their own software are also welcome.
Information: `http://www.ima.umn.edu/2008-2009/SW5.4-8.09/`.

4–8 **Stochastic and Deterministic Spatial Modeling in Population Dynamics**, American Institute of Mathematics, Palo Alto, California. (Oct. 2008, p. 1134)

7–9 **8th Mississippi State: UAB Conference on Differential Equations and Computational Simulations**, Mississippi State University, Mississippi State, Mississippi. (Nov. 2008, p. 1319)

* 8–9 **Irish Geometry Conference**, University College Cork, Cork, Ireland.
Description: The annual meeting of Irish algebraic and differential geometers and geometric topologists and allied researchers.
Information: `http://euclid.ucc.ie/pages/staff/Mckay/conferences/irish-geometry-2009/`.

* 8–10 **Workshop on "Connections in Geometry and Physics 2009"**, Perimeter Institute for Theoretical Physics, Waterloo, Ontario, Canada.
Description: The workshop aims to gather together researchers, from Canada and around the world, who work at the interface between geometry and physics. A secondary objective is to further increase Canada's presence and visibility in geometry within the wider international mathematical community, and to serve as an opportunity for geometers in the region with common interests to meet. This in particular influences the choice to focus the workshop on three main research areas: elliptic and parabolic equations in geometry, geometry and topology of moduli spaces, and structures in symplectic geometry.
Information: `http://www.math.uwaterloo.ca/~gap/`

10–15 **ICMI Study 19: Proof and Proving in Mathematics Education**, Taipei, Taiwan. (May 2008, p. 636)

* 11–13 **2009 IEEE International Conference on Technologies for Homeland Security**, The Westin Waltham Boston, 70 Third Avenue, Waltham, Massachusetts.
Description: With technical assistance from the U.S. DHS S&T Directorate, U.S. DHS DNDO, and the U.S. DOE NNSA; the ninth annual IEEE Conference on Technologies for Homeland Security HST'09, will focus on novel and innovative technologies, which address the most pressing national security problems. The conference will bring together innovators from leading universities, research laboratories, Homeland Security Centers of Excellence, small businesses, system integrators, and the end user community and provide a forum to discuss ideas, concepts, and experimental results.
Information: `http://www.ieeehomelandsecurityconference.org/`.

11–13 **TQC 2009: The 4th Workshop on Theory of Quantum Computation, Communication, and Cryptography**, University of Waterloo, Waterloo, Ontario, Canada. (Dec. 2008, p. 1448)

11–15 **Workshop and Advanced Course on Deterministic and Stochastic Modelling in Computational Neuroscience and other Biological Topics**, Barcelona, Spain. (Nov. 2008, p. 1319)

12–14 **7th International Symposium on Hysteresis Modeling and Micromagnetics (HMM-2009)**, Gaithersburg, Maryland. (Nov. 2008, p. 1319)

12–16 (NEW DATE) **First Buea International Conference on the Mathematical Sciences**, University of Buea, Cameroon. (Mar. 2008, p. 408)

* 13–15 **The 2nd International Conference on Nonlinear Analysis and Optimization**, University of Isfahan, Isfahan, Iran.
Description: The main aim of this conference is to gather researchers on nonlinear analysis and optimization, stimulate scientific information on nonlinear analysis and optimization, and to discuss recent advances in theoretical and applicable aspects of these areas. The conference also seeks to strengthen ties with the international community and enable participants to benefit from an exchange of results and experience with their colleagues from other countries.
Scientific and Organizing Committee: M. Chinaie, M. Fakhar, N. Hadjisavvas, H. Harsij, J. E. Martinez-Legaz, S. Nobakhtian, M. Pouryayevali, A. Rejali , M. Rezaei, J. Zafarani.
Tentative list of Main Speakers: F. Flores-Bazan, N. Hadjisavvas, L. J. Lin, N. Mahdavi-Amiri, J. E. Martinez-Legaz, P. Pardalos, M. Thera, X. Q. Yang, J. C. Yao.
Information: `http://www.sci.ui.ac.ir/~naop2009`; email: `nhad@aegean.gr`.

17–21 **SIAM Conference on Applications of Dynamical Systems (DS09)**, Snowbird Ski and Summer Resort, Snowbird, Utah. (Oct. 2008, p. 1134)

17–22 **Topology, C*-Algebras, and String Duality - an NSF/CBMS Regional Conference in the Mathematical Sciences**, Texas Christian University, Fort Worth, Texas. (Jun./Jul. 2008, p. 742)

* 18–21 **Mathematical Modeling in the Medical Sciences, in conjunction with the 24th Annual Shanks Lecture**, Department of Mathematics, Vanderbilt University, Nashville, Tennessee.
Description: Biomathematics encompasses the application of mathematical methods to the study of living organisms. Mathematics plays an essential role in understanding of biological systems on many different scales both size and time. For example, we can model biological processes at various scales: (1) molecular, sub-cellular, cellular, tissue, organism and population; and (2) milliseconds, seconds, minutes, hours, days and years. Mathematics has a rich history as a tool for biologists. More recently, mathematics has found applications in the medical sciences, both in the basic sciences of medicine and in patient care. The 24th Shanks Conference is a forum for all areas of biomathematics, but speakers have been invited from the special interest areas: Models of cancer growth; models of epidemics and infection; models of physiologic systems and clinical practice; and medical imaging. The featured Shanks Lecturer is Nicola Bellomo of Politecnico Torino.
Information: `http://www.math.vanderbilt.edu/~shanks2009`.

18–22 **Quantum and Kinetic Transport: Asymptotic Methods for Dissipative Particle Systems**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2008, p. 1448)

18–22 **SAMPTA'09 (Sampling Theory and Applications)**, Centre International de Rencontres Mathématiques (CIRM), Luminy campus, Marseille, France. (Dec. 2008, p. 1448)

* 18–22 **Workshop on Topological Field Theories**, Northwestern University, Evanston, Illinois.
Description: This workshop is intended primarily for graduate students and others preceding a conference on Topological Field Theory and related geometry, topology, and category theory to be held at Northwestern University during the week of Memorial Day (May 25-29, 2009). The workshop will be run by David Ben-Zvi, Jacob Lurie, and Bertrand Toen. The organizers are Kevin Costello, Ezra Getzler, and Paul Goerss. Both the conference and the workshop will be supported by the National Science Foundation and Northwestern University. If you are interested in support, please notify the organizers by February 20, 2009.
Information: `http://www.math.northwestern.edu/~pgoerss/tftemphasis/`.

18–23 **Workshop on Interacting Stochastic Particle Systems**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 78)

25–29 **6th European Conference on Elliptic and Parabolic Problems**, Hotel Serapo, Gaeta, Italy. (Oct. 2008, p. 1134)

25–29 **14th International Conference on Gambling & Risk Taking**, Harrah's Lake Tahoe, Stateline, Nevada. (Oct. 2008, p. 1134)

* **Conference on Topological Field Theory**, Northwestern University, Evanston, Illinois.
Description: This is a conference on Topological Field Theory and related geometry, topology, and category theory. There will be a workshop intended primarily for graduate students and others new to the field during the preceding week. The speaker list is on the conference web site and will be updated there. The organizers are Kevin Costello, Ezra Getzler, and Paul Goerss. Both the conference and the workshop will be supported by the National Science Foundation and Northwestern University. If you'd like support, please contact the organizers by February 20, 2009. Priority will go to those who respond early.
Information: `http://www.math.northwestern.edu/~pgoerss/tftemphasis/`; email: `tftconference@math.northwestern.edu`.

25–29 **Indam School on symmetry for elliptic PDEs (30 years after a conjecture of De Giorgi and related problems)**, Istituto Nazionale di Alta Matematica, Universita' di Roma La Sapienza, Rome, Italy. (Feb. 2009, p. 309)

* 26–29 **Fourth Symposium on Analysis and PDEs**, Purdue University, West Lafayette, Indiana.
Description: The symposium will be held on the occasion of the 55th birthday of Nicola Garofalo in recognition of his scientific achievements and his dedication to the mathematical community. It will bring together some of the world's most prominent specialists in the general areas of Partial Differential Equations, Harmonic Analysis, and Geometric PDEs. One of the purposes of the symposium is to introduce prospective and young researchers to a larger mathematical community and help them to establish professional connections with key figures in their areas of interest. Furthermore, the symposium will provide an opportunity to summarize some of the most recent progress in the field, exchange ideas towards the solution of open questions, and formulate new problems and avenues of research.
Information: `http://www.math.purdue.edu/~danielli/symposium09/Home.html`.

27–30 **17th biennial conference of the Association of Christians in the Mathematical Sciences**, Wheaton College, Wheaton, Illinois. (Jan. 2009, p. 71)

* 27–30 **Dynamical trends in Analysis**, Royal Institute of Technology, Stockholm, Sweden.

Description: This conference will focus on dynamical methods and ideas in analysis. Several world-leading experts will represent various aspects of the interaction between these subjects.
Information: `http://www.math.kth.se/dynamictrends/`.

27–June 1 **The International Conference "Infinite Dimensional Analysis and Topology"**, Yaremche, Ivano-Frankivsk, Ukraine. (May 2008, p. 636)

31–June 6 **Spring School on Analysis: Function Spaces, Inequalities and Interpolation**, Paseky nad Jizerou, Czech Republic. (Feb. 2009, p. 309)

June 2009

1–3 **Second Global Conference on Power Control and Optimization (PCO-2009)**, Bali, Indonesia. (Jan. 2009, p. 71)

1–5 **2nd Chaotic Modeling and Simulation International Conference (CHAOS2009)**, MAICh Conference Center, Chania, Crete, Greece. (Dec. 2008, p. 1449)

1–5 **Fifth Summer School in Analysis and Applied Mathematics**, Department of Mathematics, Sapienza, Universita' di Roma, Rome, Italy. (Feb. 2009, p. 309)

1–5 **Geometry & Topology at Muenster 2009**, University of Muenster, Muenster, Germany. (Jan. 2009, p. 71)

1–28 **Statistical Genomics**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Jan. 2009, p. 71)

3–5 **Conference on Character Theory of Finite Groups in honor of Martin Isaacs**, Universitat de Valencia, Spain. (Sept. 2008, p. 1031)

3–15 **Interactions Between Hyperbolic Geometry, Quantum Topology and Number Theory Workshop**, Columbia University, New York, New York. (Oct. 2008, p. 1134)

8–11 **25th Nordic and 1st British-Nordic Congress of Mathematicians**, University of Oslo, Oslo, Norway. (Jan. 2009, p. 71)

8–11 **MAMERN09: 3rd International Conference on Approximation Methods and Numerical Modeling in Environment and Natural Resources**, University of Pau, Pau, France. (Dec. 2008, p. 1449)

8–11 **The 2nd International Conference on Mathematical Modelling and Computation and The 5th East Asia SIAM Conference**, Universiti Brunei Darussalam, Bandar Seri Begawan, Brunei. (Feb. 2009, p. 309)

8–12 **Computational Methods and Function Theory 2009**, Bilkent University, Ankara, Turkey. (Jun./Jul. 2008, p. 742)

* 8–12 **Geometrie Algebrique en Liberte**, Lorents Center, Leiden, Netherlands.
Description: GAeL, Geometrie Algebrique en Liberte, is a conference organized by and for researchers in algebraic geometry at the beginning of their scientific career. The conference gives Ph.D. students and post-docs the opportunity to lecture, often for the first time, in front of an international audience. In addition, selected international experts deliver mini-courses on topics at the cutting-edge of important new developments in algebraic geometry.
Information: `http://www.lorentzcenter.nl/lc/web/2009/326/description.php3?wsid=326`.

8–13 **Workshop on Disordered Systems: Spin Glasses**, Centre de recherches mathématiques, Université de Montréal, Montréal, Québec, Canada. (Jan. 2008, p. 78)

8–19 **Geometry and Arithmetic around Galois Theory**, Galatasaray University, Istanbul, Turkey. (Dec. 2008, p. 1449)

8–19 **Recent Developments in Dynamic Equations on Time Scales**, University of Wyoming, Laramie, Wyoming. (Jan. 2009, p. 71)

* 9–13 **International Conference on Nielsen Theory and Related Topics**, St. John's, Newfoundland, Canada.
Description: Nielsen theory is the part of topological fixed point theory that employs techniques of algebraic topology to determine lower bounds on the number of fixed points of all maps in a homotopy class. Related topics include coincidence and periodic point theories. Nielsen theory has close interactions with nonlinear analysis, dynamics and geometric group theory. This conference continues a series extending back 30 years in which researchers bring each other up to date on recent developments and establish working relationships for future research projects. This conference immediately follows the meeting of the Canadian Mathematical Society that will be held in St. John's.
Organizing Committee: Philip Heath (chair), Robert F. Brown, Evelyn Hart, Edward Keppelmann.
Information: email: `keppelma@unr.edu`.

11–13 **Representation Theory**, Institut de Recherche Mathématique Avancée, Université de Strasbourg, 7 rue René Descacrtes, Strasbourg, France. (Dec. 2008, p. 1449)

* 13–17 **Symposium on Biomathematics and Ecology Research and Education**, Izmir University of Economics, Izmir, Turkey.
Description: BERE-2009 aims to bring together mathematicians, statisticians and bio-scientists who apply mathematical modeling techniques in solving their biological or life-sciences problems. With this symposium we also aim to support the initiation of connections between university researchers and bio-sciences related institutes. In addition to plenary speakers, contributions from participants in parallel sessions will constitute the main part of the conference.
Information: `http://www.biomath.ilstu.edu/bere` or `http://dm.ieu.edu.tr/konferans/bere/`; email: `oakman@ilstu.edu` or `unal.ufuktepe@ieu.edu.tr`.

14–20 **47th International Symposium on Functional Equations**, Gargnano, Italy. (Dec. 2008, p. 1449)

14–27 **ESI workshop on large cardinals and descriptive set theory**, Esi, Vienna, Austria. (Oct. 2008, p. 1134)

15–18 **The 5th International Conference "Dynamical Systems and Applications"**, "Ovidius" University of Constantza, Constantza, Romania. (Nov. 2008, p. 1319)

15–18 **SIAM Conference on Mathematical & Computational Issues in the Geosciences**, Leipziger Kubus Conference Center, Helmholtz - Centre for Environmental Research - UFZ, Leipzig, Germany. (Dec. 2008, p. 1449)

15–19 **Conference on Harmonic Analysis, Geometric Measure Theory and Quasiconformal Mappings**, Barcelona, Spain. (Nov. 2008, p. 1319)

* 15–19 **The analytic theory of automorphic forms (at the 65th birthday of Roelof Bruggeman)**, Woudschoten, The Netherlands.
Preliminary list of speakers: E. M. Baruch, K. Bringmann, R. Bruggeman, G. Chinta, N. Diamantis, O. Imamoglu*, H. Iwaniec*, M. Kaneko, E. Kowalski, W. Li, A. Mellit, R. Miatello, Y. Motohashi*, A. Reznikov, M. Risager, P. Sarnak*, A. Venkatesh*, N. Wallach* , D. Zagier, S. Zwegers (*=to be announced).
Organizers: Frits Beukers, Gunther Cornelissen (Utrecht University, The Netherlands).
Location: Woudschoten is a beautiful estate in the forests near Utrecht in The Netherlands.
Information: `http://www.math.uu.nl/rb65.html`.

