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**2016 -- Issue 3**

# Connect

The Department of Mathematics Newsletter



MEMBER THE TEXAS STATE UNIVERSITY SYSTEM™

## Connect

*The Official Newsletter of the  
Department of Mathematics  
Texas State University - San Marcos*

**Susan Morey**, Chair

**Jian Shen**, Associate Chair

**Ernest Ratliff**, Assistant Chair

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Jayne Blascke, University News Service

### Cover:

Dr. R H Bing

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# Letter from the Chair

Dear Alumni,

It has been a very exciting semester serving as the new chair of the Department of Mathematics. We are a large and highly active department in the College of Science and Engineering. We have a wide offering of general education courses, courses designed to prepare you to major in Business and STEM (Science, Technology, Engineering, and Mathematics) fields. We offer undergraduate degrees in Mathematics and Applied Mathematics, with or without teacher certification; master's degrees in Mathematics, Mathematics Education, Applied Mathematics, and Master's of Teacher Education; and a doctoral degree in Mathematics Education. With over 12,500 students enrolled in over 315 course sections, we offer something for everyone.

For students and faculty looking to experience mathematics outside the classroom, we host an active Math Club and a Pi Mu Epsilon chapter, a Putnam competition group, or come join us for our fantastic, fun, frenetic, Fridays. We start with Problem Solver's group at 11, which is designed to involve students and faculty at all levels, then move on to Talk Math 2 Me, which is a seminar for students, by students. Next come three research seminars, one each in Discrete Mathematics, Mathematics Education, and Applied Mathematics, and every other week we cap the day off with a colloquium talk.

Our faculty is growing to accommodate our growing student population. We are excited to welcome Dr. Jessica Bishop to our department, starting in Fall 2016. She will join not only our current faculty, but also have 5 additional new colleagues. We are in the process of hiring 3 faculty members in mathematics education and 2 in mathematics. It is an exciting time and I look forward to leading the department through this period of growth.

Finally, please keep in touch with the Mathematics Department through our Alumni Connection webpage, found at <http://www.math.txstate.edu>.

Best wishes,  
*Susan Morey*



## Recent Ph.D. Graduates

Jake Hammons  
Texas Women's University, Denton

Carlos Mejía Colindres  
ETS Publishing

Yuliya Melnikova  
Indiana University of Pennsylvania

Sarah Hanusch  
SUNY - Oswego

# Susan Morey Named New Chair of Mathematics

In Fall 2015, Dr. Susan Morey replaced Dr. Nathaniel Dean as Chair of the Mathematics Department. Dr. Morey joined the Department in 1997, was promoted to professor in 2010, and has served as assistant chair since 2011. She holds a Ph.D. in Mathematics from Rutgers University, and a B.S. in Mathematics from the University of Missouri.

Dr. Morey teaches mathematics courses at all levels, from freshman through doctoral. Her research focuses on commutative algebra and combinatorial commutative algebra. She has published in top journals in the field, including the *Journal of Algebra* and the *Journal of Algebraic Combinatorics*, and has presented her work nationally and internationally. She has been active in undergraduate research programs, serving six years on a national MAA committee for undergraduate research and working with multiple externally funded REU programs at Texas State University. She has served on the Faculty Senate and has won both departmental and college level awards in all three areas of teaching, research, and service.

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## News in Brief From Around Campus and Beyond

February 2015: PhD candidate (now graduate) Carlos A. Mejía Colindres published his article in the *Mathematics Teacher* entitled "Thunder and Lightning: Understanding Equidistance."



The article focuses on an activity for high school students that uses a meaningful context and dynamic geometry software to facilitate the conceptual understanding of perpendicular bisectors.

March 14, 2015 at 9:26:53: This year marked a very special Pi Day. This special mathematical day is usually just celebrated on March 14th (3/14), but since the first digits of pi are 3.141592653..., this year's Pi Day was celebrated down to the second. This was the last time this century we will be able to celebrate Pi Day to such accuracy.

Spring 2015 -- Drs. Schroff and Rauh participated in Bobcat Days, where prospective students visit the university to learn more about various majors. At the Math table, students delighted in the candy representation of Pascal's Triangle, various geometric models, and colorful origami structures provided by Dr. Balmer.

Spring 2015 -- Jean Davis and Ron Patschke both retired. Davis retired after a 31 year teaching career. During that time, she has taught both at the high school and collegiate level, arriving at Texas State in 1979. Patschke earned a Doctorate of Education from Texas A&M-Commerce in 1976. He has spent time in both the private sector and in education. Congratulations to both on their retirements!



