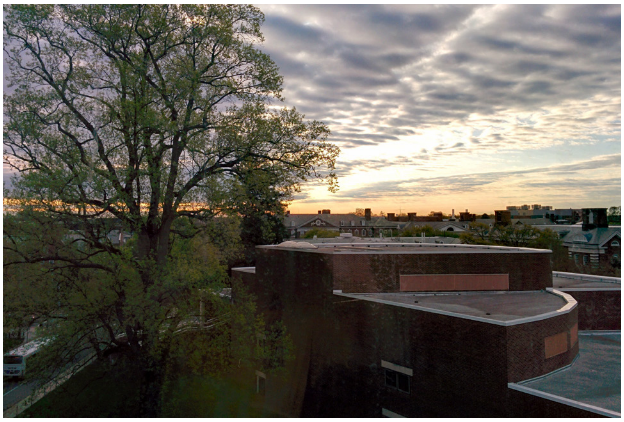
Newsletter of the Department of Mathematical Sciences @ University of Delaware

RECKONINGS

SUMMER **2014** AND **2015**

Message from the Chair

LOUIS F. ROSSI



Ewing Hall is not much to look at, nor was it designed for the purpose it now serves, home to the Department of Mathematical Sciences. As Lao Tzu pointed out in the *Tao Te Ching*, it is the space within a cup that gives it its meaning. Indeed, this building is the focus of the research and learning activities that are critical to the University of Delaware, our nation and the world. Throughout these five floors, faculty work tirelessly to pursue our educational, scholarly and outreach missions.

Mathematical Sciences is going through a time of soul searching with the publication of the National Research Council's The Mathematical Sciences in 2025. (The PDF is free to download, and it is worth reading.) The title is slightly deceptive because much of the report focuses on changes that have already occurred, specifically that mathematics is a broad, expanding and vital discipline. Indeed, there are few if any aspects of 21st century life that are not dependent on deep mathematical ideas in significant ways. Mathematics is portable, flexible and versatile, and our faculty develop knowledge, methods and techniques that shed light on many types of mathematical problems. We are a medium sized Department operating in a big world, but what we do, we do exceedingly well. I invite you as alumni and friends of our department to read more about our little part of this world in the pages of this issue of Reckonings.

Knowing talent when he saw it, Dean Watson promoted our Chair and colleague, John Pelesko, to be the Interim Associate Dean for the Natural Sciences in the College of Arts and Sciences. Under his outstanding leadership, our

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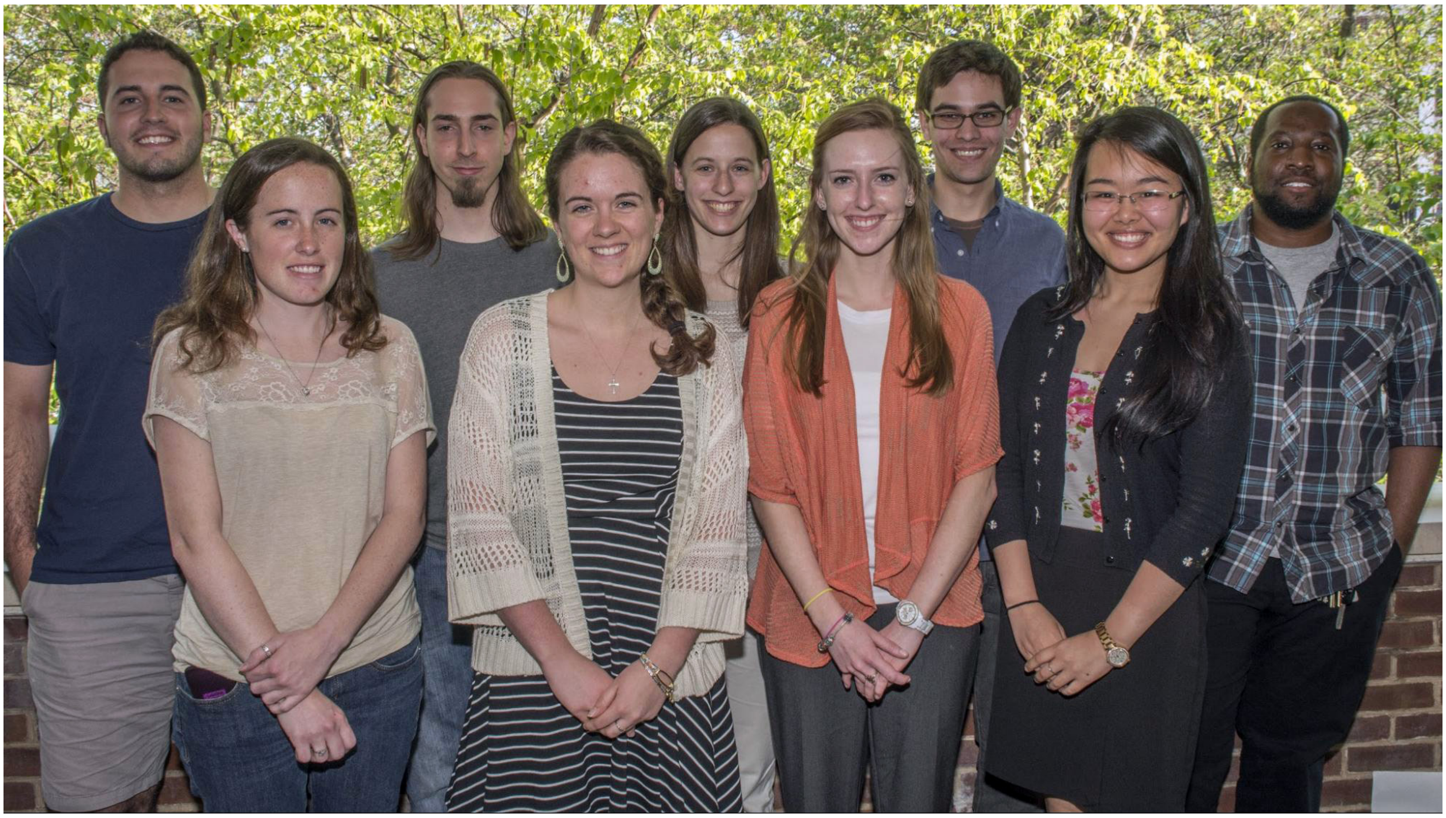
Inside

