



# UC DAVIS

## MATHEMATICS NEWSLETTER



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# Letter from the Chair by Joel Hass



- Joel Hass, travelling in Jerusalem

Although the past year saw continuing budget challenges for the University, the Mathematics Department continues to prosper. Our faculty produces a constant stream of high quality research, as recognized this year by several prestigious prizes discussed in the newsletter, by our extraordinary success in grant applications, and by other metrics. This past year alone the Department was awarded over three and one half million dollars in new research funding. These funds help to support our graduate students and postdoctoral scholars, as well as to support research in a variety of ways. A study of highly cited researchers in mathematics departments published in the *Notices of the American Mathematical Society* puts our Department at #10 in the world.

Word seems to be circulating that Mathematics is a hot field, both for its inherent beauty and for the options it opens up for students after graduation. We are attracting record numbers of new students at both the graduate and the undergraduate levels. Student numbers are growing both

in the absolute sense and as a share of the total campus population. As of Fall 2012 we have 395 undergraduate Mathematics majors, with a record incoming class of 168 new majors. In 2011-12 we had 17,376 students take our undergraduate classes, an increase of 18% in two years. We also taught 1303 students in Summer Session, up 11% over two years. Needless to say, our classes are larger and fuller than in previous years, but I am confident that the quality of our instruction remains consistently high and is well received by the students.

With 115 graduate students in the Mathematics Program and the Applied Mathematics Graduate Group, we have two of the major national graduate programs. Our Department ranked 33rd worldwide in the latest Academic Ranking of World Universities evaluation of mathematics departments.

Many thanks to all of the alumni and friends of the Department who have made contributions over the past year. Your support is much appreciated.



## New Krener Asst. Professor Pranab Sardar

Pranab received his Ph.D. from the Ramakrishna Mission Vivekananda University, India in July, 2012. In his dissertation research, supervised by Mahan MJ, Pranab generalizes the work of Bestvina-Feighn by introducing new, large scale geometric objects called metric bundles and giving sufficient condition for their hyperbolicity. The notion of metric bundles was latent in earlier work on convex cocompact subgroups of mapping class groups. Pranab's joint work with Mahan MJ on metric bundles gives criteria for subgroups of mapping class groups of surfaces with punctures to be convex cocompact.

Pranab's research interests can be broadly described as Geometric Group Theory. In July 2012 he joined the Department as a KAP, hosted by Prof. Misha Kapovich. He will work with Prof. Kapovich to extend the work of Bestvina-Feighn mentioned above. He also is also interested in studying the large scale geometry of discrete groups of isometries of higher rank symmetric spaces.

## Incoming Academic Staff



### New Krener Asst. Professor William Slofstra

Originally from Waterloo, Canada, William Slofstra completed his Ph.D. at UC Berkeley in 2011 under the supervision of Constantin Teleman. His thesis focused on applications of Lie algebra cohomology to the representation theory and combinatorics of Kac-Moody algebras. William spent the last year visiting at the University of British Columbia in Vancouver. His current work focused on the cohomology of Kac-Moody algebras and current algebras, and the combinatorics of Coxeter groups and Schubert varieties. His faculty mentor at UC Davis is Monica Vazirani.

Outside of his research, William enjoys talking about other areas of mathematics—operations research and quantum information in particular. Otherwise, William can be found hiking, visiting used bookstores, and watching competitive video games.



### New Krener Asst. Professor Jogia Bandyopadhyay

Jogia Bandyopadhyay received her doctoral degree in Physics from Georgia Institute of Technology. Her dissertation research was supervised by Professor Eric Carlen. Her first postdoctoral appointment was in the research group of Professor Antti Kupiainen in the Mathematics Department at the University of Helsinki. There she began working on the kinetic theory of a partially condensed three-dimensional Bose fluid.

Jogia's research focuses on problems in functional analysis that come from mathematical physics. In particular, she has worked on sharp Sobolev-type inequalities on Riemannian manifolds. A significant part of her current research focuses on the kinetic theory of Bose fluids. At UC Davis she will be working with Professor Bruno Nachtergaele on questions relating to quantum spin chains.



### New Krener Asst. Professor Hantaek Bae

Hantaek Bae received his Ph.D. in Mathematics in 2009 from the Courant Institute of Mathematical Sciences. His dissertation supervisor was Professor Jalal Shatah. Before coming to UC Davis he worked at the Center for Scientific Computation and Mathematical Modeling at the University of Maryland.

Hantaek's research interests encompass the types of evolution partial differential equations that arise in fluid dynamics, biology, plasma physics, and complex fluids among many other scientific areas. They focus specifically on the regularity of dissipative equations, polymeric fluids, critical threshold phenomena, long time behavior of dispersive equations, and free boundary problems. Hantaek is particularly interested in the well-posedness and regularity of initial value problems with limited regularity.

Hantaek joined the Department in 2012 as a Krener Assistant Professor. He is working with Professor Steve Shkoller on the free boundary problem of the Euler equation, which is both mathematically and physically important.

He is happily married to his wife, Wonkyung Jessica Lee, who is currently working and living in Washington, D.C. Despite being apart from his family, he is excited to be on the West Coast where he is able to enjoy great food and weather.



William Thurston at Berkeley in 1991. Photo from the Archives of the Mathematisches Forschungsinstitut Oberwolfach

## William Thurston

1946 - 2012

### William Thurston: A Personal Reminiscence

by Greg Kuperberg

**“Many people have an impression, based on years of schooling, that mathematics is an austere and formal subject concerned with complicated and ultimately confusing rules. Good mathematics is quite opposite to this. Mathematics is an art of human understanding. ... Mathematics sings when we feel it in our whole brain.”**

**Thurston, 2009**

#### Read More by Thurston

On proof and progress in mathematics  
<http://arxiv.org/abs/math/9404236>

Getting Into Shapes: from Hyperbolic  
Geometry to Cube Complexes and Back  
<http://tinyurl.com/simons-thurston-article>

Bill Thurston came to the UC Davis Mathematics Department in 1966, the same year I did. He was, of course, one of the most famous mathematicians in the world by then. His motivation for coming here might surprise those who did not know him. He did not just want to be a famous mathematician in a famous math department; he had been that for years at Princeton. He admired UC Davis because in his view it had a strong, active Mathematics Department that had not overdosed on its past prestige. Of course he also had other reasons for coming to Davis - his wife was a student at our Veterinary School. But that really was how he viewed our Department and his place in it; he wanted to be just one of the gang.