# Department Welcomes Six New Professors

*As we wish Dr. Suji Singh, Dr. Gil Cuevas, and Dr. Selena Mireles well as they enter retirement or pursue other opportunities, the Mathematics Department had the good fortune to bring in new professors as replacements. In additions, several more tenure-track faculty positions were created to meet the growing needs of the Math Department. Join us in welcoming these new faculty members.*

## *Jessica Bishop*

Jessica earned her PhD in mathematics education from the University of Texas and grew up in San Marcos. Before coming to Texas State, she was on the faculty at the University of Georgia and San Diego State University. Jessica enjoys spending time in classrooms learning about students' mathematical thinking and working with prospective and practicing mathematics teachers. In fact, she is a former public school teacher herself, having taught high school mathematics in the Dallas area. Jessica recently completed an NSF grant studying K–12 students' conceptions of integers and currently has a NSF CAREER grant investigating mathematics classroom discourse. In her free time, she likes to spend time with her family and friends and is trying to hike every National Park in the US.

## *Robert Sigley*

Robert is from New Jersey and earned his Ph.D. from Rutgers University in Mathematics Education. At Rutgers, Robert worked on several NSF-funded projects that involved studying students as they worked on tasks that provided opportunity for reinvention of their mathematical ideas through exploration and refinement of earlier ideas. For his dissertation, Robert used videos from those projects to design instructional interventions for teachers to produce growth in attending to students' mathematical reasoning. He is enthusiastic to share his knowledge and expertise with students at Texas State University. He is also eager to contribute to the local school community in San Marcos and neighboring areas, pursue research grants, and collaborate with other colleagues in the Mathematics department. In his spare time, Robert likes playing golf, practicing falconry, and watching movies.

## *Anton Dochtermann*

Anton grew up in Los Angeles and received his PhD from the University of Washington in Seattle. Before joining Texas State he held postdoctoral positions at TU Berlin, Stanford, and the University of Miami. His research interests are in topological/geometric combinatorics and commutative algebra, and he especially enjoys pursuing projects that connect seemingly disparate branches of mathematics. Anton enjoys teaching and is looking forward to engaging with the diverse student body at Texas State. He is excited to work with math majors and grad students but also is convinced that a math course can have an important and lasting impact on students in any discipline. He is especially excited about developing his own teaching techniques surrounded by the many faculty members in the department who specialize in math pedagogy. Outside the office Anton enjoys taking photographs, playing the clarinet, and riding his bike around the Austin area with his family.

## *Kate Melhuish*

Kate found her way into Mathematics Education while completing her MS in Applied Mathematics where she became deeply curious about how students thought about advanced mathematical topics and proof- particularly in abstract algebra. Her current research spans two major prongs: measuring student conceptions in group theory and supporting and analyzing how in-service teachers think and promote mathematical practices such as justifying and generalizing in their classroom. Kate finished her postdoctoral research and Ph.D. in Portland, OR at Teachers Development Group and Portland State University respectively. Prior to this work she earned her Master's degree at Western Carolina University with an emphasis on group theory and developing shortcuts to calculate Galois Groups. Kate is particularly excited about the opportunity to continue mentoring doctoral students and helping to grow and strengthen the Math Ed PhD program at Texas State. In addition to researching and teaching math, Kate enjoys bowling, table-top games, 2-stepping, watching the Phillies, and spending time with her 1-year old daughter.

# Research Provides Valuable Experience and Expertise to Graduate Students

We asked several of our Ph.D. candidates to summarize their Math Education dissertations and research.

## *Rachel Bower*

Rachel's research looks at teacher noticing in linguistically diverse classrooms. She is interested in understanding how inservice secondary mathematics teachers are utilizing noticing as well as instructional strategies and their beliefs to educate students. She conjectures that in the future teacher noticing may be used as a metric for student engagement and student centered classrooms.



## *Nama Namakshi*

Nama Namakshi is a doctoral student (ABD) in Mathematics Education at Texas State University. She has done research in the following areas of interest - math camps and the effect they have on women's learning identities and participation in STEM fields, development of Teacher Noticing skills among pre-service teachers, and curriculum development at middle/high school level.



## *Shawnda Smith*

Shawnda is interested in researching the Mathematical Knowledge for Teaching of pre-service teachers. Her dissertation focused on Geometry Teaching Knowledge and compared the differences between pre-service teachers and high school Geometry teachers. She is also interested in where this knowledge is developed.



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## *Chunmei Wang*

Chunmei is originally from China and received her PhD from Nanjing Normal University, China in 2014. Before joining Texas State University, she was a visiting assistant professor in Georgia Institute of Technology for two years. Her research interests fall under the broad heading of numerical methods and scientific computing for problems in science and engineering governed by partial differential equations, with the goal to obtain approximate solutions for PDEs arising from physical, engineering, and biological applications through predictive modeling and computational simulation. She has received two NSF awards in 2015 for her work in computational mathematics and applications. Currently, she is developing an efficient numerical solver for a fourth order PDE problem arising from fluorescence tomography modeling in medical science involving big data. She likes teaching and enjoys helping students. In her spare time, she enjoys spending time with her family.

