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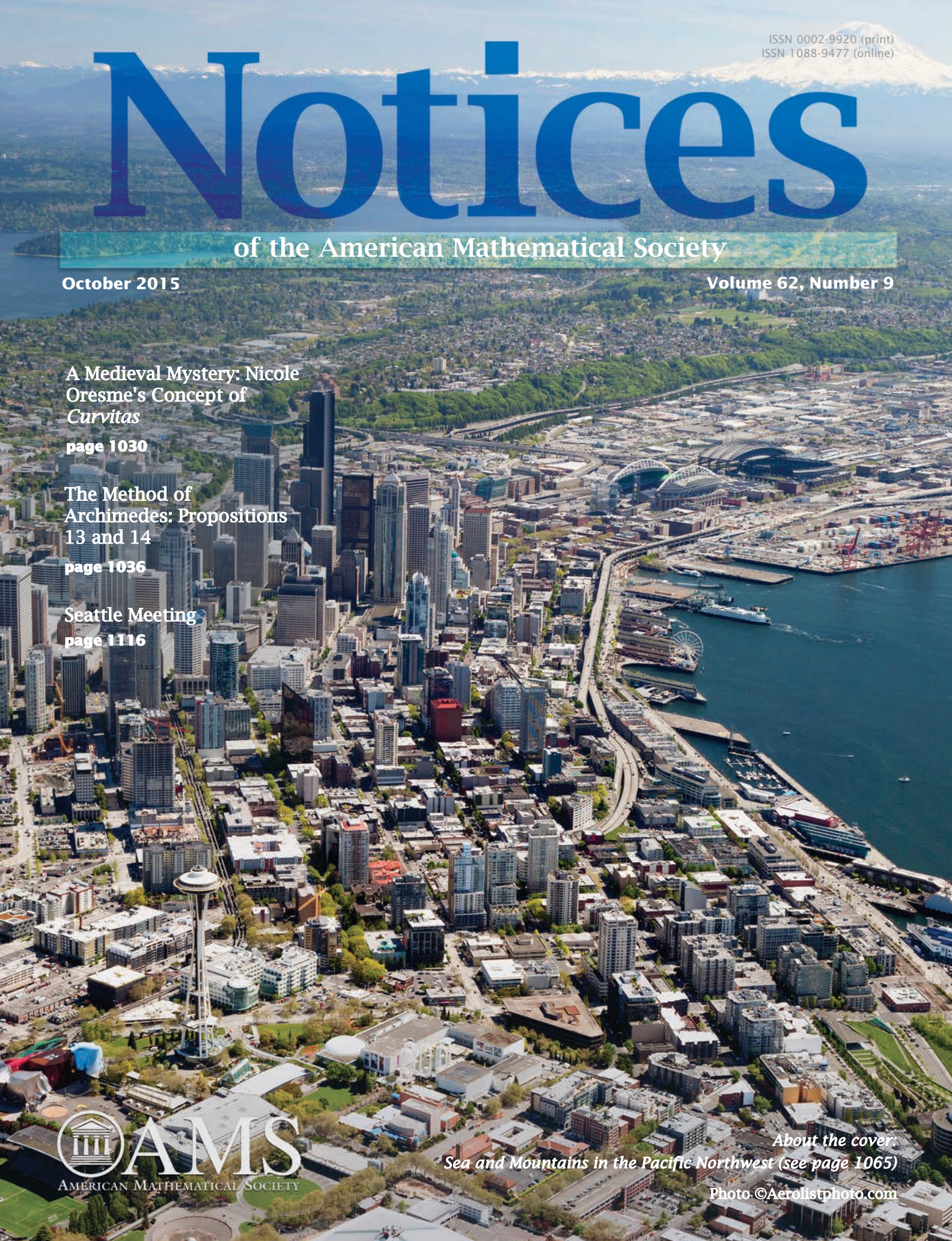

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About the cover:
Sea and Mountains in the Pacific Northwest (see page 1065)

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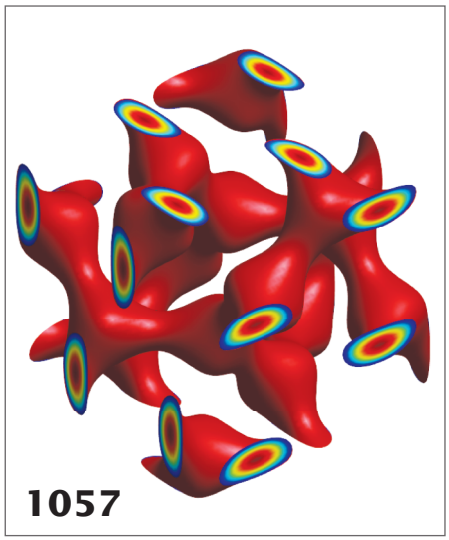
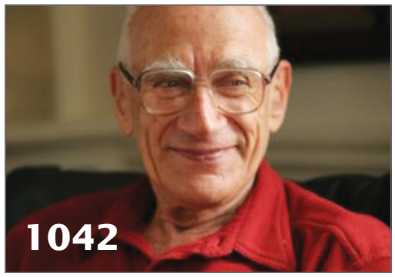
Communications

Commentary





The October issue of *The Notices* contains many pleasures. There is a feature about Archimedes's palimpsest, and another that traces the concept of curvature back to Nicole Oresme. A doctoral student and an associate professor of mathematics from Purdue have teamed to pen a *Doceamus* piece about teaching university mathematics; there is a retrospective on the life and work of topologist Dan Kan, and, finally, there is a report on the STaR program at the University of Missouri–Columbia.

—Steven G. Krantz, Editor

Features

Notices

of the American Mathematical Society

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Departments

JMM 2016:

From the AMS Secretary

972799^2_{10}=111001100000110101_5

A recent *Notices* article [1] on Kurt Mahler quoted part of his 1988 letter to van der Poorten on basimal experimental mathematics. Specifically, Mahler found 20^2_{10}= 400_{10}=1111_7=26^2_7 and stated he could not find a base 5 example of a square containing only 1s and 0s.

Richard Guy [2] has classified similar open questions in base 10 as F24 Some decimal digital problems or F31 Miscellaneous digital problems. This question is related but expands the search to other bases where the probabilities differ.

My computer search yielded 972799^2_{10}=222112144^2_5=$1110011000 00110101_5$. Web searches yield additional results: 22222111221444^2_5 and 100024441003001^2_5 [3]. Of course, 5^{2n} multiples of these numbers also work for an infinite set of examples.

—Keith G. Calkins
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References

[1] J. M. Borwein, Y. Bugeaud, M. Coons, The Legacy of Kurt Mahler, *Notices of the AMS* **62** (2015), 526–531.

[2] R. K. Guy, *Unsolved Problem in Number Theory*, third edition, Springer Verlag, New York, 2004.

[3] mathoverflow.net/questions/22/can-n2-have-only-digits-0-and-1-other-than-n-10k

(Received June 10, 2015)

Traditional Proofs vs. Structured Proofs

The authors of the article, "Investigating and Improving Undergraduate Proof Comprehension," on pp. 742–752 in the August 2015 issue of the *Notices*, deserve the highest praise for attempting to use scientific methodology to determine ways of improving proof comprehension by undergraduates. However, they seem not to have investigated a proof technique that, in my experience, is very helpful for making difficult proofs easier to understand. I am referring to what is sometimes called "structured proof."

A structured proof is like a structured computer program. At the top level there are a few steps that, provided that each of the steps is true, constitute a valid logical argument for the truth of the theorem or lemma in question. Each of the steps consists of a few substeps that, provided that each of the substeps is true, constitute a valid logical argument for the truth of the step in question. And so on, recursively, down to a sufficiently low level that each of the steps is known to be true by virtue of the knowledge assumed of any reader of the proof.

This structure can be applied to any proof, be it one page or ten pages or hundreds of pages long. The reader has only a few steps to comprehend at any time. He or she can choose the level of detail he or she wishes to deal with.

Traditional proofs require that the reader somehow understand the entire argument as he or she proceeds. This is typically difficult even if lemmas or theorems are invoked at various points in the proof. With structured proof, all proofs are "the same" (have the same structure) whereas with traditional proof, all proofs are "different" (do not have the same structure, as seen on the page).

Although there are papers in the literature, e.g., by Leslie Lamport, about structured proof, the technique has never become widely practiced, certainly not in any of the textbooks I am familiar with.

I strongly urge the authors of the above article to, (1) try structuring a few proofs, and then (2) try introducing the technique to some of their students.

I should mention that the technique is also very helpful when one is trying to create a proof of one's own.

—Peter Schorer
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(Received July 20, 2015)

Reply to Schorer

We are very grateful to Peter Schorer for his kind comments on our article, and for suggesting we investigate structured proofs. In fact there has been some empirical research on the effectiveness of this presentation method. A group from Rutgers University (Fuller, Weber, Mejía-Ramos, Rhoads & Samkoff, 2014) investigated how presenting proofs in this structured format influences undergraduates' comprehension. They found mixed results: compared to those who read a traditional proof, the students in their study who read a structured proof were significantly better at identifying a good summary of the proof, but slightly (albeit nonsignificantly) worse at all other aspects of proof comprehension (on questions concerning justifications within the proof, transferring the ideas from the proof to another setting, and illustrating the ideas of the proof using examples). However, as far as we know this is the only empirical investigation of this topic. We agree that this is an area ripe for further investigation, and we would encourage those interested in collaborating on such an endeavour to make contact.

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References

E. Fuller, K. Weber, J. P. Mejía-Ramos, K. Rhoads, and A. Samkoff, Comprehending structured proofs, *International Journal for Studies in Mathematics Education*, 7(1), (2014), 1–32.

(Received July 26, 2015)

A Medieval Mystery: Nicole Oresme's Concept of *Curvitas*

Isabel M. Serrano and Bogdan D. Suceavă

In a paper published in 1952, J. L. Coolidge (1873–1954) appreciates that the story of curvature is "unsatisfactory" [2], and he points out that "the first writer to give a hint of the definition of curvature was the fourteenth century writer Nicole Oresme, whose work was called to my attention by Carl Boyer." Then Coolidge comments: "Oresme conceived the curvature of a circle as inversely proportional to the radius; how did he find this out?" The scholarly conditions of the fourteenth century make this discovery phenomenal and the question as to how it was achieved worth researching. In the present article we describe how a fourteenth-century scholar (i) gave a correct definition for curvature of circles and attempted to extend it to general curves, (ii) tried to apply curvature to understand the behavior of real-life phenomena, and (iii) produced in his research a statement that anticipates the fundamental theorem of curves in the plane.

In various cases Oresme's work is not cited when the history of curvature is discussed (e.g., [5], [8]), while some authors (e.g., [1], p. 191) make note of his contribution to this concept. Several scholars have even concluded that the medieval sciences contributed very little to the modern scientific revolution. In addressing this perception, Edward

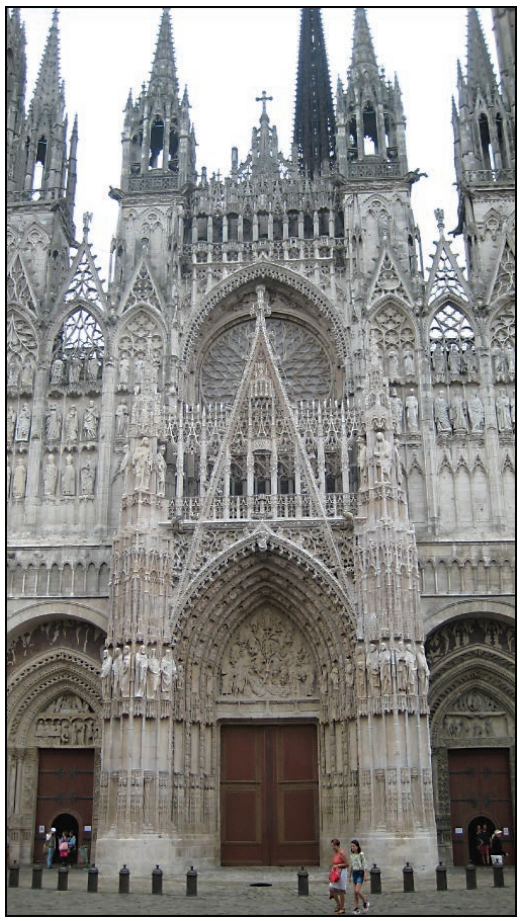

Photo courtesy of Vlad Ştefan Barbu.

The Rouen Cathedral where Nicole Oresme served first as canon, then as dean of the Cathedral, after 1362.

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Grant [3] writes: "Even if the Middle Ages made few significant contributions to the advancement of the sciences themselves, or none at all, […] if no noteworthy medieval contributions were made to help shape specific scientific advances in the seventeenth century, in what ways did the Middle Ages contribute to the Scientific Revolution and, more to the point, lay the foundations for it?" We describe in the present article that curvature is one of the concepts that was first defined in the Middle Ages. The importance of the idea of curvature is described in many works (e.g., [1], [5], [8], [10]), and we don't feel we should elaborate on this point.

Nicole Oresme was born around 1320 in the village of Allemagne, near Caen, today Fleury-sur-Orne [6]. The first certain fact in his biography is that he was a "bursar" of the College of Navarre from 1348 to October 4, 1356, when he became a Master. The College of Navarre, established by Queen Joan I of Navarre in 1305, focused on teaching the arts, philosophy, and theology. Oresme's major was in theology. As a student, he had to observe the code at the College of Navarre, where the students were required to speak and write only in Latin; his ability to work in Latin would prove critical in his future work. Oresme studied, among others, with Jean Buridan and Albert of Saxony. It was at this institution where he wrote his most important works, e.g., *De proportionibus proportionum*, which is of particular importance for the history of mathematics, or *Ad pauca respicientes,* of interest for the history of ideas in celestial mechanics. Oresme remained Grand Master of the College until December 4, 1361, when he was forced to resign [6]. On November 23, 1362, he became a canon of the Rouen Cathedral (a place of major importance in the history of France), and on March 18, 1364, he was promoted to dean of the Cathedral. Oresme was in that period king's confessor and adviser, and some time before 1370 he became one of Charles V's (1364–80) chaplains; at the king's request he translated from Latin into French Aristotle's *Ethics* (1370) and *Politics*, as well as *Economics*.

As Marshall Clagett points out [7], it is very likely that *De configurationibus* was written in the interval 1351–55. To better depict this historical period, we recall here that during this period, Geoffrey Chaucer, later considered the father of English literature, was still a child in London. These are the same years when Giovanni Boccaccio wrote the *Decameron*, largely completed by 1352. In Florence, Francesco Petrarch, the first to coin the name of the "Dark Ages", was writing in Latin *De vita solitaria*. One of the main historical references for that historical period is Jean Froissart's *Chronicles*, describing the battles from the Hundred Years' War and the Black Death, impacting most of Europe in the interval 1346–53. The cathedral Notre-Dame de Paris was just completed a few years before, in 1345, and dominated the skyline of medieval Paris. In short, this period of time was infested with conflict and tragedy, greatly occupying civilian minds and making the main focus of life survival. The poets and the scientists worked in many cases in isolation for long intervals of time.

In the time frame in which Oresme wrote, the language of functions was not yet used in mathematics. It is impressive that Oresme reached the concept of curvature before the concept of function was established. He had to invent and express his thoughts without several fundamental mathematical concepts to refer to, thus making his explanations on curvature unique. These circumstances justify why Marshall Clagett is correct in discussing a "doctrine" [7] when he described Oresme's original contributions.

Clagett's critical edition including the treatise *De configurationibus* [7] was published in 1968, over a decade after J. L. Coolidge was hoping to see a more complete history of curvature. Clagett (1916–2005) notes (see [7], pp. 50–51) that the first instance of Oresme's comments on representation of quantity by either a line or surface of a body are his remarks to *Questions on the Geometry of Euclid*, more precisely when he discusses questions 10 and 11. Oresme refers to other authors, such as Witelo and Lincoln (i.e., Robert Grosseteste), "who in this manner imagine the intensity of light," and to "Aristotle, who in the fourth [book] of the *Physics* imagines time by means of a line." He also includes "the Commentator [Campanus] in the fifth [book] of this work [the *Elements*] where he holds, in expounding ratios, that everything having the nature of a continuum can be imagined as a line, surface, or body." Clagett points out ([7], p. 51) that the reference to Aristotle's work is "to the effect that every magnitude is continuous, and movement follows magnitude; therefore movement and hence time are continuous, for motion and time seem to be proportional." In short, Oresme's "doctrine" is actually a theory describing how quantities could be described by graphs. The concept was novel at that time, although it was based on Aristotle's earlier work.

In the first part (the first forty chapters) of *De configurationibus*, Oresme sets up the groundwork for the doctrine of configurations; then he applies the doctrine to qualities, focusing on "entities" which are permanent or enduring in time. While discussing these elements, he suggests that his theory could explain numerous physical and psychological phenomena. In the second part of *De configurationibus* (the next forty chapters), Oresme describes how graphical representation can be applied to "entities that are successive"; in particular, he applies the doctrine of "figurations" to motion. He concludes this part with several examples that could be extended to psychological effects, including the perceptions that are described as magic.

Finally, Oresme describes external geometrical figures used to represent qualities and motions. He compares the areas of such figures and concludes that by comparing the areas, one may have a basis for the comparison of different qualities and motions.

The donjon tower of the Château de Vincennes, in Paris, is 52 meters high and represents the tallest medieval fortified structure in Europe. King Philip VI of France started this work about 1337. The work was completed during Charles V's reign. When Nicole Oresme was a scholar in Paris, this donjon was in the process of being erected. Later on, during the reign of Charles V, this donjon served as a residence for the royal family. Its buildings are known to have once held the library and personal study of Charles V.

To fully describe his theory, Oresme begins his *De configurationibus* with the following clarification: "Every measurable thing except numbers is imagined in the manner of continuous quantity." Then he pursues a discussion of the latitude and longitude of qualities, followed with the presentation of their quantity. He leads into his argument that qualities can be "figured." He spends several chapters discussing suitability of figures and shape of various particular cases. This discussion suggests an early analysis of curves in general position, if we are to refer to the modern concept. One important distinction appears in chapter I.xi, where Oresme examines the differences between uniform and difform qualities. He continues his focus on this topic in I.xiv with a discussion of "simple difform difformity," which is of two kinds: simple and composite. In this chapter he uses "linea curva" for a curve, and "curvitas" to express its curvature. In I.xv he begins describing four kinds of simple difform difformity, which are explained by drawing graphs. There is little doubt that the author builds here an early approach to variable quantities and their corresponding graphical representation. After this extensive discussion, performed without any algebraic notation, Oresme approaches "surface quality." Finally, in chapters I.xix, I.xx, and I.xxi, he introduces curvature. Additionally, in chapters I.xv and I.xvi, Oresme describes graphs that are concave and convex. Due to the context of his analysis, Oresme actually performs the first exploration of the possible connections between curvature and convexity.

A particular case in this doctrine of qualities is represented by curvature (chapter I.xx), endowed with "both extension and intensity." Oresme writes (in M. Clagett's translation, [7], p. 215): "We do not know with what, or with regard to what, the intensity of curvature is measured. For now it appears to me that there are only two [possible] ways [to speak of the measure of curvature]. The first is that the increase in curvature is a function of its departure from straightness, i.e., of its distance from straightness. This is [to be measured] by the quantity of the angle constituted of a straight line and a curve, e.g., an angle of contingence or perhaps another angle also constructed from a straight line and a curve." This very intuitive description is very consistent with the modern study of signed curvature and its relationship with the change of turning angle with respect to arc length. Even further, Nicole Oresme reaches a more precise description. He writes specifically that the curvature of the circle is the inverse of its radius (in chapter I.xxi, where Oresme cites Aristotle's *On Curved Surfaces*). He delves more into this concept by covering more general curves: "Difform curvature is composed of an infinite number of parts of different nature and unrelatable [to each other]" (I.xx). Thus, his study of curvature is not limited to circles but is extended to more general cases. However, Oresme does not have any precise procedure to compute such a general curvature.

In classical differential geometry, the so-called fundamental theorem of curves states (e.g., [9], p. 29) that if two single-valued continuous functions $\kappa(s)$ and $\tau(s)$, for $s > 0$, are given, then there

The Southern Wall of the Bayeux Cathedral.
*[**NOTE:** This caption has been corrected and, so, differs from the print version.]*

exists one and only one space curve, determined by its position in space, for which s is the arc length, measured from an appropriate point on the curve, κ is the curvature, and τ is the torsion. This result was obtained in the nineteenth century. It is very surprising to read in Oresme the following reasoning (representative of Oresme's style and his intuition), which leads to a statement quite similar in conclusion to the fundamental theorem of curves ([7], p. 219):

> No intensity of difform curvature can be related to another dissimilar curvature in a ratio of 2 to 1 or [even] in a ratio of $\sqrt{2}$ to 1, i.e., either in a commensurable or incommensurable ratio—or, universally, in any ratio which could be found as existing between line and line. The conclusion is hence evident that intensity of curvature is not to be imagined by lines. Nor is there some curvature which is similar in intensity to some other quality of another species. Nor is curvature to be imagined by some figure. Nor is its intensity to be assimilated to the altitude of a figure, because the altitude of every figure is designated by lines. Finally, it is evident from this that no curvature is uniformly difform, for, by reason of accident, "uniformly difform" exists throughout a whole subject of the same nature and where the ratio of intensity to intensity, or excess of intensity, in the diverse parts is as the ratio of distance to distance, and consequently as the ratio of *lines*, as it is evident from the descriptions in chapter eleven, and this [reduction to ratios between lines] can not, as was just said, be suitable for difform curvature. And so it follows finally that every difform curvature is difform in a way different from that in which any other quality of another kind could be, and [so it is difform] with a strange, marvelous, diverse kind of difformity." [1]

[1] *The last sentence in the original is ([7], p. 218): "Et inde sequitur ulterius quod omnis curvitas difformis est difformis aliter quam aliqua alia qualitas alterius generis possit esse et quadam extranea, mirabili, et diversa difformitate."*

Oresme does not work with the distinction between curvature and torsion for skew curves; all of his discussion is about planar curves, and the uniqueness part of the statement is suggested by "strange, marvelous, diverse" in the last sentence from the excerpt cited above. This shows that *curvitas difformis* is special in a unique way.

The generality of Oresme's doctrine resides in the attempt to model various phenomena by this approach. In *De configurationibus* we encounter his first attempt to apply his doctrine in chapter I.xxiv, where he discusses "On the variety of natural powers dependent on this figuration." He writes [7], p. 233: "It is manifest from natural philosophy and experience alike that all natural bodies determine in themselves their shapes, as, for example, animals, plants, some stones, and the parts of [all of] these. They also determine in themselves certain qualities which are natural to them. In addition to their shape that these qualities possess from their subject, it is necessary that they be figured with a figuration which they possess from their intensity—to employ the previously described imagery." To mention just one example, in chapter II.xl, titled "On the difformity of joys", Oresme discusses a subjective perception in the same terms as a physical quantity: "One ought to speak in the same way concerning a joy or a pleasure, which I suppose to be a certain quality extended in time and intended in degree."

The question asked by Julian Coolidge is where the idea of curvature comes from. There are many elements to suggest that the definition of curvature for curves is due to Nicole Oresme. One strong argument is that this definition was needed for his doctrine. Oresme developed it to serve his theoretical goals and to understand his configurations. Furthermore, Oresme builds upon Aristotle's conclusions and applies these ideas to a larger array of concepts where his graphs ("configurations") could be used. Some of the concepts he is interested in are today considered part of mathematics, some part of physics, while others approach the realm of psychology (e.g., the study of the question why certain perceptions lead to magic).

If Oresme clearly reached the first recorded definition of curvature for curves, then why do we see a certain hesitation to discuss and refer to his work? Perhaps because after the following generation his influence faded, his work was not continued, and his heritage was less understood. The historical reality of the Hundred Years' War limited the dissemination of Oresme's ideas. Later authors, such as Christiaan Huygens and Isaac Newton, discovered and developed fundamental concepts independently and did not build on Oresme's heritage. When mathematics benefited from the important revolution in sciences after 1600, Oresme's texts were perceived as inherited

Decorative architecture of the Rouen Cathedral.

from a different paradigm. However, by looking back at this work today, we should not imagine that *De configurationibus* is an obscure medieval text that could be described as "religious science." Instead, it should be looked on as the initial approach to introduce curvature in the context of an early theory.

Addressing this type of understanding of the medieval books and types of arguments, Edward Grant writes in [3], p. 84: "Theologians had remarkable intellectual freedom and rarely permitted theology to hinder their inquiries into the physical world. If there was any temptation to produce a 'Christian science,' they successfully resisted it. Biblical texts were not employed to 'demonstrate' scientific truths by blind appeal to divine authority. When Nicole Oresme inserted some fifty citations to twenty-three different books of the Bible in his *On the Configurations of Qualities and Motions,* a major scientific treatise of the Middle Ages, he did so only as examples, or for additional support, but in no sense to demonstrate an argument." There is no better answer to address the aforementioned concerns.

Our article does not aim more than to contribute to a long overdue discussion on the first recorded definition of curvature, pursuing J. L. Coolidge's suggestion for a more complete history of this fundamental mathematical idea.

References

[1] B.-Y. Chen, Riemannian submanifolds, in *Handbook of Differential Geometry*, vol. I, edited by F. J. E. Dillen and L. C. A. Verstraelen, Elsevier Science B.V., 2000.

[2] J. L. Coolidge, The unsatisfactory story of curvature, *American Mathematical Monthly* **59** (1952), 375–379.

[3] E. Grant, *The Foundations of Modern Science in the Middle Ages: Their Religious, Institutional and Intellectual Contexts*, Cambridge Studies in the History of Science, Cambridge University Press, 1996.

[4] _____, *Science and Religion, 400 B.C. to A.D. 1550: From Aristotle to Copernicus*, Johns Hopkins University Press, 2006.

[5] A. Knoebel, R. Laubenbacher, J. Lodder, and D. Pengelley, *Mathematical Masterpieces. Further Chronicles by the Explorers*, Springer-Verlag, 2007.

[6] Nicole Oresme, *The De Moneta of Nicholas Oresme and English Mint Documents*, translated and edited by Charles Johnson, Ludwig von Mises Institute, Kindle edition by Amazon Digital Services, Inc., 2011.

[7] _____, De configurationibus qualitatum et motuum, in *Nicole Oresme and the Medieval Geometry of Qualities and Motions*, edited with an introduction, English translation and commentary by Marshall Clagett, The University of Wisconsin Press, 1968.

[8] R. Osserman, *Poetry of the Universe: A Mathematical Exploration of the Cosmos*, Anchor Books, New York, 1995.

[9] D. J. Struik, *Lectures on Classical Differential Geometry*, second edition, Dover Publ. Inc., 1961.

[10] S. Sternberg, *Curvature in Mathematics and Physics*, Dover Books on Mathematics, Dover Publications, 2013.

The Method of Archimedes: Propositions 13 and 14

Shirley B. Gray, Daniel Ye Ding, Gustavo Gordillo, Samuel Landsberger, and Cye Waldman

No area of mathematics has attracted more international attention in the past decade than the Palimpsest of Archimedes. The 1998 auction at Christie's, followed by collaborative work centered at the Walters Art Museum led to traveling museum exhibits, newspaper articles, television specials, and dozens of presentations. Mathematicians and other scholars attracted a new and significant audience. The singed, battered, faded, mildewed, damaged 10th century manuscript—the world's oldest copy of The Method of Archimedes—sold for $2 million "under the hammer." Mathematicians and classical scholars have long wondered just how close Archimedes (287–212 BC), a mechanical genius, had come to formulating modern calculus. The clues would surely lie in Propositions 13 and 14, if only they could be read. Though now transcribed, the content may contain copyists' errors. In the true Archimedean experimental tradition, we decided to avail ourselves of the opportunity to look not retrospectively at the content of propositions in The Method but rather in terms of 21st century mathematics and technology. Moreover, we believe we participated in every scholar's quest to have a Eureka moment—we found the Golden Ratio in our attempts to image the footprint of Archimedes.

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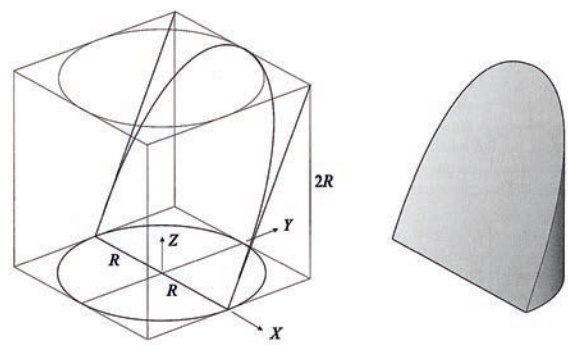


Figure 1. Development of the hoof.

Volume of the Cylinder "Hoof"

The cylinder hoof (a.k.a. "ungula", Latin for *hoof*) has been an object of fascination since Archimedes demonstrated, by geometric means alone, that the volume is one-sixth that of an enclosing cube. In the present effort, we show how to calculate the volume of the hoof by contemporary means, utilizing trigonometry and calculus, both of which were unknown to Archimedes in the third century BC.

Technical Discussion

The hoof is created by "cuts" on a cube. The sequence as in Figure 1 (left) has been demonstrated by several scholars over the past century [1–11]. We begin with a cube; the first cut leaves behind a cylinder whose diameter is equal to the side of the cube; the hoof is created by cutting the cylinder with a plane that bisects its base and passes through its upper lip. The final hoof is shown in Figure 1 (above).

As we shall be using trigonometry and calculus, we need to clearly define the coordinate system and dimensions (as shown in Figure 1). A cube of side $2R$ is centered on the $X-Y$ plane (X and Y each vary from $-R$ to R) and has a height of $2R$, i.e., Z varies from 0 to $2R$. Thus, the enclosed cylinder has a radius of R. For definiteness, we take the slant cut to intersect the X-axis. The height and base of the hoof both are $2R$.

Clearly, the volume of the hoof is then

$$V = \int_{-R}^{R} \int_{0}^{\sqrt{R^2-X^2}} \int_{0}^{2Y} dZ\, dY\, dX. \tag{1}$$

Now, the volume of an object is a physical property. So imagine that we needed to solve Eq. (1) numerically for many radii; we would have to solve each case separately. Rather, let's reduce it to a purely mathematical (and dimensionless) problem as follows: let $x = X/R$, and similarly for Y and Z. Then Eq. (1) becomes

$$V = R^3 \int_{-1}^{1} \int_{0}^{\sqrt{1-x^2}} \int_{0}^{2y} dz\, dy\, dx. \tag{2}$$

Now we can see that the volume scales exactly as R^3 and we can consider the purely numerical (i.e., dimensionless) problem that can be solved once, and for all R.

$$V = \int_{-1}^{1} \int_{0}^{\sqrt{1-x^2}} \int_{0}^{2y} dz\, dy\, dx. \tag{3}$$

This equation may easily be solved without `Mathematica`®or `MATLAB`. Let's break it down as follows:

$$\begin{aligned} V &= \int_{-1}^{1} \left[\int_{0}^{\sqrt{1-x^2}} \left[\int_{0}^{2y} dz \right] dy \right] dx \\ &\int_{0}^{2y} dz = 2y \\ &\int_{0}^{\sqrt{1-x^2}} 2y\, dy = \quad y^2 \Big|_{0}^{\sqrt{1-x^2}} = 1 - x^2 \\ V &= \int_{-1}^{1} (1-x^2)\, dx = x\left(x - \frac{x^3}{3}\right)\Big|_{-1}^{1} = \frac{4}{3}. \end{aligned} \tag{4}$$

Finally, since $V_{\text{cube}} = 8R^3$, it is apparent that $V_{\text{hoof}}/V_{\text{cube}} = 1/6$, as was first determined by Archimedes over 2,000 years ago.

Lynch [29] has shown how to calculate the volume of the hoof by calculation of single integrals. As seen in Figure 2, the calculation can be done

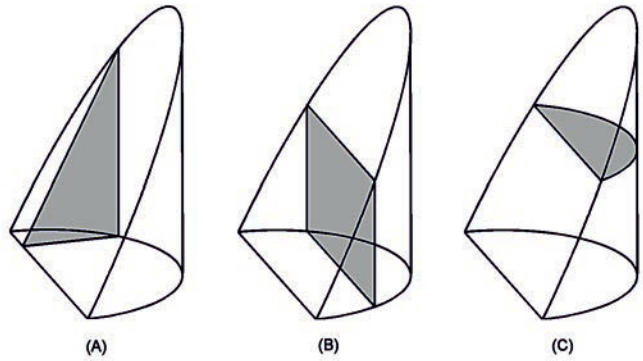


Figure 2. Cross-sections of a hoof in the x, y, z directions [after Lynch (2012)].

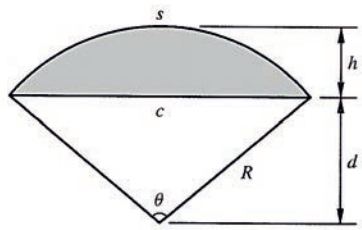


Figure 3. Segment of a circular section (shaded).

by integrating a triangle, rectangle, or segment in the x, y, and z-directions, respectively. All three integrations give the same result, of course: $V_{\text{hoof}} = 4R^3/3$. We demonstrate these calculations below, in dimensionless form. The goal is to integrate each area over the appropriate coordinate; using the procedure for nondimensionalization of the coordinates, we have

$$\begin{aligned} v &= \int_{-1}^{1} A_{\text{triangle}}(x)\, dx \\ &= \int_{0}^{1} A_{\text{rect}}(y)\, dy = \int_{0}^{2} A_{\text{segment}}(z)\, dz. \end{aligned} \tag{5}$$

The first two areas are given by

$$\begin{aligned} A_{\text{triangle}}(x) &= (1-x^2) \\ A_{\text{rect}}(y) &= 4y\sqrt{1-y^2}. \end{aligned} \tag{6}$$

It can be shown that each of these integrals is given by $v = 4/3$, in agreement with Eq. (4). The area of a circular segment, as shown in Figure 3, is given by

$$A_{\text{segment}}(y) = \cos^{-1} y - y\sqrt{(1-y^2)}. \tag{7}$$

However, we wish to integrate this function over z; noting that $z = 2y$ and letting $\zeta = z/2$, we can

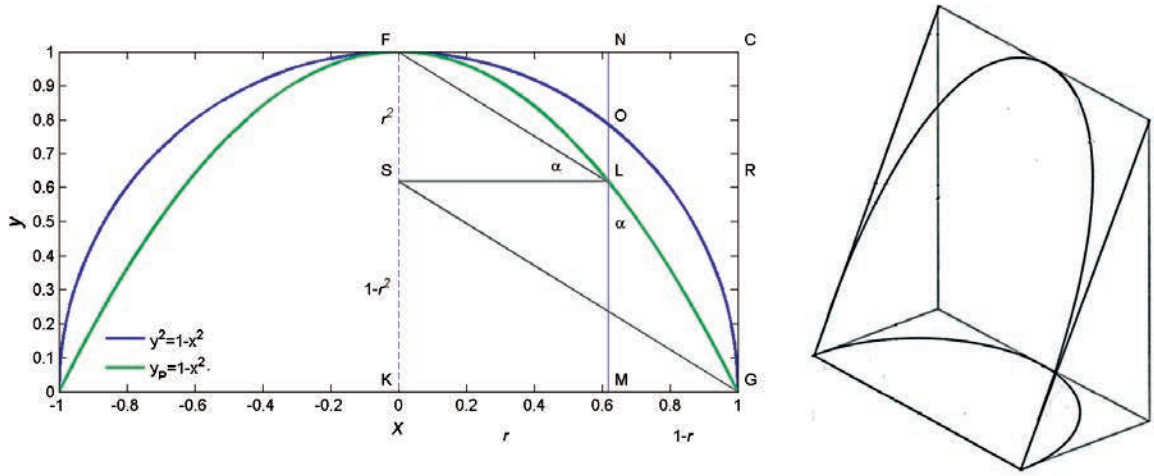


Figure 4: The footprint of the hoof and the parabola of Archimedes (left) and the hoof and prism (right).

write

$$\begin{aligned} v &= 2\int_0^1 A_{\text{segment}}(\zeta)\,d\zeta \\ &= 2\left[\zeta\cos^{-1}\zeta - \sqrt{1-\zeta^2} + \frac{1}{3}\sqrt{(1-\zeta^2)^3}\right]_0^1 \qquad (8) \\ &= \frac{4}{3}. \end{aligned}$$

In closing, let us reflect for a moment on how Archimedes solved this problem. He was essentially using the triangular method described above, but lacked the tools that are at our disposal. Archimedes considered the problem of summing the triangles in the x-direction to obtain the volume, i.e., that which we have expressed as

$$v = \int_{-1}^{1} A_{\text{triangle}}(x)\,dx = \int_{-1}^{1}(1-x^2)\,dx. \qquad (9)$$

Archimedes demonstrated in his Proposition 13 that the integrand in this equation, which derives from the circle, $y^2 = 1 - x^2$, is also the equation of a parabola in the $x - y$ plane, $y_p = 1 - x^2$, as seen in the green line in Figure 4 (above). In the notational form of ratio and proportion used by Archimedes, $\text{MN}^2 : \text{MO}^2 :: \text{MN} : \text{ML}$. Thus, the (dimensionless) volume of the hoof is equal to the (dimensionless) area of the parabolic segment! Now, this might seem confusing because we appear to have lost a dimension. That is an artifact of the nondimensionalization. In the dimensional world, this would be expressed in terms of ratios. Figure 4 (right) shows the volumes of the hoof and prism. The volume of the prism is to that of the hoof as the area of the base rectangle is to that of the parabolic segment, i.e.,

$$V_{\text{prism}}/V_{\text{hoof}} = A_{\text{rect}}/A_{\text{par}}. \qquad (10)$$

Archimedes had previously shown that the area of the rectangle to that of the parabolic segment is $A_{\text{rect}}/A_{\text{par}} = 3/2$. And noting that $V_{\text{prism}}/V_{\text{cube}} = 1/4$, we again have $V_{\text{hoof}}/V_{\text{cube}} = 1/6$.

Notably, we believe we participated in every scholar's quest to have a Eureka moment—we found the Golden Ratio in our attempts to image the footprint of Archimedes, but only when $r = \frac{R}{\varphi}$. In Figure 4 (above), note that r varies from 0 to R. None of the other scholars cited in this manuscript has ever pointed out that if using the actual magnitude of NF or NL, you can readily show from the similar (in fact, congruent) triangles $\triangle$GML~$\triangle$LSF, that $r = \frac{1}{\varphi}$, the inverse of the Golden Ratio: ME:ED::MN:MK::NF:NL= φ, and incidentally, MO= $1/\sqrt{\varphi}$.

The Animation and Computer Program

Animations shown at `curvebank.calstatela.edu/method/method.htm` demonstrate the transition from cube to cylinder to hoof. Each is composed of vertical laminae of thickness Δx that make up the volume. In the final sequence of the animation, the triangles are stripped away from the hoof to show its internals; a dis-integration, if you will. The animation was created with a variant of the `MATLAB` program. Each of the laminae is built up of bands of width Δx; these are appropriately modified to avoid a staircase effect when they are stacked together.

The code reports the ratio $V_{\text{cube}}/V_{\text{hoof}}$ and you can verify that this approaches 6 as the parameter npts increases (this essentially reduces Δx, the laminae thickness). For example, for npts= 51 we obtain $V_{\text{cube}}/V_{\text{hoof}} = 6.0024$ whereas for npts= 501 we get $V_{\text{cube}}/V_{\text{hoof}} = 6.000024$. Close enough for government work, as we say.

We also posit that a "hoof" similarly constructed from an arbitrary parallelepiped, thus composed of a slanted cylinder and elliptical cross-section, will similarly exhibit the property that the volume of the hoof is equal to one-sixth that of the parallelepiped. It all begins with a 4×4 matrix to map the points in the parallelepiped into a cube. We happily leave the details to the reader.

3-D Printer Models

Our team created two sets of models—an initial hoof on a smaller scale, and a medium-sized hoof, as well as its complement, on a larger machine. The smaller hoof, with a layer thickness of 0.01 inch, was made on a Deezmaker Bukobot printer. Its interior is practically hollow, and its surface walls have a thickness of 0.05 inch all around. The medium-sized hoof and its complement were printed using the Stratasys uPrint SE Plus on a thickness setting of 0.013 inch per layer. The dividing face common to both the hoof and its complement was omitted from their designs so that, like scoops, the final physical models can be filled with liquid. The printing processes were similar and began with computer representations of the geometric objects. In this case, a popular CAD (computer-aided design) program called SolidWorks was used to create computer representations of the medium-sized hoof and its complement, where the reference cube used was 10-inches long on each side (see Figures 5 and 6). The software was able to calculate properties such as the volume, surface area, and center of mass of each model, and by doing so, gave us an independent verification that the hoof is 1/6 the volume of the cube.

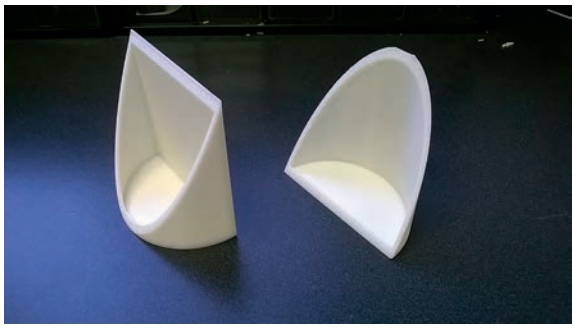


Figure 5.

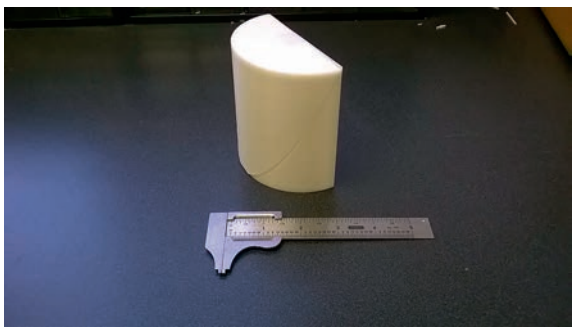


Figure 6.

References

[1] J. L. Heiberg, *Eine Neue Archimedeshandschrift*, Hermes, Volume 42, 1907, pp. 235–303.

[2] J. L. Heiberg and H. G. Zeuthen, *Eine Neuve Schrift des Archimedes*, Verlag von B. G. Teubner, Leipzig, 1907, pp. 321–363.

[3] Thomas L. Heath, *The Method of Archimedes: Recently Discovered by Heiberg*, Cambridge, 1912.

[4] _____, *The Thirteen Books of Euclid's Elements*, Volumes I, II and III, Dover, 1956.

[5] *Great Books of The Western World*, Robert Maynard Hutchins, ed., Mortimer J. Adler, Ass. ed., II: Euclid, Archimedes, Apollonius of Perga, Nicomachus, Encyclopedia Britannica, 1952.

[6] E. J. Dijksterhuis, *Archimedes with a new bibliographic essay by Wilbur R. Knorr*, Princeton University Press, 1987.

[7] Reviel Netz, Ken Saito and Natalie Tchernetska, A New Reading of *Method* Proposition 14: Preliminary Evidence from the Archimedes Palimpsest (Part I), *SCIAMSVS*, Volume 2, April, 2001, pp. 9–29.

[8] _____, A New Reading of *Method* Proposition 14: Preliminary Evidence from the Archimedes Palimpsest (Part 2), *SCIAMSVS*, Volume 3, April, 2002, pp. 109–125.

[9] Reviel Netz, *The Works of Archimedes*, Volume 1, Cambridge, 2004.

[10] Reviel Netz and William Noel, *The ARCHIMEDES CODEX*, Da Capo Press, 2007.

[11] Reviel Netz and William Noel, Natalie Tchernetska and Nigel Wilson, *The ARCHIMEDES Palimpsest*, Walters Art Museum and Cambridge, Volumes I and II, 2011.

[12] Sherman Stein, *Archimedes: What Did He Do Besides Cry Eureka*, Mathematical Association of America, 1999.

[13] *The Archimedes Palimpsest*, Christie's (Auction catalog, October 29, 1998), 502 Park Avenue, New York, 10022.

[14] S. H. Gould, The Method of Archimedes, *American Mathematical Monthly*, Volume 62, 1955, pp. 473–476.

[15] J. L. Heiberg, translated by D. C. Macgregor, *Mathematics and Physical Science in Classical Antiquity*, Chapters in the History of Science II, Charles Singer, ed., Oxford, 1922.

[16] Archimedes Text Sold for $2 Million, *The New York Times*, October 30, 1998, p. A22.

[17] Carol Vogel, Eureka, *The New York Times*, February 19, 1999.

[18] Big Literary Find in Constantinople, *The New York Times*, July 16, 1907, p. 1.
[19] Archimedes text goes to unnamed buyer for $2.2 m, *Kathimerini*, Athens, October 30, 1998, p. 1.
[20] *Half-leaf of a 10th century codex*, translated by Nigel Wilson, Cambridge University Library, Add.1879.23.
[21] W. R. Knorr, The Method of Indivisibles in Ancient Geometry, Vita Mathematica (R. Calinger, ed.,) *Mathematical Association of American*, 1996, pp. 71–74.
[22] C. H. Edwards Jr., *The Historical Development of the Calculus*, Springer-Verlag, 1979, pp. 68–76.
[23] *Archimedes Comes to America*, Science, Volume 284, June 25, 1999, p. 2083.
[24] Ivan Boserup (ed.), *Københavns Universitet 1479–1979: Klassisk filologi efter 1899*, Volume 8, 1992, pp. 367–374.
[25] Shirley B. Gray, A Centennial Celebration of Two Great Scholars, *Notices of the American Mathematical Association*, Volume 55 (7), August, 2008, pp. 776–783.
[26] J. L. Berggren, The Archimedes Codex, Book Review, *Notices of the American Mathematical Association*, Volume 55 (8), September, 2008, pp. 943–947.
[27] James Stewart, *Calculus*, 5ed, Thomson, Brooks/Cole, 2003, p. 888.
[28] Amir Alexander, *Infinitesimal*, Scientific American / Farrar, Straus and Giroux, 2014, pp. 107–111.
[29] P. Lynch, "Sharing a Pint" ThatsMaths `thatsmaths.com/2012/12/13/sharing-a-pint/` .
[30] PBS (2003) *Infinite Secrets*, NOVA Science Programming, Original PBS Date: September 30, 2003.

Websites

`curvebank.calstatela.edu/method/method.htm`

`www.cs.drexel.edu/ crorres/Archimedes/contents.html`

`www.youtube.com/watch?v=uwidw12kctI`

`www.archimedespalimpsest.org/`

`web.calstatela.edu/faculty/hmendel/Ancient%20Mathematics/Archimedes/Archimedes%20Method/Prop14/Arch.Method.Prop.14.html`

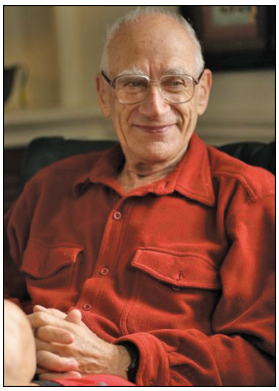
Daniel M. Kan (1927–2013)

Clark Barwick, Michael Hopkins, Haynes Miller, and Ieke Moerdijk

LIFE

In Holland

Daniel (or Daan in Dutch) M. Kan was born on August 4, 1927, and grew up as the only child in a liberal Jewish family in the southern quarter of Amsterdam, where his father worked as a lawyer. In 1939 he entered the Barlaeus Gymnasium, a secondary school in the center of Amsterdam, then and to this day one of the best schools in Amsterdam. He was only able to stay there for two years, because after the school year 1940–41, under German occupation Jewish children were no longer allowed at that school. Instead, he went to the Jewish Lyceum (*Joods lyceum*).



Daniel Kan

In the summer of 1943 a very difficult time for Kan and his family began. Together with his parents, he was picked up and sent to Westerbork, a transition camp near the eastern Dutch border. They stayed there for half a year and were next sent to Bergen-Belsen, where they remained for fifteen months. Both of his parents died of typhus soon after liberation. Dan himself barely survived, and he stayed in Germany for another three months to recover.

In the summer of 1945 Kan returned to Amsterdam, where he entered the last year of high school at the Barlaeus Gymnasium. He was interested in mathematics, but the prospect of becoming a school teacher or having a job in an insurance firm did not appeal to him. It was the Dutch topologist L. E. J. Brouwer who pointed out other career options to him that a degree in mathematics would offer. Consequently, Kan started his university studies in 1946 at the University of Amsterdam, in the program Mathematics and Physics with Chemistry. In 1948 Kan received his first degree (*kandidaatsexamen*), and in 1950 he completed his studies (*doctoraal examen*, comparable to a master's degree).

Two events from Kan's years at the University of Amsterdam turned out to have a decisive impact on some of his later choices. First of all, Kan always spoke with admiration about the lectures by Professor Johannes de Groot about "differentiation and integration." In the spring of 1949 de Groot gave a seminar lecture about the book on topology by the Princeton mathematician Solomon Lefschetz, and he organized a small reading group at his home to work through this book. Kan joined this reading group, together with several other young Dutch mathematicians, among them the late T. A. Springer. Secondly, after his *kandidaats* degree, Brouwer asked Kan to become his assistant. Brouwer gave Kan a lot of freedom, and Kan spoke of this assistantship as very inspiring. In this way, both Brouwer and de Groot influenced Kan's future career to a high degree.

In Israel

In February of 1951, equipped with letters of recommendation from de Groot and Brouwer, Kan left for Israel. After a few weeks there, he managed to obtain a job at the Weizmann Institute in a seismic oil exploration project. Kan had to do the mathematical calculations that this search required. (Oil was never found.) Kan described this work as rather monotonous and not very inspiring. After a year, Kan had to serve in the army. But the army allowed him to do his service at the Weizmann Institute itself, and he could

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thus stay there for another two and a half years. His job offered him a lot of spare time, and he began to think about topology again. In the spring of 1954, Samuel Eilenberg came from Columbia University on a visit to the Hebrew University in Jerusalem. (At the time, Eilenberg was already one of the leading figures in algebraic topology, due to his work with Saunders Mac Lane and the influential *Foundations of Algebraic Topology*, which he had just written with Norman Steenrod.) Kan knocked on Eilenberg's hotel room door, and explained his simplicial description of homotopy groups. Eilenberg asked him if he could prove the homotopy addition theorem, and Kan returned a week later with a proof. Eilenberg told Kan that he had a thesis there, engineered an ad hoc arrangement giving Kan the status of graduate student at the Hebrew University, and in the summer of 1954 Kan submitted his thesis. He formally received his PhD in 1955.

In the meantime Kan had married Nora Poliakof, the daughter of a Dutch general practitioner in Amsterdam and like Kan a survivor of Bergen-Belsen. Nora too had lost both parents during the war and immediately after had emigrated to Israel. Dan and Nora had four children: Ittai (1956), Michael (1957), Tamara (1962), and Jonathan (1965). Jonathan died in 1973 of leukemia, a heavy blow for the Kan family. Nora died in August 2007.

In the United States

After his PhD, Kan took up a postdoctoral position for a year (1955–56) with Eilenberg at Columbia University. During that year he wrote three groundbreaking papers about simplicial sets and two about adjoint functors. Subsequently, Kan went to Princeton for a year before returning to Israel to take up what we would now call a tenure-track position at the Hebrew University. However, he returned to the USA in 1959 to take an assistant professorship at MIT. After just four years he was promoted to full professor there. Kan stayed at MIT for the rest of his academic career until his formal retirement in 1993. After his departure, Kan did not have much contact with Holland anymore. He had lost his family and some of his best friends from his youth. (His wife, Nora, did go back regularly to visit some of her school friends.) But Kan was proud of his membership in the Dutch Royal Academy and published regularly in its mathematics journal, *Indagationes Mathematicae*.

Dan was an enthusiastic cyclist. Up to very late in his life, dressed in a striking red outfit, he would climb on his fancy mountain bike to go and have a cup of coffee with one of his colleagues in the neighborhood, to work on a joint paper, or simply to share the latest mathematical gossip and give some piece of sharp advice. Ismar Volic has provided a vivid image of the important role Dan played in his mathematical community; see the sidebar at the end of this article.

Dan Kan died at home on his eighty-sixth birthday, on August 4, 2013, following a brief illness.

THE KAN SEMINAR

Kan had very strong views about his role as a teacher. He had a modern view of the teaching profession, having little use for the convention of a lecture. He gave very few lecture courses at MIT and rarely spoke at conferences. Instead, he devised various alternatives. He introduced an undergraduate seminar in basic algebraic topology, in which students were given a list of definitions and theorems and were challenged to provide examples and proofs and present them in class.

In 1969 Kan instituted the "Kan Seminar," a literature seminar devoted to classic papers in algebraic topology. The charter class included Tadatoshi Akiba (mayor of Hiroshima from 1999 to 2010), Ken Brown (now at Cornell), Dan Burns (University of Michigan), Hans Salamonsen (Aarhus), Bruce Williams (Notre Dame), and W. Stephen Wilson (Johns Hopkins). It has run every fall since then (with perhaps one exception). While the list of papers has evolved somewhat, the course has remained very close to Dan's original conception. One of Dan's principles was that this was not a recruiting device to attract PhD students. The seminar was held in Dan's office, which featured a long couch and a prominent copy of C. Allan Gilbert's *All is Vanity*. It met very early—8 a.m.—and he would hold office hours before it. A central objective was the formation of a cohort of graduate students who knew each other well and worked together. To further that goal, every fall he and Nora hosted a party at his house and invited some thirty-five Boston area mathematicians along with the seminar participants. They may not have realized it, but he thought of this as an important part of the seminar, and it stopped when he stopped leading the seminar. The Kan seminar has spawned a variety of similar seminars around the world, notably Emily Riehl's recent "Kan extension seminar" [Emily Riehl, The Kan Extension Seminar: An experimental online graduate reading course, *Notices of the AMS* **61** (2014), 1357–1358].

WORK

Kan struck an independent course from the very start. Eilenberg had initiated the use of singular simplices in 1944, with the objective of constructing a transparently functorial homology theory, and Serre used a cubical analogue to ease his work on the homological structure of fibrations. Kan initially preferred cubical sets over simplicial sets. He realized that in fact one could define the homotopy groups of a cubical set provided one

could fill in the boundary of a cube minus one face: this was the "extension" or "Kan" condition. He was persuaded of the efficacy of simplicial objects in place of cubical objects by John Moore's proof that a simplicial group automatically satisfied the extension condition, and starting with this third paper everything is written simplicially. Very quickly he subsumed a lot of classical homotopy theory under the simplicial tent. He constructed a model for Serre's loop space using simplicial groups which were free on generators preserved by degeneracies. These became one of Kan's favorite ways of thinking about a homotopy type. The Hurewicz map was simply abelianization, and a simple proof of the Hurewicz theorem emerged. For connected simplicial sets one could dispense with inverses; this is the "Dold-Kan" theorem. This line of research culminated in Kan's demonstration (1959) that these free simplicial groups are just as efficient as CW complexes in their representation of homotopy types. This perspective contributed to the Kan-Thurston theorem (1976) asserting that any connected space is homologically equivalent to the classifying space of a discrete group.

The passage back and forth between spaces and simplicial sets had interesting formal properties, which Kan codified in the language of adjoint functors. (The name was insisted upon by Eilenberg.) This formalism has become so ingrained in mathematics that it seems incredible that it had an author. In the same paper, Kan defines limits, colimits, and what we know today as Kan extensions. (Mac Lane's dictum "all concepts are Kan extensions" is only a mild exaggeration.)

Kan played an important early role in the development of stable homotopy theory. Spectra were first described by Lima in 1959, and by 1963 Kan had published his account of "simplicial spectra," simple combinatorial objects behaving like simplicial sets with negative dimensional simplices. Kan's colleague George Whitehead showed (1962) that homology theories could be represented by spectra, and the two of them collaborated on the development of the theory of simplicial spectra. They investigated the smash product of spectra and orientability with respect to a sequence of ring spectra obtained from the group spectrum model of the sphere spectrum by dividing by terms in the lower central series.

Kan's interpretation of the Hurewicz theorem had already suggested that the lower central series would be interesting. He had given an interpretation of J. H. C. Whitehead's "certain exact sequence" in these terms. He helped Raoul Bott's student Edward Curtis prove a connectivity theorem for terms in the mod p lower central series, a result underlying many convergence results to this day. Soon the "Six Author Paper" (A. K. Bousfield, E. B. Curtis, D. M. Kan, D. G. Quillen, D. L. Rector, and J. W. Schlesinger, 1966) used the mod p lower central series to produce a spectral sequence coinciding stably with the Adams spectral sequence with an explicit E_1 term (described in terms of the "Lambda algebra"). Kan's student Stewart Priddy went on to make the unstable picture explicit and to found the "Koszul duality" movement.

Also at this time Kan was serving as guide to Daniel Quillen as Quillen developed the axiomatic framework of model categories. Quillen's book *Homotopical Algebra* incorporates much of Kan's world view, and Kan adopted the framework of model categories in his later work.

From this point on much of Kan's research was conducted in collaboration with former students. With A. K. Bousfield, he gave two other constructions of the unstable Adams spectral sequence. The second of these was based on an exhaustive study of cosimplicial spaces and the Tot construction on them and appears in the book *Homotopy Limits, Completions and Localizations*, which Kan always referred to as "the Yellow Monster." This served as a textbook for a generation of topologists learning simplicial methods and provided a general foundation for the process of localization and completion explored earlier by Artin and Mazur, Sullivan, and Quillen. It made extensive use of the notion of a nilpotent space, due to Kan's student Emmanuel Dror Farjoun, an optimal weakening of simple connectedness or simplicity. Bousfield and Kan published a series of papers filling out various aspects of this work.

In the late 1970s Kan began a long collaboration with Bill Dwyer, who had received his PhD under Kan's direction in 1973. In 1980 they linked Quillen's theory of model categories to another conception of what a homotopy theory is by defining a simplicial enrichment of a model category using a device they termed "hammock localization." Over the next twenty years Dwyer and Kan explored a wide swath of homotopy theory. They (along with Kan's student Chris Stover and others) developed a strategy for classifying topological realizations of various kinds of homotopical data and investigated the accompanying obstruction theory. They identified the "centric" condition on a diagram, a condition that is satisfied quite often and that dramatically simplifies the obstruction theory for realization. This has been fundamental in developments ranging from p-compact groups to elliptic cohomology. With Mike Hopkins and Jeff Smith, Dwyer and Kan explored the homotopy theory of cyclic sets.

Much of Kan's effort in the late 1990s and early 2000s was focused on a reconceptualization of homotopy theory, trying to understand what a homotopy theory is rather than understanding homotopy-theoretic properties of spaces (or simplicial sets). The fruits of this effort are presented in "the Blue Beast," *Homotopy Limit Functors on Model Categories and Homotopical Categories*, by Dwyer,

Kan, Philip Hirschhorn, and Jeff Smith. Quillen had constructed the homotopy category by inverting weak equivalences, and Dwyer and Kan had shown that the entire homotopy theory is captured by the weak equivalences. The Blue Beast provides an axiomatic development of homotopy theory from that perspective; the other components of a model category—the cofibrations and fibrations—assume their proper role as computational conveniences. This perspective was carried further into the realm of higher category theory in Kan's final collaboration, with Clark Barwick.

Dan Kan had a very strong need to express his mathematics in the most transparent way possible. Things had to fit together tightly for him; he often said, "If it rattles, it's not quite right." This imperative gives his articles a certain timelessness.

Students

James Schlesinger	1964
John Dennett	1965
Aldridge Bousfield	1966
Robert Knighten	1966
David Rector	1966
Stewart Priddy	1968
Robert Walker	1968
Emmanuel Dror Farjoun	1971
William Dwyer	1973
Jerrold Grossman	1974
Philip Hirschhorn	1977
Javier Bracho	1981
Jeffrey Smith	1981
David Blanc	1988
Christopher Stover	1988

Ismar Volic, Wellesley College

Soon after I arrived at Wellesley College in 2006, Dan knocked on my door. He had heard from my colleague and his former student Phil Hirschhorn that I had moved to the area, and he happened to be near my apartment on one of his legendary daily bike rides. Our first conversation over what would become the requisite cup of coffee must have gone well; Dan became a regular visitor, and I considered it a great professional accomplishment that one of my mathematical heroes had added me to his "topological bike tour." He always came unannounced, a spontaneity I came to cherish, as his visits made me put the grind of ordinary days on pause for an hour or so.

Naturally, Dan and I quickly found a common language in mathematics, but we especially bonded over the shared experience of war in our youth (albeit half a century apart) and, more importantly, over a common sensibility to what a balanced life should look like. He had modeled his life on the simple hierarchy where family and friends stood well above everything else, and I have tried to emulate his example by arranging my schedule so that it allows plenty of time for both. I will miss Dan's invaluable help in maintaining sight of the things that matter.

Dan was wonderful to my children as well, always bringing them thoughtful, simple gifts that fostered imagination and playfulness. They came to regard him as something of a grandfather and will miss him as much as my wife and I will. Fortunately we inherited Dan's trove of puzzles, brainteasers, and games and look forward to many hours of fun and play—exactly what Dan would want us to do in his memory.

For Your Information

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Mathematical Congress of the Americas 2017

The second Mathematical Congress of the Americas (MCA 2017) will take place on **July 24–28, 2017**, at McGill University, Montréal, Canada. The program of MCA 2017 will include plenary speakers, invited speakers, special sessions, and presentation of the MCA Prize, the Americas Prize, and the Solomon Lefschetz Medal. Based on the very successful experience of the first congress, wide participation of mathematicians and students from North America, Central America, South America, and the Caribbean is expected.

The Mathematical Congress of the Americas is organized by the Mathematical Council of the Americas (MCofA), a network for professional mathematical societies and research institutes based in the Americas dedicated to promoting the development of mathematics in all its aspects, highlighting the excellence of mathematical achievements in the Americas within the context of the international arena, and fostering the scientific integration of all mathematical communities in the Americas. Current membership of MCofA includes seventeen mathematical societies (organized as large societies, small societies, and associate members) and twelve institutes covering most countries in the Americas.

For More Information

See current information about the MCA 2017, including Plenary Lectures, Invited Lectures, and Prize Lectures, at `mca2017.org`.

Special Sessions—Call for Proposals

Proposals of special sessions at MCA 2017 are welcomed by the Special Sessions Subcommittee. Early submission of proposals is encouraged: good proposals will be approved on a regular basis before the deadline so that session speakers may be invited in plenty of time to make travel and funding arrangements.

Proposals must be submitted by email to the address `sessions@mca2017.org` no later than **July 31, 2016**.

A proposal should include:

- the names, affiliations, and contact information (including email addresses) of all the organizers, with one organizer designated as "contact organizer"
- a brief presentation of the topic and scope (up to one page)
- a preliminary list of the expected speakers

The topics should be broad and fairly well represented throughout the Americas. The list of organizers must include at least two mathematicians from different countries in the Americas. Preference will be given to proposals whose list of suggested speakers represents diversity in all aspects. Each special session will consist of two 4-hour

periods. We recommend that the organizers base their sessions on a total of sixteen half-hour time slots for their speakers. Although it is anticipated that limited financial support will be available to help with expenses for some of the participants, at present we cannot promise financial support for the special sessions.

Prizes of the Mathematical Council of the Americas—Call for Nominations

The Mathematical Council of the Americas (MCofA) welcomes nominations for the following prizes, which will be awarded on the occasion of the second Mathematical Congress of the Americas. Nominations must be submitted by email to the address `mca2017.prizes@gmail.com` no later than **December 15, 2016.**

The MCA Prize: Five prizes of US$1,000 each will be awarded to mathematicians who are no more than twelve years past their PhD in July 2017. Eligibility for consideration of nominees requires that they either received their graduate education or that they currently hold a position in one or more countries in the Americas. The choice of the prizewinners will be based on the documented mathematical achievements of the nominees. The nominations must include a justifying statement (up to two pages), the CV of the nominee, and one additional letter of support. The winners will be invited to give a lecture on their work at the congress.

The Americas Prize: One prize of US$5,000 will be awarded to an individual or a group in recognition of work to enhance collaboration and the development of research that links mathematicians in several countries in the Americas. The nominations must include a description (up to four pages) of the work and any relevant citations that justify the award of the Americas Prize. CVs of the nominees should be provided. There must be four co-nominators from at least two different countries.

The Solomon Lefschetz Medal: Two medals with an award of US$5,000 will be given to mathematicians in recognition of their excellence in research and their contributions to the development of mathematics in a country or countries in the Americas. Nominations must include a justifying statement (up to two pages) and a brief paragraph that can be used in the announcement of the medal, the CV of the nominee, and two additional supporting letters.

The selection of the winners will be made by the MCA 2017 Awards Subcommittee, which is appointed by the MCofA Executive Committee. In making their decisions the Awards Subcommittee will be guided by the information in the nominating material and detailed insights about the nominees's professional accomplishments. It is important that the nominees's most significant contributions and their impact be part of the nominating material. The Awards Subcommittee may also make nominations if it chooses to do so. An individual may make up to two nominations in each category. Self-nominations will not be accepted in any category. Requests for information concerning the nominating process should be sent by email to `mca2017.prizes@gmail.com`.

Thank you so much, this program made my summer!
Concepcion*

SPMPS SIENA

Thank you for making it possible for us to bring serious and advanced mathematics to students who need it!

Thanks for all of the support
-Dominik

Thank you!!! Your support has changed my life and made my summer ♡ xoxo
Jezebel
7th grade

Thank you sooo much! Your support has made this summer a great one!
-Elisa
7th grade

Thank You AMS!

Thanks for helping to support the future mathematicians of the AMS!
Rova

From, Silvia
Thank you for the support! It helped changed all of our lives!
-Tec

Thanks for your support!