A Celebration of Student Achievement

BY LOU ROSSI, DIRECTOR OF UNDERGRADUATE STUDIES



2014 Award and Scholarship recipients. Front row: Laura Molitoris, Colleen O'Shea, Anna Goodman, Shellee Wong
Back row: Luke Felix, Stephen Smith, Michelle Markiewitz, Dylan Chapp, Isaac Harris

For the last two years, at the spring Carl J. Rees Colloquium, Mathematical Sciences students and faculty gathered to recognize outstanding student achievements through awards and scholarship programs.

CLARK AWARD

The Clark Award goes to a graduating senior with unusual ability. The recipient of the 2014 Clark Award is Michelle Markiewitz. In addition to her research with Prof. Cioaba, the Undergraduate Studies Committee was impressed with her work off campus for Department of Defense and her outstanding academic credentials. After graduation, Michelle has been working as an Applied

Research Mathematician with the Department of Defense. The prize was awarded to Colleen O' Shea in 2015. Colleen will graduate with a BS in Mathematics and will be joining the Johns Hopkins Applied Physics Lab this Fall.

WOLFE PRIZE

The Wolfe prize is awarded to a junior math major who has demonstrated both love and talent for the subject.

The recipient of the 2014 Wolfe Scholarship is Colleen O' Shea. The Undergraduate Studies Committee was impressed with Colleen?s outstanding scholarship at UD. She was offered both an National Security Agency internship and a Naval Research Enterprise Internship (NREIP) for the summer, and she has chosen to do the NREIP internship at the Naval Surface Warfare Center in Philadelphia. The recipient of the 2015 Wolfe Scholarship is Jacek Cencek. While still a junior, Jacek has been doing well in graduate courses in math.

UNDERGRADUATE RESEARCH PRIZE

The Undergraduate Research Award in Mathematical Sciences recognizes outstanding undergraduate research in the department. The 2014 prize went to Dylan Chapp for his work on

Object Detection in Lipid Layer Images with Professor Richard Braun. The 2015 prize was awarded to Liedeke Sweitzer for her work on The Peculiar Path of Plankton with Professor Lou Rossi. Dylan graduated with a BS in Math and is pursuing an MS in Computer Science at the University of Delaware. Liedeke graduated with a BS in Quantitative

Biology and will be working as an Associate Biologist at Frontier Scientific Services.

REES SCHOLARSHIPS

The Rees Scholarships is awarded to sophomore and junior math majors based on their academic performance. For 2014 the Rees recipients were Yi Zhang, Hannah Lapp, Laura Molitoris, Hannah Kretz, Weiran Zhu, John Elia and Luke Felix. In 2015 the scholarship was shared amongst Daniel Atadan, John Elia, Amy Fligor, Alyson Grassi, Kimberly Iervoline, Nathaniel Kim, Rebecca Kline, Briana Lamet, Ryan McKenna, Molina Nichols, Jinjibang Wang and Yi Zhang.

2015 Award and Scholarship recipients.
From left to right, they are Kimberley Iervoline, Alyson Grassi, Molina Nichols, Amy Fligor, Ryan Caulfield, Colleen O" Shea, Liedeke Sweitzer, Jake Rezac.

In addition to these prizes, Ryan Caulfield won, in national competition, one of the prestigious National Science Foundation graduate fellowships, which will pay for his graduate education at any university of his choice. Ryan will graduate with a BS in Mathematics and a BS in Physics and will be pursuing a PhD in Mathematical Physics at a university he is still deciding upon.

STUDENT TEACHER AWARDS

Student Teacher Awards recognize student teachers who have demonstrated exemplary performance during their student teaching experience and exceptional skill and creativity in developing rapport with students, planning and executing lessons, and incorporating suggestions and new ideas into teaching practice. The 2014 recipients were Anna Goodman, Erin McCarthy and Shellee Wong and the 2015 recipients are Craig Chatterton, Rebecca Guarino, and Katherine Slyman. Shellee also won the 2014 Phi Delta Kappa award, a university-wide award that recognizes one undergraduate education senior who shows evidence and promise of excellence in educational research. Shellee was nominated for this award for her research on Dr. Cirillo?s project, focused on teaching proof in high school geometry.

Students who perform well in Educ 413, Educ 414 and Educ 419 are recognized by the College of Education with the Secondary Education Award for Educational Promise. The 2014 winners were Rebecca Guarino, Hannah Kretz, Toni Marcelli, and Katherine Slyman.

Hannah Kretz is the winner of the 2015 Mildred Cook Award, given to Secondary Math Education major who has shown outstanding scholarship and active participation in educationally-related activities.

BAXTER-SLOYER AWARD

The Baxter-Sloyer Award is presented to one or more graduate teaching assistants in mathematical sciences who have demonstrated superior effectiveness in teaching and in the performance of their responsibilities. For 2014 and 2015 the awardees are Isaac Harris and Jake Rezac, who have been consistently praised by students for their clear explanations, friendly demeanor, and willingness to help them understand the material so that they feel empowered, rather than defeated.

The Society for Industrial and Applied Mathematics Outstanding Efforts & Achievements Award was received in 2015 by Allan Hungria.