Bill was intellectually generous. He always had time to discuss mathematics with any interested person. It was an amazing experience to talk mathematics with him; his intuition was like an elemental force. Arguably the best way to interact or collaborate with him was just to casually talk about mathematics of mutual interest. At such times he freely gave away ideas and suggestions. But those who expected him to put on his own show quickly discovered their error.

Although he had some very strong students, it was not Bill's ambition simply to select and train the strongest candidates. He wanted - and had - the same range of students as other faculty. In fact, he was quite idealistic about other people's mathematical abilities, and their intelligence in general. He thought the human brain was amazing, and believed that anyone's intellect could be drawn out to do amazing things. This made him an ideal-

istic and enthusiastic educator. While at UC Davis he developed and extended his favorite course, titled "Geometry and the Imagination".

Given Bill's groundbreaking achievements in mathematics, it would be easy to suppose that he was a highly focused and organized person. Although he certainly could be focused when thinking about mathematics, he was not so well organized; he was only human on that score.

Although it was certainly possible to disagree with Bill, it was not possible to dislike him. Despite his fame and his accomplishments he remained unassuming and idealistic, supportive and encouraging to all.

Although Bill was here for only 7 years, he made a permanent mark on the Department. Around the time I learned that he might leave for Cornell, a rumor circulated that our Department was in a panic. Although we were all quite sad to see him go, we were not in a panic. No one thought that he would take the Department by storm only to abandon it. That was not in his character. Although he was the dominant mathematician in his field, the last thing he wanted to be was domineering.

In 2012, Bill wanted to return to UC Davis, both to see his old colleagues here and to be near his children. Unfortunately, this was not to be. In July he visited Davis to look for a house. When I saw him on July 4th he was clearly gravely ill. He died a month later.

We deeply regret his passing. We will miss him, but we remain grateful for the time we had with him.

# Thurston's Mathematical Legacy

by Michael Kapovich

Bill Thurston was certainly the most famous and accomplished mathematician ever to serve as a faculty member of the UC Davis Mathematics Department. His work, some of which is describe below, profoundly changed the field of geometric topology.

Bill was born in 1946, and got his Ph.D. from UC Berkeley in 1972. His early work was universally recognized to be so important and original that two years out of graduate school he became a Professor of Mathematics at Princeton. He moved to Berkeley in 1991 to be Director of the Mathematical Science Research Institute. In 1996 he joined the faculty at UC Davis, and remained with us until 2003, when he moved to Cornell. He was planning to move back to UC Davis, but sadly died in August 2012, before this could be accomplished.

Thurston's early work dealt with the theory of foliations of manifolds. Analytically, foliations are solutions of certain systems of linear partial differential equations in several variables. It was known prior to Thurston's work that the existence of such linear systems of equations on a manifold is governed by the topological properties of the manifold. For instance, if the manifold has zero Euler characteristic then it can support a nowhere vanishing smooth vector field, and hence admits both a linear ODE (ordinary differential equation), which can be always integrated, and a codimension 1 linear system of PDEs (partial differential equations). Shortly after getting his Ph.D., Thurston proved that every  $n$ -manifold which admits a nowhere vanishing vector field also admits a codimension 1 foliation, i.e., a foliation by  $n-1$ -dimensional submanifolds. Moreover, every codimension 1 distribution (normal space to a nonvanishing vector field) can be deformed to the tangent distribution of a foliation.

The influence of Thurston's work on this field was dramatic. Advisors told students not to work in the theory of foliations (which was quite fashionable at the time) because Thurston was "cleaning out the subject." (My friend and collaborator, John Millson, who was a graduate student at Berkeley at the same time as Thurston, told me that after meeting Thurston in his first year of graduate school he decided "whatever this guy is doing, I am going to work on something else.")

Shortly thereafter, Bill turned his attention to low-dimensional topology. Around 1976, in the process of thinking about the geometry of 3-dimensional manifolds, he propounded an amazing conjecture that commingled geometry with topology:

*The Geometrization Conjecture:* Every compact 3-dimensional manifold can be cut (in a canonical fashion) into finitely many pieces, each of which admits an appropriate geometric structure.

Thurston succeeded in proving this conjecture for a broad class of manifolds. For this proof he invented a large arsenal of new geometric and topological tools, and proved some deep results on the structure of 3-dimensional hyperbolic manifolds. The result became known as the *Hyperbolization Theorem*. For this transformational work in geometry and topology, Thurston was awarded the Fields Medal at the 1983 International Congress of Mathematicians in Warsaw.

In the early 1980's Thurston propounded a set of questions and conjectures which, together with the Geometrization Conjecture, set the course for 3-dimensional topology and geometry over the next 30 years. His key insight was that *one can prove purely topological results by verifying that manifolds admit certain geometric structures, and by analyzing the geometric properties of these structures*. Further, he found that geometric structures of these types abound in dimension 3.

One of the most prominent applications of this insight is the proof of the *Poincaré conjecture* for 3-dimensional manifolds, which states that if  $M$  is a compact 3-dimensional manifold in which every loop can shrink to a point, then  $M$  is a 3-dimensional sphere. This is a purely topological question and in higher dimensions it was solved by topological methods. In dimension 3, however, the Poincaré conjecture is a corollary of the geometrization conjecture. To date this remains its only known proof.

Remarkably, in the last 10 years essentially all the problems and conjectures proposed by Thurston have been settled in the affirmative. As a result of Thurston's work and his profound insights, our understanding of compact 3-dimensional manifolds has gone from almost nothing to "what else is left to prove?"



Photo by Bill Wingell for The New York Times

**"I used to feel that there was certain knowledge and certain ways of thinking that were unique to me. It is very satisfying to have arrived at a stage where this is no longer true — lots of people have picked up on my ways of thought, and many people have proven theorems that I once tried and failed to prove."**

**Thurston, 2012**



## Updates from The Undergraduate Program

by Jesus DeLoera, Undergraduate Program Chair

The Department awarded 51 undergraduate degrees this year – 38 in Mathematics, 11 in Applied Mathematics and 2 in Mathematical and Scientific Computation. Five of these graduates received departmental citations. In addition, Adam Afandi graduated with high honors, and Sara Cohen, Julian Gold and Asad Lodhia graduated with highest honors. The numbers of these awards testifies to the commitment and dedication of our majors.

The academic year 2012-2013 started with the admission of 168 new student majors to our program. We are proud to say that this is the largest incoming class in the history of the Mathematics Department. This is the fruit of much hard work by our faculty and staff to bring the opportunities in Mathematics at UC Davis to the attention of high school seniors as they decide where to go to College. With this large influx, the total number of students in the three majors we offer has surpassed 400, which also is an all time high for the Department.

