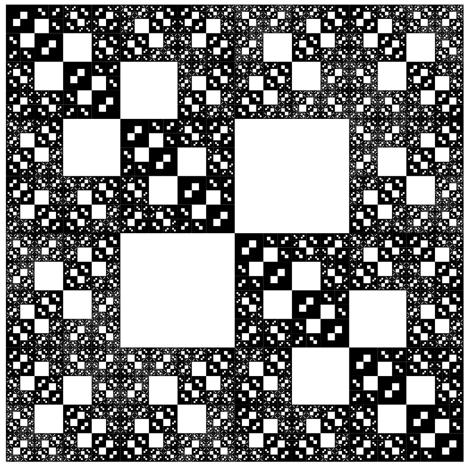
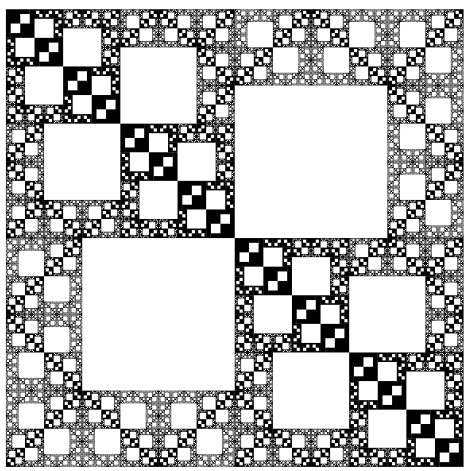
# Polymath

2013-14
Number 35
Mathematics Department Newsletter
Cal Poly, San Luis Obispo, Calif.





Fractals

*See page 3 for cover article*

CAL POLY
SAN LUIS OBISPO

## Contents



# Letter from the Department Chair

*Joseph Borzellino*

This year is my second as chair of the Mathematics Department, and I am delighted and honored to continue to lead such a noteworthy department that offers high-quality mathematics programs and is comprised of outstanding faculty, staff and students.

This year, the university faced the challenge of handling the largest incoming freshman class ever. The fall 2013 cohort was approximately 4,700 students, a 30 percent increase over last year's class. Because the Mathematics Department is fundamental to the polytechnic education that Cal Poly is known for, this increase impacted our department with an unprecedented demand for courses. I'm happy to say that we were able to meet this challenge while preserving Cal Poly's Learn by Doing principles and without increasing class sizes.

We're excited to welcome two new tenure-track faculty members who will help us meet this increased demand. Joyce Lin, an applied mathematician, joins us from the University of Utah as an assistant professor, and Danielle Champney, a mathematics education specialist, joins us from UC Berkeley. You can read more about each of them in this newsletter. Also, one of our longtime lecturers, Al Jimenez, has retired after 11 years of service, and we wish him well enjoying the good life.

Another big change at Cal Poly is the opening of the Warren J. Baker Center for Science & Mathematics. At 189,000 square feet, it replaces half of the aging Science Building and provides state-of-the-art classroom, lab and study facilities. Another benefit of the new building is that we have been able to move our entire faculty to Faculty Offices East, where the department office is still located, as well as move our graduate students closer to the office.

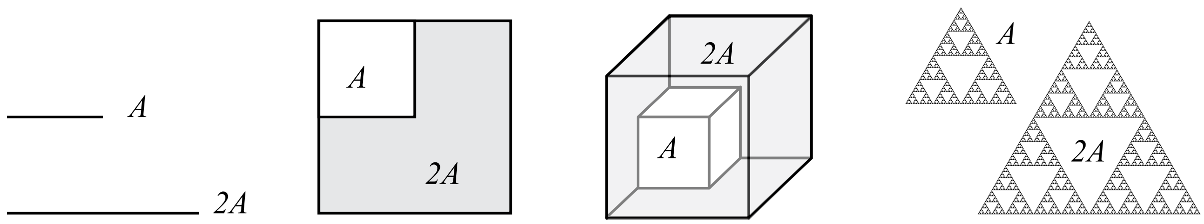
I hope you enjoy reading about the achievements of the Mathematics Department students, faculty and alumni. If you have any items of interest, please pass them along to us.

Lastly, I'd like to thank those of you who have supported us through your donations and gifts. Your generosity provides critical support for the students, faculty and staff of the department. It is very much appreciated.

Best regards,
Joseph Borzellino

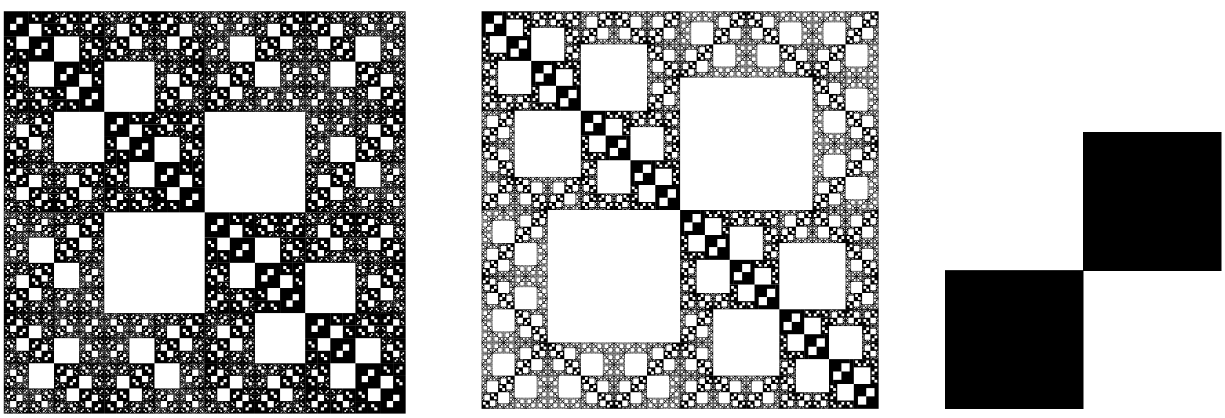
## Cover Article: Fractals - Erin Pearse

In geometry, the *dimension* of a set tells how its measure changes when the set is scaled. In each of the following examples, the set $2A$ is the set $A$ scaled by a factor of 2:



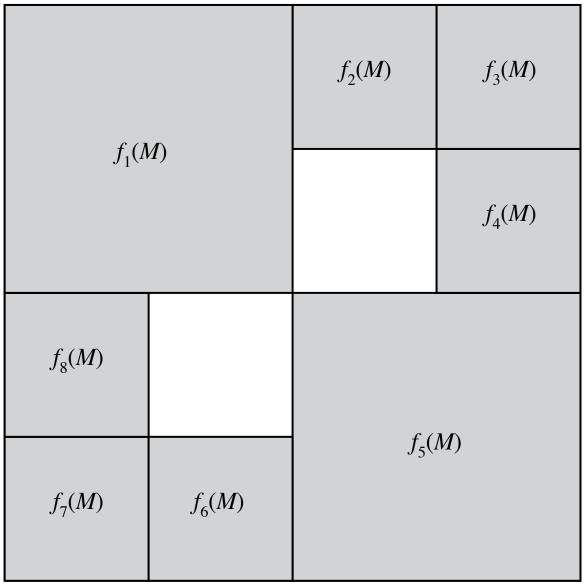

(a) (b) (c) (d)