15–19 **Waves 2009: The 9th International Conference on Mathematical and Numerical Aspects of Waves Propagation**, Pau, France. (Jun./Jul. 2008, p. 742)

15–July 3 **Summer School and Conference in Geometric Representation Theory and Extended Affine Lie Algebras**, University of Ottawa, Ottawa, Ontario, Canada. (Feb. 2009, p. 309)

16–22 **Sixth International Workshop on Optimal Codes and Related Topics: OC 2009**, Varna, Bulgaria. (Feb. 2009, p. 309)

18–19 **2nd IMA International Conference on Mathematics in Sport**, University of Groningen, The Netherlands. (Oct. 2008, p. 1134)

* 19–22 **International Conference on Asymptotic Analysis and Infinite-dimensional Dynamical Systems**, City University of Hong Kong, Hong Kong, China.
Description: In recent years, there have been great advances and developments in asymptotics including the study of exponential asymptotics and the Riemann-Hilbert approach, and of localized reaction diffusion equation with metastable behavior. Meanwhile, there has also existed significant progress in the theory of infinite-dimensional dynamical systems with many new results being obtained and various new applications being found. Such a fast advancing feature requires

mathematicians in the related areas to update and refresh their knowledge and to keep good pace with the development. The purpose of this conference is to bring together top researchers in these two areas to expose their recent new results, to exchange their new ideas, to explore new methods and new applications, to discuss future directions of research, and to initiate possible research collaborations.
Information: http://www6.cityu.edu.hk/rcms/ICAAIDS2009/.

21–27 **Eighth International Conference Symmetry in Nonlinear Mathematical Physics**, Institute of Mathematics, National Academy of Sciences of Ukraine, Kyiv (Kiev), Ukraine. (Nov. 2008, p. 1319)

21–27 **2nd Mile High Conference on Nonassociative Mathematics**, University of Denver, Denver, Colorado. (Jan. 2009, p. 72)

22–26 (NEW DATE) **5th Asian Mathematical Conference (AMC 2009)**, Penang /Kulalumpur, Malaysia. (Jun./Jul. 2008, p. 742)

22–26 **The 10th European Congress of Stereology and Image Analysis**, University of Milan, 20133 Milan, Italy. (Oct. 2008, p. 1135)

22–27 **3rd Nordic EWM Summer School for Ph.D. Students in Mathematics**, University of Turku, Turku, Finland. (Feb. 2009, p. 309)

22–27 **First Conference "Application of Mathematics in Technical and Natural Sciences" (AMiTaNS'09)**, Resort of Sozopol, Bulgaria. (Feb. 2009, p. 309)

22–July 3 **Automorphic forms and L-functions, computational aspects**, CRM, Montreal, Canada. (Feb. 2009, p. 309)

* 22–July 4 **Renormalization, graph polynomials, Hopf algebras and relations with motives (summer school). Algebraic geometry and algebra related to renormalization (workshop)**, CIMAT, Guanajuato, Mexico.
Description: The aim of the school is to familiarize participants with Feynman-graphs and renormalization theory; explain those parts of Hopf algebras relevant to physics; explain how periods of integrals can be understood from the perspective of Hodge theory; introduce motives and their connection with graph polynomials. It will be followed by a workshop where the specialists explain the recent state of the art.
Information: http://www-fourier.ujf-grenoble.fr/~peters/CIMAT/CIMAT3.html.

* 23–26 **The 9th Central European Conference on Cryptography (CECC09)**, Trebic, Czech Republic.
Description: The conference CECC09 is the next in the series of Central European Conferences on Cryptography, a series which has become a traditional meeting of people interested in all areas of cryptography. The CECC series is organized every year since the year 2000 in one of the Central European countries — Austria, Czech Republic, Hungary, Slovak Republic, and Poland. The aim of the conference is to bring together researchers in all aspects of foundations of cryptography, and related areas, theoretical or applied (e.g., encryption schemes, signature schemes, general cryptographic protocols, design of cryptographic systems, key management, computational difficulty, one-way functions, zero-knowledge proofs, pseudorandomness, information assurance, security in information systems, coding theory etc.).
Information: http://conf.fme.vutbr.cz/cecc09/.

23–26 **The 33rd Summer Symposium in Real Analysis**, Southeastern Oklahoma State University, Durant, Oklahoma. (Jan. 2009, p. 72)

25–27 **Current Geometry: The X Edition of the International Conference on Problems and Trends of Contemporary Geometry**, Palazzo Serra di Cassano, Via Monte di Dio, 80132 Naples, Italy. (Feb. 2009, p. 309)

* 28–July 2 **20th International Workshop on Combinatorial Algorithms**, Novy Hradec, Czech Republic.
Topics: Algorithms and Data Structures, Applications, Combinatorial Enumeration, Combinatorial Optimization, Complexity Theory, Computational Biology, Databases, Decompositions and Combinatorial Designs, Discrete and Computational Geometry, Graph Theory and Combinatorics.
Information: http://graphs.vsb.cz/iwoca2009/.

* 28–July 4 **XXVIII Workshop on Geometric Methods in Physics**, Bialowieza, Poland (Organized by the University of Bialystok).
A short description: It is an annual international conference organized by the Department of Mathematical Physics of the University of Bialystok since 1981, and takes place in the heart of the Bialowieza forest, one of the largest remaining parts of the primeval forest in Europe. The program consists of invited plenary lectures, often of a review nature, and more specialized shorter talks.
Plenary speakers: Daniel Beltita (Bucharest) Pierre Bieliavsky (Louvain), Victor Buchstaber (Moscow/Manchester), Alberto Cattaneo (Zurich), Boris Dubrovin (Trieste), Christian Duval (Marseille), Vladimir Fock (Aarhus), Franco Magri (Milano), Giuseppe Marmo (Napoli), Jouko Michelsson (Stockholm), Alexander Odesski (St. Catharines, Ontario), Vasilisa Shramchenko (Sherbrooke), Sergei Tabachnikov (Pennsylvania).
Organizers: A. Odzijewicz, chairman; T. Golinski. secretary; S. T. Ali (Montreal); A. Dobrogowska, P. Kielanowski (Bialystok/Mexico City), M. Schlichenmaier (Luxembourg), A. Tereszkiewicz, Th. Voronov (Manchester).
Information: http://wgmp.uwb.edu.pl/index.html. Contact person: Dr Theodore Voronov, email: theodore.voronov@manchester.ac.uk.

28–July 18 **IAS/Park City Mathematics Institute (PCMI) 2009 Summer Session: Arithmetic of L-functions**, Park City, Utah. (Sept. 2008, p. 1032)

28–July 25 **UA VIGRE: Arizona Summer Program 2009**, University of Arizona, Tucson, Arizona. (Jan. 2009, p. 72)

29–July 1 **1st Rapid Modelling Conference**, Neuchâtel, Switzerland. (Dec. 2008, p. 1450)

July 2009

1–3 **International Conference of Applied and Engineering Mathematics 2009**, Imperial College London, London, United Kingdom. (Oct. 2008, p. 1135)

1–August 31 **Mathematical Theory and Numerical Methods for Computational Materials Simulation and Design**, Institute for Mathematical Sciences, National University of Singapore, Singapore, (Jan. 2009, p. 72)

5–10 **22nd British Combinatorial Conference**, University of St. Andrews, Fife, Scotland. (Dec. 2008, p. 1450)

6–8 **SIAM Conference on Control and Its Applications**, Sheraton Denver Hotel, Denver, Colorado. (Dec. 2008, p. 1450)

6–10 **2009 SIAM Annual Meeting (AN09)**, Sheraton Denver Hotel, Denver, Colorado. (Feb. 2009, p. 309)

6–10 **26th Journées Arithmétiques**, Université de Saint-Etienne, Saint-Etienne, France. (Jun./Jul. 2008, p. 742)

6–10 **First PRIMA Pacific Rim Congress of Mathematicians**, University of New South Wales, Sydney, Australia. (Jun./Jul. 2008, p. 742)

6–10 **Journées de Géométrie Arithmétique de Rennes**, Institut de Recherche Mathématique de Rennes, Université de Rennes 1, Rennes, France. (Sept. 2008, p. 1032)

* 6–10 **Workshop on equivariant Gromov-Witten theory and symplectic vortices**, CIRM, Luminy, France.
Description: The focus of the workshop will be on the development of equivariant Gromov-Witten theory, including the study of moduli spaces of maps to quotient stacks by reductive groups, and from the symplectic point of view, moduli spaces of symplectic vortices. The workshop is organized around this specific direction, with an aim to bring together researchers in algebraic and symplectic geometry who have had no previous interaction. On the other hand, the workshop will promote discussion of the interaction of holomorphic maps, gauge theory, and group actions more broadly.
Information: http://www.math.rutgers.edu/~ctw/Luminy/index.html.

6–11 **Conference on Algebraic Topology CAT'09**, University of Warsaw, Warsaw, Poland. (Jan. 2009, p. 72)

6–11 **International Conference on Semigroups and Related Topics**, Faculty of Sciences of the University of Porto, Porto, Portugal. (Nov. 2008, p. 1319)

* 6–11 **International Conference on Topology and its Applications, ICTA 2009**, Hacettepe University, Ankara, Turkey.
Description: The aim of this conference is to bring together experts and young researchers in the field of topology from Turkey and abroad.
Topics: Asymmetric topology, symmetric topology, point-free, constructive or categorical aspects, topology on lattices and applications.
Information: `http://www.icta.hacettepe.edu.tr`.

* 9–13 **The 3rd International Workshop on Matrix Analysis and Applications**, Hangzhou (Lin'An), China.
Description: To be held at Hangzhou (Lin'An) under the auspices of Zhejiang Forestry University, Zhejiang Province, China. The purpose of this conference is to stimulate research, providing an opportunity for researchers to present their newest results and to meet for informal discussions. The previous meetings of the workshop series have taken place in Beijing (China) and Fort Lauderdale (USA). The `http://www.math.technion.ac.il/iic/ela/index.html` Electronic Journal of Linear Algebra (ELA) will devote a special issue to the conference, and abstracts of the talks will be published by World Academic Press.
Keynote Speaker: Chi-Kwong Li, Ferguson Professor of Mathematics at The College of William and Mary, USA.
Sponsor: This meeting is sponsored by the National Natural Science Foundation of China and Zhejiang Forestry University, and is endorsed by the International Linear Algebra Society (ILAS).
Organizers: Chairs of the organizing committee are Changqing Xu (Zhejiang Forestry University, China, `cqxurichard@163.com`); Guanghui Xu (Zhejiang Forestry University, China) and Fuzhen Zhang (Nova Southeastern University, Ft Lauderdale, USA, `zhang@nova.edu`).
Information: For more information and updates, visit `http://www.nova.edu/~zhang/09MatrixWorkshop.html`.

13–16 **MULTICONF-09**, Orlando, Florida. (Jan. 2009, p. 72)

13–17 **9th International Conference on Finite Fields and Applications**, University College Dublin, Dublin, Ireland. (Jun./Jul. 2008, p. 742)

13–17 **Permutation Patterns 2009**, Dipartmento di Sistemi e Informatica, Università di Firenze, Firenze, Italy. (Jan. 2009, p. 72)

13–18 **7th International ISAAC Congress**, Imperial College, London, United Kingdom. (Jan. 2009, p. 72)

14–24 **The 19th International Conference on Banach algebras**, Bedlewo, Poland. (Oct. 2008, p. 1135)

16–31 **XII Diffiety School — on Geometry of Partial differential Equations and Secondary Calculus**, Santo Stefano del Sole, Avellino, Italy. (Feb. 2009, p. 309)

20–24 **21st International Conference on Formal Power Series & Algebraic Combinatorics**, Research Institute for Symbolic Computation, Hagenberg, Austria. (Dec. 2008, p. 1450)

20–24 **AIP (Applied Inverse Problems)**, Vienna, Austria. (Nov. 2008, p. 1319)

20–24 **Equadiff 12**, Brno, Czech Republic. (Aug. 2008, p. 872)

20–31 **2009 ESSLLI Student Session**, Bordeaux, France. (Jan. 2009, p. 72)

20–December 18 **Non-Abelian Fundamental Groups in Arithmetic Geometry**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2008, p. 872)

27–30 **The Society for Mathematical Biology Annual Meeting**, University of British Columbia, Vancouver, Canada. (Nov. 2008, p. 1319)

27–31 **33rd Conference on Stochastic Processes and their Applications**, Berlin, Germany. (May 2008, p. 636)

29–July 24 **The Cardiac Physiome Project**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2008, p. 872)

31–August 2 **3rd Jairo Charris Seminar—Symmetries of differential and difference equations**, Universidad Sergio Arboleda, Bogotá, Colombia. (Feb. 2009, p. 310)

August 2009

* 3–5 **SNC2009: The 3rd International Workshop on Symbolic-Numeric Computation**, Hotel "CO-OP INN Kyoto", Kyoto, Japan.
Description: The program of SNC 2009 will include invited presentations, contributed research papers, and posters.
Topics: Specific topics include, but are not limited to: Hybrid symbolic-numeric algorithms, approximate polynomial GCD and factorization, symbolic-numeric methods for solving polynomial systems, resultants and structured matrices for symbolic-numeric computation, differential equations for symbolic-numeric computation, symbolic-numeric methods for geometric computation, symbolic-numeric algorithms in algebraic geometry, symbolic-numeric algorithms for nonlinear optimization, numeric computation of characteristic sets and Groebner bases, implementation of symbolic-numeric algorithms, approximate algebraic algorithms, applications of symbolic-numeric computation.
Information: `http://www.snc2009.cs.ehime-u.jp`.