We place great importance on providing our students with a supportive and encouraging environment throughout their time with us. A variety of activities are designed to foster this atmosphere. Our new students were invited to attend our Undergrad Welcome Event, which took place on September 27th. We discussed with them the importance of starting early to plan their individual program of study in concert with their faculty advisor. We also stressed that we are here to help all our students succeed. We described the multiple sources of support that are available when needed.

Two important mathematics interest groups are focused on undergraduates. The Math Club meets weekly (Wednesdays 5-7pm 1147 MSB). It provides a place where people with common interests in mathematics can meet and socialize, and learn about a variety of topics in current mathematics research. All mathematics students are welcome at the Math Café. Here faculty and graduate student volunteers are available to tutor any student in any course. Professor Monica Vazirani has worked hard to make this opportunity available to students. We are happy to report that it is a strong success.

This year we have initiated a weekly Undergraduate Research and Exploration seminar (Fridays 4:10-5pm, MSB 2112). This opportunity has been created and organized by professor Jesus DeLoera, the Vice Chair for Undergraduate Matters. Here undergraduates meet to discuss and present research papers, and participate in team-based investigations of interesting projects. Currently, for example, one team is examining the mathematics of voting. (Given two voting systems, what is the probability that they yield different winners?) A second team is investigating the methods and practical uses of mathematical data mining by focusing on the paradigm problem of automated recognition of the author of a text. It is anticipated that later projects also will include developing variations or special cases of the research presented in discussed papers. Students practice their mathematical and communication skills, and everyone has fun! At present about 20 students attend regularly.

The Department ran a vigorous Research Experience for Undergraduates (REU) program over the summer. This was coordinated by Professor Jesus DeLoera and involved 14 undergraduate student participants. They worked on a variety of projects spanning pure and applied mathematics, from discrete geometry to mathematical physics and mathematical biology. Many of the students who participated in this Summer REU will present their research in the Undergraduate Research and Exploration seminar.

There are many opportunities available in the Department for enrichment of the undergraduate experience. Everyone is welcome; please join us!



## Did you hear...? Mixed Integer Programming Workshop

Those walking along Putah Creek in our Arboretum this July will have seen numerous signs guiding visitors from downtown to the Mondavi Center for the mathematics workshop on Mixed Integer Programming (MIP 2012).

A sample problem gives a sense of what Mixed Integer Programming (MIP) is about. A traveler needs to visit a set of cities, starting from and returning to her home city. The cities can be visited in any order. Several modes of transportation are available. But there is a fixed budget for the trip, and it must be completed within 2 weeks. The traveler wishes to use a route and modes of transportation that keep the  $CO_2$  impact of the trip as low as possible.

A plan for this trip can be mathematically described (modeled) as a collection of yes-no decisions, such as *use a bus from city A to city B, or not*. These decisions become mathematical variables that are only allowed to take the integer values 0 (*no*) or 1 (*yes*). The constraints on budget and time can be expressed using inequalities in these variables. The goal regarding the  $CO_2$  impact is expressed as a function (the *objective function*), which we wish to minimize.

Mathematical models like this are called *integer optimization problems* or *integer programs*. When real variables and integer variables are both present, we speak of *mixed integer programs*.

The field of mathematical optimization studies how to set up the most effective mathematical models of specific MIP problems. It then develops efficient computer-implementable methods to solve them, and proves theorems about the properties of optimal solutions. Mixed Integer Programming problems arise in countless critical applications in all areas of business and industry. The methods of optimization used to solve them are very powerful mathematical tools, and are key to many successful interdisciplinary collaborations.

The first MIP workshop took place at Columbia University in 2003, and they have been held annually at various locations ever since. Their programs consist of a limited number of invited talks on cutting-edge (pref-



erably unpublished) work on Mixed Integer Programming. The talks are organized in a single track and are scheduled to leave ample time for discussion and interaction among the participants.

This year's workshop was particularly well attended with over 100 outside participants, more than 25% of whom came from abroad. It was generously supported by various industrial sponsors and funding agencies, as well as the UC Davis Department of Mathematics, Graduate School of Management, and the L&S Division of Mathematical Sciences. Thanks to the work of the local organizing committee, headed by Krener Assistant Professor Amitabh Basu, the professional staff at the Mondavi Center, and the great help of Department of Mathematics staff and volunteer graduate students, the local organization of the workshop went very smoothly. The workshop helped to put UC Davis on the map as an internationally important center for research in discrete optimization.

## Emeriti Focus Roger Wets



Although Roger Wets formally retired from UC Davis in 2008 after 24 years in the Mathematics Department, he remains extremely active in his research area. His main interest is Stochastic Variational Analysis, a field that spans probability, optimization, equilibrium theory and statistics.

In the last year he hosted visits to UC Davis by two Fulbright Fellows and four other scholars in this research area. He made extended visits to the Center of Mathematical Modeling and the Institute for Complex Engineering Systems at the Universidad de Chile in Santiago. He presented keynote and invited lectures at international conferences and workshops in Prague, Lima and St. Petersburg.

He gave a six week course on Stochastic Variational Analysis here at UC Davis, a four week minicourse on this topic at ETH-Zurich, and a Course on Stochastic Optimization at the Centre d'Énergie Atomiques in Cadarache, France. He delivered a colloquium lecture at Northwestern University on the fusion of hard and soft information in statistical estimation. And he gave research seminars at Rey Juan Carlos Universidad and at the Universidad Autónoma de Madrid in Spain.

He received New ARPA-e (DOE) funding to work on the Unit Commitment Problem in Electricity Dispatching in collaboration with Sandia National Labs, Iowa State University, New England ISO and Alstom. And he was awarded a new grant Army Research Office on Estimation and Uncertainty Quantification.

He reports that as time allows he continues to work on a graduate textbook, entitled *An Optimization Primer*.

## Honors and Awards

### James Bremer



The Alfred P. Sloan Fellowship is a prestigious national award, given to support promising researchers early in their careers. James Bremer is one of two Davis faculty members to win a Sloan Fellowship in 2012.

## Research Highlight Scattering from Complicated Shapes

James Bremer joined the Department as an Assistant Professor in 2007 after earning his Ph.D. from Yale University. His research focuses on numerical scattering theory, in particular the scattering of sonar and radar waves from complicated objects.