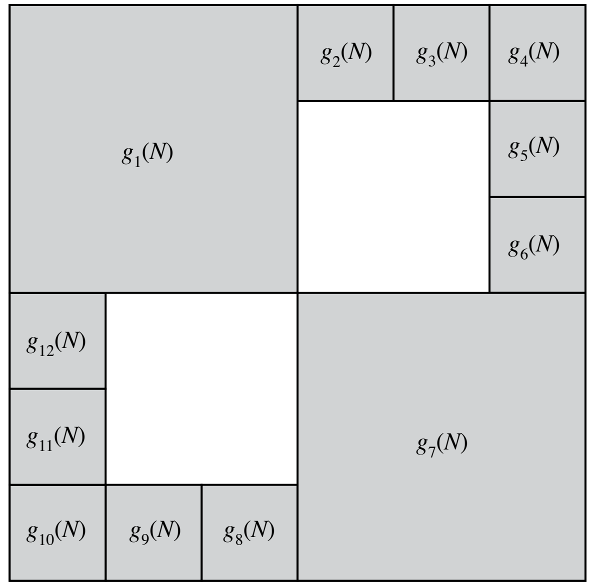
In (a), the set $A$ is 1-dimensional, and the measure (length) of $2A$ is $m(2A) = 2m(A) = 2^1 m(A)$.
In (b), the set $A$ is 2-dimensional, and the measure (area) of $2A$ is $m(2A = 4m(A) = 2^2 m(A)$.
In (c), the set $A$ is 3-dimensional, and the measure (volume) of $2A$ is $m(2A) = 8m(A) = 2^3 m(A)$.
In (d), the set $A$ is somewhere between 1-dimensional and 2-dimensional. Attempts to measure the length of this object (the Sierpinski gasket) yield a value of $\infty$, but you can also show that it has area 0 by considering the series $1-(1/4 +3/16+9/64+...)$. The set in (d) is a *fractal*: it has dimension which is not an integer. There is a way to measure such sets, and it turns out that for this set $A$, the measure of $2A$ is $m(2A)=2^{\log 3/\log 2}m(A)$. So we say $\dim A = \log 3/\log 2 \approx 1.58496$.



*M* *N* *G*

The illustration above depicts two fractal sets *M* and *N*, both formed by deleting scaled copies of the set *G* (the "generator") from a square. More precisely, each is self-similar and can be constructed by iterating a family of contraction mappings. The set *M* is generated by a mapping system of 8 mappings with scaling ratios of 1/2 or 1/4, and *N* is generated by a mapping system of 12 mappings with scaling ratios of 1/2 or 1/6, as depicted below (each shaded region is a shrunken copy of the entire figure).

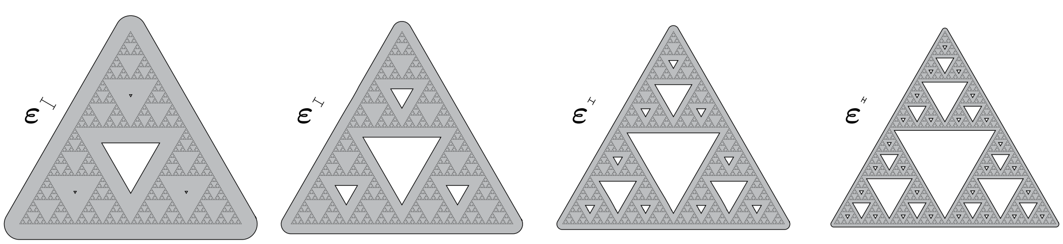



There are several definitions of "Fractal dimension" (similarity dimension, Hausdorff dimension, Minkowski dimension, packing dimension, capacity dimension, etc.) that may be different in general. However, for the two example sets *M* and *N* above, these quantities all agree. For *M*, the dimension can be found explicitly by solving the Moran equation:

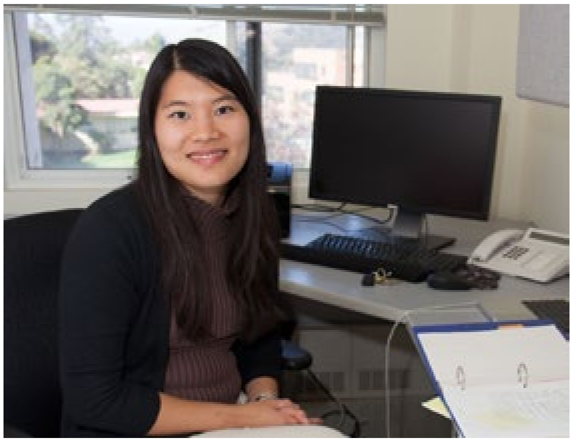
$$2\,(1/2)^x + 6\,(1/4)^x = 1;$$

one obtains $\dim M = \log_2(1+\sqrt{7})) \approx 1.8662$. For *N*, the Moran equation cannot be solved analytically, but a numerical approximation is $\dim N \approx 1.77508$. For *M*, the scaling ratios share a special number-theoretic relationship; this is not true for *N*. As a result, the two sets have marked qualitative differences. These number-theoretic properties are reflected in the geometry of the fractal sets by examining their tubular neighborhoods. The tubular neighborhood (or epsilon-neighborhood) of A consists of everything within epsilon of the original set *A*. The following figure shows four different tubular neighborhoods of the Sierpinski gasket, for decreasing values of the distance parameter epsilon.



For a given set *A*, the area of this region can be considered as a function of ε, and it is denoted $V_A(\varepsilon)$. For epsilon near 0, the function $V_N(\varepsilon)$ tends smoothly to 0, whereas the special number-theoretic relationship between the scaling factors in *M* causes $V_M(\varepsilon)$ to become highly oscillatory when epsilon tends to 0. This area of study allows for reformulation of the Riemann hypothesis in terms of fractal geometry and is an ongoing area of research.

## New Faculty - Joyce Lin

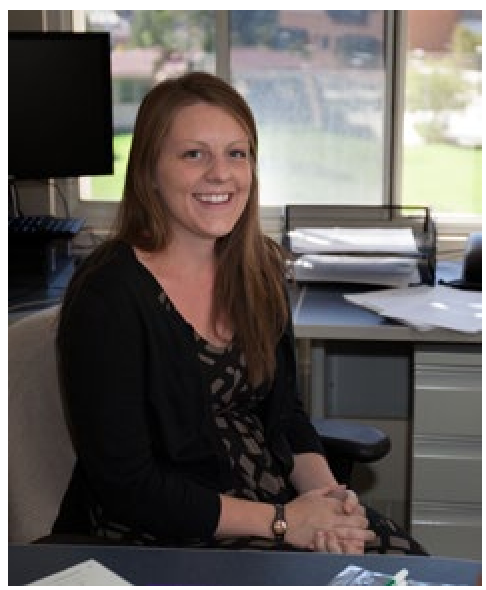


Joyce Lin grew up in Virginia, several miles outside of Washington, D.C. After attending college at the University of Virginia and majoring in mathematics, she went on to graduate school at the University of North Carolina in Chapel Hill. She earned her doctorate in applied mathematics in 2009, specializing in low Reynolds number fluid mechanics.

Switching subjects in her postdoctoral years at the University of Utah, Lin explored two different fields of research. While studying geophysical fluid flows, she worked with a polar sea ice group to study the electrical properties of fluid permeability in sea ice. She took field expeditions to both the Antarctic and the Arctic to collect data for further development into models, with the ultimate goal of improving global climate change predictions. Lin also worked with the mathematical biologists at Utah, modeling the electrical activity of cardiac tissue, her current area of research. This work involves a close collaboration with cardiovascular biomedical engineers, who provide relevant experimental data.

Lin is excited to join the West Coast community and the Math Department at Cal Poly. She especially enjoys having the beach nearby after years of living in Utah.

## New Faculty - Danielle Champney



Danielle Champney came to Cal Poly after earning her doctorate in science and mathematics education at UC Berkeley and teaching mathematics at a community college for three years. Originally from Ohio, Champney realized that she wanted to pursue mathematics education after becoming the coordinator of a supplemental instruction program at Bowling Green State University, where she studied applied mathematics. She worked to extend the supplemental instruction program's course offerings to include physics and computer science. She also spearheaded a training program for undergraduate instructors to learn to facilitate productive study practices and support all students in STEM (science, technology, engineering and math) fields. Connecting with math education professors in the Math Department at BGSU helped Champney realize that math education could be more than just a hobby, and she promptly applied to UC Berkeley's graduate program.