3–8 **XVI International Congress on Mathematical Physics (ICMP09)**, Clarion Congress Hotel Prague, Prague, Czech Republic. (Jan. 2009, p. 73)

3–14 **Pan-American Advanced Studies Institute (PASI): In Commutative Algebra and its connections to Geometry**, Olinda, Brazil. (Feb. 2009, p. 310)

10–12 **Continuing Statistics Education Workshop**, Statistics Online Computational Resource (SOCR), University of California, Los Angeles, California. (Dec. 2008, p. 1450)

10–12 **Workshop on Technology-Enhanced Probability and Statistics Education Using SOCR Resources**, Statistics Online Computational Resource (SOCR), University of California, Los Angeles, California. (Dec. 2008, p. 1451)

10–14 **Topological complexity of random sets**, American Institute of Mathematics, Palo Alto, California. (Jan. 2009, p. 73)

12–14 **18th USENIX Security Symposium**, Le Centre Sheraton Hotel Montreal, 1201 Boulevard Rene-Levesque, West Montreal, Quebec H3B 2L7 Canada. (Jan. 2009, p. 73)

12–December 18 **Dynamics of Discs and Planets**, Isaac Newton Institute for Mathematical Sciences, Cambridge, England. (Aug. 2008, p. 872)

17 **Symplectic and Contact Geometry and Topology**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2008, p. 1033)

17–21 **International Conference on Complex Analysis and Related Topics**, University of Turku, Turku, Finland. (Feb. 2009, p. 310)

17–21 **Modular forms on noncongruence groups**, American Institute of Mathematics, Palo Alto, California. (Aug. 2008, p. 872)

17–December 18 **Tropical Geometry**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2008, p. 1033)

24–28 **Relative trace formula and periods of automorphic forms**, American Institute of Mathematics, Palo Alto, California. (Sept. 2008, p. 1033)

27–29 **Ukrainian Mathematical Congress 2009 (Dedicated to the Centennial of Nikolai N. Bogoliubov)**, Institute of Mathematics of NASU, Kiev (Kyiv), Ukraine. (Jan. 2009, p. 73)

30–September 4 **Algebraic Groups and Invariant Theory**, Centro Stefano Franscini, Ascona, Switzerland. (Jan. 2009, p. 73)

September 2009

2–4 **Workshop in nonlinear elliptic PDEs**, Université Libre de Bruxelles, Brussels, Belgium. (Feb. 2009, p. 310)

4–9 **2nd Dolomites Workshop on Constructive Approximation and Applications (DWCAA09)**, Alba di Canazei, Trento, Italy. (Jan. 2009, p. 73)

8–December 11 **Long Program: Combinatorics: Methods and Applications in Mathematics and Computer Science**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Jan. 2009, p. 73)

9–16 **Combinatorics: Methods and Applications in Mathematics and Computer Science, Tutorials**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Jan. 2009, p. 73)

10–12 **Quantum topology and Chern-Simons theory**, Institut de Recherche Mathématique Avancée, Université de Strasbourg, 7 rue René Descartes, Strasbourg, France. (Jan. 2009, p. 73)

11–17 (NEW DATE) **Models in Developing Mathematics Education**, Dresden University of Applied Sciences, Dresden, Germany. (Apr. 2007, p. 498)

15–18 **Bogolyubov Kyiv Conference: "Modern Problems of Theoretical and Mathematical Physics"**, Bogolyubov Institute for Theoretical Physics, Kyiv, Ukraine. (Nov. 2008, p. 1319)

October 2009

5–8 **2009 SIAM/ACM Joint Conference on Geometric Design and Solid & Physical Modeling**, Hilton San Francisco Financial District, San Francisco, California. (Dec. 2008, p. 1451)

5–9 **Combinatorics: Probabilistic Techniques and Applications**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2008, p. 1451)

9–11 **SIAM Conference on Mathematics for Industry: Challenges and Frontiers (MI09)**, Hilton San Francisco Financial District, San Francisco, California. (Feb. 2009, p. 310)

12–16 **Algebra, Geometry, and Mathematical Physics**, The Bedlewo Mathematical Research and Conference Center, Bedlewo, Poland. (Dec. 2008, p. 1451)

14–16 **The 9th Conference Shell Structures Theory and Applications**, Neptun Hotel, Hel Peninsula, Baltic Sea, Jurata, Poland. (Dec. 2008, p. 1451)

16–18 **AMS Central Section Meeting**, Baylor University, Waco, Texas. (Aug. 2008, p. 872)

19–23 **Combinatorics: Combinatorial Geometry**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2008, p. 1451)

19–23 **Higher Reidemeister Torsion**, American Institute of Mathematics, Palo Alto, California. (Dec. 2008, p. 1451)

* 20–22 **International Conference in Modeling Health Advances 2009**, UC Berkeley, San Francisco Bay Area, California.
Description: A host of new diseases, like HIV/AIDS, BSE, Avian Flu, West Nile Virus and others have appeared on the scene during the last twenty-five years and undoubtedly, more will come in the coming years. To tackle these illnesses, the cooperation of modelers, mathematicians, statisticians, computer scientists, and others, and of researchers from the medical community is absolutely essential. Modeling is important because it gives important insight into the method of treatment. In the case of HIV/AIDS, for example, mathematical modeling indicated that a combination of both protease inhibitors and reverse transcriptase inhibitors would be far more effective than any one of these two drugs. The purpose of this conference is to bring all the people working in the area of epidemiology under one roof and encourage mutual interaction.
Information: `http://www.iaeng.org/WCECS2009/ICMHA2009.html`; email: `publication@iaeng.org`.

24–25 **AMS Eastern Section Meeting**, Pennsylvania State University, University Park, Pennsylvania. (Aug. 2008, p. 872)

30–November 1 **AMS Southeastern Section Meeting**, Florida Atlantic University, Boca Raton, Florida. (Aug. 2008, p. 872)

November 2009

* 1–6 **23rd Large Installation System Administration Conference (LISA '09)**, Baltimore Marriott Waterfront, 700 Aliceanna Street, Baltimore, Maryland.
Description: Over 1,000 system administrators of all specialties and levels of expertise meet at LISA to exchange ideas, sharpen old skills, learn new techniques, debate current issues, and meet colleagues, vendors, and friends. Talks, presentations, posters, WiPs, and BoFs address a wide range of administration specialties, including system, network, storage, and security administration on a variety of platforms including Linux, BSD, Solaris, and OS X.
Information: `http://usenix.org/events/lisa09/`.

1–December 31 **Financial Mathematics**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Jan. 2009, p. 73)

2–6 **Combinatorics: Topics in Graphs and Hypergraphs**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Jan. 2009, p. 74)

7–8 **AMS Western Section Meeting**, University of California, Riverside, California. (Aug. 2008, p. 872)

16–20 **Combinatorics: Analytical Methods in Combinatorics, Additive Number Theory and Computer Science**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Dec. 2008, p. 1452)

29–December 4 **Southern Right Delta (ΣPΔ'09) Conference on the Teaching and Learning of Undergraduate Mathematics and Statistics**, Gordon's Bay, Western Cape, South Africa. (Feb. 2009, p. 310)

December 2009

7–9 **SIAM Conference on Analysis of Partial Differential Equations (PD09)**, Hilton Miami Downtown, Miami, Florida. (Feb. 2009, p. 310)

16–18 **The 4th Indian International Conference on Artificial Intelligence: (IICAI-09)**, Tumkur (near Bangalore), India. (Dec. 2008, p. 1452)

July 2010

* 26–August 6 **Winter School on Topics in Noncommutative Geometry**, Departamento de Matematica, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Argentina.
Description: The school will cover different topics in non-commutative geometry and its connections with other areas of mathematics and physics, such as operator index theory, strings, representations, operator algebras, and K-Theory. As of December 2008, the following people have agreed in principle to come and give a course: Henrique Bursztyn, Joachim Cuntz, Pavel Etingof, Victor Ginzburg, Victor Kac, Max Karoubi, Henri Moscovici, Holger Reich, Nicolai Reshetikhin, Marc Rieffel, Jonathan Rosenberg, Georges Skandalis, Boris Tsygan.
Organizers: G. CortiÒas, M. Farinati, J. A. Guccione, J. J. Guccione, M. Graña.
Scientific Committee: G. Cortiñas, J. Cuntz, B. Tsygan.
Information: `http://cms.dm.uba.ar/Members/gcorti/workgroup.GNC/3EILS`.

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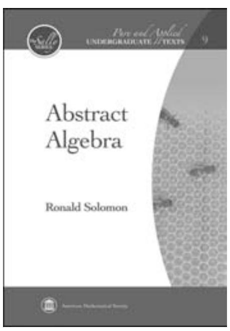
Algebra and Algebraic Geometry

COURSE ADOPTION



Abstract Algebra

Ronald Solomon, *Ohio State University, Columbus, OH*

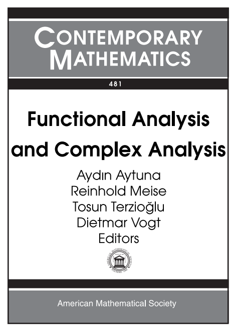
This undergraduate text takes a novel approach to the standard introductory material on groups, rings, and fields. At the heart of the text is a semi-historical journey through the early decades of the subject as it emerged in the revolutionary work of Euler, Lagrange, Gauss, and Galois. Avoiding excessive abstraction whenever possible, the text focuses on the central problem of studying the solutions of polynomial equations. Highlights include a proof of the Fundamental Theorem of Algebra, essentially due to Euler, and a proof of the constructability of the regular 17-gon, in the manner of Gauss. Another novel feature is the introduction of groups through a meditation on the meaning of congruence in the work of Euclid. Everywhere in the text, the goal is to make clear the links connecting abstract algebra to Euclidean geometry, high school algebra, and trigonometry, in the hope that students pursuing a career as secondary mathematics educators will carry away a deeper and richer understanding of the high school mathematics curriculum. Another goal is to encourage students, insofar as possible in a textbook format, to build the course for themselves, with exercises integrally embedded in the text of each chapter.

Contents: Background; Geometry; Polynomials; Numbers; The grand synthesis; Index.

Pure and Applied Undergraduate Texts, Volume 9

February 2009, 227 pages, Hardcover, ISBN: 978-0-8218-4795-4, LC 2008047399, 2000 *Mathematics Subject Classification:* 12-01, **AMS members US$50**, List US$62, Order code AMSTEXT/9

Analysis



Functional Analysis and Complex Analysis

Aydın Aytuna, *Sabancı University, İstanbul, Turkey*, **Reinhold Meise**, *University of Dusseldorf, Dusseldorf, Germany*, **Tosun Terzioğlu**, *Sabancı University, İstanbul, Turkey*, and **Dietmar Vogt**, *University of Wuppertal, Germany*, Editors

In recent years, the interplay between the methods of functional analysis and complex analysis has led to some remarkable results in a wide variety of topics. It turned out that the structure of spaces of holomorphic functions is fundamentally linked to certain invariants initially defined on abstract Fréchet spaces as well as to the developments in pluripotential theory.

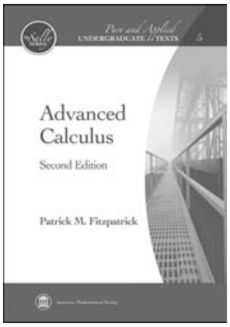
The aim of this volume is to document some of the original contributions to this topic presented at a conference held at Sabancı University in İstanbul, in September 2007. This volume also contains some surveys that give an overview of the state of the art and initiate further research in the interplay between functional and complex analysis.

Contents: C. O. Kiselman, Vyacheslav Zakharyuta's complex analysis; **Z. Błocki**, Remark on the definition of the complex Monge-Ampère operator; **J. Bonet** and **R. Meise**, Convolution operators on quasianalytic classes of Roumieu type; **J. S. Brauchart**, **D. P. Hardin**, and **E. B. Saff**, Riesz energy and sets of revolution in $\mathbb{R}_3$; **P. Djakov** and **B. Mityagin**, Bari-Markus property for Riesz projections of Hill operators with singular potentials; **M. Langenbruch**, Right inverses for differential operators on Fourier ultra-hyperfunctions and the property (DN); **S. E. Marzguioui** and **J. Wiegerinck**, Connectedness in the pluri-fine topology; **V. P. Palamodov**, Quantum shape of compact domains in phase plane; **A. Rashkovskii**, Analyticity and propagation of plurisubharmonic singularities; **D. Vogt**, Linear topological properties of spaces $\mathcal{H}^\omega$ and of spaces of ultradifferentiable functions; **J. Wengenroth**, Invertibility for Fréchet valued real analytic functions; **V. Zakharyuta**, Kolmogorov problem on widths asymptotics and pluripotential theory.

Contemporary Mathematics, Volume 481

April 2009, 196 pages, Softcover, ISBN: 978-0-8218-4460-1, LC 2008040610, 2000 *Mathematics Subject Classification:* 46E10, 46A04, 46F05, 32U15, 35E20, 32E30, 28A78, 46A63, 47B06, 32W20, **AMS members US$55**, List US$69, Order code CONM/481

COURSE ADOPTION



Advanced Calculus

Second Edition

Patrick M. Fitzpatrick, *University of Maryland, College Park, MD*

Advanced Calculus is intended as a text for courses that furnish the backbone of the student's undergraduate education in mathematical analysis. The goal is to rigorously present the fundamental concepts within the context of illuminating examples and stimulating exercises. This book is self-contained and starts with the creation of basic tools using the completeness axiom. The continuity, differentiability, integrability, and power series representation properties of functions of a single variable are established. The next few chapters describe the topological and metric properties of Euclidean space. These are the basis of a rigorous treatment of differential calculus (including the Implicit Function Theorem and Lagrange Multipliers) for mappings between Euclidean spaces and integration for functions of several real variables.

Special attention has been paid to the motivation for proofs. Selected topics, such as the Picard Existence Theorem for differential equations, have been included in such a way that selections may be made while preserving a fluid presentation of the essential material.

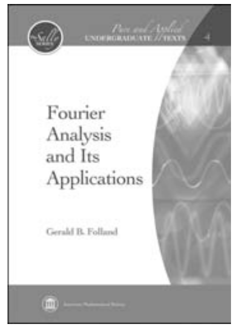
Supplemented with numerous exercises, *Advanced Calculus* is a perfect book for undergraduate students of analysis.

Contents: Preliminaries; Tools for analysis; Convergent sequences; Continuous functions; Differentiation; Elementary functions as solutions of differential equations; Integration: Two fundamental theorems; Integration: Further topics; Approximation by Taylor polynomials; Sequences and series of functions; The Euclidean space $\mathbb{R}^n$; Continuity, compactness, and connectedness; Metric spaces; Differentiating functions of several variables; Local approximation of real-valued functions; Approximating nonlinear mappings by linear mappings; Images and inverses: The inverse function theorem; The implicit function theorem and its applications; Integrating functions of several variables; Iterated integration and changes of variables; Line and surface integrals; Consequences of the field and positivity axioms; Linear algebra; Index.

Pure and Applied Undergraduate Texts, Volume 5

March 2009, 590 pages, Hardcover, ISBN: 978-0-8218-4791-6, LC 2008047395, 2000 *Mathematics Subject Classification:* 26-01, 26A06, **AMS members US$66**, List US$82, Order code AMSTEXT/5

COURSE ADOPTION



Fourier Analysis and Its Applications

Gerald B. Folland, *University of Washington, Seattle, WA*

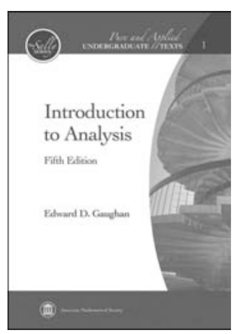
This book presents the theory and applications of Fourier series and integrals, eigenfunction expansions, and related topics, on a level suitable for advanced undergraduates. It includes material on Bessel functions, orthogonal polynomials, and Laplace transforms, and it concludes with chapters on generalized functions and Green's functions for ordinary and partial differential equations. The book deals almost exclusively with aspects of these subjects that are useful in physics and engineering, and includes a wide variety of applications. On the theoretical side, it uses ideas from modern analysis to develop the concepts and reasoning behind the techniques without getting bogged down in the technicalities of rigorous proofs.