Support
AMS Epsilon Fund for Young Scholars
www.ams.org/support

To give visit, **www.ams.org/support** or
contact the AMS Development Office by phone: 401-455-4111
or email: development@ams.org

AMS
AMERICAN MATHEMATICAL SOCIETY
www.ams.org

From the AMS Secretary

Report of the Treasurer (2014)

Introduction

One of the most important duties of the treasurer is to lead the Board of Trustees in the oversight of financial activities of the Society. This is done through close contact with the executive staff of the Society, review of internally generated financial reports, review of audited financial statements, and direct contact with the Society's independent auditors. Through these and other means, the Trustees gain an understanding of the finances of the Society and the important issues surrounding its financial reporting. The Report of the Treasurer is presented annually and discusses the financial condition of the Society as of the immediately preceding fiscal year-end and the results of its operations for the year then ended.

When reviewing the financial results of the AMS, it is important to note that the financial support for its membership and professional programs is derived from multiple sources. First, a board-designated endowment fund, the Operations Support Fund (OSF), provided $1,776,000 in operating support to the membership and professional programs in 2014. The OSF is a fund that has grown throughout the years from operating net income as well as investment gains; because the fund is dependent upon market conditions, the amount provided varies from year to year. In addition, the membership and professional programs are supported through dues income and contributions. Finally, the margin from the publication programs supports these services as well. Without the margin from publications and the OSF income, dues and contributions alone would not provide enough support to continue professional programs, such as Mathjobs, scholarships, fellowships, and *The Notices*.

In 2014, the net operating income of the Society was approximately $1.8 million, as compared to a net income of $1.2 million in 2013. This operating net income was primarily the result of a 5.6 percent increase in operating revenues, partially offset by a modest increase in operating expenses. The Society's unrestricted net assets increased by $8.7 million primarily due to a 10 percent return on the long-term investments and the $1.8 million in net operating income. We note that the net operating income in 2014 is about the same as the 2014 OSF contribution.

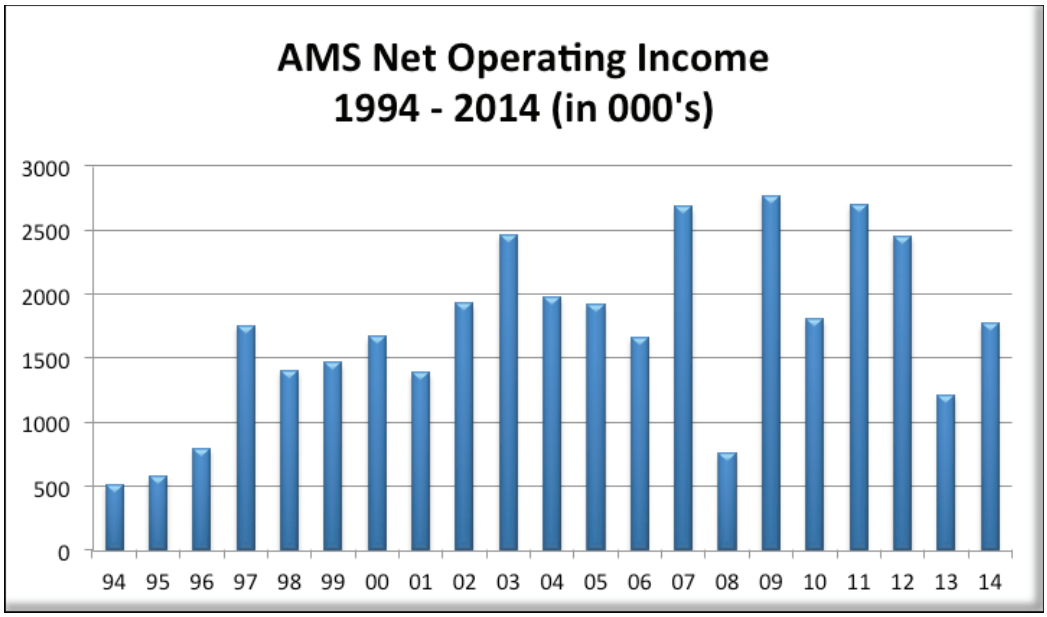

Figure 1

All currency discussed in this report refers to US dollars.

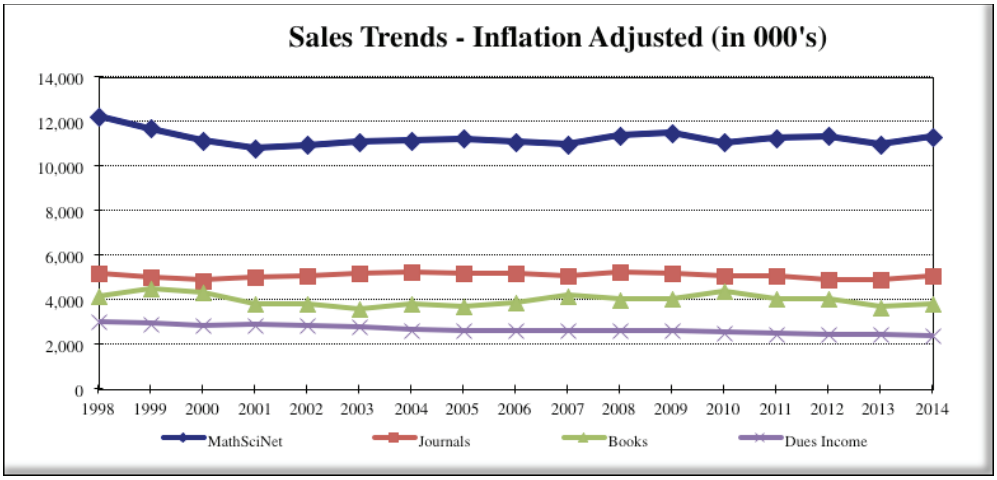

Figure 2

Operating Results

The positive net operating income of $1.8 million in 2014 is the result of several factors, including management's controls on expenses, increases in some publishing revenues, and increases in contributions and spendable income from board-designated endowment funds. As shown in Figure 1 (previous page), the Society has maintained a positive net income for more than two decades. For many years now, it has been important for the Society's management to ensure that expenses grow moderately, because publishing revenues, the Society's major source of revenue, are suffering from subscription attrition and decreased book sales. The Society is engaging in a strategic planning initiative that will address these revenue challenges as well as a continued decline in membership and related dues income.

In 2014, the Society's net operating income increased from $1.2 million in 2013 to $1.8 million. This gain was due to a $1.6 million or a 5.6 percent increase in revenues, some of which was offset by a smaller 3.8 percent increase in expenses. Increases in several different revenue items make up the revenue gains over the previous year. The largest increase of $784,000 was in publication revenues, which experienced a gain due to increased electronic backlist sales and subscription price increases. The OSF spendable income increased by about $340,000 over 2013, resulting from the excellent returns experienced in the AMS long-term investment portfolio over the past few years. Grant income increased by about $300,000 over 2013 due to an International Congress of Mathematicians federal travel grant. Another contributor to the gain in operating revenues was a large increase of $260,000 in unrestricted contributions due primarily to a large bequest from the estate of Kathleen Baxter. Although 2014 revenues did increase by 5.6 percent over 2013, when adjusted for inflation, *sales revenues have remained fairly flat over a number of years as shown in Figure 2.*

In 2014, expenses increased by 3.8 percent as compared to 2013. Personnel costs increased 3 percent over 2013 costs. Another large increase of about $325,000 occurred in contracted services, which reflects increased spending on strategic initiatives and product improvements, such as spending on a new online book platform, journal format enhancements, MathJax development, and digitization of book backlist volumes. There was a large increase of about $200,000 in physical plant costs, primarily due to an acceleration of depreciation on some building improvements.

Figure 3 shows the amounts spent on major expense categories in 2014.

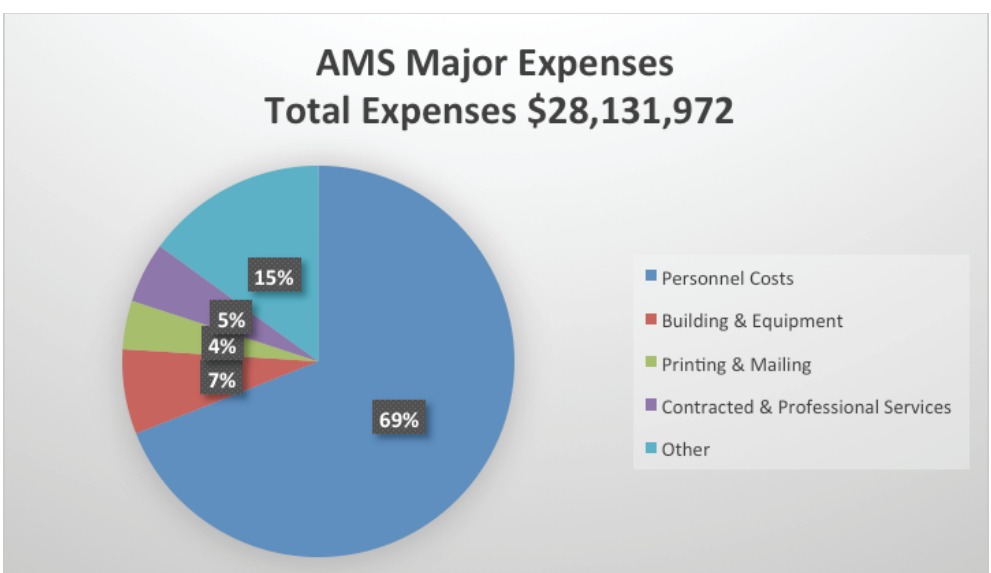

Figure 3

In the "nonoperating" section of the Society's financial statements, there are two noteworthy figures. There were unrestricted investment gains of $8.3 million recorded as revenues. In addition, a $1.2 million expense was recorded related to the Society's postretirement benefit plan. This large expense came about because of a decrease in the discount rate and new mortality tables used by an actuary to determine the Society's liability for future payments to retirees. However, a majority of this expense will most likely be reversed if discount rates rise as anticipated in the coming years.

For more detailed information regarding the Society's operating results, please see the financial

Highlights of Balance Sheets Changes from 2013 to 2014	Commentary
Cash decreased by approximately $3.7 million, while short-term investments and certificates of deposits increased by approximately $2,900,000 and $650,000, respectively.	The decrease in cash was offset almost completely by increases in certificates of deposit and short-term investments.
Prepaid expense and deposits increased approximately $290,000.	The increase is related to the timing of payments for 2015 health insurance premiums paid during 2014 and higher deposits for the Joint Mathematics Meetings.
Land, buildings and equipment, net decreased $678,000.	The decrease is related mainly to depreciation expense of $950,000 net with new additions of $290,000. The increase in depreciation expenses is related to an acceleration in depreciation of some aging building improvements.
Long-term investments increased by approximately $11.6 million or 10 percent.	Increase in long-term investments was due to appreciation in investments from unrealized gains and dividends and interest income reinvested.
Post-retirement benefit obligation increased by approximately $1,300,000 or 21 percent.	A reduction in discount rates used to measure the obligation plus the estimated impact of the new life expectancy tables drove the increase in the liability.

Table 1

statements, including the Statements of Activities, located at the end of this report.

2014 Balance Sheets Highlights

Another report within the financial statements, referred to as the Balance Sheets, is also at the end of this financial review. The Society continues to enjoy healthy balance sheets. Total net assets increased by $10 million, primarily due to investment gains and net operating income of $1.8 million. Total net assets of the organization are $128 million, of which $111 million are unrestricted. Table 1 shows highlights of the Society's 2014 Balance Sheets.

2014 Statements of Invested Funds

The Society's Statements of Invested Funds show a listing of the Society's endowments and quasi-endowments (board-designated funds). In addition, the long-term investments of the Society also contain a temporarily restricted fund, the Beal Prize, which at year-end amounted to $1.264 million. The corpus of this fund, $1,000,000, is set aside to fund a prize for solving the Beal Conjecture. The spendable income from the fund supports the Erdős Lecture and other programs. Overall, the 2014 Statements of Invested Funds show a large increase of $11.6 million over 2013 primarily due to returns from the investment markets.

The Statements of Invested Funds are divided into the permanently restricted funds that have been acquired from donations in the form of endowment funds, and the funds that have been designated by the Board of Trustees for specific purposes (quasi-endowments). In 2014, there was an addition to the endowment, the Chevalley Prize fund, which will fund a prize in Lie Theory. This new fund was established through a generous donation from George Lusztig.

The quasi-endowment funds are set aside for various purposes. The newest fund, established in 2014, is the Kathleen Baxter Memorial Fund, which will provide spendable income to support the American Mathematical Society's Centennial Fellow. The Backfile Digitization Fund is providing funding to operations for rekeying the Society's book backlist into a usable digital format for future electronic products. The Economic Stabilization Fund (ESF) is a fund set aside to cover the postretirement benefit obligation and 75 percent of the current annual operating expenses in case of disaster. In 2014, the Board of Trustees elected to self-insure against flood risk for the Society's Providence facility by adding $1.7 million to the ESF. In the near future, some of the quasi-endowment funds may be set aside to fund initiatives related to the strategic planning taking place within the Society.

Summary Financial Information

The following Statements of Activities and Balance Sheets are from the audited financial statements of the AMS, and the Statements of Invested Funds is from the internal financial records of the AMS. Any member may contact the AMS to request the full audited statements of the Society.

AMERICAN MATHEMATICAL SOCIETY

Balance Sheets

	December 31, 2014	December 31, 2013
Assets		
Cash	$ 1,022,196	$ 4,724,387
Certificates of deposit	1,601,460	951,529
Short-term investments	13,331,743	10,432,357
Accounts receivable, net of allowances of $294,801 and $263,224 in 2014 and 2013, respectively	655,752	678,298
Deferred prepublication costs	634,436	555,294
Completed books	1,194,235	1,282,908
Prepaid expenses and deposits	1,507,034	1,213,201
Land, buildings and equipment, net	4,449,507	5,127,278
Long-term investments	126,818,565	115,196,217
Total assets	**$ 151,214,928**	**$ 140,161,469**
Liabilities and Net Assets		
Liabilities:		
Accounts payable and accrued expenses	$ 3,873,144	$ 4,006,141
Accrued study leave pay	722,406	685,363
Deferred revenue	11,451,092	11,671,731
Postretirement benefit obligation	7,408,478	6,108,330
Total liabilities	**23,455,120**	**22,471,565**
Net assets:		
Unrestricted:		
Undesignated	-	1,448,012
Designated	111,171,200	101,007,256
	111,171,200	102,455,268
Temporarily restricted	11,050,480	9,968,645
Permanently restricted	5,538,128	5,265,991
Total net assets	**127,759,808**	**117,689,904**
Total liabilities and net assets	**$ 151,214,928**	**$ 140,161,469**

AMERICAN MATHEMATICAL SOCIETY

Statements of Activities

	Years Ended December 31, 2014	*2013*
Changes in unrestricted net assets:		
Operating revenue, including net assets released from restrictions:		
Mathematical Reviews	$ 11,344,158	$ 10,868,077
Journals	5,306,814	5,062,348
Books	3,687,814	3,623,632
Dues, services, and outreach	3,893,767	3,839,958
Investment returns appropriated for spending	1,799,700	1,459,970
Other publications-related revenue	631,772	636,881
Grants, prizes and awards	1,592,929	1,233,313
Meetings	1,189,114	1,253,181
Short-term investment income	381,349	262,762
Other	77,375	67,791
Total operating revenue	**29,904,792**	**28,307,913**
Operating expenses:		
Mathematical Reviews	7,596,576	7,075,759
Journals	1,501,487	1,415,180
Books	3,236,476	3,220,413
Publications indirect	1,418,636	1,168,463
Customer services, warehousing and distribution	1,751,542	1,567,644
Other publications-related expense	157,416	194,186
Membership, services and outreach	4,054,224	4,016,715
Grants, prizes and awards	1,871,237	1,504,294
Meetings	1,154,390	1,254,622
Governance	506,583	553,239
Member and professional services indirect	775,200	740,306
General and administrative	3,989,842	4,317,500
Other	118,363	66,021
Total operating expenses	**28,131,972**	**27,094,342**
Excess of operating revenue over operating expenses	**1,772,820**	**1,213,571**
Nonoperating revenues and expenses:		
Investment returns less investment returns available for spending	8,348,819	16,968,778
Use of board designated funds from Endowment Income Stabilization Fund	(6,335)	(31,112)
Use of board designated funds from Retrodigitization Fund	(159,130)	(129,481)
Effect of capitalization of labor for in house software development	-	-
Depreciation of labor for in house software development	(66,701)	(66,701)
Loss on change in paid personal leave policy	-	(935,360)
Postretirement benefit-related changes other than net periodic cost	(1,173,541)	785,425
Change in unrestricted net assets	8,715,932	17,805,120
Changes in temporarily restricted net assets:		
Contributions	$ 176,795	$ 1,161,387
Investment returns	1,459,507	2,632,530
Net assets released from restrictions	(554,467)	(608,097)
Change in temporarily restricted net assets	1,081,835	3,185,820
Change in permanently restricted net assets:		
Contributions	272,137	170,000
Change in permanently restricted net assets	272,137	170,000
Change in net assets	**10,069,904**	**21,160,940**
Net assets, beginning of year	117,689,904	96,528,964
Net assets, end of year	**$ 127,759,808**	**$ 117,689,904**

American Mathematical Society-Statements of Invested Funds
As of December 31, 2014 and 2013

Income Restricted Endowment:	**Original Gift**	**12/31/14**	**12/31/13**
Endowment Funds:	**at 12/31/14**	**Total Value**	**Total Value**
Research Prize Funds			
Steele	145,511	784,425	731,899
Birkhoff	50,132	98,481	91,886
Veblen	58,599	87,153	81,317
Wiener	29,773	52,225	48,728
Bocher	32,557	53,055	49,502
Conant	9,477	52,278	48,778
Cole Number Theory	51,813	73,593	50,989
Cole Algebra	51,463	73,262	50,989
Satter	49,720	86,018	80,258
Chevalley Fund	115,000	119,488	
Doob Prize	45,000	64,631	60,303
Robbins Prize	41,250	60,145	56,117
Eisenbud Prize	40,000	56,328	52,556
Other Prize and Award Funds			
Morgan Prize	25,000	56,892	53,082
Albert Whiteman Prize	93,618	135,999	126,892
Arnold Ross Lectures	85,212	116,603	94,483
Trjitzinsky	196,030	630,264	588,060
C.V. Newsom	100,000	293,290	273,651
Centennial	61,183	156,444	145,968
Menger	97,250	142,495	132,953
Ky Fan (China)	366,757	503,796	470,061
Gross	22,110	29,274	26,754
Epsilon	1,976,296	2,780,670	2,496,507
Einstein Lecture	100,000	145,846	136,080
Exemplary Program	100,000	144,954	135,247
Mathematical Art	20,000	28,991	27,050
Subtotal (Income Restricted)	**3,963,752**	**6,826,600**	**6,110,110**
Endowment	109,765	973,253	906,675
Morita	100,000	173,081	161,620
Henderson	548,223	5,161,172	4,819,435
Schoenfeld/Mitchell	573,447	978,535	913,743
Laha	189,309	328,751	306,983
Ritt	51,347	307,495	287,135
Moore	2,575	28,986	27,066
Subtotal (Income Unrestricted)	**1,574,666**	**7,951,273**	**7,422,657**
Total Endowment Funds	**5,538,418**	**14,777,873**	**13,532,767**
Quasi-Endowment Funds (Board-Designated):			
Journal Archive Fund		1,607,169	1,414,581
Young Scholars		868,952	812,252
Economic Stabilization Fund (ESF)		29,407,917	25,840,754
Endowment Income Stabilization Fund (EISF)		490,634	497,710
Backfile Digitization Fund		111,389	270,519
Kathleen Baxter Memorial Fund		263,625	
Operations Support Fund (OSF)		78,407,114	72,171,440
Total Quasi-Endowment Funds		**111,156,800**	**101,007,256**
Undesignated		110,985	
Beal Prize (Temporarily Restricted)	1,000,000	1,263,562	1,153,924
Total Invested Funds	**$6,538,418**	**$127,309,220**	**$115,693,947**

Statistics on Women Mathematicians
Compiled by the AMS

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

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

Male: names that were obviously male

Female: names that were obviously female

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

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

2014 Members of the AMS Residing in the US

Male:	11,562	50%
Female:	2,735	12%
Unknown:	8,918	38%
Total:	23,215	

Invited Hour Address Speakers at AMS Meetings (2005–2014)

Male:	341	81%
Female:	78	19%
Unknown:	0	0%
Total:	419	

Speakers at Special Sessions at AMS Meetings (2010–2014)

Male:	12,918	78%
Female:	3,528	21%
Unknown:	115	1%
Total:	16,561	

Percentage of Women Speakers in AMS Special Sessions by Gender of Organizers (2014)

Special Sessions with at Least One Woman Organizer

Male:	1,099	74%
Female:	387	26%
Unknown:	5	<1%
Total:	1,491	

Special Sessions with No Women Organizers

Male:	1,599	82%
Female:	340	17%
Unknown:	10	1%
Total:	1,949	

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Female:	38	17%	36	16%	36	16%	35	17%	34	16%	39	18%	37	17%	37	17%	40	18%	43	19%
Total:	222		229		230		203		212		215		213		215		222		222	

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Male:	355	72%	399	72%	396	69%	431	69%	515	69%	564	71%	574	72%	621	72%	627	73%	664	72%
Female:	141	28%	153	28%	180	31%	191	31%	227	31%	225	28%	228	28%	242	28%	230	27%	256	28%
Total:	496		552		576		622		742		790		802		863		857		920	

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Rigorous Numerics in Dynamics

Jan Bouwe van den Berg and Jean-Philippe Lessard

Motivation

Nonlinear dynamics shape the world around us, from the harmonious movements of celestial bodies, via the swirling motions in fluid flows, to the complicated biochemistry in the living cell. Mathematically these beautiful phenomena are modeled by nonlinear dynamical systems, mainly in the form of ordinary differential equations (ODEs), partial differential equations (PDEs) and delay differential equations (DDEs). The presence of nonlinearities severely complicates the mathematical analysis of these dynamical systems, and the difficulties are even greater for PDEs and DDEs, which are naturally defined on infinite-dimensional function spaces. With the availability of powerful computers and sophisticated software, *numerical simulations* have quickly become the primary tool to study the models. However, while the pace of progress increases, one may ask: just how reliable are our computations? Even for finite-dimensional ODEs, this question naturally arises if the system under study is chaotic, as small differences in initial conditions (such as those due to rounding errors in numerical computations) yield wildly diverging outcomes. These issues have motivated the development of the field of *rigorous numerics in dynamics*.

Rigorous numerics draws inspiration from the ideas in scientific computing, numerical analysis, and approximation theory. In a nutshell, rigorous computations are mathematical theorems formulated in such a way that the assumptions can be rigorously verified on a computer. This requires an a priori setup that allows analysis and numerics to go hand in hand: the choice of function spaces, the choice of the basis functions and Galerkin projections, the analytic estimates, and the computational parameters must all work together to bound the errors due to approximation, rounding, and truncation sufficiently tightly for the verification proof to go through. The goal is to provide a mathematically rigorous statement about the validity of a *concrete* numerical simulation (i.e., not in some asymptotic sense where, for example, the grid size tends to zero) as interpreted as an approximate solution of the original problem. This complements the field of scientific computing, where the goal is to achieve highly reliable results for very complicated problems. In rigorous computing one is after absolutely reliable results for somewhat less complicated (but still hard) problems.

Outside dynamics, computer-assisted proofs have been used to settle famous open problems. Two prominent examples are the four-color theorem [1] and Kepler's densest sphere packing problem [2]. In dynamical systems, an early success is the demonstration of the universality of the Feigenbaum constant [3]. More recently, rigorous numerics were used to prove the existence of the strange attractor in the Lorenz system, which seemed, for decades, tentatively intuitive from computer simulations [4]. This settled the fourteenth problem in Smale's list of problems for the twenty-first century (the only other problem from the list that has been solved is the Poincaré conjecture).

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Computers have long played a pivotal role in the study of dynamical systems. Starting from the very first glimpses of the Mandelbrot set, computer simulations have provided a way to delve deeply into the complex behavior of nonlinear dynamics. Nevertheless, the field of dynamical systems is not dominated by computers. Quite the opposite—the theory of dynamical systems is a thriving area of mathematics, as exemplified by several recent Fields Medals. While the strength of analytic results in dynamical systems lies in characterizing generic behavior, i.e., outlining what one should *typically* expect "on average" in classes of systems, it is very difficult to check that any *specific* system is sufficiently "unexceptional" to be described by these general results. It is precisely this weakness of the general analytic theory that is the strength of computer-assisted approaches. This is of importance, since in applications one is usually interested in the behavior of a specific system. Moreover, while mathematical analysis is strong on general "existence" theorems for families of problems, information about the *shape* of the solutions (e.g., the patterns they describe) can usually be obtained only with the help of computer calculations (rigorous or not). While in applications one needs to be sure that a solution exists, it is usually essential to know what the solution looks like as well.

From a mathematical point of view, the advantage of rigorously validated computations over simulations is that the outcomes can be used as components in the "building" of mathematics. This is often expressed in the form of forcing theorems: if one finds a certain type of solution, then this implies, by analytic theory, many other properties of the dynamical system. The most famous result of this type is "period-3 implies chaos" for interval maps [5]. Other such examples leading to chaos are given by the existence of a Shilnikov bifurcation [6] or the existence of a single braided periodic orbit [7]. Mathematics in general is riddled with such statements, where the assumptions in the theorems are in practice impossible to check for any specific system, at least by hand. It is in overcoming this obstacle that computer-assisted proofs are at their best.

Strategy

Let us sketch the strategy for finding a solution in a nonlinear dynamical system via a computer-assisted proof. We are looking for a "dynamically invariant object," which we denote abstractly by x and which may be an equilibrium, a periodic or connecting orbit, or more generally an invariant manifold. Having identified a formulation for such a problem of the form $f(x) = 0$ that is suitable for the analysis to follow, our starting point is a numerically obtained approximation, x_{approx}, of a zero of f, i.e., $f(x_{\text{approx}}) \approx 0$. Next, we exploit a common strategy in mathematical analysis, namely, we turn the problem $f(x) = 0$ into an equivalent fixed point problem. Instead of trying to solve $f(x) = 0$, we consider a map T whose fixed points are the zeros of f. The choice of the map T is not straightforward, but often an approximate Newton scheme of the form $T(x) = x - Af(x)$ is suitable, where the linear operator A is some cleverly chosen approximation of the inverse of $Df(x)$. The inverse of the Jacobian itself is usually too complicated to use directly.

We then set out to prove that T is a contraction on a neighborhood of x_{approx}. Although this may seem a rather trivial reformulation, the essential advantage is that instead of trying to prove *equalities* in the formulation $f(x) = 0$, contractivity involves *inequalities* only. This provides the flexibility ("room to play with") that is so typical of many arguments in analysis. In particular, in the context of computer-assisted proofs, inequalities allow the control of errors from a variety of sources: rounding of floating point numbers, finite-dimensional truncation (discretization of a continuous problem), "modeling" error (e.g., using a Taylor polynomial for modeling a nonlinearity rather than the Taylor series), as well as uncertainties in parameter values.

In this approach to computer-assisted proofs it is not the computer which does all the work. On the contrary: the hard work, by pencil and paper, is to reduce the problem to checking *finitely* many inequalities. This involves the analytic study of the defect $T(x_{\text{approx}}) - x_{\text{approx}}$ as well as the derivative of T near x_{approx}. The proof then proceeds by a Newton-Kantorovich type argument to find a small ball B around x_{approx} on which the map T is contracting.

The first central difficulty lies in analytically quantifying "how nonlinear" the map is. In that sense, the hurdle is essentially the same as for purely analytic techniques, where one also needs to control nonlinear and/or off-diagonal terms by (functional analytic) estimates. The second fundamental issue mirrors the situation in numerical analysis and scientific computing, namely, estimating the "cut-off error" caused by projecting the infinite-dimensional problem onto a finite-dimensional computational space (the error induced by truncating the continuous problem to a discrete one). Roughly, one needs to choose a well-adapted basis and/or a good preconditioner to obtain good estimates.

We note that all the obtained bounds need to be explicit and sufficiently sharp to be able to check, in the final step of the proof, that the inequalities guaranteeing contractivity of T hold. In principle the inequalities could be checked by hand, but in practice they involve too many terms to make that feasible. Moreover, the expressions for the inequalities involve the set of floating point numbers

x_{approx}, since the ball B is centered at a numerically determined point. This is a crucial difference from conventional analytic results, where the ball is typically centered around some relatively simple, asymptotic limit case that is amenable to "regular" analysis.

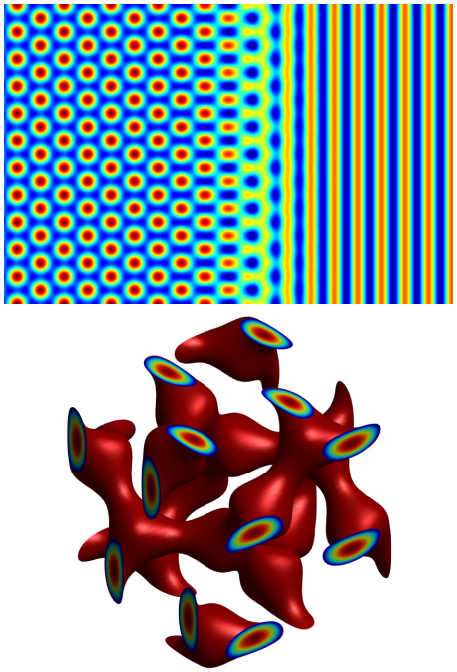

Figure 1. Top: Stationary coexistence of hexagons (spots) and rolls (stripes) of (2). Bottom: A double gyroid solution of (3) for parameter values $\mu = 0.1$ and $\gamma = 2.1$. Images courtesy of Jan Bouwe van den Berg.

Additionally, in the computer-assisted context, the definition of the linear operator A, which is a constituent of the map T, involves the numerical Jacobian of the truncated problem at x_{approx}, which is another source of floating point numbers in the inequalities to be checked. Having done the hard work in the analysis of reducing the problem to finitely many explicit inequalities, one therefore resorts to interval arithmetic computer calculations for this final step of the proof.

The above outline shows that the arguments are "quasi-analytic": the majority of the analysis is done by hand, followed by a final check of a finite list of inequalities through a computer calculation. This means that we can easily deal with parameters in the problem. Indeed, parameters play an important role in virtually all nonlinear dynamical systems that appear in applications. Therefore, rigorous parameter continuation is a vital tool in most applications, and this is incorporated in the computer-assisted approach in a relatively straightforward manner [8], [9]. Finally, we remark that contractivity implies not just existence and uniqueness but also robustness with respect to small variations in parameters. In a dynamical systems context this can be made precise in terms of *hyperbolicity* or *transversality* of the solution. Such a robustness ("no fluke") property, which is usually required to derive forcing results, is automatic from the contractivity of the operator T.

Applications

Techniques for computer-assisted proofs in dynamics are rapidly developing, and some of them, at least when applied to systems of ODEs, are becoming "routine" and are implemented in software packages such as CAPD [10]. Using such software or the ideas mentioned in the previous section, one can obtain computer-assisted proofs of existence of bounded solutions such as equilibria, periodic orbits, and connecting orbits. Bifurcation points, stable and unstable manifolds of equilibria and periodic orbits, and existence of chaos in the form of symbolic dynamics can also be studied rigorously for finite-dimensional nonlinear dynamical systems. More recently, infinite-dimensional nonlinear problems have been studied via computer-assisted proofs. Equilibria of PDEs [11], [12], [13], periodic orbits of PDEs [14], [15], solutions of boundary value problems [16], and traveling waves [17] have all been proved with the techniques of rigorous numerics. Rather than presenting an extensive list of results in the field, we choose to briefly present three sample results, and we refer to [18], [19], [20] for a more thorough discussion of applications to finite- and infinite-dimensional problems.

a) An old conjecture in delay equations. In 1955, E. M. Wright considered the equation

$$y'(t) = -\alpha y(t-1)[1 + y(t)], \ \alpha > 0, \tag{1}$$

because of its role in the distribution of prime numbers [21]. A conjecture (stated by Jones in 1962 [22]) asserts that (1) has a unique slowly oscillating periodic solution (SOPS) for all $\alpha > \pi/2$, i.e., a periodic solution that oscillates around 0, spending more than one unit of time (per period) on either side of 0. With the help of Fourier series, a rigorous parameter continuation of the SOPS was performed in [23] using the ideas of the previous section, yielding substantial progress toward the proof of the conjecture.

b) Coexistence of patterns in a PDE model. The ideas of rigorous numerics were applied in [24] to prove existence of standing waves between rolls and hexagonal patterns of the two-dimensional pattern formation PDE model

$$\begin{aligned} &\partial_t u = -(1+\Delta)^2 u + \mu u - \beta|\nabla u|^2 - u^3, \\ &u = u(x,t) \in \mathbb{R}, \ x \in \mathbb{R}^2, t \geq 0, \end{aligned} \tag{2}$$

for small parameter values $\mu, \beta \in \mathbb{R}$ (see top of Figure 1). Using the weakly nonlinear analysis of [25] proving coexistence of the patterns reduces to proving existence of heteroclinic solutions

in a system of second-order nonlinear ODEs. After reformulating the problem as a projected boundary value problem (BVP) with boundaries in the stable/unstable manifolds, the techniques of the previous section were used to compute the local manifolds and to solve the BVP using Chebyshev series.

c) Steady states of the Ohta-Kawasaki problem. The Ohta-Kawasaki equation

$$\partial_t u = -\Delta(\gamma^{-2}\Delta u + u - u^3) - (u - \mu) \tag{3}$$

models the evolution of di-block copolymers [26], [27]. Depending on the value of the parameters μ and γ, which represent a measure of the ratio of the mixture of the polymers and the incompatibility of the polymer types, respectively, there is a multitude of stationary states with a truly three-dimensional geometry. These have been studied using the rigorous numerical techniques described above (see [28]), and we depict one rigorously verified equilibrium pattern, called a double gyroid, in Figure 1 on the bottom.

Future Goals

The past decade has seen enormous advances in the development of rigorously verified computing with the most significant results for finite-dimensional systems. While encouraging first steps for infinite-dimensional systems are starting to appear, many interesting future directions remain to be explored. For instance, developing rigorous computational tools to study global dynamics of PDEs, finding bounded invariant sets for state-dependent delay equations, and demonstrating chaos in infinite-dimensional continuous dynamical systems are some of the main challenges in the field. Aiming to understand global properties of dynamical systems, combining rigorous numerics with topological methods such as Morse theory, is the subject of active research. Important contributions in that direction are currently being developed based on Morse-Conley theory [29].

Finally, it is a nontrivial problem to make sure that all steps in the process (including the code) are correct. As the code for the computer-assisted proofs is getting more and more complicated, the possibilities for human error while developing the necessary analytic estimates and while implementing the algorithms are increasing. From that point of view, mathematics in the era of computers calls for the development of automatic proof assistants; see e.g., [30].

References

[1] Neil Robertson, Daniel Sanders, Paul Seymour, and Robin Thomas, The four-colour theorem, *J. Combin. Theory Ser. B*, 70(1):2–44, 1997.

[2] Thomas C. Hales, A proof of the Kepler conjecture, *Ann. of Math. (2)*, 162(3):1065–1185, 2005.

[3] Oscar E. Lanford III, A computer-assisted proof of the Feigenbaum conjectures, *Bull. Amer. Math. Soc. (N.S.)*, 6(3):427–434, 1982.

[4] Warwick Tucker, A rigorous ODE solver and Smale's 14th problem, *Foundations of Computational Mathematics*, 2(1):53–117–117, 2002-12-21.

[5] Tien Yien Li and James A. Yorke, Period three implies chaos, *Amer. Math. Monthly*, 82(10):985–992, 1975.

[6] L. P. Shil'nikov, A case of the existence of a denumerable set of periodic motions, *Dokl. Akad. Nauk SSSR*, 160:558–561, 1965.

[7] Jan Bouwe van den Berg and Jean-Philippe Lessard, Chaotic braided solutions via rigorous numerics: Chaos in the Swift-Hohenberg equation, *SIAM J. Appl. Dyn. Syst.*, 7(3):988–1031, 2008.

[8] Jan Bouwe van den Berg, Jean-Philippe Lessard, and Konstantin Mischaikow, Global smooth solution curves using rigorous branch following, *Math. Comp.*, 79(271):1565–1584, 2010.

[9] Marcio Gameiro, Jean-Philippe Lessard, and Alessandro Pugliese, Computation of smooth manifolds of solutions of PDEs via rigorous multiparameter continuation, *Found. Comput. Math.*, 2015.

[10] CAPD: Computer assisted proofs in dynamics, a package for rigorous numerics, `capd.ii.uj.edu.pl/`.

[11] Piotr Zgliczyński and Konstantin Mischaikow, Rigorous numerics for partial differential equations: The Kuramoto-Sivashinsky equation, *Found. Comput. Math.*, 1(3):255–288, 2001.

[12] Myoungnyoun Kim, Mitsuhiro T. Nakao, Yoshitaka Watanabe, and Takaaki Nishida, A numerical verification method of bifurcating solutions for 3-dimensional Rayleigh-Bénard problems, *Numer. Math.*, 111(3):389–406, 2009.

[13] Marcio Gameiro and Jean-Philippe Lessard, Analytic estimates and rigorous continuation for equilibria of higher-dimensional PDEs, *J. Differential Equations*, 249(9):2237–2268, 2010.

[14] Gianni Arioli and Hans Koch, Integration of dissipative partial differential equations: A case study, *SIAM J. Appl. Dyn. Syst.*, 9(3):1119–1133, 2010.

[15] Piotr Zgliczyński, Rigorous numerics for dissipative partial differential equations, II. Periodic orbit for the Kuramoto-Sivashinsky PDE—a computer-assisted proof, *Found. Comput. Math.*, 4(2):157–185, 2004.

[16] B. Breuer, P. J. McKenna, and M. Plum, Multiple solutions for a semilinear boundary value problem: A computational multiplicity proof, *J. Differential Equations*, 195(1):243–269, 2003.

[17] B. Breuer, J. Horák, P. J. McKenna, and M. Plum, A computer-assisted existence and multiplicity proof for travelling waves in a nonlinearly supported beam, *J. Differential Equations*, 224(1):60–97, 2006.

[18] Warwick Tucker, *Validated Numerics, A Short Introduction to Rigorous Computations*, Princeton University Press, Princeton, NJ, 2011.

[19] Siegfried M. Rump, Verification methods: Rigorous results using floating-point arithmetic, *Acta Numer.*, 19:287–449, 2010.

[20] M. T. Nakao, Numerical verification methods for solutions of ordinary and partial differential equations, *Numer. Funct. Anal. Optim.*, 22(3-4):321–356, 2001.

[21] E. M. Wright, A non-linear difference-differential equation, *J. Reine Angew. Math.*, 194:66–87, 1955.

[22] G. Stephen Jones, On the nonlinear differential-difference equation $f'(x) = -\alpha f(x-1)\{1+f(x)\}$, *J. Math. Anal. Appl.*, 4:440–469, 1962.
[23] Jean-Philippe Lessard, Recent advances about the uniqueness of the slowly oscillating periodic solutions of Wright's equation, *J. Differential Equations*, 248(5):992–1016, 2010.
[24] Jan Bouwe van den Berg, Andréa Deschênes, Jean-Philippe Lessard, and Jason Mireles James, Stationary coexistence of hexagons and rolls via rigorous computations, *SIAM J. Appl. Dyn. Syst.*, 14(2):942–979, 2015.
[25] Arjen Doelman, Björn Sandstede, Arnd Scheel, and Guido Schneider, Propagation of hexagonal patterns near onset, *European J. Appl. Math.*, 14(1):85–110, 2003.
[26] Takao Ohta and Kyozi Kawasaki, Equilibrium morphology of block copolymer melts, *Macromolecules*, 19(10):2621–2632, 1986.
[27] M. Bahiana and Y. Oono, Cell dynamical system approach to block copolymers, *Phys. Rev. A*, 41:6763–6771, Jun 1990.
[28] Jan Bouwe van den Berg and J. F. Williams, Rigorous numerics for the Ohta-Kawasaki problem, in preparation, 2015.
[29] Zin Arai, William Kalies, Hiroshi Kokubu, Konstantin Mischaikow, Hiroe Oka, and Paweł Pilarczyk, A database schema for the analysis of global dynamics of multiparameter systems, *SIAM J. Appl. Dyn. Syst.*, 8(3):757–789, 2009.
[30] The Coq Proof Assistant, `https://coq.inria.fr`.

Teaching University Mathematics: One Mathematician's Contribution

Brooke Max and Jill Newton

What makes a "Great Teacher"? Do we learn to be one, or is it intrinsic? In December 2013, Professor Jim McClure was inducted into Purdue University's Book of Great Teachers, providing us with a case study. In this article we present background information about McClure and introduce the domains of mathematical knowledge for teaching presented by Ball, Thames, and Phelps [1]. We then synthesize comments from his colleagues and students to uncover factors of McClure's success in teaching, factors that position teaching as a skill akin to mathematics that can be refined.

In thirty-eight years working as a topologist, McClure has produced more than thirty publications, including two papers in the *Annals of Mathematics* and one in the *Journal of the American Mathematical Society*. He earned his PhD from the University of Chicago in 1978 under Professor J. Peter May. After working at Johns Hopkins University and the University of Kentucky, he settled at Purdue in 1992, where he has been named to the student-determined College of Science Top Ten Teachers list three times and was selected as the Best Teacher in the College of Science in 1999. In 2014 McClure added associate head of the Department of Mathematics to his roles and is directing the academic functions of the department while continuing topology research and mathematics teaching.

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Mathematical Knowledge for Teaching

Building on the work of Shulman [4], Ball, Thames, and Phelps [1] developed a framework for mathematical knowledge for teaching (see Figure 1), detailing the types of knowledge necessary for teaching mathematics. The framework consists of subject matter knowledge and pedagogical content knowledge, recognizing that both aspects are crucial for teaching mathematics. Subject matter knowledge includes three domains: Common Content Knowledge (CCK), Specialized Content Knowledge (SCK), and Horizon Content Knowledge (HCK). CCK refers to "the mathematical knowledge and skill used in settings other than teaching" ([1], p. 399); SCK refers to the mathematics that only teachers need to know; HCK includes knowledge about how mathematics is connected across the curriculum. Pedagogical content knowledge also contains three domains: Knowledge of Content

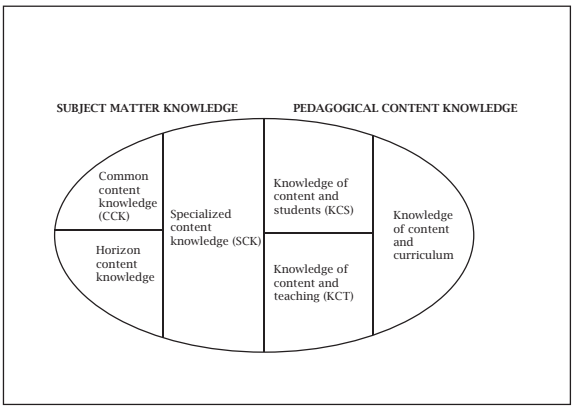


Figure 1. Domains of Mathematical Knowledge for Teaching (Ball, Thames, and Phelps, Journal of Teacher Education, November/December 2008, volume 59, p. 403, Figure 5; ©2008. Reprinted by Permission of SAGE Publications.)

and Students (KCS), Knowledge of Content and Teaching (KCT), and Knowledge of Content and Curriculum (KCC). KCS is knowledge about the relationship between mathematics and students in such a way that one can predict obstacles that may affect student learning; KCT includes the structure of the logical order of teaching mathematics and is helpful for teachers when planning curricular sequences; KCC is the knowledge of a variety of instructional materials used in teaching mathematics.

While McClure became familiar with "pedagogical knowledge" through reading Liping Ma's 1999 book *Knowing and Teaching Elementary Mathematics: Teacher's Understanding of Fundamental Mathematics in China and the United States*, we argue that McClure's work embodies this more current framework of mathematical knowledge for teaching. Below, we take a closer look at how McClure provides students opportunities to develop all domains of this framework.

Mathematical Passion and Understanding: Subject Matter Knowledge

McClure displays his passion for mathematics and desire for students to be mathematically stimulated and competent. One student recalled, "His class was very engaging and challenging. You can tell when you sit in his classroom that he loves what he does and is very passionate about mathematics." Colleague Professor David Goldberg noted McClure's desire to engage the students when teaching them how to transition from the pragmatic to axiomatic approach while introducing *Euclid [Elements] Book* I, giving students an opportunity to understand and experience CCK, thereby deepening their knowledge of mathematics.

McClure assists in the development of SCK, an understanding of mathematics for teaching. This was noted by a former student as she recalled learning from McClure, "It isn't sufficient to just know how to do the [mathematics] that one teaches, but…to know…the "whys" of the concepts and theoretical dispositions of the levels of mathematics that one shares with novice students." McClure's sharing of his mathematical insights gives students an opportunity to see SCK in action. Another student highlighted this, saying, "He always has great insight [into] the problem at hand, whether that be providing background and history of a topic or theorem, or being able to…explain the intricacies in depth…[McClure] inspired me."

In "Start where they are: Geometry as an introduction to proof," McClure [3] argued that one of the most successful ways to teach students how to do proofs is by making connections with secondary geometry concepts. Using familiar knowledge allows students to deepen HCK, the awareness of concepts spanning across mathematics. Another manner in which he aids students in developing HCK was recalled by a former student, saying McClure "was very good at relating what we were learning to other math ideas that we had learned before…he would show us how [the] same mathematical ideas/ways of thinking related to the new material we were learning."

"Start Where They Are…": Pedagogical Content Knowledge

McClure concentrates on conceptual and procedural understanding, focusing on meeting students where they are in their mathematical knowledge. This allows for the development of KCS, which requires knowing about students and knowing about mathematics. A former student commented, "I appreciated McClure's approach to teaching: He relied less on giving example problems [and] rather on the conceptual knowledge…Many times, I felt I would teach the same way he taught us when I became a teacher." Another student echoed, "He taught in a way that he knew students best understood, instead of just how he best understood the material," again showing alignment with KCS in considering students' and mathematical perspectives. Professor Guershon Harel, a friend and former colleague, noted:

> [McClure] has continually…evaluated his ideas in various mathematics classes he taught…and thought deeply about the pedagogy of mathematics… As an example, I mention his excellent paper, "Start where they are: Geometry as an introduction to proof" (McClure [3]). This paper includes strikingly innovative ideas about the role of geometry in advancing students' conception of proof.

McClure's continual reflection on the pedagogical and logical orders of teaching and

learning mathematics is also notable. This practice is aligned with KCT in that it requires considerations of task selection and sequencing. A former student mentioned McClure's pedagogical strategy in which he starts with concrete examples and connects them to prior knowledge before abstracting, stating that it "helped both with remembering the new material and being comfortable with it because he showed us it wasn't completely new, just the same ideas/thoughts applied in a different situation," demonstrating knowing about teaching and knowing about mathematics, or KCT.

McClure created a geometry course at Kentucky and has continued refining it at Purdue, sharing notes with colleagues to use when teaching the course; it is this course that is most often cited by future mathematics teachers as McClure's contribution to their future teaching. He explicitly discusses his use of Euclid's *Elements* with students in order to connect historical and foundational geometric knowledge with secondary geometry curriculum. This transparent explication of his curricular decision-making provides opportunities for students to engage with KCC.

Summary

Professor Jim McClure's pedagogical perspective, while always keeping mathematics as the focus, is what has gained him recognition as a "Great Teacher" at Purdue University. McClure provides students with opportunities to develop the domains of Mathematical Knowledge for Teaching, deepening subject matter knowledge and pedagogical content knowledge. He implements multiple characteristics of effective teaching, such as relaying his deep understanding of mathematics through his teaching approaches while considering the pedagogical and logical orders of all levels of mathematics and considering the background knowledge of his students when planning his lessons, and attempts to meet them where they are. His impact will be felt for many years through the mathematicians and the mathematics educators he has inspired.

References

[1] D. L. Ball, M. H. Thames, and G. Phelps, Content knowledge for teaching: What makes it special? *Journal of Teacher Education* **59**(5) (2008), 389–407.

[2] L. Ma, *Knowing and Teaching Elementary Mathematics: Teachers' Understanding of Fundamental Mathematics in China and the United States*, Lawrence Erlbaum Associates, Mahwah, NJ, 1999.

[3] J. E. McClure, Start where they are: Geometry as an introduction to proof, *The American Mathematical Monthly* **107**(1) (2000), 44–52.

[4] L. S. Shulman, Those who understand: Knowledge growth in teaching, *Educational Researcher* **15**(2) (1986), 4–14.

About the Cover

Sea and Mountains in the Pacific Northwest

October is the issue of *The Notices* in which we bring to your attention the annual Joint Mathematics Meetings (JMM). The upcoming 2016 JMM will take place in the city of Seattle, Washington. In good weather Seattle is a very pleasant, even beautiful, location, as the cover makes clear.

The cover photograph is looking south over downtown. The Washington State Convention Center (JMM headquarters) is at middle upper left next to Interstate I5, which is playing peek-a-boo in the shot. The mountain in the distance is Mount Rainier, and at the right are the Pike Place Market and the state ferry docks, from which routes run west and north across Puget Sound. Out of sight to the left is the Cascade Range, and out of sight to the right are the Olympic Mountains and the Pacific Ocean.

Also out of sight at left is the home of Bill Gates, on Lake Washington (not presently available for tours) and The Microsoft Redmond Campus (Microsoft's corporate headquarters).

We thank Aerolist Photographers of Tacoma, Washington for making the image available to us.

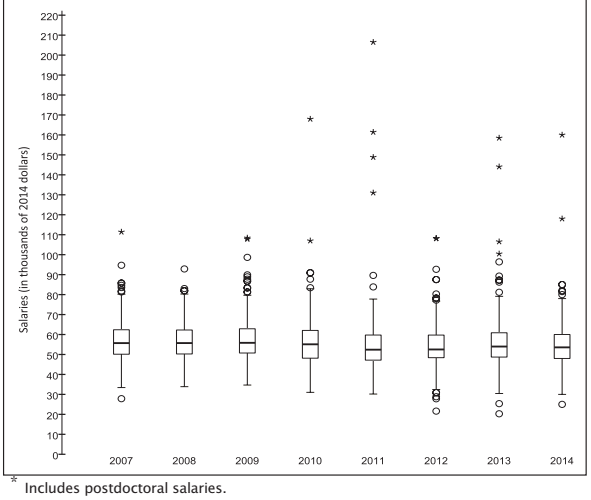
—Bill Casselman
Graphics Editor
(notices-covers@ams.org)

Correction

The Report on the 2013–2014 New Doctoral Recipients, which was published in the August 2015 issue, has an incorrect salary amount in the table on page 779. The authors of the report offer a corrected version of the table below with the adjusted figure in red.

Academic Teaching/Teaching and Research 9–10-Month Starting Salaries* (in thousands of dollars)

PhD Year	Min	Q_1	Median	Q_3	Max	
Total (187 male/108 female)						
2014 M	36.0	48.0	53.0		60.0	160.0
2014 F	25.0	50.0	54.8	60.0	85.0	
One year or less experience (151 male/97 female)						
2014 M	36.0	48.0	53.0	60.0	160.0	
2014 F	25.0	50.0	54.0	60.0	85.0	



* Includes postdoctoral salaries.

The STaR Program Continues to Rise

Barbara Reys and Robert Reys

An award from the National Science Foundation helped establish a program for early-career mathematics educators as they transition from completion of a doctoral program to a faculty position in an institution of higher education [1]. The program name (STaR) is derived from its focus on Service, Teaching, and Research. The program was initially modeled on Project NExT, a successful induction program for mathematicians entering careers in institutions of higher education, but it has subsequently established its own identity. This article provides a status report about the program.

Who can participate? The STaR program is open to anyone completing a doctorate in mathematics education and who is in their first or second year of a tenure-track position in mathematics education at an institution of higher education. The academic appointment can be in either a mathematics department or in a college or school of education. Typically thirty to thirty-five STaR Fellows are accepted each year based on available funds. In order to apply, the applicant must confirm support from their department chair or dean indicating the home institution's willingness to provide travel funds for the applicant to attend the summer institute and a follow-up meeting that coincides with the annual meeting of the Association of Mathematics Teacher Educators (AMTE). The STaR Fellows are provided lodging and some meals during the summer institute. The application process is announced each fall through the AMTE website and newsletter, as well as in the MAA *Focus*. Application review occurs in the fall with notification to applicants in January.

What happens during the summer institute? Prior to the five-day institute, STaR Fellows are asked to identify their teaching and research interests. While research interests vary, most fall into areas such as teacher knowledge/beliefs, teacher preparation, student learning, instructional materials/curriculum, and equity/diversity; whereas teaching interests tend to fall along traditional lines, such as courses directed toward elementary, middle, or secondary teacher education candidates (undergraduate and graduate level).

Four to six staff members—typically, mid- and senior-career mathematics educators—facilitate the institute. The institute consists of plenary sessions on teaching, research, and service that are led by the staff. In addition to the plenary sessions, special interest groups are established that focus on research and teaching. For example, STaR Fellows teaching courses (content or methods) that are targeted toward middle school teachers meet to discuss what they are doing, share syllabi, discuss challenges they face, and exchange ideas about teaching these courses. These special interest groups continue to dialogue during the year as they teach comparable courses. In a similar manner, research groups are formed that allow STaR Fellows to meet with other mathematics educators sharing similar research interests. These meetings might result in STaR Fellows designing and conducting a joint research effort across multiple institutions, and sometimes this work

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evolves into proposals for funds to support their collaborative research.

In addition, each STaR Fellow is asked to prepare a manuscript prior to the institute so that it can be read by the staff and other STaR Fellows who have a similar interest. The manuscript may be targeted toward teachers or researchers, but often is based on their dissertation. These manuscripts are then critiqued, discussed, and frequently revised during the institute. Continued work on these manuscripts has resulted in many scholarly publications by the STaR Fellows, some of which are coauthored with other STaR Fellows.

There is also free time during the institute that allows for continued discussion on topics of mutual interest. The personal networking established during the institute and continued throughout the years following the institute is a particular strength of the program, as many Fellows work in isolation at their home institution (e.g., they may be the only mathematics educator in their department). Fellows also meet again at the annual meeting of AMTE.

Who are the STaR Fellows? The majority of STaR Fellows have prior teaching experience in K–12 classrooms, but they come with different backgrounds and interests. About two-thirds of the STaR Fellows are female. About one-half of them have a master's degree or the equivalent in mathematics completed prior to or as a part of their doctoral preparation. Thus far, STaR Fellows have completed doctoral programs in seventy-two different institutions of higher education, most of which are in the USA (Table 1). However, the variability of doctoral programs in mathematics education has been well documented [3], [4], so the doctoral graduates enter the STaR program with a wide range of knowledge, interest, and backgrounds. Furthermore, their career goals vary, as about one-half of the STaR Fellows have their tenure home in mathematics departments, typically teaching a range of mathematics courses and courses targeted toward future K–12 teachers [2], whereas STaR Fellows in colleges/schools of education are teaching methods courses for K–12 teachers, supervising interns in K–12 schools, teaching graduates courses in mathematics education, and typically working in institutions that have doctoral programs in mathematics education.

Table 1. Institutions from which STaR Fellows received their doctorate and the number of graduates from these institutions.

Arizona State University (4)	University of Central Florida (4)
Auburn University	University of Cincinnati
Baylor University	University of Colorado
Boston College	University of Delaware (7)
Boston University (4)	University of Florida
Brigham Young University	University of Georgia (16)
Florida State University	University of Houston
Georgia State University (2)	University of Illinois-Chicago (2)
Harvard University	University of Illinois-Urbana (2)
Illinois State University (6)	University of Kansas
Indiana University (8)	University of Kentucky (2)
Iowa State University	University of London (Education Institute)
Kennesaw State University	University of Louisville
Kent State University	University of Maryland (5)
Mercer University	University of Miami
Michigan State University (11)	University of Michigan (2)
Montana State University (2)	University of Minnesota (7)
North Carolina State University (11)	University of Missouri (8)
Ohio University (2)	University of Nebraska (2)
Oklahoma State University (3)	University of Nevada-Reno (2)
Oregon State University (2)	University of North Carolina-Chapel Hill (4)
Portland State University (2)	University of North Carolina-Charlotte (2)
Purdue University	University of North Carolina-Greensboro
San Diego State University/UC-SD (5)	University of Northern Colorado (6)
Stanford University (2)	University of Pittsburgh (5)
Teachers College, Columbia University (4)	University of South Florida (4)
Texas State University-San Marcos (3)	University of Tennessee
The Ohio State University	University of Texas-Arlington
The Pennsylvania State University (5)	University of Texas-Austin (2)
University at Buffalo	University of Virginia (2)
University of Alberta	University of Washington (2)
University of Arizona (4)	University of Wisconsin (5)
University of California-Berkeley (4)	Vanderbilt University (2)
University of California-Davis	Virginia Tech (2)
University of California-Los Angeles	West Virginia University
University of California-Santa Cruz	Western Michigan University (2)

From 2010 to 2015 a total of 210 STaR Fellows have entered or completed the program. They are employed in 144 different institutions of higher education in 42 states, ranging from private liberal arts to public regional institutions to heavily research-oriented universities (Table 2, see next page). The 144 institutions are distributed across a wide range of Carnegie Classification. In fact, over half of the STaR Fellows (almost 60 percent) are faculty members in institutions that award doctoral degrees, as shown by the DRU, RU/H, and RU/VH in Table 3. Thus, the STaR Fellows find themselves in institutions with a wide range of expectations with regard to teaching, research, and service.

What do the STaR Fellows say about their STaR experience? The STaR program has led to many collaborations leading to joint work on

Table 3 . A summary of the Carnegie Classification* of the institutions where STaR Fellows had their initial academic appointments.

Carnegie	Asso/Pub-U-MC	Bac/Diverse	Bac/A&S	MastersS	MastersM	MastersL	DRU	RU/H	RU/VH
#institutions	1	3	9	4	7	63	16	41	66
%institutions	0.5	1.4	4.3	1.9	3.3	30.0	7.6	19.5	31.4

*A complete description of the Carnegie Classification is available at `carnegieclassifications.iu.edu/descriptions/basic.php`

Table 2. Institutions where STaR Fellows were employed when they participated in the STaR Program.

Appalachian State University (2)	Rowan University
Arizona State University	San Diego State University
Arkansas State University	Sonoma State University
Auburn University	Southeast Missouri State University
Bemidji State University	Southern Methodist University (2)
Berry College (2)	Southern Utah University
Black Hills State University	St. John Fisher College
Boise State University	Teachers College, Columbia University
Boston College	Texas A&M University - Corpus Christi
Boston University (3)	Texas A&M University-San Antonio
Bowling Green State University (2)	Texas A&M-Commerce
Bridgewater State University	Texas Christian University
Brigham Young University	The College of New Jersey
Bucknell University	The Ohio State University
Buffalo State University of New York	The University of Texas-Pan American
Cal Poly University-San Luis Obispo	Towson University (2)
California Polytechnic University (2)	Tuskegee University
California State University, Chico (2)	Univ. of South Florida - Sarasota Manatee
California State University, Long Beach	University of Georgia
Central Michigan University	University of Alabama (3)
City University of New York-BMCC	University of Arizona (3)
Clemson University (2)	University of Arkansas
Colorado State University	University of Central Arkansas
Drake University (2)	University of Central Missouri (2)
East Carolina University (2)	University of Cincinnati (2)
Eastern Kentucky University (2)	University of Colorado, Denver
Fayetteville State University	University of Delaware (2)
Florida State University (2)	University of Denver
George Mason University	University of Georgia (2)
Georgia Southern University	University of Idaho
Georgia State University	University of Illinois at Chicago
Hood College	University of Illinois, Urbana-Champaign
Hunter College, CUNY	University of Indianapolis (2)
Illinois Institute of Technology	University of Kentucky (3)
Illinois State University (3)	University of Louisville
Indiana State University	University of Massachusetts, Amherst
Iowa State University	University of Memphis
Ithaca College	University of Mississippi
IUPUI (2)	University of Missouri (2)
James Madison University (2)	University of Missouri-St. Louis
Kansas State University	University of Montana
Keene State College (2)	University of Nebraska-Lincoln
Kennesaw State University (7)	University of Nevada, Las Vegas
Kent State University (2)	University of New Hampshire
Lehman College (CUNY) (2)	University of New Mexico
Longwood University	University of North Carolina-Chapel Hill
McDaniel College	University of North Carolina Wilmington
Metropolitan State College of Denver	University of North Florida
Miami University (2)	University of North Texas at Dallas
Michigan State University (2)	University of Northern Iowa (3)
Middle Tennessee State University (2)	University of Oklahoma
Midwestern State University	University of Pittsburgh
Millersville University (2)	University of South Carolina (5)
Montana State University-Bozeman	University of South Florida (3)
Montclair State University (4)	University of Southern Indiana
North American University	University of St. Thomas
North Carolina State University	University of Texas At San Antonio (2)
North Georgia College & State University (2)	University of Washington
Northern Arizona University	University of West Florida
Northern Illinois University	University of Wisconsin-La Crosse
Northern Kentucky University (2)	University of Wisconsin-Madison
Ohio University	University of Wisconsin-Stevens Point
Oregon State University (5)	Utah State University
Penn State Berks	Virginia Tech University (2)
Penn State Harrisburg	Washington State University (2)
Penn State University	Weber State University, Ogden, UT
Penn State University-Abington College	West Chester University (2)
Pepperdine University	West Virginia University
Portland State University	Western Washington University
Purdue University (3)	Westminster College
Rockhurst University	

teaching experiments, research projects, proposals for external funding, scholarly publications, and presentations related to various aspects of mathematics education. The feedback from each cohort of STaR Fellows has been positive, testifying to how the STaR experience has contributed to career growth. Here are several reflections offered by STaR Fellows:

"The STaR experience has provided me with the most powerful networking experience I have had so far in my career."

"This experience was a gift. I needed this opportunity at this exact moment more than I need any other type of mentoring experience.… I have direct advice from very wise mentors about how I should make decisions related to my work, and I have connections with like-minded, serious scholars who will continue this conversation with me for many years to come."

As universities struggle to provide strong mentoring experiences for young faculty, the STaR program provides a focused experience for early-career mathematics educators. Several Fellows have commented on the power of the program in providing them such an experience that pays off well beyond the initial institute:

"There are moments in life when you know you are taking part in something great. I can honestly say that STaR was such an experience for me."

"Many conferences and workshops provide opportunities to meet colleagues, develop relationships between institutions, craft works on research, and/or advance the profession of teaching. STaR stands apart because it does all of these things, but in a way that supports the development of junior faculty across various institutions with differing demands (both in terms of work and culture). It is a significant and critical contribution to our profession."

What is the future of the STaR Program? Just as Project NExT has served mathematicians entering careers in higher education, the STaR Program has helped early-career mathematics educators address some of the challenges they face as they transition into their positions in higher education [2]. The success of the STaR Program encouraged the leadership to seek a permanent home within a professional organization that would allow the STaR Program to continue beyond NSF support, and the AMTE agreed to serve that role. Financial support for the program has come from private foundations, professional organizations, and many individuals, including STaR Fellows and AMTE members. Information about contributing to the STaR program is available at `https://amte.net/civicrm/contribute/transact?reset=1&id=13`.

In summary, each generation of scholars has a responsibility to help educate and prepare their successors in the discipline. The STaR Program

is an effort to help initiate the next generation of mathematics educators, providing support for them to develop networks that can help them launch and establish a productive career. We appreciate the vision of the National Science Foundation for supporting the establishment of the STaR Program and the commitment of AMTE for continuing the effort.

References

1. B. Reys and R. Reys, Supporting the next generation of "stewards" in mathematics education, *Notices of the American Mathematical Society* **59** (2012), no. 2, 288–290.
2. R. Reys, D. Cox, S. Dingman, and J. Newton, Transitioning to careers in higher education: Reflections from recent PhDs in mathematics education, *Notices of the American Mathematical Society* **5** (2009), no. 9, 1098–1103.
3. R. Reys and J. Kilpatrick (eds.), *One Field, Many Paths: U.S. Doctoral Programs in Mathematics Education*, Washington, D.C.: American Mathematical Society/Mathematical Association of America, 2001.
4. R. Reys and J. Dossey (eds.), *U.S. Doctorates in Mathematics Education: Developing Stewards of the Discipline*, Washington, DC: American Mathematical Society/Mathematical Association of America, 2008.

Book Review

Mathematics of the Transcendental

Reviewed by Andrej Bauer

Mathematics of the Transcendental
Alain Badiou (translated into English by A. J. Bartlett and Alex Ling)
Bloomsbury Academic, March 2014
English, 296 pages, US$24.12
ISBN-13: 978-1-441-18924-0

When a *Notices* editor asked me to review Badiou's book [2] I objected on the grounds that I am no philosopher, which only strengthened her determination. Here then is a mathematician's review of a philosopher's mathematics book.

Alain Badiou (born 1937) is a prominent French philosopher whose work may be placed somewhere between the continental and analytic traditions, although closer to the former. He has been active outside philosophy, in literature and especially in politics as a proponent of the radical left. Out of his philosophical considerations of "the multiple" came the idea that set theory was "the pure doctrine of the multiple" and that mathematics *was* ontology.

Set theory was Badiou's first excursion into mathematics, in which he related the standard axioms of set theory to his philosophy in a precise way that left some impressed and others incredulous. In his second undertaking, category theory and topos theory appeared at first as alternatives to set theory and later complemented it to make a bigger picture. The present book is an English translation by A. J. Bartlett and Alex Ling of two sets of Badiou's unpublished French notes on category theory, toposes, and logic. The two parts of the book are titled "Topos, or Logics of Onto-logy: An Introduction for Philosophers" (the dash in "onto-logy" serves a purpose) and "Being There: Mathematics of the Transcendental." While one can guess that the first part deals with toposes and logic, the second title gives no indication that it is about complete Heyting algebras, of which I shall say more shortly.