## *Lucas Rusnak*

Lucas received his PhD from Binghamton University in 2010, and was previously a Senior Lecturer at Texas State University. His research is in generalizations of graph theory and combinatorial matrix theory. Specific interests are in oriented hypergraphic generalizations of the structural and matroidal properties of signed graphs and their applications to social balance, integrated circuits, frustrated states, and chemical graph theory. He is a dedicated teacher and mentor and has served as the faculty advisor for the Undergraduate Math Club at Texas State for the past two years, as well as a research mentor for Mathworks HSMC for the past four – supervising two Regional Finalists in the Siemen's Science Competition.



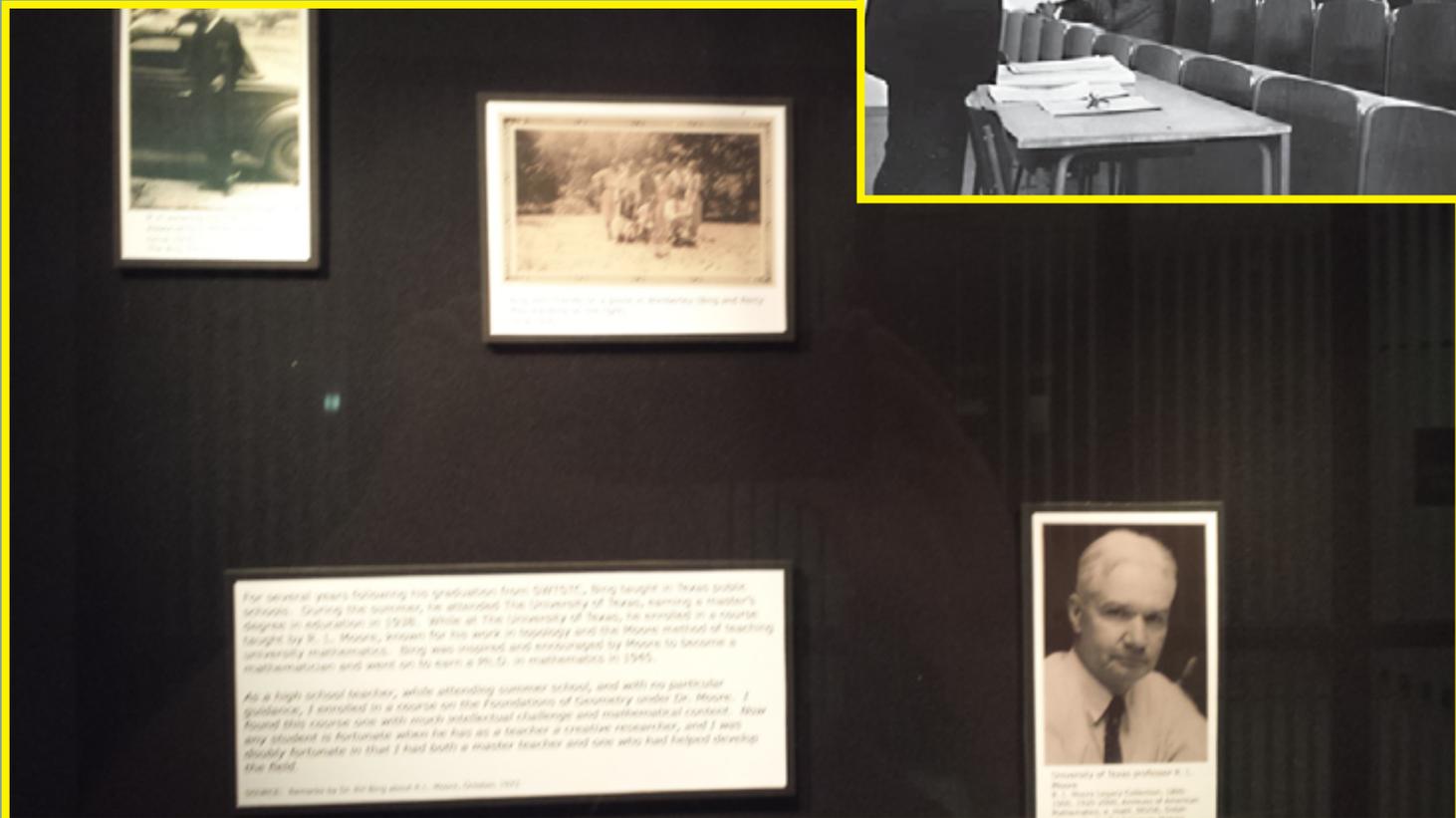
# Bing at 100

In 2014-2015, the Texas State University Math Department celebrated its most famous alumnus, Dr. R H Bing. Bing studied at Southwest Texas State Teacher's College (now Texas State) and graduated in 1935. After graduation, he taught high school math and coached football. He attended the University of Texas-Austin and graduated with a master's degree in 1938. He studied under the very famous R. L. Moore. Bing completed his PhD at UT in 1945. After several years as instructor at UT, he accepted a position at University of Wisconsin. Bing served as the President of the American Mathematical Society from 1977 -78.