Contents: Overture; Fourier series; Orthogonal sets of functions; Some boundary value problems; Bessel functions; Orthogonal polynomials; The Fourier transform; The Laplace transform; Generalized functions; Green's functions; Appendices; Answers to the exercises; References; Index of symbols; Index.

Pure and Applied Undergraduate Texts, Volume 4

March 2009, 433 pages, Hardcover, ISBN: 978-0-8218-4790-9, LC 2008047394, 2000 *Mathematics Subject Classification:* 42-01; 00A05, 33-01, 34B05, 34L10, 44A10, 46-01, **AMS members US$58**, List US$72, Order code AMSTEXT/4

COURSE ADOPTION



Introduction to Analysis

Fifth Edition

Edward D. Gaughan, *New Mexico State University, Las Cruces, NM*

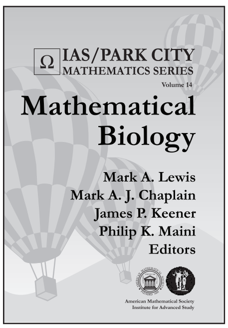
Introduction to Analysis is designed to bridge the gap between the intuitive calculus usually offered at the undergraduate level and the sophisticated analysis courses the student encounters at the graduate level. In this book the student is given the vocabulary and facts necessary for further study in analysis. The course for which it is designed is usually offered at the junior level, and it is assumed that the student has little or no previous experience with proofs in analysis. A considerable amount of time is spent motivating the theorems and proofs and developing the reader's intuition. Of course, that intuition must be tempered with the realization that rigorous proofs are required for theorems. The topics are quite standard: convergence of sequences, limits of functions, continuity, differentiation, the Riemann integral, infinite series, power series, and convergence of sequences of functions. Many examples are given to illustrate the theory, and exercises at the end of each chapter are keyed to each section. Also, at the end of each section, one finds several Projects. The purpose of a Project is to give the reader a substantial mathematical problem and the necessary guidance to solve that problem. A Project is distinguished from an exercise in that the solution of a Project is a multi-step process requiring assistance for the beginner student.

Contents: Preliminaries; Sequences; Limits of functions; Continuity; Differentiation; The Riemann integral; Infinite series; Sequences and series of functions; Index.

Pure and Applied Undergraduate Texts, Volume 1

March 2009, 240 pages, Hardcover, ISBN: 978-0-8218-4787-9, LC 2008047387, 2000 *Mathematics Subject Classification:* 26-01, **AMS members US$50**, List US$62, Order code AMSTEXT/1

Applications



Mathematical Biology

Mark A. Lewis, *University of Alberta, Edmonton, AB, Canada*, **Mark A. J. Chaplain**, *University of Dundee, Scotland*, **James P. Keener**, *University of Utah, Salt Lake City, UT*, and **Philip K. Maini**, *University of Oxford, England*, Editors

Each summer the IAS/Park City Mathematics Institute Graduate Summer School gathers some of the best researchers and educators in a particular field to present lectures on a major area of mathematics. A unifying theme of the mathematical biology courses presented here is that the study of biology involves dynamical systems. Introductory chapters by Jim Keener and Mark Lewis describe the biological dynamics of reactions and of spatial processes.

Each remaining chapter stands alone, as a snapshot of in-depth research within a sub-area of mathematical biology. Jim Cushing writes about the role of nonlinear dynamical systems in understanding complex dynamics of insect populations. Epidemiology, and the interplay of data and differential equations, is the subject of David Earn's chapter on dynamic diseases. Topological methods for understanding dynamical systems are the focus of the chapter by Leon Glass on perturbed biological oscillators. Helen Byrne introduces the reader to cancer modeling and shows how mathematics can describe and predict complex movement patterns of tumors and cells. In the final chapter, Paul Bressloff couples nonlinear dynamics to nonlocal oscillations, to provide insight to the form and function of the brain.

The book provides a state-of-the-art picture of some current research in mathematical biology. Our hope is that the excitement and richness of the topics covered here will encourage readers to explore further in mathematical biology, pursuing these topics and others on their own.

The level is appropriate for graduate students and research scientists. Each chapter is based on a series of lectures given by a leading researcher and develops methods and theory of mathematical biology from first principles. Exercises are included for those who wish to delve further into the material.

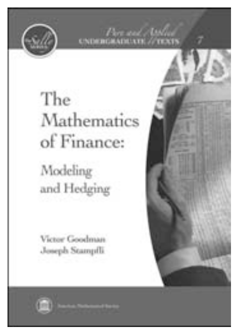
Titles in this series are co-published with the Institute for Advanced Study/Park City Mathematics Institute. Members of the Mathematical Association of America (MAA) and the National Council of Teachers of Mathematics (NCTM) receive a 20% discount from list price.

Contents: **M. A. Lewis** and **J. Keener**, Introduction; **J. P. Keener**, Introduction to dynamics of biological systems; **M. A. Lewis**, **T. Hillen**, and **F. Lutscher**, Spatial dynamics in ecology; **J. M. Cushing**, Matrix models and population dynamics; **D. J. D. Earn**, Mathematical epidemiology of infectious diseases; **L. Glass**, Topological approaches to biological dynamics; **H. Byrne**, Mathematical modelling of solid tumour growth: from avascular to vascular, via angiogenesis; **P. C. Bressloff**, Lectures in mathematical neuroscience.

IAS/Park City Mathematics Series, Volume 14

April 2009, approximately 408 pages, Hardcover, ISBN: 978-0-8218-4765-7, LC 2008047401, 2000 *Mathematics Subject Classification:* 34-02, 35-02, 37-02, 92-02, **AMS members US$63**, List US$79, Order code PCMS/14

COURSE ADOPTION



The Mathematics of Finance

Modeling and Hedging

Victor Goodman and **Joseph Stampfli**, *Indiana University, Bloomington, IN*

This book is ideally suited for an introductory undergraduate course on financial engineering. It explains the basic concepts of financial derivatives, including put and call options, as well as more complex derivatives such as barrier options and options on futures contracts. Both discrete and continuous models of market behavior are developed in this book. In particular, the analysis of option prices developed by Black and Scholes is explained in a self-contained way, using both the probabilistic Brownian Motion method and the analytical differential equations method.

The book begins with binomial stock price models, moves on to multistage models, then to the Cox–Ross–Rubinstein option pricing process, and then to the Black–Scholes formula. Other topics presented include Zero Coupon Bonds, forward rates, the yield curve, and several bond price models. The book continues with foreign exchange models and the Keynes Interest Rate Parity Formula, and concludes with the study of country risk, a topic not inappropriate for the times.

In addition to theoretical results, numerical models are presented in much detail. Each of the eleven chapters includes a variety of exercises.

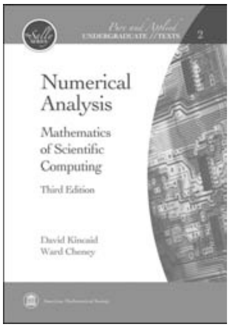
Contents: Financial markets; Binomial trees, replicating portfolios, and arbitrage; Tree models for stocks and options; Using spreadsheets to compute stock and option trees; Continuous models and the Black-Scholes formula; The analytic approach to Black-Scholes; Hedging; Bond models and interest rate options; Computational methods for bonds; Currency markets and foreign exchange risks; International political risk analysis; Answers to selected exercises; Index.

Pure and Applied Undergraduate Texts, Volume 7

April 2009, 250 pages, Hardcover, ISBN: 978-0-8218-4793-0, LC 2008047397, 2000 *Mathematics Subject Classification:* 91-01;

60H10, 60H30, 91B28, **AMS members US$50**, List US$62, Order code AMSTEXT/7

COURSE ADOPTION



Numerical Analysis

Mathematics of Scientific Computing, Third Edition

David Kincaid and **Ward Cheney**, *University of Texas at Austin, TX*

This book introduces students with diverse backgrounds to various types of mathematical analysis that are commonly needed in scientific computing. The subject of numerical analysis is treated from a mathematical point of view, offering a complete analysis of methods for scientific computing with appropriate motivations and careful proofs.

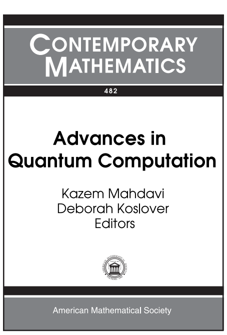
In an engaging and informal style, the authors demonstrate that many computational procedures and intriguing questions of computer science arise from theorems and proofs. Algorithms are presented in pseudocode, so that students can immediately write computer programs in standard languages or use interactive mathematical software packages.

This book occasionally touches upon more advanced topics that are not usually contained in standard textbooks at this level.

Contents: Numerical analysis: What is it?; Mathematical preliminaries; Computer arithmetic; Solution of nonlinear equations; Solving systems of linear equations; Selected topics in numerical linear algebra; Approximating functions; Numerical differentiation and integration; Numerical solution of ordinary differential equations; Numerical solution of partial differential equations; Linear programming and related topics; Optimization; Appendix A. An overview of mathematical software; Bibliography; Index.

Pure and Applied Undergraduate Texts, Volume 2

January 2009, 788 pages, Hardcover, ISBN: 978-0-8218-4788-6, LC 2008047389, 2000 *Mathematics Subject Classification:* 65-01, **AMS members US$71**, List US$89, Order code AMSTEXT/2



Advances in Quantum Computation

Kazem Mahdavi and **Deborah Koslover**, *University of Texas at Tyler, TX*, Editors

This volume represents the talks given at the Conference on Interactions between Representation Theory, Quantum Field Theory, Category Theory, Mathematical Physics, and Quantum Information Theory, held in September 2007 at the University of Texas at Tyler.

The papers in this volume, written by top experts in the field, address physical aspects, mathematical aspects, and foundational issues of quantum computation.

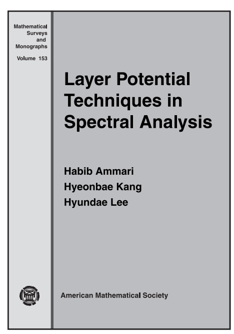
This volume will benefit researchers interested in advances in quantum computation and communication, as well as graduate students who wish to enter the field of quantum computation.

Contents: Z. Zhang and **G. Chen**, Mathematical formulations of atom trap quantum gates; **H. E. Brandt**, Charge renormalization, Apéry's number, and the trefoil knot; **Y. Zhang**, Braid group, Temperley-Lieb algebra, and quantum information and computation; **T. Schedler**, Poisson algebras and Yang-Baxter equations; **J. M. Myers** and **F. H. Madjid**, Ambiguity in quantum-theoretical descriptions of experiments; **P. Benioff**, Reference frame fields based on quantum theory representations of real and complex numbers; **E. C. Rowell**, Two paradigms for topological quantum computation; **S. Bravyi**, Contraction of matchgate tensor networks on non-planar graphs; **M. Haque**, Probing topological order in quantum Hall states using entanglement calculations; **A. Hamma**, Topological order and entanglement; **V. E. Korepin** and **Y. Xu**, Hierarchical quantum search.

Contemporary Mathematics, Volume 482

April 2009, 240 pages, Softcover, ISBN: 978-0-8218-4627-8, LC 2008042590, 2000 *Mathematics Subject Classification:* 81P68, 81T18, 81V10, 68M07, 37F25, 20F36, 57M25, 57M27, 47N55, **AMS members US$63**, List US$79, Order code CONM/482

Differential Equations



Layer Potential Techniques in Spectral Analysis

Habib Ammari, *Ecole Polytechnique, Palaiseau, France*, and **Hyeonbae Kang** and **Hyundae Lee**, *Inha University, Incheon, South Korea*

Since the early part of the twentieth century, the use of integral equations has developed into a range of tools for the study of partial differential equations. This includes the use of single- and double-layer potentials to treat classical boundary value problems.

The aim of this book is to give a self-contained presentation of an asymptotic theory for eigenvalue problems using layer potential techniques with applications in the fields of inverse problems, band gap structures, and optimal design, in particular the optimal design of photonic and phononic crystals. Throughout this book, it is shown how powerful the layer potentials techniques are for solving not only boundary value problems but also eigenvalue problems if they are combined with the elegant theory of Gohberg and Sigal on meromorphic operator-valued functions. The general approach in this book is developed in detail for eigenvalue problems for the Laplacian and the Lamé system in the following two situations: one under variation of domains or boundary conditions and the other due to the presence of inclusions.

The book will be of interest to researchers and graduate students working in the fields of partial differential equations, integral equations, and inverse problems. Researchers in engineering and physics may also find this book helpful.

This item will also be of interest to those working in applications.

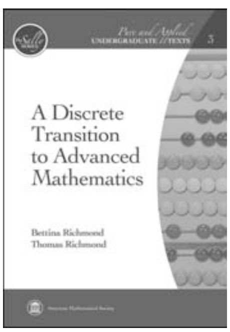
Contents: Introduction; *Gohberg-Sigal theory:* Generalized argument principle and Rouché's theorem; *Eigenvalue perturbation problems and applications:* Layer potentials; Eigenvalue perturbations of the Laplacian; Vibration testing for detecting internal corrosion; Perturbations of scattering frequencies of resonators with narrow slits and slots; Eigenvalue perturbations of the Lamé system; *Photonic and phononic band gaps and optimal design:* Floquet transform, spectra of periodic elliptic operators, and quasi-periodic layer potentials; Photonic band gaps; Phononic band gaps; Optimal design problems; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 153

March 2009, 202 pages, Hardcover, ISBN: 978-0-8218-4784-8, LC 2008048317, 2000 *Mathematics Subject Classification:* 47A55, 47A75, 31A10, 34A55, 35R30, 35B34, 45Q05, 30E25, **AMS members US$55**, List US$69, Order code SURV/153

Discrete Mathematics and Combinatorics

COURSE ADOPTION



A Discrete Transition to Advanced Mathematics

Bettina Richmond and **Thomas Richmond**, *Western Kentucky University, Bowling Green, KY*

As the title indicates, this book is intended for courses aimed at bridging the gap between lower-level mathematics and advanced mathematics. The text provides a careful introduction to techniques for writing proofs and a logical development of topics based on intuitive understanding of concepts. The authors utilize a clear writing style and a wealth of examples to develop an understanding of discrete mathematics and critical thinking skills. While including many traditional topics, the text offers innovative material throughout. Surprising results are used to motivate the reader. The last three chapters address topics such as continued fractions, infinite arithmetic, and the interplay among Fibonacci numbers, Pascal's triangle, and the golden ratio, and may be used for independent reading assignments. The treatment of sequences may be used to introduce epsilon-delta proofs. The selection of topics provides flexibility for the instructor in a course designed to spark the interest of students through exciting material while preparing them for subsequent proof-based courses.