To a mathematician like me, reading the book feels quite unusual. The mathematics is precise and correct—I point this out because Badiou's mathematical skill had been called into question by his critics—but written in an idiosyncratic way and intertwined with philosophy. Quite intentionally, there is no clear separation between the philosophical and the mathematical parts of the book, as neither is supposed to be above, under, or beside the other. To give you a feeling for what the book is like, here is how the least element of a partial order is explained (p. 173):

> Maintaining the supposition that, with regard to what appears in the situation, the transcendental T supports evaluation of intensity, it is reasonable to assume the capacity to determine a *nil intensity*.

You will never hear a professional mathematician speak like this, which precisely is the point! Where mathematics abstracts away the nonessential and keeps a narrow focus, philosophy seeks breadth and wider context at the expense of clarity and definiteness. If a mathematician can bear this fact in mind while reading the book, she or he may catch a glimpse of philosophy. I could understand many a philosophical passage only because I already knew the mathematics it referred to.

The first part explains basic notions of category theory: category, limits, opposite categories and colimits, Cartesian closed categories, and subobject classifiers (called "central objects"). These culminate in the notion of a topos, which is of central interest, as its rich structure allows us to interpret higher-order intuitionistic logic. Two examples of toposes are given: a Boolean one that models classical logic and a non-Boolean one that is properly intuitionistic. There are no functors and consequently no natural transformations or adjunctions, while toposes are approached entirely from their logical side. This is probably as much as one could expect from philosophical notes on category theory, but I wonder to what degree the

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choice of topics is fortuitous. Could Lawvere's functorial semantics serve the philosophical considerations equally well or better? In several places it would help to have presheaves and the Yoneda lemma at hand, for instance to bolster the claim that "every determination is external (by arrows or relations)" (p. 56) and to give more substance to the example of a non-Boolean topos, which is just presheaves on an arrow. While set theory is ontology for Badiou, category theory is "the space of possible logics" (p. 57) and "a description of the possible options for thought, which does not constitute by itself such an option" (p. 161). Badiou understands that set theory and category theory play essentially different foundational roles, a point that seems to elude many investigators of foundations of mathematics.

The second part begins with an introduction to complete Heyting algebras, which we learn to be complete lattices with finite meets distributing over arbitrary joins. In mathematics, these are known as frames or locales, depending on what role they are given: as frames they serve as domains of truth values for intuitionistic predicate calculus, and as locales they embody the topological notion of a (possibly point-free) space built just from abstract open neighborhoods. Badiou's interests lie in logic, so let me call them frames, although he provides a wealth of examples by noting that the topology of a space is always a complete Heyting algebra. The fact that the book calls a frame "a transcendental" is indicative of its philosophical role: "that which, in any situation, serves as a domain for the evaluation of identities and differences in appearing" (p. 167). To put it less eloquently, the elements of a frame are used to express degrees of equality between objects and degrees of truth in general. Thus the book supplements the traditional sets with frame-valued identity relations according to which elements are equal to a certain degree, not just completely equal or completely unequal. In the same way, the existence of an element is a measured quantity and is just the degree to which the element equals itself. Complete Boolean algebras are seen to be a special case of frames, and they serve as a bridge to classical logic and classical set theory. We can never be satisfied with a single frame because different situations call for different scales of measurement. Just as in the first part of the book Badiou says nothing about functors between categories, here we learn nothing about morphisms between frames. He would need them had he felt the need to relate and systematically compare the different scales of measurement.

Badiou's notes paint a peculiar picture of category theory in which categories, toposes, and complete Heyting algebras stand isolated from each other to form a plurality of structures. Any student, whether of mathematics or philosophy, should supplement this view with introductory texts, maybe those of Awodey [1] or Lawvere and Schanuel [3], to see that functors, natural transformations, and adjunctions connect categories in rich ways. I suspect that Badiou could put the connections to good philosophical use, but cannot speculate why he has not done so.

I can hardly judge Badiou's philosophical interpretations of mathematics, although I am surprised at how tightly Badiou links his philosophy with the specific mathematical structures. Is it really necessary for Badiou's philosophy to use precisely toposes and not some other kind of categories? It looks like most of the philosophical analogies would still hold in a more general setting, maybe that of hyperdoctrines or other gadgets one finds in categorical logic. It could even be argued that Tarskian model theory could satisfy most, if not all, the philosophical needs. After all, it enjoys Gödel's completeness theorem. Similarly, why should the study of the "transcendental" be limited to frames? If Badiou adopted the treatment of quantifiers as adjoints rather than infima and suprema, then (external) completeness would not be needed anymore and a wealth of new examples would be at hand. Is generality not appreciated by philosophy? Anyhow, I shall not criticize a philosopher for not knowing everything when he expended an amazing amount of energy to build not one, but two bridges from his land to mine. I am impressed by the lucidity of Badiou's remarks on the philosophical significance of category theory, especially in relation to set theory, and I invite philosophically minded mathematicians to be so too.

References

1. Steven Awodey, *Category Theory*, Oxford Logic Guides, Oxford University Press, 2010.
2. Alain Badiou, *Mathematics of the Transcendental*, translated by A. J. Bartlett and Alex Ling, Bloomsbury Academic, 2014.
3. Francis William Lawvere and Stephen H. Schanuel, *Conceptual Mathematics: A First Introduction to Categories*, Cambridge University Press, Cambridge, New York, 1997.

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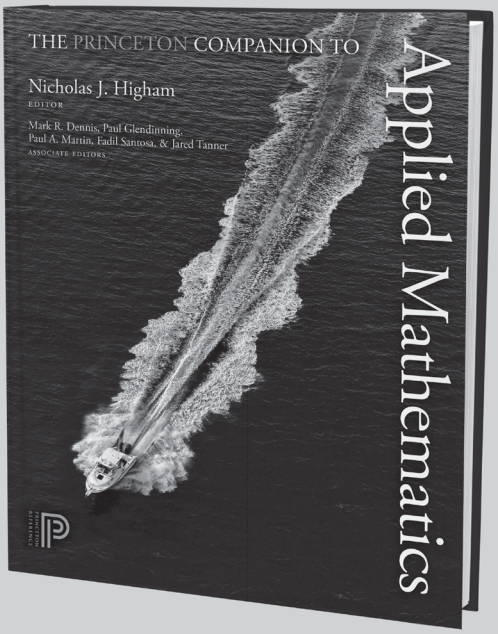

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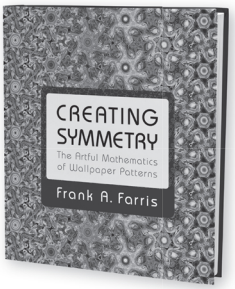

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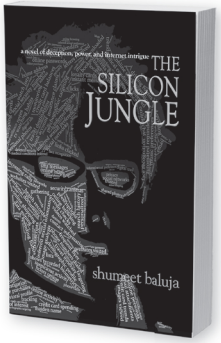

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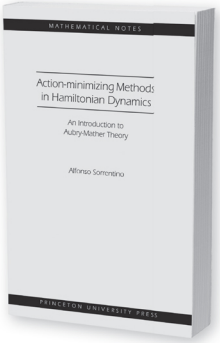

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Faltings and Iwaniec Awarded Shaw Prize

Max Planck Institute for Mathematics, Bonn, Germany.

Gerd Faltings

Nick Romanenko, Rutgers University.

Henryk Iwaniec

On June 1, 2015, the Shaw Foundation announced the awarding of the 2015 Shaw Prize in Mathematical Sciences to Gerd Faltings of the Max Planck Institute for Mathematics in Bonn, Germany, and Henryk Iwaniec of Rutgers University "for their introduction and development of fundamental tools in number theory, allowing them as well as others to resolve some long-standing classical problems." The prize carries a cash award of US$1 million.

The Shaw Prize in Mathematical Sciences Committee released the following statement about the prizewinners' work.

"Number theory concerns whole numbers, prime numbers, and polynomial equations involving them. The central problems are often easy to state but extraordinarily difficult to resolve. Success, when it is achieved, relies on tools from many fields of mathematics. This is no coincidence since some of these fields were introduced in attempts to resolve classical problems in number theory. Faltings and Iwaniec have developed many of the most powerful modern tools in algebra, analysis, algebraic and arithmetic geometry, automorphic forms, and the theory of zeta functions. They and others have used these tools to resolve long-standing problems in number theory."

DOI: http://dx.doi.org/10.1090/noti1273

The Work of Gerd Faltings

"A polynomial equation of degree n in one variable with coefficients which are rational numbers has just n complex numbers as solutions. Such an equation has a symmetry group, its Galois group, that describes how these complex solutions are related to each other.

"A polynomial equation in two variables with rational coefficients has infinitely many complex solutions, forming an algebraic curve. In most cases (that is, when the curve has genus 2 or more) only finitely many of these solutions are pairs of rational numbers. This well-known conjecture of Mordell had defied resolution for sixty years before Faltings proved it. His unexpected proof provided fundamental new tools in Arakelov and arithmetic geometry, as well as a proof of another fundamental finiteness theorem—the Shafarevich and Tate Conjecture—concerning polynomial equations in many variables. Later, developing a quite different method of Vojta, Faltings established a far-reaching higher dimensional finiteness theorem for rational solutions to systems of equations on Abelian varieties (the Lang Conjectures). In order to study rational solutions of polynomial equations by geometry, one needs arithmetic versions of the tools of complex geometry. One such tool is Hodge theory. Faltings's foundational contributions to Hodge theory over the p-adic numbers, as well as his introduction of other related novel and powerful techniques, are at the core of some of the recent advances connecting Galois groups (from polynomial equations in one or more variables) and the modern theory of automorphic forms (a vast generalization of the theory of periodic functions). The recent striking work of Peter Scholze concerning Galois representations is a good example of the power of these techniques."

The Work of Henryk Iwaniec

"Iwaniec's work concerns the analytic side of diophantine analysis, where the goal is usually to prove that equations do have integral or prime solutions, and ideally to estimate how many there are up to a given size.

"One of the oldest techniques for finding primes is sieve theory, originating in Eratosthenes's description of how to list the prime numbers. Iwaniec's foundational works and breakthroughs in sieve theory and its applications form a large part of this active area of mathematics. His proof (with John Friedlander) that there are infinitely many primes of the form $X^2 + Y^4$ is one of the most striking results about prime numbers known; the techniques introduced to prove it are the basis of many further works. The theory of Riemann's zeta function—and more generally of L-functions associated with automorphic forms—plays a central role in the study of prime numbers and diophantine equations. Iwaniec invented many of the powerful techniques for studying L-functions of automorphic forms, which are used widely today. Specifically, his techniques to estimate the Fourier coefficients of modular forms of half-integral weight and for estimating L-functions on their critical lines (the latter jointly with William Duke and John Friedlander) have led to the solution of a number of long-standing problems in number theory, including one of Hilbert's problems: that quadratic equations in integers (in three or more variables) can always be solved unless there is an 'obvious' reason that they cannot.

"In a series of papers remarkable both in terms of its concept and novel techniques, Iwaniec together with different authors (Étienne Fouvry and then Enrico Bombieri and John Friedlander) established results about the distribution of primes in arithmetic progressions which go beyond the notorious Riemann hypothesis. This opened the door to some potentially very striking applications. Yitang Zhang's much celebrated recent result on bounded gaps between primes relies heavily on the works of Iwaniec et al. Iwaniec's work mentioned above, together with his many other technically brilliant works, have a central position in modern analytic number theory."

Biographical Sketches

Gerd Faltings was born in 1954 in Gelsenkirchen-Buer, West Germany. He obtained his PhD in mathematics from the University of Münster in 1978. He then spent a year doing postdoctoral work as a research fellow at Harvard University from 1978 to 1979. He was an assistant professor at the University of Münster from 1979 to 1982. From 1982 to 1984, he was professor at the University of Wuppertal. He was professor at Princeton University from 1985 to 1994. Since 1995 he has been a director of the Max Planck Institute for Mathematics. He was awarded the Fields Medal in 1986. He held a Guggenheim Fellowship in 1988 and is also the recipient of the Gottfried Wilhelm Leibniz Prize (1996) and the King Faisal International Prize for Science (2014).

Henryk Iwaniec was born in 1947 in Elblag, Poland. He received his PhD from the University of Warsaw in 1972. He held positions at the Institute of Mathematics of the Polish Academy of Sciences until 1983, when he left Poland. He held visiting positions at the Institute for Advanced Study in Princeton, at the University of Michigan, and the University of Colorado at Boulder. He became professor of mathematics at Rutgers in 1989, where he is currently New Jersey Professor of Mathematics. He has been honored with the Ostrowski Prize (2001), the Frank Nelson Cole Prize in Number Theory (2002), and the Leroy P. Steele Prize for Mathematical Exposition (2011). He was a member of the inaugural class of AMS Fellows (2012).

About the Prize

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

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

Previous recipients of the Shaw Prize in Mathematical Sciences are George Lusztig (2014), David L. Donoho (2013), Maxim Kontsevich (2012), Demetrios Christodoulou and Richard S. Hamilton (2011), Jean Bourgain (2010), Simon K. Donaldson and Clifford H. Taubes (2009), Vladimir Arnold and Ludwig Faddeev (2008), Robert Langlands and Richard Taylor (2007), David Mumford and Wen-Tsun Wu (2006), Andrew Wiles (2005), and Shiing-Shen Chern (2004).

—From Shaw Foundation announcements

CALL FOR NOMINATIONS

AWM-AMS Noether Lecture

The Association for Women in Mathematics (AWM) established the Emmy Noether Lectures in 1980 to honor women who have made fundamental and sustained contributions to the mathematical sciences. In April 2013, this one-hour expository lecture was renamed AWM-AMS Noether Lecture. The first jointly sponsored lecture was held in January 2015 at the Joint Mathematics Meetings (JMM) in San Antonio, Texas. Emmy Noether was one of the great mathematicians of her time, someone who worked and struggled for what she loved and believed in. Her life and work remain a tremendous inspiration.

The mathematicians who have given the Noether lectures in the recent past include: Wen-Ching Winnie Li, Georgia Benkart, Raman Parimala, Barbara Keyfitz, Susan Montgomery, Carolyn Gordon, Fan Chung Graham. Additional past Noether lectures can be found at
https://sites.google.com/site/awmmath/programs/noether-lectures/noether-lecturers.

The letter of nomination should include a one-page outline of the nominee's contribution to mathematics, giving four of her most important papers and other relevant information. Nominations must be submitted by October 15, 2015 and will be held active for three years.

Nomination materials for this award should be compiled into one (1) PDF file and submitted online at
https://www.mathprograms.org/db/programs/299.

If you have questions, call 703-934-0163 or email awm@awm-math.org.

AWM
ASSOCIATION FOR WOMEN IN MATHEMATICS

AMERICAN MATHEMATICAL SOCIETY
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AMS
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What's Math Got to Do with It?

A Review by Alfred Manaster

What's Math Got To Do With It?: How Teachers and Parents Can Transform Mathematics Learning and Inspire Success
Jo Boaler
Penguin Books, revised edition, March 2015
Paperback, US$13.60
ISBN-13: 978-0-14312-829-8

Context

Why do we want to give all students good opportunities to develop an interest in and to learn mathematics? In the first place, we want to give them the best possible chance to use some mathematical habits of mind in their own lives, to help them make well-thought-out decisions for themselves and for their communities. Secondly, we want them to develop respect for mathematical and scientific methods, thinking, and results; this respect is best developed using some of these tools themselves to answer questions that interest them. This respect, in turn, can be useful in understanding the complexity of contemporary science and in evaluating the arguments of the increasing numbers of deniers of many research-based judgments and recommendations. Thirdly, we want students to have access to as many careers as possible for as long as possible; while only some will choose mathematics or other quantitatively based professions, those choices should not be closed prematurely due to inadequate backgrounds, undeveloped skills, misunderstanding of the nature of the fields, or fear of failure. Finally, we have a selfish interest in developing a mathematically and quantitatively literate public: that public is more likely to provide political support for rigorous study of both pure and applied problems.

Alfred Manaster is professor emeritus of mathematics at the University of California, San Diego. His email address is amanaster@ucsd.edu.

DOI: http://dx.doi.org/10.1090/noti1281

The Book's Concepts of Mathematics and Mathematics Education

In the revised edition (March 2015) of *What's Math Got To Do With It? How Teachers and Parents Can Transform Mathematics Learning and Inspire Success*, Jo Boaler presents important mathematical goals for all students, descriptions of classroom environments and teaching approaches that support those goals, some of the research findings that indicate these approaches work, and examples of problems that parents and teachers can offer to children to engage them in mathematics and strengthen their mathematical backgrounds.

Professor Boaler emphasizes the development of mathematical activities and ways of thinking, but she also recognizes the importance of mathematical techniques and underlying principles. Mathematics is viewed as a sense-making activity. Reasoning is a critical component of the convincing argumentation that is required for understanding. Early on (p. 21), the construction of time-resistant proofs is recognized as what mathematics is "all about."

The book's treatment of problem solving and the ways it should be presented and used is quite compatible with mathematicians' understanding of its nature. Most mathematics can be considered as arising in a context of problem solving. The choice of which problems to work on is motivated by interest and need. Theories are often developed to answer fairly broad questions, while

theorems are often formulated and proved to solve more specific problems. Problem solving is closely related to making sense and developing convincing arguments. It often starts with formulating a question and then continues with guesses or estimates of possible answers, followed by adjustments and refinements as early approaches fail. A solution is usually a precise answer to the question or a related one, which may be more specific or more general or a reformulation of the original question. To be a solution, the answer must be justified by a complete understanding of how it was found and why, based on a logical analysis, it must be correct. Even though there is usually one answer to the (final) question, there are often many ways to find it and several convincing logical analyses showing that it must be correct.

Formulating and solving problems require the development and use of a variety of representations, including verbal and algebraic languages, pictures, graphs, diagrams, and tables. Finding these representations and using them flexibly but with precision can increase understanding of both the problems and their solutions. It can also help develop generalizations of results and place them in more theoretical contexts.

A theoretical underpinning of the book's approach to mathematical education is that the best (only?) way for students to reach the central goals of mathematical understanding is through experiencing mathematical activities. What constitutes convincing proof (for example) obviously depends upon the audience, but the desire to develop convincing proofs and a yearning for understanding should be stimulated in appropriate ways throughout a child's mathematics experiences. For this to happen, students must have opportunities to work on questions that are meaningful and interesting to them. They must also have the freedom to explore their own ways of finding solutions in a supportive and collaborative environment and to make mistakes and learn from them. They should ask questions and help formulate and reformulate problems, and they should demand fully convincing answers to problems and questions.

To stimulate and maintain interest of all students with their diverse interests and ways of learning, as well as their changing responses to different social and intellectual environments, Professor Boaler calls for a variety of several kinds in mathematics classes and curricula. Effective curricula include problems ranging from long investigations to short questions. The contexts vary from applied realistic settings to abstract pure ones. Students are given ample opportunities to work alone and also to collaborate with others.

In addition to working on challenging problems and developing convincing justifications for their solutions, students must also have ample opportunities to encounter mathematical ideas, to reflect upon them, and to explore how they are related to one another. Projects must be carefully chosen "to interest the students and to provide opportunities for learning important mathematical concepts and methods" (p. 74). Learning mathematics includes discussing those concepts and methods (after they have been developed in meaningful contexts), exploring other ways of using them, and comparing them to each other.

Professor Boaler's vision for mathematics instruction follows naturally from her goals for the mathematics that students should learn. The book does not merely present this vision but also summarizes research findings that support the effectiveness of the instructional approaches she recommends. It includes extended discussion of two longitudinal studies she conducted comparing students taught using the kinds of instruction she advocates with students taught in more traditional classes: one study compared students in two United States high schools, the other students in two English middle schools. In both studies she found that students exposed to rich educational experiences made significantly greater advances on standard tests. They also gained much more self-confidence in their ability to learn mathematics and developed an enjoyment of the subject. In the US study, 41 percent of the seniors in the high school that had developed a "new approach" (compatible with Professor Boaler's recommendations) were enrolled in advanced precalculus or calculus courses; in the nearby high school, whose students entered high school with higher achievement levels but were taught mathematics using traditional methods, only 23 percent of seniors were in precalculus or calculus courses. In the study of two English middle schools, she found that eight years later, students who had been in the more project-based classes were working in more highly skilled or professional jobs than those who attended the more traditional classes, even though the levels of the parents' jobs in the two schools had been equal. In addition, the first group of students saw how they applied the mathematical reasoning skills in their lives and careers, while those in the second group were more likely to wonder why they had been forced to learn mathematics and why they couldn't use it.

Concerns and Recommendations

Boaler does not explicitly mention the abstract nature of mathematical content. Doing so might have been helpful to some readers, since the intended audience includes parents with little understanding of mathematics. Recognizing that abstraction enables the certainty of many mathematical results might help readers understand the power and the limitations of mathematics and mathematical techniques. Otherwise, some may be more dismissive of mathematics, since they are familiar with many

more concrete contexts where complete precise answers to questions are not possible.

What's Math Got To Do With It? calls for dramatically changing traditional US mathematics classes. The reasonableness of the author's goals for students and the good fit between those goals and the approaches described provide much support for that call. Her recommendation is supported further by the evidence in the author's research and other research she cites. There are questions that also need to be considered before fully embracing what is referred to at the end of the book as a revolution. As Professor Boaler indicates, the classrooms she envisions (and has seen) are much more chaotic than traditional classrooms, so that a teacher has to learn how to lead and teach in a very different way, one that may be uncomfortable for many at first. Teachers tend to teach the way they have been taught, so effective change may have to occur more slowly than Professor Boaler hopes. This point is reinforced by the need for teachers to be open to and able to build upon the wide variety of approaches that their students will take in solving problems. This, in turn, requires a broader and deeper subject matter knowledge for teachers than that required for the more traditional mathematics instruction. So, teacher education will need to address both class management and subject matter knowledge from different, probably richer, perspectives.

Another issue not addressed in the book concerns prerequisites for students enrolling in mathematics courses. The book includes compelling arguments for avoiding tracking students at an early stage, but the question of when to require students to have adequate background knowledge for the benefit of all the students in a course is neither raised nor answered. My experience has been that it is much more difficult to teach most undergraduate courses to a class with widely divergent mathematical backgrounds.

In my opinion, any mathematician who wants to support and improve precollegiate mathematics education will be more effective in doing so after carefully considering Professor Boaler's work and recommendations reported in *What's Math Got To Do With It?* Awareness of the effects of different kinds of classroom experiences on students provides an essential perspective for helping schools, districts, states, and the nation better support development of mathematical understanding for all students. The book also seems very valuable for mathematicians who teach courses designed for preservice or in-service teachers, partly so that they can begin exposing students to the kinds of learning experiences and instructional settings that have been shown to be so powerful for many elementary and secondary students.

Mathematics People

Simons Foundation Investigators

The Simons Foundation has named eighteen mathematicians, theoretical physicists, and theoretical computer scientists as Simons Investigators for 2015. The Simons Investigators program provides a stable base of support for outstanding scientists, enabling them to undertake long-term study of fundamental questions. The names and institutions of the awardees whose work involves the mathematical sciences and brief excerpts from the prize citations follow.

Ian Agol of the University of California Berkeley has made major contributions to three-dimensional topology and hyperbolic geometry, completing some of Thurston's problems elucidating the structure of 3-manifolds. He proved several deep and long-standing conjectures, including the Virtual Haken conjecture, the Marden Tameness conjecture and the Simon conjecture.

Ben Green of the University of Oxford is an expert in analytic number theory. Among his achievements is the Green-Tao theorem, establishing that primes contain arbitrarily long arithmetic progressions.

Raphaël Rouquier of the University of California Los Angeles has initiated a new field in mathematics, "higher representation theory". He constructed novel categories of geometric and representation-theoretic interest and applied these to problems in the theory of finite groups, Lie theory, algebraic geometry, and mathematical physics.

Christopher Skinner of Princeton University works in number theory and arithmetic geometry. One of his striking recent results is a proof, in joint work with collaborators, that a positive proportion of elliptic curves defined over the rational numbers satisfies the Birch–Swinnerton-Dyer conjecture.

Subhash Khot of New York University initiated a new direction in computational complexity theory and approximation algorithms based on his Unique Games conjecture, which is currently one of the most important conjectures in theoretical computer science.

Christopher Umans of the California Institute of Technology works on complexity theory, in particular algorithms and randomness in computations. He has established new upper bounds for the complexity of matrix multiplication and developed a novel algorithm for polynomial factorization.

The work of Alexei Kitaev of the California Institute of Technology on topologically protected states of matter helped found the field of topological quantum computing; his prediction that topological superconductors may sustain Majorana fermions has initiated major experimental activity. His ongoing work concerns the mathematical classification of the possible quantum phases of matter.

The work of Anastasia Volovich of Brown University on gauge and gravity theories has introduced a new perspective on Feynman diagram calculations, along with powerful and extremely efficient methods for their evaluation. Her ongoing work is uncovering deep mathematical structures within the gauge theories of particle physics.

The work of Michael Weinstein of Columbia University bridges the areas of fundamental and applied mathematics, physics, and engineering. He is known for his elegant and influential mathematical analysis of wave phenomena in diverse and important physical problems. His and his colleagues' work on singularity formation, stability, and nonlinear scattering has been central to the understanding of the dynamics of coherent structures of nonlinear dispersive wave equations arising in nonlinear optics, macroscopic quantum systems, and fluid dynamics. This led to work on resonances and radiation in Hamiltonian partial differential equations, with applications to energy flow in photonic and quantum systems. Recently, he has explored wave phenomena in novel structures such as topological insulators and metamaterials.

—From a Simons Foundation announcement

Green Awarded Sylvester Medal

Ben Green of the University of Oxford has been awarded the 2014 Sylvester Medal of the Royal Society of London "for his famous result on primes in arithmetic progression, and his subsequent proofs of a number of spectacular theorems over the last five to ten years." The Sylvester Medal is awarded in even-numbered years "for the encouragement of mathematical research." The award carries a cash prize of 1,000 pounds (approximately US$1,500).

—From a Royal Society announcement

Prizes of the London Mathematical Society

The London Mathematical Society (LMS) has awarded a number of prizes for 2015. The Pólya Prize was awarded to Boris Zilber of the University of Oxford for his visionary contributions to model theory and its applications. The Shephard Prize was awarded to Keith Ball of the University of Warwick for his many beautiful results in geometry (particularly the geometry of convex shapes), number theory, and probability theory. The Naylor Prize and Lectureship in Applied Mathematics was awarded to Stephen J. Chapman of the University of Oxford for his outstanding contributions to modeling and methods development in applied mathematics. The Anne Bennett Prize was awarded to Apala Majumdar of the University of Bath in recognition of her outstanding contributions to the mathematics of liquid crystals and to the liquid crystal community.

The Berwick Prize has been awarded to Pierre-Emmanuel Caprace of Université Catholique de Louvain and Nicolas Monod of École Polytechnique Federale de Lausanne in recognition of their papers "Isometry groups of nonpositively curved spaces: Structure theory" and "Isometry groups of nonpositively curved spaces: Discrete subgroups," *Journal of Topology* **2** (2009), no. 4, 661–700; 701–746.

The LMS also awarded a number of Whitehead Prizes. The Senior Whitehead Prize was awarded to Robert MacKay of the University of Warwick for his outstanding contributions to research in dynamical systems and its applications. A remarkably creative and prolific mathematician, in addition to the broad impact of his research, he has made an outstanding contribution to the mathematical community generally.

The Whitehead Prizes are given to mathematicians with less than fifteen years' experience at the postdoctoral level (allowing for career breaks). This year's Whitehead Prizes were awarded to the following individuals: Peter Keevash of the University of Oxford for his work in combinatorics, in particular his stunning proof of the existence of combinatorial designs for all parameters satisfying the obvious necessary conditions; James Maynard of the University of Oxford for his spectacular results on gaps between prime numbers; Christoph Ortner of the University of Warwick for contributions to the mathematical foundations, development, and implementation of the quasicontinuum method; Mason Porter of the University of Oxford in recognition of his outstanding interdisciplinary contributions and in particular to the emerging field of network science; Dominic Vella of the University of Oxford for his spectacular contributions to the modeling of instability and interfacial phenomena in fluids and solids; and David Loeffler of the University of Warwick and Sarah Zerbes of University College London for their joint work in number theory, in particular for their discovery of a new Euler system, and for their applications of this to generalizations of the Birch–Swinnerton-Dyer conjecture.

The Hirst Prize and Lectureship was awarded to John O'Connor and Edmund Robertson of the University of St. Andrews for their creation, development, and maintenance of the MacTutor History of Mathematics website. The Communication Prize was awarded to Christopher Budd of the University of Bath in recognition of his sustained excellence and innovation in the communication of mathematics.

—From an LMS announcement

International Mathematical Olympiad

A team from the United States won first place at the fifty-sixth International Mathematical Olympiad (IMO) held in Chiang Mai, Thailand, July 4–13, 2015, finishing with 185 points.

The members of the US team were Ryan Alweiss (Bergen County Academies, Hackensack, New Jersey), Allen Liu (Penfield Senior High School, Penfield, New York), Yang Liu (Ladue Horton Watkins High School, St. Louis, Missouri), Shyam Narayanan (Blue Valley West High School, Overland Park, Kansas), and David Stoner (South Aiken High School, Aiken, South Carolina), all of whom were awarded gold medals, and Michael Kural (Greenwich High School, Greenwich, Connecticut), who earned a silver medal. Allen Liu and Yang Liu were also gold medal winners in the 2014 competition.

The team from China finished second with 181 points, and the team from South Korea was third with 161 points.

The IMO is the preeminent mathematical competition for high-school-age students from around the world. The IMO consists of solving six extremely challenging mathematical problems in a nine-hour competition administered over two days. The 2016 IMO will be held in Hong Kong, July 6–16, 2016.

—From an IMO announcement

Karen E. Smith named 2016 Noether Lecturer

Photo courtesy of Karen E. Smith.

Karen E. Smith

The Association for Women in Mathematics (AWM) and the American Mathematical Society (AMS) are pleased to announce that Karen E. Smith will deliver the Noether Lecture at the 2016 Joint Mathematics Meetings. Dr. Smith is the Keeler Professor of Mathematics at the University of Michigan. She has been selected as the 2016 Noether Lecturer for her outstanding work in commutative algebra and its interface with algebraic geometry.

Smith received a bachelor's degree in mathematics in 1987 from Princeton University. After a year of teaching high school, she went to the University of Michigan and received a PhD in mathematics in 1993 under the direction of Melvin Hochster. Immediately after receiving her doctorate Smith spent a year at Purdue University as an NSF postdoc working with Craig Huneke, followed by a position as a Moore Instructor at MIT. In 1997, even though she was promoted to assistant professor at MIT, she chose to move back to the University of Michigan, where she continues to teach and do research.

Smith's research in commutative algebra was recognized in 2001 when she received the Ruth Lyttle Satter Prize. Given every two years, this prize recognizes an outstanding contribution to mathematics research by a woman in the previous six years. The citation states: "The Ruth Lyttle Satter Prize in Mathematics is awarded to Karen E. Smith of the University of Michigan for her outstanding work in commutative algebra, which has established her as a world leader in the study of tight closure, an important tool in the subject introduced by Hochster and Huneke. It is also awarded for her more recent work which builds new bridges between commutative algebra and algebraic geometry via the concept of tight closure."

—From an AWM Announcement

Inside the AMS

From the AMS Public Awareness Office

Art of Problem Solving sponsors Who Wants to Be a Mathematician. The AMS is pleased to welcome AoPS as a sponsor of the game. AoPS is the online community sponsor of Who Wants to Be a Mathematician and is providing gift certificates to all participating schools in 2015–2016. Since 2003, AoPS has developed a wide range of educational materials for outstanding K–12 math students. Its online community at `aops.com` has over 180,000 members and hundreds of thousands of visitors each month. See more at `www.ams.org/wwtbam`.

Joint AMS-EMS-SPM Meeting. See highlights of the Joint International Meeting of the AMS, European Mathematical Society (EMS), and Portuguese Mathematical Society/Sociedad Portuguesa de Matemática (SPM). The meeting, held at the University of Porto in the UNESCO world heritage city of Porto, Portugal, June 10–13, drew 1,103 participants from fifty-nine countries. See `www.ams.org/ams-portugal-mtg15`.

AMS for Students. High school and undergraduate students and mentors in mathematical sciences can follow news and find information on special math programs, graduate schools, competitions, and awards, as well as where to publish and present research, how math is applied, where to find internships, get free math help, and enjoy math outside the classroom. See `www.ams.org/students`.

Awards, Fellowships & Opportunities. Visitors to the Awards, Fellowships & Opportunities page can browse, search, and post calls for fellowship and grant applications, prize and award nominations, and meeting and workshop proposals. The page, updated on an ongoing basis, serves mathematics faculty/scientists, institutions, programs, postdocs/early-career mathematicians, graduate students, undergraduate students, and high school students and teachers. Institutions and organizations are invited to submit calls for their opportunities at `www.ams.org/opportunities`.

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

Search for an Executive Director for the American Mathematical Society

Position

The Trustees of the American Mathematical Society seek candidates for the position of Executive Director of the Society to replace Dr. Donald McClure, who plans to retire in the summer of 2016. This position offers the appropriate candidate the opportunity to have a strong positive influence on all activities of the Society, as well as the responsibility of overseeing a large, complex, and diverse spectrum of people, publications, and budgets. The desired starting date is July 1, 2016.

Duties and terms of appointment

The American Mathematical Society, with headquarters in Providence, RI, is the oldest scientific organization of mathematicians in the U.S. The Society's activities are mainly directed toward the promotion and dissemination of mathematical research and scholarship, broadly defined; the improvement of mathematical education at all levels; increasing the appreciation and awareness by the general public of the role of mathematics in our society; and advancing the professional status of mathematicians. These aims are pursued mainly through an active program of publications, meetings, and conferences. The Society is a major publisher of mathematical books and journals, including MathSciNet, an organizer of numerous meetings and conferences each year, and a leading provider of electronic information in the mathematical sciences. The Society maintains a Washington office for purposes of advocacy and to improve interaction with federal agencies.

The Executive Director is the principal executive officer of the Society and is responsible for the execution and administration of the policies of the Society as approved by the Board of Trustees and by the Council. The Executive Director is a full-time employee of the Society appointed by the Trustees and is responsible for the operation of the Society's offices in Providence and Pawtucket, RI; Ann Arbor, MI; and Washington, DC. The Executive Director is an ex-officio member of the policy committees of the Society and is often called upon to represent the Society in its dealings with other scientific and scholarly bodies.

The Society employs a staff of about 200 in the four offices. The directors of the various divisions report directly to the Executive Director. A major part of the Society's budget is related to publications. Almost all operations (including the printing) of the publications program are done in-house. Information about the operations and finances of the Society can be found in its Annual Reports, available at www.ams.org/annual-reports.

The Executive Director serves at the pleasure of the Trustees. The terms of appointment, salary, and benefits will be consistent with the nature and responsibilities of the position and will be determined by mutual agreement between the Trustees and the prospective appointee.

Qualifications

Candidates for the office of Executive Director should have a Ph.D. (or equivalent) in mathematics, published research beyond the Ph.D., and significant administrative experience. The position calls for interaction with the staff, membership, and patrons of the Society as well as leaders of other scientific societies and publishing houses; thus leadership, communication skills, and diplomacy are prime requisites.

Applications

A search committee chaired by Robert Bryant (bryant@math.duke.edu) and Ruth Charney (charney@brandeis.edu) has been formed to seek and review applications. All communication with the committee will be held in confidence. Suggestions of suitable candidates are most welcome. Applicants can submit a CV and letter of interest to:

Executive Director Search Committee
c/o Carla D. Savage
Secretary, American Mathematical Society
Department of Computer Science
North Carolina State University
Raleigh, NC 27695-8206
ed-search@ams.org

The American Mathematical Society is an Affirmative Action/Equal Opportunity Employer.

Mathematics Opportunities

Call for Proposals for the 2017 AMS Short Courses

The AMS Short Course Subcommittee invites submissions of preliminary proposals for Short Courses on fields of application of mathematics to be given at the 2017 Joint Mathematics Meetings. Members are also invited to submit names of colleagues who they think would conduct an inspiring short course. A Short Course consists of a coherent sequence of survey lectures and discussions on a single theme. A Short Course ordinarily extends over a period of two days immediately preceding the Joint Mathematics Meetings held in January. Usually there are about six different lecturers, and it is anticipated that the proceedings of the Short Course will be published in the series Proceedings of Symposia in Applied Mathematics. Preliminary proposals may be as short as one page. After reviewing the preliminary proposals, the subcommittee may ask for more details from some of the proposers. Proposals should be sent via email to the Associate Executive Director (`aed-mps@ams.org`) with a copy to Robin Hagan Aguiar (`rha@ams.org`). For full consideration for the 2017 Short Courses, proposals should be submitted by **December 21, 2015**.

—AMS Associate Executive Director

*NSF Project ADVANCE

The goal of the National Science Foundation's (NSF) ADVANCE program is to increase the representation and advancement of women in academic science and engineering careers, thereby contributing to the development of a more diverse science and engineering workforce.

ADVANCE encourages institutions of higher education and the broader science, technology, engineering, and mathematics (STEM) community, including professional societies and other STEM-related not-for-profit organizations, to address various aspects of STEM academic culture and institutional structure that may differentially affect women faculty and academic administrators.

Since 2001 the NSF has invested over US$130 million to support ADVANCE projects at more than one hundred institutions of higher learning and STEM-related not-for-profit organizations in forty-one states, the District of Columbia, and Puerto Rico.

Additional information about ADVANCE programs, as well as application deadlines, can be found at `www.nsf.gov/funding/pgm_summ.jsp?pims_id=5383&org=DMS&sel_org=DMS&from=fund`.

—From an NSF announcement

*NSF Conferences and Workshops in the Mathematical Sciences

The National Science Foundation (NSF) supports conferences, workshops, and related events (including seasonal schools and international travel by groups). Proposals for conferences, workshops, or conference-like activities may request funding of any amount and for durations of up to three years. Proposals may be submitted only by universities and colleges and by nonprofit nonacademic institutions. For full information, including deadlines for each disciplinary program, see the web page `www.nsf.gov/funding/pgm_summ.jsp?pims_id=11701&org=DMS&sel_org=DMS&from=fund`.

—From an NSF announcement

**The most up-to-date listing of NSF funding opportunities from the Division of Mathematical Sciences can be found online at:* `www.nsf.gov/dms` *and for the Directorate of Education and Human Resources at* `www.nsf.gov/dir/index.jsp?org=ehr`. *To receive periodic updates, subscribe to the DMSNEWS listserv by following the directions at* `www.nsf.gov/mps/dms/about.jsp`.

News from IPAM

The Institute for Pure and Applied Mathematics (IPAM) is a National Science Foundation (NSF) mathematics institute located at the University of California Los Angeles. IPAM holds long programs (three months) and workshops (three to five days) throughout the academic year for junior and senior mathematicians and scientists who work in academia, research laboratories, and industry. In the summer, IPAM offers an industrial research experience for undergraduates and a summer school for graduate students and postdocs.

IPAM seeks program proposals from the math and science communities. Please send your idea for a workshop, long program, or summer school to `director@ipam.ucla.edu`.

The current long program is **New Directions in Mathematical Approaches for Traffic Flow Management**. The three remaining workshops in the program are: Traffic Estimation (October 12–16), Traffic Control (October 26–30), and Decision Support for Traffic (November 16–20). A mini-workshop on October 7 includes a field trip to the Los Angeles Regional Transportation Management Center. You may register for the workshops online.

On Tuesday, October 6, IPAM will celebrate its fifteenth anniversary and the renewal of support from the National Science Foundation. Former program participants, board members, and the public are invited to the fifteenth anniversary event, which will feature three talks by former participants of IPAM programs whose research was greatly influenced by their participation at IPAM, followed by a reception. You can find more information and register online.

IPAM's other upcoming programs are listed below. Please go to `www.ipam.ucla.edu` for detailed information and to find application and registration forms.

2016 Winter Workshops. You may apply for support or register for each workshop online.

January 11–15, 2016: Optimization and Equilibrium in Energy Economics.

January 19–22, 2016: Uncertainty Quantification for Multiscale Stochastic Systems and Applications.

January 25–29, 2016: Partial Order: Mathematics, Simulations, and Applications.

February 8–12, 2016: Shape Analysis and Learning by Geometry and Machine.

February 22–26, 2016: Algebraic Geometry for Coding Theory and Cryptography.

March 7–June 10, 2016: Culture Analytics. You may apply online for support to be a core participant for the entire program or apply or register for individual workshops.

March 8–11, 2016: Tutorials.

March 21–24, 2016: Workshop I: Mathematical Analysis of Cultural Expressive Forms: Images, Videos, Music, and Cognition.

April 11–15, 2016: Workshop II: Culture Analytics and User Experience Design.

May 9–13, 2016: Workshop III: Cultural Patterns: Multiscale Data-Driven Models.

May 23–27, 2016: Workshop IV: Mathematical Analysis of Cultural Expressive Forms: Text Data.

September 12–December 16, 2016. Understanding Many-Particle Systems with Machine Learning. You may apply online for support to be a core participant for the entire program or may apply or register for individual workshops.

September 13–16, 2016: Tutorials.

September 26–30, 2016: Workshop I: Machine Learning Meets Many-Particle Problems.

October 24–28, 2016: Workshop II: Collective Variables in Classical Mechanics.

November 14–18, 2016: Workshop III: Collective Variables in Quantum Mechanics.

December 5–9, 2016: Workshop IV: Synergies between Machine Learning and Physical Models.

The spring 2017 long program (March 20–June 9, 2017) is entitled "Computational Issues in Oil Field Applications." Please check our upcoming programs page soon for information on individual workshops.

—IPAM announcement

Mathematical Sciences Research Institute, Berkeley, CA

MSRI invites applications for Research Members and Postdoctoral Fellows in the following programs: Geometric Group Theory (August 15–December 16, 2016), Analytic Number Theory (January 17–May 26, 2017), and Harmonic Analysis (January 17–May 26, 2017). Research Memberships are intended for researchers who will be making contributions to a program and who will be in residence for one or more months. Postdoctoral Fellowships are intended for recent PhDs. Interested individuals should carefully describe the purpose of their proposed visit and indicate why a residency at MSRI will advance their research program. To receive full consideration, application must be complete, including all letters of support, by December 1, 2015. Application information can be found at `https://www.msri.org/web/msri/scientific/member-application`.

It is the policy of MSRI actively to seek to achieve diversity in its programs and workshops. Thus, a strong effort is made to remove barriers that hinder equal opportunity, particularly for those groups that have been historically underrepresented in the mathematical sciences.

Programs funded by the National Science Foundation.

—MSRI announcement

Mathematics Calendar

The most comprehensive and up-to-date Mathematics Calendar information is available on the AMS website at www.ams.org/mathcal/.

Please submit conference information for the Mathematics Calendar through the Mathematics Calendar submission form at www.ams.org/cgi-bin/mathcal-submit.pl.

October 2015

* 5–9 **Autumn School in Nonlinear Science**, Instituto Superior Tecnico, Lisbon, Portugal.
Description: The school aims at bringing together prominent researchers, known for their expertise in modeling, analysis and simulation of nonlinear phenomena, and graduate and post-graduate students from around the world for five days of research training. The school comprises an intensive program of week-long short courses complemented by tutorial sessions. It will focus on nonlocal or nonlinear partial differential equations with applications ranging from phase transitions and free boundary problems to porous media flows and contaminant transport in subsurface environments.
Information: `nls2015.math.tecnico.ulisboa.pt/`.

* 10–11 **Workshop on Springer Theory and Related Topics**, University of Massachusetts–Amherst, Amherst, MA.
Description: A two-day workshop on representation theory related to Springer theory.
Information: `www.math.lsu.edu/~pramod/UMass2015/`

* 14–16 **Advanced Course on Competing Risks: Concepts, Methods and Software**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.
Description: Competing risks: concepts, methods and software Lecturer: Ronald Geskus, Academic Medical Center, Amsterdam, The Netherlands; The course will alternate sessions that are devoted to explanation of the theory with sessions in which the concepts learned can be practiced through exercises, mostly by using the R statistical computing environment. A good working knowledge of survival analysis and R is recommended.
Information: `www.crm.cat/en/Activities/Curs_2015-2016/Pages/Competing-risks.aspx`

* 24–26 **Relevance of Ramanujan's Work and its Applications in Mathematical Sciences**, Department of Mathematics, T.D.P.G. College, Jaunpur-222002 (U.P.), India.
Description: Ramanujan Society of Mathematics and Mathematical Sciences and Department of Mathematics T.D.P.G. College, Jaunpur are going to organize a "National Conference on Relevance of Ramanujan's Work and its Applications in Mathematical Sciences," during October 24–26, 2015. The aim of the Conference is to bring together Mathematicians and Research scholars from different parts of the Country for exchange of ideas and latest developments in special functions and analysis. Expected topics to be covered in this Conference are Hypergeometric Series, Lie theory, Orthogonal polynomials, Partition theory, Continued fractions, Combinatorial analysis and other interesting works of the great Indian Mathematician Srinivasa Ramanujan. Kindly send the topic of your talk/abstract of paper latest by October 10, 2015 on emails: `snsp39@yahoo.com`; `snsp39@gmail.com`. You are requested to kindly forward this mail/message among your colleagues and young research scholars for its wide circulations.

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 in the Meetings & Conferences Section 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. 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 `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*. New information about meetings and conferences that will occur beyond the current 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 given twelve-month period.
The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available through the AMS website: `www.ams.org/`.

November 2015

* 16–18 **Advanced Course on Flexible Regression and Smoothing**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.
Description: This short course will be an exposition of the GAMLSS framework using throughout practical examples. In particular the following topics will be covered: An introduction to GAMLSS and its statistical modelling philosophy. An introduction to the R implementation of GAMLSS. A description of the different distributions which can be used for modelling the response variable, and their properties. This includes: i) continuous (positively or negatively skewed and with high or low kurtosis) (ii) discrete and iii) mixed distributions. The different additive terms for modelling the parameters of the distribution will be explored including: linear, nonparametric smoothing and random effects terms. Exposition to different modelling selection techniques and diagnostics for checking the model adequacy. Further statistical modelling examples (including centile estimation).
Information: `www.crm.cat/en/Activities/Curs_2015-2016/Pages/Flexible-Regression-and-Smoothing.aspx`

* 23–25 **The 11th IMT-GT International Conference on Mathematics, Statistics and Its Applications 2015**, Pattaya, Thailand.
Description: The 11th IMT-GT International Conference on Mathematics, Statistics and Its Applications 2015 (ICMSA 2015) will be held during November 23–25, 2015 at Ambassador City Jomtien Hotel, Pattaya, Thailand, organized and hosted by Department of Mathematics, King Mongkuts Institute of Technology Ladkrabang (KMITL) in association with the Indonesia-Malaysia-Thailand Growth Triangle (IMT-GT) conference. This conference provides opportunities to exchange new ideas and application experiences to enhance the knowledge in the field of Mathematics, Statistics and its applications.
Information: `www.icmsa2015.kmitl.ac.th`

January 2016

* 18–21 **Third EACA International School on Computer Algebra and its Applications**, IMUS and Facultad de Matematicas, University of Seville, Seville, Spain.
Description: We are pleased to announce the Third EACA International School on Computer Algebra and its Applications. University of Seville, Spain.
Information: `www.imus.us.es/EACASCHOOL16/index.php?carga=home`

February 2016

* 1–April 30 **Intensive Research Programme in Nonsmooth Dynamics**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.
Description: This program will take stock of recent advances in Nonsmooth Dynamics and where the field is going. As a general theory of how switches, impacts, and other discontinuities affect dynamical systems, Nonsmooth Dynamics has always been strongly informed by applications. By bringing theoretical and practical insights together at a time of rapidly growing interest, we will try to solve some major outstanding problems in an intensive but open forum. Activities to be held in the Research Programme are: Conference on "Open Problems in Nonsmooth Dynamics;" February 1–5, 2016, 3 short courses on
1. Nonsmooth networks
2. The complementarity approach applied
3. The Filippov approach and beyond; February 29–March 4, 2016; Workshop on "Nonsmooth Dynamics, the way forward" April 25–29, 2016.
Information: `www.crm.cat/en/Activities/Curs_2015-2016/Pages/Advances-in-Nonsmoothe-Dynamics.aspx`

March 2016

* 1–July 31 **Intensive Research Programme on Constructive Approximation and Harmonic Analysis**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.
Description: This research program focuses on the interaction between constructive approximation and harmonic analysis. The aim is to facilitate broader and deeper interaction among researchers in these fields. Activities in the Research Programme are:
Workshop on Function Spaces and High-dimensional Approximation from May 2 to 6, 2016
Advanced course on Constructive Approximation and Harmonic Analysis, from May 30 to June 4, 2016
Conference on Harmonic Analysis and Approximation Theory (HAAT 2016), from June 6 to 10, 2016
Information:
`www.crm.cat/en/Activities/Curs_2015-2016/Pages/IRP-Approximation-and-Harmonic-Analysis.aspx`

May 2016

* 11–13 **International Arab Conference on Mathematics and Computations**. The conference will held at Zarqa University, Zarqa, Jordan.
Description: The languages of the conference are English and Arabic. The scopes of the conference are:
1 - Pure Mathematics
2 - Applied Mathematics
3 - Statistics and its Techniques
Information: `www.iacmc.org`

* 29–June 3 **Whitney Extension Problems: C^m and Sobolev functions on subsets of R^n**, Technion - Israel Institute of Technology, Haifa, Israel.
Description: The conference will focus on some of the most vibrant developments in function theory related to the celebrated Whitney extension and trace problems for classes of smooth functions. These include new analytic and geometric methods in the study of differentiable structures on finite sets, extension and trace problems for functions in Sobolev spaces and spaces of generalized smoothness defined on closed subsets of R^n, geometric description of Sobolev extension domains, etc. The purpose of the conference is to bring together an international group of experts in the areas of function theory and functional and geometric analysis to report on and discuss recent progress and open problems in the area of Whitney type problems and thus foster interaction and collaboration between researchers in these fields.

June 2016

* 19–25 **BIOMATH International Conference on Mathematical Methods and Models in Biosciences**, Conference Center "Bachinovo", South West University, Blagoevgrad, Bulgaria.
Description: BIOMATH is an international conference on Mathematical Methods and Models in Biosciences. It is devoted to recent research in life sciences based on applications of mathematics as well as mathematics applied to or motivated by biological studies. It is a multidisciplinary meeting forum for researchers who develop and apply mathematical and computational tools to the study of phenomena in the broad fields of biology, ecology, medicine, biotechnology, bioengineering, environmental science, etc. BIOMATH 2015 includes as an integral part a School for Young Scientists and an Instructional Workshop on Advanced Mathematical Methods in Life Sciences.
Information: `www.biomath.bg/2016`

* 19–25 **BIOMATH Young Scientists School**, Conference Center "Bachinovo", South West University, Blagoevgrad, Sofia, Bulgaria.
Description: BIOMATH Young Scientists School is an integral part of the conference BIOMATH. It consists of foundational, keynote

lectures, hot topics workshop, presentations of participants, evaluation and feedback.
Information: www.biomath.bg/2016

* 27–July 1 **3rd Barcelona Summer School on Stochastic Analysis**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.
Description: The Barcelona Summer School on Stochastic Analysis is a one-week scientific activity consisting mainly of courses addressed to PhD students and young researchers on current research topics in Stochastic Analysis. Selected participants are also given the opportunity to deliver short talks or to display posters. The courses in 2016 will be the following: On Approximations of Stochastic PDEs, by István Gyöngy (University of Edinburgh, UK) Regularity Structures, by Martin Hairer (University of Warwick, UK).
Information:
www.crm.cat/en/Activities/Curs_2015-2016/Pages/3rd-BCN-Summer-School-on-Stochastic-Analysis.aspx

* 27–July 2 **26th International Conference in Operator Theory**, West University, Timisoara, Romania.
Description: The 26th International Conference in Operator Theory is organized jointly in Timisoara by the Institute of Mathematics Simion Stoilow of the Romanian Academy and the West University in Timisoara. As usual, the conference is devoted to operator theory, operator algebras and their applications (differential operators, complex functions, mathematical physics, matrix analysis, system theory, etc.).
Information: operatortheory26.wordpress.com/

July 2016

* 4–9 **14th International Conference on p-Adic Functional Analysis**, Aurillac, France.
Scientific Committee: Helge Glockner (Paderborn, Germany), Khodr Shamseddine (Winnipeg, Canada), Alain Escassut (Clermont-Ferrand, France), Cristina Perez Garcia (Santander, Spain), Jerzy Kakol (Poznan, Poland).

August 2016

* 1–5 **International Conference in K-theory**, University of Western Sydney, Sydney, Australia.
Description: The International Conference in K-theory 2016 will be held at the Parramatta Campus of University of Western Sydney.
Organizers: C. Heasemeyer (UCLA), R. Hazrat (UWS) and A. Neeman (ANU). The conference will cover a wide spectrum of topics related or influenced by K-theory. For contributed talks, please visit the conference homepage.
Information: https:sites.google.com/site/interconfonktheory2016/

* 2–5 **31st Summer Conference on Topology and its Applications**, University of Leicester, University Road, Leicester, LE1 7RH, England, United Kingdom.
Description: This conference brings together mathematicians with research interests in Topology. Provisional list of special sessions: Algebraic Topology Asymmetry and its Applications, General Topology, Foliated Spaces, Dynamics and Continua and Topological Groups. Details of workshops are yet to be finalised. The organisers are: Alex Clark, Simona Paoli and Dimitrina Stavrova [all based at the University of Leicester. The administrator is Alison Gibson. There will be a Welcome Reception on the preceding evening–Monday, January 8, 2015. The Conference Dinner will take place on the evening of Thursday, August 4, 2016. It is also proposed to run a trip to Leicester's Richard III Centre and a programme of events during the day for delegates' partners. This event is sponsored by the Leverhulme Trust. Other sponsorship is also being sought.
Information: www.le.ac.uk/topology2016

* 15–19 **AIM Workshop: The Complex Monge-Ampére Equation**, American Institute of Mathematics, San Jose, CA.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to the complex Monge-Ampére equation and its applications in complex geometry and analysis.
Information:
aimath.org/workshops/upcoming/mongeampere

* 22-26 **Introductory Workshop: Geometric Group Theory**, Mathematical Sciences Research Institute, Berkeley, California.
Description: This will be an introductory workshop to the MSRI jumbo program Geometric Group Theory being held during the Fall Semester of 2016. The purpose of the workshop is to provide an overview of key areas of research to be covered in the program, including an introduction to open problems of current interest.
Information: www.msri.org/workshops/769.

September 2016

* 30–October 2 **SIAM Conference on Mathematics of Planet Earth (MPE16)**, DoubleTree by Hilton Hotel Philadelphia Center City, Philadelphia, Pennsylvania.
Description: SIAM Conference on Mathematics of Planet Earth (MPE16) September 30–October 2, 2016 DoubleTree by Hilton Hotel Philadelphia Center City Philadelphia, Pennsylvania, USA. The call for presentations will be linked from www.siam.org/meetings/mpe16/ in November 2015.
Information: www.siam.org/meetings/mpe16/

The following new announcements will not be repeated until the criteria in the next to the last paragraph at the bottom of the first page of this section are met.

November 2016

* 7–11 **AIM Workshop: Polyhedral Geometry and Partition Theory**, American Institute of Mathematics, San Jose, CA.
Description: This workshop, sponsored by AIM and the NSF, will be devoted to the study of problems at the interface of polyhedral geometry and partition theory. Recent results have demonstrated that polyhedral geometry is a powerful tool connecting problems in lattice point enumeration, permutation statistics, and partition theory.
Information:
aimath.org/workshops/upcoming/polypartition

July 2017

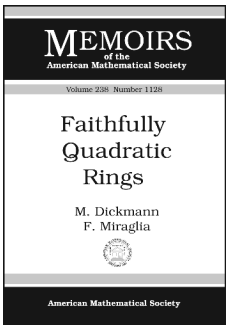
* 17–21 **28th IFIP TC7 Conference 2017 on System Modelling and Optimization**, Middle East Technical University, Ankara, Turkey.
Description: In a cycle of two years, the International Federation for Information Processing (IFIP) Technical Committee 7—System Modeling and Optimization—arranges highly regarded conferences on several topics of Applied Optimization such as Optimal Control of Ordinary and Partial Differential Equations, Modeling and Simulation, Inverse Problems, Nonlinear, Discrete, and Stochastic Optimization and Industrial Applications.
Information: iam.metu.edu.tr/ifip17

* 24–28 **Mathematical Congress of the Americas 2017**, Montréal, Quebec, Canada.
Description: This will be the second Mathematical Congress of the Americas (MCA). The website maintained by the Mathematical Congress of the Americas is www.mcofamericas.org/.
Call for Special Session Proposals: (deadline) July 31, 2016.
Information: mca2017.org

New Publications Offered by the AMS

To subscribe to email notification of new AMS publications, please go to www.ams.org/bookstore-email.

Algebra and Algebraic Geometry



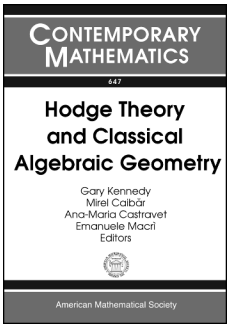
Faithfully Quadratic Rings

M. Dickmann, *Institut de Mathématiques de Jussieu-Paris Rive Gauche, France*, and **F. Miraglia**, *University of São Paulo, Brazil*

Contents: Basic concepts; Rings and special groups; The notion of T-faithfully quadratic ring. Some basic consequences; Idempotents, Products and T-isometry; First-order axioms for quadratic faithfulness; Rings with many units; Transversality of representation in p-rings with bounded inversion; Reduced *f*-rings; Strictly representable rings; Quadratic form theory over faithfully quadratic rings; Bibliography; Index of symbols; Subject index.

Memoirs of the American Mathematical Society, Volume 238, Number 1128

October 2015, 129 pages, Softcover, ISBN: 978-1-4704-1468-9, 2010 *Mathematics Subject Classification:* 11E81, 11E70, 12D15, 03C65, 06E99, 46E25, 54C40, **Individual member US$48.60**, List US$81, Institutional member US$64.80, Order code MEMO/238/1128



Hodge Theory and Classical Algebraic Geometry

Gary Kennedy and **Mirel Caibăr**, *Ohio State University, Mansfield, OH*, and **Ana-Maria Castravet** and **Emanuele Macrì**, *Northeastern University, Boston, MA*, Editors

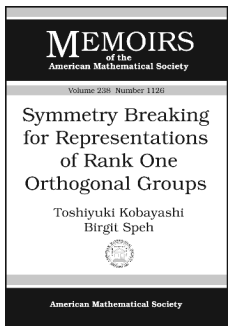
This volume contains the proceedings of a conference on Hodge Theory and Classical Algebraic Geometry, held May 13–15, 2013, at The Ohio State University, Columbus, OH.

Hodge theory is a powerful tool for the study and classification of algebraic varieties. This volume surveys recent progress in Hodge theory, its generalizations, and applications. The topics range from more classical aspects of Hodge theory to modern developments in compactifications of period domains, applications of Saito's theory of mixed Hodge modules, and connections with derived category theory and non-commutative motives.

Contents: **A. Bertram**, **S. Marcus**, and **J. Wang**, The stability manifolds of $\mathbb{P}^1$ and local $\mathbb{P}^1$; **M. Green** and **P. Griffiths**, Reduced limit period mappings and orbits in Mumford-Tate varieties; **E. Izadi** and **J. Wang**, The primitive cohomology of theta divisors; **J. Kollár**, Neighborhoods of subvarieties in homogeneous spaces; **M. Marcolli** and **G. Tabuada**, Unconditional noncommutative motivic Galois groups; **Z. Ran**, Differential equations in Hilbert-Mumford calculus; **C. Schnell**, Weak positivity via mixed Hodge modules.

Contemporary Mathematics, Volume 647

September 2015, 137 pages, Softcover, ISBN: 978-1-4704-0990-6, LC 2015006623, 2010 *Mathematics Subject Classification:* 14C30, 14D07, 32G20, 58A14, **AMS members US$84**, List US$105, Order code CONM/647



Symmetry Breaking for Representations of Rank One Orthogonal Groups

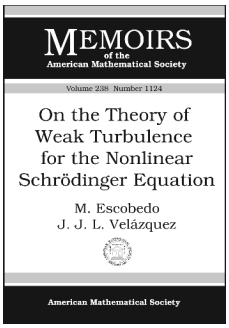
Toshiyuki Kobayashi, *University of Tokyo, Japan*, and **Birgit Speh**, *Cornell University, Ithaca, NY*

Contents: Introduction; Symmetry breaking for the spherical principal series representations; Symmetry breaking operators; More about principal series representations; Double coset decomposition $P' \backslash G/P$; Differential equations satisfied by the distribution kernels of symmetry breaking operators; K-finite vectors and regular symmetry breaking operators $\widetilde{\mathbb{A}}_{\lambda,\nu}$; Meromorphic continuation of regular symmetry breaking operators $K^{\mathbb{A}}_{\lambda,\nu}$; Singular symmetry breaking operator $\widetilde{\mathbb{B}}_{\lambda,\nu}$; Differential symmetry breaking operators; Classification of symmetry breaking operators; Residue formulae and functional identities; Image of symmetry breaking operators; Application to analysis on anti-de Sitter space; Application to branching laws of complementary series; Appendix; References; List of symbols.

Memoirs of the American Mathematical Society, Volume 238, Number 1126

October 2015, 112 pages, Softcover, ISBN: 978-1-4704-1922-6, 2010 *Mathematics Subject Classification:* 22E46; 33C45, 53C35, **Individual member US$48**, List US$80, Institutional member US$64, Order code MEMO/238/1126

Differential Equations



On the Theory of Weak Turbulence for the Nonlinear Schrödinger Equation

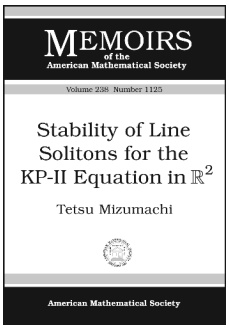
M. Escobedo, *Universidad del País Vasco, Bilbao, Spain*, and **J. J. L. Velázquez**, *Institute for Applied Mathematics, Bonn, Germany*

This item will also be of interest to those working in mathematical physics.

Contents: Introduction; Well-posedness results; Qualitative behaviors of the solutions; Solutions without condensation: Pulsating behavior; Heuristic arguments and open problems; Auxiliary results; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 238, Number 1124

October 2015, 107 pages, Softcover, ISBN: 978-1-4704-1434-4, 2010 *Mathematics Subject Classification:* 45G05, 35D30, **Individual member US$48**, List US$80, Institutional member US$64, Order code MEMO/238/1124



Stability of Line Solitons for the KP-II Equation in $\mathbb{R}^2$

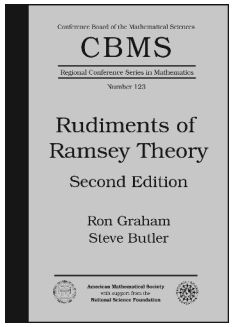
Tetsu Mizumachi, *Kyushu University, Fukuoka, Japan*

Contents: Introduction; The Miura transformation and resonant modes of the linearized operator; Semigroup estimates for the linearized KP-II equation; Preliminaries; Decomposition of the perturbed line soliton; Modulation equations; Á priori estimates for the local speed and the local phase shift; The $L^2(\mathbb{R}^2)$ estimate; Decay estimates in the exponentially weighted space; Proof of Theorem 1.1; Proof of Theorem 1.4; Proof of Theorem 1.5; Appendix A. Proof of Lemma 6.1; Appendix B. Operator norms of S_k^j and $\widetilde{C}_k$; Appendix C. Proofs of Claims 6.2, 6.3 and 7.1; Appendix D. Estimates of R^k; Appendix E. Local well-posedness in exponentially weighted space; Bibliography.

Memoirs of the American Mathematical Society, Volume 238, Number 1125

October 2015, 95 pages, Softcover, ISBN: 978-1-4704-1424-5, 2010 *Mathematics Subject Classification:* 35B35, 37K40, **Individual member US$45.60**, List US$76, Institutional member US$60.80, Order code MEMO/238/1125

Discrete Mathematics and Combinatorics



Rudiments of Ramsey Theory

Second Edition

Ron Graham, *University of California, San Diego, La Jolla, CA*, and **Steve Butler**, *Iowa State University, Ames, IA*

In every sufficiently large structure which has been partitioned there will always be some well-behaved structure in one of the parts. This takes many forms. For example, colorings of the integers by finitely many colors must have long monochromatic arithmetic progressions (van der Waerden's theorem); and colorings of the edges of large graphs must have monochromatic subgraphs of a specified type (Ramsey's theorem). This book explores many of the basic results and variations of this theory.

Since the first edition of this book there have been many advances in this field. In the second edition the authors update the exposition to reflect the current state of the art. They also include many pointers to modern results.

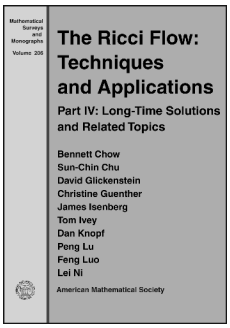
A copublication of the AMS and CBMS.

Contents: Introduction; Three views of Ramsey theory; Ramsey's theorem; van der Waerden's theorem; The Hales-Jewett theorem; Szemerédi's theorem; Graph Ramsey theory; Euclidean Ramsey theory; A general Ramsey product theorem; The theorems of Schur, Folkman, and Hindman; Rado's theorem; Current trends; Bibliography.