Although scattering theory is a venerable topic of study and many numerical methods for the simulation of scattering are available, most existing techniques are unable to produce highly-accurate simulations of scattering from complicated real-world objects such as airplanes or submarines. Bremer's research is focused on developing extremely robust, high-accuracy methods that are capable of treating such cases. He is particularly interested in developing methods to simulate scattering from curved surfaces with edges and corner points. He has found that in these complicated situations classical integral equations have numerous advantages over more popular approaches like finite element methods. Using integral equation techniques, Bremer has made several important contributions to scattering theory. These include developing a new method to discretize integral operators on surfaces, and a fast solver for certain integral equations that arise in complex scattering problems.

His current work focuses on developing fast direct solvers for three-dimensional problems. Most numerical methods for solv-

ing linear systems are iterative; they function by repeatedly applying the coefficient matrix of the linear system. The performance of this strategy depends strongly on the spectrum of the operator under consideration, which in turn depends on the geometry of the scattering object. For instance, scattering from surfaces with inclusions and scattering from multiply-connected domains are two cases that are notoriously difficult for iterative solvers to address. Traditionally, preconditioning was the method of choice for such problems. But, in the last decade, more robust and powerful methods, called fast direct solvers, have been developed. These new approaches exploit the analytic structure of specific classes of operators to rapidly form a compressed inverse of the coefficient matrix of the linear system under consideration. This overcomes many of the difficulties with iterative methods. However, fast direct solvers have not yet been developed for variety of cases, including integral equations on surfaces.

Bremer's current research aims to develop  $O(N)$  fast direct solvers specifically for integral equations on surfaces. The combination of these solvers with high-order discretization techniques for integral equations on surfaces will enable the development of realistic, high-accuracy models of scattering from extremely complicated surfaces.

## Mathematics for the Future

The Department of Mathematics wishes to thank all alumni, parents, students, faculty, staff and friends who support the Department each year. For a list of our endowed funds, please see our web site:

<http://www.math.ucdavis.edu/contact/donation/>

Your gift to the Department is tax deductible, and you can choose to have your name published, or remain anonymous.

Your gift can be used towards undergraduate and graduate support, faculty and research

support, and/or Departmental priorities. Your gifts ensure our future success.

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<http://giving.ucdavis.edu/DeptMath/General>

Please choose "Mathematics General Support" for the gift designation and follow the prompts.

A list of donors can be found on the back cover of this newsletter. Thank you for your continuing support.

We appreciate the many donors who double or triple the impact of their gifts through their employers' matching gift program. For more information about matching gifts, you can go to:

<http://matchinggifts.com/ucdavis/>

For additional questions please contact the Development Office at (530) 752-3429.



# The Boundary of the Perfect Wave by Steve Shkoller

I have always been mesmerized by waves. Here is an example of the kind of wave that I like. Of course, there are all sorts of waves cruising around the universe, but if you're speaking with a surfer about waves, then you will undoubtedly be discussing ocean waves, and not any type of ocean wave but those large, fast-moving, cylindrical waves, that pitch-out into a perfect barrel and break down the line.

Remarkably, the motion of that translucent blue-green salt-water is rather nicely described by the oldest set of partial differential equations known to man, the Euler equations of fluid dynamics. These are a coupled set of nonlinear conservation laws for the three components of the velocity as well as the pressure. They are set in a domain that is changing in time, and is itself one of the basic unknowns of the problem; hence, this is a free-boundary problem.

It is of great importance to ascertain if solutions to the Euler equations exist. A solution must solve the Euler equations inside the moving domain, while simultaneously transporting the moving interface between the air and water. A variety of interesting questions can be asked: If solutions exist, are they unique? Is the free-boundary smooth? Do solutions exist for all time, or is there a finite-time singularity? These basic problems are central to my research program.

To answer them we must move away from the classical picture of breaking waves introduced a half century ago, in which a wave "breaks" when its tangent plane becomes vertical. Instead we use a more realistic definition, which allows the wave's slope to become vertical, then turn over and become cylindrical (the ideal), and then finally break, in the sense of the crest of wave falling down onto its trough. In this view the free-boundary is not a graph over the horizontal plane. We must employ a description of the fluid that follows the trajectories of the fluid particles, and views the moving fluid domain as a diffeomorphic copy of its initial state. We have found the Lagrangian description of fluid dynamics to be ideally suited for this purpose. This allows us to control the geometry of the moving free-boundary, and hence also provides a priori control of the velocity and pressure. This "control" involves a new structure obtained from the nonlinear interaction between the cofactor matrix of the diffeomorphism taking the initial boundary to its current location and specially constructed derivatives of the velocity field. Having this geometric control in hand, we introduced a new class of solutions to the Euler equations that are well-defined all the way to the breaking-singularity. (This is when

the crest touches the trough so the fluid domain has a self-intersecting boundary with a singular cusp.) This method has shown that unique solutions exist to the Euler equations which propagate the free-boundary and, in finite-time, turn over and break.

There are many other physical scenarios in which similar surfaces of discontinuity are propagated. One intriguing example from astrophysics is the expansion of the cloud produced by a supernova explosion. Here a compressible gas, modeled by the compressible Euler equations, expands into a vacuum, the moving free boundary of the gas is the surface along which the density vanishes. Mathematically, this vanishing of the density function introduces tremendous degeneracy into this nonlinear system, making traditional methods for hyperbolic equations useless for proving existence or regularity. To address this problem we have developed new, high order inequalities new energy structures associated with nonlinear wave interactions. This establishes a framework for analyzing degenerate, hyperbolic moving free-boundary problems that can be used in a variety of contexts.

There are vast number of physical systems that give rise to free-boundary problems. For example, fluid-structure problems treat interactions between an elastically deformable solid and a viscous fluid. Here the deformations of the solid produce a moving, time-dependent material interface between the structure and the fluid that is itself an unknown in the problem. The swimming of a dolphin is a very interesting example that led me into this class of free-boundary problems. In 1936 the British zoologist Sir James Gray showed that the muscles of dolphins simply were not strong enough to propel them at the speeds they in fact achieve. This came to be known as "Gray's Paradox." Early attempts to resolve this paradox failed to correctly include the nonlinear interaction responsible for accelerating the fluid and allowing the dolphin to swim. In simplest mathematical terms, the viscous fluid can be viewed as governed by a heat (or diffusion) equation and the dolphin by a wave (or conservative) equation. Intuition suggests that when coupling these two regimes diffusion will win out and dominate the wave equation. But in fact, to our great surprise, we found that the wave regime takes over, and makes the viscous fluid behave like a conservative wave equation. This showed that it is essential, when treating nonlinear fluid-structure interaction problems, to analyze the structure simultaneously with the fluid, keeping all nonlinearities intact. Our analysis showed that wave-like vibrations of the dolphin's rough skin creates tiny vortices in the fluid, which in turn, accelerate the dolphin.