(Right) Dr. Bing giving a presentation.

(Below) Part of the Exhibit featured in Alkek Library honoring Dr. Bing.



R H is born on  
October 20

1914

Graduated from  
Southwest Texas  
State Teacher's  
College

1935

Master of  
Education from  
UT

1938

Became  
instructor at  
UT; married  
Mary Hobbs

1943

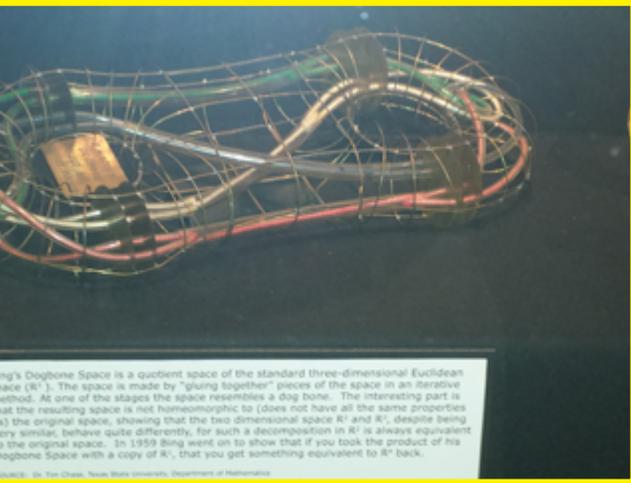
Earned PhD in  
Math at UT

1945

Published paper  
on pseudo-arc  
homogeneity

1948

# Mathematical Descendants of R H Bing

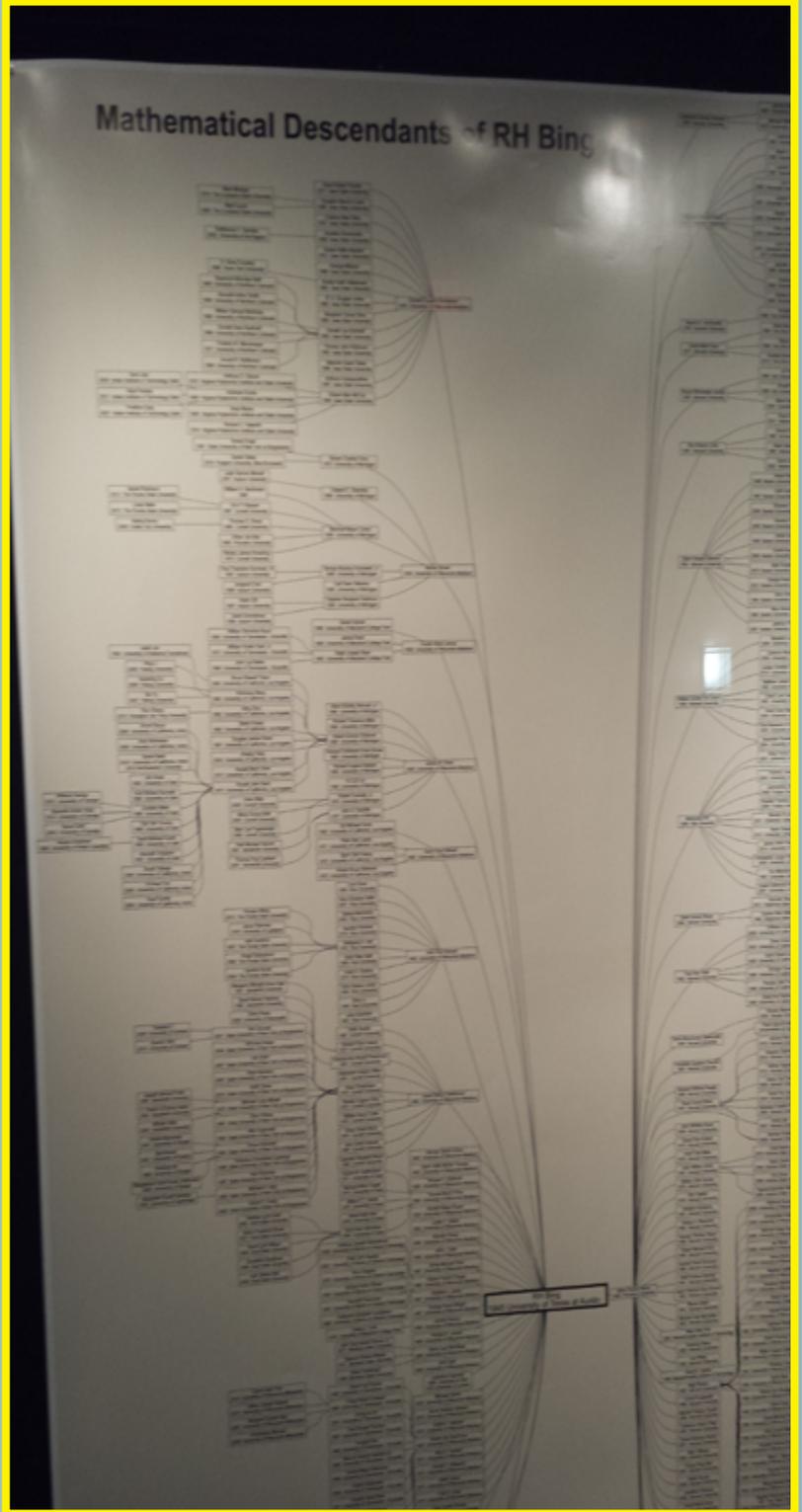


Bing's Dogbone Space is a quotient space of the standard three-dimensional Euclidean space ( $\mathbb{R}^3$ ). The space is made by "gluing together" pieces of the space in an iterative method. At one of the stages the space resembles a dog bone. The interesting part is that the resulting space is not homeomorphic to (does not have all the same properties as) the original space, showing that the two dimensional space  $\mathbb{R}^2$  and  $\mathbb{R}^1$ , despite being very similar, behave quite differently, for such a decomposition in  $\mathbb{R}^2$  is always equivalent to the original space. In 1959 Bing went on to show that if you took the product of his Dogbone Space with a copy of  $\mathbb{R}^1$ , that you get something equivalent to  $\mathbb{R}^3$  back.

Bing's "DogBone"



Texas State's two most famous alumni



Proved Bing-Nagata-Smirnov metrization theorem

1951

Showed double Alexander horned sphere is 3-sphere

1952

President of MAA

1957-58

Institute for Advanced Study at Princeton

1962-63

Returned to UT

1973

Retired from UT

1985

Passed away on April 28

1986

Math Department honors Dr. Bing with colloquia and exhibit in Alkek Library.

2014-15



# Math Department Award Winners -- Spring 2015



## Undergraduate Recognition for Academic Achievement

This award is presented to undergraduate mathematics majors who have completed at least 30 hours of college level course work at Texas State and have a Texas State grade point average of at least 3.00 but less than 3.25.