Her research interests include exploring how students make sense of calculus and how they use visual images to understand difficult mathematical topics. She is particularly interested in the way engineering students see distinctions and harmonies in their physics and mathematics experiences and how that impacts their understanding of physics and calculus. Champney has also worked closely with pre-service teachers during their master's and credential program and looks forward to continuing to engage with these wonderful students at Cal Poly!

## Summer Research Program 2013

Six Cal Poly Mathematics Department faculty members and 18 undergraduate and graduate mathematics majors worked on research projects during summer 2013. These projects were funded by the Cal Poly College-Based Fee Initiative.

*Patton (lower left) with students (left to right) Burnett, McGovern, Burton and Stamer*

Professor Linda Patton worked with students Shelby Burnett, Kathryn Burton, Jeff McGovern and Leah Stamer. They studied numerical ranges of certain matrices. The numerical range of a matrix is a convex set in the complex plane. This set contains the eigenvalues of the matrix and reflects other properties of the matrix as well.

The group studied four by four matrices whose numerical ranges have four-fold symmetry about the origin. In particular, they classified these matrices in terms of their block decompositions into smaller matrices, produced some plots of generalized numerical ranges, and showed that certain generalized numerical ranges have four-fold symmetry whenever the classical numerical range does.

Professor Dana Paquin worked with students David Sacco and John Shamshoian on a project studying mathematical modeling of chronic myelogenous leukemia (CML). In previous work, a system of delay differential equations was used both to model the interaction between CML and the anti-leukemia immune response and to study various treatment strategies for CML using the drug imatinib. However, the previous work did not incorporate the possibility of imatinib-resistant cancer cells.

*Paquin (right) with students (left to right) Sacco and Shamshoian*

This summer, the students added imatinib resistance to the mathematical model and studied the effects of resistance on strategic treatment interruptions (STIs) as a potential therapeutic strategy for CML patients. The students studied optimal start and end times for the STIs to maximally leverage the anti-leukemia immune response. The simulations demonstrated that, even with the possibility of imatinib resistance, STIs may prevent leukemia from relapsing for significantly longer than continuous imatinib treatment, and that, in many cases, STIs may completely eliminate leukemia. In the future, they plan to study analytic conditions for starting and stopping the STIs, as well as more advanced models of imatinib resistance.

## Summer Research Program 2013

*Camp (left) with student Gibson*

Cal Poly undergraduate Tanner Gibson worked with Professor Charles D. Camp on the time series analysis of paleoclimate data records and the development and analysis of computational models for the Pleistocene climate. The project focused on using new analysis techniques to analyze recent benthic (ocean sediment) records in order to characterize the Mid-Pleistocene transition (MPT) in the Earth's climate. Gibson and Camp then used these analyses to validate various mathematical models of climate dynamics throughout the MPT. Research on this project is continuing during the 2013-14 academic year with support from the National Science Foundation via the Mathematics and Climate Research Network.

Professor Dana Paquin worked with undergraduates David Kato and Jeremiah Magni to develop and analyze a mathematical model for the effects of grandmothering on human longevity (commonly known as the Grandmother Hypothesis in evolutionary theory). This theory hypothesizes that post-menopausal females have contributed to increased longevity in humans (as compared to great apes and other close relatives) by supplying care for weaned infants, thereby allowing fertile females to have more children sooner without risking the survival of previous offspring. The students used Matlab to simulate a dynamical systems model to describe population growth with and without grandmothering and demonstrated that grandmother effects are sufficient to transform a great ape-like life history in which females typically die during the fertile years into a human one in which they do not.

*Paquin (center) with students Kato (left) and Magni*

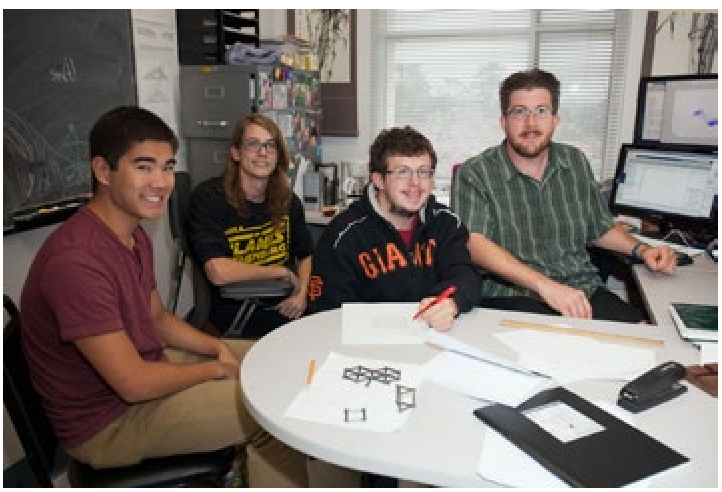
*Todorov (right) with student Schmitt*

Professor Todor Todorov worked with graduate student Michelle Schmitt. Together they did research on the "Algebra of Infinitesimals." This is a branch of mathematics closely related to Robinson's non-standard analysis. They studied different non-Archimedean totally ordered fields, i.e., totally ordered fields that contain non-zero infinitesimals and infinitely large numbers. The research is continuing during this academic year.

## Summer Research Program 2013

*Richert (second from the right) with students (left to right) Jones, Ion, Elwood, Miller and Campbell*

Professor Ben Richert worked with undergraduates Jason Elwood, Brian Jones and Caleb Miller and graduate students Michael Campbell and Mike Ion. They explored Richard Stanley's conjecture that pure simplicial complexes whose corresponding squarefree monomial ideals have Cohen-Macaulay quotients are partitionable. The quotient of a squarefree monomial ideal is said to be Cohen-Macaulay if its dimension is equal to its depth; that is, if two of the standard measures of the size of the quotient agree. A pure simplicial complex is said to be partitionable if it can be sliced up into non-intersecting closed intervals (where the relation is containment), each of which has as its right endpoint a maximal face. The research group was able to demonstrate that this conjecture is true for all dimension 2 pure simplicial complexes on at most 6 vertices and also demonstrated that there is (up to renaming the variables) only one simplicial complex on 6 variables that is not shellable (another combinatorial condition about how a complex may be decomposed) but whose corresponding squarefree monomial ideal has a Cohen-Macaulay quotient.



*Pearse (right) with students (left to right) Eckman, Lindgren and Sacco*

Erin Pearse conducted research with students Chad Eckman, Jonathan Lindgren and David Sacco on network-based methods of data analysis. The group focused on two problems from machine learning: dimensionality reduction and imputation of missing values.

Dimensionality reduction refers to plotting a 2-dimensional or 3-dimensional picture of a large dataset so that the data can be visually inspected. This is a useful step in exploratory data analysis, as it often allows clusters and other structures or trends to be discovered. However, it is challenging to reduce dimensionality without destroying its essential structure: consider drawing a 2-dimensional picture of a 3-dimensional object in a way that minimizes distortion and has the property that distant points are drawn far apart, and nearby points are drawn close together. (A familiar example of such distortion appears in the Mercator projection used commonly for world maps.)

Imputation of missing values refers to the problem of datasets that have missing values. If there are holes in the data, how should one go about calculating averages and other statistics?

The research team studied both problems by first converting the dataset into a related network and then studying the properties of the random walk on this network. They studied one strategy that uses the eigenvector decomposition of the random walk and one strategy that uses the entropy of the underlying probability distributions.

# Focus on Faculty Research - Goro Kato

The Mathematics Department faculty are engaged in a wide range of research activities. In this newsletter, we asked Goro Kato to explain some of his recent professional work.