SIAM Outstanding Efforts & Achievements Award. Pam Cook the SIAM president, Allan Hungria, Lou Rossi

Pam Cook elected SIAM president and named UNIDEL Professor

On January 1, 2015, Prof. L. Pamela Cook started her two year presidency of the Society for Industrial and Applied Mathematics (SIAM). Prof. Cook served as the SIAM vice president for publications in 2012 and 2013. She is a SIAM Fellow (class of 2009). SIAM has over 13,000 individual members worldwide including applied and computational mathematicians, computer scientists, numerical analysts, engineers and statisticians. SIAM's institutional members gather close to 500 academic, industrial, consulting, government, and military organizations. To serve this diverse group of professionals, in addition to holding an annual meeting as well as many specialized conferences, SIAM publishes 16 peer-reviewed research journals and approximately 25 books per year.

Prof. Cook's research has focused on the mathematical modeling and analysis of fluids, and the prediction of flow properties with a current emphasis on complex fluids. She is an expert in the mathematics of transonic aerodynamics, complex (viscoelastic) fluids, and the theory of asymptotic and perturbation methods. She is also a Fellow of the American Association for the Advancement of Science, and Associate Fellow of the American Institute for Aeronautics and Astronautics.

Prof. Cook earned her doctorate in mathematics at Cornell University, received a NATO postdoctoral fellowship to Utrecht University in the Netherlands, and then spent ten years in the mathematics department at the University of California in Los Angeles, where she was tenured, before joining UD. She has held visiting positions at the California Institute of Technology, the University of Maryland College Park and the Institute for Mathematics and Its Applications (IMA) at the University of Minnesota, and is the co-author of the book *Transonic Aerodynamics*. At UD, she served as Chair of the Department of Mathematical Sciences for nine years, Chair of the University's Commission on the Status of Women for six years, Associate Dean of the College of Arts and Sciences, and she is now Associate Dean of Engineering. She has also served on the Scientific Advisory Board of the Fields Institute for Research in the Mathematical Sciences at the University of Toronto, and on the Board of Governors of IMA, an NSF funded institute.

As a co-PI on UD's NSF ADVANCE PAID award, Prof. Cook has directed efforts to improve the recruitment and retention of women faculty in science, technology, engineering and mathematics (STEM) disciplines. She received the 2012 University Change Agent Award from the Women in Engineering ProActive Network, the 2009 University of Delaware Trabant Award for Women's Equity, and the 2014 UD Women's Caucus Torch Award, in recognition of her work towards equality for women. Her work in promoting equity and mentoring women in STEM disciplines is highly praised.

Prof. Pamela Cook has been named UNIDEL Professor of Mathematical Sciences, effective November 1, 2013, in recognition of her outstanding contributions to scholarly research, teaching, mentoring, service to the University and to the mathematical community at large. UNIDEL Professorships are awarded by the UNIDEL Foundation, which was established by Amy E. DuPont, a noted sportswoman and philanthropist who supported women's education at Delaware and bequeathed her estate to create the foundation. The UNIDEL Foundation makes grants to finance specific projects to enrich educational programs at UD.

Faculty Special Awards

PROF. DRISCOLL IS CAS OUTSTANDING SCHOLARSHIP AWARD WINNER

Professor Toby Driscoll is the winner of the College of Arts & Sciences Outstanding Scholarship Award for the year 2013-2014. The Arts & Sciences Outstanding Scholarship Award is based on publications, professional honors, receipt of competitive grants, scholarly contributions to one's field, and acknowledged reputation in scholarship. With over 600 faculty in the college, this is a great mark of distinction and a true testament to the high quality of Professor Driscoll's research. The recipient receives a check for $1,000 and a plaque. It is the second year in a row that a member of the Department of Mathematical Sciences receives this award.

Congratulations to Professor Driscoll on this well-deserved honor!

Toby Driscoll

PROF. CAI APPOINTED AS EDITOR OF JRME

Professor Jinfa Cai has been appointed as the Editor of the *Journal for Research in Mathematics Education (JRME)* in the next five years (2015-2020, the first year as the Editor-Designate). *JRME* is the

Jinfa Cai

premier research journal in mathematics education. Established in 1970 as an official journal of the National Council of Teachers of Mathematics (NCTM), JRME advances the frontiers of mathematics education by disseminating the highest quality research on the learning and teaching of mathematics at all levels—preschool through college. The work published in *JRME* over the past several decades has helped to guide research, foster innovations in practice, and inform policy debates and decisions. In addition, Professor Cai is also editing the *Handbook for Research in Mathematics Education* to be published in 2016. The *Handbook* involves nearly 100 scholars worldwide for about 40 chapters.

CIRILLO WINS NSF EARLY CAREER AWARD

Dr. Michelle Cirillo was selected by the National Science Foundation to receive a Faculty Early Career Development Award for her work in secondary mathematics education. The $874,000 grant, *Proof in Secondary Classrooms: Decomposing a Central Mathematical Practice*, will support a five-year study focused on improving the teaching and learning of proof in high school mathematics classrooms. Cirillo will make use of data and findings from a previous exploratory study that was funded by the Knowles Science Teaching Foundation. She will develop materials to be piloted and improved through cycles of lesson study. The goal is to publish a professional development program for high school teachers and to develop a theoretical framework focused on decomposing the practice of proving.

This work is needed because, despite the fact that there have been ongoing calls to focus on reasoning and proof in school mathematics, success with teaching proof has remained elusive. The pilot study findings suggested a promising approach to scaffolding the introduction to proof in high school geometry. Understanding that reasoning and proof should also be taught outside of geometry, a goal of this project is to leverage the existence of proof in geometry (i.e., in current practice, textbooks, and standards) to explore alternative ways to teach it across the grades. The results of the study are expected to have implications for teaching proof in mathematics more broadly, including at the middle school and undergraduate levels.