Alexander E. Bush	Ethan C. McCamant
Jorge Canada	Justin D. Mccaw
Maximo Castillo III	Emily Melton
Justin E. Chavez	Jacqueline J. Moad
Martina A. Coad	Nicholas B. Montefusco
Rhianna L. Daddona	Demeraya L. Moore
Desiree D. De Leon	Leonel Ponce
Ryan A. DeElena	Maggie R. Purdum
Zach C. Drogosch	Jose G. Rivera
Adele M. DuBay	Robert T. Salit
Shelby R. Hart	Meghan D. Sealey
Jose L. Hernandez, Jr	Glen M. Stevenson
Amber J. Herrera	Raymond Tijerina III
Gabriella J. Iverson	David T. Torres
Tyler D. Luker	Andrea Zermenon
Stefan A. McBride	

## Undergraduate Recognition for Academic Distinction

This award is presented to undergraduate mathematics majors who have completed at least 30 hours of college level course work at Texas State and have a Texas State grade point average of at least 3.25 but less than 3.6.

Dalya Ali	Robert G. McAlmon
Andrew J. Baxter	Alanna R. Miller
Quinton D. Brown	Warren Pekarek
Alyssa L. Campos	Jeffrey R. Perez
Jose M. Castro	Ryan L. Pescaia
Bianca R. Caudillo	Roxanne Ramirez
Edward C. Chapa	Joshua A. Rice
David E. Curry	Laura M. Rice
Julian Davalos	Callie M. Salverino
Joshua E. Deslongchamps	Courtney A. Sanders
Megan K. Fairchild	Martin T. Schmidt
Jordan D. Goble	Taylor N. Shimek
Colin J. Hamilton	James A. Shook
James A. Hazzard	Adrian B. Smith
Jeffrey M. Henze	Jason D. Smith
Melton V. Holcomb IV	Hailey M. Stirneman
Jessica F. Jalbert	Nathan E. Tropiano
Dean Koehne	Katelyn C. Webster
Yu Ri Lee	Nancy A. Wien
Angelika N. Licon	Danielle K. Wolesensky

## Undergraduate Recognition for Academic Excellence

This award is presented to undergraduate mathematics majors who have completed at least 30 hours of college level course work at Texas State and have a Texas State grade point average of at least 3.6.