My most recent book is titled “Elements of Temporal Topos.” Quantum gravity is designed to unite quantum physics and general relativity, which is required to understand where microcosm and macrocosm become the same, as in a big bang (and very soon after a big bang) and in a black hole. During my visit to the University of Antwerp in April 2013, which was supported by the European Science Foundation, I gave a talk that summarized the theory of temporal topos (t-topos) and its application to quantum gravity. Prof. dr. F. van Oystaeyen, who invited me, has his own theory, which was published by Taylor and Francis Group in the book “Virtual Topology and Functor Category.” We know that our theories are related; however, so far, we cannot give precise formulations of exactly how. Next year I plan to give talks on the theory of t-topos in Japan in addition to the topics on the *derived categories based on topos*.

My background is algebraic geometry, especially the *p-adic cohomology* theory of Lubkin, my doctoral advisor. (By the way, according to the AMS mathematical genealogy project, I am an eighth descendant from Gauss.) Such a cohomology theory is one of the theories that can be used to prove *A. Weil's conjectures*. Several people received Fields medals from the activities around Weil's conjectures, including Grothendieck, Serre and Deligne.

For a non-singular scheme $X$ over a finite field of characteristic $p > 0$, one considers the de Rham cohomology of a smooth lifting $\underline{X}$, with a certain growth condition on the coefficient complex of sheaves of differential forms, i.e., *hypercohomologies* (more precisely *hyperderived functors*) with coefficients in the complex of $p$-forms with the *dagger-growth condition*. Note that this dagger is stronger than the formal completion. Interestingly, this cohomological invariant of a lifting $\underline{X}$ over characteristic zero does not depend upon a particular lifting, i.e., it becomes a functor on $X$. Namely, such invariants become functors on the category of non-singular schemes over a finite field. In particular, one can consider an *algebraic family* of *elliptic curves* called the *Weierstrass* family. Then one can compute zeta matrices for the entire family of elliptic curves via Frobenius morphisms induced on such cohomologies for the Weierstrass family in characteristic $p > 0$. This computation requires, however, a generalized version since such a family is defined over the ring $Z_p[g_2,g_3]$. In order to treat the case where *singular fibres* are involved, one needs to embed the singular scheme into a smooth scheme, which requires the $Z_p[g_2,g_3] \otimes_Z Q$-adic relative hypercohomology.

This area of study of zeta functions of elliptic curves began to be tremendously active again around 2000 after my work with Lubkin during the late 1970s and early 1980s. This method has strong connections to the theory of *D*-modules, namely it is the algebraic study of systems of partial differential equations whose roots are from one of the Hilbert problems (*monodromy* and *Fuchsian equations* are ideally generalized to the *D-module* formulations). One cannot avoid the possibility of generalizations of various notions in the Grothendieck style algebraic geometry. For me, they are the notions of *derived categories* and *toposes* and *sites* combined with the above cohomologies. It is mainly these notions that are useful for the study of *quantum gravity* in this style. There are several very active schools that are aiming at quantum gravity. For my approach, the strongest is the theoretical physics group at Imperial College London — where I announced the theory of temporal topos for the first time several years ago at the second international conference for topos and theoretical physics — and Oxford University in the U.K.

## 2012-13 Graduates


## Bachelor of Science

Benjamin A. Arthur
Elizabeth A. Baldwin
Garrett D. Bates*
Nathan S. Berger
Stephen C. Calabrese*
Michael J. Campbell
Ashley A. Cascio
Katherine M. Chiccone*
Paul C. Coombs
Eric S. Cramer***
Joshua J. Crawley
Grace M. DeTore
Chad K. Duna**
Jacob T. Ferrarelli

Matthew R. Gagne
Max B. Garcia
Ashley S. Gomer
Kelsey L. Grantham***
Matthew T. Griego
Evan E. T. Hedge
Dana N. Hipolite*
Michael G. Ion
Katrina A. Kretsch
Zeno J. Muscarella
Khoa Nguyen
Sarah M. Ortiz
Mikaele C. Pepin
Ryan K. Pollard*
Andres M. Rodriguez*
Marino Romero

Noradino Salas Jr.
Allison A. Scheppelmann
Bailey A. Schmidt
Ciani J. Sparks
Kristin M. Symer
Maro Tsiifte*
Hieu M. Truong

* *Cum laude*
** *Magna cum laude*
*** *Summa cum laude*


## Master of Science

Garrett D. Bates
Steven A. Tartakovsky

# Alumni News

Jeff Mintz (B.S., Mathematics and Computer Engineering, 2000; M.S. Mathematics, 2001) and Jenny (Thorner) Mintz (B.S. Math, 1999, M.S. Math, 2001) have been living in the Santa Barbara area for 12+ years since graduating from Cal Poly in 2001. Jeff continues to work for Green Hills Software, where he is currently an engineering manager, splitting his time between developing products and managing product releases. Jenny taught for two years at local city colleges before shifting to life as a stay-at-home mother. Jeff and Jenny have three children, Abbie (10), Emily (7) and Jacob (3).

Green Hills Software creates embedded development tools that are used to build and debug the software used in a variety of products, such as airplanes, automobiles, inkjet printers and the Nintendo Wii-U. Jeff works in the Target Connections group, which builds JTAG debug probes that connect the debugger software to the customer development hardware. Over the years, Jeff has added debug support for several PowerPC and Intel x86 processors. In his current role as engineering manager, Jeff coordinates with the developent, testing, documentation and support teams to ensure that new versions of probe support are released on schedule at an appropriate level of quality.

Abbie and Emily are involved with their gymnastics teams. Abbie is competing in her second season, while Emily is preparing to compete in 2014. Emily has also done ballet for three years. Jacob likes blenders and vacuum cleaners and playing his guitar. Jenny enjoys getting some time to herself by running, typically about 50 miles per week. She has completed nine marathons, including the Boston Marathon in 2008 and the California International Marathon in 2011. Jeff has also stayed active, completing more than a dozen triathlons and four marathons. Jeff also enjoys genealogy research and photography.

In the summers, the Mintzes have a tradition of tent camping vacations, typically in the Tuolumne Meadows campground of Yosemite National Park and, on occasion, at Big Sur State Campground.

## Workshop on Inquiry-Based Learning

In June, Stan Yoshinobu, a professor in the Mathematics Department and director of the Academy of Inquiry-Based Learning, hosted a workshop on Inquiry-Based Learning, funded by the National Science Foundation and the Mathematical Association of America. The workshop hosted 42 math professors from across the country. They spent a week in Poly Canyon Village investigating video lessons, discussing advanced teaching strategies, and developing courses that they will implement this academic year. More information about the academy and the workshop are available at www.inquirybasedlearning.org and www.iblworkshop.org.

## 2013 Department Photo

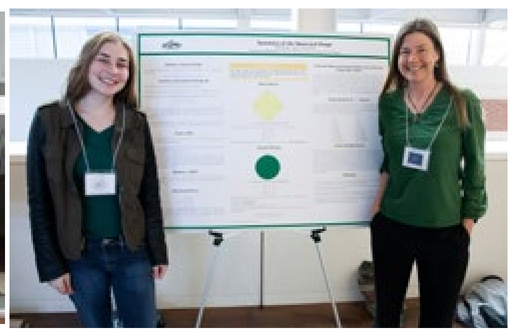

**Row 1** (Bottom Row): Jonathan Shapiro, Mollee Huisinga, Mike LaMartina, Anne Nakano, Lana Grishchenko, Cheryl Schweizer, Don Hartig, Raymond Terry, Todor Todorov
**Row 2**: Leah Avila, Saba Gerami, David Sacco, Michelle Schmitt, Linda Patton, Dave Camp, Mike Robertson
**Row 3**: Katherine Muckle, Blanca Lopez, Clint Florka, Brian Jones, Joyce Lin, Dana Paquin, Carly Burdge, Danielle Champney, Caixing Gu
**Row 4**: Anna Kopcrak, Michael Shultz, Timothy McCaughey, Dong-O Kang, Amelie Schinck-Mikel, Kate Riley, Emily Hamilton, Joe Borzellino, Paul Choboter
**Row 5**: Elsa Medina, Carole Simard, Stepan Paul, Christian Ponder, Vincent Bonini, Erin Pearse, Colleen Kirk
**Row 6**: Cami Reece, Marian Robbins, Chad Eckman, Michael Campbell, Jeff Liese, Anton Kaul, Mike Ion, Don Rawlings, Stan Yoshinobu
**Row 7**: George Lewis, Mark Stankus, Derik Birdsall, Bill Hesselgrave, Robert Easton, Bryce Jenkin, Dylan Retsek, Eric Brussel, Zach Straus, Ben Richert

## Students Attend Northern California MAA Meeting

In February, 11 students attended the Northern California Mathematical Association of America (MAA) meeting at the University of the Pacific in Stockton, Calif., along with with professors Jonathan Shapiro, Morgan Sherman and Linda Patton. Three groups of Cal Poly students presented posters of their research work.