CBMS Regional Conference Series in Mathematics, Number 123

October 2015, 82 pages, Softcover, ISBN: 978-0-8218-4156-3, LC 2015020900, 2010 *Mathematics Subject Classification:* 05C55, 05D10, **AMS members US$23.20**, List US$29, Order code CBMS/123

Geometry and Topology



The Ricci Flow: Techniques and Applications

Part IV: Long-Time Solutions and Related Topics

Bennett Chow, *University of California, San Diego, La Jolla, CA*, **Sun-Chin Chu**, *National Chung Cheng University, Chia-Yi, Taiwan*, **David Glickenstein**, *University of Arizona, Tucson, AZ*, **Christine Guenther**, *Pacific University, Forest Grove, OR*, **James Isenberg**, *University of Oregon, Eugene, OR*, **Tom Ivey**, *The College of Charleston, SC*, **Dan Knopf**, *University of Texas at Austin, TX*, **Peng Lu**, *University of Oregon, Eugene, OR*, **Feng Luo**, *Rutgers University, Piscataway, NJ*, and **Lei Ni**, *University of California, San Diego, La Jolla, CA*

Ricci flow is a powerful technique using a heat-type equation to deform Riemannian metrics on manifolds to better metrics in the search for geometric decompositions. With the fourth part of their volume on techniques and applications of the theory, the authors discuss long-time solutions of the Ricci flow and related topics.

In dimension 3, Perelman completed Hamilton's program to prove Thurston's geometrization conjecture. In higher dimensions the Ricci flow has remarkable properties, which indicates its usefulness to understand relations between the geometry and topology of manifolds. This book discusses recent developments on gradient Ricci solitons, which model the singularities developing under the Ricci flow. In the shrinking case there is a surprising rigidity which suggests the likelihood of a well-developed structure theory. A broader class of solutions is ancient solutions; the authors discuss the beautiful classification in dimension 2. In higher dimensions they consider both ancient and singular Type I solutions, which must have shrinking gradient Ricci soliton models. Next, Hamilton's theory of 3-dimensional nonsingular solutions is presented, following his original work. Historically, this theory initially connected the Ricci flow to the geometrization conjecture. From a dynamical point of view, one is interested in the stability of the Ricci flow. The authors discuss what is known about this basic problem. Finally, they consider the degenerate neckpinch singularity from both the numerical and theoretical perspectives.

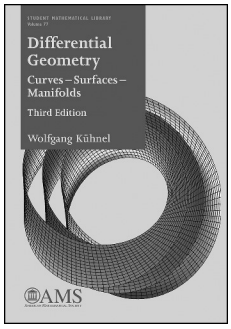
This book makes advanced material accessible to researchers and graduate students who are interested in the Ricci flow and geometric evolution equations and who have a knowledge of the fundamentals of the Ricci flow.

This item will also be of interest to those working in differential equations.

Contents: Noncompact gradient Ricci solitons; Special ancient solutions; Compact 2-dimensional ancient solutions; Type I singularities and ancient solutions; Hyperbolic geometry and 3-manifolds; Nonsingular solutions on closed 3-manifolds; Noncompact hyperbolic limits; Constant mean curvature surfaces and harmonic maps by IFT; Stability of Ricci flow; Type II singularities and degenerate neckpinches; Implicit function theorem; Bibliography; Index.

Mathematical Surveys and Monographs, Volume 206

October 2015, 374 pages, Hardcover, ISBN: 978-0-8218-4991-0, LC 2007275659, 2010 *Mathematics Subject Classification:* 53C44, 53C21, 53C43, 58J35, 35K59, 35K05, 57Mxx, 57M50, **AMS members US$88**, List US$110, Order code SURV/206



Differential Geometry

Curves — Surfaces — Manifolds, Third Edition

Wolfgang Kühnel, *University of Stuttgart, Germany*

This carefully written book is an introduction to the beautiful ideas and results of differential geometry. The first half covers the geometry of curves and surfaces, which provide much of the motivation and intuition for the general theory. The second part studies the geometry of general manifolds, with particular emphasis on connections and curvature. The text is illustrated with many figures and examples. The prerequisites are undergraduate analysis and linear algebra. This new edition provides many advancements, including more figures and exercises, and—as a new feature—a good number of solutions to selected exercises.

This new edition is an improved version of what was already an excellent and carefully written introduction to both differential geometry and Riemannian geometry. In addition to a variety of improvements, the author has included solutions to many of the problems, making the book even more appropriate for use in the classroom.

—***Colin Adams, Williams College***

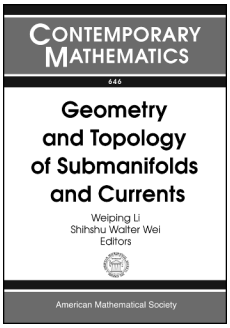
This book on differential geometry by Kühnel is an excellent and useful introduction to the subject. … There are many points of view in differential geometry and many paths to its concepts. This book provides a good, often exciting and beautiful basis from which to make explorations into this deep and fundamental mathematical subject.

—***Louis Kauffman, University of Illinois at Chicago***

Contents: Notations and prerequisites from analysis; Curves in $\mathbb{R}^n$; The local theory of surfaces; The intrinsic geometry of surfaces; Riemannian manifolds; The curvature tensor; Spaces of constant curvature; Einstein spaces; Solutions to selected exercises; Bibliography; List of notation; Index.

Student Mathematical Library, Volume 77

November 2015, approximately 412 pages, Softcover, ISBN: 978-1-4704-2320-9, LC 2015018451, 2010 *Mathematics Subject Classification:* 53-01, **AMS members US$39.20**, **All Individuals US$39.20**, List US$49, Order code STML/77



Geometry and Topology of Submanifolds and Currents

Weiping Li, *Southwest Jiaotong University, Chengdu, Sichuan Province, People's Republic of China, and Oklahoma State University, Stillwater, OK*, and **Shihshu Walter Wei**, *University of Oklahoma, Norman, OK*, Editors

The papers in this volume are mainly from the 2013 Midwest Geometry Conference, held October 19, 2013, at Oklahoma State University, Stillwater, OK, and partly from the 2012 Midwest Geometry Conference, held May 12–13, 2012, at the University of Oklahoma, Norman, OK.

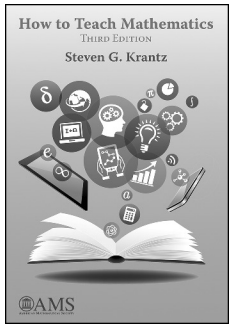
The papers cover recent results on geometry and topology of submanifolds. On the topology side, topics include Plateau problems, Voevodsky's motivic cohomology, Reidemeister zeta function and systolic inequality, and freedom in 2- and 3-dimensional manifolds. On the geometry side, the authors discuss classifying isoparametric hypersurfaces and review Hartogs triangle, finite volume flows, nonexistence of stable p-currents, and a generalized Bernstein type problem. The authors also show that the interaction between topology and geometry is a key to deeply understanding topological invariants and the geometric problems.

Contents: **R. M. Hardt**, Plateau problems in metric spaces and related homology and cohomology theories; **P. F. dos Santos**, **P. Lima-Filho**, and **R. M. Hardt**, Relating equivariant and motivic cohomology via analytic currents; **W. Li**, Braids and symplectic Reidemeister zeta functions; **L. Chen** and **W. Li**, Systoles of surfaces and 3-manifolds; **Q.-S. Chi**, Ideal theory and classification of isoparametric hypersurfaces; **M.-C. Shaw**, The Hartogs triangle in complex analysis; **W. Hu**, Finite volume flows and Witten's deformation; **R. Howard** and **W. Wei**, On the existence and nonexistence of stable submanifolds and currents in positively curved manifolds and the topology of submanifolds in Euclidean spaces; **S. W. Wei**, **L. Wu**, and **Y. Zhang**, Remarks on stable minimal hypersurfaces in Riemannian manifolds and generalized Bernstein problems.

Contemporary Mathematics, Volume 646

September 2015, 186 pages, Softcover, ISBN: 978-1-4704-1556-3, LC 2015006591, 2010 *Mathematics Subject Classification:* 13D10, 14G10, 14P15, 26C05, 28A75, 32Q10, 32W05, 53A10, 53C40, 57M27, 58A25, **AMS members US$84**, List US$105, Order code CONM/646

Math Education



How to Teach Mathematics

Third Edition

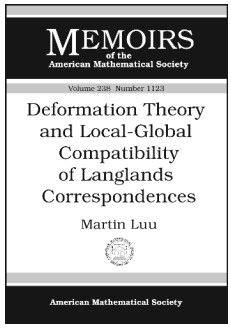
Steven G. Krantz, *Washington University, St. Louis, MO*

This third edition is a lively and provocative tract on how to teach mathematics in today's new world of online learning tools and innovative teaching devices. The author guides the reader through the joys and pitfalls of interacting with modern undergraduates—telling you very explicitly what to do and what *not* to do. This third edition has been streamlined from the second edition, but still includes the nuts and bolts of good teaching, discussing material related to new developments in teaching methodology and technique, as well as adding an entire new chapter on online teaching methods.

Contents: Guiding principles; Practical matters; Spiritual matters; The electronic world; Difficult matters; A new beginning; Bibliography; Index.

October 2015, 146 pages, Softcover, ISBN: 978-1-4704-2552-4, LC 2015021663, 2010 *Mathematics Subject Classification:* 97D40, 97Q60, 97U20, 97U50, 97U70, **AMS members US$28**, List US$35, Order code MBK/89

Number Theory



Deformation Theory and Local-Global Compatibility of Langlands Correspondences

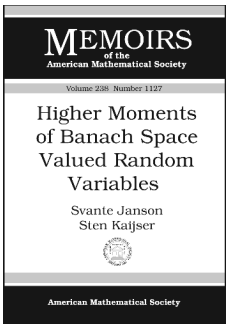
Martin Luu, *Stanford University, CA*

Contents: Introduction; Preliminaries; Local-global compatibility for Hilbert modular forms; Local-global compatibility results via crystalline periods; Local semi-simplifications: The case of general linear groups; Local semi-simplifications: The case of symplectic groups; Congruences; Local monodromy operators: The case of general linear groups; Local monodromy operators: The case of symplectic groups; Bibliography; Index.

Memoirs of the American Mathematical Society, Volume 238, Number 1123

October 2015, 101 pages, Softcover, ISBN: 978-1-4704-1422-1, 2010 *Mathematics Subject Classification:* 11F80; 11F55, **Individual member US$48**, List US$80, Institutional member US$64, Order code MEMO/238/1123

Probability and Statistics



Higher Moments of Banach Space Valued Random Variables

Svante Janson and **Sten Kaijser**, *Uppsala University, Sweden*

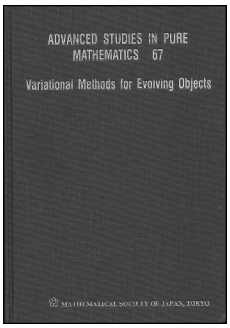
Contents: Introduction; Preliminaries; Moments of Banach space valued random variables; The approximation property; Hilbert spaces; $L^p(\mu)$; $C(K)$; $c_0(S)$; $D[0,1]$; Uniqueness and convergence; Appendix A. The reproducing Hilbert space; Appendix B. The Zolotarev distances; Bibliography.

Memoirs of the American Mathematical Society, Volume 238, Number 1127

October 2015, 110 pages, Softcover, ISBN: 978-1-4704-1465-8, 2010 *Mathematics Subject Classification:* 60B11; 46G10, **Individual member US$48**, List US$80, Institutional member US$64, Order code MEMO/238/1127

New AMS-Distributed Publications

Analysis



Variational Methods for Evolving Objects

Luigi Ambrosio, *Scuola Normale Superiore, Pisa, Italy*, **Yoshikazu Giga**, *University of Tokyo, Japan*, **Piotr Rybka**, *University of Warsaw, Poland*, and **Yoshihiro Tonegawa**, *Tokyo Institute of Technology, Japan*, Editors

This volume consists of eight original survey papers written by invited lecturers in connection with a conference "Variational Methods for Evolving Objects" held at Hokkaido University, Sapporo, Japan, July 30–August 3, 2012. The topics of papers vary widely from problems in image processing to dynamics of topological defects, and all involve some nonlinear phenomena of current major research interests. These papers are carefully prepared so that they serve as a good starting point of investigation for graduate students and newcomers to the field and are strongly recommended.

Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Advanced Studies in Pure Mathematics, Volume 67

June 2015, 298 pages, Hardcover, ISBN: 978-4-86497-028-0, 2010 *Mathematics Subject Classification:* 49J40; 35K55, 49Q20, **AMS members US$49.60**, List US$62, Order code ASPM/67

Classified Advertisements

Positions available, items for sale, services available, and more

CALIFORNIA

CALIFORNIA INSTITUTE OF TECHNOLOGY
Division of Physics, Mathematics and Astronomy

The Division of Physics, Mathematics and Astronomy at the California Institute of Technology invites applications for a tenure-track professorial position at the junior level in mathematics.

Applicants working in any field of pure mathematics will be considered. We are seeking highly qualified candidates committed to a career in research and teaching. Applications should include curriculum vitae, a list of papers published and submitted (with refereed papers indicated), a brief essay describing the applicant's research interests and the program of research he/she proposes to carry out at Caltech, and a brief teaching statement. Applicants are also requested to have at least three letters of reference uploaded to `https://applications.caltech.edu/job/math`.

The names and email addresses of the referees should be included in the application. Application materials must be submitted electronically in pdf format (not password protected) at `https://applications.caltech.edu/job/math`.

Consideration of applications will begin on Oct 1, 2015, and applicants are encouraged but not required to meet that deadline.

We are an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, or national origin, disability status, protected veteran status, or any other characteristic protected by law.

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CALIFORNIA INSTITUTE OF TECHNOLOGY
Harry Bateman Research Instructorships in Mathematics

Description: Appointments are for two years with one-year terminal extension expected. The academic year runs from approximately October 1 to June 1. Instructors typically are expected to teach one course per quarter for the full academic year and to devote the rest of their time to research. During the summer months there are no duties except research.

Eligibility: Open to persons who have recently received their doctorates in mathematics.

Deadline: January 1, 2016.

Application information: Please apply online at `mathjobs.org`. You can also find information about this position at `pma.caltech.edu/content/mathematics-postdoctoral-scholars`. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

000039

CALIFORNIA INSTITUTE OF TECHNOLOGY
Olga Taussky and John Todd Instructorships in Mathematics

Description: Appointments are for three years. There are three terms in the Caltech academic year, and instructors typically are expected to teach one course in all but two terms of the total appointment. These

two terms will be devoted to research. During the summer months there are no duties except research.

Eligibility: Offered to persons within three years of having received the PhD who show strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.

Deadline: January 1, 2016.

Application information: Please apply online at `mathjobs.org`. You can also find information about this position at `pma.caltech.edu/content/mathematics-postdoctoral-scholars`. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

000041

CALIFORNIA INSTITUTE OF TECHNOLOGY
Scott Russell Johnson Senior Postdoctoral Scholar in Mathematics

Description: There are three terms in the Caltech academic year. The fellow is typically expected to teach one course in two terms each year, and is expected to be in residence even during terms when not teaching. The initial appointment is for three years with an additional three-year terminal extension expected.

Eligibility: Offered to a candidate within six years of having received their PhD who shows strong research promise in one of the areas in which Caltech's mathematics faculty is currently active.

Deadline: January 1, 2016.

Application information: Please apply online at `mathjobs.org`. You can also find information about this position at `pma.caltech.edu/content/mathematics-postdoctoral-scholars`. To avoid duplication of paperwork, your application may also be considered for an Olga Taussky and John Todd Instructorship. Caltech is an Affirmative Action/Equal Opportunity Employer. Women, minorities, veterans, and disabled persons are encouraged to apply.

000040

UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875- Job #02900

Visiting Assistant Professor in Mathematics. Applications are invited for Visiting Assistant Professors, renewable up to three years, in all areas of mathematics. VAPs teach no more than five quarter classes per year. Strong promise in research and teaching is required. Appointments will be effective July 1, 2016, or later. A PhD degree is required. Completed applications must be submitted through `www.mathjobs.org` and must contain: (1) AMS cover sheet. Indicate your area of mathematical specialization. (2) Cover letter (3) CV (4) Research statement (5) Teaching statement (6) Selected reprints and/or preprints (7) At least three reference letters (at least one addressing teaching) sent electronically through `www.mathjobs.org`. Please reference job #02900 in the subject line of all correspondence. Applications are welcome at any time. The review process starts November 1, 2015, and will continue until positions are filled. The University of California, Irvine is an Equal Opportunity/Affirmative Action Employer advancing inclusive excellence. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability, age, protected veteran status, or other protected categories covered by the UC nondiscrimination policy.

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UNIVERSITY OF CALIFORNIA, IRVINE
Department of Mathematics
Irvine, CA 92697-3875- Job #02907
Assistant Professor positions in Mathematics

The Department of Mathematics at the University of California, Irvine, is seeking outstanding candidates to fill one or more tenure-track positions to start July 1, 2016. Applicants must hold a PhD and should have demonstrated excellence in research and teaching. We encourage applications from any area in pure and applied mathematics. Applications are welcome at any time. The review process starts November 1, 2015, and will continue until the positions are filled. A separate statement that addresses past and/or potential contributions to diversity, equity and inclusion should also be included in the application materials. The University of California, Irvine is an Equal Opportunity/Affirmative Action Employer advancing inclusive excellence. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability, age, protected veteran status, or other protected categories covered by the UC nondiscrimination policy. Completed applications must be submitted through `www.mathjobs.org` and must contain: (1) AMS cover sheet (2) Curriculum Vitae (3) Cover letter (4) Research statement (5) Teaching statement (6) Selected reprints and/or preprints (7) At least three reference letters (at least one addressing teaching) sent electronically through `www.mathjobs.org` (8) Statement of Diversity- A brief statement that addresses past and/or potential contributions to diversity, equity and inclusion (optional). Instructions for the electronic application process can be found at `www.mathjobs.org`. Indicate your area of mathematical specialization in field labeled "Area of Specialization" example: "Algebra".

000029

UNIVERSITY OF CALIFORNIA, LOS ANGELES
Department of Mathematics
Faculty Positions 2016–17

Tenured/Tenure-Track positions 2016–17

The Department of Mathematics at the University of California, Los Angeles, invites applications for tenure-track or tenured faculty positions starting July 1, 2016. Outstanding candidates in all areas of mathematics may be considered. Applicants must possess a PhD and should have outstanding accomplishments in both research and teaching. Duties include mathematical research, undergraduate and graduate teaching, and departmental and university service. Level of appointment will be based on qualifications, with appropriate salary per UC pay scales.

Applications will be accepted until the position is filled. To guarantee full consideration, the application should be received by November 15, 2015. Job Tracking #1010-1617-05

The Department of Mathematics at the University of California, Los Angeles, invites applications for temporary and visiting appointments in the categories 1–5 below. Depending on the level, candidates must give evidence of potential or demonstrated distinction in scholarship and teaching.

Temporary Positions:

(1) **E. R. Hedrick Assistant Professorships**: Salary range is $66,800–$70,100, and appointments are for three years. The teaching load is four one-quarter courses per year. **Job Tracking #1010-1617-01**

(2) **Computational and Applied Mathematics (CAM) Assistant Professorships**: Salary range is $66,800–$70,100, and appointments are for three years. The teaching load is normally reduced by research funding to two one-quarter courses per year. **Job Tracking #1010-1617-02**

(3) **Program in Computing (PIC) Assistant Adjunct Professorships**: Salary range is $73,100–$75,300. Applicants for these positions must show very strong promise in teaching and research in an area related to computing. The teaching load is four one-quarter programming courses each year and one additional course every two years. Initial appointments are for one year and possibly longer, up to a maximum service of four years. **Job Tracking #1010-1617-03**

(4) **Assistant Adjunct Professorships and Research Postdocs**: Appointments are normally for one year, with the possibility of renewal. Strong research and teaching background required. The salary is $62,900–$64,800. The teaching load for

Adjuncts is six one-quarter courses per year. **Job Tracking #1010-1617-04**

(5) **RTG Assistant Adjunct Professorship in Analysis**: Salary is $59,300–$61,000, and appointments are for three years. This position is limited to US citizens or permanent residents who have received a PhD within 18 months of June 1, 2016. The successful recipient will receive a summer stipend of $10,000 for two summers and $9,000 over three years for travel, equipment, and supplies. The teaching load is three one-quarter courses per year. **Job Tracking #1010-1617-08**

Appointments will be effective July 1, 2016 or later. Applications will be accepted until all positions are filled. For fullest consideration, all application materials should be submitted on or before November 15, 2015.

Applications and supporting documentation must be submitted online via `www.mathjobs.org`.

All letters of evaluation are subject to UCLA campus policies on confidentiality. Refer potential reviewers to the UCLA statement of confidentiality at `https://www.apo.ucla.edu/policies/the-call/summary-of-procedures/summary-10-statement-of-confidentiality`

Lecturer Positions in Mathematics

The UCLA Department of Mathematics receives on an ongoing basis applications for quarter positions (fall/winter/spring or for Summer Session) for Lecturers to teach undergraduate mathematics or math education courses. Positions are very limited and temporary. Responsibilities include lecturing, conducting office hours, writing and grading exams and supervising teaching assistants. Previous teaching experience at the college level or experience as a Financial Actuary is required and a PhD is preferred. Salary is commensurate with experience. **Job Tracking #1010-1617-07**

Lecturer with Potential Security of Employment in the Department of Mathematics

The UCLA Department of Mathematics seeks applications for a full-time career Lecturer with Potential Security of Employment (similar to tenure-track) beginning July 1, 2016.

Qualifications: Candidates must possess a PhD in mathematics or a closely related field. The successful applicant will be a broadly trained mathematician who is dedicated to undergraduate teaching and pedagogy and is interested in belonging to a top research department.

Duties and Responsibilities: In addition to making significant contributions to lower and upper-division teaching (4.5 quarter-courses per year), the Lecturer will engage in a combination of: curriculum development, advisement of undergraduate students, mentoring visiting and junior faculty, participation in service activities, as well as research. In addition to teaching, specific duties may include the development and implementation of new courses and curricula at the undergraduate level, as well as leadership roles in undergraduate activities and advising, community outreach activities and in improving instructional resources. It is expected that the Lecturer will be involved in program development, attend relevant professional meetings, review programs, and be involved in mentoring of visiting and junior faculty. Level of appointment will be based on qualifications, with appropriate salary per UC pay scales. Further information about mathematics at UCLA can be found at `www.math.ucla.edu`.

Applicants should submit a letter of interest outlining experiences and qualifications including teaching philosophy and mathematical interests and accomplishments together with a curriculum vita and publication record, and arrange for at least three letters of recommendation to be sent. Materials should be submitted electronically via `www.mathjobs.org`. Applications received on or before **01/01/2016** will be given full consideration.

Job Tracking #1010-1617-10

The department is especially interested in candidates who can contribute to the diversity & excellence of the academic community through teaching and service.

Applications and supporting documentation for all positions must be submitted online via `www.mathjobs.org`.

All letters of evaluation are subject to UCLA campus policies on confidentiality. Refer potential reviewers to the UCLA statement of confidentiality at `https://www.apo.ucla.edu/policies/the-call/summary-of-procedures/summary-10-statement-of-confidentiality`

UCLA statement of confidentiality at `www.math.ucla.edu/people/confidentiality.pdf`

The University of California is an Equal Opportunity/Affirmative Action Employer. All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability, age or protected veteran status. For the complete University of California nondiscrimination and affirmative action policy see: UC Nondiscrimination and Affirmative Action Policy, `policy.ucop.edu/doc/4000376/NondiscrimAffirmAct`.

The University of California asks that applicants complete the Equal Opportunity Employer survey for Letters and Science at the following URL: `cis.ucla.edu/facultysurvey/`. Under Federal Law, the University of California may employ only individuals who are legally authorized to work in the United States as established by providing documents specified in the Immigration Reform and Control Act of 1986.

000020

CONNECTICUT

UNIVERSITY OF CONNECTICUT
Department of Mathematics
Assistant, Associate, Full Professor

The Department of Mathematics at the University of Connecticut, Storrs invites applications for three full-time, 9-month tenure-track faculty positions at the rank of Assistant, Associate, or Full Professor in Mathematics beginning in fall 2016. We are seeking exceptionally well-qualified individuals with research interests in all areas of Mathematics compatible with those in the department. The successful candidate will be expected to teach mathematics courses at all levels and to have a vigorous externally funded research program.

UConn has grown rapidly in the past decade to become one of the nation's Top 20 public universities, with an ambitious goal, at this transformational time in its history, to aspire to join the ranks of the greatest universities in the world. As one of the University's emphasized STEM programs, supported by the $1.7B Next Generation Connecticut (`nextgenct.uconn.edu/`) investment, the math department enjoys an active and dynamic academic environment. The department currently has 35 research faculty members with diverse research interests (including financial mathematics and actuarial science, algebra and number theory, analysis, applied math, geometry and topology, mathematical logic, math education, numerical analysis, partial differential equations, and probability) and a strong record of external funding. Faculty members in the department participate in a range of interdisciplinary projects with Physics, Philosophy, the Life Sciences, and Statistics, and with the Neag School of Education. The department will move into a new building in fall 2016.

Minimum Qualifications: A PhD or an equivalent foreign degree in mathematics or a closely related area by August 22, 2016, demonstrated evidence of excellent teaching and outstanding research.

Preferred Qualifications: An outstanding research program in an area that complements the research activity in the department. A record of attracting external funding and a commitment to effective teaching at the undergraduate and graduate levels.

Evaluation of applications will begin on November 20, 2015 and will continue until the position is filled. Rank and salary will be commensurate with qualifications and experience.

To apply, submit a cover letter, curriculum vitae, teaching statement (including teaching philosophy, teaching experience, commitment to effective learning, concepts for new course development, etc.); research and scholarship statement (innovative concepts that will form the basis of academic career, experience in

proposal development, mentorship of graduate students, etc.); commitment to diversity statement (including broadening participation, integrating multicultural experiences in instruction and research and pedagogical techniques to meet the needs of diverse learning styles, etc.); sample journal articles or books online at www.mathjobs.org/jobs, including at least four letters of reference, one of which addresses the applicant's teaching. Questions or requests for further information should be sent to the Hiring Committee at mathhiring@uconn.edu.

Employment of the successful candidate will be contingent upon the successful completion of a pre-employment criminal background check. All employees are subject to adherence to the State Code of Ethics which may be found at www.ct.gov/ethics/site/default.asp.

The University of Connecticut is committed to building and supporting a multicultural and diverse community of students, faculty and staff. The diversity of students, faculty and staff continues to increase, as does the number of honors students, valedictorians and salutatorians who consistently make UConn their top choice. More than 100 research centers and institutes serve the University's teaching, research, diversity, and outreach missions, leading to UConn's ranking as one of the nation's top research universities. UConn's faculty and staff are the critical link to fostering and expanding our vibrant, multicultural and diverse University community. As an Affirmative Action/Equal Employment Opportunity employer, UConn encourages applications from women, veterans, people with disabilities and members of traditionally underrepresented populations.

000035

YALE UNIVERSITY
J. Willard Gibbs
Assistant Professorships
in Mathematics
2016–17

The Gibbs Assistant Professorships are intended primarily for men and women who received their PhD degree and show definite promise in research in pure or applied mathematics. Appointments are for three years. The salary will be at least $77,000. Each recipient of a Gibbs Assistant Professorship will be given a moving allowance based on the distance to be moved.

The teaching load for Gibbs Assistant Professors will be kept light, so as to allow ample time for research. This will consist of three one-semester courses per year. Part of the duties may consist of a one-semester course at the graduate level in the general area of the instructor's research. Yale is an Affirmative Action/Equal Opportunity Employer. Qualified women and persons with disabilities, protected veterans, and members of minority groups are encouraged to apply. Review of applications will begin immediately with an application deadline of November 30, 2015.

Submit applications and supporting material through MathJobs.org. Submit inquiries to math.positions@yale.edu. Offers expected to be made in early February 2016.

000044

ILLINOIS

UNIVERSITY OF CHICAGO
Department of Mathematics

The University of Chicago Department of Mathematics invites applications for the following positions:

1. L. E. Dickson Instructor: This is open to mathematicians who have recently completed or will soon complete a doctorate in mathematics or a closely related field, and whose work shows remarkable promise in mathematical research. The appointment typically is for two years, with the possibility of renewal for a third year. The teaching obligation is up to four one-quarter courses per year.

2. Assistant Professor: This is open to mathematicians who are further along in their careers, typically two or three years past the doctorate. These positions are intended for mathematicians whose work has been of outstandingly high caliber. Appointees are expected to have the potential to become leading figures in their fields. The appointment is generally for three years, with the possibility for renewal and a teaching obligation of up to three one-quarter courses per year.

Applicants will be considered for any of the positions above which seem appropriate. Complete applications consist of (a) a cover letter, (b) a curriculum vitae, (c) three or more letters of reference, at least one of which addresses teaching ability, and (d) a description of previous research and plans for future mathematical research. Applicants are strongly encouraged to include information related to their teaching experience, such as a teaching statement or evaluations from courses previously taught, as well as an AMS cover sheet. If you have applied for an NSF Mathematical Sciences Postdoctoral Fellowship, please include that information in your application, and let us know how you plan to use it if awarded. Applications must be submitted online through www.mathjobs.org. Questions may be directed to apptsec@math.uchicago.edu. We will begin screening applications on November 1, 2015. Screening will continue until all available positions are filled.

All qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, age, protected veteran status or status as an individual with disability.

The University of Chicago is an Affirmative Action/Equal Opportunity/Disabled Veterans Employer.

Job seekers in need of a reasonable accommodation to complete the application process should call 773-702-5671 or email ACOppAdministrator@uchicago.edu with their request.

000025

MASSACHUSETTS

BOSTON COLLEGE
Tenure-track Positions

The Department of Mathematics at Boston College invites applications for tenure-track positions at the level of Assistant Professor beginning in fall 2016 in Geometry and Topology or a related area. In exceptional cases, a higher level appointment may be considered. The teaching load for each position is three semester courses per year. Requirements include a PhD or equivalent in Mathematics awarded in 2014 or earlier, a record of very strong research combined with outstanding research potential, and demonstrated excellence in teaching mathematics. A completed application should contain a cover letter, a description of research plans, a statement of teaching philosophy, curriculum vitae, and at least four letters of recommendation. One or more of the letters of recommendation should directly comment on the candidate's teaching credentials. Applications completed no later than November 1, 2015 will be assured our fullest consideration. Please submit all application materials through MathJobs.org. Applicants may learn more about the department, its faculty and its programs, and about Boston College at www.bc.edu/math. Electronic inquiries concerning these positions may be directed to math@bc.edu. Boston College is an Affirmative Action/Equal Opportunity Employer. Applications from women, minorities and individuals with disabilities are encouraged.

000038

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Cambridge, MA

The Mathematics Department at MIT is seeking to fill positions in Pure and Applied Mathematics, and Statistics at the level of Assistant Professor or higher beginning July 2016 (for the 2016–2017 academic year). Appointments are based primarily on exceptional research qualifications. Appointees will be required to fulfill teaching duties and pursue their own research program. PhD in Mathematics

or related field required by employment start date.

For more information and to apply, please visit www.mathjobs.org. To receive full consideration, submit applications by December 1, 2015. MIT is an Equal Opportunity, Affirmative Action Employer.

000032

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Cambridge, MA

The Mathematics Department at MIT is seeking to fill positions in Pure and Applied Mathematics, and Statistics at the level of Instructor beginning July 2016 (for the 2016–2017 academic year). Appointments are based primarily on exceptional research qualifications. Appointees will be expected to fulfill teaching duties and pursue their own research program. PhD in Mathematics or related field required by employment start date.

For more information and to apply, please visit www.mathjobs.org. To receive full consideration, submit applications by December 1, 2015. MIT is an Equal Opportunity, Affirmative Action Employer.

000033

WILLIAMS COLLEGE
Department of Mathematics and Statistics

The Williams College Department of Mathematics and Statistics invites applications for two full-time visiting positions in mathematics for the 2016–2017 year. The teaching load is four courses. Preference will be given to candidates who will have a PhD in mathematics by September 2016.

Applicants can apply electronically at mathjobs.org. Evaluations of applications will begin on or after November 15 and will continue until the position is filled. All offers of employment are contingent upon completion of a background check dean-faculty.williams.edu/prospective-faculty/background-check-policy. For more information on the Department of Mathematics and Statistics, visit math.williams.edu. Williams College is a coeducational liberal arts institution located in the Berkshire Hills of western Massachusetts. The college has built its reputation on outstanding teaching and scholarship and on the academic excellence of its approximately 2,000 students. Please visit the Williams College website (www.williams.edu). Beyond meeting fully its legal obligations for non-discrimination, Williams College is committed to building a diverse and inclusive community where members from all backgrounds can live, learn, and thrive.

000042

NEBRASKA

UNIVERSITY OF NEBRASKA—LINCOLN
Faculty Positions, Department of Mathematics

The Department of Mathematics at the University of Nebraska—Lincoln invites applications for the following positions:

(1) Milton Mohr Professor of Mathematics, at the Associate Professor or Full Professor level. Review of applications will begin December 15, 2015 and continue until a suitable candidate (or candidates) is found.

(2) Two Tenure-Track Assistant Professor positions in Mathematics. Review of applications will begin November 13, 2015 and continue until suitable candidates are found.

Each of these positions begins August 2016. For more information about these positions and information on how to apply for them, please go to: www.math.unl.edu/department/jobs/. The University of Nebraska is committed to a pluralistic campus community through affirmative action, equal opportunity, work-life balance and dual careers.

000036

NEW JERSEY

INSTITUTE FOR ADVANCED STUDY
School of Mathematics
Princeton, NJ

The School of Mathematics at the Institute for Advanced Study has a limited number of memberships with financial support for research during the 2016–2017 academic year. The School frequently sponsors special programs. However, these programs comprise no more than one-third of the memberships so that each year a wide range of mathematics is supported. Candidates must give evidence of ability in research comparable at least with that expected for the PhD degree, but otherwise can be at any career stage. Successful candidates will be free to devote themselves full time to research. About half of our members will be postdoctoral researchers within 5 years of their PhD We expect to offer some two-year postdoctoral positions.

Up to 8 von Neumann Fellowships will be available for each academic year. To be eligible for the von Neumann Fellowships, applications should be at least 5, but no more than 15 years following the receipt of their PhD.

The Veblen Research Instructorship is a three-year position in partnership with the department of Mathematics at Princeton University. Three-year instructorships will be offered each year to candidates in pure and applied mathematics who have received their PhD within the last 3 years. Usually the first and third year of the instructorship will be spent at Princeton University and will carry regular teaching responsibilities. The second year is spent at the Institute and dedicated to independent research of the instructor's choice. Candidates interested in a Veblen instructorship position may apply directly at the IAS website https://applications.ias.edu or they may apply through MathJobs. If they apply at MathJobs, they must also complete the application form at https://applications.ias.edu but do not need to submit a second set of reference letters. Questions about the application procedure should be addressed to applications@math.ias.edu. In addition, there are also two-year postdoctoral positions in computer science and discrete mathematics offered jointly with the following institutions: The Department of Computer Science at Princeton University, www.cs.princeton.edu, DIMACS at Rutgers, The State University of New Jersey, www.dimacs.rutgers.edu and the Simons Foundation Collaboration on Algorithms and Geometry, https://www.simonsfoundation.org/mathematics-and-physical-science/algorithms-and-geometry-collaboration/.

School term dates for 2016–2017 academic year are: term I, Monday September 19 to December 16, 2016; term II, Monday January 16, 2017, to Friday, April 14, 2017.

During the 2016–2017 academic year, the School will have a special program on Homological Mirror Symmetry, and Paul Seidel from MIT will be the Distinguished Visiting Professor. Maxim Kontsevich from IHES will be attending the program for one month during each of the fall and spring terms (from mid-October to mid-November) and for the month of February. Denis Auroux from UC Berkeley will be attending for term II.

Homological Mirror Symmetry (HMS) was initiated by Kontsevich. It benefits from a close relation with string theory and has developed into a powerful and versatile idea. During the program, we will consider the core conjectures of HMS and its role as a framework within which wider questions from mirror symmetry and other parts of mathematics can be studied. This is still a developing subject, and the program is open to a variety of approaches and viewpoints.

The intention is that the fall term will have a greater focus on the core building blocks of HMS as currently understood: the A-model theory (Lagrangian submanifolds, holomorphic curves and their generalizations), the B-model theory (derived categories in algebraic geometry) and mathematical interpretations of the Strominger-Yau-Zaslow approach, including the Gross-Siebert program. Specific questions of interest include: the role of singular Lagrangian submanifolds (such as Lagrangian skeleta); the effect of instanton corrections on the construction of mirror manifolds; and the structure of wrapped Fukaya categories. We will also

consider the interplay between the various algebraic notions that appear in HMS.

The second term would widen the focus, allowing space for emerging interactions between HMS and other areas. Examples are the theory of Special Lagrangian submanifolds, tropical geometry and non-archimedean analytic geometry, as well as sheaf-theoretic methods. We also intend to look at applications of ideas from homological mirror symmetry to specific classes of manifolds, such as complex symplectic manifolds and cluster varieties.

There will be two workshops during the special program. The term I workshop "homological mirror symmetry: methods and structures", will be held November 7–11, 2016. The term II workshop, "homological mirror symmetry: emerging developments and applications", will be held March 13–17, 2017.

000022

PRINCETON UNIVERSITY
Program in Applied and Computational Mathematics
Postdoctoral Research Associate

The Program in Applied and Computational Mathematics invites applications for Postdoctoral Research Associates to join in research efforts of interest to its faculty. Domains of interest include nonlinear partial differential equations, computational fluid dynamics and material science, dynamical systems, numerical analysis, stochastic problems and stochastic analysis, graph theory and applications, mathematical biology, financial mathematics and mathematical approaches to signal analysis, information theory, and structural biology and image processing. Appointments are possible for up to three years, renewable yearly, if funding is available and performance is satisfactory. For details on specific faculty members and their research interests, please go to: `www.pacm.princeton.edu/index.shtml`. Princeton University is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability status, protected veteran status, or any other characteristic protected by law. Applicants should submit a cover letter, CV, bibliography/publications list, statement of research and three letters of recommendation. Applicants must have received or will receive a doctorate. This position is subject to the University background check policy.

000026

NORTH CAROLINA

NORTH CAROLINA STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics at North Carolina State University invites applications for one or more tenure-track position(s) beginning Fall 2016, depending on the availability of funding. We are seeking exceptionally well-qualified individuals in the general area of pure mathematics, who will complement and strengthen our current research groups. Candidates must have a PhD in the mathematical sciences or related areas; a successful post-doctoral experience; an outstanding research program; a commitment to effective teaching at the undergraduate and graduate levels; and demonstrated potential for excellence in both research and teaching. The Department of Mathematics has strong research programs in applied and pure mathematics. Information about the department is available at `www.math.ncsu.edu`.

Submit your application materials at `www.mathjobs.org/jobs/ncsu`. Please include curriculum vitae, at least three letters of recommendation, a description of current and planned research, a teaching statement, and a list of publications. You will then receive instructions to complete a faculty profile at `jobs.ncsu.edu/`. For questions concerning the position contact: `math-jobs@math.ncsu.edu`. North Carolina State University is an Equal Opportunity and Affirmative Action Employer and welcomes all persons without regard to sexual orientation. The College of Sciences welcomes the opportunity to work with candidates to identify suitable employment opportunities for spouses or partners. Priority will be given to applications received by 15 November 2015.

000037

PENNSYLVANIA

PENN STATE UNIVERSITY
Department of Mathematics

The Department of Mathematics is seeking outstanding applicants for up to two tenure or tenure-track faculty positions in all areas of Mathematics. Preference will be given to Probability and Numerical Analysis. A PhD is required. Applicants must complete the Penn State application at `https://psu.jobs/job/58819` and must submit an application through `Mathjobs.org` (`https://www.mathjobs.org/jobs`) with the following materials in order for the application to be complete: (1) at least three reference letters, one of which should address in detail the candidate's abilities as a teacher, (2) Curriculum Vitae, (3) Publication List, (4) Research Statement, and (5) Teaching Statement. We encourage applications from individuals of diverse backgrounds. Review of applications will begin November 16, 2015 and continue until all positions are filled.

000031

RHODE ISLAND

BROWN UNIVERSITY
J. D. Tamarkin Assistant Professorships

One or more three-year non-tenured non-renewable appointments, beginning July 1, 2016. The teaching load is one course one semester, and two courses the other semester and consists of courses of more than routine interest. Candidates are required to have received a PhD degree or equivalent by the start of their appointment, and they may have up to three years of prior academic and/or postdoctoral research experience.

Applicants should have strong research potential and a commitment to teaching. Field of research should be consonant with the current research interests of the department.

For full consideration, applicants must submit a curriculum vita, an AMS Standard Cover Sheet and three letters of recommendation by December 1, 2015. Applicants are encouraged to identify Brown faculty with similar research interests. Please submit all application materials on line at `www.mathjobs.org`. Email inquiries should be addressed to `juniorsearch@math.brown.edu`. Brown University is committed to fostering a diverse and inclusive academic global community; as an EEO/AA employer, Brown considers applicants for employment without regard to, and does not discriminate on the basis of, gender, race, protected veteran status, disability, or any other legally protected status.

000024

TENNESSEE

VANDERBILT UNIVERSITY
Nashville, Tennessee
Non Tenure-Track Assistant Professor Positions

We invite applications for several visiting and non tenure-track assistant professor positions in the research areas of the Mathematics Department beginning fall 2016. These positions will have variable terms and teaching loads but most will be three-year appointments with a 2-2 teaching load. We anticipate that some of these appointments will carry a 1-1 teaching load and provide a stipend to support research.

We are looking for individuals with outstanding research potential and a strong commitment to excellence in teaching. Preference will be given to recent doctorates. Submit your application and supporting materials electronically through the AMS website `Mathjobs.org` via the

link www.mathjobs.org/jobs. Alternatively, application materials may be sent to: NTT Appointments Committee, Vanderbilt University, Department of Mathematics, 1326 Stevenson Center, Nashville, TN 37240. These materials should include a letter of application, a curriculum vitae, a publication list, a research statement, a teaching statement, at least four letters of recommendation and the AMS Cover Sheet. One of the letters must discuss the applicant's teaching qualifications. Reference letter writers should be asked to submit their letters online through Mathjobs.org. Evaluation of the applications will commence on December 1, 2015 and continue until the positions are filled. For information about the Department of Mathematics at Vanderbilt University, please consult the web at as.vanderbilt.edu/math/.

Vanderbilt is an Equal Employment Opportunity/Affirmative Action employer. Women and minorities are especially invited to apply.

000028

TEXAS

TEXAS TECH UNIVERSITY
Department of Mathematics and Statistics
Chair and Professor

The Department of Mathematics and Statistics at Texas Tech University invites applications for the position of Department Chair and Professor beginning fall 2016. The salary will be competitive and commensurate with qualifications and experience.

Candidates must have demonstrated outstanding vision, leadership, and scholarship, possess strong commitments to interdisciplinary research and educational activities, and be a collegial motivator and advocate for faculty. A PhD in mathematics or statistics is required. The successful candidate is expected to work with the faculty to develop the department under a strategic vision, foster excellence in research and teaching, and provide appropriate service to the college, university, and profession.

The department currently has 45 full-time faculty members with active research groups in pure and applied mathematics and statistics. Six degrees are offered: BA, BS, MA, MS, and PhD in Mathematics and M.S. in Statistics, as well as several interdisciplinary and combined undergraduate and graduate degrees. For further information regarding the Department of Mathematics and Statistics, please refer to the department's website: www.math.ttu.edu.

Texas Tech University, located in west Texas in the city of Lubbock, was founded in 1923. The student population is 35,000 and is anticipated to grow to 40,000. Texas Tech is a state-designated national research university. Its strategic plan charts a course for becoming a great public research university by 2020. The university has the characteristics of a Carnegie-classified doctoral granting university with very high research productivity.

Applicants should apply at www.texastech.edu/careers/ using Requisition 4369BR. Applicants should submit a detailed letter of application along with a current resumé including externally-funded research, teaching, administrative experience, publications. and four letters of professional reference. Questions about the position and/or the application process can be directed to mathchairsearch@ttu.edu.

Review of applications will begin immediately. Applications will be accepted until the position is filled, with those received prior to October 1, 2015, assured full consideration.

As an Equal Employment Opportunity/Affirmative Action employer, Texas Tech University is dedicated to the goal of building a culturally diverse faculty committed to teaching and working in a multicultural environment. We actively encourage applications from all those who can contribute, through their research, teaching, and/or service, to the diversity and excellence of the academic community at Texas Tech University. The university welcomes applications from minorities, women, veterans, persons with disabilities, and dual-career couples.

000027

AUSTRIA

IST AUSTRIA
Call for Assistant Professors and Professors

IST Austria invites applications for Tenure-Track Assistant Professor And Tenured Professor positions in all areas of Mathematics, Statistics, and Optimization.

IST Austria is a recently founded public institution dedicated to basic research and graduate education near Vienna. Currently active fields of research include biology, neuroscience, physics, mathematics, and computer science. IST Austria is committed to become a world-class centre for basic science and will grow to about 90 research groups by 2026. The institute has an interdisciplinary campus, an international faculty and student body, as well as state-of-the-art facilities. The working language is English. Successful candidates will be offered competitive research budgets and salaries. Faculty members are expected to apply for external research funds and participate in graduate teaching. Candidates for tenured positions must be internationally accomplished scientists in their respective fields.

Deadlines: Open call for Professor applications. For full consideration, Assistant Professor applications should arrive on or before November 3, 2015. Application material must be submitted online: www.ist.ac.at/professor-applications.

IST Austria values diversity and is committed to equal opportunity. Female researchers are especially encouraged to apply.

000034

HONG KONG

THE UNIVERSITY OF HONG KONG
Tenure-Track Associate Professor/ Assistant Professor in the Department of Mathematics (Ref.: 201500788)

Applications are invited for tenure-track appointment as Associate Professor/ Assistant Professor in the Department of Mathematics, to commence from September 1, 2016 or as soon as possible thereafter. The appointment will initially be made on a three-year term basis, with the possibility of renewal and with consideration for tenure before the expiry of the second three-year contract.

The Department of Mathematics provides a solid general undergraduate education in mathematics, offers supervision in graduate study for students with a strong interest in and a capacity for mathematics, and engages in teaching and research aiming at a high international standing. Information about the Department can be obtained at www.hku.hk/math/.

Candidates in all areas of Applied Mathematics and Mathematical Sciences will be considered, with preference given to those working in the areas of Scientific Computing, Computational Mathematics, Financial Mathematics, Operations Research, and Optimization. The appointee is expected to actively engage in outreach and service.

A globally competitive remuneration package commensurate with qualifications and experience will be offered. At current rates, salaries tax does not exceed 15 percent of gross income. The appointment will attract a contract-end gratuity and University contribution to a retirement benefits scheme, totalling up to 15 percent of basic salary, as well as annual leave, and medical benefits. Housing benefits will be provided as applicable.

Applicants should send a completed application form, together with an up-to-date CV containing information on educational and professional experience, a complete list of publications, a survey of past research and teaching experience, a research plan for the next few years, and a statement on teaching philosophy by email to scmath@hku.hk. They should also arrange for submission, to the same e-mail address as stated above, three reference letters from senior academics. One of these senior academics should be asked to comment on the applicant's ability in

teaching, or the applicant should arrange to have an additional reference letter on his/her teaching sent to the same e-mail address as stated above. Please indicate clearly which level they wish to be considered for and the reference number in the subject of the email. Application forms (341/1111) can be downloaded at `www.hku.hk/apptunit/form-ext.doc`. Further particulars can be obtained at `jobs.hku.hk/`. Review of applications will start from December 1, 2015 and continue until the post is filled.

The University thanks applicants for their interest, but advises that only candidates shortlisted for interviews will be notified of the application result.

The University is an equal opportunities employer and is committed to a No-Smoking Policy.

000021

SINGAPORE

NATIONAL UNIVERSITY OF SINGAPORE (NUS)
Department of Mathematics

The Department of Mathematics at the National University of Singapore (NUS) invites applications for tenured, tenure-track and visiting positions at all levels, beginning in August 2016.

NUS is a leading global university centred in Asia. The Department of Mathematics has about 65 faculty members and teaching staff whose expertise cover major areas of contemporary mathematical research.

We seek promising scholars and established mathematicians with outstanding track records in any field of pure and applied mathematics. The Department, housed in a newly renovated building equipped with state-of-the-art facilities, offers internationally competitive salary with start-up research grants, as well as an environment conducive to active research, with ample opportunities for career development. The teaching load for junior faculty is kept especially light.

The Department is particularly interested in, but not restricted to, considering applicants specializing in any of the following areas:

- Data Science
- Operations Research and Financial Mathematics
- Probability
- Partial Differential Equations and Applied Analysis
- Combinatorics

Application materials (as PDF files) should be sent to the Search Committee via email `search@math.nus.edu.sg`.

Please include the following supporting documentation in the application:

1. NUS Personal Data Consent for Job Applicants `http://www.nus.edu.sg/careers/potentialhires/applicationprocess/NUS-Personal-Data-Consent-for-Job-Applicants.pdf`.
2. an American Mathematical Society Standard Cover Sheet;
3. a detailed CV including publications list;
4. a statement (max. of 3 pages) of research accomplishments and plan;
5. a statement (max. of 2 pages) of teaching philosophy and methodology. Please attach evaluation on teaching from faculty members or students of your current institution, where applicable;
6. at least three letters of recommendation including one which indicates the candidate's effectiveness and commitment in teaching. Please ask your referees to send their letters directly to `search@math.nus.edu.sg`.

Enquiries may also be sent to this email address. Review process will begin on October 15, and will continue until positions are filled.

For further information about the department, please visit `www.math.nus.edu.sg`.

000023

THE CHINESE UNIVERSITY OF HONG KONG

Applications are invited for:-

Department of Mathematics
Research Assistant Professor
(Ref. 1516/036(576)/2)

The Department invites applications for a Research Assistant Professorship in all areas of mathematics.

Applicants should have (a) a relevant PhD degree; and (b) good potential for research and teaching.

Appointment will initially be made on contract basis for up to two years, renewable subject to mutual agreement.

Applications will be accepted until the post is filled.

Salary and Fringe Benefits
Salary will be highly competitive, commensurate with qualifications and experience. The University offers a comprehensive fringe benefit package, including medical care, plus a contract-end gratuity for an appointment of two years and housing benefits for eligible appointee. Further information about the University and the general terms of service for appointments is available at https://www2.per.cuhk.edu.hk/. The terms mentioned herein are for reference only and are subject to revision by the University.

Application Procedure
Application forms are obtainable (a) at https://www2.per.cuhk.edu.hk/, or (b) in person/by mail with a stamped, self-addressed envelope from the Personnel Office, The Chinese University of Hong Kong, Shatin, Hong Kong.

Please send the completed application form and/or full curriculum vitae, together with copies of qualification documents, a publication list and/or abstracts of selected published papers, and names, addresses and fax numbers/e-mail addresses of three referees to whom the applicants' consent has been given for their providing references (unless otherwise specified), to the Personnel Office by post or by fax to (852) 3942 0947.

Please quote the reference number and mark 'Application – Confidential' on cover. The Personal Information Collection Statement will be provided upon request.

Director of Education and Diversity

Division of Meetings and Professional Services

The American Mathematical Society (AMS) invites applications for the position of **Director of Education and Diversity**. This new position is focused on graduate education in the mathematical sciences, the preparation of students to enter graduate programs, mentoring of students for success in graduate school, and the promotion of diversity and inclusiveness at the graduate level.

About the AMS: The AMS, founded in 1888 to further the interests of mathematical research and scholarship, serves the national and international community through its publications, meetings, advocacy and other programs supporting professionals in the mathematical sciences. The Society supports mathematical education at all levels and advances the status of the profession of mathematics, encouraging and facilitating full participation of all individuals.

Responsibilities: The Director of Education and Diversity provides leadership for the Society's programs supporting education. Primary goals for the position are to improve the students' preparation and success rate in graduate programs leading to an advanced degree in the mathematical sciences, especially for those from underrepresented groups, including women. The director is expected to work closely with the AMS Committee on Education, with AMS membership and professional program activities, and with academic departments at the undergraduate and graduate levels toward these goals. The responsibilities include identifying opportunities for external funding and overseeing the preparation of funding proposals to achieve these goals.

Experience and Qualifications: Significant academic and administrative experience and familiarity with Ph.D. programs in the mathematical sciences. A candidate for the position should have an earned doctorate in a mathematical science (mathematics, applied mathematics, statistics or theoretical computer science, for example). Experience with programs that help women or other underrepresented groups succeed in doctoral programs in a mathematical science is desirable.

This is a full-time position at the AMS headquarters in Providence, with a starting date of January 1, 2016. Salary will be commensurate with experience.

Applications: Applications must include a curriculum vitae and a letter describing the applicant's administrative and academic experience and his or her interest in the position. Nominations and applications should be sent to:

Search Committee—
Education and Diversity
c/o Executive Director's Office
American Mathematical Society
201 Charles Street
Providence, RI 02904-2294 USA

Or email to: aed-mps@ams.org

Confidential inquiries about the position can be directed to T. Christine Stevens (aed-mps@ams.org) or Donald E. McClure (exdir@ams.org).

The American Mathematical Society is an Affirmative Action/Equal Opportunity Employer.

AMS
AMERICAN MATHEMATICAL SOCIETY
ams.org

Mathematical Sciences Employment Center

Washington State Convention Center, Seattle, Washington
January 6–9, 2016

The Employment Center offers a convenient, safe and practical meeting place for employers and job seekers attending the Joint Meetings. The focus of the Employment Center is on PhD-level mathematical scientists and those that seek to hire them from academia, business, and government.

Employment Center Web Services

Employment Center registration information should be accessed through the MathJobs.org system. For those who do not have existing MathJobs.org accounts, it will be possible to set up special Employment Center accounts at `www.mathjobs.org`. The website and all information will be available beginning in early September 2015 and will remain accessible through January 9, 2016 (the last day of the Employment Center). While some schools may delay appointment setting until late December 2015, virtually all scheduling will be done before any Joint Mathematics Meetings (JMM) travel takes place, so applicants should expect few or no additional appointments to be available after arrival. Registering on-site, for applicants, serves no real purpose.

No Admittance Without a JMM Badge

All applicants and employers planning to enter the Employment Center—even just for one interview—must present a 2016 Joint Meetings Registration badge. Meeting badges are obtained by registering for the JMM and paying a meeting registration fee. The Advanced registration deadline is December 22, 2015. See the JMM website at: `jointmathematicsmeetings.org/jmm` for registration instructions and rates.

Employers: Choose a Table

There are three table types available for employers, based on the number of interviewers who will be present at any given time:

• One or two interviewers per table in the "Quiet Area" (US$340), each additional table (US$175).

• Three to six interviewers per table in the "Committee Table" area (US$430), each additional table (US$190).

• Free electricity is supplied to every table with purchase of the table.

• New this year, "One Day Tables" allow for on-site interviewing for one day without placing an ad. These tables, which can accommodate up to three interviewers, may only be purchased starting December 23, 2015 through January 8, 2016. The fee is (US$195). Please register online at `www.mathjobs.org` and choose the "EC-One Day Table purchase".

Employers: Schedule an Interview

All Employment Center data and registration must be entered on the MathJobs.org site. An existing account can be used for accessing Employment Center services and for paying applicable fees. If no account exists, participants can start an account solely for Employment Center use.

Employers are expected to create their own interview schedules as far in advance as possible by using the assisted-email system in MathJobs.org or by using other means of communication. Please do not schedule an interview to begin until fifteen minutes after the Employment Center opens (see schedule below).

2016 Employment Center Schedule:

December 22, 2015 is the deadline for table registration. After this date only "One Day Tables" will be available for purchase. This is also the deadline to register for the JMM badge, needed for admittance to the EC, at Advanced Registration Prices.

HOURS of OPERATION (Please note there is no access to the EC prior to the opening times listed.)**:**

Wednesday, January 6, 2016–8:00 am–5:30 pm

Thursday, January 7, 2016–8:00 am–5:30 pm

Friday, January 8, 2016–8:00 am–5:30 pm

Saturday, January 9, 2016–9:00 am–12:00 noon

Location: Exhibit Hall 4B, Fourth Level, Washington State Convention Center, 800 Convention Place, Seattle, Washington.

Do not schedule an interview to begin until 15 minutes after opening.

©Goen South.

Please mark appointments as confirmed in your MathJobs.org account, as this will allow the appointments to display in the applicants' schedules. At the time of each interview, meet the applicant in the on-site waiting area and escort him or her to your table.

Employers: How to Register

• Registration runs early September 2015 through December 22, 2015 at the following website: `www.mathjobs.org`. After December 22, only "One Day Tables" will be available. They should be reserved and paid for through MathJobs.org.

• Use your existing MathJobs.org account or create a new Employer account at `www.mathjobs.org`. Once a table is reserved, the ad can be placed at any time (or never) and will run until late January.

• For new users of MathJobs.org, click the NEW EMPLOYER link on the main page of `www.mathjobs.org.` Choose your table type and fill out the New Employer Form.

• For existing users of MathJobs.org, go to `www.mathjobs.org`. Log into your existing account. Purchase a table by clicking the "EmpCent" logo in the menus along the top tool bar. Use the "buy tables" link. Then post a job using the NewJob link or attach an existing job to your table.

• Each person who will need to enter the Employment Center area must have a meeting badge (obtained by registering for the JMM and paying a meeting registration fee).

To display an ad on-site, and use no Employment Center services at all, submit your one-page paper ad on-site in Seattle to the Employment Center staff. There is no fee for this service.

For complete information, visit `www.ams.org/emp-reg/.`

Applicants: Making the Decision to Attend

• The Employment Center offers no guarantees of interviews or jobs. Hiring decisions are not made during or immediately following interviews. In the current job market, the ratio of applicants to employers is about 10:1, and many applicants go completely unnoticed.

• There will ordinarily be no research-oriented postdoctoral positions listed or discussed at the Employment Center.

• Interviews will go to applicants who applied to jobs during the fall and are now being sought out by the institutions for in-person meetings during the JMM.

• There will be no opportunity to speak to employers without a prearranged interview, and no walk-up job information tables. Scheduling of interviews will be complete prior to the JMM.

The majority of Employment Center employers are academic departments of mathematical sciences seeking to meet a short list of applicants who applied for their open positions during the fall. Each year, a few government or industry employers are present. Often, they are seeking US citizens only due to existing contracts.

All job postings are available on the website in advance, and now that this electronic service is in place, there is no other messaging conducted on paper.

Past attendees have pointed out that all interviews are arranged in advance, and there is no opportunity to make connections on-site if it has not happened before the meeting. In a recent survey, 50 percent of respondents reported being invited for at least one on-campus visit to an employer they had interviewed with at the Employment Center. Please visit the Employment Center website for further advice, information and program updates at `www.ams.org/emp-reg/.`

Applicants: How to Register

• Early registration is vital since most employers will finalize schedules before arriving in Seattle.

• To register, applicants should log into their MathJobs.org accounts or create a new account, look for the EmpCent icon across the top tool bar and mark that they will be attending by clicking the link: "click here if you are attending the Employment Center". You can then upload documents and peruse the list of employers attending and the positions available. You do not have the option to request an interview with an employer. However, if you are interested in any position, you can apply to the job. The employer will be aware that you are also attending the event and will contact you directly if interested in setting up an interview.

There are no Employment Center fees for applicants; however, admission to the Employment Center room requires a 2016 JMM badge, obtainable by registering (and paying a fee) for the JMM. To register for the meeting, go to the website: `jointmathematicsmeetings.org/jmm.`

It is possible to attend one or more privately arranged interviews without an official Employment Center registration; however, a meeting badge is required to access the interview room.

Applicants should keep track of their interview schedules and note their busy times in their accounts. If invited for an interview at a conflicting time, please ask the employer to offer a new time or suggest one.

For complete information, visit: `www.ams.org/emp-reg/.`

Questions about the Employment Center registration and participation can be directed to Pamela Morin, AMS Membership and Programs Department, at 800-321-4267, ext. 4060 or by email to `emp-info@ams.org`.

CALL FOR Suggestions

Your suggestions are wanted by:

the Nominating Committee, for the following contested seats in the 2016 AMS elections:
vice president, trustee,
and five members at large of the Council.

Deadline for suggestions: November 1, 2015

the President, for the following contested seats in the 2016 AMS elections:
three members of the Nominating Committee and
two members of the Editorial Boards Committee.

Deadline for suggestions: January 31, 2016

the Editorial Boards Committee, for appointments to various editorial boards of AMS publications.

Deadline for suggestions: Can be submitted any time

Send your suggestions for any of the above to:

Carla D. Savage, Secretary
American Mathematical Society
Department of Computer Science
North Carolina State University
Raleigh, NC 27695-8206 USA
secretary@ams.org
or submit them online at www. ams.org/committee-nominate

AMS
American Mathematical Society
www.ams.org

AMS Short Course in Seattle, WA

AMS Short Course on Rigorous Numerics in Dynamics

This two-day course will take place on Monday and Tuesday, January 4 and 5, before the joint meeting actually begins. It is co-organized by **Jean-Philippe Lessard**, Université Laval, Québec, Canada, & **Jan Bouwe van den Berg**, VU University Amsterdam, Netherlands.

Nonlinear dynamics shape the world around us, from the harmonious movements of celestial bodies, via the swirling motions in fluid flows, to the complicated biochemistry in the living cell. Mathematically these beautiful phenomena are modelled by nonlinear dynamical systems, mainly in the form of ordinary differential equations (ODEs), partial differential equations (PDEs) and delay differential equations (DDEs). The presence of nonlinearities severely complicates the mathematical analysis of these dynamical systems, and the difficulties are even greater for PDEs and DDEs, which are naturally defined on infinite dimensional function spaces. With the availability of powerful computers and sophisticated software, numerical simulations have quickly become the primary tool to study the models. However, while the pace of progress increases, one may ask: just how reliable are our computations? Even for finite dimensional ODEs, this question naturally arises if the system under study is chaotic, as small differences in initial conditions (such as those due to rounding errors in numerical computations) yield wildly diverging outcomes. These issues have motivated the development of the field of rigorous numerics in dynamics.

Rigorous numerics draws inspiration from the ideas in scientific computing, numerical analysis and approximation theory.

It is well suited to a short course, as it concerns recent research progress in applied mathematics, while only a basic mathematical background is required to appreciate the striking interplay between theory, computations and applications.

Dynamics and Chaos For Maps and The Conley Index

Sarah Day, The College of William & Mary

Sarah Day

Discrete-time dynamical systems modeled by iteration of continuous maps exhibit a wide variety of interesting behaviors. One illustrative example is the one-dimensional logistic model. For the logistic model, chaotic dynamics may be proven via a topological conjugacy onto an appropriate subshift of finite type, a symbolic system for which a proof of chaos is attainable. Analysis and proofs of dynamics for other discrete-time models, especially in dimensions larger than one, often prove to be more challenging. In this course, we examine methods for constructing *outer approximations*, finite representations of discrete-time models that are amenable to computational studies and computer-assisted proofs. These methods rely heavily on *Conley index theory*, an algebraic topological generalization of Morse Theory. Both theory and algorithms will be presented in this course. Studies of models including pulse-coupled oscillator systems and the infinite-dimensional Kot–Schaffer model from ecology will serve as illustrations of the methods.

References

[1] S. Day, O. Junge, K. Mischaikow, *Toward automated chaos verification*, In EQUADIFF 2003, pages 157–162, World Sci. Publ., Hackensack, NJ, 2005.

[2] Z. Arai., W. Kalies, H. Kokubu, K. Mishchaikow, H. Oka, P. Pilarczyk, A database schema for the analysis of global dynamics of multiparameter systems, *SIAM J. Appl. Dyn. Syst.*, 8(3):757–789, 2009.

[3] S. Day, R. Frongillo, R. Treviño, Algorithms for rigorous entropy bounds and symbolic dynamics, *SIAM J. Appl. Dyn. Syst.*, 7(4):1477–1506, 2008.

[4] T. Kaczynski, K. Mischaikow, M. Mrozek, Computational homology, volume 157 of *Applied Mathematical Sciences*, Springer-Verlag, New York, 2004.

[5] K. Mischaikow and M. Mrozek, Conley index, In *Handbook of Dynamical Systems*, Vol. 2, pages 393–460, North-Holland, Amsterdam, 2002.

Delay Differential Equations and Continuation

Jean-Philippe Lessard, Université Laval

Université Laval/Marc Robitaille.

Jean-Philippe Lessard

An intriguing feature of the study of nonlinear delay differential equations (DDEs) is that progress in understanding their dynamics has been slow and has involved deep mathematical ideas. This is perhaps not surprising as a large class of DDEs naturally give rise to infinite dimensional nonlinear dynamical systems. Even for the simplest-looking DDEs, many fundamental dynamical questions remain open. In particular, the study of the global dynamics of Wright's equation defined by

$$y'(t) = -\alpha y(t-1)[1 + y(t)], \qquad \alpha \in \mathbb{R} \tag{1}$$

has been the subject of active research for sixty years. In 1955, E. M. Wright considered this equation because of its role in the distribution of prime numbers [6]. A conjecture (stated by Jones in 1962 [7]) asserts that (1) has a unique slowly oscillating periodic solution for all $\alpha > \pi/2$; i.e., a periodic solution that oscillates around 0, spending more than one unit of time (per period) on either side of 0.

In this lecture we show how ideas from rigorous computations can be used to study the dynamics of DDEs. In particular, with the help of Fourier series, we introduce a continuation method to compute global branches of periodic solutions of DDEs. We discuss progress on the study of the long-standing above mentioned conjecture, as discussed in [2].