# Alumni Update

## Scott F. Beaver

Ph.D., 2004

Professor Beaver took a postdoc at the University of New Mexico before becoming a tenured professor at Western Oregon University in Monmouth, Oregon, where he presently teaches.

He has two children, Elizabeth, 9, and Evan, 6. His wife, Cheryl, is also a professor at Western Oregon, and their adjacent offices make life and study convenient.

## Sean L. Casey

B.S., 1978

Not long after graduating, Sean became a system analyst at System Development Corp. A few years later he moved on, becoming a project engineer at TRW Inc. for some time while he worked on getting his M.S. in Operations Research at UCLA in 1986. He eventually became senior staff engineer at Qualcomm.

Sean now lives in Solana Beach, California, where he's deep in study on how to properly bum about his house. He asks that we take it easy on his son, who started his first math course this Fall.

## Sandy Feder

B.S., 1972

After getting her B.S. in Mathematics, Sandy moved on to get a Masters in Computer Science. She taught math at Sacramento State and Fairfield High School before moving on to more computer oriented fields, programming medical software and, later, working for Spring and Aerojet TechSystems.

Professor Sandy now teaches Computer Science for Sacramento City College. She's working hard to start a Web Professional Academy there, working with high schools to prepare students for college. Her plan involves connecting students to a 4-year university to get their degree, while they remain employed creating web pages to pay their way.

She reaches out to math instructors to learn more about Project S.E.E.D. (Special Elementary Education to the Disadvantaged), which helps teach underprivileged children in grades 1 to 4.

## Updates from The Graduate Programs

by Thomas Strohmer, Graduate Program Chair  
and Steve Shkoller, GGAM Chair

The Graduate Program in Mathematics graduate program welcomes 13 new graduate students this year. These were selected from more than 200 applicants, which is the largest applicant pool the Program has ever had. This demonstrates how the quality and reputation of our program continue to grow.

The 3rd Annual Davis Math Conference took place on September 27, 2012. This conference was organized by the graduate students under the auspices of the Galois Group. It showcased research projects of students from both the GPM and the GGAM graduate programs. Davis also was the location of the 23rd Bay Area Discrete Math Day (BADMath Day), which took place in October 2011.

The Graduate Group in Applied Mathematics welcomes 20 new students into its program this year. The group also welcomes two new faculty to its membership. Tony Tyson of the Physics Department joins us, as does Paul Ullrich from Atmospheric Science. At present there are 89 faculty in the Graduate Group from 22 Departments and 6 Colleges. There also are 66 graduate students currently enrolled in GGAM.

The seventh Annual GGAM Miniconference was held on January 21, 2012. This annual event brings together the faculty and students of GGAM, together with all other interested participants, in an informal forum to share research interests and foster collaborations. The talks presented, as well as more informal discussions, provide students a sense of the breadth of research opportunities available to them. This year's program, which was coordinated by James Bremer, spanned topics from random networks and discrete optimization to the neurobiology of locomotion and swimming in low Reynold's number fluids. More than 70 participants attended the dinner that followed this event.

I am happy to report that our graduate students continue to be successful in earning awards and fellowships. David Renfrew, who completed his Ph.D. in Spring 2012 under Prof. Alexander Soshnikov, has been awarded the prestigious 2012 MPS Dean's Graduate Student Prize in the College of Letters and Sci-

ences for his dissertation research on probability, random matrix theory and mathematical physics. This Prize is given to the most outstanding graduate student in the Division of Mathematics and Physical Sciences. This is the second year in a row that this Prize has been awarded to a student in our program. Chelsea Weaver has been awarded a 2012 National Defense Science and Engineering Graduate (NDSEG) Fellowship. This is a highly competitive national honor that provides three years of support. Matt Stamps, who graduated in 2012, was awarded a National Science Foundation Postdoctoral Fellowship. This will support his research work at the Royal Institute of Technology (KTH) in Stockholm, Sweden. Ben Fogelson received a National Science Foundation Graduate Research Fellowship, while Eric Brattain-Morrin and David Stein were given Honorable Mentions in the competition for that award. Dustin Mayeda and Wenjing Liao received Alice Leung Scholarships in Mathematics. Jeffrey Anderson was the recipient of the William K. Schwarze Scholarship. Nam Lam and Kristin Lui received the Henry Alder Prize for excellence in teaching. Robert Hildebrand and Owen Lewis were awarded Yueh-Jing Lin Scholarships. These Department awards are detailed further on pages 12-13.

Finally, the Department was awarded another GAANN grant. As always, our staff has been most helpful through out this application process. This grant runs for three years, providing fellowship funding for four graduate students per year.

# 2011 - 2012 Graduate Degree Recipients

**Sonya Berg**, Ph.D., Math : Professor, Marianopolis College, "A Quantum Algorithm for the Quantum Schur-Weyl Transform," Prof. Kuperberg

**Jefferey Ferreira**, Ph.D., Math : Postdoctoral Researcher National Science Agency (NSA), "Row-Strict Quasisymmetric Schur Functions, Characterizations of Demazure Atoms, and Permuted Basement Nonsymmetric Macdonald Polynomials," Prof. Vazirani

**Benjamin Fineman**, Ph.D., Math : Lecturer, UC Davis, "Bounds for the Number of Permutations with a Low Density of Patterns," Prof. Babson

**Mihaela Ifrim**, Ph.D., Math : Postdoctoral Researcher, McMaster University, "Normal Form Transformations for Quasilinear Wave Equations," Prof. Hunter

**Jen (Josh) Oyoung**, Ph.D., Applied : "Totally Asymmetric Simple Exclusion Process for Particles of Different Hopping Rates," Prof. Tracy

**David Renfrew**, Ph.D., Applied: RTG Assistant Adjunct Professor UCLA, "Outliers of Finite Rank Deformations to Random Matrices and Related Functionals," Prof. Soshnikov

**Gregory Shinault**, Ph.D., Applied : Van Vleck Visiting Asst Professor, UW Madison, "Inhomogeneous Tilings of the Aztec Diamond and the Airy Process," Prof. Tracy

**Matthew Stamps**, Ph.D. Math : Postdoctoral Researcher, Aalto University, "Topological Methods in Matroid Theory," Prof. Babson