Michelle Cirillo

NAYANTARA BHATNAGAR'S SLOAN RESEARCH FELLOWSHIP

The Sloan Research Fellowships are awarded to early-career scientists with the purpose of stimulating fundamental research by these researchers. The award was established in 1955 and at first, awarded to physicists, chemists and mathematicians. Over the years, the scope of the award expanded to include fields like neuroscience, computer science, and computational and evolutionary molecular biology. The Sloan Research Fellows are free to use the grant to pursue lines of research of most interest to them.

My application for the fellowship focused on two topics I have been pursuing for the past several years. The first is the reconstruction problem, a kind of probabilistic inference or inverse problem. The problem is motivated by the study of noisy signals over a network, which arises in applications such as phylogenetic tree reconstruction and noisy computation. The basic question is to reconstruct a signal that has been broadcast from a node in a network from observations of the signal at distant nodes. The transmission between nodes is noisy and thus the signal may be corrupted on the way. A fundamental case where we now understand reconstruction for different noise models is when the network is a tree. This has turned out to be important for understanding the reconstruction problem in sparse random graphs, since it coincides with what physicists call the clustering phase in spin glasses. The long-term aim is to connect the reconstruction problem with this clustering transition rigorously and to mathematically prove the detailed picture that statistical physicists have conjectured using the sophisticated but heuristic cavity method.

The second line of research is on the longest increasing subsequence (LIS) problem in non-uniformly random permutations. The particular distribution we study is called the Mallows distribution and it weighs a permutation exponentially using a real parameter q according to the number of inversions. The long-term aim is to determine the asymptotics and limiting distribution of the LIS for different regimes of the parameter q. This is of interest since powerful analytic and combinatorial techniques that have been applied in the case of $q=1$ cannot be used for other values of q. Our preliminary work indicates that there is a transition in the distribution of the LIS from Gaussian for small values of q to Tracy-Widom for $q=1$ and our aim is to understand how this transition occurs and its location.

Continued from page 1

Department saw an expansion in our stature on and off campus, growth in the size and quality of our undergraduate and graduate programs, and expansion of our research activities. From our new Mathematical Sciences Learning Laboratory in McKinly Hall over to our Active Learning Classroom on the second floor up to the coffee machine in our lounge, John's dedication to the faculty and students has been exemplary, and he will be missed. The good news is that his new office is not very far away, and I look forward to working with him in the coming years. Taking the helm mid-year was not easy, and I thank my colleagues, staff and students for their support during the transition.

Exciting times lie ahead. The University has been crafting its latest strategic plan entitled Delaware Will Shine during the last year with an unprecedented amount of faculty input. The current draft calls for UD to emerge as a "pre-eminent learner-centered research university." Meeting this challenge will be no easy task, but in many ways, our Department is ahead of the game. Our faculty are constantly re-imagining what a mathematics classroom should be and how best to reach students. At the same time, our research mission continues to expand into new areas with projects receiving national and international recognition. We have two CAREER fellows and a Sloan fellow amongst our junior faculty. Among our senior faculty, we have associate editors and chief editors of some of the highest ranked journals in our profession, two recipients of the Arts and Sciences Outstanding Researcher Award as well as the current President of the Society for Industrial and Applied Mathematics (SIAM). Our student clubs and organizations continue to thrive, and we are pleased to see our students complete their educations with us and move into exciting careers. We welcome news from our alumni. When you have a chance, send us a note math-contactus@udel.edu or a tweet #UDmath.

I will end as I began with Ewing Hall. It's not much to look at, but every day something new and exciting is happening inside. Here you will find faculty, students and visitors all sharing a common passion for solving problems. The Ewing facade might not be inspiring, but the view from within is spectacular.

The Launch of the Mathematical Sciences Learning Laboratory (MSLL)

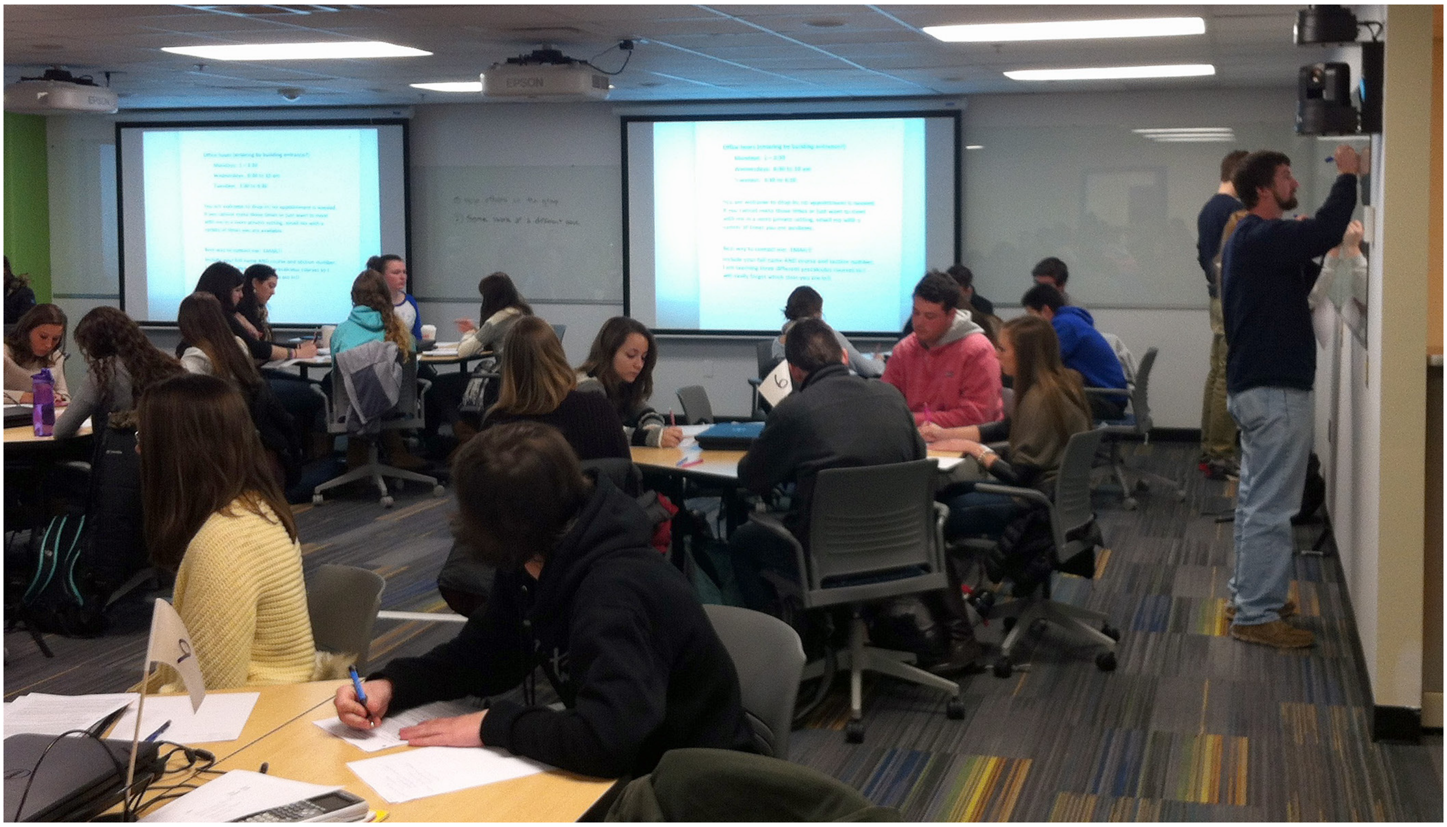
The department's remedial and introductory mathematics courses are a highly critical transition point between high school mathematics and university-level calculus. Nationally, the level of mathematics preparation among graduating high school students is of great concern, with only about 40% of students prepared for a calculus-level math course upon entry to college. The profile of incoming students at the University of Delaware (UD) reflects this national trend. More than half of UD students, including many students intending to major in a STEM discipline, are placed into the department's remedial and introductory-level mathematics courses. These courses have high DFW rates (the percent of students earning a grade of D or F or withdrawing from the course) which negatively impact overall retention at UD as well as retention in the STEM majors specifically.