References

[1] R. D. Nussbaum, *Functional differential equations*, Handbook of dynamical systems, Vol. 2, 461–499, North-Holland, Amsterdam, 2002.

[2] J.-P. Lessard, *Recent advances about the uniqueness of the slowly oscillating periodic solutions of Wright's equation*, Journal of Differential Equations, 248 (5): 992–1016, 2010.

[3] G. Kiss and J.-P. Lessard, *Computational fixed point theory for differential delay equations with multiple time lags*, Journal of Differential Equations, 252 (4): 3093–3115, 2012

[4] _____, *Rapidly and slowly oscillating periodic oscillations of a delayed van der Pol oscillator*, Submitted, 2015.

[5] O. Diekmann, S. A. van Gils, S. M. Verduyn Lunel and H.-O. Walther, *Delay equations. Functional, complex, and nonlinear analysis*, Applied Mathematical Sciences, 110, Springer-Verlag, New York, 1995.

[6] E. M. Wright, *A nonlinear difference-differential equation*, J. Reine Angew. Math., 194:66–87, 1955.

[7] G. S. Jones, *On the nonlinear differential-difference equation* $f'(x) = -\alpha f(x-1)1 + f(x)$, J. Math. Anal. Appl., 4:440–469, 1962.

Rigorous Computation of (Un)Stable Manifolds and Connecting Orbits

J. D. Mireles James, Florida Atlantic University

J. D. Mireles James

The study of dynamical systems begins with consideration of basic invariant sets such as equilibria and periodic solutions. After local stability, the next important question is how these basic invariant sets fit together dynamically. Connecting orbits play an important role as they are low dimensional objects which carry global information about the dynamics. This principle is seen at work in the homoclinic tangle theorem of Smale, in traveling wave analysis for reaction diffusion equations, and in Morse homology.

This lecture builds on the validated numerical methods for periodic orbits presented in the lecture of J. B. van den Berg. We will discuss the functional analytic perspective on validated stability analysis for equilibria and periodic orbits as well as validated computation of their local stable/unstable manifolds. With this data in hand we study heteroclinic and homoclinic connecting orbits as solutions of certain projected boundary value problems, and see that these boundary value problems are amenable to an a posteriori analysis very similar to that already discussed for periodic orbits. The discussion will be driven by several application problems including connecting orbits in the Lorenz system and existence of standing and traveling waves.

References

[1] J. B. van den Berg, J. D. Mireles James, J.-P. Lessard, and Konstantin Mischaikow, Rigorous numerics for symmetric connecting orbits: even homoclinics of the Gray-Scott equation. SIAM J. Math. Anal., vol. 43, No. 4, 1557–1594, 2011.

[2] J.-P. Lessard, C. Reinhardt and J. D. Mireles James, Computer assisted proof of transverse saddle-to-saddle connecting orbits for first order vector fields, *Journal of Dynamics and Differential Equations*, vol. 26, Issue 2, 267–313, 2014.

[3] J. B. van den Berg, Andréa Deschênes, J.-P. Lessard and

J. D. Mireles James, Stationary coexistence of hexagons and rolls via rigorous computations, *SIAM J. Applied Dynamical Systems*, vol. 14, No. 2, 942–997, 2015.

[4] R. Castelli, J.-P. Lessard and J. D Mireles James, Parameterization of invariant manifolds for periodic orbits I: efficient numerics via the Floquet normal form, *SIAM J. Applied Dynamical Systems*, vol. 14, no. 1, 132–167, 2015.

[5] J. D. Mireles James, Polynomial approximation of one parameter families of (un)stable manifolds with rigorous computer assisted error bounds, *Indagationes Mathematicae*, vol. 26, Issue 1, 225–265, 2015.

Introduction: General Setup And An Example That Forces Chaos

Jan Bouwe van den Berg, VU University Amsterdam

Studio VU/Riechelle van der Valk.

Jan Bouwe van den Berg

In this lecture the basic concepts of rigorous computing in a dynamical systems context will be outlined. We often simulate dynamics on a computer, or calculate a numerical solution to a partial differential equation. This gives very detailed, stimulating information. However, mathematical insight and impact would be much improved if we can be sure that what we see on the screen genuinely represents a solution of the problem. In particular, rigorous validation of the computations allows such objects to be used as ingredients of theorems.

The past few decades have seen enormous advances in the development of computer assisted proofs in dynamics. In this introductory talk we discuss the basic functional analytic setup underlying the rigorous computational method that is the central topic of this AMS short course. As the central example we will use the problem of finding a particular periodic orbit in a nonlinear ordinary differential equation that describes pattern formation in fluid dynamics. This simple setting keeps technicalities to a minimum. Nevertheless, the rigorous computation of this single periodic orbit implies chaotic behavior via topological arguments (in a sense very similar to "period 3 implies chaos" for interval maps).

References

[1] J. B. van den Berg and J.-P. Lessard, Chaotic braided solutions via rigorous numerics: chaos in the Swift–Hohenberg equation, *SIAM Journal on Applied Dynamical Systems*, 7(3): 988–1031, 2008.

[2] A. Hungria, J.-P. Lessard and J. D. Mireles James, Rigorous numerics for analytic solutions of differential equations: the radii polynomial approach, to appear in *Mathematics of Computation*, 2015.

Bifurcations and an Application in Materials Science

Thomas Wanner, George Mason University

Thomas Wanner

The diblock copolymer model is a fourth-order parabolic partial differential equation which models phase separation with fine structure. The equation is a gradient flow with respect to an extension of the standard van der Waals free energy functional which involves nonlocal interactions, and the long-term dynamical behavior of the diblock copolymer model is described by its finite-dimensional attractor. However, even on one-dimensional domains, the dynamics on the attractor is not fully understood, and rigorous mathematical results on the long-term dynamics of solutions created via phase separation seem to be out of the reach of classical mathematical methods.

In the recent paper [2], it was shown that the location of certain numerically computed bifurcation points in the equilibrium bifurcation diagram can shed light onto this problem. In this lecture we therefore describe how rigorous computational techniques can be used to obtain computer-assisted existence proofs for these bifurcation points. While our presentation is focusing on the diblock copolymer case, the method applies more generally to bifurcation points in infinite-dimensional problems. Particular emphasis is put on fold points and pitchfork bifurcations which are forced through symmetry breaking, as well as the continuation of such bifurcation points in two-parameter problems. The lecture will contain the necessary background material from bifurcation theory, and the approach will be demonstrated using the one-dimensional diblock copolymer equation. Time permitting, we will briefly discuss possible applications in the context of nucleation in a different parabolic partial differential equation known as the Cahn–Morral system.

References

[1] T. Wanner, *Topological analysis of the diblock copolymer equation*, submitted for publication, 2015.

[2] I. Johnson, E. Sander, T. Wanner, *Branch interactions and long-term dynamics for the diblock copolymer model in one dimension*, Discrete and Continuous Dynamical Systems, Series A 33(8), pp. 3671–3705, 2013.

[3] J. P. Desi, H. Edrees, J. J. Price, E. Sander, T. Wanner, *The dynamics of nucleation in stochastic Cahn–Morral systems*, SIAM Journal on Applied Dynamical Systems 10(2), pp. 707–743, 2011.

[4] A. Spence, B. Werner, *Nonsimple turning points and cusps*, IMA Journal of Numerical Analysis 2(4), pp. 413–427, 1982.

[5] B. Werner, A. Spence, *The computation of symmetry-breaking bifurcation points*, SIAM Journal on Numerical Analysis 21(2), pp. 388–399, 1984.

[6] J.-P. Lessard, E. Sander, T. Wanner, *Rigorous continuation of bifurcation points in the diblock copolymer equation*, in preparation, 2015.

Every Calculation an Existence Proof: Towards Automated Rigorous Computing

J. F. Williams, Simon Fraser University

J. F. Williams

For an abstract problem posed as $F(x) = 0$ rigorous computing is, at its core, a strategy to use a computer to evaluate functional analytic bounds numerically. When these bounds are satisfied we prove existence of a true solution in a neighborhood of a numerical candidate. Typically, there is much pencil and paper work to be done to find these bounds required to set up the computation.

In this lecture we will show how to combine algorithms from automatic differentiation with interval arithmetic and the radii polynomial approach to automate both the verification AND construction of the bounds. We will present algorithms to rigorously compute solutions to

a) $f(x) = 0$ for $f: R^n \mapsto R^n$

b) $-\partial u = f(u)$

with the user required to provide little more than an initial guess and the specified function f. The algorithm will then determine the necessary bounds and attempt to verify the solution. Time permitting we will also discuss how to perform continuation on these same problems.

This lecture will assume that participants are familiar (possibly from earlier lectures) with the basics of radii polynomials. We will explain the basics of automatic differentiation, interval arithmetic and explain the framework in which we are using the radii polynomials.

References

1) N. Yamamoto, A numerical verification method for solutions of boundary value problems with local uniqueness by Banach fixed-point theorem, *SIAM J. Numer. Anal.*, **35** (1998), pp. 2004–2013 (electronic).

2) L. B. Rall and G. F. Corliss, An Introduction to Automatic Differentiation in Computational Differentiation: Techniques, Applications, and Tools, *SIAM* (1996).

3) R. E. Moore, R. Baker Kearfott and M. J. Cloud, Introduction to Interval Analysis, *SIAM* (2009).

4) S. M. Rump, INTLAB - INTerval LABoratory, in *Developments in Reliable Computing*, Tibor Csendes, ed., Kluwer Academic Publishers, Dordrecht, 1999.

5) J. B. van den Berg, J.-P. Lessard and K. Mischaikow, Global smooth solution curves using rigorous branch following, *Mathematics of Computation*, **79** (271), 1565–1584, 2010.

6) J. B. van den Berg, C. M. Groothedde, and J. F. Williams, Rigorous Computation of a Radially Symmetric Localized Solution in a Ginzburg–Landau Problem, *SIAM Journal on Applied Dynamical Systems* 14:1, 2015, 423–447.

Registration

There are separate fees to register for this Short Course. Advanced registration fees for members are US$110; nonmembers are US$165, and students/unemployed or emeritus members are US$58. These fees are in effect until December 22, 2015. If you choose to register on-site, the fees for members are US$144; nonmembers are US$195, and students/unemployed or emeritus members are US$79. Advanced registration starts on September 2, 2015. On-site registration will take place on Tuesday, January 5, 2016, at a location to be announced.

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 `www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL.

THIS ONLINE MEETINGS & CONFERENCES LISTING CONTAINS JMM 2016 UPDATES THAT WERE NOT AVAILABLE AT PRESS-TIME AND SO ARE NOT PRESENT IN THE PRINT VERSION

Chicago, Illinois

Loyola University Chicago

October 3–4, 2015

Saturday–Sunday

Meeting #1112

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: June 2015
Program first available on AMS website: August 20, 2015
Issue of *Abstracts*: Volume 36, Issue 4

Deadlines

For organizers: 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

Julia Chuzhoy, Toyota Technological Institute at Chicago, *Excluded Grid Theorem: Improved and Simplified.*

Andrew Neitzke, The University of Texas at Austin, *Some new geometric applications of quantum field theory.*

Sebastien Roch, University of Wisconsin-Madison, *Mathematics of the Tree of Life—From Genomes to Phylogenetic Trees and Beyond.*

Peter Sarnak, Princeton University, and IAS Princeton, *Markoff Surfaces, Numbers and Strong Approximation* (Erdős Memorial Lecture).

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Algebraic Methods Common to Association Schemes, Hopf Algebras, Tensor Categories, Finite Geometry, and Related Areas, **Harvey Blau**, Northern Illinois University, **Sung Y. Song**, Iowa State University, and **Bangteng Xu**, Eastern Kentucky University.

Algebraic Statistics and its Interactions with Combinatorics, Computation, and Network Science, **Sonja Petrovic**, Illinois Institute of Technology, and **Despina Stasi**, University of Cyprus and Illinois Institute of Technology.

Algebraic and Combinatorial Invariants of Knots, **Micah Chrisman**, Monmouth University, **Heather Dye**, McKendree University, **Aaron Kaestner**, North Park University, **Louis Kauffman**, University of Illinois at Chicago, and **Emily Peters**, Loyola University Chicago.

Analysis of Partial Differential Equations and Fluid Dynamics, **Mimi Dai**, University of Illinois at Chicago, **Vera Mikyoung Hur**, University of Illinois at Urbana-Champaign, and **Yao Yao**, University of Wisconsin-Madison.

Automorphic Forms and Representations, **Moshe Adrian**, University of Toronto, and **Shuichiro Takeda** and **Aaron Wood**, University of Missouri-Columbia.

Automorphisms of Riemann Surfaces and Related Topics, **S. Allen Broughton**, Rose-Hulman Institute of Technology, **Peter Turbek**, Purdue University Calumet, **Anthony Weaver**, Bronx Community College, the City University of New York, and **Aaron Wootton**, University of Portland.

Coding Theory and Its Applications, **W. Cary Huffman**, Loyola University Chicago.

Cohomology of Algebras and Deformation Theory, **Anthony Giaquinto**, Loyola University Chicago, **Mihai D. Staic**, Bowling Green State University, and **Alin Stancu**, Columbus State University.

Combinatorial and Computational Algebra, **David Cook II**, Eastern Illinois University, and **Sonja Mapes**, University of Notre Dame.

Combinatorial and Geometric Representation Theory, **Ben Salisbury**, Central Michigan University, and **Peter Tingley**, Loyola University Chicago.

Commutative Algebra, **Youngsu Kim** and **Paolo Mantero**, University of California, Riverside, and **Jonathan Montano**, Purdue University.

Computability Theory and Applications, **Denis Hirschfeldt**, University of Chicago, and **Steffen Lempp**, University of Wisconsin-Madison.

Enumerative Algebraic and Geometric Combinatorics, **Kyle Petersen**, DePaul University, and **Steven Klee**, Seattle University.

Enumerative Combinatorics and Graph Theoretic Applications, **Adam Goyt**, Minnesota State University, and **Lara Pudwell**, Valparaiso University.

Ergodic and Symbolic Actions of Amenable Groups, **Ayşe Şahin** and **Ilie Ugarcovici**, DePaul University.

Frontiers in Computational Mathematics, **Sou-Cheng (Terrya) Choi**, NORC at the University of Chicago, and Illinois Institute of Technology.

Generalized Derivatives, **J. Marshall Ash**, DePaul University, and **Paul Musial**, Chicago State University.

Geometric Partial Differential Equations, **Morgan Sherman**, California Polytechnic State University, and **Valentino Tosatti** and **Ben Weinkove**, Northwestern University.

Geometric Perspectives in Knot Theory, **David Krcatovich** and **Allison Moore**, Rice University.

Graduate Student Perspectives on Undergraduate Research, **Mindy Capaldi** and **Zsuzsanna Szaniszlo**, Valparaiso University.

Groups, Rings, Group Rings, and Hopf Algebras (celebrating the 75th birthday of Donald S. Passman), **Jeffrey Bergen**, **Stefan Catoiu**, and **William Chin**, DePaul University.

History of Mathematics, **Steven Jordan**, Loyola University Chicago.

Hopf Algebraic Combinatorics, **Marcelo Aguiar**, Cornell University, and **Aaron Lauve**, Loyola University Chicago.

K-loops, Neardomains, Loops, and Nonassociative Division Algebras, **Alper Bulut**, American University of the Middle East, **C. E. Ealy Jr.**, Western Michigan University, **Hubert Kiechle**, University of Hamburg, **Benjamin Phillips**, University of Michigan Dearborn, and **J. D. Phillips**, Northern Michigan University.

Mathematical Analysis and Computation of Nematic Liquid Crystals, **Patricia Bauman**, **Daniel Phillips**, and **Changyou Wang**, Purdue University.

Mathematics of Evolution, **Ruth Davidson**, University of Illinois Urbana-Champaign, and **Ruriko Yoshida**, University of Kentucky.

Metric Spaces: Geometry, Group Theory, and Dynamics, **Tullia Dymarz**, University of Wisconsin-Madison, and **Anton Lukyanenko**, University of Michigan.

Model Theory, **Uri Andrews**, University of Wisconsin-Madison, **Isaac Goldbring**, University of Illinois at Chicago, and **Maryanthe Malliaris**, University of Chicago.

Nonlinear PDEs and Calculus of Variations, **Emmanuel Barron**, **Marian Bocea**, and **Robert Jensen**, Loyola University Chicago.

Nonlocal Diffusions, **Jinqiao Duan**, **Xiaofan Li**, and **Xiaoxia Xie**, Illinois Institute of Technology.

Probability Theory, **Antonio Auffinger**, Northwestern University, **Jian Ding**, University of Chicago, and **Sebastien Roch**, University of Wisconsin-Madison.

Recent Advances in Non-Commutative Analysis, **Hari Bercovici**, Indiana University, and **John Williams**, Universität des Saarlandes.

Recent Developments in Graph and Matroid Theory, **Sergei Bezrukov**, University of Wisconsin-Superior, **Dalibor Froncek**, University of Minnesota Duluth, and **Xiaofeng Gu** and **Steven Rosenberg**, University of Wisconsin-Superior.

Recent Developments in the Theory and Applications of Reaction Network Models, **Carsten Conradi**, Max Planck Institute, and **Casian Pantea**, West Virginia University.

Singularities in Algebra, Geometry and Topology, **Manuel Gonzalez Villa** and **Laurentiu Maxim**, University of Wisconsin-Madison.

Stochastic Analysis With Applications to Quantitative Finance, **Igor Cialenco** and **Ruoting Gong**, Illinois Institute of Technology.

The Langlands Program and Related Topics, **Andrei Jorza**, University of Notre Dame, and **Martin Luu**, University of Illinois at Urbana-Champaign.

Topics in Graph Theory, Hypergraphs and Set Systems, **John Engbers**, Marquette University, and **David Galvin**, University of Notre Dame.

Variational Analysis, Optimization, and Control (Dedicated to Terry Rockafellar on the occasion of his 80th birthday), **Rafal Goebel**, Loyola University Chicago.

Memphis, Tennessee

University of Memphis

October 17–18, 2015

Saturday–Sunday

Meeting #1113

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: August 2015
Program first available on AMS website: September 3, 2015
Issue of *Abstracts*: Volume 36, Issue 3

Deadlines

For organizers: 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

Mark van Hoeij, Florida State University, *Solving problems with the LLL algorithm.*

Vaughan Jones, Vanderbilt University, *Are all subfactors related to quantum field theory?*

Mette Olufsen, North Carolina State University, *Patient specific modeling of cardiovascular system dynamics.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Advances in Operator Theory and Applications, in memory of James Jamison, **Fernanda Botelho**, University of Memphis, and **T.S.S.R.K. Rao**, Indian Statistical Institute Bangalore.

Analysis of Differential and Integral Equations, **D. P. Dwiggins** and **T. Hagen**, University of Memphis.

Banach Spaces and Applications, **Anna Kaminska**, **Peikee Lin**, and **Bentuo Zheng**, University of Memphis.

Cahn-Hilliard and Related Equations and Applications, **Giséle Ruiz Goldstein**, University of Memphis, and **Alain Miranville**, Université de Poitiers.

Computational Analysis, **George Anastassiou**, University of Memphis.

Control and Inverse Problems for Partial Differential Equations, **Matthias Eller**, Georgetown University, **Shitao Liu**, Clemson University, and **Roberto Triggiani**, University of Memphis.

Difference Equations and Applications, **Michael A. Radin**, Rochester Institute of Technology, and **Youssef Raffoul**, University of Dayton.

Ergodic Theory, **James T. Campbell** and **Mate Wierdl**, University of Memphis.

Evolution Equations and Partial Differential Equations, **Jerome A. Goldstein**, University of Memphis, **Rainer Nagel**, Universitaet Tuebingen, and **Guillermo Reyes**, University of Southern California.

Extremal Graph Theory (in memory of Ralph Faudree), **Paul Balister**, University of Memphis, **Béla Bollobás**, University of Cambridge UK, and University of Memphis, and **Vladimir Nikiforov**, University of Memphis.

Fractal Geometry and Dynamical Systems, **Mrinal Kanti Roychowdhury**, University of Texas Rio Grand Valley.

Probabilistic Combinatorics, **Paul Balister**, University of Memphis, and **Béla Bollobás**, University of Cambridge UK, and University of Memphis.

Recent Advances in Commutative Algebra, **Sandra Spiroff**, University of Mississippi, and **Lance Miller**, University of Arkansas.

Recent Developments in the Statistical Analysis of Large Clustered Data, **E. Olusegun George**, University of Memphis.

Spectra of Graphs and Hypergraphs, **Vladimir Nikiforov**, University of Memphis.

Stabilization, Control, and Analysis of Evolutionary Partial Differential Equations, **George Avalos**, University of Nebraska Lincoln, **Scott Hansen**, Iowa State University, and **Justin Webster**, North Carolina State University & College of Charleston.

The Analysis, Geometry, and Topology of Groupoids, **Emily Proctor**, Middlebury College, and **Christopher Seaton**, Rhodes College.

Topological Combinatorics, **Eric Gottlieb**, Rhodes College, and **Russ Woodroofe**, Mississippi State University.

von Neumann Algebras, **Vaughan Jones**, Vanderbilt University, and **David Penneys**, University of California Los Angeles.

Fullerton, California

California State University, Fullerton

October 24–25, 2015

Saturday–Sunday

Meeting #1114

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2015
Program first available on AMS website: September 10, 2015
Issue of *Abstracts*: Volume 36, Issue 4

Deadlines

For organizers: 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

Mina Aganagic, University of California-Berkeley, *Refined Chern-Simons Index and Knot Homology.*

John Lott, University of California–Berkeley, *3D Ricci flow since Perelman.*

Eyal Lubetzky, Microsoft Research, Redmond, *Title to be announced.*

Zhiwei Yun, Stanford University, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Algebraic and Combinatorial Structures in Knot Theory, **Allison Henrich**, Seattle University, **Aaron M. Kaestner**, North Park University, **Sam Nelson**, Claremont McKenna College, and **Matt Rathbun**, California State University, Fullerton.

Analysis on Metric Spaces (in honor of Fred Gehring on the occasion of his 90th birthday), **Zair Ibragimov**, California State University, Fullerton.

Applied Mathematics in Industry: In Memory of Professor John G. Pierce (1942–2015), **Charles H. Lee** and **Angel R. Pineda**, California State University, Fullerton.

Fixed Point Theory and Applications, **Clement B. Ampadu** and **Talat Nazir**, Malardalen University, and **Xavier A. Udo-Utun**, University of Uyo.

Geometric Analysis, **John Lott**, University of California, Berkeley, and **Aaron Naber**, Northwestern University.

History and Philosophy of Mathematics, **Jim Tattersall**, Providence College, and **Shawn McMurran**, California State University, San Bernardino.

Homological Methods in Commutative Algebra, **Amanda Croll**, Concordia University, Irvine, and **Jack Jeffries**, University of Michigan.

Humanistic Mathematics, **Mark Huber**, Claremont McKenna College, and **Gizem Karaali**, Pomona College.

Mathematical Techniques in Quantum Theories and Quantum Finance, with applications, **Alfonso F. Agnew**, California State University at Fullerton, and **David Carfi**, University of Messina, Italy.

Mathematical/Statistical Modeling and its Applications to Science and Engineering, **Kanadpriya Basu**, University of Texas at El Paso.

Mathematicians and Outreach Programs, **Olga Radko**, University of California Los Angeles, and **Bogdan D. Suceavă**, California State University, Fullerton.

Recent Advances in Computational and Mathematical Biology, **Fengzhu Sun**, University of Southern California, and **Jianjun Paul Tian** and **Mary Ballyk**, New Mexico State University.

Recent Advances in Finite Groups and their Representations, **Adam Glesser**, California State University, Fullerton, and **Mandi Schaeffer Fry**, Metropolitan State University of Denver.

Recent Advances in Number Theory, **Christopher Lyons**, California State University, Fullerton, and **Karl Rubin** and **Alice Silverberg**, University of California, Irvine.

Recent Developments in Nonlinear Partial Differential Equations, **Changyou Wang**, Purdue University, and **Yifeng Yu**, University of California at Irvine.

Recent Results in Operator Theory and Operator Algebras, **Asuman G. Aksoy**, Claremont McKenna College, **Don Hadwin**, University of New Hampshire, and **Hassan Yousefi**, California State University, Fullerton.

Research in Mathematics by Early Career Graduate Students, **Tamas Forgacs**, **Carmen Caprau**, and **Oscar Vega**, California State University, Fresno.

Spatial Graphs, **Erica Flapan**, Pomona College, **Thomas Mattman**, California State University, Chico, **Blake Mellor**, Loyola Marymount University, **Ramin Naimi**, Occidental College, and **Ryo Nikkuni**, Tokyo Women's Christian University.

Spatio-Temporal Modeling of Neuronal Data, **Reza Ramezan** and **Sam Behseta**, California State University, Fullerton.

Spectral Asymptotics of Large Matrices, **Alain Bourget** and **Tyler McMillen**, California State University, Fullerton.

Spectral Theory of Ergodic Schrödinger Operators and related models, **S. Jitomirskaya**, University of California, Irvine, and **Christoph Marx**, Oberlin College.

Stochastic modeling and statistical inference, **Qidi Peng**, Claremont Graduate University.

Strategies of Training Pre-Service Teachers, **Margaret Kidd**, **Cherie Ichinose**, **David Pagni**, and **Bogdan D. Suceavă**, California State University, Fullerton.

New Brunswick, New Jersey

Rutgers University

November 14–15, 2015

Saturday–Sunday

Meeting #1115

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: September 2015
Program first available on AMS website: October 1, 2015
Issue of *Abstracts*: Volume 36, Issue 4

Deadlines

For organizers: Expired
For abstracts: September 22, 2015

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Lee Mosher, Rutgers University, *The geometry and dynamics of the outer automorphism group of a free group.*

Jill Pipher, Brown University, *Title to be announced.*

David Vogan, Massachusetts Institute of Technology, *Matrices (nearly) of order two.*

Wei Zhang, Columbia University, *Euler product and Taylor expansions of L-functions.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Advances in Valuation Theory (Code: SS 6A), **Samar El Hitti**, New York City College of Technology, City University of New York, **Franz-Viktor Kuhlmann**, University of

Saskatchewan, and **Hans Schoutens**, New York City College of Technology, City University of New York.

Algebraic Geometry and Combinatorics (Code: SS 9A), **Elizabeth Drellich**, University of North Texas, **Erik Insko**, Florida Gulf Coast University, **Aba Mbirika**, University of Wisconsin-Eau Claire, and **Heather Russell**, Washington College.

Applications of CAT(0) Cube Complexes (Code: SS 1A), **Sean Cleary**, City College of New York and the City University of New York Graduate Center, and **Megan Owen**, Lehman College of the City University of New York.

Aspects of Minimal Surfaces in Riemannian Manifolds (Code: SS 4A), **Zheng Huang** and **Marcello Lucia**, City University of New York, Staten Island and Graduate Center.

Aspects of Resolutions and Syzygies in Commutative Algebra (Code: SS 12A), **Courtney Gibbons**, Hamilton College, and **Denise Rangel Tracy**, Syracuse University.

Commutative Algebra (Code: SS 2A), **Laura Ghezzi**, New York City College of Technology, City University of New York, and **Jooyoun Hong**, Southern Connecticut State University.

Difference Equations and Applications (Code: SS 5A), **Manos Drymonis**, Providence College, **Evelina Lapierre**, Johnson and Wales University, and **Michael Radin**, Rochester Institute of Technology.

Geometric Analysis (Code: SS 22A), **Paul Feehan**, **Manos Maridakis**, and **Natasa Sesum**, Rutgers University.

Geometric Topology: A Celebration of Jim West's 70th Birthday (Code: SS 3A), **Alexandre Dranishnikov**, University of Florida, **Steve Ferry**, Rutgers University, and **Boris Goldfarb**, State University of New York at Albany.

Geometry and Combinatorics of Polytopes (Code: SS 19A), **Egon Schulte**, Northeastern University, and **Asia Ivić Weiss**, York University.

Geometry of Groups, Surfaces and 3-manifolds (Code: SS 14A), **Abhijit Champanerkar**, College of Staten Island and The Graduate Center, City University of New York, **Feng Luo**, Rutgers University, and **Joseph Maher**, College of Staten Island and The Graduate Center, City University of New York.

Invariants of Knots, Links and 3-Manifolds (Code: SS 16A), **Ilya Kofman**, College of Staten Island and The Graduate Center, City University of New York, and **Adam Lowrance**, Vassar College.

Modern Schubert Calculus (Code: SS 17A), **Anders Buch** and **Chris Woodward**, Rutgers University.

Multiple Combinatorial Numbers and Associated Identities (Code: SS 8A), **Hasan Coskun**, Texas A&M University-Commerce.

Multiscale Methods in Cell and Developmental Biology (Code: SS 15A), **Anastasios Matzavinos**, Brown University, and **Chuan Xue**, Ohio State University.

Nonlinear Waves in Differential Equations (Code: SS 10A), **Linghai Zhang**, Lehigh University.

Number theory, spectral theory, and homogeneous dynamics (Code: SS 13A), **Dubi Kelmer**, Boston College, and **Alex Kontorovich**, Rutgers University.

Partial Differential Equations in Geometric Analysis (Code: SS 23A), **Jeffrey Case** and **Alice Chang**, Princeton University, and **Yi Wang**, Johns Hopkins University and Institute for Advanced Study.

Probability, Combinatorics and Statistical Mechanics (Code: SS 20A), **Nayantara Bhatnagar**, University of Delaware, **Brian Rider**, Temple University, and **Douglas Rizzolo**, University of Delaware.

Representation Theory, Vertex Operator Algebras, and Related Topics (Code: SS 7A), **Corina Calinescu**, New York City College of Technology, City University of New York, **Andrew Douglas**, New York City College of Technology and Graduate Center, City University of New York, and **Joshua Sussan**, Medgar Evers College, City University of New York.

Representations of Reductive Groups (Code: SS 11A), **Jeffrey Adams**, University of Maryland, **Stephen D. Miller**, Rutgers University, and **David Vogan**, Massachusetts Institute of Technology.

Smooth and Symbolic Ergodic Theory (Code: SS 21A), **Andrey Gogolev**, State University of New York at Binghamton, and **Federico Rodriguez Hertz** and **Zhiren Wang**, Pennsylvania State University.

Topological Data Analysis: Computations, Statistics, and Applications (Code: SS 18A), **Miroslav Kramar** and **Rachel Levanger**, Rutgers University.

Seattle, Washington

Washington State Convention Center and Sheraton Seattle

January 6–9, 2016

Wednesday–Saturday

Meeting #1116

Joint Mathematics Meetings, including the 122nd Annual Meeting of the AMS, 99th 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 of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

AMS Associate Secretary: Michel Lapidus
Announcement issue of *Notices*: October 2015
Program first available on AMS website: To be announced

Deadlines

For organizers: Expired
For abstracts: September 22, 2015
The scientific information listed below may be dated. For the latest information, see `www.ams.org/meetings/national.html`.

Joint Invited Addresses

Jennifer Chayes, Microsoft Research, *Network Science: From the online world to cancer genomics*; Saturday, 3:00 pm (MAA-AMS-SIAM Gerald and Judith Porter Public Lecture)

Kristin Lauter, Microsoft Research, *Title to be announced*; Friday, 11:10 am (AMS-MAA**).**

Xiao-Li Meng, Harvard University, *Statistical paradises and paradoxes in big data*; Friday, 11:10 am (AMS-MAA**).**

Karen E Smith, University of Michigan, *Title to be announced*. Thursday, 10:05 am (AWM-AMS Noether Lecture).

Joint Prize Session

In order to showcase the achievements of recipients of the various prizes, the AMS and MAA are co-sponsoring this event at 4:25 pm on Thursday. A cash bar reception will immediately follow. All participants are invited to attend. The AMS, ASA, MAA, and SIAM will announce the JPBM Communications Award winner. The AMS, MAA, and SIAM will award the Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student. The AMS and SIAM will announce the Norbert Wiener Prize in Applied Mathematics. The AMS will announce the winners of the Award for Distinguished Public Service, Chevalley Prize in Lie Theory, Levi L. Conant Prize, E. H. Moore Research Article Prize, David P. Robbins Prize, Leroy P. Steele Prizes, and the Oswald Veblen Prize in Geometry. The MAA will award the Chauvenet Prize, Euler Book Prize, Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching of Mathematics, and the Yueh-Gin Gung and Dr. Charles Y. Hu Award for Distinguished Service to Mathematics. The AWM will present the Louise Hay Award for Contributions to Mathematics Education, the M. Gweneth Humphreys Award for Mentorship of Undergraduate Women in Mathematics, and the Alice T. Schafer Prize for Excellence in Mathematics by an Undergraduate Woman.

122nd Meeting of the AMS

AMS Invited Addresses

Panagiota Daskalopoulos, Columbia University, *Title to be announced*; Saturday, 9:00 am

Alex Eskin, University of Chicago, *The SL(2,ℝ) action on moduli space*; Friday, 10:05 am

Timothy Gowers, University of Cambridge, *Generalizations of Fourier analysis, and how to apply them*. Wednesday–Friday, 1:00 pm (Colloquium Lectures)

Marta Lewicka, University of Pittsburgh, *Prestrained elasticity: curvature constraints and differential geometry with low regularity*; Wednesday, 10:05 am

Daniel A. Spielman, Yale University, *Title to be announced*; Wednesday, 8:30 pm (Josiah Willard Gibbs Lecture)

David Vogan, Massachusetts Institute of Technology, *Conjugacy classes and group representations*; Thursday, 3:20 pm (AMS Retiring Presidential Address)

Steven M. Zelditch, Northwestern University, *Title to be announced*; Thursday, 2:15 pm

AMS Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `jointmathematicsmeetings.org/meetings/abstracts/abstract.pl?type=jmm`.

Some sessions are co-sponsored with other organizations. These are noted within the parentheses at the end of each listing, where applicable.

Advances in Free Analysis: the Theory and Applications of Noncommutative Functions, Inequalities, and Domains, **Joseph A. Ball**, Virginia Polytechnic Institute, and **Paul S. Muhly**, University of Iowa, Iowa City.

Advances in the Theory and Application of Reaction Diffusion Models, **Jerome Goddard, II**, Auburn University, and **Ratnasingham Shivaji**, University of North Carolina, Greensboro.

Algebraic Theory of Differential and Functional Equations , **Taylor Dupuy**, Hebrew University of Jerusalem and University of Vermont, and **Alexey Ovchinnikov**, CUNY Queens College, New York.

Algebraic and Topological Methods in Combinatorics, **Andrew Berget**, Western Washington University, **Steven Klee**, Seattle University, and **Isabella Novik**, University of Washington, Seattle.

Analysis and Geometry in Nonsmooth Metric Measure Spaces, **Luca Capogna**, Worcester Polytechnic Institute, and **Jeremy Tyson**, University of Illinois at Urbana-Champaign.

Analysis, Geometry, and Data, **Kevin R. Vixie**, Washington State University, Pullman, and **Bala Krishnamoorthy**, Washington State University, Vancouver.

Analytic Function Spaces and Operators on Them, **Tim Ferguson** and **Hyun Kwon**, University of Alabama, Tuscaloosa.

Analytic Methods in Geometry, **Eric Bahuaud** and **Dylan Helliwell**, Seattle University.

Applications of Logic, Model Theory, and Theoretical Computer Science to Systems Biology, **James Lynch**, Clarkson University, and **Leo Marcus**, Santa Monica, CA (AMS-ASL).

Applied and Computational Topology, **Pawel Dlotko**, INRIA Saclay, France, **Nicholas Scoville**, Ursinus College, and **Matthew Wright**, IMA University of Minnesota.

Arithmetic Dynamics, **Matthew Baker**, Georgia Institute of Technology, and **Joseph Silverman**, Brown University.

Big Demand for Big Data: How Do We Create the Big Supply?, **Rick Cleary**, Babson College, and **Xiao-Li Meng**, Harvard University.

Classification Problems in Operator Algebras, **Marcel Bischoff** and **Ben Hayes**, Vanderbilt University.

Combinatorial Design Theory, **Esther R. Lamken**, California Institute of Technology.

Commutative Algebra, **Karen Smith**, University of Michigan, Ann Arbor, **Emily Witt**, University of Utah, and **Irena Swanson**, Reed College (AMS-AWM).

Commutative Algebra and Its Interactions with Algebraic Geometry, **Daniel Hernández**, University of Utah, **Jack Jeffries**, University of Michigan, Ann Arbor, and **Karl Schwede**, University of Utah (AMS-AWM).

Commutative Algebra, I (a Mathematics Research Communities Session), **Linquan Ma**, University of Utah, **Sarah**

Mayes-Tang, Quest University, and **Jonathan Moñtano**, University of Kansas.

Current Areas of Interest in the Mathematical Sciences of Medieval Islam, **Mohammad K. Azarian**, University of Evansville, and **Mohammad Javaheri** and **Emelie A. Kenney**, Siena College.

Data-Intensive Modeling in Ecology, **Nikolay Strigul**, Washington State University, Vancouver, and **Bala Krishnamoorthy**, Washington State University, Vancouver.

Difference Equations and Applications, **Michael A. Radin**, Rochester Institute of Technology.

Differential Equations, Probability and Sea Ice, I (a Mathematics Research Communities Session) , **B. Cael Barry**, MIT and Woods Hole Oceanographic Institution, **Kaitlin Hill**, Northwestern University, **Ross Lieb-Lappen**, Dartmouth College, **Christian Sampson**, University of Utah, and **Alexandria Volkening**, Brown University.

Distribution of Zeros of Entire Functions, **Matthew Chasse**, Rochester Institute of Technology, **Tamás Forgács**, California State University, Fresno, and **Andrzej Piotrowski**, University of Alaska Southeast, Juneau.

Early Career Female Mathematicians in Algebra and Topology, **Jocelyn Bell**, United States Military Academy, West Point, **Bethany Kubik**, University of Minnesota, Duluth, and **Candice Price**, Sam Houston State University.

Equations of Fluid Motion , **Elaine Cozzi** and **Radu Dascaliuc**, Oregon State University, and **James P. Kelliher**, University of California Riverside.

Essential Mathematical Structures and Practices in K–12 Mathematics, **William McCallum**, University of Arizona, Tucson, **Kristin Umland**, University of New Mexico, and **Ellen Whitsides**, University of Arizona, Tucson.

Financial Mathematics, I (a Mathematics Research Communities Session), **Triet Pham**, Rutgers University, **Wilber A. Ventura**, University of Texas at Arlington, and **Kim Weston**, Carnegie Mellon University.

Fractal Geometry and Dynamical Systems, **John Rock**, Cal Poly Pomona, **Machiel van Frankenhuijsen**, Utah Valley University, and **Michel L. Lapidus**, University of California, Riverside.

Geometric and Categorical Methods in Representation Theory, **Anthony Licata**, Australian National University, and **Julia Pevtsova**, University of Washington, Seattle.

Global Harmonic Analysis, **Steven Zelditch**, Northwestern University, **Hart Smith**, University of Washington, Seattle, and **Chris Sogge**, Johns Hopkins University.

Graduate Mathematics Courses and Programs for Secondary Mathematics Teachers, **James J. Madden**, Louisiana State University, Baton Rouge, and **James A. Mendoza Epperson**, University of Texas, Arlington.

Graph Products, **Richard Hammack** and **Dewey Taylor**, Virginia Commonwealth University.

Higher Genus Curves and Fibrations of Higher Genus Curves in Mathematical Physics and Arithmetic Geometry, **Andreas Malmendier**, Utah State University, Logan, and **Tony Shaska**, Oakland University, Rochester.

Innovative Ideas in Enhancing Success in Mathematics Classes, **Natali Hritonenko**, Prairie View A&M University, **Ellina Grigorieva**, Texas Woman's University, and **Michael A. Radin**, Rochester Institute of Technology (AMS-MAA).

Integrable Systems, Painlevé Equations, and Random Matrices, **Anton Dzhamay**, University of Northern Colorado, **Christopher M. Ormerod**, California Institute of Technology, and **Virgil U. Pierce**, University of Texas-Pan American.

Interactions between Noncommutative Algebra, Algebraic Geometry, and Representation Theory, **Ellen Kirkman**, Wake Forest University, and **James Zhang**, University of Washington.

Knots in Washington (State), **Allison Henrich**, Seattle University, **Sam Nelson**, Claremont McKenna College, **Jozef Przytycki**, George Washington University, and **Radmila Sazdanovic**, North Carolina State University, Raleigh.

Mathematical Information in the Digital Age of Science, **Patrick Ion**, University of Michigan, Ann Arbor, **Olaf Teschke**, zbMATH, Berlin, and **Stephen Watt**, University of Western Ontario.

Mathematical Programming on Integral Invexity, **Ram Verma**, Texas State University, San Marcos, and **Alexander Zaslavski**, Israel Institute of Technology.

Mathematics and Public Policy, **Paul Dreyer**, RAND Corporation.

Mathematics in Natural Resource Modeling, **Catherine A. Roberts**, College of the Holy Cross, and **Shandele M. Henson**, Andrews University.

Metrical and Topological Fixed Point Theory with Applications, **Clement Boateng Ampadu**, Boston, MA, **Talat Nazir**, Mälardalen University, Sweden, and **Hudson Akewe**, University of Lagos, Nigeria.

Modular Forms, q-Series, and Mathematics Inspired by Ramanujan, **Chris Jennings-Shaffer**, University of Florida, Gainesville, and Oregon State University, Corvallis, and **Holly Swisher**, Oregon State University, Corvallis.

Moduli Spaces in Algebraic Geometry, **Yaim Cooper**, Harvard University.

Moduli Spaces in Symplectic Geometry, **Nathaniel Bottman**, MIT, **Joel Fish**, IAS, Princeton, and the University of Massachusetts, Boston, **Sheel Ganatra**, Stanford University, and **Katrin Wehrheim**, University of California Berkeley.

Nonlinear Algebra, **Bernd Sturmfels**, University of California Berkeley, and **Rekha Thomas**, University of Washington, Seattle.

Nonlinear Waves and Coherent Structures, **Natalie Sheils** and **Chris Swierczewski**, University of Washington, Seattle.

Number Theory and Cryptography, **Matilde Lalin**, University of Montreal, **Michelle Manes**, University of Hawaii, Honolulu, and **Christelle Vincent**, University of Vermont.

Operators, Function Spaces, and Models, **Alberto Condori**, Florida Gulf Coast University, Fort Myers, and **William Ross**, University of Richmond.

Origami Methods and Applications, **Erik Demaine**, MIT, **Thomas C. Hull**, Western New England University, and **Robert J. Lang**, Lang Origami.

Parabolic Geometries, Twistor Theory, and the AdS/CFT Correspondence , **Jonathan Holland** and **George Sparling**, University of Pittsburgh, and **Daniela Mihai**, Carnegie Mellon University.

Partial Differential Equations in Complex Analysis, **Debraj Chakrabarti**, Central Michigan University, and **Yunus Zeytuncu**, University of Michigan, Dearborn.

Problems and Challenges in Financial Engineering and Risk Management, **Matthew Lorig**, University of Washington, Seattle, and **Haijun Li** and **Hong-Ming Yin**, Washington State University, Pullman.

Problems in Geometry and Design of Materials, **Marta Lewicka**, University of Pittsburgh, and **Petronela Radu**, University of Nebraska.

Pseudorandomness and Its Applications, **Timothy Gowers**, University of Cambridge, and **Jozsef Solymosi**, University of British Columbia.

Quantum Walks, Quantum Markov Chains, Quantum Computation and Related Topics, **Chaobin Liu**, Bowie State University, **Takyua Machida**, Japan Society for the Promotion of Science, **Salvador E. Venegas-Andraca**, Technológico de Monterrey, Mexico, and **Nelson Petulante**, Bowie State University.

Random and Complex Dynamics of Reaction-Diffusion Systems, **Michael Anton Hoegele**, Universidad de Los Andes, Bogota, Colombia, and **Yuncheng You**, University of South Florida, Tampa.

Recent Advances in Dynamical Systems and Mathematical Biology, **Guihong Fan**, Columbus State University, **Jing Li**, California State University Northridge, and **Hongying Shu**, Tongji University, China.

Recent Advances in Orthogonal Polynomials and Special Functions, **Xiang-Sheng Wang**, Southeast Missouri State University, Cape Girardeau.

Recent Developments in Dispersive Partial Differential Equations and Harmonic Analysis, **William Green**, Rose-Hulman Institute of Technology, Terre Haute, and **Jennifer Beichman**, University of Wisconsin, Madison.

Representation Theory of Algebraic Groups, **Daniel K. Nakano**, University of Georgia, and **Cornelius Pillen**, University of South Alabama.

Research by Postdocs of the Alliance for Diversity in Mathematics, **Aloysius Helminck**, North Carolina State University, Raleigh, and **Michael Young**, Iowa State University, Ames.

Research from the 2014 and 2015 Rocky Mountain-Great Plains Graduate Research Workshop in Combinatorics, **Michael Ferrera**, University of Colorado, Denver, Greeley, **Leslie Hogben**, Iowa State University, Ames, **Paul Horn**, University of Denver, and **Derrick Stolee**, Iowa State University, Ames.

Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, **Darren A. Narayan** and **Jobby Jacob**, Rochester Institute of Technology, **Tamas Forgacs**, California State University, Fresno, and **Ugur Abdulla**, Florida Institute of Technology (AMS-MAA-SIAM).

Set-Valued Optimization and Variational Problems with Applications, **Baasansuren Jadamba** and **Akhtar A. Kahn**, Rochester Institute of Technology, **Mau Nam Nguyen**, Portland State University, **Miguel Sama**, Universidad Nacional de Educacion a Distancia, Spain, and **Christiane Tammer**, Martin Luther University of Halle-Wittenberg.

Special Functions and q-Series, **Richard Askey**, University of Wisconsin, Madison, **Mourad E. H. Ismail**, University of Central Florida and King Saud University, Riyadh, and **Erik Koelink**, Radboud University, Nijmegen, The Netherlands.

Stochastic Effects in Models for Mathematical Biology and Ecology, **Olcay Akman**, Illinois State University, **Timothy D. Comar**, Benedictine University, and **Daniel Hrozencik**, Chicago State University.

Stochastic Models in Population Biology, **Brian Dennis**, University of Idaho, Moscow, and **Eddy Kwessi**, Trinity University.

Surreal Numbers, **Philip Ehrlich**, Ohio University, Athens, and **Ovidiu Costin**, Ohio State University, Columbus (AMS-ASL).

Tensor Decompositions and Secant Varieties, **Zach Teitler**, Boise State University.

The History of Mathematics, **Patti Hunter**, Westmont College, **Adrian Rice**, Randolph-Macon College, **Sloan Despeaux**, Western Carolina University, and **Deborah Kent**, Drake University (AMS-MAA).

The Mathematics of Computation, **Susanne C. Brenner**, Louisiana State University.

Topological Graph Theory: Structure and Symmetry, **Jonathan L. Gross**, Columbia University, and **Thomas W. Tucker**, Colgate University.

Topological Representation Theory, **Charles Frohman**, University of Iowa, Iowa City, and **Helen Wong**, Carleton College.

Water Waves, **John Carter**, Seattle University, **Bernard Deconinck**, University of Washington, Seattle, and **Katie Oliveras**, Seattle University.

What's New in Group Theory?, **Arturo Magidin**, University of Louisiana at Lafayette, and **Elizabeth Wilcox**, Oswego State University of New York.

AMS Sessions for Contributed Papers

There will be sessions of ten-minute contributed talks. Although an individual may present only one contributed paper at a meeting, any combination of joint authorship may be accepted, provided no individual speaks more than once on the program. Contributed papers will be grouped together by related subject classifications into sessions.

Submission of Abstracts for AMS Sessions

Authors must submit abstracts of talks through `joint mathematicsmeetings.org/meetings/abstracts/abstact.pl?type=jmm`. Indicate the number of authors for the paper, click on the "New Abstract" button, and you will be taken to the submission form. Simply follow the step-by-step instructions (read them carefully) until you receive your unique abstract receipt number. No submission is complete until you are given this number. **The deadline for all submissions is September 22, 2015**. Late papers cannot be accommodated. Please email `abscoord@ams.org` if you have questions. If you make an inquiry about your specific abstract, please include your abstract receipt number.

Other AMS Sessions

AMS Committee on the Profession Panel Discussion: Promoting mathematics to policy makers and the public, Wednesday, 4:30 pm–6:00 pm. Mathematicians are often dismayed at the difficulties encountered in trying to convince nonexperts of the value of mathematics.

How can we, as individuals and as a profession, explain to non-mathematicians what it is that we do? Is it possible to shape the perception of mathematics and convince others that math is important enough to be worthy of support? How can such messages be made effectively and to as wide and diverse an audience as possible? A panel of mathematicians who have dealt with these and related issues share their insights. Organizers are **Allan Greenleaf**, University of Rochester; **Hal Sadofsky**, University of Oregon; and **Suzanne L. Weekes**, Worcester Polytechnic Institute. Panelists are: **Sam Rankin**, AMS; **Jordan Ellenberg**, University of Wisconsin; **Kristin Lauter**, Microsoft Research; and **William Massey**, Princeton University.

Navajo Math Circles, Wednesday, 6:30 pm–7:50 pm. Hundreds of Navajo children in recent years have found themselves at the center of a lively collaboration with mathematicians from around the world. The children stay late after school and assemble over the summer to study mathematics, using a model called math circles, which originated in Eastern Europe and which has proliferated across the United States. This notion of student-centered learning puts children in charge of exploring mathematics to their own joy and satisfaction, with potentially long-lasting results.

Navajo Math Circles is a one-hour film that is documenting the meeting of two worlds: that of some of the country's most accomplished mathematicians and math educators, with the children and teachers in the underserved, largely rural Navajo educational system. An 8-minute trailer gives a taste of the film.

The project is supported by the Mathematical Sciences Research Institute (MSRI) in Berkeley, California with a generous grant from the Simons Foundation, and by Vision Maker Media (VMM), Lincoln, Nebraska, and by the Corporation for Public Broadcasting (CPB). Following this premiere screening at the 2016 Joint Mathematics Meeting (JMM), Vision Maker Media will work with the Corporation for Public Broadcasting to schedule a national broadcast.

This film was directed by **George Csicsery** and produced by MSRI. Co-sponsored by the AMS and MAA.

AMS-MAA-SIAM Panel Discussion: Computing Across the Curriculum: Opportunities and Challenges, organized by **Rachel Levy**, Harvey Mudd College; and **Lee Zia**, National Science Foundation; Thursday, 8:30 am–10:00 am. As data science, industrial mathematics, and mathematical modeling have gained attention as popular tools in the workforce, a new focus on computation has entered mathematical sciences courses. In this panel, faculty will share their experiences incorporating computing across the mathematics curriculum. Computing will be discussed as a major focus of a course or as new modules or assignments integrated into existing courses. Challenges and opportunities associated with these efforts will also be presented, along with potential NSF funding avenues. This panel is co-sponsored by the AMS, MAA, and SIAM.

Conversation on Nonacademic Employment, Thursday, 10:30 am–noon. This session will concentrate on how to find nonacademic positions, types of jobs, the interview process, work environments, and advancement opportunities. The discussion will be led by a panel of mathematical scientists working in government and industry.

AMS & AWM Committees on Education Panel Discussion: Work in Mathematics Education in Departments of Mathematical Sciences, organized by **Jacqueline Dewar**, and **Pao-sheng Hsu**, AWM Education Committee; Thursday, 10:30 am–12:00 pm. Many in the mathematics community in the US are now involved in mathematics education in various capacities. This panel is designed to illustrate the breadth and range of these activities. It will highlight examples of contributions to mathematics education by members in the mathematical sciences, and include the perspectives of mathematicians and mathematics educators who contribute in areas such as: teacher education (pre- and in-service); instructional materials development in K–16 mathematics; scholarship of teaching and learning; mathematics education research. Panelists will discuss their work and may reflect on how their work is received in their departments. The moderator for this panel will be **Elizabeth Burroughs**, Montana State University; panelists are: **Curtis Bennett,** Loyola Marymount University; **Brigitte Lahme,** Sonoma State University; **Kristin Umland**, University of New Mexico; and **Megan Wawro,** Virginia Polytechnic Institute and State University.

AMS Committee on Education Panel Discussion: What is a Mathematics PhD? Thursday, 1:00 pm–2:30 pm. The panel will discuss a variety of issues related to the training and mentoring of mathematics PhDs, including best practices for mentoring; expectations and responsibilities for mentors; TA preparation and graduate teaching responsibilities; special challenges for women; minorities and international students; what is the optimal size of a graduate program?; process of administration of oral, defense and exit exams and opportunities for professional development. Sponsored by the AMS Committee on Education.

Grad School Fair, Friday, 8:30 am–10:30 am. Here is the opportunity for undergrads to meet representatives from mathematical sciences graduate programs from universities all over the country. January is a great time for juniors to learn more, and college seniors may still be able to refine their search. This is your chance for one-stop shopping in the graduate school market. At last year's meeting about 300 students met with representatives from 50 graduate programs. If your school has a graduate program and you are interested in participating, a table will be provided for your posters and printed materials for US$75 (registration for this event must be made by a person already registered for the JMM), and you are welcome to personally speak to interested students. Complimentary coffee will be served. Co-sponsored by the the AMS and MAA.

Who Wants to Be a Mathematician—National Contest, organized by **Michael A. Breen**, AMS, and **William T.**

Butterworth, DePaul University; Friday, 9:30 am–11:00 am. See ten of the nation's best high school students compete for a US$5,000 first prize for themselves and US$5,000 for their school's math department. Semifinals are at 9:30 am and finals at 10:30 am. You are invited to come and match wits with the contestants.

Current Events Bulletin, organized by **David Eisenbud**, Mathematical Sciences Research Institute; Friday, 1:00 pm–5:00 pm. Speakers in this session follow the model of the Bourbaki Seminars in that mathematicians with strong expository skills speak on work not their own. Written versions of the talks will be distributed at the meeting and will also be available online at `www.ams.org/ams/current-events-bulletin.html` after the conclusion of the meeting.

Committee on Science Policy Panel Discussion*: *The Role of Research in Preserving the American Dream, Friday, 2:30 pm–4:00 pm.

Congressional Fellowship Session, organized by **Samuel M. Rankin III**, AMS; Friday, 4:30 pm–6:30 pm. This fellowship provides a public policy learning experience, demonstrates the value of science-government interaction and brings a technical background and external perspective to the decision-making process in Congress. Learn more about this program and speak with current and former AMS Fellows. Application deadline for the 2016–17 AMS Congressional Fellowship is **February 15, 2016.**

Other AMS Events

Council, Tuesday, 1:30 pm.

Business Meeting, Saturday, 11:45 am. The secretary notes the following resolution of the Council: Each person who attends a business meeting of the Society shall be willing and able to identify himself as a member of the Society. In further explanation, it is noted that each person who is to vote at a meeting is thereby identifying himself as and claiming to be a member of the American Mathematical Society. The Society has a Committee on the Agenda for Business Meetings. The purpose is to make business meetings orderly and effective. The committee does not have legal or administrative power. It is intended that the committee consider what may be called "quasipolitical" motions. The committee has several possible courses of action on a proposed motion, including but not restricted to:

(a) doing nothing,

(b) conferring with supporters and opponents to arrive at a mutually accepted amended version to be circulated in advance of the meeting,

(c) recommending and planning a format for debate to suggest to a business meeting,

(d) recommending referral to a committee, and

(e) recommending debate followed by referral to a committee.

There is no mechanism that requires automatic submission of a motion to the committee. However, if a motion has not been submitted through the committee, it may be thought reasonable by a business meeting to refer it rather than to act on it without benefit of the advice of the committee.

In order that a motion for this business meeting receive the service offered by the committee in the most effective manner, it should be in the hands of the AMS Secretary by **December 13, 2015**.

AMS Short Course on Rigorous Numerics in Dynamics

This two-day course will take place on Monday and Tuesday before the meeting actually begins. It is co-organized by **Jean-Philippe Lessard**, Université Laval, Quebec, Canada, and **Jan Bouwe van den Berg**, VU University Amsterdam, Netherlands, who will give talks on *Delay Differential Equations and Continuation*, and *Introduction: General Setup and An Example That Forces Chaos* (respectively). The 2016 Short Course also features these talks by **Sarah Day**, The College of William & Mary, *Dynamics and Chaos For Maps and The Conley Index*; **J. D. Mireles James**, Florida Atlantic University, *Rigorous Computation of (Un)Stable Manifolds and Connecting Orbits*; **Thomas Wanner**, George Mason University, *Bifurcations and An Application in Materials Science*; and **J. F. Williams**, Simon Frasier University, *Every Calculation An Existence Proof: Towards Automated Rigorous Computing.*

There are separate registration fees to participate in this course. Advance registration **(before December 22, 2015)**: Member, US$110; Non-member, US$165; Student, unemployed, or emeritus, US$58. On-site registration: Member, US$144; Non-member, US$195; Student, unemployed, or emeritus, US$79. Please see the complete article on page 1100 of this issue or at `www.ams.org/meetings/short-courses/short-course-general`.

NSF-EHR Grant Proposal Writing Workshop

Developing a Competitive Proposal for NSF-EHR, Monday (two days before the first day of the JMM), 3:00 pm–6:00 pm. Workshop goals are to familiarize participants with current direction/priorities in EHR, familiarize participants with key EHR education research and development programs, consider common issues of competitive proposals, and prepare participants to write a competitive proposal. There is no registration fee for this workshop, but participants must register separately in advance. Please contact the AMS Washington Office at 401-455-4116 or `amsdc@ams.org` for further information.

Department Chairs Workshop

This annual one-day workshop for department chairs and leaders is held on Tuesday, 8:00 am–6:30 pm, the day before the JMM actually begins, and is designed to stimulate discussion on a wide range of issues facing departments today, including personnel issues (staff and faculty), long-range planning, hiring, promotion and tenure, budget management, assessments, outreach, stewardship, junior faculty development, communication, and departmental leadership. There is a separate registration and fee to participate. Interested participants should also consider attending the NSF-EHR Grant Proposal Writing Workshop to be held on Monday, January 4. For further information, please contact

the AMS Washington Office at 401-455-4116 or amsdc@ams.org.

99th Meeting of the MAA

MAA Invited Addresses

Steven Brams, New York University, *Fair Division;* Thursday, 9:00 am.

Katherine D. Crowley, Washington and Lee University, *Mathematics and Policy: Strategies for Effective Advocacy;* Wednesday, 3:20 pm.

Charles R. Hadlock, Bentley University, *A Mathematical Tour Through a Collapsing World;* Saturday, 10:05 am.

Alan Schoenfeld, University of California, Berkeley, *What Makes for Powerful Classrooms and What Can We Do, Now That We Know?,* Friday, 9:00 am.

T. Christine Stevens, American Mathematical Society, *Singing Along with Math: The Mathematical Work of the Opera Singer Jerome Hines*; Wednesday, 2:15 pm.

Presentations by MAA Teaching Award Recipients

Friday, 2:30 pm–3:50 pm, organized by MAA Secretary **Barbara Faires**, Westminster College, and MAA President **Francis Su**, Harvey Mudd College. Winners of the Deborah and Franklin Tepper Haimo Awards for Distinguished College or University Teaching will give presentations on the secrets of their success.

MAA Invited Paper Sessions

Current Trends in Mathematical and Computational Biology, organized by **Brian Walton**, James Madison University, and **Maeve McCarthy**, Murray State University; Thursday morning. Mathematical and computational biology encompasses a diverse range of biological phenomena and quantitative methods of exploring those phenomena. This session of current research topics will sample from this diversity. Biological application areas will address current research in growth and control of populations, spread and development of disease, evolution and bioinformatics, and molecular interactions in the cell. Mathematical approaches will include deterministic and stochastic dynamical models as well as combinatorial and algebraic models. This session is sponsored by BIO SIGMAA.

Fair Division, organized by **Michael Jones**, Mathematical Reviews, and **Jennifer Wilson**, The New School; Thursday 1:00 pm–4:15 pm. The goal of the session is to show how different types of mathematics can be used to address questions in both theoretical and applied aspects of fair division. Although a relatively new field, fair division now encompasses a wide variety of approaches (analytic, combinatoric, geometric, and axiomatic) to address both discrete and continuous problems. Fairness criteria can be applied to such diverse applications as cake cutting, the establishment of priority lists, and resource allocation.

Although the talks will be research oriented, speakers will include an expository overview to introduce fair division to a diverse audience including students.

This MAA Invited Paper Session accompanies Steven Brams' invited address on the same topic.

What Do We Know About University Mathematics Teaching, and How Can it Help Us?, presented by **Alan Schoenfeld**, University of California Berkeley; Friday 1:00 pm–5:00 pm. Research on university-level mathematics teaching and learning has grown over the past few decades from a cottage industry into a robust enterprise, both in general (with findings on problem solving, "powerful teaching," and understanding how and why teachers make the choices they do while teaching) and with regard to specific courses (e.g., developmental mathematics, linear algebra, proof). In turn, the research has led to applications to teaching. This too is in general (with professional development framed around the issues raised in research leading to changes in teaching) and in particular courses.

MAA Minicourses

MAA Minicourses are open only to persons who register for the Joint Meetings and pay the Joint Meetings registration fee in addition to the appropriate minicourse fee. The MAA reserves the right to cancel any minicourse that is undersubscribed. Participants should read the descriptions of each minicourse thoroughly as some require participants to bring their own laptops and special software; laptops will not be provided in any minicourse. The enrollment in each minicourse is limited to 50; the cost is US$85.

Minicourse #1. ***Introductory Proposal Writing for Grant Applications to the NSF EHR/Division of Undergraduate Education***, presented by **John Haddock**, **Teri Jo Murphy**, and **Lee Zia**, Division of Undergraduate Education, National Science Foundation; Part A, Tuesday, 9:00 am–11:00 am, and Part B, Tuesday, 2:00 pm–3:00 pm. The presenters will describe the general NSF grant proposal process and consider particular details relevant to programs in the Division of Undergraduate Education. This course is geared toward those who have not submitted a proposal to NSF and are unfamiliar with the organization. If you believe you have an idea, project or program worthy of Federal support that will positively impact undergraduate education in mathematics, you should attend this session. This two-part short course will provide information on the specific components of a NSF proposal, demonstrate the NSF peer review process, provide access to previously funded proposals and explicate the NSF merit review criteria by which proposals are reviewed. Participants should leave this minicourse with a draft of a project summary.

N.B. This course is offered on Tuesday, January 5, the day before the Joint Mathematics Meetings officially begin.

Minicourse #2. ***Visual Topics in Undergraduate Complex Analysis,*** presented by **Michael Brilleslyper,** US Air Force Academy**,** and **Michael Dorff,** Brigham Young University; Part A, Wednesday, 4:45 pm–6:45 pm, and Part B, Friday, 3:30 pm–5:30 pm. Complex analysis is a staple of the undergraduate mathematics curriculum. It is a beautiful mathematical subject that unifies and extends many topics from other courses. The course readily pulls together the theories of polynomial equations, differentiation, integration, and series, while also including geometry and function theory. Unfortunately, many undergraduate

courses end right where the cool stuff starts. In this minicourse, the proposers intend to expose the participants to two of the myriad of topics that are possible: (1) an introduction to minimal surfaces, and (2) the dynamics and locations of zeros of families of polynomials. Both of these topics are accessible to an audience having familiarity with the basics of complex analysis. The course is aimed at instructors of complex variables who are looking for some interesting topics for their courses, mathematicians who want to start learning something about the proposed areas, and instructors looking for potential undergraduate research projects to do with their students. Participants will need to bring their own computers with a current version of `Mathematica`, `Maple`™, or `MATLAB`. There will be limited support for `Sage`.

Minicourse #3. ***Designing and Implementing a Problem Based Mathematics Course***, presented by **Gail Burrill,** Michigan State University; **Bowen Kerins,** Educational Development Center; and **Darryl Yong,** Harvey Mudd College; Part A, Wednesday, 4:45 pm–6:45 pm, and Part B, Friday, 3:30 pm–5:30 pm. This is a problem based math course, where students spend most of the time in an interactive, collaborative environment, working on problems connecting various mathematical domains, which can simultaneously engage a broad range of students and enlarge their understanding of what it means to do math. The panelists will discuss the design of such a course, consider issues related to teaching the course, and describe how it might be implemented in a mathematics program. Such courses were originally developed for teachers at the Park City Mathematics Institute but are applicable for undergraduate majors, prospective teachers, or as part of continuing education programs for experienced teachers. Discussion will be framed by asking what the mathematical goals of such a course might be, how these goals could contribute to a better student understanding of what it means to do mathematics and how such courses might be part of the offerings in a typical math department.

Minicourse #4. ***Teaching Mathematics with Sports Applications***, presented by **Rick Cleary,** Babson College; Part A, Wednesday, 2:15 pm–4:15 pm, and Part B, Friday, 1:00 pm–3:00 pm. This minicourse is designed to help participants who wish to develop a course in mathematics and sports, or to incorporate sports applications into existing courses. The depth of the problems will range from those that require little mathematical background (elementary probability, statistics and combinatorics) that would be suitable in a first year seminar or general education course, to more sophisticated topics (linear algebra, operations research, mathematics of finance) that can make up an elective for mathematics majors or minors. Examples will come from many different sports including baseball, basketball, football, figure skating, distance running and others depending on the interest of participants. Application topics will include strategy, ranking and judging, efficient scheduling and optimization. Participants will find many of the issues are connected to essays in the MAA-published book *Mathematics and Sports* edited by Joe Gallian.