Abigail Angeles Martinez	Maren Lowke
Hayley M. Boynton	Angela L. Mitchum
Melisa G. Cantu	William R. Moody
Zachary W. Coleman	Stuart J. Olsen
Esther D. Conrad	Joseph G. Powell
Jose M. Cruz	Mark A. Proctor
Brittany S. Enfield	Ryan A. Rholes
Haley K. Entingh	Ellen B. Robinson
Leah R. Erenwert	Sharisse A. Robinson
Melanie R. Fischl	Jose M. Rocha, Jr.
Zachary M. Fresquez	Christopher M. Roosa
Kyle R. Gates	Chris A. Smith
Elizabeth A. Geisinger	Nathan A. Steinle
Kurt A. Grace	Katherine P. Super
Traci L. Hollister	Frank A. Tallerrine, Jr.
Kendall P. Homoky	Maria E. Tomasso
Kathryn E. Hoyte	Mary F. Traxler
Henry E. Ickes	Madelaine J. Werran
Madison M. Kuyawa	David A. Young
Jorge R. Longoria	

## Graduate Recognition for Academic Excellence

This award is presented to graduate mathematics majors at the Master's level who have completed at least 15 hours of 5000+ level mathematics courses at Texas State and have a Texas State grade point average of at least 3.75.

Michael D. Hicks	Joseph W. Skelton
Rodney L. Overtuff II	Christina R. Zunker

## Graduate Recognition for Academic Excellence

This award is presented to graduate mathematics majors at the Ph.D. level who have completed at least 36 hours of 7000 level mathematics courses at Texas State and have a Texas State grade point average of at least 3.75.

Nichole A. Armand	Alexander N. Rasche
Sonalee Bhattacharyya	Joni J. Schneider
Daniel C. Cheshire	Shawnda R. Smith
Christine A. Herrera	Christina Starkey
Geoffrey F. Miller	Joshua B. Wilkerson

## Don and Helen Cude Award

Dalya Ali Leah R. Erenwert

## Robert and Brita Northcutt Scholarship

Leah R. Ramirez

## R.H. Bing Award

Ellen B. Robinson

## Graduate Student Award for Outstanding Achievement

Joseph W. Skelton Christina M. Starkey



# Give back -- Support Mathematics Education

Contributions to our scholarship funds are always welcome. As the university and Math Department grow, more and more students rely on your generous gifts to support their education. Please consider giving support to our majors in one of these scholarship funds.

## *Established Scholarship Funds*

\_\_\_\_\_ Department of Mathematics Discretionary Fund

\_\_\_\_\_ Robert and Brita Northcutt Scholarship – awarded to Texas State student majoring in mathematics with Texas State GPA of at least 3.0 on at least 30 hours of coursework at Texas State.

\_\_\_\_\_ Lynn H. Tulloch Math Scholarship – awarded to full time Texas State student majoring in mathematics and pursuing teacher certification. Preference should be given to athletes. The student should have a Texas State GPA of at least 3.0 on at least 30 hours of coursework at Texas State.

\_\_\_\_\_ Don and Helen Cude Award – awarded to undergraduate mathematics major pursuing teacher certification who has the highest GPA among senior level students who have completed at least seven upper level mathematics courses.

\_\_\_\_\_ R. H. Bing Award – awarded to undergraduate mathematics major not pursuing teacher certification who has completed at least seven upper level mathematics courses.

\_\_\_\_\_ Wayment Award Fund

\_\_\_\_\_ Mathworks Fund

To contribute, mark the scholarship fund to donate to and complete the form below:

Name: \_\_\_\_\_

Address: \_\_\_\_\_

City: \_\_\_\_\_ State: \_\_\_\_\_ ZIP: \_\_\_\_\_

Country: \_\_\_\_\_ Phone: \_\_\_\_\_

Email: \_\_\_\_\_

Signature: \_\_\_\_\_

Check Number: \_\_\_\_\_ Amount: \_\_\_\_\_

Please return to

**Donor Services**  
**JCK 480**  
**601 University Drive**  
**San Marcos, Texas 78666**

## Alumni Connections

<http://www.math.txstate.edu/resources/alumni-connections.html>

We'd like to hear from you -- our treasured alumni! We've made it easy for you to reconnect with Texas State University and the Math Department. Go to the website below to register your information. You'll be able to stay connected with the happenings here in San Marcos.