The Mathematical Sciences Learning Laboratory (MSLL) was launched to tackle this issue head-on. Opening in Spring 2015, MSLL offers a new integrated learning space, a new model of teaching, and highly-leveraged technology to better support students' learning in the remedial and introductory-level courses.

The space is a completely renovated space located in 053 McKinly Lab, featuring a 66-seat problem-based learning classroom with fully embedded technology, a dedicated testing center, an on-site faculty team, and a fully staffed tutorial center. Renovations of the space were funded by a grant from the UNIDEL Foundation.

The new model of teaching is a collaborative team-based approach, with teams consisting of faculty, classroom assistants, and undergraduate tutors. Courses are taught on-site in an active, problem-based learning format. ALEKS, a web-based, artificially intelligent learning and assessment system, is used for targeting instruction to individual student needs. The work is driven by a model of continuous improvement which involves engaging in repeated design cycles to collect data and systematically improve the courses over time.

MSLL will also serve as a "laboratory" in the sense of serving as a site for teacher training and for research in mathematics teaching and learning. Headed by its new Director, Dr. Dawn Berk, this effort will be strongly tied to disciplinary expertise as well as to expertise in mathematics education.



Phase Transitions through Probability

BY NAYANTARA BHATNAGAR

In the last 50 years or so, there has been an increasing interaction between mathematics and fields such as computer science and statistical physics. Mathematicians have contributed by using probability and statistics to solve problems about the behavior of systems consisting of large numbers of interacting particles or objects, for example users on the internet or atoms in a magnet. Since the number of variables grows in proportion to the size of the system exact analysis can be difficult but probabilistic methods, in particular, Markov chains, have proven to be very useful for these problems.

Roughly, a Markov chain is a sequence of random states describing the evolution of the system. At each time, given the current state, the chain is updated to a new random state. Often, this update occurs by changing the value of a variable of the system looking only at the values of a few of the other variables that are closely connected to it, i.e. the update is "local" in some sense, so you don't need to take into account the entire system. In the long term, if you look at the states the Markov chain is in, you can get an idea about the average properties of the system.

In the 1950's, at Los Alamos, a group of researchers led by Nicholas Metropolis, John von Neumann and Stanislaw Ulam were interested in obtaining precise numerical simulations of certain simple liquids. They came up with a general purpose method known as Markov chain Monte Carlo which is a statistical method for simulating and estimating quantities related to large systems of particles where there is an underlying probability distribution over states.

Here's a simple example of Monte Carlo for a slightly different problem: say you want to estimate the value of pi.

You could do this by drawing a circle of diameter 1 inside a square of side 1, throwing many darts randomly into the square and counting what proportion fall inside the circle. The more darts you throw, the more accurately you would be able to estimate pi. In this case, by throwing darts, you are sampling from the the distribution which is uniform over the circle and zero outside it on the square. Throwing darts is a way of "simulating" this distribution. Markov chain Monte Carlo simulations simulations have become ubiquitous in fields such as genomics, chemistry and computer vision.

One question that arises in the simple example above is: how many darts do you need to throw to get an estimate of pi within some desired accuracy? A great deal of theoretical work by researchers in probability, functional analysis and theoretical computer science has been devoted to understanding how long Monte Carlo simulations needed to be run in order to guarantee that that the errors in the physical quantities calculated by simulation are not too large.

The "mixing time" refers to the time required by the Monte Carlo simulation to yield samples which are very close in distribution to the target distribution. Among the techniques developed to give bounds on the mixing time are coupling—a method which couples two distributions together to obtain information about how close they are, spectra of graphs—which relate the eigenvalues of a matrix associated with the Markov chain to its mixing time, and multicommodity flows—a method from optimization which says that in a graph we can route no more flow than the smallest bottleneck of the graph.