**Rohit Thomas**, Ph.D., Math : "Decorated 3-manifolds and invariants of Hopf words," Prof. Kuperberg

**Hsiao-Chieh (Arcade) Tseng**, Ph.D., Applied : Postdoctoral Researcher, UC Davis, Land, Air and Water Resources, "Compressive Sensing and Its Applications in Radar Imaging and Rough Surface Scattering," Prof. Fannjiang

**Anna Vershynina**, Ph.D., Math : Research Associate, Princeton University, "Existence of the Thermodynamic Limit and Asymptotic Behavior of Some Irreversible Quantum Dynamical Systems"

**Colin Middleton**, M.S., Applied : Currently Job Searching

**Paul Prue**, M.A., Math : Currently Job Searching

**Anna Vershynina**, M.A., Math : Research Associate, Princeton University

**Han Wang**, M.A., Math : Currently Job Searching

**Amanda Young**, M.A., Math : Continuing with Ph.D., UCD

## Alumni Update

### Dean H. Fearn

Ph.D., 1971

After graduating at UC Davis in 1971, Professor Fearn taught statistics at California State Univ., Hayward, before ultimately moving to CSU, East Bay. He became an Emeritus there in 2004.

He continues to live in Stockton, and serves as web master for the San Francisco Bay Area Chapter of the American Statistical Association.

### Brian H. Dong

B.S. Mathematics, 2004

M.A. Education, 2006

After completing a degree in mathematics, Brian went on to get a teaching credential program under Professor Allan Bellman. He currently teaches math and computer science at Monte Vista High School in Fremont. He's been teaching there since 2005.

### Christine A. Shoemaker

B.S., 1966

Dr. Shoemaker was elected to the National Academy of Engineering. She received this honor for her development of decision-making optimization algorithms for environmental and water resources problems. Dr. Shoemaker is the Joseph P. Ripley Professor of Engineering in the School of Civil and Environmental Engineering at Cornell University.

## Are You a Graduate?

We want to hear from you! Please send us information about yourself so that we can stay in touch and share in your experiences outside of UC Davis.

Please complete our Alumni Questionnaire:  
[http://www.math.ucdavis.edu/news/alumni\\_quest](http://www.math.ucdavis.edu/news/alumni_quest)  
or send e-mail to:

[mso@math.ucdavis.edu](mailto:mso@math.ucdavis.edu)

We will do our best to include it in the next newsletter.



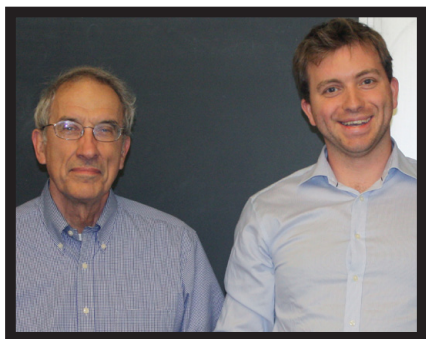
Chun Yu Hong



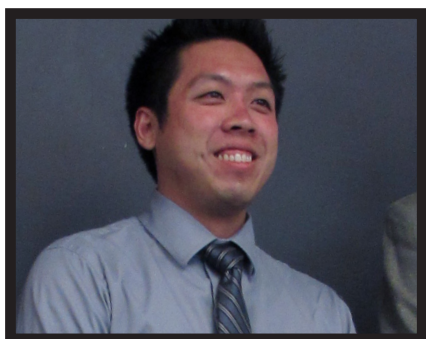
Jeffrey Anderson



Wenjing Liao, Dustin Mayeda



Prof. Emeritus Sallee with Prof. Coward



Nam Lam

# 2011-2012 Department Awards Recipients

## Eric C. Ruliffson Scholarship in Mathematics

Eric Canady Ruliffson attended UC Davis from 1964-1968, loved the study of math and excelled in it. He was first and foremost a problem solver, which helped him to achieve life-long personal and professional success. While attending UC Davis, Eric worked as a summer intern in the actuarial department of Pacific Mutual Insurance in Los Angeles, and was hired by them upon graduation. After serving in the Navy, Eric attended graduate school in demography at UC Berkeley. In 1973 he resumed his actuarial career at Pacific Mutual Insurance. He became a partner at the San Francisco office of Coopers & Lybrand and named a Fellow in the Society of Actuaries. He was subsequently elected to the Board of Partners for Coopers and Lybrand, the first actuary to be so honored, and later served on the Board of Partners for PricewaterhouseCoopers, the world's largest consulting firm. The Eric C. Ruliffson Scholarship in Mathematics is awarded annually to students of junior or senior standing majoring in mathematics.

Recipient – Chun Yu Hong

## William K. Schwarze Scholarship in Mathematics

William Karl Schwarze was born in 1942 in San Francisco. He excelled in mathematics in high school and at UC Davis, where he received a bachelor's degree. He went on to graduate school at Berkeley and a career as a mathematics teacher in San Francisco. Perhaps due to his mathematical insights, Bill also became a successful investor in real estate. After his death in 1988, a trust he established with the SF Foundation has donated to a variety of humanitarian purposes, in particular to the Schwarze Scholarship to be presented today. This award is given to graduate students in Mathematics who have demonstrated outstanding mathematical scholarship and exceptional promise of making a strong professional contribution as a mathematics teacher and educator at the pre-college or college level.

Recipient – Jeffrey Anderson

## Robert Lewis Wasser Memorial Scholarship

Robert Lewis Wasser was born in 1973 in Sacramento. He excelled in many areas--he was selected as a National Merit Scholar in 1991, and participated in the Academic Decathlon. Robert began at UC Davis in 1991. His academic achievements were numerous and impressive. He was one of the few students in our Department who had already taken as a sophomore some of our most challenging courses, such as Math 127. His instructor in that course, Professor Don Chakerian, said how much he was inspired by their discussions and that Robert's presence made the whole class much more lively and spirited. After his tragic death in an automobile accident in 1993, prior to his Junior year, his grandmother, Vera May Wasser, initiated the Robert Lewis Wasser Endowment in his memory, with contributions from family and friends. Its goal is to benefit promising mathematics students at UC Davis.

Recipient – Chun Yu Hong

## Alice Siu-Fun Leung Scholarship in Mathematics

Alice Siu-Fun Leung received a Masters degree in Mathematics in 1975 from UC Davis. She later worked as a global property management accountant in Hong Kong. She remembered with fondness her days at UC Davis. She enjoyed gardening and working as a volunteer helping animals.