# Kodosky Foundation Fulfills \$1.5M Pledge To Mathworks

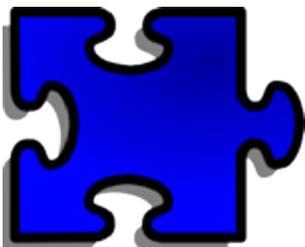
Jeff and Gail Kodosky of Austin have completed their \$1.5M endowment match challenge to Mathworks, a center for mathematics education at Texas State University. The Kodoskys and their foundation made a \$1.2M match challenge in November of 2010, along with a \$300,000 outright gift. Mr. Kodosky said that the goal of their pledge was to spur long-term investments in workforce development, and encourage others in the high-tech community to help raise the bar of mathematics achievement of all students. The Kodosky donation will support the Mathworks endowment, enhance ongoing research and development of model programs in mathematics education, and provide opportunities to students of all socioeconomic backgrounds.

The Kodosky Foundation match challenge had a seven-year timeline. Thanks to numerous supporters, Mathworks has successfully raised endowment donations to complete the match ahead of schedule. Supporters of the Mathworks endowment include the RGK Foundation, the KLE Foundation, Sarah and Ernest Butler, the Siemens Foundation, and numerous Mathworks alumni, families, and friends.

As a center for mathematics education, Mathworks conducts research and development of summer programs for K-12 students, teacher training, and curriculum development. These programs impact middle school students, high school students, math teachers, and undergraduate and graduate students. Over the past 25 years, more than 8,000 students and 600 teachers have attended Mathworks summer math programs, with many of them attending on a scholarship funded by foundations and corporations. Mathworks provides early classroom math teaching experiences to undergraduate students, and research opportunities for Mathematics Education Ph.D. students. Proficiency in mathematics is strongly correlated with success in science and engineering, and Mathworks programs provide a model for how to develop the critical and creative thinking abilities of students of all ages, thereby opening more doors of opportunities for future degrees and careers.

Mathworks Director Max Warshauer, a professor in the mathematics department, said, "We thank Jeff and Gail for their wonderful gift that helped launch the Mathworks endowment, which will sustain and enhance our programs for years to come. They are an inspiration to us all as we continue to provide exciting mathematical opportunities for all students and work on related research about mathematics pedagogy and learning."

For more information about Mathworks programs and its ongoing endowment campaign, please contact Mathworks at (512) 245-3626 or [mathworks@txstate.edu](mailto:mathworks@txstate.edu), and visit [www.txstate.edu/mathworks](http://www.txstate.edu/mathworks).



**Puzzle:** Mr. Robert Katz is going to build a ten-story hotel in the heart of beautiful San Marcos. Each floor will be painted maroon or gold with the following provisions: (1) the floor immediately above a gold floor must be painted maroon, and (2) the floor immediately above a maroon floor can be either maroon or gold. How many ways can the hotel be painted? (Answer can be found on [www.math.txstate.edu](http://www.math.txstate.edu).)

# New Colloquium Series Brings Diverse Areas of Research to Texas State Faculty and Students

The Mathematics Department recently renewed its commitment to providing faculty and graduate students a wide range of research topics. In the Spring 2015 semester, an extremely diverse group of speakers were brought in to present their research. Among these included Dongwoo Sheen of Seoul National University, Anderson Norton of Virginia Tech, and renowned algebraist Martin Issacs of University of Wisconsin-Madison. These talks ranged from stable cheapest nonconforming finite element methods for the Navier-Stokes equations to the develop of iPad apps to promote math education for middle school students.

In April, colloquium talks focused on topology in honor of Dr. R H Bing. These colloquia included presentations from Robert Daverman, James Kessling, and Erica Flapan.

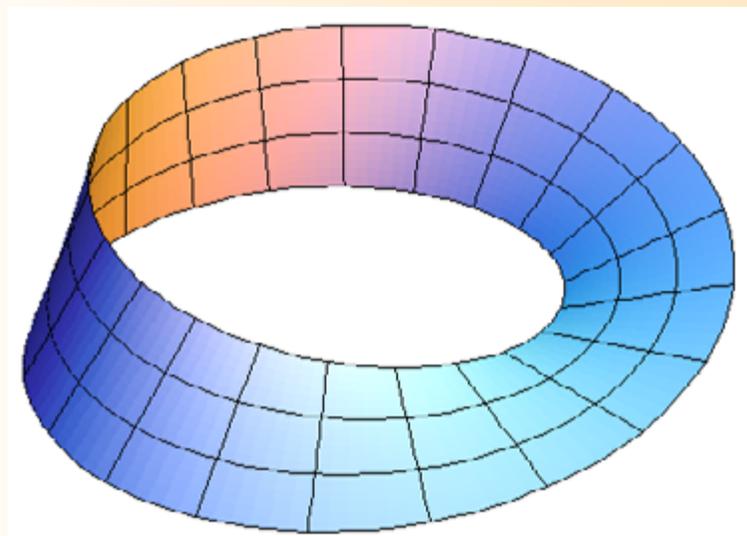


Dr. Anderson Norton of Virginia Tech speaks to faculty and graduate students on his research involving middle school math students and their perceptions of units.