Left: A group photo of the students who attended the MAA meeting.

Students Matthew Gagne and Chad Duna present their poster.



Linda Patton (right) with student Shelby Burnett and her poster.

## MathFest 2013

Professor Linda Patton and students Shelby Burnett and Leah Stamer attended MathFest 2013 in Hartford, Conn. Burnett and Stamer presented their research titled "Numerical Ranges of Keystone Matrices." The numerical range of a an $n$ x $n$ matrix is a certain convex set in the complex plane. It is invariant under unitary similarity. In their work, they discuss the numerical ranges of a particular family of $4$ x $4$ matrices for which the numerical ranges display four-fold symmetry.

# A Visit to the Tomb of Leonhard Euler

In July, George Lewis, professor emeritus, traveled to Saint Petersburg, Russia. While there, he visited the tomb of Leonhard Euler, considered by many to be the greatest mathematician of the 18th century. Shown with Lewis are his wife, Louise Noel, and two grandchildren, Emmett (left) and Quentin.

Euler was born in 1707 in Basel, Switzerland. He spent most of his life working in Saint Petersburg and Berlin. Euler made enormous contributions to analysis, number theory, graph theory, applied mathematics, physics, astronomy and logic. His works included more than 800 papers. He died in 1783 and is now buried at the Alexander Nevsky Monastery in Saint Petersburg.

# Faculty Publications and Activities 2012-13

***Publications:***

**M. Stankus,** "m-Isometries, n-Symmetries and Other Linear Transformations Which are Hereditary Roots," Integr. Equ. Oper. Theory 75 (2013), 301-321.

**J. Borzellino** and **V. Brunsden** (Penn State, Altoona). "The Stratified Structure of Spaces of Smooth Orbifold Mappings," Communications in Contemporary Mathematics, 15 (2013) no. 5.

**J. Borzellino** and **V. Brunsden** (Penn State, Altoona). "Elementary Orbifold Differential Topology," Topology and its Applications, 159 (2012), 3583-3589.

**A. Schinck-Mikel**, **J. Watson, J. Lim,** and **J.-L. Chae**, "Varied Meanings and Engagement in School Mathematics: Cross-Case Analysis of Three High-achieving Young Adolescent Girls," School Science and Mathematics Journal, 13(4), 191-200.

**G. Kato**, "Grasping a Concept as an Image or as a Word," Scientific Research and Reports 2(2): 682-691,

**G. Kato**, *Elements of Temporal Topos*, a book published by Abramis Academic, Suffolk, U. K. May 2013.

**E. Medina,** "A Lesson in Spanish on Number Sequences," Beyond Good Teaching (2012): Advancing Mathematics Education for ELLs, National Council of Teachers of Mathematics.

**J. Shapiro**, **C. Gu**, with Cal Poly students **C. Duna** and **M. Gagne**, "Toeplitzness of products of composition operators and their adjoints," J. Math. Anal. Appl., 410 (2014), 577–584.

**A. Mendes**, "Hook and content bijections," Discrete Mathematics, 313, (2013) no. 2, 182-185.

**D. Retsek**, "Chop wood, carry water, use definitions: lessons of an IBL rookie," PRIMUS, Vol. 23, Issue 2, (2013), 173-192.

**T. Grundmeier**, **D. Retsek**, and Cal Poly student **D. Stepanek**, "A Foray Into Describing Mathematics Majors' Self-Inquiry During Problem Solving," *Proceedings of the 16th Annual Conference on Research in Undergraduate Mathematics Education*. (2013) Denver, CO.

**T. Grundmeier**, with Cal Poly students **A. Eubank** and **S. Garrity**, "Proof Structure in the Context of Inquiry-Based Learning," Proceedings of the 16th Annual Conference on Research in Undergraduate Mathematics Education. (2013) Denver, CO.

**T. Grundmeier**, "Developing the Problem Posing Abilities of Prospective Elementary and Middle School Teachers," (Eds.) J. Cai, N. Ellerton, and F. M. Singer, *Problem Posing in Mathematics Learning and Teaching, Springer.*

**M. Sherman**, "Local Calabi and curvature estimates for the Chern-Ricci flow," New York J. Math. 19 (2013), 565-582.

**C. Kirk**, **A. Kadem**, **M. Kirane**, **W. E. Olmstead**, "Blowing-up solutions to systems of fractional differential and integral equations with exponential non-linearities," IMA J Appl Math, Advance Access published February 12, 2013

**C. Kirk**, **W. Olmstead**, **C. Roberts**, "A system of nonlinear Volterra equations with blow-up solutions," Journal of Integral Equations and Applications, (2013).

**E. Hamilton**, **H. Wilton**, and **P. Zalesskii**, "Separability of double cosets and conjugacy classes in 3-manifold groups," Journal of the London Mathematical Society, (2012), 20 pages.

*Publications (continued):*

**E. Pearse** and **P. Jorgensen,** “Multiplication operators on the energy space,” J. Operator Theory, 69:1(2013), 135—159.

*Talks and other Activities:*

**Joe Borzellino** was an invited speaker at the international conference Interactions Between Logic, Topological Structures and Banach Spaces Theory, at the Eilat Campus of Ben-Gurion University of the Negev, Israel, May 19-24, 2013. He gave a talk titled “Orbifolds, Spaces of Smooth Mappings Between Them, and Embeddings.” The conference was sponsored by the Israel Science Foundation and The Center for Advanced Studies and Mathematics.

**Amélie Schinck-Mikel** and **Elsa Medina** gave an invited presentation, a 75-minute workshop, titled The Math Academy: A model for Engaging High School Students and Teachers in Rich Mathematics Problems, at the 2013 Noyce Conference, Washington D.C. Attendees were 30 Noyce Scholars from around the country.

**Goro Kato** gave a talk on T-Topos, at the University of Antwerp, Belgium, in April 2013, to promote and discuss his book “Elements of Temportal Topos.” At the University of Antwerp in 2011, he gave a series of talks on p-adic cohomology of an algebraic family called the Weierstrass family in characteristic $p > 0$ and the zeta invariants. These visits were supported by the European Science Foundation.

**Erin Pearse** attended the week-long Bremen Winter School on Multifractals and Number Theory and was one of the speakers. He also was a guest of Steffen Winter at the Karlsruhe Institute of Technology for a week, where he worked on volume formulas for tubular neighborhoods of self-similar fractals (see cover article).

**Charles D. Camp** gave invited talks at two international conferences, the CliMathNet Conference 2013, July 1-5, 2013, University of Exeter, Exeter, U.K., and the Davos Atmosphere and Cryosphere Assembly (DACA-13), July 8-12, 2013, Davos, Switzerland. Both talks were titled “A Characterization of Pleistocene Climate as Revealed by Empirical Mode Decomposition.”