In her will, Ms. Leung generously provided funding to award scholarships annually to graduate students in Mathematics. This award is given to students who have shown exceptional promise in all aspects of mathematics, including research, scholarship and teaching.

Recipients – Wenjing Liao, Dustin Mayeda

## G. Thomas Sallee Mathematics Teaching Award

The G. Thomas Sallee Mathematics Teaching Award honors Professor Emeritus Tom Sallee's 40-year career with the Department, his dedication to being an excellent teacher, and his life goal of developing and supporting talented mathematics educators.

An endowment was established in his name that allows the Department to recognize the best teaching of lower-division mathematics courses on an annual basis.

Recipient – Alexander Coward

## G. Thomas Sallee Mathematics Prize

This award is also given in recognition of Professor Emeritus Tom Sallee, and reaffirms his life goal of developing and supporting talented individuals in mathematics. This prize recognizes exceptional undergraduate students of junior or senior standing who competed in this year's Spring Mathematics Competition, held on May 7, 2011.

**Recipient – Jianyang Zhao**

**Honorable Mentions – Mincheng Zhou, Ruian Chen**

## Henry L. Alder Award

Professor Henry L. Alder received his Ph.D. from UC Berkeley in 1947. After spending a year on the faculty in the Department of Mathematics at Berkeley, he joined the Davis faculty as an Instructor of Mathematics. He advanced to the rank of Professor in 1965, and officially retired in 1992. He then served as Department Chair from 1992 to 1994. After his retirement, Prof. Alder continued to teach in the Department for many years.

Professor Alder was also active in other campus programs and was always a strong advocate for quality teaching. In 1999, Prof. Alder gave a gift to the UC Davis Foundation to establish an endowment. This provides support to mathematics graduate students at UC Davis through the Henry L. Alder Prize for Excellence in Teaching, an award given each year to the graduate student who is deemed to be the top teacher among all graduate students in mathematics.

**Recipients – Kristin Lui, Nam Lam**

## Evelyn M. Silvia Scholarship for Future Mathematics Teachers

The Evelyn M. Silvia Scholarship for Future Mathematics Teachers was established by generous donations from family and friends of the late Professor Evelyn Silvia. Evelyn was hired by the Department in 1973 after receiving her Ph.D. from Clark University. The focus of Evelyn's passion and unwavering commitment was to develop talented mathematics teachers at the K-12 grade level. She was extremely generous with her time, whether it was as a campus committee member or as an adviser assisting students.

This scholarship honors Professor Silvia's memory by encouraging students who aspire to be future mathematics teachers. It recognizes a junior or senior with a major in mathematics, applied mathematics or statistics who has shown an interest in teaching mathematics.

**Recipient – Eva Dominguez**

## Yueh-Jing Lin Scholarship in Mathematics

Yueh-Jing (Jean) Lin and Chau-Hsiung (Mike) Chuang created the Yueh-Jing Lin Fund in 2009. This endowment provides scholarship support to one or more mathematics students each year. The scholarships are available to high-achieving mathematics students, either undergraduate or graduate. Mr. and Mrs. Chuang are alumni of UC Davis who met while they were graduate students on campus. Jean received her Master's degree in mathematics in 1971, and Mike received his master's degree in agricultural education in 1969.

**Graduate – Robert Hildebrand and Owen Lewis**

**Undergraduate – Libby Johnson and Zhijie (Jay) Zheng**

## Galois Group Service Award

The Galois Group is "the official voice of the graduate students in Mathematics." All graduate students in the Department of Mathematics are members of Galois; this is how graduate students in mathematics collectively communicate with Department faculty and staff. The group also coordinates and facilitates various activities, such as Monthly Game Nights and New Student Welcomes.

Every year, the Galois Group presents an award to recognize outstanding service and/or sustained commitment to the graduate group.

**Recipient – Naoki Saito**

## Departmental Citation Awards

These citations recognize undergraduate students of exceptional ability who have taken a very strong selection of mathematics courses and distinguished themselves with exceptionally high grade point averages. In addition, they have all received strong recommendations from the faculty.

**Recipients – Wei Gao, Michael Glaros, Julian Gold, Asad Lodhia, and Katherine Pannell**

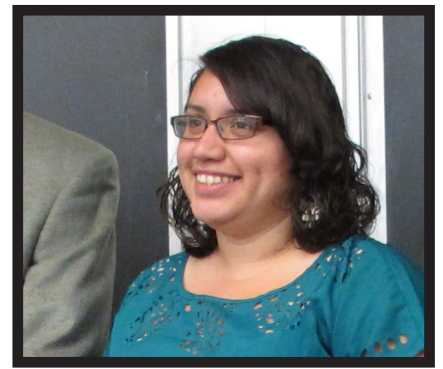
## Departmental Honors Awards

Every year, undergraduate students have the opportunity to participate in mathematical research, culminating in a senior thesis. Students typically work under the guidance of a faculty mentor to complete original research. The results are reviewed, and pending on the quality and substance, the student can receive Departmental high or highest honors.

**Recipients of Highest Honors –**

**Sara Cohen, Julian Gold**

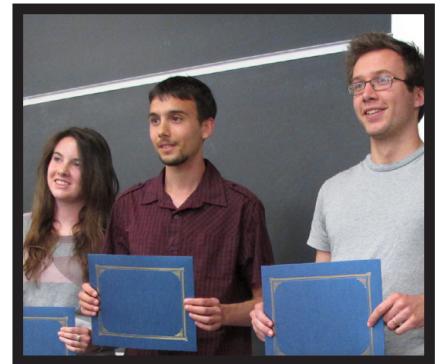
**Recipient of High Honors – Adam Afandi**



Eva Dominguez



Owen Lewis, Robert Hildebrand



Katherine Pannell, Michael Glaros,  
Julian Gold



Sara Cohen, Adam Afandi



## Julie Blackwood

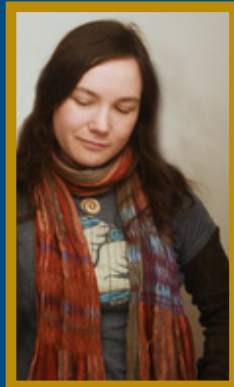
Ph.D. 2010

After graduating from UC Davis in 2010, I moved to Ann Arbor, MI to begin work as a postdoctoral researcher at the University of Michigan. My appointment is joint between the Department of Ecology and Evolutionary Biology and the Center for the Study of Complex Studies.