## Teacher's Corner: The Möbius Strip

Take a long strip of paper, give the end a half-twist, and then tape or glue the two ends together. What do you get? You get the famous Möbius Strip! The Möbius Strip is a great tool for enriching your classroom and challenging your students to think in different ways.

Among the questions: (1) How many sides does the Möbius Strip have? To answer this first question, have students take a pencil, place it in the center of the strip and draw the path from the point while rotating the strip. Eventually, they will reach the original point, all without lifting up the pencil. Thus, the strip in this sense only has one side!



Other questions: (2) What is the result of taking a Möbius Strip and cutting it down the center long ways until you reach the original cut?

(3) Instead of cutting it down the center, what happens when you cut it one-third of the way from the edge all the way until you reach the original edge?

What other questions did your students come up with? Share them with us via Twitter @TxStateMath.

# Math in the Picture Contest Winners

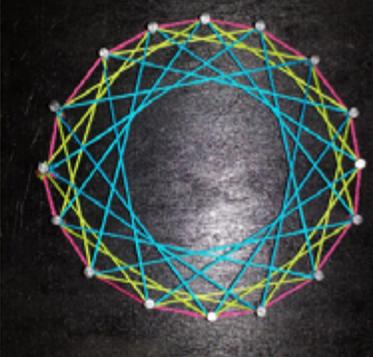
Posters created by Joni Schneider and Ellen Robinson took top honors at this year's contest. The contest is run for undergraduates, graduates, and pre-college. Check out the math website on how your students can enter the contest this coming Fall in the Future Bobcat category.

### Cayley Graphs:

*Reminiscing about Spiro graphs*

A key issue in designing communication networks is to reduce the complexity of massively parallel processing systems. Symmetric graphs can be used to model networks so that the same routing algorithms apply to all the vertices. A good example would be the hypercube, which is a popular communication network design, noted for its symmetry and expandability. However, recent studies have shown that optimal Cayley graphs constructed by using groups can outperform hypercubes and other popular network topologies in terms of capacity and efficiency of the network.

A Cayley graph can be formally defined as follows:  
 Let  $\Gamma$  be a finite set and  $A$  be a subset of  $\Gamma$ .  
 The Cayley graph of  $\Gamma$  generated by  $A$  denoted by  $\text{Cay}(\Gamma, A)$  is the graph with vertex set  $\Gamma$  and edge set  $\{uv \mid uv \in A\}$  in  $\Gamma$ .



The Cayley graph shown above is  $\text{Cay}(Z_{16}, \{1, 3, 5\})$ . That is, each element of  $Z_{16}$  is represented by one of the vertices and that the edges connect  $n$  to  $n+1$ ,  $n+3$  or  $n+5$  for  $1 \leq n \leq 16$ .

Photo taken by Joni Schneider. References: Schneider, J. (2012). Extremal Cayley Graphs. (Masters Thesis). Texas State University, San Marcos, TX.

### The Math of a Massé Shot



As a cue ball is hit with a massé shot, it is forced down into the felt and the rotational side spin uses the friction of the table to cause the ball to slide and curve in a parabolic arc. Once the ball is no longer sliding, it begins to roll and the trajectory can be represented with a line. These parabolic and linear functions, and therefore the trajectory of the ball, can be altered by the player's choice of angle, speed, spin, elevation and stroke.

When calculating these choices for making a massé shot, it is key to locate the vertex and axis of symmetry of the parabola. Then, instead of aiming for the object ball, the player can aim for the vertex of the parabolic path they want the ball to follow while applying spin to the ball in order to cause it to curve. Careful calculations result in more accurate shots.

The curves traced out by the moving ball can be represented by a piecewise function of a parabola and a line.

**MASSÉ TOP VIEW**



$$y = \begin{cases} -0.25x^2 + 1 & x \leq 0 \\ -0.25x + 2.5 & x > 0 \end{cases}$$

$$y = \begin{cases} -0.25x^2 + 1 & x \leq 0 \\ -0.25x + 2.5 & x > 0 \end{cases}$$


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 Department of Mathematics  
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