It is now well known that the mixing time can actually be prohibitively large even for computer simulation when the target distribution is multimodal, that is with many valleys and high peaks. A local Markov chain is like a random hiker taking small steps in the landscape. It unlikely the hiker can cross from one valley to another if there is a large mountain in between. In statistical physics, multimodal distributions often arise in the presence of a phase transition in the system (a transition in the state of a system accompanied by an abrupt change in the properties, for example when water turns to ice there is an increase in the volume at the freezing point).

Some of my research involves understanding phase transitions in statistical physics models and the connections with mixing times of Markov chains. The presence of certain types of phase transitions can mean that MCMC converges very slowly—too slowly to be simulated efficiently on computers. Simulated tempering is an MCMC based method, where a temperature parameter is randomly raised or lowered during the simulation. The motivation is that peaks at one "temperature" which block access to valleys with fixed temperature Monte Carlo can be bypassed by moves to higher temperatures where the peak is flatter.

Although simulated tempering is widely used in practice, and in many situations seems to speed up mixing time, there is a lack of many precise bounds on the mixing times. My research in this area involves rigorous analysis of such heuristics and finding new efficient heuristics. For example in work with Randall, we show how in spite of the presence of phase transition, a modification of simulated tempering mixes rapidly for the mean-field Potts model, a model for ferromagnetism from physics.

Some of my other research is on how information flows in trees and random networks. The problem of reconstructing a noisy signal in the broadcast model arises in several contexts such as evolutionary biology, the study of noisy computation where there is some rate of failure in each transistor and in statistical physics where it is connected to the study of a class of measures known as Gibbs measures.

In a simple version of the broadcast model on a tree, we start with a bit - 0 or 1 at the root of the tree. There is a noisy channel on each edge which independently transmits the bit of a parent node in the tree to the child, or introduces an error and flips the bit. In this way, the bit at the root is transmitted down through the tree to the leaves. If a typical configuration of states at the leaves generated by this random process gives information about the state at the root even as the depth of the tree become infinite, then we say the model is "reconstruction solvable." As the degree of the tree increases (that is, each vertex has more branches), there is phase transition from reconstruction non-solvability to solvability, indicating that in one regime information is quickly lost as we move away from the root due to the errors, while in another regime, no matter how far we move away from the root, enough information is retained in order to be able to reconstruct its state due to the redundancy of the many branches.

This is also a type of phase transition, in a combinatorial system, rather than a physical one. In a series of works that were done in collaboration with Maneva, Sly, Tetali, Vera, Vigoda and Weitz, we study this phenomenon for different statistical physics models and

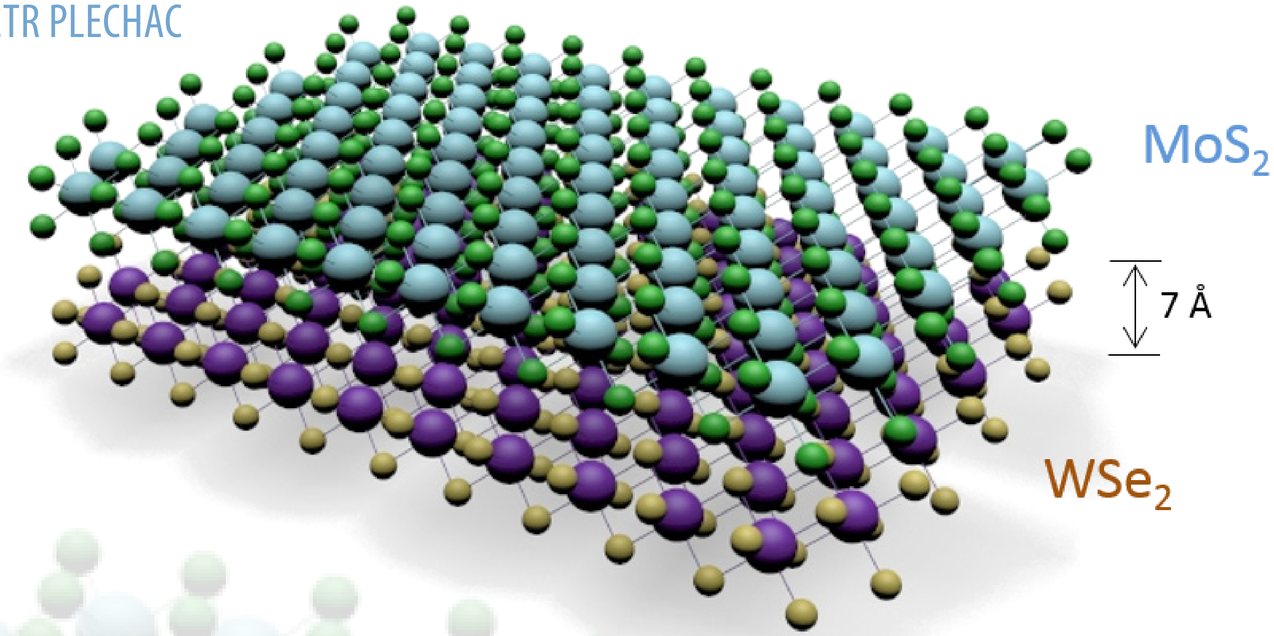
> The presence of certain types of phase transitions can mean that MCMC converges very slowly—too slowly to be simulated efficiently on computers.

show when, in terms of the parameters of the model, this phase transition occurs. This is an exciting area of research and recent results of other researchers have shown that the reconstruction phenomenon for the tree has connections with the difficulty of finding solutions to random constraint satisfaction problems, which can be thought of as a random system of equations that variables must obey simultaneously. This suggests the possibility that reconstruction plays a role in determining the regime of parameters for which local methods such as Markov chain Monte Carlo can be used for sampling or finding solutions to these random systems of equations. For one range of parameters, local algorithms are able to find solutions while for another range of parameters, they are unable to because the space of solutions has very different structure.