Minicourse #5. ***Teaching Introductory Statistics for Instructors New to Teaching Statistics***, presented by **Carolyn K. Cuff,** Westminster College; Part A, Wednesday, 9:00 am–11:00 am, and Part B, Friday, 9:00 am–11:00 am. This minicourse, intended for instructors new to teaching statistics, exposes participants to the big ideas of statistics and the ASA-endorsed Guidelines for Assessment and Instruction in Statistics Education (GAISE) report. It considers ways to engage students in statistical literacy and thinking, and contrast conceptual and procedural understanding in the first statistics course. Participants will engage in many of the classic activities that all statistics instructors should know. A set of approximately 6–8 hands-on classroom-ready activities will be given to participants. Parts of each activity will be done by the participants, other parts will be summarized by the presenter and the main statistical ideas of the activity will be explained to the participants. The activities have been chosen so that they require minimal adaptation for a wide variety of classrooms and are easy to implement. Each activity includes goals, key ideas, prerequisite skills and concepts, connection to other statistical concepts, objectives, known student difficulties and assessment questions. Internet sources of real data, activities, and best practices articles will be examined. Participants will find out how they can continue to learn about the best practices for the first course in Statistics by becoming involved in statistics education related conferences, newsletters, and groups.

Minicourse #6. ***Getting Started in the Scholarship of Teaching and Learning***, presented by **Jacqueline M. Dewar** and **Curtis D. Bennett,** Loyola Marymount University; Part A, Thursday, 8:30 am–10:30 am, and Part B, Saturday, 9:00 am–11:00 am. This course will introduce participants to the scholarship of teaching and learning (SoTL) in mathematics and help them begin projects of their own. We describe a taxonomy of SoTL questions, provide examples of SoTL projects in mathematics, and discuss methods for investigation. Participants will learn about collecting and analyzing different types of evidence, dealing with human subjects requirements, and selecting venues for presenting or publishing their work. With the presenters' guidance, participants interactively select and transform a teaching problem of their own into a question for scholarly investigation and identify several types of evidence to gather.

Minicourse #7. ***Making Sense of Calculus with Mapping Diagrams***, presented by **Martin Flashman**, Humboldt State University; Part A, Thursday, 1:00 pm–3:00 pm, and Part B, Saturday, 1:00 pm–3:00 pm. In this minicourse participants will learn how to use mapping diagrams (MD) to visualize functions for many calculus concepts. For a given function, f, a mapping diagram is basically a visualization of a function table that can be made dynamic with current technology. The MD represents x and $f(x)$ from the table as points on parallel axes, and arrows between the points indicate the function relation. The course will start with an overview of MD's and then connect MD's to key calculus definitions and theory including: linearity, limits, derivatives, integrals, and series. Participants will

learn how to use MD's to visualize concepts, results and proofs not easily realized with graphs for both single and multi-variable calculus. Participants are encouraged to bring a laptop with wireless capability.

Minicourse #8. ***Algebraic Geometry: A Problem Based Course***, presented by **Thomas Garrity**, Williams College, and **Ryan Brown**, Georgia College; Part A, Wednesday, 2:15 pm–4:15 pm, and Part B, Friday, 1:00 pm–3:00 pm. Participants will learn how to structure an introductory undergraduate course in algebraic geometry that is problem based (and hence an inquiry based learning course). As algebraic geometry is one of the core subjects of mathematics, such a course allows undergraduates to be introduced to a tremendous amount of material. Further, such a course can be and has been taught either with a linear algebra prerequisite or with an abstract algebra prerequisite. This type of course should be of interest to students who want to become secondary school teachers and also to those students who plan to pursue graduate work in mathematics. People who want to teach an IBL algebraic geometry course or who just want a brief introduction to algebraic geometry are encouraged to attend.

Minicourse #9. ***Increasing Student Engagement and Understanding through Active Learning Strategies in Calculus***; presented by **Debbie Gochenaur**, Shippensburg University; **Larissa Schroeder**, University of Hartford; **Matt Boelkins**, Grand Valley State University; **Angie Hodge**, University of Nebraska Omaha; **Carrie Diaz Eaton**, Unity College; and **Dana Ernst**, Northern Arizona University; Part A, Wednesday, 2:15 pm–4:15 pm, and Part B, Friday, 1:00 pm–3:00 pm. Participants will learn curricular and co-curricular evidence-based, active learning strategies to embed in a Calculus I course. Active learning is a process whereby students engage in activities, such as writing, discussion, or problem solving that promote analysis, synthesis, and evaluation of class content; positively impacting student success can begin with an increase in student engagement within the classroom. This minicourse, intended for the novice user, will include small group discussion and hands-on development of active learning strategies. Participants should bring digital copies of their own curriculum material so that strategies can be embedded into personal material during the workshop. Bring a laptop with wireless capability.

Minicourse #10. ***Directing Undergraduate Research***, presented by **Aparna Higgins**, University of Dayton; Part A, Thursday, 1:00 pm–3:00 pm, and Part B, Saturday, 1:00 pm–3:00 pm. This minicourse will cover many aspects of facilitating research by undergraduates, such as getting students involved in research, finding appropriate problems, deciding how much help to provide, and presenting and publishing the results. Similarities and differences between research conducted during summer programs and research that can be conducted during the academic year will be discussed. The minicourse is designed for faculty who are new to directing undergraduate research. Although the examples used will be primarily in the area of discrete mathematics, the strategies discussed can be applied to any area of mathematics.

Minicourse #11. ***Implementing Inquiry-Oriented Curricula for Linear Algebra, Differential Equations, and Abstract Algebra***, presented by **Estrella Johnson**, Virginia Tech; **Karen Keene**, North Carolina State University; and **Christy Andrews-Larson**, Florida State University; Part A, Wednesday, 9:00 am–11:00 am, and Part B, Friday, 9:00 am–11:00 am. This session is designed to inform and support instructors interested in implementing inquiry-oriented curriculum. By inquiry-oriented we mean that the students are engaging in authentic mathematical inquiry and the teachers are actively involved in inquiring into students' mathematical thinking. This mini-course will have two components. In the first component participants will engage with mathematical tasks from three different research-based inquiry-oriented curricula that have been developed for Linear Algebra, Differential Equations, and Abstract Algebra. The goals of this component are to familiarize participants with the curricular tasks, the nature of the instruction, and common ways of student thinking. The second component will focus on high-leverage teaching practices that can be used in any inquiry-oriented setting. Examples of such practices include leading whole class discussions and launching instructional tasks. The goals of this component are to provide instructors with opportunities to develop some of the necessary teaching practices needed to implement inquiry-oriented curricula.

Minicourse #12. ***Humanistic Mathematics***, presented by **Gizem Karaali**, Pomona College, and **Eric Marland**, Appalachian State University; Part A, Wednesday, 9:00 am–11:00 am, and Part B, Friday, 9:00 am–11:00 am. The phrase humanistic mathematics is historical, going back about thirty years, and awakens many connotations in those who hear it. Indeed humanistic mathematics can include a broad range of topics; we use it in two distinct manners. First, as a scholarly perspective, humanistic mathematics describes an approach to mathematics that views it as a human endeavor and focuses on the paths of inquiry that study its aesthetic, cultural, historical, literary, pedagogical, philosophical, psychological, and sociological aspects. Second, as a pedagogical stance, humanistic mathematics explores and builds on the relationship of mathematics with its nontraditional partners in the humanities, the fine arts, and social sciences, providing additional perspective for the role of mathematics in a liberal arts education. This mini-course will introduce participating mathematics faculty to the ideas and scholarship of humanistic mathematics, a body of literature that eschews disciplinary jargon (e.g., edu-speak) in favor of reaching a more diverse audience. As concrete outcomes, participants will: develop a viable plan for a liberal arts course that they can offer at their own campuses to invite many new students into the fascinating world of mathematics; come up with ideas for possible scholarly projects in order to contribute to the ongoing conversations in the field; connect with like-minded colleagues; and get informed about possible venues of communication, collaboration, and dissemination of materials related to humanistic mathematics.

Minicourse #13. ***Introduction to Process Oriented Guided Inquiry Learning (POGIL) in Mathematics Courses***, presented by **Laurie Lenz**, Marymount University, and **Catherine Beneteau**, University of South Florida; Part A, Thursday, 1:00 pm–3:00 pm, and Part B, Saturday, 1:00 pm–3:00 pm. This minicourse will introduce faculty to the guided inquiry instructional method called POGIL (Process Oriented Guided Inquiry Learning). Participants will use hands-on activities to learn the crucial elements in a successful guided inquiry classroom. The workshop will provide participants with a basic introduction to facilitation techniques and an opportunity to reflect on how facilitation can enhance or interfere with student learning as well as how facilitation strategies can be critical in the development of student process skills. The participants will have the opportunity to examine a POGIL calculus activity and be introduced to the way the learning structure that is integrated into all POGIL activities is implemented in a mathematics specific activity. By the end of the workshop, participants will be trained to begin implementing guided inquiry activities in their own mathematics classrooms.

Minicourse #14. ***Teaching Quantitative Reasoning with Common Sense and Common Knowledge***, presented by **Maura B. Mast**, and **Ethan D. Bolker**, University of Massachusetts Boston; Part A, Thursday, 9:00 am–11:00 am, and Part B, Saturday, 9:00 am–11:00 am. Ten years from now, what do you want or expect your Quantitative Reasoning students to remember? Our answers to those questions profoundly shaped our approach to the course. We realized that in ten years, what matters will be how students approach a problem using the tools they carry with them–common sense and common knowledge–not the particular mathematics we chose for the curriculum. This has changed how and what we teach. In this minicourse we will provide hands-on experience with class activities using our approach and practice creating examples and exercises from current news.

Minicourse #15. ***Teaching Statistics using R and RStudio***, presented by **Randall Pruim**, Calvin College; Part A, Thursday, 10:00 am–12:00 noon, and Part B, Saturday, 10:00 am–12:00 noon. R is a freely available language and environment for statistical computing and graphics that has become popular in academia and in many industries. But can it be used with students? This mini-course will introduce participants to teaching applied statistics courses using computing in an integrated way. The presenter has been using R to teach statistics to undergraduates at all levels for the last decade and will share an approach and some favorite examples. Topics will include workflow in the RStudio environment, providing novices with a powerful but manageable set of tools, data visualization, basic statistical inference using R, and resampling. Much of this will be facilitated using the mosaic package. The minicourse is designed to be accessible to those with little or no experience teaching with R, and will provide participants with skills, examples, and resources that they can use in their own teaching. Participants should bring a laptop to the session.

Minicourse #16. ***Mobile Mathematics—Interactive Apps for Teaching and Learning***, presented by **Lila Roberts**, Clayton State University, and **Andrew G. Bennett**, Kansas State University; Part A, Wednesday, 4:45 pm–6:45 pm, and Part B, Friday, 3:30 pm–5:30 pm. Mobile devices have made their way into our lives and our classrooms. In this minicourse, participants will learn about various ways to integrate tablets and other mobile devices into mathematics courses. The presenters will demonstrate interactive resources that they have developed as well as other applications/materials that are ready-made and easily available. In addition, participants will learn how to use various ways to develop new and/or adapt existing resources for their face-to-face and online classrooms. Bring your own mobile device and/or a wireless capable laptop computer.

MAA Contributed Papers

The MAA Committee on Contributed Paper Sessions solicits papers pertinent to the sessions listed below. Contributed Paper Session presentations are limited to fifteen minutes, except in the general session where they are limited to ten minutes. Each session room is equipped with a computer projector and a screen. Please note that the days and times scheduled for these sessions remain tentative. Several of these sessions have specific suggestions for the appropriateness of submissions. Potential submitters are advised to read the full descriptions of these sessions at `jointmathematicsmeetings.org/meeting/national/jmm2016/2181_maacall`.

The deadline for submission of abstracts is Tuesday, September 22, 2015.

MAA Contributed Paper Sessions with Themes

Addressing the Needs of Mathematics and Computer Science Majors in Discrete Mathematics Courses, organized by **Ksenija Simic-Muller**, Pacific Lutheran University; and **Tom J. Edgar**, Pacific Lutheran University; Saturday afternoon.

Assessing Student Learning: Alternative Approaches, organized by **David Clark**, Grand Valley State University; **Jane Butterfield**, University of Victoria; **Robert Campbell**, College of St. Benedict/St. John's University; and **Cassie Williams**, James Madison University; Wednesday morning.

Bringing the Community into the College Mathematics Classroom, organized by **Ksenija Simic-Muller**, Pacific Lutheran University; Thursday afternoon.

The Broad Impact of Math Circles, organized by **Katherine Morrison**, University of Northern Colorado; **Amanda Matson**, Clarke University, and **Philip Yasskin**, Texas A&M University; Thursday afternoon. Sponsored by the SIGMAA on Math Circles for Students and Teachers.

Common Core State Standards (CCSS) for Mathematics Practices and Content: The Role of Math Departments in Preparing Math Education Candidates for New Assessments, organized by **William Martin**, North Dakota State University; **Karen Morgan**, New Jersey City University; **Gulden Karakok**, University of Northern Colorado; and **James A. Mendoza Epperson**, University of Texas-Arlington; Thursday afternoon. Sponsored by the MAA Committee on the Mathematical Education of Teachers (COMET) and the MAA Committee on Assessment.

Contemplative Pedagogy and Mathematics, organized by **Luke Wolcott**, Lawrence University; and ***Justin Brody***, Goucher College; Friday afternoon.

The Contributions of Minorities to Mathematics Throughout History, organized by **Amy Shell-Gellasch**, Montgomery College; and **Lloyd Douglas**, University of North Carolina; Friday morning. Sponsored by the SIGMAA on the History of Mathematics.

Conversations with the Partner Disciplines: Collaborations to Improve the Mathematics Curriculum, organized by **Victor Piercey**, Ferris State University; **Suzanne I. Doree**, Augsburg College; **Jason Douma**, University of Sioux Falls; and **Susan Ganter**, East Carolina University; Saturday afternoon. Sponsored by the Curriculum Renewal Across the First Two Years (CRAFTY) and Mathematics Across the Disciplines (MAD) subcommittees of CUPM and the journal PRIMUS: Problems, Resources, and Issues in Undergraduate Mathematics Studies.

The Development and Adoption of Open Educational Resources for Teaching and Learning, organized by **Benjamin Atchison**, Framingham State University; and **Jeremy Russell**, The College of New Jersey; Friday afternoon.

Experiences and Innovations in Teaching Probability Theory, organized by **Jonathon Peterson**, Purdue University; and **Nathaniel Eldredge**, University of Northern Colorado; Wednesday morning.

Graduate Students Teach Too: Ideas and Best Practices, organized by **Samuel L. Tunstall**, Appalachian State University; Saturday morning.

Helping Students See Beyond Calculus, organized by **David Strong**, Pepperdine University; **James Tanton**, MAA; **Courtney Davis**, Pepperdine University; and **Angela Spalsbury**, Youngstown State University; Saturday afternoon. Sponsored by the SIGMAA Teaching Advanced High School Mathematics.

Incorporating the History of Mathematics into Developmental Math Courses, organized by **Van Herd**, University of Texas Austin; and **Amy Shell-Gellasch**, Montgomery College; Saturday morning. Sponsored by the SIGMAA on the History of Mathematics.

Innovative Approaches to One-Semester Calculus Courses, organized by **Joel Kilty** and **Alex M. McAllister**, Centre College; Thursday morning.

Innovative and Effective Ways to Teach Linear Algebra, organized by **David Strong**, Pepperdine University; **Gil Strang**, MIT; and **Megan Wawro**, Virginia Tech; Friday afternoon.

Innovative Targeted Solutions in Teaching Introductory Statistics, organized by **Patti Frazer Lock**, St. Lawrence University; **Randall Pruim**, Calvin College; and **Sue Schou**, Idaho State University; Thursday afternoon. Sponsored by the SIGMAA on Statistics Education.

Integrating Research into the Undergraduate Classroom, organized by **Shannon R. Lockard**, Bridgewater State University; and **Timothy B. Flowers**, Indiana University of Pennsylvania; Saturday afternoon.

Inquiry-Based Teaching and Learning, organized by **Brian Katz**, Augustana College; and **Victor Piercey**, Ferris State University; Friday morning.

Mathematical Modeling in the Undergraduate Curriculum, organized by **Jason Douma**, University of Sioux Falls; and **Rachel Levy**, Harvey Mudd College; Saturday morning. Sponsored by the MAA CUPM Mathematics Across the Disciplines Subcommittee and the SIAM Education Committee.

Mathematics and the Arts, organized by **Douglas Norton**, Villanova University; Wednesday morning and afternoon. Sponsored by the SIGMAA on Mathematics and the Arts.

Mathematics Experiences and Projects in Business, Industry, and Government, organized by **Carla D. Martin**, Dept. of Defense; and **Allen Butler**, Wagner Associates; Friday afternoon. Sponsored by the SIGMAA on Business, Industry, and Government.

Mathematics and Sports, organized by **Drew Pasteur**, College of Wooster; and **John David**, Virginia Military Institute; Saturday morning.

New Ideas in Teaching Upper-Level Statistics Courses, organized by **Patti Frazer Lock**, St. Lawrence University; **Randall Pruim**, Calvin College; and **Sue Schou**, Idaho State University; Friday afternoon. Sponsored by the SIGMAA on Statistics Education.

Origami in the Mathematics K–12 Classroom, organized by **Roger Alperin**, San Jose State University; and **Perla Myers**; University of San Diego; Saturday afternoon.

Preparation, Placement and Support of Elementary Mathematics Specialists, organized by **Laurie J. Burton**, Western Oregon University; **Cheryl Beaver**, Western Oregon University; and **Klay Kruczek**, Southern Connecticut State University; Thursday morning. Sponsored by the MAA Committee on the Mathematical Education of Teachers.

Professional Development for Mathematicians: A Session for MAA PREP Organizers and Participants, organized by **Jon Scott**, Montgomery College; **Barbara Edwards**, Oregon State University; **Nancy Hastings**, Dickinson College; and **Stan Yoshinobu**, Cal Poly San Luis Obispo; Wednesday afternoon. Sponsored by the MAA Committee on Professional Development.

Proofs and Mathematical Reasoning in the First Two Years of College, organized by **Joanne Peeples**, El Paso Community College; **Chris Oehrlein**, Oklahoma City Community College; and **Dean Gooch**, Santa Rosa Junior College; Wednesday morning. Sponsored by the MAA Committee on Two Year Colleges.

Quantitative Literacy in the K–16 Curriculum, organized by **Aaron Montgomery**, Central Washington University; **Gary Franchy**, Southwestern Michigan College; **Gizem Karaali**, Pomona College; **Andrew Miller**, Belmont University; and **Victor Piercey**, Ferris State University; Wednesday afternoon. Sponsored by the SIGMAA on Quantitative Literacy.

Recreational Mathematics: Puzzles, Card Tricks, Games, Game Shows, and Gambling, organized by **Paul R. Coe**, **Sara B. Quinn**, and **Marion Weedermann**, Dominican University; Thursday morning.

Research in Undergraduate Mathematics Education, organized by **Karen A. Keene**, North Carolina State University; Thursday morning and afternoon. Sponsored by

the SIGMAA on Research in Undergraduate Mathematics Education.

Revitalizing Complex Analysis, organized by **Russell Howell**, Westmont College; **Paul Zorn**, St. Olaf College; and **Alan Noellni**, Oklahoma State University; Saturday morning.

The Scholarship of Teaching and Learning in Collegiate Mathematics, organized by **Jacqueline Dewar**, Loyola Marymount University; **Thomas Banchoff**, Brown University; **Curtis Bennett**, Loyola Marymount University; **Pam Crawford**, Jacksonville University; and **Edwin Herman**, University of Wisconsin-Stevens Point; Wednesday morning and afternoon.

The Teaching and Learning of Undergraduate Ordinary Differential Equations, organized by **Christopher S. Goodrich**, Creighton Preparatory School; and **Beverly H. West**, Cornell University; Friday morning. Sponsored by the Community of Ordinary Differential Equations Educators (CODEE).

Topics and Techniques for Teaching Real Analysis, organized by **Erik Talvila**, University of the Fraser Valley; **Paul Musial**, Chicago State University; **Robert Vallin**, Lamar University; and **James Peterson**, Alma College; Wednesday afternoon.

Trends in Undergraduate Mathematical Biology Education, organized by **Timothy Comar**, Benedictine University; and **Daniel Hrozencik**, Chicago State University; Friday morning. Sponsored by the SIGMAA on Mathematical and Computational Biology.

Using Philosophy to Teach Mathematics Analysis, organized by **Carl Behrens**, Alexandria, VA; and **Dan Sloughter**, Furman University; Thursday morning. Sponsored by the SIGMAA on the Philosophy of Mathematics.

General Contributed Paper Sessions, organized by **Bem Cayco**, San Jose State University; **Timothy Comar**, Benedictine University, and **T. James Reid**, University of Mississippi; Wednesday, Thursday, Friday, and Saturday, mornings and afternoons. These sessions accept contributions in all areas of mathematics, curriculum, and pedagogy. When you submit your abstract you will be asked to classify it according to the following scheme: *Algebra*; *Analysis*; *Applied Mathematics*; *Assessment*; *Geometry*; *Graph Theory*; *History or Philosophy of Mathematics*; *Interdisciplinary Topics in Mathematics*; *Linear Algebra*; *Logic and Foundations*; *Mathematics and Technology*; *Mentoring*; *Modeling and Applications*; *Number Theory*; *Outreach*; *Probability and Statistics*; *Teaching and Learning Introductory Mathematics*; *Teaching and Learning Calculus*; *Teaching and Learning Advanced Mathematics*; *Teaching and Learning Developmental Mathematics*; *Topology*; or *Other*.

Submission Procedures for MAA Contributed Paper Abstracts

Abstracts may be submitted electronically at `jointmathematicsmeetings.org/meetings/abstracts/abstract.pl?type=jmm`. Simply fill in the number of authors, click "New Abstract," and then follow the step-by-step instructions. **The deadline for abstracts submission is Tuesday, September 22, 2015**.

Each participant may give at most one talk in the MAA contributed paper sessions. If your paper cannot be accommodated in the session to which it was submitted, it will automatically be considered for the general session.

The organizer(s) of your session will automatically receive a copy of the abstract, so it is not necessary for you to send it directly to the organizer. All accepted abstracts are published in a book that is available to registered participants at the meeting. Questions concerning the submission of abstracts should be addressed to `abs-coord@ams.org`.

MAA Panels, Posters, Workshops, and Other Sessions

Creating a Meaningful Calculus I Experience for Students Entering with High School Calculus, organized by **Alison Reddy**, University of Illinois; Wednesday, 8:00 am–9:20 am. Jim McClure of Purdue once said, "Once a student has been exposed to calculus it is hard to treat them." With the sharp increase in the number of students enrolling in Calculus I who have had some calculus experience in high school (as high as 70 percent at some research universities*), programs are struggling with the question of how to best serve these students in their introductory Calculus courses. In this session we will explore and discuss approaches used at different universities to address this concern. [*Bressoud, CBMS talk on "Building for Success in Calculus", Oct. 2014] Panelists are: **Michael Boardman**, Pacific University; **Randy McCarthy**, University of Illinois; **Robin Permantle**, University of Pennsylvania; and **Uri Treisman**, University of Texas. Co-sponsored by MAA/NCTM Joint Committee on Mutual Concerns, and College Board/MAA Joint Committee on Mutual Concerns.

NSF Funding Opportunities for the Learning and Teaching of the Mathematical Sciences, organized by **John Haddock** and **Lee Zia**, Division of Undergraduate Education, NSF; **Karen King**, Division of Research on Learning, NSF; **Tasha Inniss**, Division of Human Resource Development, NSF; and **Jennifer Slimowitz Pearl**, Division of Mathematical Sciences, NSF. A number of NSF divisions offer a variety of grant programs that support innovations in learning and teaching in the mathematical sciences. These programs will be discussed along with examples of successful projects in two sessions. Anticipated budget highlights and other new initiatives for the next fiscal year, as appropriate, will also be presented. Sponsored by the MAA Committee on Professional Development.

Part I: Undergraduate/Graduate Education, Department of Mathematics Infrastructure, and Human Resource Development (DUE/DGE/DMS/HRD) Wednesday, 8:00 am–9:15 am, and

Part II: The K–16 Continuum: Learning Science & Research and Pre- and In-Service Teachers (DUE/DRL) Wednesday, 9:30 am–10:30 am.

Advanced Placement Calculus Today: Opportunities and Challenges, organized by **Ben Hedrick**, College Board; Wednesday, 9:35 am–10:55 am. There is a growing debate as to whether more students should take calculus in high school. The data suggest that the public believes they should, as more and more students enroll in Honors

and Advanced Placement Calculus classes. This increased enrollment dramatically affects the AP Calculus Program and university course offerings. The panelists will discuss the AP Calculus Program, how it aligns to post-secondary calculus courses, recent changes in the course content and examination, the development of assessment items, and the exam scoring process. The discussion will also focus on mathematical practices for AP Calculus that engage students in developing conceptual understanding of core concepts, those ideas that are necessary to apply important techniques and procedures. As a consequence of expanding enrollment in high school calculus, participants will be asked to consider the prerequisite skills and knowledge for an AP Calculus course. Panelists are: **Don King**, Northeastern University; **Dan Teague**, North Carolina School of Science and Mathematics; **Gail Burrill**, Michigan State University; and **Stephen Davis**, Davidson University

Developing the MAA Pedagogy Guide, organized by **Martha Abell,** Georgia Southern University; Wednesday, 2:15 pm–3:35 pm. In the process of revising the Curriculum Guide, the MAA Committee on the Undergraduate Program in Mathematics (CUPM) encountered questions related to "how we teach" instead of "what we teach". As a result in September 2014, the MAA Committee on the Teaching of Undergraduate Mathematics (CTUM) was charged with developing a Pedagogy Guide to help faculty become more aware of research-based pedagogical approaches, course design, and assessment of student learning. Panel members will discuss various aspects of the Pedagogy Guide, including successful approaches for teaching various mathematics content areas, instructional techniques such as inquiry-based learning and "flipped classrooms," approaches to addressing student skills such as writing and other forms of communication, course design, classroom climate and student motivation. The panel discussion also provides an opportunity for members of the mathematics community to provide input to the Pedagogy Guide as it is being developed. Panelists are: **Jacqueline Dewar**, Loyola Marymount University; **Gavin LaRose**, University of Michigan; **Carol Schumacher**, Kenyon College; **Lew Ludwig**, Denison University; and **Diana White**, University of Colorado Denver.

The Enjoyment of Employment: Finding the Right Organizational Culture, organized by **Douglas Kalish**, University of California Berkeley; Wednesday, 2:15 pm–3:35 pm. This workshop is targeted to graduate students and postdocs who are considering nonacademic careers. Are you considering a nonacademic career after graduate school or your postdoc? Are you aware of the different kinds of workplace cultures you'll encounter? People look for different things in a job: one person might want to change the world, while another just wants a paycheck. Matching your work personality to the culture of the organization is one of the prime factors in workplace happiness. In this workshop you'll assess your workplace personality, which we will then match against different work environments to see what kinds of organizations are compatible with your work style. We'll end with a checklist and timeline for starting your job search so that you'll be fully prepared when the time comes. Before the workshop, go to `www.dougsguides.com/personality`, take the personality assessment and bring the results with you.

Project NExT–YMN Poster Session, organized by **Jonathan Needleman**, Le Moyne College, and **Thomas Wakefield,** Youngstown State University, Wednesday, 2:15 pm–4:15 pm. This session is intended to highlight the research activities, both mathematical and pedagogical, of recent or future Master's/ PhD's in mathematics and related fields. The organizers seek to provide an open venue for people who are near completion, or have finished their graduate studies in the last five years, to present their work and make connections with other same-stage professionals, in much the same spirit as YMN and Project NExT. The poster size will be 48" wide by 36" high. Poster boards and materials for posting pages on the posters will be provided on site. We expect to accept about forty posters from different areas within the mathematical sciences. To apply, send a poster abstract, when and where you have or will receive your PhD or master's degree, and your current college or university affiliation to the organizers. Potential applicants should send a poster abstract to one of the organizers, Thomas Wakefield, `tpwakefield@ysu.edu`, or Jonathan Needleman, `needlejs@lemoyne.edu`, to apply for the session. The deadline for submissions is **December 15, 2015.** Sponsored by the Young Mathematicians' Network and Project NExT.

Finding a Thesis Topic and Advisor, organized by **Nicholas Scoville**, Ursinus College**,** and **Emily Cilli-Turner**, Salve Regina University***;*** Wednesday, 3:50 pm–5:10 pm. Your choice of graduate school is an important career decision, but equally important is your choice of thesis advisor and topic. An advisor and topic that is right for you can give you the jumpstart you need for your career, while a poorly chosen one can be detrimental. In this panel, our experts will offer advice and tips on choosing both a thesis advisor and a topic, addressing such questions as: Do I have to come up with my own research problem? Does it matter if I "like" or get along well with my advisor? How much does my advisor's reputation in the mathematical community matter? What if I need to change my advisor or my advisor retires or changes schools? How much guidance should I expect from my advisor? Should I choose a graduate school based on a potential advisor? This panel is not only for graduate students, but also undergraduates who are planning on attending graduate school. Panelists are: **Allison Henrich**, Seattle University, and **Brooke Shipley**, University of Illinois at Chicago. This panel is sponsored by the Young Mathematicians Network.

Improving the Preparation of Graduate Students to Teach Mathematics: An NSF-Funded Project, organized by **Jessica Deshler**, West Virginia University; Wednesday, January 6, 3:50 pm–5:10 pm. The mathematics community's responsibility for preparing graduate students to teach is an issue of increasing concern. While there are many departments and faculty who would like to provide teaching-related professional development (PD) for their graduate students (Austin, 2002; Blair, Kirkman, Maxwell, 2013), there is no central clearinghouse that makes the resources broadly visible and easily accessible to the

mathematics community. A second barrier to the development of PD programs for TAs is the limited interaction and collaboration between researchers of undergraduate mathematics teaching and those who prepare graduate students to teach, all of whom share a common interest in improving the teaching of undergraduate mathematics. A recently funded NSF IUSE project aims to develop stronger connections and support networks between three groups: (1) those who conduct research on teaching assistant professional development, (2) those who create professional development materials for TAs and (3) those who deliver the professional development in their departments. Panelists will discuss background work that led to the development of the project as well as project components, including an on-line Resources Suite, workshops for those who wish to provide TA PD, networks for those involved in all aspects of TA PD and distance delivery of PD for mathematics TAs. Panelists are: **Jack Bookman**, Duke University; **Robin Gottlieb,** Harvard University; **Shandy Hauk**, WestEd; **Sarah Schott**, Duke University; and **Natasha Speer**, University of Maine. Sponsored by the MAA Committee on Professional Development.

Navajo Math Circles, Wednesday, 6:30 pm–7:50 pm. Hundreds of Navajo children in recent years have found themselves at the center of a lively collaboration with mathematicians from around the world. The children stay late after school and assemble over the summer to study mathematics, using a model called math circles, which originated in Eastern Europe and which has proliferated across the United States. This notion of student-centered learning puts children in charge of exploring mathematics to their own joy and satisfaction, with potentially long-lasting results.

Navajo Math Circles is a one-hour film that is documenting the meeting of two worlds: that of some of the country's most accomplished mathematicians and math educators, with the children and teachers in the underserved, largely rural Navajo educational system. An 8-minute trailer gives a taste of the film.

The project is supported by the Mathematical Sciences Research Institute (MSRI) in Berkeley, California with a generous grant from the Simons Foundation, and by Vision Maker Media (VMM), Lincoln, Nebraska, and by the Corporation for Public Broadcasting (CPB). Following this premiere screening 2016 Joint Mathematics Meeting (JMM), Vision Maker Media will work with the Corporation for Public Broadcasting to schedule a national broadcast.

This film was directed by **George Csicsery**, and produced by MSRI. Co-sponsored by the AMS and MAA.

Guiding Your PhDs to Nonacademic Careers, organized by **Douglas Kalish**, University of California Berkeley; Thursday, 8:00 am–9:20 am. According to the NSF, in 2010 nearly 50 percent of mathematics and statistics PhDs held nonacademic positions. More faculty are accepting and promoting nonacademic career alternatives for their graduate students and postdocs. But for some faculty without extensive industry experience or contacts, it's difficult to offer advice and counsel to these students. This workshop provides information and tools for faculty who want to mentor their PhDs as to the opportunities available and additional skills required for a successful nonacademic job search. Some of the topics we will cover will include: the nonacademic job market for quantitative PhDs; skills required of PhDs for nonacademic jobs; making industry internships work for the PhD and advisor; counseling and networking resources for nonacademically-bound PhDs; supporting nonacademic career PhDs emotionally and behaviorally; managing academic and nonacademic career PhDs in the same department; and sharing experiences and challenges in mentoring nonacademic career PhDs. The tools and topics of this workshop are targeted to mathematical sciences faculty who embrace (or at least accept) nonacademic career choices for their graduate students and postdocs. This workshop is not a discussion of the appropriateness of a graduate education for nonacademic career candidates

Applications of Gapminder for Undergraduate Mathematics and Statistics Courses, organized by **Samuel L. Tunstall**, **Sarah Greenwald**, and **Bill Bauldry**, Appalachian State University; Thursday, 8:00 am–9:20 am. Do a nation's GDP and its youth's math ability go hand-in-hand? Are geriatric car crashes on the decline? Which nations are the most "developed"? These are all captivating questions, and the commonality among them is that they were tackled by students using data from `Gapminder.org`. While such questions are nontrivial for a mathematician or sociologist to approach, it is worthwhile for students to approach them–doing the work could change their mind about the utility of mathematics. Created in 2005, `Gapminder` is a nonprofit site with the goal of enhancing sustainable global development through an increased use of information regarding social, economic, and environmental development at local and international levels. With more than 520 data sets to peruse, the site is a powerhouse for applications in the classroom; one might use it for demonstrations, short-term assignments, or semester-long research projects. Notwithstanding, deciding how to use the tools so that neither you nor your students becomes overwhelmed can be a challenge. As such, the first component of this interactive workshop is to familiarize instructors with the site and its visualization tools. Next, we will move on to discuss the applications of it in classes such as college algebra, first-year seminar, introductory and upper-level statistics, differential equations, and other modeling courses. Finally, participants will work in teams to create new assignments for immediate use in their classrooms. Whether one has used the site before or not, each participant should expect to take away meaningful, tangible strategies for its use. Participants should come prepared to learn more about the world and how to bring it into your classroom!

AMS-MAA-SIAM Panel Discussion: Computing across the curriculum: Opportunities and challenges, organized by **Rachel Levy**, Harvey Mudd College; and **Lee Zia**, National Science Foundation; Thursday, 8:30 am–10:00 am. As data science, industrial mathematics, and mathematical modeling have gained attention as popular tools in the workforce, a new focus on computation has entered mathematical sciences courses. In this panel, faculty will share their experiences incorporating computing across

the mathematics curriculum. Computing will be discussed as a major focus of a course or as new modules or assignments integrated into existing courses. Challenges and opportunities associated with these efforts will also be presented, along with potential NSF funding avenues. This panel is co-sponsored by the AMS, MAA, and SIAM.

MAA Session for Chairs: What Department Chairs Should Know About Teaching with Technology, organized by **Catherine M. Murphy**, Purdue University Calumet, and **Daniel Maki,** Indiana University; Thursday, 9:00 am–10:20 am. Based on their experience as developers and users of technology to support teaching, the panelists will address the following: the goals for learning outcomes and pedagogy, infrastructure and other resources needed for a new initiative, institutionalizing the results of successful pilot programs, ADA requirements. During the discussion following the panelists' presentations, attendees are invited to share their experiences as well as ask questions of the panelists. Panelists for this session are: **Michael Gage,** University of Rochester; **Gavin LaRose**, University of Michigan; and **Peter Turbek**, Purdue University Calumet.

Mathematical Outreach Programs, organized by **Elizabeth Yanik**, Emporia State University; Thursday, 10:00 am–12:00 noon. This poster session is designed to highlight special programs which have been developed to encourage students to maintain an interest in and commitment to succeeding in mathematics. These programs might include such activities as after school clubs, weekend activities, one-day conferences, mentoring opportunities, summer camps, etc. This poster session encompasses a wide variety of outreach efforts for a variety of age groups. For example, programs might be designed to reach out to underrepresented groups. The projects supported by MAA Tensor and Summa grants will find this an ideal venue in which to share the progress of their funded projects. Another possible type of outreach might involve mathematical enrichment programs. For example recipients of Dolciani Mathematics Enrichment Grants might wish to highlight their programs. Other examples might include innovative programs to motivate undergraduates to study mathematics. We encourage everyone involved with offering mathematical outreach activities to consider submitting an abstract to the session organizer, Betsy Yanik, `eyanik@emporia.edu`. This poster session is sponsored by the MAA Committee on the Participation of Women.

Career Options for Undergraduates, organized by **Thomas P. Wakefield**, Youngstown State University, and **Kristine Roinestad**, US Census Bureau; Thursday, 10:35 am–11:55 am. A common question for math majors to ask is, "What options are available for someone with a math degree?" In today's global marketplace, employers are increasingly seeking candidates with a degree in mathematics, applied mathematics, or statistics. Panelists **Dr. Thomas A. Grandine**, technical fellow with Boeing; **Dr. Katie Oliveras**, assistant professor, Seattle University; and a representative of the Society of Actuaries will showcase options for career paths in academia as well as settings such as industry, government, and nonprofits. They also will speak on their own career experiences. Panelists are: **Thomas Grandine**, Boeing Corporation; **Katie Oliveras**, Seattle University; and **Marcia A. Ciol**, University of Washington. This panel is sponsored by the Young Mathematicians Network.

Developing Mathematical Concepts with Technology, organized by **Gail Burrill**, Michigan State University; Thursday, 10:35 am–11:55 am. Although technology is often used as a tool for doing mathematics–creating graphs and crunching numbers–it can also be a powerful tool for developing understanding of mathematical concepts. Interactive dynamic technology can play a central role in helping students grapple with and come to understand ideas in mathematics. CAS technology, in particular, offers the potential for students to explore sophisticated and subtle mathematical concepts helping them develop some of the fundamentals that are necessary for moving fluently among the ideas and making connections among concepts. The panelists will share examples from calculus, geometry, introductory statistics, linear algebra and differential equations; discuss the affordances and limitations of technology; offer suggestions from research about how technology can be used effectively; and engage the audience in a discussion about the effective use of the technology. The discussion will focus on interactive dynamic technology but will also include a broader perspective on technologies available for use in teaching. Panelists will include **Wade Ellis**, West Valley Community College; **Tom Dick**, Oregon State University; **Andrew Bennett**, University of Kansas; and **Gail Burrill**, Michigan State University.

Interdisciplinary Modeling Experiences for Undergraduates, organized by **Amanda Beecher**, Ramapo College of New Jersey, and **Chris Arney**, United States Military Academy; Thursday, 1:00 pm–2:20 pm. This panel will feature faculty discussing the opportunities and challenges of developing interdisciplinary modeling experiences for undergraduates. Ideas for how to develop these experiences inside (courses or projects) or outside (contests, learning communities, community service experiences) the classroom will be presented. Each of the panelists will focus on advantages and disadvantages faced while developing interdisciplinary modeling opportunities, including time, resources, and institutional support. This panel is designed for faculty teaching or leading any form of modeling or problem solving. Significant time will be reserved for questions from the audience and between the panelists. Panelists are **Heidi Berger**, Simpson College; **Jessica Libertini**, Virginia Military Institute; **Gary Olson**, University of Colorado Denver; and **Robert Wooster**, Wooster College.

Mid-Career Faculty: Charting the Next Half of Your Career, organized by **Jenna P. Carpenter**, Louisiana Tech University; Thursday, 1:00 pm–2:20 pm. Mentoring programs often focus on new faculty but mid-career faculty can benefit from mentoring, too. While they have issues and interests that differ from faculty just starting their career, they also have a wider spectrum of opportunities open to them. This panel session features several successful mid-career faculty who have taken different paths post-tenure. They will share some of their wisdom for charting

an interesting second half of one's career. Panelists are: **Jonathan K. Hodge**, Grand Valley State University; **Judith Covington**, Louisiana State University at Shreveport; **Annalisa Crannell**, Franklin and Marshall College; **Brigitte Lahme**, Sonoma State University; and **Ronald Taylor,** Berry College. Sponsor for this panel is the MAA Committee on Professional Development.

Projects Supported by the NSF Division of Undergraduate Education, organized by **Jon Scott**, Montgomery College; Thursday, 2:00 pm–4:00 pm. This session will feature principal investigators (PIs) presenting progress and outcomes from various NSF funded projects in the Division of Undergraduate Education. The poster session format will permit ample opportunity for attendees to engage in small group discussions with the PIs and to network with each other. Information about presenters and their projects will appear in the program.

Is Online Inquiry-Based Learning (IBL) Possible? organized by **Padraig McLoughlin** and **Perry Y. C. Lee**, both of Kutztown University of Pennsylvania; Thursday, 2:35 pm–3:55 pm. Inquiry-Based Learning (IBL) is insistent on having students do mathematics: the pedagogy is based on challenging students to create, discover, produce solutions to problems, conjecture, experiment, explore, interact, opine, and prove or disprove claims. IBL encourages students to engage so students cannot simply sit and "absorb." Faculty cannot figuratively open heads and "pour in the knowledge." Students are to conjecture, experiment, explore, and solve problems. Socratic inquiry via IBL is not a 'process' where there is 'information' exchanged. IBL is not a unary philosophy of mathematics teaching insofar as there are a number of types of IBL methods across the full range of schooling and ranges from active learning to discovery learning through to the Moore method. A fundamental part of IBL is that students are guided through well-crafted notes in mathematical discovery. This panel discussion will focus on whether IBL can be achieved in an online course. Panelists will discuss their successes, or lack thereof, with IBL for online courses or a hybrid (a way that augments face-to-face classes) manner which do not sacrifice depth for breadth, that do foster discussion, and that do support authentic inquiry. We also shall include panelists who will justify why they opine that such goals cannot be achieved within the framework of IBL. Panelists to be determined.

Summer Research Programs, organized by **Lloyd E. Douglas**, Independent Consultant; **William A. Hawkins Jr.**, MAA and University of the District of Columbia; and **Robert Megginson**, University of Michigan; Thursday, 2:35 pm–3:55 pm. The MAA has sponsored Summer Research Programs with funding from NSF and NSA since 2003. Each program consists of a small research group of at least four minority undergraduates mentored by a faculty member. About one hundred thirty sites have been funded as of summer 2015. **Yunus Zeytuncu**, University of Michigan-Dearborn; **Brett Sims**, Borough of Manhattan Community College; and **Min-Lin Lo**, California State University, San Bernardino, will discuss their programs. There will be ample time for questions and discussion. It is expected that funding will be available for summer 2016. Additional information can be found on the NREUP website at `www.maa.org/programs/faculty-and-departments/underrepresented-groups/nreup`. Sponsor for this panel is the MAA Committee on Minority Participation and the MAA Office of Minority Participation.

Find a Research Collaborator Social Hour, organized by **Jacob White**, Texas A&M University, and **Timothy Goldberg**, Lenoir-Rhyne University; Thursday, 3:15 pm–4:15 pm. As freshly graduated PhD's will start their research career at a new institution, two of the most common obstacles observed are (1) finding collaborators in other departments or institutions, and (2) finding topics to work on. This event will consist of small group discussions based on research interests, with the goal of sharing ideas of how to find collaborators and topics, as well as possibly finding a collaborator during the event. Sponsored by the Young Mathematicians' Network.

Poetry + Art + Math, organized by **Gizem Karaali**, Pomona College; **Lawrence M. Lesser**, University of Texas at El Paso; and **Douglas Norton**, Villanova University; Thursday, 5:30 pm–7:00 pm. In the last few years, JMM attendees have enjoyed eclectic poetry readings. This year's poetry reading will be augmented by a guest lecture by Seattle mathematical artist / poet Michael Schultheis. Schultheis's art will also be displayed during the session. All who are interested in mathematical poetry and/or mathematical art are invited. Come to share your poetry or simply enjoy the poetry-art-math! Though we do not discourage last-minute decisions to participate, we invite and encourage poets to submit poetry (no more than three poems, no longer than five minutes) and a bio in advance—and, as a result, be listed on our printed program. Inquiries and submissions (by December 1, 2015) may be made to Gizem Karaali (`gizem.karaali@pomona.edu`). Sponsors for this event include the Journal of Humanistic Mathematics and SIGMAA ARTS.

College Calculus and the Preparation Gap: Identified Problems and Models for Improvement, organized by **Michael Boardman**, Pacific University; **Gail Burrill**, Michigan State University; and **David Bressoud**, Macalester College; Friday, 8:00 am–9:20 am. Mathematics departments and their faculty face the difficult task of providing effective Introductory Calculus courses for students with significantly different backgrounds in mathematics. Some students have completed high school calculus, in courses of varied quality, and others have never seen calculus before. Some have strong preparation for college calculus, while others have significant deficits in their backgrounds. Panelists will share results of recent research about the nature and impact of these challenges and will describe some models for success in dealing with this issue. Panelists to include **David Bressoud**, Macalester College; **Deborah Hughes Hallett**, Harvard University; **Robin Cruz**, College of Idaho; **Dave Dwyer**, University of Evansville; and **Chad Topaz**, Macalester College. Sponsors for this panel are MAA/NCTM Joint Committee on Mutual Concerns, and the College Board/MAA Joint Committee on Mutual Concerns.

Guidelines for Statistics Education: MAA Curriculum Guide, ASA Guidelines, GAISE II, and SET. Organizers include **Patti Frazer Lock**, St. Lawrence University; **Sue**

Schou, Idaho State University; and **Randall Pruim**, Calvin College; Friday, 8:00 am–9:20 am. In recognition of the increasing importance of statistics and statistics education, there have been four major new reports on statistics education in the last year and a half. This panel focuses on these reports:

• The MAA 2015 Curriculum Guide recommends that "every mathematical sciences major should have, at a minimum, … a command of data analysis and statistical inference at a level equivalent to that obtained in an applied data analysis course." The Curriculum Guide links to a report giving recommendations for this course, as well as a report giving recommendations for statistics programs.

• The American Statistical Association published its Curriculum Guidelines for Undergraduate Programs in Statistical Science in November 2014. These Guidelines update previous guidelines published in 2000.

• The original GAISE (Guidelines for Assessment and Instruction in Statistics Education) College Report was written in 2005 and endorsed by the ASA and AMATYC. These guidelines are being updated this year and the GAISE 2016 report is expected in early 2016.

• The Statistics Education of Teachers (SET) report came out in early 2015 and gives specific recommendations for the statistics education of pre-service K–12 teachers. The Conference Board of the Mathematical Sciences (CBMS) identified the statistical preparation of teachers as an area of concern in their document, Mathematics Education of Teachers 2 (MET2). The SET report addresses this concern.

We will have four panelists, each an author on one of these four reports. The panelists will share the results of the different reports and will discuss implications of the reports for programs in mathematics, statistics, and mathematics education. Panelists present will be **Patti Frazer Lock**, St. Lawrence University; **Michelle Everson**, Ohio State University; **Chris Franklin**, University of Georgia; and **Beth Chance**, Cal Poly–San Luis Obispo. Sponsored by SIGMAA STAT ED.

Pure and Applied Talks by Women Math Warriors presented by EDGE (Enhancing Diversity in Graduate Education), organized by **Candice R. Price**, Sam Houston State University, and **Amy L. Buchmann**, Tulane University; Friday, 8:00 am–10:55 am. Since its beginning in 1998, nearly two hundred women have participated in the EDGE program. Approximately seventy are currently working toward a PhD, over one hundred have earned Masters and fifty-seven have gone on to successfully complete PhDs. This session will be comprised of research talks in a variety of different sub-disciplines given by women involved with the EDGE program. For more information on the EDGE program see `www.edgeforwomen.org`.

Instructional Strategies That Can Make a Difference, organized by **Gail Burrill**, Michigan State University; Friday, 9:35 am–10:55 am. Research has suggested some ways of supporting learning can make a difference in what students learn and what they remember. The NCTM's recent publication, Principles to Action, describes what these could look like in K–12 classrooms, for example, facilitating productive discussion, posing meaningful questions, using and connecting mathematical representations. Are there counterparts for instruction at the post-secondary level? Panelists will talk about what these might be and how they can look in post secondary classrooms. Panelists are: **Tom Dick**, Oregon State University; **Diane Briars**, National Council of Teachers of Mathematics; **Brian Hopkins**, St. Peters University; and **Darryl Yong**, Harvey Mudd College. Sponsored by the MAA/NCTM Joint Committee on Mutual Concerns.

Perspectives on IBL Teaching: Novice, Experienced, and Master, organized by **Judith Covington**, LSU Shreveport, and **Theron Hitchman**, University of Northern Iowa; Friday, 9:35 am–10:55 am. Panelists will share their experiences in getting started with Inquiry Based Learning (IBL) and perspectives on maintaining these techniques over time. They will share a quick thought on the opportunities and challenges of IBL courses, but a large fraction of the time will be reserved for questions from the audience. Our panelists include someone new to IBL teaching, someone with enough experience to feel comfortable designing a new course, and an acknowledged master teacher who has mentored others in IBL teaching. Panelists are: **Angie Hodge**, University of Nebraska Omaha; **Mitchel T. Keller**, Washington and Lee University; and **Carol Schumacher**, Kenyon College.

Learning from Each Other: International Perspectives on the Mathematical Education of Teachers, organized by **Bonnie Gold**, Monmouth University, and **David C. Carothers**, James Madison University; Friday, 1:00 pm–2:20 pm. Every country has its own ways of educating its teachers, due to a combination of historical factors and the way the country is organized. So we cannot simply look at another country and say, "Wow, they do so much better than us on the TIMSS (or PISA)–let's do what they do." For example, some countries are less concerned about including students with disabilities than we are. However, there is still value in looking at what other countries do and considering whether some aspects of their approaches might be worthwhile for us to modify and adopt. There have been several studies of what is being done in other countries: China, Korea, and Germany, among others. Panelists will speak on aspects of mathematical education of teachers in other countries that perhaps are worth discussing in the US. Panelists are: **Tad Watanabe**, Kennesaw State University; **Catherine B. Kessel**, Mathematics Education Consultant, Berkeley, CA; and **William Schmidt**, Michigan State University. This panel is sponsored by the MAA Committee on the Mathematical Education of Teachers (COMET).

Undergraduate Research as a Capstone Course, organized by **Aklilu Zeleke**, Michigan State University; **James Solazzo**, Coastal Carolina University; and **Michael Karls**, Ball State University; Friday, 1:00 pm–2:20 pm. Undergraduate research in the mathematical sciences has flourished over the past decade. The number of undergraduates engaging in mathematical sciences research has increased dramatically over the past few years. Indicators of this growth include the size of the undergraduate poster session at the Joint Mathematics Meetings (e.g., over 300 posters at the 2014 meeting), the number of mathematics

Research Experience for Undergraduates programs (now close to 70), and the recent creation of journals devoted to mathematics undergraduate research (e.g., Involve at UC Berkeley). Undergraduate research is now a major factor in preparing students for graduate school and industrial careers. There are many models of undergraduate research in the mathematical sciences, such as semester–long projects that are completed for honors or thesis credit, nationally funded summer REUs, and research projects that engage students over a longer period, usually two to four semesters. All these models have one thing in common: the research experience is not targeting all students in a class or institution. At many institutions, mathematics majors fulfill a capstone course. Usually such courses are nonstandard and/or interdisciplinary and are not normally offered as part of the undergraduate curriculum. Students are expected to read research articles, write expository reports and make presentations. In this panel we seek examples of models that have incorporated undergraduate research as a component of a capstone course. The panel will discuss strategies for selecting appropriate projects, mentoring students for successful outcomes and assessment of students' work. Panelists are: **Anant Godbole**, East Tennessee State University; **Keshav Jagannathan**, Coastal Carolina University; **Rebecca Garcia**, Sam Houston State University; and **Sergio Loch**, Grand View University. Sponsored by the MAA Subcommittee on Research by Undergraduates.

Renewing the First Two Years Curriculum: Calculus, Quantitative Reasoning, Statistics, Pre-calculus, and Developmental Mathematics, organized by **Suzanne I. Dorée**, Augsburg College; Friday, 2:35 pm–3:55 pm. This broad array of mathematics courses taught in the first two years is key to student success in college, both for prospective majors in STEM and as part of the general education for all majors. National efforts to renew the first two years' curriculum are underway with the goal that introductory courses be interesting and engaging for students, reflect modern workforce use of mathematics, and prepare students for subsequent coursework and their lives as citizens. To accomplish these lofty goals, we all need to revise our curriculum—updating standard courses and reconsidering courses that no longer work. Where is your department in this effort? A great place to start is to learn more about successful programs that you might easily adapt to your needs. Whether you are just getting started or already renewing your curriculum, come learn more about what's happening on the national scene. Panelists will describe innovative trends and resources for renewing calculus, building quantitative reasoning courses, modernizing introductory statistics, improving courses that prepare students for calculus, and restructuring developmental mathematics. Department chairs, academic leaders, and faculty engaged in curriculum renewal of mathematics courses in the first two years are especially encouraged to attend. Panelists are: **Michael Axtell**, University of St. Thomas; **Caren Diefenderfer**, Hollins University; **Patti Frazer Lock**, St. Lawrence University; **Rebecca Hartzler**, Seattle Central College; and **Bruce Yoshiwara**, Pierce College. Sponsored by MAA Committee on Curriculum Renewal Across the First Two Years (CRAFTY)

A Common Vision for the Undergraduate Mathematics Program in 2025, organized by **Karen Saxe**, Macalester College; Friday, 2:35 pm–3:55 pm. Each year approximately 50 percent of students fail to pass college algebra with a grade of 'C' or better. Failure rates under traditional lecturing are 55 percent higher than the rates observed under active learning. Challenges like these are highlighted in reports such as "The Mathematical Sciences in 2025" (NRC) and "Engage to Excel" (PCAST), and have led to differentiated responses from different groups in the mathematical sciences. The Common Vision project [NSF DUE-1446000] has brought together leaders from five professional associations in the mathematical sciences—AMATYC, AMS, ASA, MAA, and SIAM—to provide a snapshot of the current thinking about undergraduate mathematics. The Common Vision report reflects a consensus that failure rates in traditional entry-level courses at two- and four-year institutions are unacceptably high, and that other pathways to college-credit-bearing courses are needed. The five associations are working closely together for the first time and work growing out of this project should guide future progress to incrementally improve education in the mathematical sciences. Panelists will update the community on the project. Panelists are: **Tara Holm**, Cornell University; **Helen Burn**, Highline College; **Rachel Levy**, Harvey Mudd College; and **Matthew Ando**, University of Illinois Urbana-Champaign.

Change Is the Norm!, organized by **Patrick Brewer**, Lebanon Valley College; **Robert Buck**, Slippery Rock University; **Bettye Case**, Florida State University; **Kevin Charlwood**, Washburn University; **Michelle Guan**, Indiana University Northwest; **Steve Paris**, Florida State University; and **Sue Staples**, Texas Christian University; Friday, 5:00 pm–7:00 pm. To meet expectations of students intending actuarial careers, changes are needed faster than the usual deliberative academic pace. There is constant need for curriculum modification. Possibly the most important discussions for this, the 24th in this series of JMM actuarial sessions, will center on changes and initiatives not yet announced as it is planned. The outside-class activity of a strong program can stress both students and actuarial advisors. Sessions seek to support faculty involved with actuarial science offerings; they are organized by faculty from a variety of such programs. Presentations feature Seattle area actuaries and include representatives from professional and publishing organizations. Comments from actuaries at differing career stages and paths will touch on "what I wish I had known before I began working". One of the career demands these actuaries mention is certain to be about credentialing. This major commitment is sometimes undertaken by faculty and the resulting demands will be described by recently credentialed faculty members. Panelists are: **Steve Armstrong**, Casualty Actuarial Society; **Robert Buck**, Slippery Rock University; **Robert Fisette**, Milliman; **Michelle Guan**, Indiana University Northwest; **Stuart Klugman**, Society of Actuaries; **John Leo**, Regence Group; and **Steve Paris**, Florida State University.

Managing Your Own Course Social Hour, organized by **Jacob A. White**, Texas A&M University, and **Timothy Goldberg**, Lenoir-Rhyne University, Hood College; Friday, 4:00 pm–5:00 pm. One of the many challenges facing new faculty members (and sometimes advanced teaching assistants) is managing their own courses. This event will consist of small group discussions based on types of courses and perhaps types of institutions, with the goal of sharing ideas and experiences about managing one's own course. This may also include discussions on creating a new course. Sponsored by the Young Mathematicians' Network.

Mathematically Bent Theater, featuring **Colin Adams** and the **Mobiusbandaid Players**; Friday, 6:00 pm–7:00 pm. Is laughter the body's attempt to eject excess phlegm? Why did Plato write dialogues instead of monologues? Who walked off with my copy of "Quasi-Linear Perturbations of Hamiltonian Klein-Gordon Equations on Spheres" at the AMS Fellows Reception at the San Antonio Joint Meetings? These are just a few of the questions we will not answer in this theatrical presentation of several short mathematically inclined humorous pieces.

Backgammon! organized by **Arthur Benjamin**, Harvey Mudd College; Friday, 8:00 pm–10:00 pm. Learn to play backgammon from expert players. It's a fun and exciting game where players with a good mathematics background have a decisive advantage. Boards and free lessons will be provided by members of the US Backgammon Federation. Stop by anytime!

How to Think Brilliantly and Creatively in Mathematics: A Guide for K–12 Educators and Their Students, organized by **Deanna Haunsperger**, Carleton College; Saturday, 8:00 am–8:50 am. This lecture is a guide for thinking brilliantly and creatively in mathematics for K–12 educators, their students, and all seeking joyful doing in mathematics. How do we model and practice uncluttered thinking and joyous doing in the classroom? Pursue deep understanding over rote practice and memorization? Develop the art of successful flailing? Our complex society demands of its next generation not only mastery of quantitative skills, but also the confidence to ask new questions, explore, wonder, flail, persevere, innovate, and succeed. Let's not only send humans to Mars, let's teach our next generation to solve problems and get those humans back if something goes wrong! In this talk, **James Tanton**, MAA, will explore five natural principles of mathematical thinking. We will all have fun seeing how school mathematical content is the vehicle for ingenuity and joy. All are so welcome to attend! The sponsor for this lecture is the MAA Council on Outreach.

Starting a New Track: Actuarial Science, Biomathematics, Environmental Science, Climate Studies, organized by **Julie Barnes**, Western Carolina University; **Martha Siegel**, Towson University; and **Linda McGuire**, Muhlenberg College; Saturday, 9:00 am–10:20 am. Mathematicians that have successfully implemented either a track within the mathematics major, a double major, or a fully integrated major in Actuarial Science, Biomathematics, or Environmental Science and Climate Studies will briefly describe the necessary components of such a program, including the opportunities and the obstacles to implementation in a mathematics department. For each such program, there will be ample time to consult with the experts so as to determine how one's own department might encourage the professional development of its mathematics faculty and/or the cooperation within an institution to allow for implementation of some level of interdisciplinary tracks in these three areas. Panelists are: **Jim Daniel**, University of Texas at Austin; **Tim Comar**, Benedictine University; and **Ben Galluzzo**, Shippensburg University. This panel is sponsored by the MAA Committee on the Undergraduate Program in Mathematics (CUPM) and MAA Committee on Professional Development.

High School Quadratics: How to Think About and Do Everything About Them Brilliantly and Creatively, organized by **Deanna Haunsperger**, Carleton College; Saturday, 9:15 am–10:45 am. Presenter, **James Tanton**, MAA, will now put brilliant and creative thinking practices into an actual high-school topic: the study of quadratics in algebra II. Let's see how to bring the light of ease and joyful doing into this standard classroom unit. By letting go of a focus on jargon and memorization we can effectively help our students develop the confidence to "power their way" through questions and challenges, to engage in problem solving, and to develop the confidence to persevere. We can teach our students to be confident and agile thinkers and still master the curriculum content they are required to know. This workshop will model the presentation of the entire standard quadratics content, illustrating how doing less leads to more! Sponsored by the MAA Council on Outreach.

What's Beyond the Curriculum? organized by **Martha Siegel**, Towson University; Saturday, 10:35 am–11:55 am. The 2015 CUPM Curriculum Guide to Majors in the Mathematical Sciences has been available for about one year. CUPM presents some important ways to use the Guide to craft some or all of a mathematics major program and expands on its recommendations for managing the elements beyond the curriculum that will contribute to success. Sponsored by the MAA Committee on the Undergraduate Program in Mathematics.

Math Circle Demonstration, organized by **Zvezdelina Stankova**, Mills College; **Tatiana Shubin**, San Jose State University; and **Paul Zeitz**, University of San Francisco; Saturday, 11:00 am–11:50 am. A math circle is an enrichment experience that brings mathematics professionals in direct contact with pre-college students and/or their teachers. Circles foster passion and excitement for deep mathematics. This demonstration session offers the opportunity for conference attendees to observe and then discuss a math circle experience designed for local students. While students are engaged in a mathematical investigation, mathematicians will have a discussion focused on appreciating and better understanding the organic and creative process of learning that circles offer, and on the logistics and dynamics of running an effective circle. Presenting at this demonstration will be **Zvezdelina Stankova**, Mills College, Berkeley Math Circle Director. The sponsor for this demonstration is SIGMAA MCST.

International Engagement in Research and Education in the Mathematical Sciences, organized by **Overtoun Jenda**, Auburn University; Saturday, 1:00 pm–2:20 pm. This session will showcase international programs involving research and education. Speakers will discuss unique features and goals of their programs and will give examples of their activities including specific collaborative research projects. Activities and research collaborations can involve faculty, graduate students and/or undergraduate students. Programs where US faculty and students visit other countries and vice versa will be discussed. Speakers will also share opportunities, challenges, and lessons learned in developing, implementing, and sustaining such programs. The Southern Africa Mathematical Sciences Association's Masamu Program is one example that will be presented. Panelists are: **Neal Koblitz**, University of Washington; **Overtoun Jenda**, Auburn University; **Suzanne Lenhart**, University of Tennessee; **Yuan Lou**, Ohio State University; and **Fred Roberts**, Rutgers University.

Math Wrangle, organized by **Mark Saul**, American Math Competitions, and **Ed Keppelmann**, University of Nevada Reno; Saturday, 1:00 pm–2:30 pm. Math Wrangle will pit teams of students against each other, the clock, and a slate of great math problems. The format of a Math Wrangle is designed to engage students in mathematical problem solving, promote effective teamwork, provide a venue for oral presentations, and develop critical listening skills. A Math Wrangle incorporates elements of team sports and debate, with a dose of strategy tossed in for good measure. The intention of the Math Wrangle demonstration at the Joint Math Meetings is to show how teachers, schools, circles, and clubs can get students started in this exciting combination of mathematical problem solving with careful argumentation via public speaking, strategy and rebuttal. Sponsors for this event are SIGMAA-MCST and American Mathematics Competitions.

Special Interest Groups of the MAA (SIGMAAs)

SIGMAAs will be hosting a number of activities, sessions, and guest lectures. There are currently twelve such focus groups in the MAA offering members opportunities to interact, not only at meetings, but throughout the year, via newsletters and email-based communications. For more information visit `www.maa.org/community/sigmaas`.

SIGMAA Officers Meeting, Thursday, 10:30 am to noon.

SIGMAA on Mathematics and the Arts (SIGMAA ARTS)

Mathematics and the Arts, Wednesday morning and afternoon (see MAA Contributed Paper Sessions).

Poetry+Art+Math, Thursday, 5:30 pm–7:00 pm.

SIGMAA on Business, Industry, and Government (BIG SIGMAA)

Mathematics Experiences and Projects in Business, Industry, and Government, Friday afternoon (see MAA Contributed Paper Sessions).

SIGMAA on Mathematical and Computational Biology (BIO SIGMAA)

Current Trends in Mathematical and Computational Biology, Thursday, 9:00 am–11:20 am (see MAA Invited Paper Sessions).

Trends in Undergraduate Mathematical Biology Education, *Friday morning* (see MAA Contributed Papers Section).

SIGMAA on the History of Mathematics (HOM SIGMAA)

Business Meeting and Reception, Wednesday, 5:30 pm–6:20 pm.

Guest Lecture, Wednesday, 6:30 pm–7:20 pm, **James Evans**.

The Contributions of Minorities to Mathematics Throughout History, Friday morning (Contributed Paper Session).

Incorporating the History of Mathematics into Developmental Math Courses, Saturday morning (Contributed Paper Session).

SIGMAA on Math Circles for Students and Teachers (SIGMAA MCST)

The Broad Impact of Math Circles, Thursday afternoon (Contributed Paper Session).

Math Circle Demonstration, Saturday, 11:00 am–11:50 am.

Math Wrangle, Saturday, 1:00 pm–2:30 pm.

SIGMAA on the Philosophy of Mathematics (POM SIGMAA)

Using Philosophy to Teach Mathematics, Thursday morning (see MAA Contributed Paper Sessions).

Reception, Thursday, 5:30 pm–5:50 pm.

Business Meeting, Thursday, 6:00 pm–6:20 pm.

Guest Lecture, Thursday, 6:30 pm–7:20 pm, **Bonnie Gold**, Monmouth University.

SIGMAA on Quantitative Literacy (SIGMAA QL)

Quantitative Literacy in the K-16 Curriculum, Wednesday afternoon (see MAA Contributed Paper Sessions).

Reception (joint with SIGMAA STAT-ED), Thursday, 5:30 pm–5:50 pm.

Business Meeting, Thursday, 6:00 pm–6:45 pm.

SIGMAA on Research in Undergraduate Mathematics Education (SIGMAA RUME)

Research in Undergraduate Mathematics Education, Thursday morning and afternoon (see MAA Contributed Paper Sessions).

SIGMAA on Statistics Education (SIGMAA Stat Ed)

Reception (with SIGMAA QL), Thursday, 5:30 pm–6:00 pm.

Business Meeting, Thursday, 6:00 pm–6:45 pm.