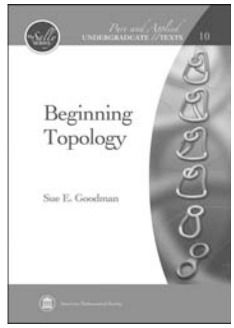
Contents: Sets and logic; Proofs; Number theory; Combinatorics; Relations; Functions and cardinality; Graph theory; Sequences; Fibonacci numbers and Pascal's triangle; Continued fractions; Answers or hints for selected exercises; Bibliography; Index.

Pure and Applied Undergraduate Texts, Volume 3

February 2009, 424 pages, Hardcover, ISBN: 978-0-8218-4789-3, LC 2008047393, 2000 *Mathematics Subject Classification:* 00-01, **AMS members US$58**, List US$72, Order code AMSTEXT/3

Geometry and Topology

COURSE ADOPTION



Beginning Topology

Sue E. Goodman, *University of North Carolina, Chapel Hill, NC*

Beginning Topology is designed to give undergraduate students a broad notion of the scope of topology in areas of point-set, geometric, combinatorial, differential, and algebraic topology, including an introduction to knot theory. A primary goal is to expose students to some recent research and to get them actively involved in learning. Exercises and open-ended projects are placed throughout the text, making it adaptable to seminar-style classes.

The book starts with a chapter introducing the basic concepts of point-set topology, with examples chosen to captivate students' imaginations while illustrating the need for rigor. Most of the material in this and the next two chapters is essential for the remainder of the book. One can then choose from chapters on map coloring, vector fields on surfaces, the fundamental group, and knot theory.

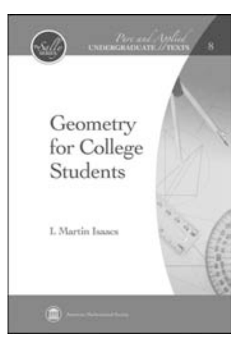
A solid foundation in calculus is necessary, with some differential equations and basic group theory helpful in a couple of chapters. Topics are chosen to appeal to a wide variety of students: primarily upper-level math majors, but also a few freshmen and sophomores as well as graduate students from physics, economics, and computer science. All students will benefit from seeing the interaction of topology with other fields of mathematics and science; some will be motivated to continue with a more in-depth, rigorous study of topology.

Contents: Introduction to point set topology; Surfaces; The Euler characteristic; Maps and graphs; Vector fields on surfaces; The fundamental group; Introduction to knots; Bibliography and reading list; Index.

Pure and Applied Undergraduate Texts, Volume 10

February 2009, 236 pages, Hardcover, ISBN: 978-0-8218-4796-1, LC 2008047400, 2000 *Mathematics Subject Classification:* 55-01, 57-01, **AMS members US$50**, List US$62, Order code AMSTEXT/10

COURSE ADOPTION



Geometry for College Students

I. Martin Isaacs, *University of Wisconsin, Madison, WI*

One of the challenges many mathematics students face occurs after they complete their study of basic calculus and linear algebra, and they start taking courses where they are expected to write proofs. Historically, students have been learning to think mathematically and to write proofs by studying Euclidean geometry. In the author's opinion, geometry is still the best way to make the transition from elementary to advanced mathematics.

The book begins with a thorough review of high school geometry, then goes on to discuss special points associated with triangles, circles and certain associated lines, Ceva's theorem, vector techniques of proof, and compass-and-straightedge constructions. There is also some emphasis on proving numerical formulas like the laws of sines, cosines, and tangents, Stewart's theorem, Ptolemy's theorem, and the area formula of Heron.

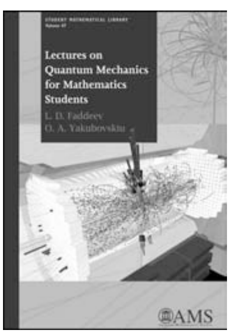
An important difference of this book from the majority of modern college geometry texts is that it avoids axiomatics. The students using this book have had very little experience with formal mathematics. Instead, the focus of the course and the book is on interesting theorems and on the techniques that can be used to prove them. This makes the book suitable to second- or third-year mathematics majors and also to secondary mathematics education majors, allowing the students to learn how to write proofs of mathematical results and, at the end, showing them what mathematics is really all about.

Contents: The basics; Triangles; Circles and lines; Ceva's theorem and its relatives; Vector methods of proof; Geometric constructions; Some further reading; Index.

Pure and Applied Undergraduate Texts, Volume 8

April 2009, 222 pages, Hardcover, ISBN: 978-0-8218-4794-7, LC 2008047398, 2000 *Mathematics Subject Classification:* 51-01, **AMS members US$50**, List US$62, Order code AMSTEXT/8

Mathematical Physics



Lectures on Quantum Mechanics for Mathematics Students

L. D. Faddeev, *Steklov Mathematical Institute, St. Petersburg, Russia*, and **O. A. Yakubovskiĭ**, *St. Petersburg University, Russia*

with an appendix by Leon Takhtajan

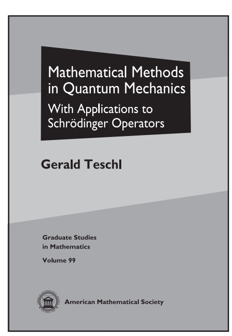
This book is based on notes from the course developed and taught for more than 30 years at the Department of Mathematics of Leningrad University. The goal of the course was to present the basics of quantum mechanics and its mathematical content to students in mathematics. This book differs from the majority of other textbooks on the subject in that much more attention is paid to general principles of quantum mechanics. In particular, the authors describe in detail the relation between classical and quantum mechanics. When selecting particular topics, the authors emphasize those that are related to interesting mathematical theories. In particular, the book contains a discussion of problems related to group representation theory and to scattering theory.

This book is rather elementary and concise, and it does not require prerequisites beyond the standard undergraduate mathematical curriculum. It is aimed at giving a mathematically oriented student the opportunity to grasp the main points of quantum theory in a mathematical framework.

Contents: The algebra of observables in classical mechanics; States; Liouville's theorem, and two pictures of motion in classical mechanics; Physical bases of quantum mechanics; A finite-dimensional model of quantum mechanics; States in quantum mechanics; Heisenberg uncertainty relations; Physical meaning of the eigenvalues and eigenvectors of observables; Two pictures of motion in quantum mechanics. The Schrödinger equation. Stationary states; Quantum mechanics of real systems. The Heisenberg commutation relations; Coordinate and momentum representations; "Eigenfunctions" of the operators Q and P; The energy, the angular momentum, and other examples of observables; The interconnection between quantum and classical mechanics. Passage to the limit from quantum mechanics to classical mechanics; One-dimensional problems of quantum mechanics. A free one-dimensional particle; The harmonic oscillator; The problem of the oscillator in the coordinate representation; Representation of the states of a one-dimensional particle in the sequence space l_2; Representation of the states for a one-dimensional particle in the space $\mathcal{D}$ of entire analytic functions; The general case of one-dimensional motion; Three-dimensional problems in quantum mechanics. A three-dimensional free particle; A three-dimensional particle in a potential field; Angular momentum; The rotation group; Representations of the rotation group; Spherically symmetric operators; Representation of rotations by 2×2 unitary matrices; Representation of the rotation group on a space of entire analytic functions of two complex variables; Uniqueness of the representations D_j; Representations of the rotation group on the space $L^2(S^2)$. Spherical functions; The radial Schrödinger equation; The hydrogen atom. The alkali metal atoms; Perturbation theory; The variational principle; Scattering theory. Physical formulation of the problem; Scattering of a one-dimensional particle by a potential barrier; Physical meaning of the solutions ψ_1 and ψ_2; Scattering by a rectangular barrier; Scattering by a potential center; Motion of wave packets in a central force field; The integral equation of scattering theory; Derivation of a formula for the cross-section; Abstract scattering theory; Properties of commuting operators; Representation of the state space with respect to a complete set of observables; Spin; Spin of a system of two electrons; Systems of many particles. The identity principle; Symmetry of the coordinate wave functions of a system of two electrons. The helium atom; Multi-electron atoms. One-electron approximation; The self-consistent field equations; Mendeleev's periodic system of the elements; Lagrangian formulation of classical mechanics.

Student Mathematical Library, Volume 47

April 2009, approximately 242 pages, Softcover, ISBN: 978-0-8218-4699-5, 2000 *Mathematics Subject Classification:* 81-01, 81Qxx, **AMS members US$31**, List US$39, Order code STML/47



Mathematical Methods in Quantum Mechanics

With Applications to Schrödinger Operators

Gerald Teschl, *University of Vienna, Austria*

Quantum mechanics and the theory of operators on Hilbert space have been deeply linked since their beginnings in the early twentieth century. States of a quantum system correspond to certain elements of the configuration space and observables correspond to certain operators on the space. This book is a brief, but self-contained, introduction to the mathematical methods of quantum mechanics, with a view towards applications to Schrödinger operators.

Part 1 of the book is a concise introduction to the spectral theory of unbounded operators. Only those topics that will be needed for later applications are covered. The spectral theorem is a central topic in this approach and is introduced at an early stage. Part 2 starts with the free Schrödinger equation and computes the free resolvent and time evolution. Position, momentum, and angular momentum are discussed via algebraic methods. Various mathematical methods are developed, which are then used to compute the spectrum of the hydrogen atom. Further topics include the nondegeneracy of the ground state, spectra of atoms, and scattering theory.

This book serves as a self-contained introduction to spectral theory of unbounded operators in Hilbert space with full proofs and minimal prerequisites: Only a solid knowledge of advanced calculus and a one-semester introduction to complex analysis are required. In particular, no functional analysis and no Lebesgue integration theory are assumed. It develops the mathematical tools necessary to prove some key results in nonrelativistic quantum mechanics.

Mathematical Methods in Quantum Mechanics is intended for beginning graduate students in both mathematics and physics and provides a solid foundation for reading more advanced books and current research literature. It is well suited for self-study and includes numerous exercises (many with hints).

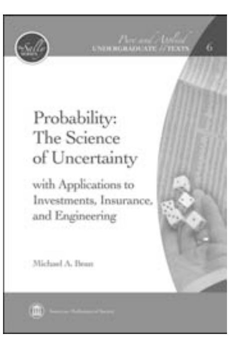
Contents: *Preliminaries:* A first look at Banach and Hilbert spaces; *Mathematical foundations of quantum mechanics:* Hilbert spaces; Self-adjointness and spectrum; The spectral theorem; Applications of the spectral theorem; Quantum dynamics; Perturbation theory for self-adjoint operators; *Schrödinger operators:* The free Schrödinger operator; Algebraic methods; One dimensional Schrödinger operators; One-particle Schrödinger operators; Atomic Schrödinger operators; Scattering theory; *Appendix:* Almost everything about Lebesgue integration; Bibliographical notes; Bibliography; Glossary of notation; Index.

Graduate Studies in Mathematics, Volume 99

April 2009, approximately 302 pages, Hardcover, ISBN: 978-0-8218-4660-5, LC 2008045437, 2000 *Mathematics Subject Classification:* 81-01, 81Qxx, 46-01, 34Bxx, 47B25, **AMS members US$47**, List US$59, Order code GSM/99

Probability

COURSE ADOPTION



Probability: The Science of Uncertainty

with Applications to Investments, Insurance, and Engineering

Michael A. Bean

This book covers the basic probability of distributions with an emphasis on applications from the areas of investments, insurance, and engineering. Written by a Fellow of the Casualty Actuarial Society and the Society of Actuaries with many years of experience as a university professor and industry practitioner, the book is suitable as a text for senior undergraduate and beginning graduate students in mathematics, statistics, actuarial science, finance, or engineering as well as a reference for practitioners in these fields. The book is particularly well suited for students preparing for professional exams, and for several years it has been recommended as a textbook on the syllabus of examinations for the Casualty Actuarial Society and the Society of Actuaries.

In addition to covering the standard topics and probability distributions, this book includes separate sections on more specialized topics such as mixtures and compound distributions, distributions of transformations, and the application of specialized distributions such as the Pareto, beta, and Weibull. The book also has a number of unique features such as a detailed description of the celebrated Markowitz investment portfolio selection model. A separate section contains information on how graphs of the specific distributions studied in the book can be created using Mathematica™.

The book includes a large number of problems of varying difficulty. A student manual with solutions to selected problems are available. For more information regarding the student manual, please contact AMS Member and Customer Services at cust-serv@ams.org.

An instructor's manual with complete solutions to all the problems as well as supplementary material is available to teachers using the book as the text for the class. To receive it, send e-mail to textbooks@ams.org.

Contents: Introduction; A survey of some basic concepts through examples; Classical probability; Random variables and probability distributions; Special discrete distributions; Special continuous distributions; Transformations of random variables; Sums and products of random variables; Mixtures and compound distributions; The Markowitz investment portfolio selection model; Appendixes; Answers to selected exercises; Index.

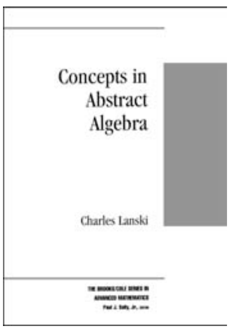
Pure and Applied Undergraduate Texts, Volume 6

February 2009, 448 pages, Hardcover, ISBN: 978-0-8218-4792-3, LC 2008047396, 2000 *Mathematics Subject Classification:* 60-01, **AMS members US$58**, List US$72, Order code AMSTEXT/6

New AMS-Distributed Publications

Algebra and Algebraic Geometry

COURSE ADOPTION



Concepts in Abstract Algebra

Charles Lanski, *University of Southern California, Los Angeles, CA*

The style and structure of *Concepts in Abstract Algebra* are designed to help students learn the core concepts and associated techniques in algebra deeply and well. Providing a fuller and richer account of material than time allows in a lecture, this text presents interesting examples of sufficient complexity so that students can see the concepts and results used in a nontrivial setting. Charles Lanski gives students the opportunity to practice by offering many exercises that require the use and synthesis of the techniques and results. Both readable and mathematically interesting, the text also helps students learn the art of constructing mathematical arguments. Overall, students discover how mathematics proceeds and how to use techniques that mathematicians actually employ.

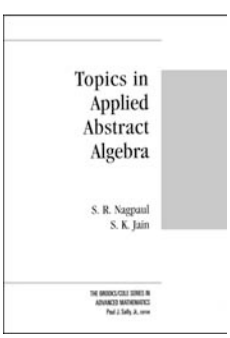
Available exclusively from the AMS.

A publication of Brooks/Cole: Cengage Learning.