My postdoctoral research is in the field of disease ecology, where I have two primary projects. First, despite long-standing vaccination programs a resurgence of pertussis (whooping cough) has been reported in several countries. I use statistical inference to parameterize models of pertussis, with the goal of understanding the complex dynamics of immunity to this disease and the mechanisms that have led to its resurgence. Second, vampire bat transmitted rabies virus (VBRV) is one of the most important zoonoses in Latin America, accounting for tens of thousands of livestock deaths and \$30 million in annual economic damages. I have developed transmission models that investigate how such a highly lethal pathogen can persist within bat populations, and assess the implications of control programs on cross-species transmission.

Currently I am applying for faculty jobs and hope to find a position to begin in the Fall of 2013.

Aside from keeping busy with research and the job hunt, I recently became engaged. My fiance and I will be married this summer at a vineyard in Buffalo NY; we couldn't be happier!



## Amanda O'Rourke

B.S. 2008

After skydiving to celebrate my 2008 UC Davis graduation in mathematics, I moved across the country, becoming a fledgling graduate student in the Atmospheric and Oceanic Sciences Program at Princeton University. There I began work with Prof. Geoff Vallis on a question of midlatitude atmospheric dynamics, specifically investigating the variability of the jet stream.

I've passed a few milestones since arriving at Princeton. Most importantly, I survived my first two years of graduate school, passing my General Exams in the spring of 2010. This enabled me to take on the coveted title of Ph.D. candidate. Soon after I attended the Woods Hole Oceanographic Institution's Summer Program in Geophysical Fluid Dynamics. There I worked with Profs. Jean-Luc Thiffeault (U. Wisconsin-Madison) and Tiffany Shaw (Columbia Univ.) on optimal methods for mixing a tracer over the surface of a sphere.

In the intervening years I've baked far too many cookies, traveled from Vancouver to Edinburgh, and, of course, continued my thesis research on atmospheric jet dynamics. I have now been at Princeton four years working with idealized models of the atmosphere, and



will probably be here another year or so before moving on.

When I started as an undergraduate at UC Davis I never imagined myself becoming a graduate student. I blame Prof. Joseph Biello for inspiring me to apply the mathematics I learned to investigate geophysical fluid dynamics, and specifically to analyze the large scale atmospheric circulation. It's been an adventure!



## Lola Muldrew

M.A.T. 2007

Ph.D., Education (Math)

After completing my Master's degree in the Mathematics Department's Master of Arts in Teaching (MAT) program in 2007, I returned to UC Davis for further education. I am excited to announce that I have completed my dissertation and have earned my Ph.D. in Math Education! In addition I have been teaching Precalculus and Algebra 2/Trigonometry to high school students in San Jose, CA.

My dissertation research examined Black and African-American students' perceptions of adversity in traditional K-12 math classes in the United States. One goal of this research was to learn how to make the efforts of math teachers more relevant to students' needs.

My teaching philosophy focuses on developing student-centered classrooms, something that is very much in line with the philosophy of the UCD MAT program. I believe that math lessons should connect to the prior knowledge and experience of learners. Unlike didactic teaching practices in which rules, procedures and expectations of passivity restrict

student participation, my practice emphasizes collaborative discussions that guide students to higher levels of mathematical reasoning. Students are active participants in discussion-driven learning, and are given opportunities to develop and demonstrate autonomy and agency. By carefully scaffolding questions, I attempt to develop mathematically logical progressions of ideas that connect the concepts a student knows with what I want the student to learn.

Aside from "eating, drinking and sleeping" the obligations of a high school math teacher, I also enjoy the company of my boyfriend, Tshombe, and my cat, Drusilla (a.k.a., Mouse). Last summer, I enjoyed a summer off for the first time in my 20 years of working in math education. It was ridiculously exciting and wonderful ... and it was so needed!

## Notable Awards

Art Krener, Emeritus Professor of Mathematics, received the 2012 Richard E. Bellman Control Heritage Award from the American Automatic Control Council. This is the highest recognition of professional achievement by scientists and engineers working in the United States in the field of Control Systems.

James Bremer, Assistant professor, was awarded a 2012 Alfred P. Sloan Research Fellowship. Dr. Bremer's research interests are described in an article in this newsletter.

Five faculty members were elected to the inaugural class of Fellows of the American Mathematical Society. They are Joel Hass, Greg Kuperberg, Bruno Nachtergaele, Abby Thompson and Craig Tracy.

Dr. Amitabh Basu, a Krener Assistant Professor, was one of three finalist for the A.W. Tucker Prize, awarded annually by the Mathematical Optimization Society for the best doctoral dissertation in this area.

Dan Romik and Anne Schilling have been awarded Simons Fellowships for 2012-13. These fellowships are intended to provide increased opportunities for research to especially promising investigators by funding extended sabbaticals.

## Staff News

### Change is in the Air

by Gladis Lopez

The 2011-12 academic year brought several changes to the staff in the Department of Mathematics. Jessica Potts, who worked in the Department for many years, accepted a managerial position in the Chemistry Department, and Gladis Lopez was hired as the new manager. DeAnn Ronning also transferred to Chemistry, and we welcome Matthew Silver as our new academic personnel coordinator.

During this year, we continued to experience budget reductions. However, we have adjusted to these difficult times without compromising the quality of our services thanks to our talented and dedicated staff who have been working hard to cope with the changes.

Our staff family is growing! I am pleased to announce the birth of Porter Seguin, Tina Denena's son; Zoe Johnson, Zach Johnson's daughter; and Audrey Lai, Leng Lai's daughter.

## Emeriti Updates

### Art Krener

Although Art Krener retired from UC Davis in 2006, he remains very active in his research area of Control Theory. He was the recipient of the 2012 Richard E. Bellman Control Heritage Award from the American Automatic Control Council.

### Washek Pfeffer

Professor Washek Pfeffer retired from UC Davis in 1994 after having taught for 28 years in the Department. He also is still highly active in mathematics research. He has recently published his fourth book, entitled "The Divergence Theorem and Sets of Finite Perimeter," from the CRC Press.

## Join us on Facebook!



The Department of Mathematics is on Facebook! Visit us there to get updates on current seminars, events and news. We'd be happy to include any memories or photos you have of the Department on our wall.

To "like" us, search for "Department of Mathematics - UC Davis" on the Facebook web page:

<https://www.facebook.com/>

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### Featuring the 2011-12 Academic Year

#### Newsletter Committee:

Craig Benham, Editor  
Gladis Lopez, Management Services Officer  
Marianne Waage, Designer

## Thanks for Your Support

The Department of Mathematics wishes to gratefully acknowledge the generosity of the following donors, who have contributed to its support over the past three years.

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