Guest Lecture, Thursday, 6:50 pm–7:40 pm, **Hadley Wickham**, **Tim Hesterburg**, Google.

Panel Session: ***Guidelines for Statistics Education***, Friday, 8:00 am–9:20 am.

Innovative Targeted Solutions in Teaching Introductory Statistics, Thursday afternoon (Contributed Paper Session).

New Ideas in Teaching Upper-Level Statistics Courses Friday afternoon (Contributed Paper Session).

SIGMAA on the Teaching of Advanced High School Mathematics (SIGMAA TAHSM)

Helping Students See Beyond Calculus, Saturday afternoon (see MAA Contributed Paper Sessions).

SIGMAA on Undergraduate Research (UR SIGMAA)

Business Meeting: Thursday, 5:30 pm–6:30 pm.

All are invited to the first meeting of the MAA's newest SIGMAA! Members and friends of the SIGMAA on Undergraduate Research (UR SIGMAA) will gather to meet each other, discuss our first elections, and plan our first year as a SIGMAA. Those who are considering joining are especially welcome!

SIGMAA on Mathematics Instruction Using the Web (WEB SIGMAA)

Business Meeting and Reception, Friday, 5:30 pm–5:50 pm.

Guest Lecture, Friday, 6:00 pm–6:50 pm, **Matthew Leingang**, New York University, *Streamlining assessment, feedback, and archival with auto-multiple-choice.*

Poster Session: *Me and My Gadgets–Teaching with Technology.*

MAA Sessions for Students

How to Think Brilliantly and Creatively in Mathematics: A Guide for K–12 Educators and Their Students, organized by **Deanna Haunsperger**, Carleton College; Saturday, 8:00 am–8:50 am. This lecture is a guide for thinking brilliantly and creatively in mathematics for K–12 educators, their students, and all seeking joyful doing in mathematics. How do we model and practice uncluttered thinking and joyous doing in the classroom? Pursue deep understanding over rote practice and memorization? Develop the art of successful flailing? Our complex society demands of its next generation not only mastery of quantitative skills, but also the confidence to ask new questions, explore, wonder, flail, persevere, innovate, and succeed. Let's not only send humans to Mars, let's teach our next generation to solve problems and get those humans back if something goes wrong! In this talk, James Tanton, MAA, will explore five natural principles of mathematical thinking. We will all have fun seeing how school mathematical content is the vehicle for ingenuity and joy. All are so welcome to attend! The sponsor for this lecture is the MAA Council on Outreach.

High School Quadratics: How to Think About and Do Everything About Them Brilliantly and Creatively, organized by **Deanna Haunsperger**, Carleton College; Saturday, 9:15 am–10:45 am. Presenter, **James Tanton**, MAA, will now put brilliant and creative thinking practices into an actual high-school topic: the study of quadratics in algebra II. Let's see how to bring the light and ease of joyful doing into this standard classroom unit. By letting go of a focus on jargon and memorization we can effectively help our students develop the confidence to "power their way" through questions and challenges; to engage in problem solving, and to develop the confidence to persevere. We can teach our students to be confident and agile thinkers and still master the curriculum they are required to know. This workshop will model the presentation of the entire standard quadratics content, illustrating how doing less leads to more! Sponsored by the MAA Council on Outreach.

Grad School Fair, Friday, 8:30 am–10:30 am. Here is the opportunity for undergrads to meet representatives from mathematical sciences graduate programs from universities all over the country. January is a great time for juniors to learn more, and college seniors may still be able to refine their search. This is your chance for one-stop shopping in the graduate school market. At last year's meeting about 300 students met with representatives from 50 graduate programs. If your school has a graduate program and you are interested in participating, a table will be provided for your posters and printed materials for US$75 (registration for this event must be made by a person already registered for the JMM), and you are welcome to personally speak to interested students. Complimentary coffee will be served. Co-sponsored by the the AMS and MAA.

MAA Lecture for Students, Friday, 1:00 pm–1:50 pm, will be given by **Robert Devaney**, Boston University, on *The Fractal Geometry of the Mandelbrot Set.*

MAA Student Poster Session, organized by **Joyati Debnath**, Winona State University; Friday, 4:30 pm–6:00 pm. This session features research done by undergraduate students. First-year graduate students are eligible to present if their research was completed while they were still undergraduates. Research by high school students can be accepted if the research was conducted under the supervision of a faculty member at a post-secondary institution.

Appropriate content for a poster includes, but is not limited to, a new result, a new proof of a known result, a new mathematical model, an innovative solution to a Putnam problem, or a method of solution to an applied problem. Purely expository material is not appropriate for this session.

Participants should submit an abstract describing their research in 250 words or less by midnight, Friday, October 9, 2015. Notification of acceptance or rejection will be sent by November 2, 2015. See `www.maa.org/programs/students/undergraduate-research/jmm-student-poster-session` for further information on what should be included in the abstract and a link to the abstract submission form.

Posters will be judged during the session and award certificates will be mailed to presenters with the highest scores. Trifold, self-standing 48" by 36" tabletop poster boards will be provided. Additional materials and equipment are the responsibility of the presenters. Participants must set up posters between 2:30 pm and 3:30 pm and must be available at their posters from 3:30 pm to 6:00 pm. Judging will begin at 3:30 pm, and general viewing will begin at

4:30 pm. Judges results will be available at the MAA Pavilion in the Exhibit Hall the following day until the exhibits close.

Questions regarding this session should be directed to Joyati Debnath jdebnath@winona.edu.

More advanced students might be interested in these sessions listed elsewhere in this announcement: ***The Enjoyment of Employment: Finding the Right Organizational Culture***, Wednesday, 2:15 pm–3:35 pm; ***YMN/Project NExT Poster Session***, Wednesday at 2:15 pm; ***Finding a Thesis Topic and Advisor***, Wednesday, 3:50 pm–5:10 pm; ***Career Options for Undergraduates***, Thursday, 10:35 am–11:55 am; ***Summer Research Programs***, Thursday, 2:35 pm–3:55 pm. See the full descriptions in the "MAA Panels..." section. You may also be interested in the ***CBMS–TPSE Math Panel Discussion: Recent Graduates, What we Wish we had Learned***, Thursday, 9:00 am–10:30 am; see the listing under Other AMS Sessions.

Other MAA Events

Board of Governors, Tuesday, 9:00 am–5:00 pm.

Department Liaisons Meeting, Wednesday, 9:30 am–11:00 am.

MAA Section Officers Meeting, Wednesday, 4:00 pm–5:00 pm, chaired by **Betty Mayfield**, Hood College. Section officers will meet with members of the Committee on Sections and MAA staff to share information and discuss current initiatives.

SIGMAA Officers Meeting, Thursday, 10:30 am–12:00 noon, chaired by **Karen A Marrongelle**, Portland State University.

MAA Business Meeting, Saturday, 11:10 am–11:40 am, chaired by MAA President **Francis Su**, Boston University.

MAA Ancillary Workshops (these take place on Monday and Tuesday, January 4 and 5, before the JMM actually begins)

National Research Experiences for Undergraduates Workshop, organized by **Dennis Davenport**, Howard University; Tuesday, 9:00 am–4:30 pm. This workshop will teach participants how to write a competitive grant proposal. This workshop is a hands-on experience where participants write a summary of a proposal and rate an NSF-awarded proposal in a mock panel review. Participants will also learn many helpful hints and fatal flaws to proposal writing. This workshop is appropriate for current PIs of MAA's NREUP grants and for those who were denied funding for an MAA grant. Advanced registration is required. Send an email to the organizer at dennis.davenport@howard.edu to register for the workshop.

Bringing Passion to your Introductory Statistics Classroom: a supportive, multidisciplinary project-based approach. The presenter for this workshop will be **Lisa Dierker,** Wesleyan University; organized by **Lorey Burghard**, Pennsylvania State University; **Lisa Dierker**, Wesleyan University; and **Dennis Pearl**, Pennsylvania State University; Monday, 9:00 am–4:30 pm. This workshop will support instructors who teach an introductory statistics or quantitative research course in designing or redesigning any or all portions of their course to engage students in the rich, complicated, decision-making process of real statistical inquiry. Core features of this passion-driven, flipped classroom approach include providing opportunities for students to flexibly apply their statistical knowledge in the context of real data, the use of computing as a window to core statistical concepts, supporting students with varying levels of preparation, and attracting and inspiring students from underrepresented groups. The workshop will include very brief presentations focused on the nuts and bolts of supporting project-based experiences, followed by ample hands-on opportunities that will be supported by experienced faculty and students. Similar to the approach that will be presented; your experience in the workshop will be individualized to your own interests, background and needs. Sponsored by the Consortium for the Advancement of Undergraduate Statistics Education (CAUSE).

Teaching the Statistical Investigation Process with Randomization-Based Inference. Presenters for this workshop are **Lorey Burghard**, Pennsylvania State University; **Dennis Pearl**, Pennsylvania State University, and **Nathan Tintle**, Dordt College; organized by **Lorey Burghard**, Pennsylvania State University, and **Dennis Pearl**, Pennsylvania State University; Tuesday, 9:00 am–4:30 pm. The goals of this workshop are to help participants to revise their introductory statistics course in two ways: 1. Using randomization-based methods, as opposed to methods based on the normal distribution, to introduce concepts of statistical inference, and 2. Emphasizing the overarching process of conducting statistical investigations, from formulating a question and collecting data through exploring data and drawing inferences to communicating results, throughout the course. The workshop will provide direct experience with hands-on activities designed to introduce students to fundamental concepts of inference using randomization-based methods. The learning activities involve using freely available applets to explore concepts and analyze real data from genuine research studies. The presenters will also offer implementation and assessment suggestions during these activity-based sessions and discussion sessions based on the experiences of the presenters with randomization-based curricula in their own classrooms. More information about the project on which this workshop is based can be found at: www.math.hope.edu/isi. Sponsored by the Consortium for the Advancement of Undergraduate Statistics Education (CAUSE).

Activities of Other Organizations

This section includes scientific sessions. Several organizations or special groups are having receptions or other social events. Please see the "Social Events" section of this announcement for those details.

Association for Symbolic Logic (ASL)

This two-day program on Friday and Saturday will include sessions of contributed papers as well as Invited Addresses by **Dana Bartosova**, Universidade de Sao Paulo; **Natasha Dobrinen**, University of Denver; **James**

Freitag, University of California Berkeley; **Carl Jockusch**, University of Illinois at Urbana-Champaign; **Bakhadyr Khoussainov**, University of Auckland; **Lou van den Dries**, University of Illinois at Urbana-Champaign; and **Jindrich Zapletal**, University of Florida.

See also the session co-sponsored by the ASL on *Applications of Logic, Model Theory, and Theoretical Computer Science to Systems* on Saturday in the "AMS Special Sessions" listings.

Association for Women in Mathematics (AWM)

Thirty-Seventh Annual Noether Lecture, Thursday, 10:05 am, will be given by **Karen E. Smith**, University of Michigan, title to be announced.

Also see the sessions on Commutative Algebra and Its Interactions with Algebraic Geometry, jointly sponsored by the AWM, in the "AMS Special Sessions" listings.

Research Collaboration Conferences for Women: Who, What, Where, When, Why, and How? organized by **Michelle Manes**, University of Hawaii at Manoa; Wednesday, 2:15 pm–3:40 pm. Research Collaboration Conferences for Women are a new model of working research conference designed to build networks of female researchers in different areas of mathematics. Several conferences have been held at math institutes over the past few years, each focused on building collaboration groups consisting of senior and junior women in a given area. These include: Women in Numbers (WIN) and the three follow-up conferences at Banff and Lunimy; Algebraic Combinatorixx and Women in Topology (WIT) at Banff; Women in Shape (WiSh) at IPAM; and two Women in Applied Math conferences at IMA, Dynamical Systems with Applications to Biology and Medicine (WhAM!) and Numerical PDEs and Scientific Computer (WhAM2!). Each of these conferences has resulted in new, high-quality mathematics research as well as lasting collaborations among attendees. Hear from organizers and participants about why they attended a Research Collaboration Conference, what their experience was like, how these networks are spreading through other AWM events, and how you or your students can get involved. This session is open to all JMM attendees. Panelists include **Maria Basterra**, University of New Hampshire (WIT); **Susanne Brenner**, Louisiana State University (WhAM2!); **Ellen Eischen**, University of Oregon (WIN); **Kristin Lauter**, Microsoft Research (WIN), **Kathryn Leonard**, California State University, Channel Islands (WiSh); and **Ami Radunskaya**, Pomona College (WhAM!). `https://sites.google.com/site/awmpanel2016/`

Business Meeting, Wednesday, 3:45 pm–4:15 pm. **Chair, Kristen Lauter**, AWM President.

AMS–AWM Committee on Education Panel Discussion: Work in mathematics education in departments of mathematical sciences, organized by **Jacqueline Dewar**, and **Pao-sheng Hsu**, AWM Education Committee; Thursday, 10:30 am–12:00 pm. Many in the mathematics community in the US are now involved in mathematics education in various capacities. This panel is designed to illustrate the breadth and range of these activities. It will highlight examples of contributions to mathematics education by members in the mathematical sciences, and include the perspectives of mathematicians and mathematics educators who contribute in areas such as: teacher education (pre- and in-service); instructional materials development in K–16 mathematics; scholarship of teaching and learning; and mathematics education research. Panelists will discuss their work and may reflect on how their work is received in their departments. The moderator for this panel will be **Elizabeth Burroughs**, Montana State University; panelists are: **Curtis Bennett**, Loyola Marymount University; **Brigitte Lahme**, Sonoma State University; **Kristin Umland**, University of New Mexico; and **Megan Wawro,** Virginia Polytechnic Institute and State University.

Workshop Poster Presentations and Reception, Friday, 6:00 pm–7:15 pm. AWM will conduct its workshop poster presentations by women graduate students. AWM seeks volunteers to serve as mentors for workshop participants. If you are interested, please contact the AWM office at `awm@awm-math.org`. This session is open to all JMM attendees. Organizers for these presentations are **Brenda Johnson**, Union College and **Catherine Searle**, Wichita State University.

AWM Workshop: Special Session on Algebraic Combinatorics, Saturday, 8:00 am–5:00 pm. AWM will conduct its workshop with presentations by senior and junior women researchers. Updated information about the workshop is available at `www.awm-math.org/workshops.html`. AWM seeks volunteers to serve as mentors for workshop participants. If you are interested, please contact the AWM office at `awm@awm-math.org`. All JMM attendees are invited to attend the program. Organizers for this workshop are **Gizem Karaali**, Pomona College and **Rosa Orellana**, Dartmouth College.

Reception, Wednesday, 9:30 pm–11:00 pm. See the listing in the "Social Events," section of the announcement. See also the sessions co-sponsored by the AWM on ***Commutative Algebra I and II*** on Friday and Saturday in the "AMS Special Sessions" listings. Organizers for these sessions are **Karen Smith**, University of Michigan, Ann Arbor, **Emily Witt**, University of Utah and **Irena Swanson**, Reed College.

National Association of Mathematicians (NAM)

Granville-Brown-Hayes Session of Presentations by Recent Doctoral Recipients in the Mathematical Sciences, Friday, 1:00 pm–4:00 pm.

Cox-Talbot Address, to be given Friday after the banquet by **Tanya Moore**, Building Diversity in Science / City of Berkeley, title to be announced.

Panel Discussion; ***Work Hard, Play Hard: Balancing Career, Hobbies, and Family***, Saturday, 9:00 am–9:50 am. Moderator: **Duane Cooper**, Morehouse; Panelists to include: **Ron Buckmire**, Occidental College; **Emille Davie Lawrence**, University of San Francisco, **Robin Wilson**, California State Polytechnic University.

Business Meeting, Saturday, 10:00 am–10:50 am.

Claytor-Woodward Lecture, Saturday, 1:00 pm, **Tatiana Toro**, University of Washington, title to be announced.

See details about the banquet on Friday in the "Social Events" section.

National Science Foundation (NSF)

The NSF will be represented at a booth in the exhibit area. NSF staff members will be available to provide counsel and information on NSF programs of interest to mathematicians. The booth is open the same days as the exhibit is. Times that staff will be available will be posted at the booth.

Pi Mu Epsilon (PME)

Council Meeting, Thursday, 8:00 am–11:00 am.

Project NExT

Project NExT Workshop, Wednesday–Saturday, 8:00 am–6:00 pm.

Project NExT Lecture, Thursday, 2:00 pm–2:50 pm.

Poster Session: ***Young Mathematicians Network–Project NExT Poster Session***, Organized by **Jonathan Needleman**, Le Moyne College, and **Thomas Wakefield**, Youngstown State University, Wednesday, 2:15 pm–4:15 pm.

See details about the reception on Friday in Social Events.

Society for Industrial and Applied Mathematics (SIAM)

This program consists of an Invited Address, ***Stochastic facilitation and sensitivities in discontinuous dynamics*** at 11:10 am on Thursday given by **Rachel Kuske**, University of British Columbia, and a series of Mini-symposia to include ***Probability Meets Dynamics in Biology***, **Rachel Kuske**, University of British Columbia; ***Graphical Models for High Dimensional Data***, **Andrea Bertozzi**, University of California, Los Angeles; ***Trends in the Mathematics of Signal Processing and Imaging***, **Zuhair Nashed**, University of Central Florida; ***Inverse Problems and Applications***, **Gunther Ullmann**, University of Seattle; ***Optimization***, **Juan Meza**, University of California, Merced; and one other to be announced.

The program also includes a co-sponsored panel discussion, ***AMS-MAA-SIAM Panel Discussion: Computing across the curriculum: Opportunities and challenges***, organized by **Rachel Levy**, Harvey Mudd College and **Lee Zia**, National Science Foundation; Thursday, 8:30 am–10:00 am. As data science, industrial mathematics, and mathematical modeling have gained attention as popular tools in the workforce, a new focus on computation has entered mathematical sciences courses. In this panel, faculty will share their experiences incorporating computing across the mathematics curriculum. Computing will be discussed as a major focus of a course or as new modules or assignments integrated into existing courses. Challenges and opportunities associated with these efforts will also be presented, along with potential NSF funding avenues. This panel is co-sponsored by the AMS, MAA, and SIAM.

Others

CBMS–TPSE Math Panel Discussion: Recent Graduates, What we Wish we had Learned, organized by **Tara Holm**, Cornell University, and **Charles Steinhorn**, Vassar College; Thursday, 9:00 am–10:30 am. The undergraduate mathematical sciences curriculum, particularly the first two years of the post-secondary curriculum, is a topic of substantial current interest. Efforts including TPSE Math, the MAA Common Vision project, and the Fall 2014 CBMS Forum on The First Two Years of College Math: Building Student Success all put a spotlight on this subject. The recent National Research Council publication, The Mathematical Sciences in 2025, informs the discussion as well. Recent graduates in the workforce can provide powerful insights to contribute to this conversation. At the fall 2014 CBMS forum and a recent TPSE Math meeting, a recent Vassar mathematics graduate spoke forcefully about those topics in the mathematical sciences to which, in hindsight, she would have liked to have been exposed during her undergraduate studies.

The proposed panel will bring together recent graduates with varied mathematical backgrounds who work in a wide range of fields to discuss what they would have like to have learned prior to beginning their careers.

The Moderator for this panel will be **Don Saari**, Conference Board of Mathematical Sciences.

Mathematical Art Exhibition, organized by **Robert Fathauer**, Tessellations Company; **Nathaniel A. Friedman**, ISAMA and SUNY Albany, **Anne Burns**, Long Island University C. W. Post Campus, **Reza Sarhangi**, Towson University, and **Nathan Selikoff**, Digital Awakening Studios. A popular feature at the Joint Mathematics Meetings, this exhibition provides a break in your day. On display are works in various media by artists who are inspired by mathematics and by mathematicians who use visual art to express their findings. Topology, fractals, polyhedra, and tiling are some of the ideas at play here. Don't miss this unique opportunity for a different perspective on mathematics. The exhibition will be located inside the Joint Mathematics Exhibits and open during the same exhibit hours.

Summer Program for Women in Mathematics (SPWM) Reunion, organized by **Murli M. Gupta**, George Washington University; Saturday, 1:00 pm–3:00 pm. This is a reunion of the summer program participants from the past 20 years (1995–2015) who are in various states of their mathematical careers: some are students (undergraduate or graduate), others are in various jobs, both in academia as well as government and industry. The participants will describe their experiences relating to all aspects of their careers. There will also be a presentation on the increasing participation of women in mathematics over the past two decades and the impact of SPWM and similar programs.

See `www.gwu.edu/~spwm`.

Success in Graduate School (and the Rest of Your Life), organized by **Patricia Hale**, California State Polytechnic University, Pomona; **Magnhild Lien**, California State University, Northridge; and **Bernd Sturmfels**, University of California at Berkeley; Thursday, 1:00 pm–2:30 pm. There is anecdotal evidence that the rate of female participation in PhD programs in mathematics has been decreasing in recent years. This panel will explore a wide range of issues that may be relevant to the personal choices behind this trend. We focus on choosing a graduate program, and

on life during and after graduate school. Specific topics, relevant for both women and men, include work/life balance, family planning, and career options. We especially welcome the participation of undergraduate students, who may be thinking about the pros and cons of going to graduate school: the panelists will be delighted to address your questions. Sponsored by the Joint Committee on Women in the Mathematical Sciences.

Social Events

All events listed are open to all registered participants. It is strongly recommended that for any event requiring a ticket, tickets should be purchased through advance registration. Only a very limited number of tickets, if any, will be available for sale on site. If you must cancel your participation in a ticketed event, you may request a 50 percent refund by returning your tickets to the Mathematics Meetings Service Bureau (MMSB) by **January 2, 2015**. After that date no refunds can be made. Special meals are available at banquets upon advance request, but this must be indicated on the Advanced Registration/Housing Form.

2016 AMS Dinner Celebration: Join your colleagues on this special occasion in celebration of service and volunteerism in the mathematical community. The AMS will recognize long-term members as well as honor the recipients of Programs That Make a Difference Award and the Exemplary Programs Award. Enjoy delicious meals from gourmet food stations, special entertainment, and enter to win fun prizes at the raffle table! This evening of celebration will be held on Saturday, January 9th with a reception at 6:30 pm and doors opening at 7:30 pm. Tickets are US$69 including tax and gratuity. The student ticket price is US$29.

Association of Christians in the Mathematical Sciences (ACMS) Reception and Lecture, Thursday, 5:30 pm–7:30 pm. The reception will take place between 5:30 pm and 6:30 pm, followed by a talk at 6:30 pm titled "Math. Love. Danger." given by **John Roe**, Penn State University, at 6:30 pm. See `www.acmsonline.org`.

Association of Lesbian, Gay, Bisexual, and Transgendered Mathematicians Reception, Thursday, 6:00 pm–8:00 pm. This annual reception is for lesbian, gay, bisexual, and transgender mathematicians, as well as their allies. We are affiliated with NOGLSTP, the National Organization of Gay and Lesbian Scientists and Technical Professionals, Inc. `www.noglstp.net/qmath.`

Association for Women in Mathematics Reception and Awards Presentation. The AWM Reception, which is open to all JMM attendees, will be held on Wednesday at 9:30 pm after the AMS Gibbs Lecture. The AWM President at 10:00 pm will recognize all of the honorees of the AWM Alice T. Schafer Prize for Excellence in Mathematics by an Undergraduate Woman, the recipients of the AWM-Microsoft Research Prize in Algebra and Number Theory, the AWM-Sadosky Research Prize in Analysis, and the AWM Service Awards.

Backgammon! organized by **Arthur Benjamin**, Harvey Mudd College; Friday, 8:00 pm–10:00 pm. Learn to play backgammon from expert players. It's a fun and exciting game where players with a good mathematics background have a decisive advantage. Boards and free lessons will be provided by members of the US Backgammon Federation. Stop by anytime on Friday evening.

Budapest Semesters in Mathematics Annual Alumni Reunion, Friday, 6:00 pm–7:30 pm.

Budapest Semesters in Mathematics Education Informational Session, Friday, 12:00 pm–1:00 pm. BSME is a semester-long program in Budapest, Hungary, designed for American and Canadian undergraduates (and recent graduates) interested in teaching middle school or high school mathematics. Participants will study the *Hungarian approach* to learning and teaching, in which a strong and explicit emphasis is placed on problem solving, mathematical creativity, and communication. Come learn more about this exciting new program.

University of Chicago, Mathematics Alumni Reception, Thursday, 6:00 pm–7:00 pm.

Reception for Graduate Students and First-Time Participants, Wednesday, 5:30 pm–6:30 pm. The AMS and MAA co-sponsor this social hour. Graduate students and first-timers are especially encouraged to come and meet some old-timers to pick up a few tips on how to survive the environment of a large meeting. Light refreshments will be served.

Knitting Circle, Thursday, 8:00 pm–9:30 pm. Bring your needlework and come knit (crochet, cross-stitch, etc.) with us while talking about math or other relaxing subjects. Catch up with your friends and meet new ones during this fun social event.

MAA/Project NExT Reception, Friday, 8:00 pm–10:00 pm, organized by **Julia Barnes**, Western Carolina University; **Alissa Crans**, Loyola Marymount University; **Matt DeLong**, Taylor University; **Dave Kung**, St. Mary's College of Maryland; and **Anthony Tongen**, James Madison University. All Project NExT Fellows, consultants, and other friends of Project NExT are invited.

MAA Two-Year College Reception, Thursday, 5:45 pm–7:00 pm, is open to all meeting participants, particularly two-year faculty members. This is a great opportunity to meet old friends and make some new ones. There will be hot and cold refreshments and a cash bar.

Mathematical Reviews Reception, Friday, 6:00 pm–7:00 pm. All friends of the Mathematical Reviews (MathSciNet) are invited to join reviewers and MR editors and staff (past and present) for a special reception in honor of all of the efforts that go into the creation and publication of the Mathematical Reviews database. Refreshments will be served.

Mathematical Institutes Open House, Wednesday, 5:30 pm–8:00 pm. Members of the AMS and MAA who are attending the Joint Mathematics Meetings are warmly invited to come to the Mathematical Institutes Open House reception, co-sponsored by several of the mathematical sciences institutes in North America. This reception precedes the Gibbs Lecture. We hope to see you there! `https://icerm.brown.edu/events/mioh/2016.`

MSRI Reception for New and Prospective MSRI Donors, Thursday, 6:30 pm–8:00 pm. Why private support matters–MSRI thanks its supporters who are ensuring MSRI's well being today and in the future. MSRI is thankful for the many mathematicians who support MSRI's programs and workshops through their membership in the Archimedes Society or the Gauss Society. Not a member yet? Come and learn about why your support matters. Archimedes Society members support MSRI with annual gifts. Gauss Society members support MSRI with a planned gift through arrangements in their will and estates. David Eisenbud, MSRI's Director, and Hélenè Barcelo, MSRI's Deputy Director, will speak about current events at MSRI. For more information, please contact: Heike Friedman, Director of Development, `hfriedman@msri.org`; 510-643-5056.

National Association of Mathematicians Banquet, Friday, 6:00 pm–8:40 pm. A cash bar reception will be held at 6:00 pm, and dinner will be served at 6:30 pm. Tickets are US$63 each, including tax and gratuity. The Cox-Talbot Invited Address will be given after the dinner.

NSA Women in Mathematics Society Networking Session, Thursday, 6:00 pm–8:00 pm. All participants are welcome to this annual event. Please stop by the NSA booth in the exhibit hall for information and the location of the event.

Pennsylvania State University Mathematics Alumni Reception, Thursday, 5:30 pm–7:30 pm. Please join us for hors d'oeuvres, beverages, and mingling, with math alumni, faculty, and College of Science representatives.

SIMIODE Reception–Free Refreshments and Door Prizes–Open to All, Friday, January 8, 2016, 7:00 pm–9:00 pm. SIMIODE-Systemic Initiative for Modeling Investigations and Opportunities with Differential Equations at `www.simiode.org`, a free and open community for using modeling to motivate the study of differential equations, sponsors this mixer. All are encouraged to meet colleagues interested in using SIMIODE to bring motivational modeling to their differential equations classroom and learn how the SIMIODE community can provide support. Engage in conversations while enjoying light refreshments and door prizes.

Student Hospitality Center, Wednesday–Friday, 9:00 am–5:00 pm, and Saturday, 9:00 am–3:00 pm, sponsored by the MAA Committee for Undergraduate Student Activities.

Reception for Undergraduates, Wednesday, 4:00 pm–5:00 pm.

Registering in Advance

The importance of registering for the meeting cannot be overemphasized. Advanced registration fees are considerably lower than on-site registration fees. The AMS and the MAA encourage all participants to register for the meeting. When a participant pays the registration fee, he or she is helping to support a wide range of activities associated with planning, organizing, and execution of the meetings.

All participants who wish to attend sessions are expected to register and should be prepared to show their badges if so requested. Badges are required to enter the Joint Mathematics Meetings (JMM) Exhibits, the Employment Center, or to obtain discounts at the AMS and MAA Book Sales and cash a check with the Joint Meetings cashier.

All JMM registrations are processed by the Mathematics Meetings Service Bureau (MMSB). Participants who register by November 17, 2015, may receive their badges, programs, and tickets (where applicable) in advance by US mail approximately three weeks before the meetings. Those who do not want their materials mailed should check the appropriate box on the Registration and Housing Form. Materials cannot be mailed to Canada, Mexico, or other countries outside of the US. Participants from these countries must pick up their materials at the Joint Meetings Registration Desk, which will be located on the fourth floor of the Washington State Convention Center. Please note that a replacement fee of US$5 will be charged for programs and badges that were mailed but not brought to the meeting.

Online Registration: The form to register for the meeting and to reserve a hotel room online is located at `www.jointmathematicsmeetings.org/meetreg?meetnum=2181`. VISA, MasterCard, Discover, and American Express are the only methods of payment accepted for online registrations, and charges to credit cards will be made in US funds. All registration acknowledgments will be sent by email to all email addresses provided.

Paper Form Registration: The form to register for the meeting and to reserve a hotel room by paper is located at `www.jointmathematicsmeetings.org/meetings/national/jmm2016/jmm16_regform.pdf`. Forms must be mailed or faxed to the MMSB at MMSB, P.O. Box 6887, Providence, RI 02940 or 401-455-4004. For security reasons, credit card numbers by email or fax cannot be accepted. If a participant is registering by paper form and would like to pay for the registration or guarantee your hotel reservation by credit card, he or she should indicate this on the form and someone from the MMSB will call that person.

Participant Lists and Mailing Lists: If any participant would like to opt-out of any mailing lists or participant lists that are generated for the meeting, he or she should check the appropriate box on the Registration and Housing Form. All participants who do not opt-out will be included in all mailing lists and participant lists that are generated and distributed for the meeting.

Cancellation Policy: Participants who cancel their registration for the meetings, minicourses, or short course by **December 31, 2015** will be eligible to receive a 50 percent refund of fees paid. Participants who cancel their banquet tickets by **January 2, 2016** will be eligible to receive a 50 percent refund of monies paid. No refunds will be issued after these deadlines.

Joint Mathematics Meetings Registration Fees

	Advanced (by Dec. 22)	At Meeting
Member of AMS, ASL, CMS, MAA, SIAM	US$282	US$371
Non-member	448	571
Graduate Student Member of AMS, ASL, CMS, MAA, SIAM	63	74
Graduate Student Non-member	101	112
Undergraduate Student Member of AMS, ASL, CMS, MAA, PME, KME, SIAM	63	74
Undergraduate Student Non-member	101	112
Temporarily Employed	230	263
Emeritus Member of AMS, MAA; Unemployed; High School Teacher; Developing Countries; Librarian	63	74
High School Student	6	12
One-Day Member of AMS, ASL, CMS, MAA, SIAM	N/A	202
One-Day Non-member	N/A	315
Non-mathematician Guest	18	18
Commercial Exhibitor	0	0
MAA Minicourses	85	85
Grad School Fair Table	75	75
AMS Short Course:		
Member of AMS	110	144
Non-member	165	195
Student/Unemployed/Emeritus	58	79

Registration Category Definitions

Full-Time Students: Any person who is currently working toward a degree or diploma is eligible. Students are asked to determine whether their status can be described as a graduate (working toward a degree beyond the bachelor's), an undergraduate (working toward a bachelor's degree), or high school (working toward a high school diploma) and to mark the Registration and Housing Form accordingly. See membership distinctions below.

Graduate Student Member: Any graduate student who is a member of the AMS, ASL, CMS, MAA, or SIAM is eligible. Students should check with their department administrator to check their membership status.

Undergraduate Student Member: Any undergraduate student who is a member of the AMS, ASL, CMS, MAA, SIAM, PME, or KME is eligible. Students should check with their department administrator to check their membership status.

Emeritus: Any person who has been a member of the AMS for twenty years or more and who retired because of age or long-term disability from his or her latest position is eligible. Anyone person who has been a member of the MAA for 25 years and who is 70+ years of age is eligible.

Librarian: Any librarian who is not a professional mathematician is eligible.

Unemployed: Any person who is currently unemployed, actively seeking employment, and is not a student is eligible. This category is not intended to include any person who has voluntarily resigned or retired from his or her latest position.

Developing Country Participant: Any person employed in developing countries where salary levels are radically not commensurate with those in the US is eligible.

Temporarily Employed: Any person currently employed but who will become unemployed by June 1, 2016, and who is actively seeking employment is eligible.

Non-mathematician Guest: Any family member or friend, who is not a mathematician, and who is accompanied by a participant in the meetings is eligible. Guests will receive a badge and may accompany a mathematician to a session or talk and may also enter the exhibit area.

Commercial Exhibitor: Any person exhibiting in the Joint Mathematics Meetings Exhibits and in the Mathematical Art Exhibition is eligible for this category. This does not include anyone participating in any poster sessions. Any exhibitor who is a mathematician and wants to attend sessions, talks, etc. is expected to register separately for the meeting.

Registration Deadlines

There are three separate registration deadlines, each with its own benefits:

EARLY meetings registration (free room drawing) is **November 2.**

ORDINARY meeting registration (hotel reservations, materials mailed) is **November 17.**

FINAL meeting registration (advanced registration, short course, minicourses, and banquets) is **December 22.**

Early Registration: Participants who **register by the early deadline of November 2** will be included in a random drawing to select winners of complimentary hotel room nights during the meeting. Rooms with multiple occupants will be included in the drawing. The location of these rooms will be based on the number of complimentary room nights earned in the various hotels; a free room will not necessarily be in winner's first-choice hotel. All winners will be notified by phone and email prior to December 22, so register early!

Ordinary Registration: Participants who register **after November 2 and by the ordinary deadline of November 17** may use the housing services offered by the MMSB but are not eligible for the free room drawing. They may also elect to receive their badges and programs by mail in advance of the meeting (US participants only).

Final Registration: Participants who register **after November 17 and by the final deadline of December 22** must pick up their badges, programs, and any tickets for social events at the meeting. Unfortunately it is sometimes not possible to provide final participants with housing, so everyone is strongly urged to make their hotel reservations by November 17. Please note that the final deadline of December 22 is firm. Any forms received after that date will be returned with full refunds. Registration materials may be picked up at the Meetings Registration Desk located on the fourth floor of the Washington State Convention Center.

How to Obtain Hotel Accommodations – 2016 Joint Mathematics Meetings

Importance of Staying in an Official Joint Mathematics Meetings Hotel

The importance of reserving a hotel room at one of the official Joint Mathematics Meetings (JMM) hotels cannot be stressed enough. The AMS and the MAA make every effort to keep participants expenses at the meeting, registration fees, and hotel rooms for the meeting as low as possible. They work hard to negotiate the best hotel rates and to make the best use of your registration dollars to keep the meetings affordable. The AMS and MAA encourage all participants to register for the meeting. When anyone pays the registration fee and reserves a room with an official JMM hotel, he or she is helping to support not only the JMM in 2016, but also future meetings.

General

Participants are encouraged to register for the JMM in order to reserve hotel rooms at the contracted JMM rates. If a participant needs to reserve a hotel room before they are registered for the JMM, he or she must contact the MMSB at `mmsb@ams.org` or 1-800-321-4267 ext. 4137 or ext. 4144 for further instructions.

Special rates have been negotiated exclusively for this meeting at the following hotels: **Sheraton Seattle** (headquarters), **Grand Hyatt Seattle**, **Fairmont Olympic Hotel Seattle**, **The Westin Seattle**, **Renaissance Seattle Hotel, The Paramount Hotel Seattle**, **Hyatt Olive 8 Seattle**, **Washington Athletic Club**, **Crowne Plaza Seattle Downtown**, and **The Roosevelt Hotel**. (See details on these hotels below.)

To receive the JMM rates, reservations for these hotels must be made through the Mathematics Meetings Service Bureau (MMSB). The hotels will not be able to accept reservations directly until after **December 14, 2015**, and at that time, rooms and rates will be based on availability. Any rooms reserved directly with the hotels before **December 14, 2015** are subject to rates higher than the JMM rates.

A link to the 2016 JMM housing site will be included at the end of the online registration form. It will also be included in the email confirmation that will be sent for registration for the meeting. If anyone needs to have the link emailed to him or her, please send the request to `mmsb@ams.org`. If anyone cannot reserve a room online, please complete the housing section of the Registration and Housing Form and send it by email to the MMSB at `mmsb@ams.org` or by fax at 401-455-4004 before **December 14, 2015.** Sorry, reservations cannot be accepted over the phone.

All reservations must be guaranteed by either a credit card or check deposit in an amount equivalent to the first night's stay. Only a credit card guarantee can be accepted for any reservation made online. If a paper form is used to reserve a room, a credit card or a check may be given for the guarantee. For security reasons, credit card numbers will not be accepted by postal mail, email, or fax. If anyone who is reserving a room by paper form wants to guarantee his or her room by credit card, he or she should call the MMSB at 1-800-321-4267, ext. 4137 or 4144. Note that the paper version of the registration form is located at the end of this announcement.

ADA Accessibility

We strive to take the appropriate steps required to ensure that no individual with a disability is excluded, denied services, segregated, or otherwise treated differently. If special assistance, auxiliary aids, or other reasonable accommodations to fully participate in this meeting is required, it should be indicated in the appropriate section on the Registration and Housing Form or emailed to the MMSB at `mmsb@ams.org`. Requests for ADA-accessible rooms should also be clearly indicated when making hotel reservations. All requests for special accommodations under the Americans with Disabilities Act of 1990 (ADA) must be made allowing enough time for evaluation and appropriate action by the AMS and MAA. Any information obtained about any disability will remain confidential.

Cancellation Policies

· 24-hour cancellation policy prior to check-in: Sheraton Seattle Hotel, Grand Hyatt Seattle, Hyatt Olive 8 Seattle, The Paramount Hotel Seattle

· 48-hour cancellation policy prior to check-in: The Fairmont Olympic Hotel

· 72-hour cancellation policy prior to check-in: The Westin Seattle, Renaissance Seattle Hotel, Inn at the Washington Athletic Club, Crowne Plaza Seattle Downtown, The Roosevelt Hotel Seattle

Check-in/Check-out

· Check-in at 3:00 p.m. and check-out at Noon: Sheraton Seattle Hotel, The Fairmont Olympic Hotel, The Westin Seattle, Hyatt Olive 8 Seattle, Inn at the Washington Athletic Club

· Check-in at 3:00 p.m. and check-out at 11:00 a.m.: Grand Hyatt Seattle

· Check-in at 4:00 p.m. and check-out at Noon: Renaissance Seattle Hotel, Crowne Plaza Seattle Downtown, The Roosevelt Hotel Seattle, The Paramount Hotel Seattle

Complimentary Room Drawing

Participants who register and reserve a hotel room by **November 2, 2015** will be included in a lottery for complimentary hotel room nights during the meeting. Rooms with multiple occupants will be included. The winners will be notified by phone and/or email prior to **December 22, 2015**.

Confirmations

An immediate and real-time email confirmation number will be provided for each hotel reservation made online. This confirmation number will provide each participant with direct access to edit reservations up to **December 14, 2015**. After this date, a second email confirmation for the hotel reservation will be sent from the hotel prior to your arrival. Those who did not receive a confirmation number from their hotels or who have any questions about the reservation process should contact the MMSB at `mmsb@ams.org` or 1-800-321-4267, ext. 4137 or 4144.

Deadlines

- Complimentary Room Drawing: **November 2**
- Badge/Program Mailed: **November 17**
- Reservations, Changes, and Cancellations through the MMSB: **December 14**

Environmental Policies

All of the hotels listed have environmental-friendly programs in place.

Internet Access/Wireless

· Complimentary wireless internet in all public areas, the lobby, and all sleeping rooms: Sheraton Seattle Hotel, Grand Hyatt Seattle, The Fairmont Olympic Hotel, Renaissance Seattle Hotel, Hyatt Olive 8 Seattle, Inn at the Washington Athletic Club, The Roosevelt Hotel Seattle, The Paramount Hotel Seattle, Crowne Plaza Seattle Downtown, The Westin Seattle

Looking for a Roommate?

For participants looking for a roommate, an interactive search board is available at: `http://bboards.jointmathematicsmeetings.org.`

Rates

All rates are subject to applicable local and state taxes in effect at the time of check-in; currently 15.6% state tax.

Parking

Please see the Parking section under "Travel" for options at the convention center. Parking information for each hotel is listed below.

JOINT MATHEMATICS MEETINGS
SEATTLE · JAN 6-9, 2016
AMERICAN MATHEMATICAL SOCIETY
MATHEMATICAL ASSOCIATION OF AMERICA

Sheraton Seattle Hotel (headquarters)

0.2 miles from the Washington State Convention Center

1400 Sixth Avenue
Seattle, WA 98101
Traditional Room, Single/Double Rate: US$166
Deluxe Room, Single/Double Rate: US$186
Club Level Room, Single/Double Rate: US$206
Traditional Room, Student Single/Double Rate: US$124.50

Smoke-free hotel. Restaurants: Fountain Wine Bar and Lounge, Daily Grill Restaurant, and Loulay Kitchen; Fitness center; Indoor lap pool; 24-hour business center available to registered guests; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Windows do not open; Children under 17 are free in room with an adult; Cribs available upon request at no charge; Rollaways available only in king-bedded rooms; Dogs under 60 pounds (only) allowed at no additional cost; Valet parking US$50 per day with in/out privileges; Parking rates are subject to change. The hotel offers a private car service and reservations are required in advance. Confirmations sent by email only.

Grand Hyatt Seattle

0.1 mile from the Washington State Convention Center

721 Pine Street
Seattle, WA 98101
Standard King Room, Single/Double Rate: US$159
Standard King Room, Student Single/Double Rate:US$125

Smoke-free hotel. Restaurants: Ruth's Chris Steakhouse, Blue C Sushi, NYC Deli Market, and Starbucks; Fitness center with a whirlpool, a steam room, and a sauna; a 24-hour business center available to registered guests; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Some windows open to let air in; Children under 17 are free in room with an adult; Cribs available upon request at no charge; Rollaways available only in king-bedded rooms for a nightly charge of US$15; One dog under 50 pounds or two dogs with a maximum weight of 75 pounds are allowed for US$100 up to six nights; Valet parking US$45.15 per day with in/out privileges; Self-parking US$30 per day with in/out privileges; Parking rates are subject to change. Confirmations sent by email only.

The Fairmont Olympic Hotel

0.4 miles from the Washington State Convention Center

411 University Street
Seattle, WA 98101
Deluxe King Room, Single/Double Rate: US$152
Deluxe Double Room, Single/Double Rate: US$152

Smoke-free hotel. Restaurants: The Georgian, Shuckers, and The Terrace; Fitness center; Indoor pool; 24-hour business center available to registered guests; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Windows do not open; Children under 17 are free in room with an adult; Cribs available upon request at no charge; Rollaways available only in king-bedded rooms for a one-time cost of US$15; Dogs and cats are welcomed. Pets must be 40 pounds or under. There is a pet cleaning fee of US$40 per night; Valet parking US$49 per day with in/out privileges; Self-parking US$39 per night with in/out privileges; Parking rates are subject to change. Confirmations sent by email only.

The Westin Seattle

0.4 miles from the Washington State Convention Center

1900 Fifth Avenue
Seattle, WA 98101
Standard Room, Single/Double Rate: US$139
Standard Room, Student Single/Double Rate: US$104

Smoke-free hotel. Restaurants: Relish Burger Bistro and Lobby Bar; Fitness center; Heated indoor pool; 24-hour business center available to registered guests; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Windows do not open; Children under 17 are free in room with an adult; Rollaways available only in king-bedded rooms if sofa sleepers are not used; Dogs under 80 pounds (only) allowed at no additional cost; Valet parking US$52 per day with in/out privileges; Self-parking US$43 per day with in/out privileges; Parking rates are subject to change. Confirmations sent by email only.

Renaissance Seattle Hotel	The Paramount Hotel Seattle	Hyatt Olive 8 Seattle
0.4 miles from the Washington State Convention Center 515 Madison Street Seattle, WA 98104 Standard Room, Single/Double Rate: US$139 Standard Room, Student Single/Double Rate: US$129 Smoke-free hotel. Restaurants: Maxwell's and Lobby Court Coffee Bar & Lounge; Fitness center; 24-hour business center available to registered guests; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Some windows open to let air in; Children under 12 are free in room with an adult; Rollaways available only in king-bedded rooms; Dogs under 30 pounds (only) allowed for a US$50 fee; Valet parking US$42 per day with in/out privileges; Self-parking US$34 per day with in/out privileges; Parking rates are subject to change. Confirmations sent by email only.	**0.1 miles from the Washington State Convention Center** 724 Pine Street Seattle, WA 98104 Standard Room, Single/Double Rate: US$130 Standard Room, Student Single/Double Rate: US$120 Smoke-free hotel. Restaurant: in partnership with Dragonfish Café located on the first floor; Fitness center; 24-hour business center available to registered guests; Limited amenities in guest rooms; Laptop-sized safes in guest rooms; Windows do not open; Children under 15 are free in room with an adult; Rollaways available only in king-bedded rooms; No pets allowed; Valet parking US$36 per day with in/out privileges; Parking rates are subject to change. The hotel offers a private car service and reservations are required. Confirmations sent by email only.	**0.1 miles from the Washington State Convention Center** 1635 Eighth Street Seattle, WA 98101 Standard Room, Single/Double Rate: US$125 Smoke-free hotel. Restaurant: Urbane Restaurant and Lounge; Fitness center; Indoor pool; 24-hour business center available to registered guests; Full amenities in guest rooms; Full spa; Laptop-sized safes in guest rooms; Windows do not open; Children under 17 are free in room with an adult; Rollaways available only in king-bedded rooms ; One dog under 50 pounds or two dogs with a maximum weight of 75 pounds are allowed for US$100 up to six nights; Valet parking US$45.15 per day with in/out privileges; Parking rates are subject to change. Confirmations sent by email only.
Inn at the Washington Athletic Club	**Crowne Plaza Seattle Downtown**	**The Roosevelt Hotel Seattle**
0.2 miles from the Washington State Convention Center 1356 Sixth Street Seattle, WA 98101 Standard Room, Single/Double: US$125 Smoke-free club and hotel. Restaurants: Torchy's and Sports Cafe; Starbucks onsite; Complimentary Access - 25-yard indoor pool, track, basketball court and athletic courts; Comprehensive fitness floors/classes $18.00 per day; Full Spa, Salon and Barbershop; Wellness Center: Club Shop; 24-hour business center; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Windows open; Children under 18 are free in room with an adult; Rollaways are limited, inquire directly with the MMSB; No pets allowed; Valet parking US$37 per day with in/out privileges; Self-parking is available at $35. Confirmations sent by email only.	**0.3 miles from the Washington State Convention Center** 1113 Sixth Avenue Seattle, WA 98101 Standard Room, Single/Double: US$125 Standard Room, Student Single/Double: US$115 Smoke-free hotel. Restaurant: Regatta Bar and Grille; Fitness center; 24-hour business center available to registered guests; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Sleep amenities in all guest rooms; Windows do not open; Children under 17 are free in room with an adult; Rollaways only available in king-bedded rooms; Refrigerators in all guest rooms; Pet friendly, contact the hotel for rates; Valet parking US$39 per day with in/out privileges; Parking rates are subject to change. Confirmations sent by email only.	**0.1 miles from the Washington State Convention Center** 1531 Seventh Avenue Seattle, WA 98101 Standard Room, Single/Double: US$120 Smoke-free hotel. Fitness center; 24-hour business center available to registered guests; Full amenities in guest rooms; Laptop-sized safes in guest rooms; Windows do open; Children under 15 are free in room with an adult; Sofa beds are available in all king-bedded rooms; Pet friendly, contact the hotel for rates; Valet parking US$38 per day with in/out privileges; Parking rates are subject to change. Confirmations sent by email only.


LEGEND
Approx. .25 mile
1. Sheraton Seattle Hotel
2. Crowne Plaza Hotel Seattle
3. The Fairmont Olympic Hotel
4. Grand Hyatt Seattle
5. Hyatt at Olive 8
6. Inn at the Washington Athletic Club
7. The Paramount Hotel Seattle
8. Renaissance Seattle Hotel
9. The Roosevelt Hotel
10. The Westin Seattle
S. LAKE UNION STREETCAR
BUS/LIGHT RAIL TUNNEL
SEATTLE CENTER MONORAIL
E. Republican St.
Union St.
Minor Ave.
Boren Ave.
Terry Ave.
9th Ave.
8th Ave.
7th Ave.
Seneca St.
Spring St.
Madison St.
James St.
Jefferson St.
Marion St.
Columbia St.
WASHINGTON STATE CONVENTION CENTER
6th Ave.
5th Ave.
4th Ave.
3rd Ave.
2nd Ave.
1st Ave.
Pike St.
Pine St.
University St.
WESTLAKE PARK
Westlake Ave. N.
Stewart St.
Virginia St.
Lenora St.
Blanchard St.
Bell St.
Battery St.
Wall St.
Vine St.
Cedar St.
Clay St.
Broad St.
Eagle St.
Western Ave.
Elliott Ave.
PIKE PLACE MARKET
STEINBRUECK PARK
Alaskan Way
Republican St.
Harrison St.
Thomas St.
John St.
DENNY PARK
6th Ave. N.
Taylor Ave. N.
5th Ave. N.
Denny Way
BILL & MELINDA GATES FOUNDATION
EMP MUSEUM
SEATTLE CENTER
CHIHULY GARDEN & GLASS
PACIFIC SCIENCE CENTER
Queen Anne Ave. N.
W. Republican St.
W. Harrison St.
W. Thomas St.
W. John St.
MYRTLE EDWARDS PARK
OLYMPIC SCULPTURE PARK
PIER 69
VICTORIA CLIPPER
PIER 67
BELL HARBOR CONFERENCE CENTER
PIERS 62 & 63
PIER 59
SEATTLE AQUARIUM
WATERFRONT PARK
PIER 57
SEATTLE GREAT WHEEL
PIER 55
ARGOSY CRUISES/TILLICUM VILLAGE
Ferry to Tillicum Village
N
E
S
W

Miscellaneous Information

Audio-Visual Equipment: A projection screen is included as standard equipment in all session rooms. Invited 50-minute speakers are automatically provided with an ELMO visual presenter (document camera/projector), and a laptop projector; AMS Special Sessions and Contributed Papers, and MAA Invited and Contributed Paper Sessions, are provided with a screen and a laptop projector. Blackboards are not available, nor are Internet connections in session rooms. Any request for additional equipment should be sent to `meet@ams.org` and received by November 1.

Equipment requests made at the meetings most likely will not be granted because of budgetary restrictions. Unfortunately no audiovisual equipment can be provided for committee meetings or other meetings or gatherings not on the scientific program.

Child Care: The AMS and the MAA will provide reimbursement grants of US$250 per family to help with the cost of child care for a number of registered participants at JMM2016. The funds may be used for child care that frees a parent to participate more fully in JMM.

Information about child care grants and deadlines for requesting support will be available prior to the opening of advance registration in September; watch the website at `jointmathematicsmeetings.org/meetings/national/jmm2016/2181_childcare`.

Email Services: Limited email access for all Joint Meetings participants will be available in an email center located near the JMM Registration Desk, Atrium Lobby, on the fourth level in the Washington State Convention Center. The hours of operation will be published in the program. Participants should be aware that **complimentary internet access** will be available in the networking center located in Skybridge (Hall 4D), fourth level of the convention center.

Information Distribution: Tables are set up in the exhibit area for dissemination of general information of possible interest to the members and for the dissemination of information of a mathematical nature not promoting a product or program for sale. Information must be approved by the AMS Director of Meetings and Conferences prior to being placed on these tables.

If a person or group wishes to display information of a mathematical nature promoting a product or program for sale, they may do so in the exhibit area at the Joint Books, Journals, and Promotional Materials exhibit for a fee of US$50 (posters are slightly higher) per item. Please contact the exhibits coordinator, MMSB, P.O. Box 6887, Providence, RI 02940, or by email at `cpd@ams.org` for further details.

The administration of these tables is in the hands of the AMS-MAA Joint Meetings Committee, as are all arrangements for Joint Mathematics Meetings.

Local Information: For information about the city, see `visitseattle.org`.

Photograph and Video Policy: The videotaping of any AMS or joint sponsored events, talks, and sessions is strictly forbidden without the explicit written permission of the AMS Director of Meetings and Conferences. The policy for videotaping of any MAA events, talks, and sessions is posted at `www.maa.org/about-maa/policies-and-procedures/recording-or-broadcasting-of-maa-events`. Photographs and videos of meeting interactions will be taken by professional photographers hired by the Joint Mathematics Meetings or by AMS and MAA staff. These photographs and videos may occasionally be used for publicity purposes. By participating in the Joint Mathematics Meetings, attendees acknowledge that their photograph or a video that includes them may be published in material produced by the Joint Meetings, AMS or MAA. AMS and MAA are not responsible for unauthorized photographs or other images not taken by professional photographers hired by the Joint Mathematics Meetings or AMS and MAA staff.

Telephone Messages: It will be possible to leave a message for any registered participant at the meetings registration desk from January 6 through 9 during the hours that the desk is open. These messages will be posted on the Mathematics Meetings Message Board in the networking center; however, staff at the desk will try to locate a participant in the event of a bona fide emergency. The telephone number will be published in the program and daily newsletter.

Travel/Transportation

Seattle is on Pacific Time. The principal airport is the Seattle-Tacoma International Aiport (SEA, frequently referred to as Sea-Tac) which is served by all major airlines. The website for Seattle-Tacoma International airport is `www.portseattle.org/Sea-Tac/Pages/default.aspx` and the street address is 17801 International Boulevard, Seatac, WA, 98158. It is located approximately twelve miles from downtown Seattle.

The 2016 Joint Mathematics Meetings will be held in the Washington State Convention Center in downtown Seattle, 800 Convention Place, Seattle, WA, 98101. The main entrance is on Eighth Avenue between Pike and Seneca.

Airline

The official airline for this meeting is Delta. Participants are encouraged to book their flights for the meeting, if possible, with Delta and receive special pricing (in most cases, a 5 percent discount) on scheduled service to Seattle. Discounts are applicable to US and Canada originating passengers. This discount is not valid with other discounts, certificates, coupons, or promotional offers.

To make a reservation, go to `www.delta.com`, and click on the box that says "Book a Trip". At the bottom of the drop-down, click on "Advanced Search" (includes Flexible Airport and Meeting Event Code). On the reservation screen, please enter the Meeting Event Code NMLNH. It is located to the right of "Number of Passengers." Reservations can also be made by calling Delta Meeting Network Reservations at 1-800-328-1111 and citing the meeting event code. A direct ticketing charge will apply for booking by phone.

Ground Transportation

Car Rental: All major rental car companies have offices at the Sea-Tac airport. There is a separate rental car facility with dedicated shuttle buses operating on a 24-hour-a-day

schedule. Two passenger pick-up areas are located outside baggage claim at the north and south ends of the main terminal. Proceed to the baggage claim level and pick up your checked bags. Exit the sliding glass doors near either carousel #1 or #15 and walk to one of the two designated shuttle bus pick-up areas for transportation to the rental car facility.

Hertz is the official car rental company for the meeting. A brochure with the information for this meeting is located at `jointmathematicsmeetings.org/Hertz-info-Seattle.pdf`. To access the JMM special meeting rates at www.hertz.com, enter the standard information (pickup location, dates, etc.) and then click the box that says "Enter a discount or promo code" and enter 04N30006 as the convention number (CV#). Reservations can also be made by calling Hertz directly at 800-654-2240 (US and Canada) or 405-749-4434.

Meeting rates include unlimited mileage and are subject to availability. Advance reservations are recommended and blackout dates may apply. Government surcharges, taxes, tax reimbursement, airport-related fees, vehicle licensing fees and optional items are extra. Standard rental conditions and qualifications apply. Vehicles must be returned to the renting location. Minimum rental age is 20 (age differential charge for 20–24 applies).

Weekend rentals are available in the continental US and Canada for pickup between noon Thursday and noon Sunday and must be returned no later than Monday at 11:59 pm. Thursday pick-up requires a minimum three-day keep. Friday pick-up requires a minimum two-day keep, and Saturday and Sunday pick-up require a one-day keep. Weekly rentals are from five to seven days. Extra day rate for weekly rentals will be one-fifth the Weekly Rate.

Driving Directions from the Airport to the Center: The Washington State Convention Center (WSCC) is located at 800 Convention Place, Seattle, WA 98101-2350. Take a slight left onto Airport Expressway. Merge onto WA-518 E toward I-5/I-405 Seattle/Tacoma. Merge onto I-5 N via the exit on the left toward Seattle. Take Exit 164A, Madison Street, from I-5 N. At the underpass, stay to the left and then merge into the right lane. Follow the exit toward Madison Street/Convention Center. Move to the right lane. This lane becomes 7th Avenue. Turn right onto Madison Street. Immediately move to the left turn lane. Turn left at the end of the block onto Eighth Avenue. Follow Eighth Avenue a short distance over the bridge. Turn right into the WSCC parking garage. The trip takes approximately 25 minutes, depending on traffic.

Driving Directions from the Airport to the Sheraton: The Sheraton Seattle Hotel is located at 1400 Sixth Avenue, Seattle, WA, 98101. Take a slight left onto Airport Expressway. Merge onto WA-518 E toward I-5/I-405 Seattle/Tacoma. Merge onto I-5 N via the exit on the left toward Seattle. Take Exit 165, Seneca Street, on the left. Turn right onto Sixth Avenue. The trip takes approximately 25 minutes, depending on traffic.

Taxi: The taxi stand is located on the third floor of the airport garage. The phone number for Seattle Yellow Cab is 206-622-6500, and the website is `www.seattleyellowcab.com/seatac-taxi-rides/`. One-way fare to the downtown area is approximately US$45.

Seattle Sound Transit Link Light Rail: The SeaTac/Airport Station is connected to the fourth floor of the airport parking garage by a covered walkway. Wheelchair service is available. Take the train at SeaTac/Airport station and go to the end of the line at Westlake Center. Westlake Center is located at 4th Avenue and Pine Street. To go to the Sheraton Seattle from Westlake Center, go 1/2 block east on Pine Street, and 2 blocks south on Sixth Avenue. Trains run every 8–15 minutes from 5:00 am to 1:00 am on weekdays, and every 15 minutes on Saturday. On Sunday, the trains run from 6:00 am to midnight. One way fare is currently US$2.75. The trip takes approximately 35 minutes. The schedule and more information is located at `www.soundtransit.org/Schedules/Link-light-rail`.

Downtown Airporter Shuttle: The Downtown Airporter/Shuttle Express picks up and drops off at the inner drive curb on the third floor of the airport garage. It departs twice an hour from 6:30 am to 9:00 pm, with service to and from many downtown Seattle hotels, including the Crowne Plaza, Fairmont Olympic, Grand Hyatt, Renaissance Seattle, Seattle Sheraton, and the Westin Hotel. Online reservations are required. The fare is approximately US$19 one way, and the trip can take up to an hour, depending on traffic. Share ride and private service is also available. Call 425-981-7000 or go to `shuttle-express.com/seattle/airport/downtown-airporter` for more detail.

Parking: The Washington State Convention Center operates two parking garages, the WSCC Garage and the Freeway Park Garage. The WSCC Garage entrance is located on Eighth Avenue between Pike and Seneca, and it is open daily between 5:30 am and midnight. The entrance to the Freeway Park Garage is located on Hubbell Place between Pike and Seneca. It is open Monday-Friday, 5:30 am to 8:00 pm. Directions to the parking garages and rates are located at `www.wscc.com/parking-directions`. The parking map is located at `www.wscc.com/sites/default/files/find-it/files/2014.09.09_FIND_IT_Parking_map.pdf`.

See hotel page for details on parking at the hotels.

Welcoming Environment Policy

The AMS and MAA strive to ensure that participants in the Joint Mathematics Meetings (JMM) enjoy a welcoming environment. In all JMM activities, the two organizations seek to foster an atmosphere that encourages the free expression and exchange of ideas. The AMS and MAA support equality of opportunity and treatment for all participants, regardless of gender, gender identity or expression, race, color, national or ethnic origin, religion or religious belief, age, marital status, sexual orientation, disabilities, or veteran status.

Harassment is a form of misconduct that undermines the integrity of JMM activities as well as the AMS and MAA missions.The AMS and MAA will make every effort to maintain an environment that is free of harassment, even though they do not control the behavior of third parties. A

commitment to a welcoming environment is expected of all attendees at JMM activities, including mathematicians, students, guests, staff, contractors and exhibitors, and participants in scientific sessions and social events. To this end, the AMS and MAA will include a statement concerning their expectations toward maintaining a welcoming environment in registration materials, and have put in place a mechanism for reporting violations. Violations may be reported confidentially and anonymously to 855-282-5703 or at `www.mathsociety.ethicspoint.com`. The reporting mechanism ensures the respect of privacy while alerting the AMS and MAA to the situation.

Athens, Georgia

University of Georgia

March 5–6, 2016

Saturday–Sunday

Meeting #1117

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: January 2016
Program first available on AMS website: To be announced
Issue of *Abstracts*: Volume 37, Issue 2

Deadlines

For organizers: Expired
For abstracts: January 19, 2016

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Michele Benzi, Emory University, *Title to be announced.*

Frank Garvan, University of Florida, *Title to be announced.*

William Graham, University of Georgia, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Algebraic Structures in Knot Theory (Code: SS 5A), **Sam Nelson**, Claremont McKenna College, and **Mohamed Elhamdadi**, University of South Florida.

Combinatorial and Computational Algebra (Code: SS 7A), **Huy Tai Ha**, Tulane University, **Kuei-Nan Lin**, Penn State Greater Allegheny, and **Augustine O'Keefe**, Connecticut College.

Commutative Algebra (Code: SS 6A), **Jon F. Carlson**, University of Georgia, and **Andrew Kustin**, University of South Carolina.

Elliptic Curves (Code: SS 1A), **Abbey Bourdon** and **Pete L. Clark**, University of Georgia.

Lie Theory, Representation Theory, and Geometry (Code: SS 3A), **Shrawan Kumar**, University of North Carolina, and **Daniel K. Nakano** and **Paul Sobaje**, University of Georgia.

Mathematical Physics and Spectral Theory (Code: SS 4A), **Stephen Clark**, Missouri University of Science and Technology, and **Roger Nichols**, The University of Tennessee at Chattanooga.

Moduli Spaces and Vector Bundles (Code: SS 8A), **Patricio Gallardo** and **Anna Kazanova**, University of Georgia.

Probabilistic and Analytic Tools in Convexity (Code: SS 2A), **Joseph Fu**, University of Georgia, **Galyna Livshyts**, Georgia Institute of Technology, and **Elisabeth Werner**, Case Western Reserve University.

The Combinatorics of Symmetric Functions (Code: SS 9A), **Sarah K. Mason**, Wake Forest University, and **Elizabeth Niese**, Marshall University.

Stony Brook, New York

State University of New York at Stony Brook

March 19–20, 2016

Saturday–Sunday

Meeting #1118

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2016
Program first available on AMS website: To be announced
Issue of *Abstracts*: Volume 37, Issue 2

Deadlines

For organizers: Expired
For abstracts: February 2, 2016
The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Simon Donaldson, Stony Brook University, *Title to be announced.*

Dmitry Kleinbock, Brandeis University, *Title to be announced.*

Irena Lasiecka, University of Memphis, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Geometric Measure Theory and Its Applications (Code: SS 2A), **Matthew Badger**, University of Connecticut, and **Christopher J. Bishop** and **Raanan Schul**, Stony Brook University.

Holomorphic Dynamics (Code: SS 4A), **Artem Dudko** and **Raluca Tanase**, Stony Brook University.

Invariants of Closed Curves on Surfaces (Code: SS 1A), **Ara Basmajian**, Hunter College and Graduate Center, City University of New York, and **Moira Chas**, Stony Brook University.

Mathematical General Relativity (Code: SS 3A), **Lan-Hsuan Huang**, University of Connecticut, **Marcus Khuri**, Stony Brook University, and **Christina Sormani**, Lehman College and City University of New York Graduate Center.

Salt Lake City, Utah

University of Utah

April 9–10, 2016

Saturday–Sunday

Meeting #1119

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: January 2016
Program first available on AMS website: To be announced
Issue of *Abstracts*: Volume 37, Issue 2

Deadlines

For organizers: September 9, 2015
For abstracts: February 16, 2016

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Ravi Vakil, Stanford University, *Cutting and pasting in algebraic geometry* (Erdős Memorial Lecture).

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Algebraic Geometry (association with the Erdős Lecture by Ravi Vakil) (Code: SS 1A), **Ravi Vakil**, Stanford University, and **Christopher Hacon** and **Karl Schwede**, University of Utah.

CR geometry and partial differential equations in complex analysis (Code: SS 4A), **Yuan Yuan**, Syracuse University, and **Yuan Zhang**, Indiana University-Purdue University Fort Wayne.

Inverse Problems (Code: SS 2A), **Hanna Makaruk**, Los Alamos National Laboratory (LANL), and **Robert Owczarek**, University of New Mexico, Albuquerque and UNM, Los Alamos.