**Todor Todorov** participated in a workshop Non-Archimedean Geometry and Analysis, September 2-6, 2013, organized by the University of Vienna (Austria). He presented three talks at this workshop: on “Axiomatic Approach to Colombeau Theory of Generalized Functions”; on “Regularity Problem in Generalized Functions” and on “A Ferma Ring with Infinitely Large Elements.” A talk on the first topic was also presented at the end of August in a theoretical physics seminar in the Bulgarian Academy of Sciences, Sofia (Bulgaria).

**Dylan Retsek** presented a talk on his paper “Chop wood, carry water, use definitions: lessons of an IBL rookie” at the R. L. Moore Legacy Conference in June 2012, and also gave a talk about his paper “A Foray Into Describing Mathematics Majors’ Self-Inquiry During Problem Solving” at the Research in Undergraduate Mathematics Education conference in January 2013.

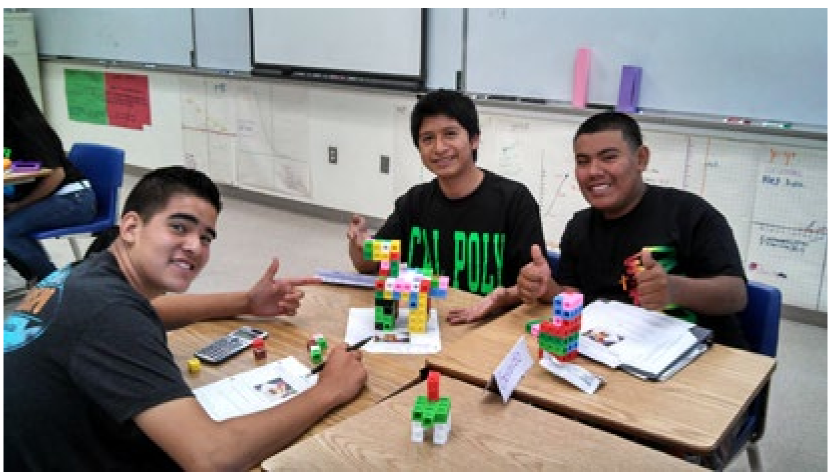
**Paul Choboter** gave a talk at the SIAM meeting in July 2013 in San Diego, “Nesting ROMS and UCOAM: A Case Study in Monterey Bay.”

**Todd Grundmeier** gave two talks at the Conference of SIGMAA - Research in Undergraduate Mathematics Education in February 2013, titled “Self-Inquiry in the Context of Undergraduate Problem Solving,” and “Proof Structure in the context of Inquiry-Based Learning.”

# Summer Math Academy

Professors Amélie Schinck-Mikel and Elsa Medina ran the second annual Cal Poly Math Academy in Santa Maria on July 22-26, 2013. Twenty-four high school students from Santa Maria High School and Pioneer Valley High School attended the academy for a week of fun with mathematics. In addition to the students, three high school teachers and three Cal Poly students interested in teaching participated in the academy for the professional development component.

The academy also attracted much attention from local news. Four local news stations broadcast reports about the academy, and you can find an article about the academy in the Santa Maria Times at http://santamariatimes.com/news/local/education/math-academy-seeks-donations-for-college-visits/article_011282b4-f4eb-11e2-9aff-001a4bcf887a.html.



## Putnam Math Competition 2012

In December 2012, the Cal Poly team, coached by Professor Lawrence Sze (far right), participated in the annual William Lowell Putnam Mathematics Competition. The high scorers from Cal Poly were Derek Tietze (fifth from the left) with 18 points and Brian Jones (fourth from the left) with 10 points.

## Mathematical Contest in Modeling 2013

The Mathematical Contest in Modeling took place in February. Cal Poly fielded four teams of three students each, coached by Charles D. Camp.

The Cal Poly teams for the 2013 MCM were:

Team 1: Caleb Miller, David Kato and Minnal Kunnan
Team 2: Austen Greene, Jeffrey McGovern and Matthew Murachver
Team 3: Sanjay Khatri, Donna Martin and Skyler Young
Team 4: Ian Powell, Matthew Josten and Sedric Mart

Team 4 received a designation of honorable mention for their submission. They worked on Problem A: When baking in a rectangular pan, heat is concentrated in the 4 corners, and the product gets overcooked at the corners (and to a lesser extent at the edges). In a round pan the heat is distributed evenly over the entire outer edge and the product is not overcooked at the edges. However, since most ovens are rectangular in shape using round pans is not efficient with respect to using the space in an oven. Develop a model to show the distribution of heat across the outer edge of a pan for pans of different shapes - rectangular to circular and other shapes in between.

# 10th Annual Math Awards Banquet

**Robert P. Balles Mathematics Scholarships**
*Ashley Chandler and Matthew Rodrigues with Math Department Chair Joe Borzellino*

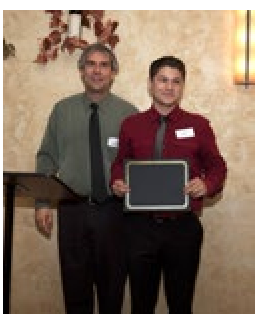
**Ed Glassco Scholarship**
*Samantha Saenz with Joe Borzellino*

**Katrina J. Killgore Memorial Scholarship**
*Adrian Tamayo with Joe Borzellino*

**W. Boyd Judd Awards**
*Caleb Miller and Adrian Tamayo with Joe Borzellino and Carol and Anita Judd*

**Ralph M. Warten Memorial Scholarships**
*Lumin Sperling, Caleb Miller, Adam Liu, Vincent Escoto, David Kato and Adrian Tamayo with Joe Borzellino*

**Volmar A. and Viola I. Folsom Scholarships**
*Nicholas Jones, Nicholas Greyn, Jordanne Adamski, Javier Rodriguez, Sergio Villalpando and Nicolas Rodriguez (photo on right) with Joe Borzellino*



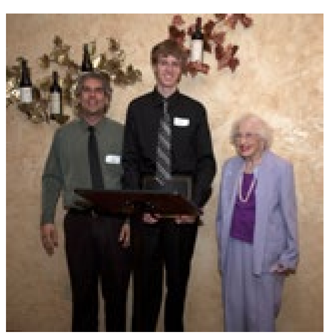
**George C. Laumann Scholarship**
*Vincent Escoto with Joe Borzellino*

**Scholarship for the Advancement of Science and Technology**
*Leah Stamer with Joe Borzellino*

**TC Reece Mathematics Award**
*Katherine Chiccone with Cami Reece*

**Marie Porter Lehman Math Educator Scholarship**
*Andres Rodriguez with Joe Borzellino and Nancy Lehman*

**Kappa Mu Epsilon Founders Award**
*Stephen Calabrese with Joe Borzellino*



**Carol S. and W. Boyd Judd Scholarship**
*Zachary Straus with Joe Borzellino and Carol Judd*

**George H. McMeen Scholarships**
*Anthony Kling, Shelby Burnett, Jenny Aguayo Vazquez and Kathryn Burton with Joe Borzellino*

# Outstanding Students

**Outstanding Teaching Associate**
*Anna Kopcrak with*
*Joe Borzellino and Dylan Retsek*

**Charles J. Hanks Excellence in Mathematics Award**
*Chad Duna with Joe Borzellino and Marjorie Hanks*

**Outstanding Mathematics Educator Awards**
*Dara Stepanek and Veronica Snider with Joe Borzellino*

**Accenture Outstanding Junior in Mathematics**
*Ashley Chandler with Joe Borzellino*

**Outstanding Seniors in Mathematics**
*Eric Cramer and Chad Duna with Joe Borzellino*

**Bryant Russell Memorial Award**
*Elizabeth Baldwin and Michael Ion with*
*Joe Borzellino*

**Robert Noyce Scholarships**
*Aristotle Ou, Mikaele (Mimi) Pepin, Elizabeth Baldwin, Ashley Cascio,*
*Trent Speier, Cheyanne Sousa and Ben Woodford*
*with Joe Borzellino and Todd Grundmeier*