Brooks/Cole: Cengage Learning, Volume 14

September 2004, 550 pages, Hardcover, ISBN: 978-0-534-42323-0, **AMS members US$71**, List US$89, Order code CENGAGE/14

COURSE ADOPTION



Topics in Applied Abstract Algebra

S. R. Nagpaul and **S. K. Jain**, *Ohio University, Athens, OH*

This book presents interesting applications of abstract algebra to practical real-world problems. Especially for those whose interest in algebra is not confined to abstract theory, the text makes the study of abstract algebra more exciting and meaningful. The book is appropriate as either a text for an applied abstract algebra course or as a supplemental text for a standard course in abstract algebra. While fully developed, the algebraic theory presented is just what is required for the applications discussed in the book.

Available exclusively from the AMS.

A publication of Brooks/Cole: Cengage Learning.

Brooks/Cole: Cengage Learning, Volume 15

October 2004, 336 pages, Hardcover, ISBN: 978-0-534-41911-0, **AMS members US$55**, List US$69, Order code CENGAGE/15

Analysis

Measured Quantum Groupoids

Franck Lesieur, *Université de Caen, France*

In this volume, the author gives a definition for measured quantum groupoids. He aims to construct objects with duality including both quantum groups and groupoids. J. Kustermans and S. Vaes' works about locally compact quantum groups the author generalizes thanks to formalism introduced by M. Enock and J. M. Vallin in the case of inclusion of von Neumann algebras. From a structure of Hopf-bimodule with left and right invariant operator-valued weights, the author defines a fundamental pseudo-multiplicative unitary. To get a satisfying duality in the general case, he assumes the existence of an antipode given by its polar decomposition. This theory is illustrated with many examples, among them the inclusion of von Neumann algebras (M. Enock) and a sub family of measured quantum groupoids with easier axiomatic.

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; Recalls; Fundamental pseudo-multiplicative unitary; *Part I. Measured quantum groupoids:* Definition; Uniqueness, modulus and scaling operator; A density theorem; Manageability of the fundamental unitary; Duality; *Part II. Examples:* Adapted measured quantum groupoids; Groupoids; Finite quantum groupoids; Quantum groups; Compact case; Quantum space quantum groupoid; Pairs quantum groupoid; Inclusions of von Neumann algebras; Operations on adapted measured quantum groupoids; Bibliography.

Mémoires de la Société Mathématique de France, Number 109

November 2008, 122 pages, Softcover, ISBN: 978-2-85629-233-4, 2000 *Mathematics Subject Classification:* 46Lxx, **Individual member US$36**, List US$40, Order code SMFMEM/109

General and Interdisciplinary

Séminaire Bourbaki

Volume 2006/2007 Exposés 967–981

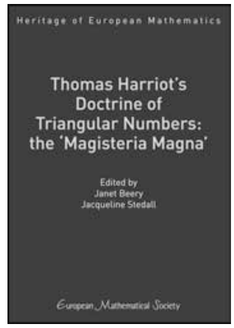
As in the preceding volumes of this seminar, one finds here fifteen survey lectures on topics of current interest: three lectures on algebraic geometry, two on arithmetic geometry, one about Diophantine approximation, two on number theory, three on differential geometry, two about groups or Lie algebras, and two about mathematical physics.

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: *Novembre 2006:* **Y. F. Bilu**, The many faces of the subspace theorem; **A. Chambert-Loir**, Compter (rapidement) le nombre de solutions d'équations dans les corps finis; **V. Colin**, Livres ouverts en géométrie de contact; **O. Debarre**, Systèmes pluricanoniques sur les variétés de type général; **A. Zuk**, Groupes engendrés pour les automates; *Mars 2007:* **C. De Lellis**, Ordinary differential equations with rough coefficients and the renormalization theorem of Ambrosio; **F. Pellarin**, Aspects de l'indépendance algébrique en caractéristique non nulle; **J. V. Pereira**, Algebraization of codimension one Webs; **J.-M. Roquejoffre**, Propriétés qualitatives des solutions des équations de Hamilton–Jacobi; **O. Schiffmann**, Variétés carquois de Nakajima; *Juin 2007:* **H. Carayol**, La conjecture de Sato–Tate; **Y. C. de Verdière**, Semi-classical measures and entropy; **D. Harari**, Points rationnels sur les sous-variétés des variétés abéliennes au-dessus d'un corps de fonctions; **C. Torossian**, La conjecture de Kashiwara–Vergne; **C. Voisin**, Géométrie des esapces de modules de courbes et de surfaces K3.

Astérisque, Number 317

November 2008, 535 pages, Softcover, ISBN: 978-2-85629-230-3, 2000 *Mathematics Subject Classification:* 11J68, 11D61, 11G30, 11G35, 11J81, 57R17, 53D35, 14J40, 14F17, 14E25, 14E30, 20F69, 37C10, 35Q35, 35B65, 35L65, 49N60, 11J93, 11G09, 12H10, 14L17, 11G05, 11G20, 11G25, 11Y16, 14G15, 14G40, 14Q05, 35A05, 35C15, 35D10, 37J50, 70H20, 14J10, 17B65, 11F80, 37D20, 37D40, 58J40, 58J50, 14G05, 17Bxx, 17B25, 22Exx, 53C35, 53D55, 14H10, 14J15, 14J28, **Individual member US$81**, List US$90, Order code AST/317



Thomas Harriot's Doctrine of Triangular Numbers: the 'Magisteria Magna'

Janet Beery, *University of Redlands, CA*, and **Jacqueline Stedall**, *The Queens College, Oxford, England*, Editors

Thomas Harriot (1560–1621) was a mathematician and astronomer who founded the English school of algebra. He is known not only for his work in algebra and geometry but also as a prolific writer with wide-ranging interests in ballistics, navigation, and optics. (He discovered the sine law of refraction now known as Snell's law.)

By about 1614, Harriot had developed finite difference interpolation methods for navigational tables. In 1618 (or slightly later) he composed a treatise entitled 'De numeris triangularibus et inde de progressionibus arithmeticis, Magisteria magna', in which he derived symbolic interpolation formulae and showed how to use them. This treatise was never published and is here reproduced for the first time. Commentary has been added to help the reader follow Harriot's beautiful but almost completely nonverbal presentation.

The introductory essay preceding the treatise gives an overview of the contents of the 'Magisteria' and describes its influence on Harriot's contemporaries and successors over the next sixty years. Harriot's method was not superseded until Newton, apparently independently, made a similar discovery in the 1660s. The ideas in the 'Magisteria' were spread primarily through personal communication and unpublished manuscripts, and so, quite apart from their intrinsic mathematical interest, their survival in England during the seventeenth century provides an important case study in the dissemination of mathematics through informal networks of friends and acquaintances.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Thomas Harriot and the 'Magisteria magna': A short chronology; Thomas Harriot's 'Magisteria magna' and constant difference interpolation in the seventeenth century; Bibliography; De numeris triangularibus et inde de progressionibus arithmeticis: Magisteria magna; Acknowledgements.

Heritage of European Mathematics, Volume 2

November 2008, 144 pages, Hardcover, ISBN: 978-3-03719-059-3, 2000 *Mathematics Subject Classification:* 01-02, **AMS members US$67**, List US$84, Order code EMSHEM/2

Geometry and Topology

Groups of Diffeomorphisms

In Honor of Shigeyuki Morita on the Occasion of His 60th Birthday

Robert Penner, *University of Southern California, Los Angeles, CA*, **Dieter Kotschick**, *Ludwig-Maximilians Universität, München, Munich, Germany*, **Takashi Tsuboi** and **Nariya Kawazumi**, *University of Tokyo, Japan*, **Teruaki Kitano**, *Soka University, Tokyo, Japan*, and **Yoshihiko Mitsumatsu**, *Chuo University, Tokyo, Japan*, Editors

This volume is dedicated to Shigeyuki Morita on the occasion of his 60th birthday. It consists of selected papers on recent trends and results in the study of various groups of diffeomorphisms, including mapping class groups, from the point of view of algebraic and differential topology, as well as dynamical ones involving foliations and symplectic or contact diffeomorphisms.

Most of the authors were invited speakers or participants of the *International Symposium on Groups of Diffeomorphisms 2006*, which was held at the University of Tokyo (Komaba) in September 2006. The editors believe that the scope of this volume well reflects Morita's mathematical interests and hope this book inspires not only the specialists in these fields but also a wider audience of mathematicians.

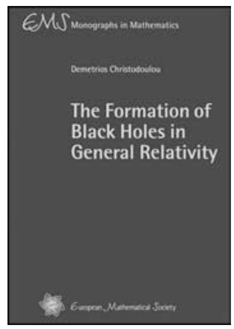
Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Contents: **S. R. Fenley**, Asymptotic geometry of foliations and pseudo-Anosov flows—a survey; **K. Igusa**, Pontrjagin classes and higher torsion of sphere bundles; **T. Kitano** and **T. Morifuji**, L^2-torsion invariants and the Magnus representation of the mapping class group; **H.-V. Lê** and **K. Ono**, Parameterized Gromov–Witten invariants and topology of symplectomorphism groups; **R. C. Penner**, Mapping class actions on surface group completions; **T. Sakasai**, Johnson's homomorphisms and the rational cohomology of subgroups of the mapping class group; **T. Akita**, On mod p Riemann-Roch formulae for mapping class groups; **J. S. Birman**, **T. E. Brendle**, and **N. Broaddus**, Calculating the image of the second Johnson-Morita representation; **J. S. Birman**, **D. Johnson**, and **A. Putman**, Symplectic Heegaard splittings and linked abelian groups; **D. Burago**, **S. Ivanov**, and **L. Polterovich**, Conjugation-invariant norms on groups of geometric origin; **H. Endo**, A generalization of Chakiris' fibrations; **K. Fujiwara**, Subgroups generated by two pseudo-Anosov elements in a mapping class group. I. Uniform exponential growth; **K. Gomi**, Differential characters and the Steenrod squares; **R. Hain**, Relative weight filtrations on completions of mapping class groups; **Y. Kasahara**, Remarks on the faithfulness of the Jones representations; **N. Kawazumi**, On the stable cohomology algebra of extended mapping class groups for surfaces; **D. Kotschick**, Stable length in stable groups; **Y. Mitsumatsu** and **E. Vogt**, Foliations and compact leaves on 4-manifolds I. Realization and self-intersection of compact leaves; **S. Morita**, Symplectic automorphism groups of nilpotent quotients of fundamental groups of surfaces; **G. Segal** and **U. Tillmann**, Mapping configuration spaces to moduli spaces; **M. Suzuki**, New examples of elements in the kernel of the Magnus representation of the Torelli group; **T. Tsuboi**, On the simplicity of the group of contactomorphisms; **T. Tsuboi**, On the uniform perfectness of diffeomorphism groups.

Advanced Studies in Pure Mathematics, Volume 52

November 2008, 524 pages, Hardcover, ISBN: 978-4-931469-48-8, 2000 *Mathematics Subject Classification:* 57-06; 19D06, 19D10, 37C85, 37D40, 37E10, 37E25, 37E30, 53D05, 53D10, 53D12, 53D35, 53D40, 53D45, 55P35, 55P47, 55P62, 55R35, 55R40, 57R17, 57R19, 57R20, 57R30, 57R32, 57R50, 57S05, 57S25, 57S30, 58H10, **AMS members US$69**, List US$86, Order code ASPM/52

Mathematical Physics



The Formation of Black Holes in General Relativity

Demetrios Christodoulou, *Eidgen Technische Hochschule, Zürich, Switzerland*

In 1965 Penrose introduced the fundamental concept of a trapped surface, on the basis of which he proved a theorem which asserts that a spacetime containing such a surface must come to an end. The presence of a trapped surface implies, moreover, that there is a region of spacetime, the black hole, which is inaccessible to observation from infinity.

Since that time a major challenge has been to find out how trapped surfaces actually form, by analyzing the dynamics of gravitational collapse. The present monograph achieves this aim by establishing the formation of trapped surfaces in pure general relativity through the focusing of gravitational waves.

The theorems proved in this monograph constitute the first foray into the long-time dynamics of general relativity in the large, that is, when the initial data are no longer confined to a suitable neighborhood of trivial data. The main new method, the short pulse method, applies to general systems of Euler–Lagrange equations of hyperbolic type and provides the means to tackle problems which have hitherto seemed unapproachable.

This monograph will be of interest to people working in general relativity, geometric analysis, and partial differential equations.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: The optical structure equations; The characteristic initial data; L^∞ estimates for the connection coefficients; $L^4(S)$ estimates for the 1st derivatives of the connection coefficients; The uniformization theorem; $L^4(S)$ estimates for the 2nd derivatives of the connection coefficients; L^2 estimates for the 3rd derivatives of the connection coefficients; The multiplier fields and the commutation fields; Estimates for the derivatives of the deformation tensors of the commutation fields; The Sobolev inequalities on the C_u and the $\underline{C}_{\underline{u}}$; The S-tangential derivatives and the rotational Lie derivatives; Weyl fields and currents. The existence theorem; The multiplier error estimates; The 1st-order Weyl current error estimates; The 2nd-order Weyl current error estimates; The energy-flux estimates. Completion of the continuity argument; Trapped surface formation; Bibliography; Index.

EMS Monographs in Mathematics, Volume 4

January 2009, 600 pages, Hardcover, ISBN: 978-3-03719-068-5, 2000 *Mathematics Subject Classification:* 83C57, 35L70, 35Q75, 58J45, 83C75, **AMS members US$102**, List US$128, Order code EMSMONO/4

Surveys on Geometry and Integrable Systems

Martin Guest, *Tokyo Metropolitan University, Japan*, **Reiko Miyaoka**, *Tohoku University, Japan*, and **Yoshihiro Ohnita**, *Osaka City University, Japan*

The articles in this volume provide a panoramic view of the role of geometry in integrable systems, firmly rooted in surface theory but currently branching out in all directions. The longer articles by Bobenko (the Bonnet problem), Dorfmeister (the generalized Weierstrass representation), Joyce (special Lagrangian 3-folds) and Terng (geometry of soliton equations) are substantial surveys of several aspects of the subject. The shorter ones indicate more briefly how the classical ideas have spread throughout differential geometry, symplectic geometry, algebraic geometry, and theoretical physics.

Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Contents: A. I. Bobenko, Exploring surfaces through methods from the theory of integrable systems: The Bonnet problem; **J. Dorfmeister**, Generalized Weierstraß representations of surfaces; **A. Fujioka** and **J. Inoguchi**, Timelike surfaces with harmonic inverse mean curvature; **C. Gu**, Darboux transformations and generalized self-dual Yang–Mills flows; **F. Hélein** and **P. Romon**, From CMC surfaces to Hamiltonian stationary Lagrangian surfaces; **D. Joyce**, Special Lagrangian 3-folds and integrable systems; **X. Liu**, Quantum product, topological recursion relations, and the Virasoro conjecture; **S. Matsutani**, A generalized Weierstrass representation for a submanifold S in $\mathbb{E}^n$ arising from the submanifold Dirac operator; **I. McIntosh**, Harmonic tori and their spectral data; **R. Miyaoka**, Isoparametric geometry and related fields; **H. Pedersen**, Kähler Ricci solitons; **W. Rossman**, **M. Umehara**, and **K. Yamada**, Period problems for mean curvature one surfaces in H^3 (with applications to surfaces of low total curvature); **C.-L. Terng**, Geometries and symmetries of soliton equations and integrable elliptic equations; **P. Topalov**, A-integrability of geodesic flows and geodesic equivalence.