Another problem that I am interested in concerns the length of a longest increasing subsequence (LIS) in a permutation. For example, in the permutation 13524, the longest length of an increasing subsequence is 3, corresponding to the subsequences 124 and 135. The LIS has connections with diverse areas such as combinatorics, representation theory and random matrices. What is the typical length of the LIS in a uniformly random permutation of length n? This question, first asked by Stanislaw Ulam, has been studied since the 60's and has continued to yield new and interesting mathematics until this date. Researchers showed that the typical length of the LIS for a random permutation is $2\sqrt{n}$ and varies by about $n^{1/6}$ in a typical permutation. In fact, in 1999, by using the connection of the LIS to Young tableaux, a type of combinatorial object, a group of researchers was able to determine the distribution of the LIS. They found that when properly normalized, the distribution is exactly the distribution of the largest eigenvalue of a certain family of random matrices. This was a surprising connection between two seemingly unrelated areas. Some of my research tries to understand the typical length, fluctuations and distribution of the LIS when the permutations are not uniformly random, but rather, come from a different distribution which gives more weight to permutations which have fewer pairs of numbers out of order. This work seems to hint that there may be a phase transition in the behavior of the LIS depending on how much we bias towards "well-ordered" permutations.

Multiscale Mathematical Modeling and Design Realization of Novel 2D Functional Materials

BY PETR PLECHAC



The research undertaken by the MURI collaboration project develops efficient and reliable multiscale methods to couple atomistic scales to the mesoscopic and the macroscopic continuum for layered heterostructures. Mathematical formulation and analysis is led by Mitchell Luskin (U. Minnesota) and Petr Plechac (U. Delaware), physics and engineering-based modeling is led by Tim Kaxiras (Harvard), Ellad Tadmor (U. Minnesota) and Hossein Mossallaei (Northeastern U.), while experimental discovery and model verification is conducted by Philip Kim (Harvard).

Layered heterostructures represent a dynamic new field of research that has emerged from recent advances in producing single atomic layers of semi-metals (graphene), insulators (boron nitride) and semiconductors (transition metal dichalcogenides). Combining the properties of these layers opens almost unlimited possibilities for novel devices with desirable, tailor-made electronic, optical, magnetic, thermal and mechanical properties. The vast range of possible choices requires theoretical and computational guidance of experimental searches; experimental discovery can in turn inform, refine and constrain the theoretical predictions.

The research project develops efficient and reliable strongly-linked multiscale methods for coupling several scales based on a rigorous mathematical basis. Specifically:

- The rigorous coupling of quantum to molecular mechanics will be achieved by properly taking into account the mathematics of aperiodic layered structures.
- The coupling of atomistic-to-continuum will be achieved by methods that can reach the length scales necessary to include long-range elastic effects while accurately resolving defect cores.
- New accelerated hybrid molecular simulation methods, specially tailored for the weakly interacting van der Waals heterostructures, will be developed that can reach the time scales necessary for synthesis and processing by chemical vapour deposition (CVD) or molecular beam epitaxy (MBE)

The simulations will be linked to macro and electromagnetic modelling to understand the physics and bridge to experimental investigation.

The challenge of modeling layered heterostructures will promote the development of strongly-linked multiscale models capable of handling many other materials systems with varied applications, including composites, meta-atoms (atomically engineered structures), and bio-materials.

NEW FACULTY

MOKSHAY MADIMAN

Mokshay Madiman has joined the department as an associate professor. He was educated at the Indian Institute of Technology, Bombay (B.Tech. in electrical engineering) and at Brown University (Sc.M. and Ph.D. in applied mathematics). From 2005 until moving to Delaware, he worked at the Department of Statistics at Yale University, first as a Gibbs Assistant Professor, then as an Assistant Professor and finally as an Associate Professor of Statistics and Applied Mathematics. He has been a semester—long visitor at the Tata Institute of Fundamental Research, Mumbai; the Indian Institute of Science, Bangalore; Princeton University; and IMA Minneapolis. He also holds a position as an adjunct professor of mathematics at the Tata Institute of Fundamental Research, India.

Mokshay's current research interests include aspects of information theory, statistical inference, high-dimensional probability, additive combinatorics, convex geometry, and semantics. He has particularly focused on developing the theory of information inequalities, which connects many of these seemingly disparate areas. He received a Faculty Early Career Development (CAREER) Award in 2011 from the National Science Foundation. For their ongoing research in semantics, he and his collaborators in the Department of Linguistics at Yale University have also received an INSPIRE grant from the National Science Foundation.

When not teaching or doing mathematics, Mokshay enjoys reading everything from science fiction to philosophy, and spending time with his delightful young daughters.

DOUGLAS RIZZOLO

Douglas Rizzolo received his PhD in Mathematics from the University of California, Berkeley in 2012 under the supervision of Jim Pitman. His dissertation focused on the asymptotic properties of random trees and their connections to Brownian motion. He is currently a postdoctoral researcher at the University of Washington.

Douglas's current research focuses on probability and stochastic processes with connections to combinatorics and statistical mechanics. A recurring theme in his work is the connection between the microscopic and macroscopic behavior of stochastic models. Recent projects have included studying the asymptotic properties of pattern-avoiding permutations and investigating the influence of an external field on a randomly reflecting particle.

DAWN BERK

Dawn Berk joined the department in Fall 2014 as the founding Director of the Mathematical Sciences Learning Laboratory (MSLL) and an Assistant Professor. She earned a Ph.D. in Mathematics Education and an M.S. in Mathematics from the University of New Hampshire. Before joining the department, she was an Assistant Professor in the School of Education at the University of Delaware.