**Charles J. Hanks Scholarship**
*Brian Jones with Joe Borzellino*
*and Marjorie Hanks*

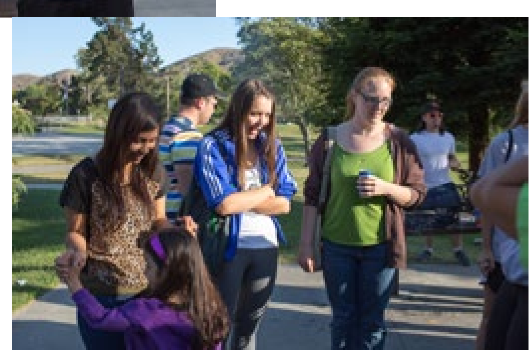
**Ralph E. Weston Memorial Award**
*Brian Jones and Derek Tietze with Joe Borzellino*

**Outstanding Faculty Member of the Year**
*Marian Robbins with Allison Scheppelmann*

# End-of-Year BBQ and Softball Game

**Undergrads vs. Faculty and Graduate Students**

**The student team won this round, 10-2. It was the first time in many years that the students won. Can they turn this victory into a streak?**



## Newsletter Puzzle Challenge

Continuing our new series of newsletter puzzles, which are an extension of our weekly departmental Puzzle of the Week, Morgan Sherman has provided another challenge for you, courtesy of Erin Pearse.

An elderly king with no heir wanted his kingdom to go to the smartest man in the land. He rounded up the three knights with the highest grades in “Real Analysis with Applications to Jousting,” and sat them down at a table. “I need to find out which of you is the most intelligent,” said the king, “so I will paint a dot on each of your foreheads. It will either be a black dot or a white dot, but you will not know which. You will have to figure it out using logic. The only hint I will give you is that I will not give all three of you a white dot. As soon as you have figured out what color dot you have, you should come to me and explain your reasoning to claim your prize.”

At this point, the king painted a black dot on each of their foreheads in such a way that none knew what color they wore, and then left to wait for the winner in the throne room. The three men sat for some time, each looking at the other two (and in particular, at the dots painted on the foreheads of the other two), without communicating in any way. Eventually, one cried, “Eureka! I must have a black dot!” He ran out to tell the king and, sure enough, claimed his prize.

We invite you to submit your solution by email to sherman1@calpoly.edu. We will recognize those submitting correct solutions to the newsletter puzzle in next year’s newsletter. There were no solutions submitted for last year’s puzzle, so your chances for glory are high. You can also view the solution to last year’s puzzle online.

# Steven J. Agronsky, Professor of Mathematics Emeritus
## In memorium, 1948 – 2014
## by Jim Mueller

It is with profound sadness that we report the passing of Steven J. Agronsky on Wednesday, January 22, 2014. Steve was regarded as one of the finest professors in the Mathematics Department, a person who loved teaching as much as he loved mathematics. His courses were challenging, but the support and care he showed for his students was known by all who had the pleasure of being in his classes. Whether teaching freshman calculus or graduate analysis, he explained the power of mathematics with clarity and verve.Steve was also a master of humor, sometimes raucous but more often subtle, with well-timed jokes that could be missed by those not fully engaged in his lectures.

Steve earned his bachelor's, master's and doctorate at the University of California, Santa Barbara, where he completed his dissertation under Andrew Bruckner. In the 1970s, Steve taught at the University of Montana, Missoula, for Chapman College on a U.S. naval ship stationed in the Far East, and a couple quarters at Cal Poly. After teaching at UC Davis from 1978-81, he then joined the Math Department full-time in fall 1981. For many years, he was the area director of the California Mathematics Diagnostic Testing Program. He retired from Cal Poly in 2012 but continued to teach intermittently until his passing.

Andy Bruckner recounts Steve's mathematical accomplishments: "Most of Steve Agronsky's research is in the area of Real Function Theory. His interests were in two areas: the study of those delicate properties of functions related to differentiation theory and the iterative behavior of functions mapping an interval into itself. Two examples, one in each area, might give an idea of his interests.

Many important classes of functions can be characterized in various ways. For example, a function $f$ defined on an interval $[a,b]$ is continuous if and only if it is a uniform limit of a sequence of polynomials. An entirely different characterization is that the inverse images of open sets are open : $U$ open implies $f^{-1}(U)$ open. In 1911, W. H. Young posed a problem now known as the problem of characterizing derivatives: find necessary and sufficient conditions for a function $f$ to be the derivative of some function $F$. Young, who later became president of the London Mathematical Society, discussed the importance of this problem. A number of first-rate mathematicians attacked this problem without real success, though their works had a number of important consequences. Perhaps the most important paper on this subject was presented by Z. Zahorski in 1950. He tried to characterize derivatives via inverse images of open sets. He did not succeed, though he managed to obtain such characterizations for various classes of functions related to the derivative. Earlier, in the 1930's, I. Maximoff tried a different and very complicated method to obtain such a characterization. He, too, did not succeed, but did obtain some important results.

In 1982, Steve studied the Zahorski and Maximoff methods. He created an abstract setting in which the two methods could be compared and showed that under rather general conditions the two methods were equivalent — if one method gave a characterization for a class of functions, so did the other. He also obtained characterizations for other classes using his method. In addition, he showed that Maximoff's method could not work for the derivative.

Steve collaborated in solving a problem concerning the iteration of continuous functions mapping a closed interval into itself. Let $f\colon [a,b] \to [a,b]$ be continuous. Let $f_1 = f,\ f_2 = f \circ f,\ f_3 = f \circ f \circ f$, etc. For $x \varepsilon [a,b]$, consider the set $E$ of cluster points of the sequence $\{ f_n(x) \}$. This set is called the omega limit set of $x$ under $f$. The open question was 'What sets $E \subset [a,b]$ are omega limit sets for some continuous function?' The result is that $E$ is such a set if and only if $E$ is either a finite union of closed intervals, or $E$ is a nonempty nowhere dense closed set. This result surprised some of the experts in the field because it contradicted a (false) theorem previously thought to be correct.

Steve has many other significant papers in these two areas. These papers add considerably to our understanding of the behavior of functions related to differentiation or to our understanding of the iterative behavior of continuous self-maps of an interval. Some of his papers are quite technical. The two outlined ones are very technical but allow nontechnical descriptions that might illustrate the flavor of his research interests."

Steve also had many interests aside from mathematics. A world traveler who eschewed the beaten path, his itineraries spanned the jungles of the Philippines to the rivers of Alaska. Steve was also a gentleman farmer who took pride in sharing the fresh eggs from his chickens and the bounty from his fruit orchard. He is survived by his wife and best friend, Jaine Rice, who shared his many hobbies with him.

## Henry Bernard Strickmeier Jr., Professor of Mathematics Emeritus
### In memorium, 1940 – 2013

It is with deep regret that we report that H. Bernard Strickmeier died on December 27, 2013, at the age of 73 in College Station, Texas. Many of you may have had the pleasure of knowing and working with him.

Bernard graduated from Ball High School in Galveston, Texas, in 1958. He earned his bachelor's degree in mathematics from Texas Lutheran College in Seguin, Texas, in 1962, a master's of arts in mathematics education from the University of Texas in Austin in 1967 and a doctorate in mathematics education from the University of Texas in Austin in 1970. He retired as a professor emeritus of mathematics at California Polytechnic State University, San Luis Obispo in 2002.

While at Cal Poly, he served as the university coordinator for the Single Subject Credential Program and on several committees including chair of the Mathematics Department Peer Review Committee, member of the University Center for Teacher Education Steering Committee, and member of the University Center for Teacher Education Leadership Team. In addition, Bernard was a leader in the department's efforts to dramatically improve its master's degree program.

In 1996, he was appointed to the Board of Institution Reviewers of the California Commission on Teacher Credentialing. In 2002, he received an award from the Teacher Education Department at Cal Poly for "Outstanding Contributions to Teacher Education." At one point during his tenure at Cal Poly, a third of the middle and high school teachers in San Luis Obispo County had done their student teaching under his guidance. He had a great influence on the teaching of mathematics in our county.