Representations of reductive p-adic groups (Code: SS 3A), **Shiang Tang** and **Gordan Savin**, University of Utah.

Fargo, North Dakota

North Dakota State University

April 16–17, 2016

Saturday–Sunday

Meeting #1120

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: February 2016
Program first available on AMS website: To be announced
Issue of *Abstracts*: Volume 37, Issue 2

Deadlines

For organizers: September 16, 2015
For abstracts: February 23, 2016

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Rodrigo Banuelos, Purdue University, *Title to be announced.*

Laura Matusevich, Texas A&M University, *Title to be announced.*

Jeff Viaclovsky, University of Wisconsin-Madison, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Commutative Algebra and Its Interactions with Combinatorics and Algebraic Geometry (Code: SS 4A), **Susan Cooper**, North Dakota State University, and **Adam Van Tuyl**, McMaster University.

Commutative Ring Theory (Code: SS 6A), **Catalin Ciuperca** and **Sean Sather-Wagstaff**, North Dakota State University.

Contemporary Issues in Mathematics Education (Code: SS 8A), **Abraham Ayebo**, North Dakota State University.

Convexity and Harmonic Analysis (Code: SS 2A), **Maria Alfonseca-Cubero**, North Dakota State University, and **Dmitry Ryabogin**, Kent State University.

Ergodic Theory and Dynamical Systems (Code: SS 1A), **Dogan Comez**, North Dakota State University, and **Mrinal Kanti Roychowdhury**, University of Texas-Pan American.

Frames, Harmonic Analysis, and Operator Theory (Code: SS 7A), **Gabriel Picioroaga**, University of South Dakota, and **Eric Weber**, Iowa State University.

Integrable Dynamical Systems and Special Functions (Code: SS 5A), **Oksana Bihun**, Concordia College.

Mathematical Finance (Code: SS 3A), **Indranil SenGupta**, North Dakota State University.

Brunswick, Maine

Bowdoin College

September 24–25, 2016

Saturday–Sunday

Meeting #1121

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: June 2016
Program first available on AMS website: To be announced
Issue of *Abstracts*: Volume 37, Issue 3

Deadlines

For organizers: February 24, 2016
For abstracts: July 19, 2016

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Tim Austin, New York University, *Title to be announced.*

Moon Duchin, Tufts University, *Title to be announced.*

Thomas Lam, University of Michigan, *Title to be announced.*

Denver, Colorado

University of Denver

October 8–9, 2016

Saturday–Sunday

Meeting #1122

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2016
Program first available on AMS website: To be announced
Issue of *Abstracts*: Volume 37, Issue 2

Deadlines

For organizers: March 8, 2016
For abstracts: August 16, 2016
The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at `www.ams.org/cgi-bin/abstracts/abstract.pl`.

Algebraic Logic (Code: SS 1A), **Nick Galatos**, University of Denver, and **Peter Jipsen**, Chapman University.

Analysis on Graphs and Spectral Graph Theory (Code: SS 2A), **Paul Horn** and **Mei Yin**, University of Denver.

Nonassociative Algebra (Code: SS 3A), **Izabella Stuhl**, University of Debrecen and University of Denver, and **Petr Vojtěchovský**, University of Denver.

Noncommutative Geometry and Fundamental Applications (Code: SS 4A), **Frederic Latremoliere**, University of Denver.

Operator Algebras and Applications (Code: SS 5A), **Alvaro Arias**, University of Denver.

Recent Trends in Semigroup Theory (Code: SS 6A), **Michael Kinyon**, University of Denver, and **Ben Steinberg**, City College of New York.

Set Theory of the Continuum (Code: SS 7A), **Natasha Dobrinen** and **Daniel Hathaway**, University of Denver.

Unimodularity in Randomly Generated Graphs (Code: SS 8A), **Florian Sobieczky**, University of Denver.

Vertex Algebras and Geometry (Code: SS 9A), **Andrew Linshaw**, University of Denver, and **Thomas Creutzig**, University of Alberta.

Zero Dimensional Dynamics (Code: SS 10A), **Nic Ormes** and **Ronnie Pavlov**, University of Denver.

Minneapolis, Minnesota

University of St. Thomas

October 28–30, 2016

Friday–Sunday

Meeting #1123

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2016
Program first available on AMS website: To be announced
Issue of *Abstracts*: Volume 37, Issue 3

Deadlines

For organizers: March 22, 2016
For abstracts: August 30, 2016

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Thomas Nevins, University of Illinois Urbana-Champaign, *Title to be announced.*

Charles Rezk, University of Illinois Urbana-Champaign, *Title to be announced.*

Christof Sparber, University of Illinois at Chicago, *Title to be announced.*

Samuel Stechmann, University of Wisconsin-Madison, *Title to be announced.*

Raleigh, North Carolina

North Carolina State University at Raleigh

November 12–13, 2016

Saturday–Sunday

Meeting #1124

Southeastern Section

Associate secretary: Brian D. Boe
Announcement issue of *Notices*: September 2016
Program first available on AMS website: To be announced
Issue of *Abstracts*: Volume 37, Issue 4

Deadlines

For organizers: April 12, 2016
For abstracts: September 13, 2016

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Ricardo Cortez, Tulane University, *Title to be announced.*

Jason Metcalfe, University of North Carolina at Chapel Hill, *Title to be announced.*

Agnes Szanto, North Carolina State University, *Title to be announced.*

Atlanta, Georgia

Hyatt Regency Atlanta and Marriott Atlanta Marquis

January 4–7, 2017

Wednesday–Saturday

Meeting #1125

Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: October 2016
Program first available on AMS website: To be announced
Issue of *Abstracts*: Volume 38, Issue 1

Deadlines

For organizers: April 1, 2016
For abstracts: To be announced

Charleston, South Carolina

College of Charleston

March 10–12, 2017

Friday–Sunday

Meeting #1126

Southeastern Section
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: November 10, 2016
For abstracts: To be announced

Bloomington, Indiana

Indiana University

April 1–2, 2017

Saturday–Sunday

Meeting #1127

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For abstracts: To be announced

Pullman, Washington

Washington State University

April 22–23, 2017

Saturday–Sunday

Meeting #1128

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For abstracts: To be announced

New York, New York

Hunter College, City University of New York

May 6–7, 2017

Saturday–Sunday

Meeting #1129

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 14, 2016
For abstracts: March 21, 2017

Montréal, Quebec Canada

McGill University

July 24–28, 2017

Monday–Friday

Meeting #1130

Mathematical Congress of the Americas 2017 (MCA 2017), the Second Mathematical Congress of the Americas (MCA).
Associate secretary: Brian D. Boe
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: July 31, 2016
For abstracts: To be announced

Buffalo, New York

State University of New York at Buffalo

September 16–17, 2017

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
Issue of *Abstracts*: To be announced

Deadlines

For organizers: February 14, 2017
For abstracts: To be announced

Riverside, California

University of California, Riverside

November 4–5, 2017

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
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 10–13, 2018

Wednesday–Saturday
Joint Mathematics Meetings, including the 124th Annual Meeting of the AMS, 101st Annual Meeting of the Mathematical Association of America (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 of Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2017
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 1, 2017
For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center, Hilton Baltimore, and Baltimore Marriott Inner Harbor Hotel

January 16–19, 2019

Wednesday–Saturday
Joint Mathematics Meetings, including the 125th Annual Meeting of the AMS, 102nd 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 of 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 2018
Program first available on AMS website: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 2, 2018
For abstracts: To be announced

Program at a Glance

THIS ONLINE PROGRAM CONTAINS UPDATES THAT WERE NOT AVAILABLE AT PRESS-TIME AND SO ARE NOT PRESENT IN THE PRINT VERSION

This document provides a thumbnail sketch of all scientific and social events so you can easily see which events may overlap and better plan your time.

JOINT MATHEMATICS MEETINGS

SEATTLE • JAN 6-9, 2016

AMERICAN MATHEMATICAL SOCIETY

MATHEMATICAL ASSOCIATION OF AMERICA

Monday, January 04

9:00 am–5:30 pm	**AMS SHORT COURSE ON RIGOROUS NUMERICS IN DYNAMICS, PART I**
9:00 am–4:30 pm	**MAA ANCILLARY WORKSHOP** *Bringing Passion to your Introductory Statistics Classroom: a supportive, multidisciplinary project-based approach*
3:00 pm–6:00 pm	**NSF-EHR GRANT PROPOSAL WRITING WORKSHOP**

Tuesday, January 05

8:00 am–4:45 pm	**AMS SHORT COURSE ON RIGOROUS NUMERICS IN DYNAMICS, PART II**
8:00 am–6:30 pm	**AMS DEPARTMENT CHAIRS WORKSHOP**
9:00 am–11:00 am	**MAA MINICOURSE #1: PART A** *Introductory proposal writing for grant applications to the NSF EHR/Division of Undergraduate Education.*
9:00 am–4:30 pm	**MAA ANCILLARY WORKSHOP** *National research experiences for undergraduates.*
9:00 am–4:30 pm	**MAA ANCILLARY WORKSHOP** *Teaching the Statistical Investigation Process with Randomization-Based Inference*
9:00 am–5:00 pm	**MAA BOARD OF GOVERNORS**
2:00 pm–3:00 pm	**MAA MINICOURSE #1: PART B** *Introductory proposal writing for grant applications to the NSF EHR/Division of Undergraduate Education.*
1:30 pm–10:00 pm	**AMS COUNCIL**
3:00 pm–8:00 pm	**JOINT MEETINGS REGISTRATION**, Atrium Lobby, 4th Floor, Washington State Convention Center
3:00 pm–8:00 pm	**EMAIL CENTER**

Wednesday, January 06

7:00 am–8:45 am	**MAA MINORITY CHAIRS MEETING**
7:30 am–6:00 pm	**JOINT MEETINGS REGISTRATION**, Atrium Lobby, 4th Floor, Washington State Convention Center
7:30 am–9:30 pm	**EMAIL CENTER**
	AMS SPECIAL SESSIONS:
8:00 am–11:00 am	*Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, I (AMS-MAA-SIAM)*

8:00 am–11:00 am	*Innovative Ideas in Enhancing Success in Mathematics Classes, I (AMS-MAA)*
8:00 am–11:00 am	*Set-Valued Optimization and Variational Problems with Applications, I*
8:00 am–11:00 am	*Operators, Function Spaces, and Models, I*
8:00 am–11:00 am	*Interactions between Noncommutative Algebra, Algebraic Geometry, and Representation Theory, I*
8:00 am–11:00 am	*Origami Methods and Applications, I*
8:00 am–11:00 am	*Recent Advances in Dynamical Systems and Mathematical Biology, I*
8:00 am–11:00 am	*Moduli Spaces in Symplectic Geometry*
8:00 am–11:00 am	*Modular Forms, q-Series, and Mathematics Inspired by Ramanujan*
8:00 am–11:00 am	*Recent Developments in Dispersive Partial Differential Equations and Harmonic Analysis, I*
8:00 am–11:00 am	*Mathematics and Public Policy*
8:00 am–10:50 am	*Topological Representation Theory, I*
8:00 am–11:00 am	*Research from the 2014 and 2015 Rocky Mountain-Great Plains Graduate Research Workshop in Combinatorics, I*
8:00 am–11:00 am	*Analysis and Geometry in Nonsmooth Metric Measure Spaces, I*
8:00 am–11:00 am	*Integrable Systems, Painlevé Equations, and Random Matrices, I*
8:00 am–11:00 am	*Mathematical Information in the Digital Age of Science, I*
8:00 am–11:00 am	*Tensor Decompositions and Secant Varieties*
8:00 am–11:00 am	*Arithmetic Dynamics, I*
8:00 am–10:55 am	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
	MAA CONTRIBUTED PAPER SESSIONS:
8:00 am–11:00 am	*Assessing Student Learning: Alternative Approaches*
8:00 am–11:00 am	*The Scholarship of Teaching and Learning in Collegiate Mathematics*
8:00 am–11:00 am	*Mathematics and the Arts, I*
8:00 am–11:00 am	*Proofs and Mathematical Reasoning in the first Two Years of College*
8:00 am–11:00 am	*Experiences and Innovations in Teaching Probability Theory*
8:00 am–10:55 am	**MAA GENERAL CONTRIBUTED PAPER SESSIONS**
8:00 am–10:55 am	**SIAM MINI-SYMPOSIUM ON OPTIMIZATION**
8:00 am– 9:20 am	**MAA/NCTM JOINT COMMITTEE ON MUTUAL CONCERNS, COLLEGE BOARD/MAA JOINT COMMITTEE ON MUTUAL CONCERNS PANEL DISCUSSION** *Creating a meaningful calculus I experience for students entering with high school calculus.*
8:00 am– 9:15 am	**MAA COMMITTEE ON PROFESSIONAL DEVELOPMENT SESSION: NSF FUNDING OPPORTUNITIES FOR THE LEARNING AND TEACHING OF THE MATHEMATICAL SCIENCES, PART I** *Undergraduate/Graduate education, department of mathematics infrastructure, and human resource development.(DUE/DGE/DMS/HRD)*
8:30 am– 5:30 pm	**EMPLOYMENT CENTER**
9:00 am–11:00 am	**MAA MINICOURSE #11: PART A** *Implementing inquiry-oriented curricula for linear algebra, differential equations, and abstract algebra.*
9:00 am–11:00 am	**MAA MINICOURSE #12: PART A** *Humanistic mathematics.*
9:00 am–11:00 am	**MAA MINICOURSE #5: PART A** *Teaching introductory statistics for instructors new to teaching statistics.*
9:00 am–10:30 am	**AMS DIRECTORS OF GRADUATE STUDIES**
9:00 am– 5:00 pm	**STUDENT HOSPITALITY/INFORMATION CENTER**
9:30 am–10:30 am	**MAA COMMITTEE ON PROFESSIONAL DEVELOPMENT: NSF FUNDING OPPORTUNITIES FOR THE LEARNING AND TEACHING OF THE MATHEMATICAL SCIENCES, PART II** *The K-16 continuum-learning science and research and pre- and in-service teachers. (DUE/DRL)*
9:35 am–10:55 am	**MAA PANEL DISCUSSION** *Advanced placement calculus today: Opportunities and challenges.*
10:05 am–10:55 am	**AMS INVITED ADDRESS** *Prestrained elasticity: curvature constraints and differential geometry with low regularity.* **Marta Lewicka**
11:10 am–12:00 pm	**AMS-MAA INVITED ADDRESS** *Statistical paradises and paradoxes in big data.* **Xiao-Li Meng**

12:15 pm–5:30 pm	**EXHIBITS AND BOOK SALES**
1:00 pm–2:00 pm	**AMS COLLOQUIUM LECTURES: LECTURE I** *Generalizations of Fourier analysis, and how to apply them (Part I).* **Timothy A. Gowers**
	MAA CONTRIBUTED PAPER SESSION:
2:00 pm–6:00 pm	*Topics and Techniques for Teaching Real Analysis*
2:15 pm–3:05 pm	**MAA INVITED ADDRESS** *Singing along with math: The mathematical work of the opera singer Jerome Hines.* **T. Christine Stevens**
	AMS SPECIAL SESSIONS:
2:15 pm–6:15 pm	*Innovative Ideas in Enhancing Success in Mathematics Classes, II (AMS-MAA)*
2:15 pm–6:15 pm	*The History of Mathematics, I (AMS-MAA)*
2:15 pm–6:15 pm	*Set-Valued Optimization and Variational Problems with Applications, II*
2:15 pm–6:15 pm	*Operators, Function Spaces, and Models, II*
2:15 pm–6:15 pm	*Interactions between Noncommutative Algebra, Algebraic Geometry, and Representation Theory, II*
2:15 pm–6:15 pm	*What's New in Group Theory?, I*
2:15 pm–6:15 pm	*Parabolic Geometries, Twistor Theory, and the AdS/CFT Correspondence, I*
2:15 pm–6:15 pm	*Origami Methods and Applications, II*
2:15 pm–6:15 pm	*Recent Advances in Dynamical Systems and Mathematical Biology, II*
2:15 pm–6:15 pm	*Recent Developments in Dispersive Partial Differential Equations and Harmonic Analysis, II*
2:15 pm–6:15 pm	*Topological Representation Theory, II*
2:15 pm–6:15 pm	*Research from the 2014 and 2015 Rocky Mountain-Great Plains Graduate Research Workshop in Combinatorics, II*
2:15 pm–6:15 pm	*Analysis and Geometry in Nonsmooth Metric Measure Spaces, II*
2:15 pm–6:15 pm	*Integrable Systems, Painlevé Equations, and Random Matrices, II*
2:15 pm–6:15 pm	*Mathematical Information in the Digital Age of Science, II*
2:15 pm–6:15 pm	*Metrical and Topological Fixed Point Theory with Applications*
2:15 pm–6:15 pm	*Problems in Geometry and Design of Materials, I*
2:15 pm–6:15 pm	*Pseudorandomness and Its Applications, I*
2:15 pm–6:15 pm	*Big Demand for Big Data: How Do We Create the Big Supply?, I*
2:15 pm–4:15 pm	**MAA MINICOURSE #4: PART A** *Teaching mathematics with sports applications.*
2:15 pm–4:15 pm	**MAA MINICOURSE #8: PART A** *Algebraic geometry: A problem-based course.*
2:15 pm–4:15 pm	**MAA MINICOURSE #9: PART A** *Increasing student engagement and understanding through active learning strategies in calculus.*
2:15 pm–5:55 pm	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
	MAA CONTRIBUTED PAPER SESSIONS:
2:15 pm–6:00 pm	*Quantitative Literacy in the K–16 Curriculum*
2:15 pm–6:00 pm	*Mathematics and the Arts, II*
2:15 pm–6:00 pm	*Professional Development for Mathematicians: A Session for MAA PREP Organizers and Participants*
2:15 pm–5:55 pm	**MAA GENERAL CONTRIBUTED PAPER SESSIONS**
2:15 pm–6:00 pm	**SIAM MINI-SYMPOSIUM ON INVERSE PROBLEMS AND APPLICATIONS**
2:15 pm–3:35 pm	**MAA WORKSHOP** *The enjoyment of employment: finding the right organizational culture.*
2:15 pm–3:35 pm	**MAA PANEL DISCUSSION** *Developing the MAA Pedagogy Guide.*
2:15 pm–4:15 pm	**PROJECT NEXT-YOUNG MATHEMATICIANS' NETWORK- POSTER SESSION**
2:15 pm–3:40 pm	**ASSOCIATION FOR WOMEN IN MATHEMATICS PANEL DISCUSSION** *Research collaboration conferences for women: who, what, where, when, why, and how?*
3:20 pm–4:10 pm	**MAA INVITED ADDRESS** *Mathematics and policy: Strategies for effective advocacy.* **Katherine D. Crowley**
3:45 pm–4:15 pm	**AWM BUSINESS MEETING**

3:50 pm–5:10 pm	**MAA COMMITTEE ON PROFESSIONAL DEVELOPMENT PANEL DISCUSSION** *Improving the preparation of graduate students to teach mathematics: An NSF-funded project.*
3:50 pm–5:10 pm	**MAA YOUNG MATHEMATICIANS' NETWORK PANEL DISCUSSION** *Finding a thesis topic and advisor.*
4:00 pm–5:00 pm	**MAA SECTION OFFICERS**
4:30 pm–6:00 pm	**AMS COMMITTEE ON THE PROFESSION PANEL DISCUSSION** *Promoting mathematics to policy makers and the public*
4:30 pm–5:30 pm	**RECEPTION FOR UNDERGRADUATE STUDENTS**
4:45 pm–6:45 pm	**MAA MINICOURSE #16: PART A** *Moble mathematics—interactive apps for teaching and learning.*
4:45 pm–6:45 pm	**MAA MINICOURSE #2: PART A** *Visual topics in undergraduate complex analysis.*
4:45 pm–6:45 pm	**MAA MINICOURSE #3: PART A** *Designing and implementing a problem-based mathematics course.*
5:30 pm–6:30 pm	**RECEPTION FOR GRADUATE STUDENTS AND FIRST-TIME PARTICIPANTS**
5:30 pm–8:00 pm	**MATHEMATICAL INSTITUTES OPEN HOUSE**
8:30 pm–9:30 pm	**AMS JOSIAH WILLARD GIBBS LECTURE** *Title to be announced.* **Daniel A. Spielman**
9:30 pm–11:00 pm	**ASSOCIATION FOR WOMEN IN MATHEMATICS RECEPTION AND AWARDS PRESENTATION**

Thursday, January 07

7:30 am–4:00 pm	**JOINT MEETINGS REGISTRATION**, Atrium Lobby, 4th Floor, Washington State Convention Ctr.
7:30 am–9:00 pm	**EMAIL CENTER**
	AMS SPECIAL SESSIONS:
8:00 am–12:00 pm	*The History of Mathematics, II (AMS-MAA)*
8:00 am–12:00 pm	*Fractal Geometry and Dynamical Systems, I*
8:00 am–12:00 pm	*Quantum Walks, Quantum Markov Chains, Quantum Computation and Related Topics, I*
8:00 am–12:00 pm	*Topological Graph Theory: Structure and Symmetry, I*
8:00 am–12:00 pm	*Advances in Free Analysis: the Theory and Applications of Noncommutative Functions, Inequalities, and Domains, I*
8:00 am–12:00 pm	*What's New in Group Theory?, II*
8:00 am–12:00 pm	*Graduate Mathematics Courses and Programs for Secondary Mathematics Teachers*
8:00 am–12:00 pm	*Parabolic Geometries, Twistor Theory, and the AdS/CFT Correspondence, II*
8:00 am–12:00 pm	*Knots in Washington (State), I*
8:00 am–12:00 pm	*Analysis, Geometry, and Data*
8:00 am–12:00 pm	*Research by Postdocs of the Alliance for Diversity in Mathematics, I*
8:00 am–12:00 pm	*Combinatorial Design Theory, I*
8:00 am–12:00 pm	*Mathematical Information in the Digital Age of Science, III*
8:00 am–12:00 pm	*Problems in Geometry and Design of Materials, II*
8:00 am–12:00 pm	*Pseudorandomness and Its Applications, II*
8:00 am–12:00 pm	*Big Demand for Big Data: How Do We Create the Big Supply?, II*
8:00 am–11:50 am	*Commutative Algebra, I (a Mathematics Research Communities Session)*
8:00 am–11:50 am	*Financial Mathematics, I (a Mathematics Research Communities Session)*
8:00 am–11:50 am	*Differential Equations, Probability and Sea Ice, I (a Mathematics Research Communities Session)*
8:00 am–11:55 am	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
	MAA CONTRIBUTED PAPER SESSIONS:
8:00 am–12:00 pm	*Preparation, Placement and Support of Elementary Mathematics Specialists*
8:00 am–12:00 pm	*Recreational Mathematics: Puzzles, Card Tricks, Games, Game Shows, and Gambling*
8:00 am–12:00 pm	*Trends in Undergraduate Mathematical Biology Education*
8:00 am–12:00 pm	*Research in Undergraduate Mathematics Education, I*

8:00 am–12:00 pm	*Innovative Approaches to One-Semester Calculus Courses*
8:00 am–12:00 pm	*Using Philosophy to Teach Mathematics*
8:00 am–11:55 am	**MAA GENERAL CONTRIBUTED PAPER SESSION**
8:00 am–11:00 am	**SIAM MINI-SYMPOSIUM ON PROBABLITY MEETS DYNAMICS IN BIOLOGY**
8:00 am– 9:20 am	**MAA WORKSHOP** *Applications of Gapminder for undergraduate mathematics and statistics courses.*
8:00 am– 9:20 am	**MAA WORKSHOP** *Guiding your PhDs to nonacademic careers.*
8:30 am–10:30 am	**MAA MINICOURSE #6: PART A** *Getting started in the scholarship of teaching and learning.*
8:30 am–10:00 am	**AMS-MAA-SIAM PANEL DISCUSSION** *Computing across the curriculum: Opportunities and challenges.*
8:30 am– 5:30 pm	**EMPLOYMENT CENTER**
9:00 am– 9:50 am	**MAA INVITED ADDRESS** *Fair division.* **Steven Brams**
	MAA INVITED PAPER SESSIONS:
9:00 am–11:20 am	*Current Trends in Mathematical and Computational Biology*
9:00 am–11:00 am	**MAA MINICOURSE #14: PART A** *Teaching quantitative reasoning with common sense and common knowledge.*
9:00 am–10:20 am	**MAA SESSION FOR CHAIRS** *What department chairs should know about teaching with technology.*
9:00 am– 5:00 pm	**STUDENT HOSPITALITY/INFORMATION CENTER**
9:00 am–10:30 am	**CBMS - TPSE MATH PANEL DISCUSSION** *Recent Graduates, What we Wish we had Learned*
9:30 am– 5:30 pm	**EXHIBITS AND BOOK SALES**
10:00 am–12:00 pm	**MAA MINICOURSE #15: PART A** *Teaching statistics using R and RStudio.*
10:00 am–12:00 pm	**MAA POSTER SESSION** *Mathematical outreach programs.*
10:05 am–10:55 am	**AWM-AMS NOETHER LECTURE** *Title to be announced.* **Karen E. Smith**
10:30 am–12:00 pm	**AMS SPECIAL PRESENTATION** *A conversation on nonacademic employment.*
10:30 am–12:00 pm	**SIGMAA OFFICERS MEETING**
10:30 am–12:00 pm	**AMS & AWM COMMITTEES ON EDUCATION PANEL DISCUSSION** *Work in Mathematics Education in Departments of Mathematical Sciences.*
10:35 am–11:55 am	**MAA PANEL DISCUSSION** *Developing mathematical concepts with technology.*
10:35 am–11:55 am	**MAA-YOUNG MATHEMATICIANS' NETWORK PANEL DISCUSSION** *Career options for undergraduates.*
11:10 am–12:00 pm	**SIAM INVITED ADDRESS** *Stochastic facilitation and sensitivities in discontinuous dynamics.* **Rachel Kuske**
1:00 pm– 2:00 pm	**AMS COLLOQUIUM LECTURES: LECTURE II** *Generalizations of Fourier analysis, and how to apply them (Part II).* **Timothy A. Gowers**
1:00 pm– 2:30 pm	**JOINT COMMITTEE ON WOMEN PANEL DISCUSSION** *Success in graduate school (and the rest of your life).*
	AMS SPECIAL SESSIONS:
1:00 pm– 4:00 pm	*The History of Mathematics, III (AMS-MAA)*
1:00 pm– 4:00 pm	*Surreal Numbers, I (AMS-ASL)*
1:00 pm– 4:00 pm	*Representation Theory of Algebraic Groups*
1:00 pm– 4:00 pm	*Fractal Geometry and Dynamical Systems, II*
1:00 pm– 4:00 pm	*Topological Graph Theory: Structure and Symmetry, II*
1:00 pm– 4:00 pm	*Advances in Free Analysis: the Theory and Applications of Noncommutative Functions, Inequalities, and Domains, II*
1:00 pm– 4:00 pm	*Parabolic Geometries, Twistor Theory, and the AdS/CFT Correspondence, III*
1:00 pm– 4:00 pm	*Knots in Washington (State), II*
1:00 pm– 4:00 pm	*Research by Postdocs of the Alliance for Diversity in Mathematics, II*
1:00 pm– 4:00 pm	*Analysis and Geometry in Nonsmooth Metric Measure Spaces, III*

1:00 pm–4:00 pm	*Combinatorial Design Theory, II*
1:00 pm–4:00 pm	*Stochastic Models in Population Biology*
1:00 pm–4:00 pm	*Essential Mathematical Structures and Practices in K–12 Mathematics*
1:00 pm–4:00 pm	*Problems in Geometry and Design of Materials, III*
1:00 pm–4:00 pm	*Number Theory and Cryptography, I*
1:00 pm–3:50 pm	*Commutative Algebra, II (a Mathematics Research Communities Session)*
1:00 pm–3:50 pm	*Financial Mathematics, II (a Mathematics Research Communities Session)*
1:00 pm–3:50 pm	*Differential Equations, Probablity and Sea Ice, II (a Mathematics Research Communities Session)*
1:00 pm–4:00 pm	*The Mathematics of Computation*
	MAA INVITED PAPER SESSION:
1:00 pm–4:15 pm	*Fair Division*
1:00 pm–3:00 pm	**MAA MINICOURSE #10: PART A** *Directing undergraduate research.*
1:00 pm–3:00 pm	**MAA MINICOURSE #13: PART A** *Introduction to process-oriented, guided-inquiry learning (POGIL) in mathematics courses.*
1:00 pm–3:00 pm	**MAA MINICOURSE #7: PART A** *Making sense of calculus with mapping diagrams.*
1:00 pm–4:10 pm	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
	MAA CONTRIBUTED PAPER SESSIONS:
1:00 pm–4:00 pm	*Innovative Targeted Solutions in Teaching Introductory Statistics*
1:00 pm–4:00 pm	*Research in Undergraduate Mathematics Education, II*
1:00 pm–4:00 pm	*Common Core State Standards (CCSS) for Mathematics Practices and Content: The Role of Math Departments in Preparing Math Education Candidates for New Assessments*
1:00 pm–4:00 pm	*The Broad Impact of Math Circles*
1:00 pm–4:00 pm	*Bringing the Community into the College Mathematics Classroom*
1:00 pm–4:10 pm	**MAA GENERAL CONTRIBUTED PAPER SESSIONS**
1:00 pm–4:10 pm	**EDUCATION COMMITTEE SESSION**
1:00 pm–2:30 pm	**AMS COMMITTEE ON EDUCATION PANEL DISCUSSION** *What is a Mathematics PhD?*
1:00 pm–2:20 pm	**MAA PANEL DISCUSSION** *Interdisciplinary modeling experiences for undergraduates.*
1:00 pm–2:20 pm	**MAA COMMITTEE ON PROFESSIONAL DEVELOPMENT PANEL DISCUSSION** *Mid-career faculty: Charting the next half of your career.*
1:00 pm–3:00 pm	**SUMMER PROGRAM FOR WOMEN IN MATHEMATICS (SPWM) REUNION**
2:00 pm–3:00 pm	**PROJECT NEXT LECTURE**
2:00 pm–4:00 pm	**MAA POSTER SESSION ON PROJECTS SUPPORTED BY THE NSF DIVISION OF UNDERGRADUATE EDUCATION**
2:15 pm–3:05 pm	**AMS INVITED ADDRESS** *Title to be announced.* **Steven M. Zelditch**
2:35 pm–3:55 pm	**MAA COMMITTEE ON MINORITY PARTICIPATION AND THE MAA OFFICE OF MINORITY PARTICIPATION PANEL DISCUSSION** *Summer Research Programs.*
2:35 pm–3:55 pm	**MAA PANEL DISCUSSION** *Is online inquiry-based learning (IBL) possible?*
3:20 pm–4:10 pm	**AMS RETIRING PRESIDENTIAL ADDRESS** *Conjugacy classes and group representations.* **David Vogan**
4:25 pm–5:25 pm	**JOINT PRIZE SESSION**
5:30 pm–7:00 pm	**MAA SPECIAL PRESENTATION** *Poetry+Art+Math.*
5:30 pm–6:00 pm	**SIGMAA ON QUANTITATIVE LITERACY AND SIGMAA ON STATISTICS EDUCATION JOINT RECEPTION**
5:30 pm–7:00 pm	**ASSOCIATION OF CHRISTIANS IN THE MATHEMATICAL SCIENCES RECEPTION AND LECTURE**
5:30 pm–6:30 pm	**JOINT PRIZE SESSION RECEPTION**
5:30 pm–7:30 pm	**PENNSYLVANIA STATE UNIVERSITY MATHEMATICS ALUMNI RECEPTION**
5:30 pm–7:00 pm	**UNIVERSITY OF MICHIGAN ALUMNI AND FRIENDS RECEPTION**

5:45 pm– 7:00 am	**MAA TWO-YEAR COLLEGE RECEPTION**
6:50 pm– 7:40 pm	**SIGMAA ON STATISTICS EDUCATION BUSINESS MEETING**
6:00 pm– 7:00 pm	**UNIVERSITY OF CHICAGO MATHEMATICS ALUMNI RECEPTION**
6:00 pm– 8:00 pm	**ANNUAL RECEPTION FOR LESBIAN, GAY, BISEXUAL, AND TRANSGENDERED MATHEMATICIANS**
6:00 pm– 8:00 pm	**NSA'S WOMEN IN MATHEMATICS SOCIETY NETWORKING SESSION**
6:50 pm– 7:40 pm	**SIGMAA ON STATISTICS EDUCATION GUEST LECTURE** *Title to be announced*. **Hadley Wickham, Tim Hesterburg**
8:15 pm– 9:45 pm	**KNITTING CIRCLE** *Knitting Circle: Bring a project (knitting/crochet/tatting/beading/etc.) and chat with other mathematical crafters!*

Friday, January 08

7:00 am– 8:00 am	**SIMIODE OPEN HOUSE WITH DISCUSSION GROUPS**
7:30 am– 4:00 pm	**JOINT MEETINGS REGISTRATION**, Atrium Lobby, 4th Floor, Washington State Convention Center
7:30 am– 8:00 pm	**EMAIL CENTER**
	AMS SPECIAL SESSIONS:
8:00 am–11:00 am	*Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, II (AMS-MAA-SIAM)*
8:00 am–11:00 am	*Commutative Algebra, I (AMS-AWM)*
8:00 am–11:00 am	*Geometric and Categorical Methods in Representation Theory, I*
8:00 am–11:00 am	*Quantum Walks, Quantum Markov Chains, Quantum Computation and Related Topics, II*
8:00 am–11:00 am	*Water Waves, I*
8:00 am–11:00 am	*Partial Differential Equations in Complex Analysis, I*
8:00 am–11:00 am	*Mathematics in Natural Resource Modeling, I*
8:00 am–11:00 am	*Special Functions and q-Series, I*
8:00 am–11:00 am	*Algebraic and Topological Methods in Combinatorics, I*
8:00 am–11:00 am	*Knots in Washington (State), III*
8:00 am–11:00 am	*Classification Problems in Operator Algebras, I*
8:00 am–12:00 pm	*Higher Genus Curves and Fibrations of Higher Genus Curves in Mathematical Physics and Arithmetic Geometry, I*
8:00 am–11:00 am	*Equations of Fluid Motion, I*
8:00 am–11:00 am	*Difference Equations and Applications*
8:00 am–11:00 am	*Global Harmonic Analysis, I*
8:00 am–11:00 am	*Pseudorandomness and Its Applications, III*
8:00 am–11:00 am	*Arithmetic Dynamics, II*
8:00 am–10:55 am	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
8:00 am–10:55 am	**ASL INVITED ADDRESSES**
	MAA CONTRIBUTED PAPER SESSIONS:
8:00 am–10:55 am	*MAA-EDGE (Enhacing Diversity in Graduate Education) Pure and Applied Talks by Women Math Warriors*
8:00 am–11:00 am	*The Teaching and Learning of Undergraduate Ordinary Differential Equations*
8:00 am–11:00 am	*Inquiry-Based Teaching and Learning*
8:00 am–11:00 am	*The Contributions of Minorities to Mathematics Throughout History*
8:00 am–10:55 am	**MAA GENERAL CONTRIBUTED PAPER SESSIONS**
8:00 am–10:55 am	**SIAM MINI-SYMPOSIUM ON NUMERICAL PARTIAL DIFFERENTIAL EQUATIONS**

8:00 am– 9:20 am	**MAA-NCTM JOINT COMMITTEE ON MUTUAL CONCERNS, COLLEGE BOARD/MAA JOINT COMMITTEE ON MUTUAL CONCERNS PANEL DISCUSSION** *College calculus and the preparation gap: Identified problems and models for improvement.*
8:00 am– 9:20 am	**SIGMAA ON STATISTICS EDUCATION PANEL DISCUSSION** *Guidelines for Statistics Education: MAA Curriculum Guide, ASA Guidelines, GAISE II, and SET.*
8:30 am–10:30 am	**AMS-MAA GRAD SCHOOL FAIR** *Undergrads! Take this opportunity to meet representatives from mathematical science graduate programs.*
8:30 am– 5:30 am	**EMPLOYMENT CENTER**
9:00 am– 9:50 am	**MAA INVITED ADDRESS** *What makes for powerful classrooms—and what can we do now that we know?* **Alan Schoenfeld**
9:00 am–11:00 am	**MAA MINICOURSE #11: PART B** *Implementing inquiry-oriented curricula for linear algebra, differential equations, and abstract algebra.*
9:00 am–11:00 pm	**MAA MINICOURSE #12: PART B** *Humanistic mathematics.*
9:00 am–11:00 am	**MAA MINICOURSE #5: PART B** *Teaching introductory statistics for instructors new to teaching statistics.*
9:00 am– 5:00 pm	**STUDENT HOSPITALITY/INFORMATION CENTER**
9:30 am–11:00 am	**AMS SPECIAL PRESENTATION** *Who wants to be a mathematician—National contest.*
9:30 am– 5:30 pm	**EXHIBITS AND BOOK SALES**
9:35 am–10:55 am	**MAA PANEL DISCUSSION** *Perspectives on IBL teaching: novice, experienced and master.*
9:35 am–10:55 am	**MAA/NCTM JOINT COMMITTEE ON MUTUAL CONCERNS PANEL DISCUSSION** *Instructional strategies that can make a difference.*
10:05 am–10:55 am	**AMS INVITED ADDRESS** *The SL(2, $\mathbb{R}$) action on moduli space.* **Alex Eskin**
11:10 am–12:00 pm	**AMS-MAA INVITED ADDRESS** *Title to be announced.* **Kristin Lauter**
12:00 pm– 1:00 pm	**BUDAPEST SEMESTERS IN MATHEMATICS EDUCATION INFORMATIONAL SESSION**
1:00 pm– 2:00 pm	**AMS COLLOQUIUM LECTURES: LECTURE III** *Generalizations of Fourier analysis, and how to apply them (Part III).* **Timothy A. Gowers**
1:00 pm– 1:50 pm	**MAA LECTURE FOR STUDENTS** *The fractal geometry of the Mandelbrot Set.* **Robert Devaney**
1:00 pm– 6:00 pm	**CURRENT EVENTS BULLETIN**
	AMS SPECIAL SESSIONS:
1:00 pm– 6:00 pm	*The History of Mathematics, IV (AMS-MAA)*
1:00 pm– 6:00 pm	*Surreal Numbers, II (AMS-ASL)*
1:00 pm– 6:00 pm	*Commutative Algebra and Its Interactions with Algebraic Geometry, I (AMS-AWM)*
1:00 pm– 6:00 pm	*Geometric and Categorical Methods in Representation Theory, II*
1:00 pm– 6:00 pm	*Water Waves, II*
1:00 pm– 6:00 pm	*Partial Differential Equations in Complex Analysis, II*
1:00 pm– 6:00 pm	*Mathematics in Natural Resource Modeling, II*
1:00 pm– 6:00 pm	*Problems and Challenges in Financial Engineering and Risk Management, I*
1:00 pm– 6:00 pm	*Early Career Female Mathematicians in Algebra and Topology*
1:00 pm– 6:00 pm	*Algebraic and Topological Methods in Combinatorics, II*
1:00 pm– 6:00 pm	*Algebraic Theory of Differential and Functional Equations*
1:00 pm– 6:00 pm	*Classification Problems in Operator Algebras, II*
1:00 pm– 6:00 pm	*Higher Genus Curves and Fibrations of Higher Genus Curves in Mathematical Physics and Arithmetic Geometry, II*
1:00 pm– 6:00 pm	*Equations of Fluid Motion, II*
1:00 pm– 6:00 pm	*Moduli Spaces in Algebraic Geometry, I*
1:00 pm– 6:00 pm	*Global Harmonic Analysis, II*
1:00 pm– 6:00 pm	*Number Theory and Cryptography, II*
	MAA INVITED PAPER SESSION:
1:00 pm– 5:00 pm	*What Do We Know about University Mathematics Teaching, and How Can It Help Us?*
1:00 pm– 3:00 pm	**MAA MINICOURSE #4: PART B** *Teaching mathematics with sports applications.*

1:00 pm–3:00 pm	**MAA MINICOURSE #8: PART B** *Algebraic geometry: A problem-based course.*
1:00 pm–3:00 pm	**MAA MINICOURSE #9: PART B** *Increasing student engagement and understanding through active learning strategies in calculus.*
1:00 pm–5:55 pm	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
1:00 pm–6:00 pm	**ASL INVITED ADDRESSES**
	MAA CONTRIBUTED PAPER SESSIONS
1:00 pm–6:00 pm	*The Development and Adoption of Open Educational Resources for Teaching and Learning*
1:00 pm–6:00 pm	*Mathematics Experiences and Projects in Business, Industry, and Government*
1:00 pm–6:00 pm	*Innovative and Effective Ways to Teach Linear Algebra*
1:00 pm–6:00 pm	*New Ideas in Teaching Upper-Level Statistics Courses*
1:00 pm–6:00 pm	*Contemplative Pedagogy and Mathematics*
1:00 pm–5:55 pm	**MAA GENERAL CONTRIBUTED PAPER SESSIONS**
1:00 pm–6:00 pm	**SIAM MINI-SYMPOSIUM ON TRENDS IN THE MATHEMATICS OF SIGNAL PROCESSING AND IMAGING**
1:00 pm–4:00 pm	**NAM GRANVILLE-BROWN-HAYNES SESSION OF PRESENTATIONS BY RECENT DOCTORAL RECIPIENTS IN THE MATHEMATICAL SCIENCES**
1:00 pm–2:20 pm	**MAA COMMITTEE ON THE MATHEMATICAL EDUCATION OF TEACHERS (COMET) PANEL DISCUSSION** *Learning from each other: International perspectives on the mathematical education of teachers.*
1:00 pm–2:20 pm	**MAA SUBCOMMITTEE ON RESEARCH BY UNDERGRADUATES PANEL DISCUSSION** *Undergraduate research as a capstone course.*
2:30 pm–3:50 pm	**PRESENTATIONS BY MAA TEACHING AWARD RECIPIENTS**
2:30 pm–4:00 pm	**AMS COMMITTEE ON SCIENCE POLICY PANEL DISCUSSION** *The role of research in preserving the American dream.*
2:35 pm–3:55 pm	**MAA COMMITTEE ON CURRICULUM RENEWAL ACROSS THE FIRST TWO YEARS (CRAFTY) PANEL DISCUSSION** *Renewing the first two years curriculum: calculus, quantitative reasoning, statistics, pre-calculus, and developmental mathematics.*
2:35 pm–3:55 pm	**MAA PANEL DISCUSSION** *A common vision for the undergraduate mathematics program in 2025.*
3:15 pm–4:15 pm	**MAA SOCIAL HOUR** *Find a research collaborator.*
3:30 pm–5:30 pm	**MAA MINICOURSE #16: PART B** *Mobile mathematics—interactive apps for teaching and learning.*
3:30 pm–5:30 pm	**MAA MINICOURSE #2: PART B** *Visual topics in undergraduate complex analysis.*
3:30 pm–5:30 pm	**MAA MINICOURSE #3: PART B** *Designing and implementing a problem-based mathematics course.*
4:00 pm–5:00 pm	**MAA SOCIAL HOUR** *Managing your own course.*
4:00 pm–5:30 pm	**NATIONAL SCIENCE FOUNDATION: UPDATE FROM THE DIVISION OF MATHEMATICAL SCIENCES**
4:30 pm–6:00 pm	**AMS CONGRESSIONAL FELLOWSHIP SESSION**
5:00 pm–7:00 pm	**MAA PANEL DISCUSSION** *Change is the norm!*
6:00 pm–7:15 pm	**AWM WORKSHOP POSTER PRESENTATIONS AND RECEPTION**
6:00 pm–7:00 pm	**MATHEMATICALLY BENT THEATER** *Performed by Colin Adams and the Mobiusbandaid Players.*
6:00 pm–7:30 pm	**BUDAPEST SEMESTERS IN MATHEMATICS ALUMNI REUNION**
6:00 pm–7:00 pm	**AMS MATHEMATICAL REVIEWS RECEPTION**
6:00 pm–8:40 pm	**NAM RECEPTION AND BANQUET**
7:45 pm–8:35 pm	**NAM COX-TALBOT ADDRESS** *Title to be announced.* **Tanya Moore**
8:00 pm–10:00 pm	**BACKGAMMON!**

8:00 pm–10:00 pm	**PROJECT NEXT RECEPTION** *All Project NExT Fellows, consultants, and other friends of Project NExT are invited.*

Saturday, January 09

1:00 am– 3:00 am	**MAA MINICOURSE #7: PART B** *Making sense of calculus with mapping diagrams.*
7:30 am– 2:00 pm	**JOINT MEETINGS REGISTRATION**, Atrium Lobby, 4th Floor, Washington State Convention Center
7:30 am– 2:00 am	**EMAIL CENTER**
	AMS SPECIAL SESSIONS:
8:00 am–12:00 pm	*Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, III (AMS-MAA-SIAM)*
8:00 am–12:00 pm	*Commutative Algebra, II (AMS-AWM)*
8:00 am–12:00 pm	*Quantum Walks, Quantum Markov Chains, Quantum Computation and Related Topics, III*
8:00 am–12:00 pm	*Recent Advances in Orthogonal Polynomials and Special Functions, I*
8:00 am–12:00 pm	*Applied and Computational Topology, I*
8:00 am–12:00 pm	*Nonlinear Waves and Coherent Structures*
8:00 am–12:00 pm	*Random and Complex Dynamics of Reaction-Diffusion Systems, I*
8:00 am–12:00 pm	*Special Functions and q-Series, II*
8:00 am–12:00 pm	*Current Areas of Interest in the Mathematical Sciences of Medieval Islam, I*
8:00 am–12:00 pm	*Algebraic and Topological Methods in Combinatorics, III*
8:00 am–12:00 pm	*Nonlinear Algebra, I*
8:00 am–12:00 pm	*Data-Intensive Modeling in Ecology*
8:00 am–12:00 pm	*Analytic Function Spaces and Operators on Them*
8:00 am–12:00 pm	*Global Harmonic Analysis, III*
8:00 am–12:00 pm	*Pseudorandomness and Its Applications, IV*
8:00 am–12:00 pm	*Arithmetic Dynamics, III*
8:00 am–10:55 am	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
8:00 am–12:00 pm	**ASL INVITED ADDRESSES**
	MAA CONTRIBUTED PAPER SESSIONS:
8:00 am–12:00 pm	*Mathematical Modeling in the Undergraduate Classroom*
8:00 am–12:00 pm	*Incorporating the History of Mathematics into Development Math Courses*
8:00 am–12:00 pm	*Revitalizing Complex Analysis*
8:00 am–12:00 pm	*Mathematics and Sports*
8:00 am–12:00 pm	*Graduate Students Teach Too: Ideas and Best Practices*
8:00 am–10:55 am	**MAA GENERAL CONTRIBUTED PAPER SESSIONS**
8:00 am–12:00 pm	**SIAM MINI-SYMPOSIUM ON GRAPHICAL MODELS FOR HIGH DIMENSIONAL DATA**
8:00 am– 5:00 pm	**AWM WORKSHOP: SPECIAL SESSION ON ALGEBRAIC COMBINATORICS**
9:00 am– 9:50 am	**AMS INVITED ADDRESS** *Title to be announced.* **Panagiota Daskalopoulos**
9:00 am–11:00 am	**MAA MINICOURSE #14: PART B** *Teaching quantitative reasoning with common sense and common knowledge.*
9:00 am–11:00 am	**MAA MINICOURSE #6: PART B** *Getting started in the scholarship of teaching and learning.*
9:00 am–10:20 am	**MAA COMMITTEE ON THE UNDERGRADUATE PROGRAM IN MATHEMATICS (CUPM) AND MAA COMMITTEE ON PROFESSIONAL DEVELOPMENT PANEL DISCUSSION** *Starting a new track: actuarial science, biomathematics, environmental science, climate studies.*
9:00 am– 9:50 am	**NAM PANEL DISCUSSION** *Work hard, play hard: balancing career, hobbies, and family.*
9:00 am– 3:00 am	**STUDENT HOSPITALITY/INFORMATION CENTER**
9:00 am–12:00 pm	**EXHIBITS AND BOOK SALES**

9:00 am–12:00 pm	**EMPLOYMENT CENTER**
10:00 am–12:00 pm	**MAA MINICOURSE #15: PART B** *Teaching statistics using R and RStudio*
10:00 am–10:50 am	**NAM BUSINESS MEETING**
10:05 am–10:55 am	**MAA INVITED ADDRESS** A mathematical tour through a collapsing world. **Charles R. Hadlock**
10:35 am–11:55 am	**MAA COMMITTEE ON THE UNDERGRADUATE PROGRAM IN MATHEMATICS PANEL DISCUSSION** *What's beyond the curriculum?*
11:10 am–11:40 am	**MAA BUSINESS MEETING**
11:45 am–12:15 pm	**AMS BUSINESS MEETING**
1:00 pm–1:50 pm	**NAM CLAYTOR-WOODARD LECTURE** *Title to be announced.* **Tatiana Toro**
1:00 pm–5:30 pm	**ASL INVITED ADDRESSES**
	AMS SPECIAL SESSIONS:
1:00 pm–6:00 pm	*Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, IV (AMS-MAA-SIAM)*
1:00 pm–6:00 pm	*Applications of Logic, Model Theory, and Theoretical Computer Science to Systems Biology (AMS-ASL)*
1:00 pm–6:00 pm	*Applied and Computational Topology, II (AMS-AAAS)*
1:00 pm–6:00 pm	*Recent Advances in Orthogonal Polynomials and Special Functions, II*
1:00 pm–6:00 pm	*Random and Complex Dynamics of Reaction-Diffusion Systems, II*
1:00 pm–6:00 pm	*Problems and Challenges in Financial Engineering and Risk Management, II*
1:00 pm–6:00 pm	*Current Areas of Interest in the Mathematical Sciences of Medieval Islam, II*
1:00 pm–6:00 pm	*Advances in the Theory and Application of Reaction Diffusion Models*
1:00 pm–6:00 pm	*Stochastic Effects in Models for Mathematical Biology and Ecology*
1:00 pm–6:00 pm	*Commutative Algebra and Its Interactions with Algebraic Geometry, II*
1:00 pm–6:00 pm	*Distribution of Zeros of Entire Functions*
1:00 pm–6:00 pm	*Nonlinear Algebra, II*
1:00 pm–6:00 pm	*Analytic Methods in Geometry*
1:00 pm–6:00 pm	*Moduli Spaces in Algebraic Geometry, II*
1:00 pm–6:00 pm	*Number Theory and Cryptography, III*
1:00 pm–6:00 pm	*Mathematical Programming on Integral Invexity*
1:00 pm–6:00 pm	*Graph Products*
1:00 pm–3:00 pm	**MAA MINICOURSE #10: PART B** *Directing undergraduate research.*
1:00 pm–3:00 pm	**MAA MINICOURSE #13: PART B** *Introduction to process-oriented, guided-inquiry learning (POGIL) in mathematics courses.*
1:00 pm–5:55 pm	**AMS SESSIONS FOR CONTRIBUTED PAPERS**
	MAA CONTRIBUTED PAPER SESSIONS
1:00 pm–6:00 pm	*Origami in the Mathematics K–12 Classroom*
1:00 pm–6:00 pm	*Integrating Research into the Undergraduate Classroom*
1:00 pm–6:00 pm	*Conversations with the Partner Disciplines: Collaborations to Improve the Mathematics Curriculum*
1:00 pm–6:00 pm	*Addressing the Needs of Mathematics and Computer Science Majors in Discrete Mathematics Courses*
1:00 pm–6:00 pm	*Helping Students See Beyond Calculus*
1:00 pm–4:55 pm	**MAA GENERAL CONTRIBUTED PAPER SESSIONS**
1:00 pm–5:30 pm	**SIAM MINI-SYMPOSIUM ON APPLIED ANALYSIS OF PARTIAL DIFFERENTIAL EQUATIONS**
1:00 pm–2:20 pm	**MAA PANEL DISCUSSION** *International engagement in research and education in the mathematical sciences.*
3:00 pm–4:00 pm	**MAA-AMS-SIAM GERALD AND JUDITH PORTER PUBLIC LECTURE** *Network Science: From the Online World to Cancer Genomics.* **Jennifer Chayes**
6:30 pm–7:30 pm	**AMS DINNER RECEPTION**
7:30 pm–10:30 pm	**AMS DINNER CELEBRATION**

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Central Section: **Georgia Benkart**, University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706-1388; e-mail: benkart@math.wisc.edu; telephone: 608-263-4283.

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The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. Information in this issue may be dated. Up-to-date meeting and conference information can be found at www.ams.org/meetings/.

Meetings:

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 200 in the February 2015 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 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 in Cooperation with the AMS: (See www.ams.org/meetings/ for the most up-to-date information on these conferences.)

December 16–19, 2015: Amrita School of Engineering hosts the International Conference on Graph Theory and its Applications, Tamil Nadu, India (For further information see https://www.amrita.edu/site/icgta15/.)

2016 Joint Mathematics Meetings Advanced Registration/Housing Form

JOINT MATHEMATICS MEETINGS
SEATTLE · JAN 6-9, 2016
AMERICAN MATHEMATICAL SOCIETY
MATHEMATICAL ASSOCIATION OF AMERICA

Name _____
(please write name as you would like it to appear on your badge)

Mailing Address _____

_____

Telephone _____ Fax: _____

In case of emergency (for you) at the meeting, call: Day #_____ Evening #:_____

Email Address _____ Additional email address for receipt_____

Acknowledgment of this registration and any hotel reservations will be sent to the email address(es) given here. **Check this box to receive a copy in U.S. Mail:** ☐

Affiliation for badge _____ (company/university) Nonmathematician guest badge name: _____ (Note fee of US$18)

☐ **I DO NOT want my program and badge to be mailed to me on 12/11/15. (Materials will be mailed to the address listed above unless you check this box.)**

Registration Fees

Membership please ✓ all that apply. First row is eligible to register as a member.
For undergraduate students, membership in PME and KME also applies.

☐ AMS ☐ MAA ☐ ASL ☐ CMS ☐ SIAM
Undergraduate Students Only: ☐ PME ☐ KME
Other Societies: ☐ AWM ☐ NAM ☐ YMN ☐ AMATYC

Joint Meetings	**by Dec 22**	**at mtg**	**Subtotal**
☐ Member AMS, MAA, ASL, CMS, or SIAM	US$ 282	US$ 371	
☐ Nonmember	US$ 448	US$ 571	
☐ Graduate Student Member (AMS, MAA ASL, CMS, or SIAM)	US$ 63	US$ 74	
☐ Graduate Student (Nonmember)	US$101	US$ 112	
☐ Undergraduate Student Member (AMS, ASL, CMS, MAA, PME, KME, or SIAM)	US$ 63	US$ 74	
☐ Undergraduate Student (Nonmember)	US$101	US$ 112	
☐ High School Student	US$ 6	US$ 12	
☐ Unemployed	US$ 63	US$ 74	
☐ Temporarily Employed	US$ 230	US$ 263	
☐ Developing Countries Special Rate	US$ 63	US$ 74	
☐ Emeritus Member of AMS or MAA	US$ 63	US$ 74	
☐ High School Teacher	US$ 63	US$ 74	
☐ Librarian	US$ 63	US$ 74	
☐ Press	US$ 0	US$ 0	
☐ Exhibitor (Commercial)	US$ 0	US$ 0	
☐ Artist Exhibitor (work in JMM Art Exhibit)	US$ 0	US$ 0	
☐ Nonmathematician Guest of registered mathematician	US$ 18	US$ 18	
			$_____

AMS Short Course: *Rigorous Numerics in Dynamics (1/4-1/5)*

☐ Member of AMS	US$ 110	US$ 144	
☐ Nonmember	US$ 165	US$ 195	
☐ Student, Unemployed, Emeritus	US$ 58	US$ 79	
			$_____

MAA Minicourses (see listing in text)
I would like to attend: ☐ One Minicourse ☐ Two Minicourses
Please enroll me in MAA Minicourse(s) #_____ and #_____
Price: US$ 85 for each minicourse.
(For more than 2 minicourses, call or email the MMSB.) $_____

Graduate School Fair
☐ Graduate Program Table US$ 75 US$ 75
(includes table, posterboard & electricity) $_____

Receptions & Banquets
☐ Graduate Student/First-Time Attendee Reception (1/6) (no charge)
☐ NAM Banquet (1/8) US$63 #____Chicken #____Vegetarian #____Kosher
☐ AMS Dinner (1/9) Regular Price #____US$ 69
Student Price #____US$ 29
(Additional fees may apply for Kosher meals.) $_____

Total for Registrations and Events $_____

Registration for the Joint Meetings is not required for the short course but it is required for the minicourses and the Employment Center. To register for the Employment Center, go to www.ams.org/profession/employment-services/employment-center.

Payment

Registration & Event Total (total from column on left) $ _____
Hotel Deposit (only if paying by check) $ _____

Total Amount To Be Paid **$** _____

Method of Payment

☐ **Check**. Make checks payable to the AMS. For all check payments, please keep a copy of this form for your records.

☐ **Credit Card**. All major credit cards accepted. For your security, we do not accept credit card numbers by postal mail, email or fax. If the MMSB receives your registration form by fax or postal mail, it will contact you at the phone number provided on this form. For questions, contact the MMSB at mmsb@ams.org.

Signature:_____

☐ **Purchase Order #** _____ (please enclose copy)

Other Information

Mathematical Reviews field of interest #_____

☐ I am willing to serve as a judge for the MAA Undergraduate Student Poster Session
☐ For planning purposes for the MAA Two-year College Reception, please check if you are a faculty member at a two-year college.
☐ I am a mathematics department chair.
☐ Please do not include my name and postal address on any promotional mailing lists. (The JMM does not share email addresses.)
☐ Please do not include my name on any list of JMM participants other than the scientific program if I am, in fact, making a presentation that is part of the meeting.
☐ Please ✓ this box if you have a disability requiring special services.

Deadlines

Eligible for the complimentary room drawing:	**Nov. 2, 2015**
Receiving badges/programs in the mail:	**Nov. 17, 2015**
Housing reservations, changes/cancellations through the JMM website:	**Dec. 14, 2015**
Advance registration for the Joint Meetings, short course, minicourses, and tickets:	**Dec. 22, 2015**
50% refund on banquets, cancel by	**Jan. 2, 2016***
50% refund on advanced registration, minicourses, and short course, cancel by	**Dec. 31, 2015***

***no refunds issued after this date**

Mailing Address/Contact:

Mathematics Meetings Service Bureau (MMSB)
P. O. Box 6887
Providence, RI 02940-6887 **Fax**: 401-455-4004; **Email:** mmsb@ams.org
Telephone: 401-455-4144 or 1-800-321-4267 x4144 or x4137

2016 Joint Mathematics Meetings Hotel Reservations – Seattle, WA

(Please see the hotel page in the announcement or on the web for detailed information on each hotel.) To ensure accurate assignments, please rank hotels in order of preference by writing 1, 2, 3, etc. in the column on the left and by circling the requested bed configuration. If your requested hotel and room type is no longer available, you will be assigned a room at the next available comparable rate. Please call the MMSB for details on suite configurations, sizes, availability, etc. All reservations, including suite reservations, must be made through the MMSB to receive the JMM rates. Reservations made directly with the hotels before **December 14, 2015** may be changed to a higher rate. All rates are subject to applicable local and state taxes in effect at the time of check-in; currently 15.6% state tax PLUS an additional US$2 per night for travel and tourism tax. **Guarantee requirements: First night deposit by check (add to payment on reverse of form) or a credit card guarantee.**

☐ **Deposit enclosed (see front of form**)

☐ **Hold with my credit card**. **For your security, we do not accept credit card numbers by postal mail, email or fax.** If the MMSB receives your registration form by postal mail or fax, we will contact you at the phone number provided on the reverse of this form.

Date and Time of Arrival _____ **Date and Time of Departure** _____ **Number of adult guests in room** _____ **Number of children** _____

Name of Other Adult Room Occupant (s) _____ **Arrival Date** _____ **Departure Date** _____

Housing Requests:.(example: rollaway cot, crib, nonsmoking room, low floor) _____

☐ I have disabilities as defined by the ADA that require a sleeping room that is accessible to the physically challenged. My needs are: _____

☐ I am a member of a hotel frequent-travel club and would like to receive appropriate credit. The hotel chain and card number are: _____

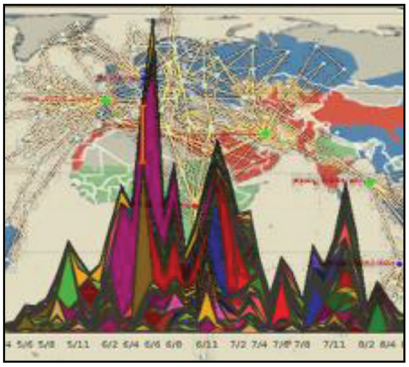
☐ I am not reserving a room. I am sharing with _____ , who is making the reservation.

Order of choice	Hotel	Single	Double 1 bed-2 people	Double 2 beds- 2 people	Triple 3 adults-2 beds	Quad 4 adults-2 beds	Rollaway Cot Fee (add to special requests if reserving online)
	Sheraton Seattle (headquarters)	US$ 166	US$ 166	US$ 166	US$ 191	US$ 216	Rollaways available only in king-bedded rooms at no charge
	Deluxe Rate	US$ 186	US$ 186	US$ 186	US$ 211	US$ 236	
	Club Level	US$ 206	US$ 206	US$ 206	US$ 231	US$ 256	
	Student Rate	US$ 124.50	US$ 124.50	US$ 124.50	US$ 149.50	UD$ 174.50	
	Grand Hyatt	US$ 159	US$ 159	US$ 159	US$ 184	US$ 209	Rollaways available only in king-bedded rooms only for a nightly charge of US$15
	Student Rate	US$ 125	US$ 125	US$ 125	US$ 150	US$ 175	
	Fairmont Olympic Hotel Seattle	US$ 152	US$ 152	US$ 152	US$ 182	US$ 212	Rollaways available only in king-bedded rooms for a one-time $15 fee
	The Westin Seattle	US$ 139	US$ 139	US$ 139	US$ 169	US$ 199	Rollaways available only in king-bedded rooms at no charge; sleeper sofas in some rooms
	Student Rate	US$ 104	US$ 104	US$ 104	US$ 134	US$ 164	
	Renaissance Seattle Hotel	US$ 139	US$ 139	US$ 139	US$ 159	US$ 179	Rollaways available only in king-bedded rooms at no charge
	Student Rate	US$ 129	US$ 129	US$ 129	US$ 149	US$ 169	
	The Paramount Hotel Seattle	US$ 130	US$ 130	US$ 130	US$ 150	US$ 170	Rollaways available only in king-bedded rooms at no charge
	Student Rate	US$ 120	US$ 120	US$ 120	US$ 140	US$ 160	
	Hyatt Olive 8 Seattle	US$ 125	US$ 125	US$ 125	US$ 150	US$ 175	Rollaways available only in king-bedded rooms at no charge
	The Inn at the Washington Athletic Club	US$ 125	US$ 125	US$ 125	US$ 145	US$ 165	Rollaways are extremely limited, inquire directly with the MMSB
	Crowne Plaza Seattle Downtown	US$ 125	US$ 125	US$ 125	US$ 145	US$ 165	Rollaways available only in king-bedded rooms for a one-time $25 fee
	Student Rate	US$ 115	US$ 115	US$ 115	US$ 135	US$ 155	
	The Roosevelt Hotel	US$ 120	US$ 120	US$ 120	US$ 140	US$ 160	Sofa beds are available in all rooms

People interested in suites should contact the MMSB directly by email at mmsb@ams.org or by calling 800-321-4267, ext. 4137 or 4144 (401-455-4137 or 401-455-4144).

INSTITUTE FOR PURE AND APPLIED MATHEMATICS

Los Angeles, California



Culture Analytics

March 7-June 10, 2016

ORGANIZING COMMITTEE: Tina Eliassi-Rad (Rutgers University), **Mauro Maggioni** (Duke University), **Lev Manovich** (CUNY), **Vwani Roychowdhury** (UCLA), **Timothy Tangherlini** (UCLA)

Scientific Overview

The explosion in the widespread use of the Internet and social media and the ubiquity of low cost computing have increased the possibilities for understanding cultural behaviors and expressions, while at the same time have facilitated opportunities for making cultural artifacts both accessible and comprehensible. The rapidly proliferating digital footprints that people leave as they crisscross these virtual spaces offer a treasure trove of cultural information, where culture is considered to be expressive of the norms, beliefs and values of a group. This program encourages the exploration of the unsolved mathematical opportunities that are emerging in this cultural information space. Many successful approaches to the analysis of cultural content and activities have been developed, yet there is still a great deal of work to be done. In this program, we aim to promote a vigorous collaboration across disciplines and devise new approaches and novel mathematics to address these problems of culture analytics, by bringing together leading scholars in the social sciences and humanities with those in applied mathematics, engineering, and computer science.

Workshop Schedule

- Tutorials: March 8-11, 2016.
- Workshop I: Culture Analytics Beyond Text. March 21-24, 2016.
- Workshop II: Culture Analytics and User Experience Design. April 11-15, 2016.
- Workshop III: Cultural Patterns: Multi-scale Data-driven Models. May 9-13, 2016.
- Workshop IV: Mathematical Analysis of Cultural Expressive Forms: Text Data. May 23-27, 2016.

Participation

Most participants, including senior and junior researchers, will be in residence at IPAM for the entire period. Between the workshops there will be a program of activities involving the long-term and short-term participants, and visitors. Applications will be accepted through December 7, 2015, but decisions will be made starting in July. We have funding especially to support the attendance of graduate students and researchers in the early stages of their career, but we welcome applications from researchers at all levels. Encouraging the careers of women and minority mathematicians and scientists is an important component of IPAM's mission and we welcome their applications.

For more information: www.ipam.ucla.edu/ca2016

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