Advanced Studies in Pure Mathematics, Volume 51

November 2008, 510 pages, Hardcover, ISBN: 978-4-931469-46-4, 2000 *Mathematics Subject Classification:* 70H06; 35Q53, 37K05, 37K10, 53A05, 53A07, 53A10, 58D25, 58D27, 58E20, **AMS members US$61**, List US$76, Order code ASPM/51

Classified Advertisements

Positions available, items for sale, services available, and more

UTAH

UNIVERSITY OF UTAH
College of Science

Director of the Center for Mathematics and Science Education with Appointment as Senior Faculty Member in the College of Science and the College of Education.

The University's College of Science and College of Education are designing a unique and exciting interdisciplinary research and instructional program that will begin with the creation of the Center for Mathematics and Science Education.

The candidate for director should be an established distinguished scientist within his or her discipline, holding a tenured position in biology, chemistry, mathematics, or physics. Candidate must have a strong interest and background in mathematics and science education. The director of the center will have a dual tenured appointment in both the College of Science and the College of Education, and will be expected to continue an active scholarly program in conjunction with responsibilities associated with the design and development of the center with a commitment to building diverse racial, ethnic, and linguistic learning environments that support students' mastery in math and science.

The Search Committee will begin reviewing applications in January 2009. The anticipated starting date for the position is August 15, 2009. Salary is highly competitive, and the appointment is on a nine-month academic year schedule with funding available for summer administrative duties. A liberal benefits package is provided.

Nominations and applications should be directed to Pierre Sokolsky, Dean of the College of Science, and Search Committee Co-Chair Michael Hardman, Dean of the College of Education, University of Utah, 1705 East Campus Center Drive, Room 225, Dean's Office Education, Salt Lake City, Utah 84112.

Applications should include: (1) a letter of intent, (2) the names and contact information of three references who can speak to the candidate's qualifications, (3) recent research publications and/or manuscripts, and (4) a current curriculum vitae. Direct inquiries to Pierre Sokolsky (801-581-6958, `ps@physics.utah.edu`) or Michael Hardman (801-581-8221, `Michael.Hardman@utah.edu`).

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000017

CHILE

PONTIFICIA UNIVERSIDAD CATOLICA DE CHILE
Departamento de Matemáticas

The Department of Mathematics invites applications for one tenure-track position at the assistant professor level beginning either March or August 2010. Applicants should have a Ph.D. in mathematics, proven research potential either in pure or applied mathematics, and a strong commitment to teaching and research. The regular teaching load for assistant professors consists of three one-semester courses per year, reduced to two during the first two years. The annual salary will be US\$36,000. Please send a letter indicating your main research interests, potential collaborators in our department (`http://www.mat.puc.cl`), detailed curriculum vitae, and three letters of recommendation to:

Director
Departamento de Matemáticas
Pontificia Universidad Católica de Chile
Av. Vicuña Mackenna 4860
Santiago, Chile;
fax: (56-2) 552-5916;
email: `mchuaqui@mat.puc.cl`.

For full consideration, complete application materials must arrive by June 30, 2009.

000018

INDIA

INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH
Assistant Professor in Mathematics
IISER Mohali, India

Indian Institute of Science Education and Research (IISER), Mohali, is in the process of building a School of Mathematics and Computer Science. The institute has started an integrated five-year MS program in basic sciences as well as a Ph.D. program from August 2007. The focus of the institute is to combine cutting edge research with pedagogy of science. Outstanding candidates having a flair for teaching and a strong research background are encouraged to apply for faculty positions. For details see: `http://www.iisermohali.ac.in/faculty_openings.htm`. IISER Mohali is funded by the Ministry of Human Resource Development, Government of India, and is a degree-granting institution. Mohali is adjacent to Chandigarh near the foothills of the Himalayas.

000019

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.

Urbana, Illinois

University of Illinois at Urbana-Champaign

March 27–29, 2009

Friday – Sunday

Meeting #1047

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: January
Program first available on AMS website: February 12, 2009
Program issue of electronic *Notices*: March
Issue of *Abstracts*: Volume 30, Issue 2

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

Jeffrey C. Lagarias, University of Michigan, *From Apollonian circle packings to Fibonacci Numbers* (Erdős Memorial Lecture).

Jacob Lurie, Massachusetts Institute of Technology, *On topological quantum field theories*.

Gilles Pisier, Texas A&M University, *Complex interpolation for Banach spaces of operators*.

Akshay Venkatesh, New York University-Courant Institute, *Title to be announced*.

Special Sessions

Algebra, Geometry and Combinatorics, **Rinat Kedem** and **Alexander T. Yong**, University of Illinois at Urbana-Champaign.

Algebraic Methods in Statistics and Probability, **Marlos A. G. Viana**, University of Illinois at Chicago.

Complex Dynamics and Value Distribution, **Aimo Hinkkanen** and **Joseph B. Miles**, University of Illinois at Urbana-Champaign.

Concrete Aspects of Real Positive Polynomials, **Victoria Powers**, Emory University, and **Bruce Reznick**, University of Illinois at Urbana-Champaign.

Differential Geometry and Its Applications, **Stephanie B. Alexander**, University of Illinois at Urbana-Champaign, and **Jianguo Cao**, University of Notre Dame.

Geometric Function Theory and Analysis on Metric Spaces, **Sergiy Merenkov**, **Jeremy Taylor Tyson**, and **Jang-Mei Wu**, University of Illinois at Urbana-Champaign.

Geometric Group Theory, **Sergei V. Ivanov**, **Ilya Kapovich**, **Igor Mineyev**, and **Paul E. Schupp**, University of Illinois at Urbana-Champaign.

Graph Theory, **Alexander V. Kostochka** and **Douglas B. West**, University of Illinois at Urbana-Champaign.

Holomorphic and CR Mappings, **John P. D'Angelo**, **Jiri Lebl**, and **Alex Tumanov**, University of Illinois at Urbana-Champaign.

Hyperbolic Geometry and Teichmüller Theory, **Jason Deblois**, University of Illinois at Chicago, **Richard P. Kent IV**, Brown University, and **Christopher J. Leininger**, University of Illinois at Urbana-Champaign.

Local and Homological Methods in Commutative Algebra, **Florian Enescu**, Georgia State University, and **Sandra Spiroff**, University of Mississippi.

Mathematical Visualization, **George K. Francis**, University of Illinois at Urbana-Champaign, **Louis H. Kauffman**, University of Illinois at Chicago, **Dennis Martin Roseman**, University of Iowa, and **Andrew J. Hanson**, Indiana University.

Nonlinear Partial Differential Equations and Applications, **Igor Kukavica**, University of Southern California, and **Anna L. Mazzucato**, Pennsylvania State University.

Number Theory in the Spirit of Erdős, **Kevin Ford** and **A. J. Hildebrand**, University of Illinois at Urbana-Champaign.

Operator Algebras and Operator Spaces, **Zhong-Jin Ruan**, **Florin P. Boca**, and **Marius Junge**, University of Illinois at Urbana-Champaign.

Probabilistic and Extremal Combinatorics, **Jozsef Balogh** and **Zoltan Furedi**, University of Illinois at Urbana-Champaign.

The Interface Between Number Theory and Dynamical Systems, **Florin Boca**, University of Illinois at Urbana-Champaign, **Jeffrey Lagarias**, University of Michigan, and **Kenneth Stolarsky**, University of Illinois at Urbana-Champaign.

The Logic and Combinatorics of Algebraic Structures, **John Snow**, Concordia University, and **Jeremy Alm**, Illinois College.

Time, Scale and Frequency Methods in Harmonic Analysis, **Richard S. Laugesen**, University of Illinois at Urbana-Champaign, and **Darrin M. Speegle**, St. Louis University.

Topological Dynamics and Ergodic Theory, **Alica Miller**, University of Louisville, and **Joseph Rosenblatt**, University of Illinois at Urbana-Champaign.

Topological Field Theories, Representation Theory, and Algebraic Geometry, **Thomas Nevins**, University of Illinois at Urbana-Champaign, and **David Ben-Zvi**, University of Texas at Austin.

q-Series and Partitions, **Bruce Berndt**, University of Illinois at Urbana-Champaign, and **Ae Ja Yee**, Pennsylvania State University.

Raleigh, North Carolina

North Carolina State University

April 4–5, 2009

Saturday – Sunday

Meeting #1048

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: January 2009
Program first available on AMS website: February 19, 2009
Program issue of electronic *Notices*: April 2009
Issue of *Abstracts*: Volume 30, Issue 2

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

Nathan Dunfield, University of Illinois at Urbana-Champaign, *Surfaces in finite covers of 3-manifolds: The virtual Haken conjecture.*

Reinhard C. Laubenbacher, Virginia Bioinformatics Institute, *Algebraic models in systems biology.*

Jonathan C. Mattingly, Duke University, *Stochastically forced fluid equations: Transfer between scales and ergodicity.*

Raman Parimala, Emory University, *Arithmetic of linear algebraic groups over 2-dimensional geometric fields.*

Michael S. Waterman, University of Southern California, *Reading DNA sequences: Twenty-first century technology with eighteenth century mathematics* (Einstein Public Lecture in Mathematics).

Special Sessions

Advancements in Turbulent Flow Modeling and Computation, **Leo G. Rebholz**, Clemson University, and **Traian Iliescu**, Virginia Polytechnic Institute and State University.

Algebraic Groups and Symmetric Spaces, **Stacy Beun**, Cabrini College, and **Aloysius Helminck**, North Carolina State University.

Applications of Algebraic and Geometric Combinatorics, **Seth M. Sullivant**, Harvard University, and **Carla D. Savage**, North Carolina State University.

Applications of Dynamical Systems to Problems in Biology, **John E. Franke** and **James F. Selgrade**, North Carolina State University.

Brauer Groups, Quadratic Forms, Algebraic Groups, and Lie Algebras, **Eric S. Brussel** and **Skip Garibaldi**, Emory University.

Commutative Rings and Monoids, **Scott T. Chapman**, Sam Houston State University, and **James B. Coykendall**, North Dakota State University.

Computational Methods in Lie Theory, **Eric Sommers**, University of Massachusetts, Amherst, and **Molly Fenn**, North Carolina State University.

Deferred Correction Methods and their Applications, **Elizabeth L. Bouzarth** and **Anita T. Layton**, Duke University.

Enumerative Geometry and Related Topics, **Richard L. Rimanyi**, University of North Carolina, Chapel Hill, and **Leonardo C. Mihalcea**, Duke University.

Galois Module Theory and Hopf Algebras, **Robert G. Underwood**, Auburn University Montgomery, and **James E. Carter**, College of Charleston.

Geometry of Differential Equations, **Thomas A. Ivey**, College of Charleston, and **Irina A. Kogan**, North Carolina State University.

Homotopical Algebra with Applications to Mathematical Physics, **Thomas J. Lada**, North Carolina State University, and **Jim Stasheff**, University of North Carolina, Chapel Hill.

Kac-Moody Algebras, Vertex Algebras, Quantum Groups, and Applications, **Bojko N. Bakalov**, **Kailash C. Misra**, and **Naihuan N. Jing**, North Carolina State University.

Low-Dimensional Topology and Geometry, **Nathan M. Dunfield**, University of Illinois at Urbana-Champaign,

John B. Etnyre, Georgia Institute of Technology, and **Lenhard Ng**, Duke University.

Mathematical Progress and Challenges for Biological Materials, **Mansoor A. Haider**, North Carolina State University, and **Gregory Forest**, University of North Carolina, Chapel Hill.

Mathematics of Immunology and Infectious Diseases, **Stanca M. Ciupe**, Duke University, and **Jonathan Forde**, Hobart and William Smith Colleges.

Nonlinear Dynamics and Control, **Anthony M. Bloch**, University of Michigan, Ann Arbor, and **Dmitry Zenkov**, North Carolina State University.

Numerical Solution of Partial Differential Equations and Applications, **Alina Chertock** and **Zhilin Li**, North Carolina State University.

Recent Advances in Symbolic Algebra and Analysis, **Michael F. Singer** and **Agnes Szanto**, North Carolina State University.

Rings, Algebras, and Varieties in Combinatorics, **Patricia Hersh**, North Carolina State University, **Christian Lenart**, SUNY Albany, and **Nathan Reading**, North Carolina State University.

Stochastic Dynamics, **Yuri Bakhtin**, Georgia Institute of Technology, and **Scott McKinley** and **Jonathan C. Mattingly**, Duke University.

The Mathematics of Biochemical Reaction Networks, **Anne Shiu**, University of California Berkeley, **Manoj Gopalkrishnan**, University of Southern California, and **Gheorghe Craciun**, University of Wisconsin-Madison.

San Francisco, California

San Francisco State University

April 25–26, 2009

Saturday – Sunday

Meeting #1049

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: February 2009
Program first available on AMS website: March 12, 2009
Program issue of electronic *Notices*: April 2009
Issue of *Abstracts*: Volume 30, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: March 3, 2009

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Yehuda Shalom, University of California Los Angeles, *Title to be announced*.

Roman Vershynin, University of California Davis, *Title to be announced*.

Karen Vogtmann, Cornell University, *Title to be announced*.

Efim Zelmanov, University of California San Diego, *Title to be announced*.

Special Sessions

Advances in the Theory of Integer Linear Optimization and its Extensions (Code: SS 7A), **Matthias Koeppe** and **Peter Malkin**, University of California Davis.

Algebra and Number Theory with Polyhedra (Code: SS 11A), **Matthias Beck**, San Francisco State University, and **Christian Haase**, Freie Universität Berlin.

Applications of Knot Theory to the Entanglement of Biopolymers (Code: SS 10A), **Javier Arsuaga**, San Francisco State University, **Kenneth Millett**, University of California Santa Barbara, and **Mariel Vazquez**, San Francisco State University.

Aspects of Differential Geometry (Code: SS 9A), **David Bao**, San Francisco State University, and **Lei Ni**, University of California San Diego.

Banach Algebras, Topological Algebras and Abstract Harmonic Analysis (Code: SS 1A), **Thomas V. Tonev**, University of Montana-Missoula, and **Fereidoun Ghahramani**, University of Manitoba.

Concentration Inequalities (Code: SS 3A), **Sourav Chatterjee**, University of California Berkeley, and **Roman Vershynin**, University of California Davis.

Geometry and Topology of Orbifolds (Code: SS 6A), **Elizabeth Stanhope**, Lewis & Clark University, and **Joseph E. Borzellino**, California State University San Luis Obispo.