On the personal side, while at Texas Lutheran, Bernard received his black belt in judo. He enjoyed playing golf and poker and above all black jack. As any fine mathematician would do, he counted cards. He enjoyed wine tasting and cooking. In the latter category, he raised the level of the local cuisine with his contribution that will always be remembered as Bernard's Beans. He loved watching football, in particular the Cowboys and the Longhorns. Bernard was a conversationalist and enjoyed discussing, among other things, politics, departmental issues and sports. His interests were wide-ranging.

Bernard will be remembered fondly by all his friends within the university as well as those in the larger San Luis community. A remembrance is being planned in his honor for spring 2014.

# 2012 - 13 Honor Roll

## HONOR ROLL OF CORPORATIONS, FOUNDATIONS AND ORGANIZATIONS

The Mathematics Department is grateful to the following corporations, foundations, and organizations who made gifts for general and special purposes and for matching gifts.

*ATK Alliant Techsystems Inc*
*Educational Advancement Foundation*
*IBM Corporation*
*Intel Corporation*
*Keving McMahon Transmissions*
*Lockheed Martin Corporation*
*Oscar P. Ortega Landscaping*
*Pacific Gas and Electric Company*
*Pacific Life Insurance Company*
*Ross & Elizabeth Miyazawa Rev Trust*
*Santa Barbara Foundation*
*Sousa Engineering Services*
*The Boeing Company*
*Yahoo! Inc*

## HONOR ROLL OF INDIVIDUALS

The Mathematics Department wishes to thank the following individuals for their contributions and support.

**Dean's Honor Roll**
**$1,000 and above**

*Robert P. Balles*
*Glenn B. and Karen E. Cook*
*Donald B. Gibson*
*Marjorie L. and *Charles J. Hanks*
*Dianne and Donald Jackson*
*Carol S. Judd*
*Lynette L. Kragness*
*Debra L. Magana*
*Paul F. and Barbara J. Murphy*
*Brian K. and Susyn C. Normington*
*Charlene A. Sims*
*Jacqueline Wyland and*
*Stephen J. Corcoran*

**COLLEGE CABINET**
**$500 - $999**

*Megan J. Evans*
*Leah J. Griffith*
*Robert J. and Barbara Gulliford*
*Myron and Sue Hood*
*Stephen C. and Suzan J. Plath*

**DEPARTMENT COUNCIL**
**$250 - $499**

*Anonymous Donor*
*Jay A. Austin and*
*Elizabeth C. Austin-Minor*
*Gary A. Gale*
*Barry A. and Virgina L.*
*Langdon-Lassagne*
*Henry T. and Theresa L. Liu*
*Craig J. and Leslie V. Nelson*
*Charles A. Pasquini*
*Adrian Pell*
*Cami A. and Terry R. Reece*
*Gordon S. and Ann H. Umemoto*

**COLLEGE PARTNERS**
**$100 - $249**

*Elizabeth A. and Phillip J. Adamski*
*Jeanne C. Barks*
*Lisa N. and Robert D. Bates*
*Frank A. Blesi and Susan L. Marietta*
*Robert K. Bohi*
*Eric W. Burdick*
*James V. and Beverly A. Carlson*
*Michael F. and Nancy K. Chase*
*Teri T. and Henry K. Chiang*
*Douglas N. Cummings*
*Doren E. Curtiss*
*Rose M. De Palma*
*James S. DeGracie*
*Arthur R. and Jane M. Delgadillo*
*Hugh G. and Susan A. Eccles*
*Meryl D. and Russell W. Evans*
*David J. and Martha S. Falore*
*Sonia J. Fiorenza*
*Thomas K. Furukawa*
*Daniel W. and Karen L. Hancock*
*Jody Ann S. and John W. Jacobs*
*Patricia M. and Patrick M. Kawaguchi*
*Bob and Lisa M. Kernaghan*
*Kerry J. King*
*Gail A. Kirschenmann*
*Barbara M. Martinelli*
*Elizabeth A. and Ross I. Miyazawa*
*Douglas R. and Karen B. Morgan*
*Charles N. and Karli A. Morris*
*Dora M. and Oscar P. Ortega*
*Robert O. and Ann D. Ray*
*Robert M. Reinsch*
*Kevin R. and Pamela R. Reynier*
*Robert H. and Carol Schmiederer*
*Margery L. Segraves*
*Florence L. and Richard D. Shahbazian*
*Julie T. and James E. Stallman*
*David G. Vandermolen*
*Kenneth J. Vodicka*
*Susan G. Waterbury*
*Sidney R. Wong*
*Brian C. and Nancy E. Wright*
*Peggy S. Wroble*
*Richard E. Wroble*
*Eileen M. Zeiller*

**CONTRIBUTORS**

*Richard S. Bilheimer and*
*Sarah M. Minahan*
*Claudia A. and Richard D. Bouslough*
*George W. Brown*
*Hugo S. Campos*
*Gregory S. and Yancey L. Chapman*
*Gaylen M. and George F. Clark*
*Richard Dievendorff*
*Nancy E. Fetterman*
*Donald W. and Elizabeth D. Gallaher*
*Cecilia J. Harrison*
*Ruth E. Huehn*
*Joanne P. and Timothy C. Hurley*
*Gerald D. and Glanda R. Katt*
*Emiko A. and Wayne K. Jasper*
*Sue Ann B. Joy*
*George L. Lang*
*Marta L. Lansing*
*John H. Lee*
*David S. and Judi I. Licata*
*Diana R. Martin*
*Richard M. and Mary Ann Marvel*
*Gibson McConnell IV*
*Steve A. and Tara McCullough*
*Kevin McMahon*

**Deceased*

## 2012 - 2013 Honor Roll (continued)

**CONTRIBUTORS**

*Kim M. and Tom Modugno*
*Stuart and June L. Moy*
*Ellen M. and Richard C. Nelson*
*Claire A. Rees*
*Bruce L. and Elizabeth Renfrew*
*Gary and Elizabeth Riley*
*John S. and Nancy P. Robertson*
*Rolf R. and Lisa Schumann*
*Candy A. and Terry L. Shell*
*Grant T. Shimada*
*Richard A. and Joy K. Spohn*
*Manny R. Sousa*
*Phyllis L. Swanson*
*Laura and Tom Taylor*
*Randolph J. and Katherine G. Taylor*
*Dale R. Durran and Janice K. Tervonen*
*Julie M. Turney*
*Lyle I. and Marian A. Van Vleet*
*Susan P. Vanni*
*Matthew W. Williams*
*Anika K. Wong*

This list includes those who gave to the department from July 2012 - June 2013. Every effort has been made to list our donors correctly. If there is an error, please bring it to our attention immediately. We apologize in advance if there is an omission.

## Keeping in Touch

We would love to hear from you. Please drop us a line and let us know what you're up to and how you are using your Cal Poly degree. Please include your degree, your graduation year and any professional and/or personal information you wish to share with the Cal Poly mathematics community in our alumni news column. A picture of you or your family along with your story would be appreciated.

Please email your alumni news submission to math@calpoly.edu OR mail to:
Polymath Editor, Mathematics Department
California Polytechnic State University
San Luis Obispo, CA 93407


*Polymath* is published by the Mathematics Department.
Inquiries, suggestions and comments are welcome.

Faculty Editor, Production Editor and Graphic Design: Jonathan Shapiro
Copyediting: Joseph Borzellino, Carly Burdge
Photographer: Jonathan Shapiro (with photo contributions from others)

Phone: 805-756-2206 FAX: 805-756-6537
E-mail: math@calpoly.edu Web: math.calpoly.edu


Please update your contact information on the Alumni Association Website so you can continue to receive the electronic version of our newsletter.