Lie Group Actions, Teichmüller Flows and Number Theory (Code: SS 12A), **Jayadev Athreya**, Yale University, **Yitwah Cheung**, San Francisco State University, and **Anton Zorich**, Rennes University.

Matroids in Algebra and Geometry (Code: SS 8A), **Federico Ardila**, San Francisco State University, and **Lauren Williams**, Harvard University.

Nonlinear Dispersive Equations (Code: SS 4A), **Sebastian Herr**, University of California Berkeley, and **Jeremy L. Marzuola**, Columbia University.

Nonlinear Partial Differential Equations (Code: SS 13A), **Igor Kukavica**, **Amjad Tuffaha**, and **Mohammed Ziane**, University of Southern California.

Recent Progress in Geometric Group Theory (Code: SS 2A), **Seonhee Lim** and **Anne Thomas**, Cornell University.

Worcester, Massachusetts

Worcester Polytechnic Institute

April 25–26, 2009

Saturday – Sunday

Meeting #1050

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: February 2009
Program first available on AMS website: March 12, 2009
Program issue of electronic *Notices*: April 2009
Issue of *Abstracts*: Volume 30, Issue 3

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: March 3, 2009

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Octav Cornea, Université de Montréal, *Lagrangian submanifolds: From physics to number theory*.

Fengbo Hang, Courant Institute of New York University, *Topology of weakly differentiable maps*.

Umberto Mosco, Worcester Polytechnic Institute, *Fractal spectra between Scylla and Charybdis*.

Kevin Whyte, University of Illinois at Chicago, *A rapid survey of coarse geometry*.

Special Sessions

Algebraic Graph Theory, Association Schemes, and Related Topics (Code: SS 8A), **William J. Martin**, Worcester Polytechnic Institute, and **Sylvia A. Hobart**, University of Wyoming.

Analysis of Weakly Differentiable Maps with Constraints and Applications (Code: SS 11A), **Fengbo Hang**, Courant Institute, New York University, and **Mohammad Reza Pakzad**, University of Pittsburgh.

Discrete Geometry and Combinatorics (Code: SS 5A), **Egon Schulte**, Northeastern University, and **Brigitte Servatius**, Worcester Polytechnic Institute.

Effective Dynamics and Interactions of Localized Structures in Schrödinger Type Equations (Code: SS 10A), **Fridolin Ting**, Lakehead University.

Number Theory (Code: SS 4A), **John T. Cullinan**, Bard College, and **Siman Wong**, University of Massachusetts, Amherst.

Quasi-Static and Dynamic Evolution in Fracture Mechanics (Code: SS 6A), **Christopher J. Larsen**, Worcester Polytechnic Institute.

Real and Complex Dynamics of Rational Difference Equations with Applications (Code: SS 9A), **M. R. S. Kulenovic** and **Orlando Merino**, University of Rhode Island.

Scaling, Irregularities, and Partial Differential Equations (Code: SS 7A), **Umberto Mosco** and **Bogdan M. Vernescu**, Worcester Polytechnic Institute.

Symplectic and Contact Topology (Code: SS 1A), **Peter Albers**, Purdue University/ETH Zurich, and **Basak Gurel**, Vanderbilt University.

The Mathematics of Climate Change (Code: SS 3A), **Catherine A. Roberts** and **Gareth E. Roberts**, College of the Holy Cross, and **Mary Lou Zeeman**, Bowdoin College.

Topological Robotics (Code: SS 2A), **Li Han** and **Lee N. Rudolph**, Clark University.

Waco, Texas

Baylor University

October 16–18, 2009

Friday – Sunday

Meeting #1051

Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: August 2009
Program first available on AMS website: September 3, 2009
Program issue of electronic *Notices*: October 2009
Issue of *Abstracts*: Volume 30, Issue 4

Deadlines

For organizers: March 17, 2009
For consideration of contributed papers in Special Sessions: June 30, 2009
For abstracts: August 25, 2009

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

David Ben-Zvi, University of Texas at Austin, *Title to be announced*.

Alexander A. Kiselev, University of Wisconsin, *Title to be announced*.

Michael C. Reed, Duke University, *Title to be announced*.

Igor Rodnianski, Princeton University, *Title to be announced*.

Special Sessions

Commutative Algebra: Module and Ideal Theory (Code: SS 4A), **Lars W. Christensen**, Texas Tech University, **Louiza Fouli**, University of Texas at Austin, and **David Jorgensen**, University of Texas at Arlington.

Dynamic Equations on Time Scales: Analysis and Applications (Code: SS 1A), **John M. Davis**, **Ian A. Gravagne**, and **Robert J. Marks**, Baylor University.

Lie Groups, Lie Algebras, and Representations (Code: SS 6A), **Markus Hunziker**, **Mark Sepanski**, and **Ronald Stanke**, Baylor University.

Mathematical Models of Neuronal and Metabolic Mechanisms (Code: SS 3A), **Janet Best**, Ohio State University, and **Michael Reed**, Duke University.

Numerical Solutions of Singular or Perturbed Partial Differential Equation Problems with Applications (Code: SS 2A), **Peter Moore**, Southern Methodist University, and **Qin Sheng**, Baylor University.

Topological Methods for Boundary Value Problems for Ordinary Differential Equations (Code: SS 5A), **Richard Avery**, Dakota State University, **Paul W. Eloe**, University of Dayton, and **Johnny Henderson**, Baylor University.

University Park, Pennsylvania

Pennsylvania State University

October 24–25, 2009

Saturday – Sunday

Meeting #1052

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: August 2009
Program first available on AMS website: September 10, 2009
Program issue of electronic *Notices*: October 2009
Issue of *Abstracts*: Volume 30, Issue 4

Deadlines

For organizers: March 24, 2009
For consideration of contributed papers in Special Sessions: July 7, 2009
For abstracts: September 1, 2009

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Michael K. H. Kiessling, Rutgers University, *Title to be announced.*

Kevin R. Payne, Universita degli di Milano, *Title to be announced.*

Laurent Saloff-Coste, Cornell University, *Title to be announced.*

Robert C. Vaughan, Penn State University, *Title to be announced.*

Special Sessions

Difference Equations and Applications (Code: SS 2A), **Michael A. Radin**, Rochester Institute of Technology.

Homotopy Theory (Code: SS 1A), **James Gillespie** and **Mark W. Johnson**, Pennsylvania State University, **Simona Paoli**, University of Haifa, and **Donald Yau**, Ohio State University.

Boca Raton, Florida

Florida Atlantic University

October 30 – November 1, 2009

Friday – Sunday

Meeting #1053

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: August 2009
Program first available on AMS website: September 17, 2009
Program issue of electronic *Notices*: October 2009
Issue of *Abstracts*: Volume 30, Issue 4

Deadlines

For organizers: March 30, 2009
For consideration of contributed papers in Special Sessions: July 14, 2009
For abstracts: September 8, 2009

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Spyros Alexakis, Princeton University, *Title to be announced.*

Kai-Uwe Bux, University of Virginia, *Title to be announced.*

Dino J. Lorenzini, University of Georgia, *Title to be announced.*

Eduardo D. Sontag, Rutgers University, *Title to be announced.*

Special Sessions

Commutative Ring Theory (Code: SS 3A), **Alan Loper**, Ohio State University, and **Lee C. Klingler**, Florida Atlantic University.

Concentration, Functional Inequalities, and Isoperimetry (Code: SS 2A), **Mario Milman**, Florida Atlantic University, **Christian Houdre**, Georgia Institute of Technology, and **Emanuel Milman**, Institute for Advanced Study.

Constructive Mathematics (Code: SS 1A), **Robert Lubarsky**, **Fred Richman**, and **Martin Solomon**, Florida Atlantic University.

Dynamical Systems (Code: SS 6A), **William D. Kalies** and **Vincent Naudot**, Florida Atlantic University.

Enumerative Combinatorics (Code: SS 4A), **Christian Krattenthaler**, University of Vienna, and **Aaron D. Meyerowitz**, **Heinrich Niederhausen**, and **Wandi Wei**, Florida Atlantic University.

Harmonic Analysis (Code: SS 5A), **Galia D. Dafni**, Concordia University, and **J. Michael Wilson**, University of Vermont, Burlington.

Homological Aspects of Module Theory (Code: SS 7A), **Andrew R. Kustin**, University of South Carolina, **Sean M. Sather-Wagstaff**, North Dakota State University, and **Janet Vassilev**, University of New Mexico.

Riverside, California

University of California

November 7–8, 2009

Saturday – Sunday

Meeting #1054

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: September 2009
Program first available on AMS website: September 24, 2009
Program issue of electronic *Notices*: November 2009
Issue of *Abstracts*: Volume 30, Issue 4

Deadlines

For organizers: April 6, 2009
For consideration of contributed papers in Special Sessions: July 21, 2009
For abstracts: September 15, 2009

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Christopher Hacon, University of Utah, *Title to be announced.*

Birge Huisgen-Zimmerman, University of California Santa Barbara, *Title to be announced.*

Jun Li, Stanford University, *Title to be announced.*

Joseph Teran, University of California Los Angeles, *Title to be announced.*

Special Sessions

Algebraic Geometry (Code: SS 1A), **Christopher Hacon**, University of Utah, and **Ziv Ran**, University of California Riverside.

Fluid Mechanics (Code: SS 5A), **James Kelliher** and **Qi Zhang**, University of California Riverside.

Fractal Geometry, Dynamical Systems, Number Theory and Analysis on Rough Spaces (Code: SS 6A), **Michel L. Lapidus**, University of California Riverside, **Hung Lu**, Hawaii Pacific University, and **Erin P. J. Pearse**, University of Iowa.

History and Philosophy of Mathematics (Code: SS 4A), **Shawnee L. McMurran**, California State University San Bernardino, and **James J. Tattersall**, Providence College.

Homotopy Theory and Higher Algebraic Structures (Code: SS 8A), **John Baez** and **Julie Bergner**, University of California Riverside.

Interactions Between Algebraic Geometry and Noncommutative Algebra (Code: SS 9A), **Kenneth R. Goodearl**, University of California Santa Barbara, **Daniel S. Rogalski**, University of California San Diego, **James Zhang**, University of Washington.

Noncommutative Geometry (Code: SS 2A), **Vasiliy Dolgushev** and **Wee Liang Gan**, University of California Riverside.

Representation Theory (Code: SS 3A), **Vyjayanthi Chari**, **Wee Liang Gan**, and **Jacob Greenstein**, University of California Riverside.

Representations of Finite Dimensional Algebras (Code: SS 7A), **Frauke Bleher**, University of Iowa, **Birge Huisgen-Zimmermann**, University of California at Santa Barbara, and **Markus Schmidmeier**, Florida Atlantic University.

Research Conducted by Students (Code: SS 10A), **Robert G. Niemeyer**, University of California Riverside, and **Jack R. Bennett**, University of California Riverside.

Seoul, Korea

December 16–20, 2009

Wednesday – Sunday

First Joint International Meeting of the AMS and the Korean Mathematical Society.

Meeting #1055

Associate secretary: Georgia Benkart
Announcement issue of *Notices*: June 2009
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

San Francisco, California

Moscone Center West and the San Francisco Marriott

January 13–16, 2010

Wednesday – Saturday

Joint Mathematics Meetings, including the 116th Annual Meeting of the AMS, 93rd Annual Meeting of the Mathematical Association of America (MAA), annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society of Industrial and Applied Mathematics (SIAM).

Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2009
Program first available on AMS website: November 1, 2009
Program issue of electronic *Notices*: January 2010
Issue of *Abstracts*: Volume 31, Issue 1

Deadlines

For organizers: April 1, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Lexington, Kentucky

University of Kentucky

March 27–28, 2010

Saturday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
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 28, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

St. Paul, Minnesota

Macalester College

April 10–11, 2010

Saturday – Sunday
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 10, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Albuquerque, New Mexico

University of New Mexico

April 17–18, 2010

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*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 17, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Hoboken, New Jersey

New Jersey Institute of Technology

May 22–23, 2010

Saturday – Sunday
Eastern Section
Associate secretary: Steven H. Weintraub
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: November 23, 2009
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Berkeley, California

University of California Berkeley

June 2–5, 2010

Wednesday – Saturday
Eighth Joint International Meeting of the AMS and the Sociedad Matemática Mexicana.
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: February 2010
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

Notre Dame, Indiana

Notre Dame University

September 18–19, 2010

Saturday – Sunday
Central Section
Associate secretary: Susan J. Friedlander
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: February 19, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Los Angeles, California

University of California Los Angeles

October 9–10, 2010

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*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 10, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

New Orleans, Louisiana

New Orleans Marriott and Sheraton New Orleans Hotel

January 5–8, 2011

Wednesday – Saturday
Joint Mathematics Meetings, including the 117th Annual Meeting of the AMS, 94th 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: Steven H. Weintraub
Announcement issue of *Notices*: October 2010
Program first available on AMS website: November 1, 2010
Program issue of electronic *Notices*: January 2011
Issue of *Abstracts*: Volume 32, Issue 1

Deadlines

For organizers: April 1, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Statesboro, Georgia

Georgia Southern University

March 12–13, 2011

Saturday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
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 12, 2010
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Boston, Massachusetts

John B. Hynes Veterans Memorial Convention Center, Boston Marriott Hotel, and Boston Sheraton Hotel

January 4–7, 2012

Wednesday – Saturday
Joint Mathematics Meetings, including the 118th Annual Meeting of the AMS, 95th 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: Michel L. Lapidus
Announcement issue of *Notices*: October 2011

Program first available on AMS website: November 1, 2011
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 33, Issue 1

Deadlines

For organizers: April 1, 2011
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 9–12, 2013

Wednesday – Saturday
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: Susan J. Friedlander
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: April 1, 2012
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: 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

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

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: Susan J. Friedlander, Department of Mathematics, University of Illinois at Chicago, 851 S. Morgan (M/C 249), Chicago, IL 60607-7045; e-mail: `susan@math.nwu.edu`; telephone: 312-996-3041.

Eastern Section: Lesley M. Sibner (until January 31, 2009), Department of Mathematics, Polytechnic University, Brooklyn, NY 11201-2990; e-mail: `lsibner@duke.poly.edu`; telephone: 718-260-3505. **Steven H. Weintraub** (after January 31, 2009), Department of Mathematics, Lehigh University, Bethlehem, PA 18105-3174; e-mail: `steve.weintraub@lehigh.edu`; telephone: 610-758-3717.

Southeastern Section: Matthew Miller, Department of Mathematics, University of South Carolina, Columbia, SC 29208-0001, e-mail: `miller@math.sc.edu`; telephone: 803-777-3690.

2009 Seoul, Korea Meeting: 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.

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:

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 89 in the January 2009 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.)

Co-sponsored conferences:

February 12–16, 2009: AAAS Meeting in Chicago, IL (see page 86, January 2009 issue for more information).

June 13–July 3, 2009: Mathematics Research Communities, Snowbird, UT (see `www.ams.org/amsmtgs/mrc.html` for more information).

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