Dawn's research interests focus on the teaching and learning of undergraduate mathematics. Her research involves designing and implementing instructional modules, testing their effects on students' learning, and then using data to refine the modules so that they are more effective. She also investigates approaches for supporting prospective and practicing teachers to teach mathematics more effectively. She is currently the PI on two grants from the National Science Foundation to investigate the effects of mathematics teacher preparation on teachers' mathematics knowledge, skills, and classroom practice. As the Director of MSLL, Dawn facilitates the work of a team of faculty to improve the teaching and learning in the foundational mathematics courses by employing an evidence-based, continuous improvement model to determine what works, what does not, and why.

In her spare time, Dawn enjoys spending time with her family, hiking with her dogs, playing and watching football and soccer, and renovating her home.

Conference Corner

Prof. Colton, the principal lecturer for NSF-CBMS Conference

NSF-CBMS CONFERENCE

The National Science Foundation awarded support for eight NSF-CBMS Regional Research Conferences in the Mathematical Sciences in 2014. These bring to 353 the total number of such conferences since the NSF-CBMS Regional Research Conference Series began in 1969. These conferences are intended to stimulate interest and activity in mathematical research. Each five day conference features a distinguished lecturer who delivers ten lectures on a topic of important current research in one sharply focused area of the mathematical sciences. The lecturer subsequently prepares an expository monograph based upon these lectures, which is normally published as a part of a regional conference series. Support for about 30 participants is provided and the conference organizer invites both established researchers and interested newcomers, including postdoctoral fellows and graduate students, to attend.

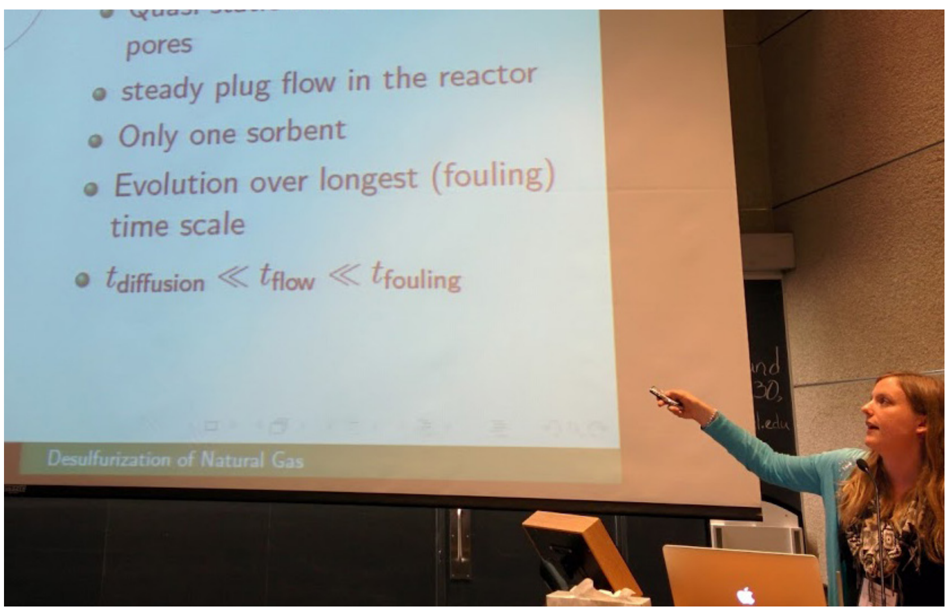
An NSF-CBMS Conference, with ten lectures by Prof. Colton, on "Inverse Scattering and Transmission Eigenvalues" was held on May 27-31, 2014, at the University of Texas at Arlington. Detailed information can be found at http://fermat.uta.edu/cbms2014.

WORKSHOP ON MATHEMATICAL PROBLEMS IN INDUSTRY

During June 2015, the Department hosted the week-long Workshop on Mathematical Problems in Industry (MPI) for the seventh time. At the workshop, representatives from Bloom Energy, Clypd, Corning, and Gore presented industrial problems that needed mathematical modeling and solution. The problems covered topics such as filtering sulfur from natural gas, flooding of porous media filters, the manufacture of thin glass for television screens, and assigning advertising slots to television programs. About 80 faculty, postdocs, and grad students worked on the various problems, presenting their work in a Friday session. The presenters were excited about the progress that was made, and plan on using the work at their individual companies. The local organizers, Profs. Rossi and Edwards, obtained a $5K NSF support for the event. More details about the workshop may be found at http://tinyurl.com/ns4q8dr.

UD SEMINAR ON STOCHASTIC PROCESSES

The Seminar on Stochastic Processes 2015, held at UD from April 1 to 4, 2015, was the latest incarnation of the most important regular conference series for probabilists in North America, held annually since 1981 and at UD for the second time. SSP 2015 featured the fifth annual Kai Lai Chung Lecture given by Michel Ledoux from the University of Toulouse, as well as 4 invited lectures



Workshop on Mathematical Problems in Industry, held June 2015

DelMar Numerics Day, 2015

by Maria Gordina (U Conn), Haya Kaspi (Technion), Lionel Levine (Cornell), and Brian Rider (Temple). The conference included a 3-hour tutorial by Ivan Corwin (Columbia/Institut Henri Poincare), a panel discussion to benefit junior researchers, a poster session with 5-minute advertisement talks by Ph.D. students and postdocs, and a session to remember the mathematical achievements and contributions of beloved UD faculty member and prominent probabilist Wenbo Li, who passed away in 2013. SSP 2015 was supported by NSF, the UD Department of Mathematical Sciences, and the Chung Fund (UC San Diego), and locally organized by Profs. Nayantara Bhatnagar, Mokshay Madiman, Petr Plechac and Douglas Rizzolo. The conference organizers obtained a $40K NSF support for this event. The conference website is at http://www.mathsci.udel.edu/events/conferences/ssp/Pages/default.aspx

DELMAR NUMERICS DAY 2014 AND 2015

DelMar Numerics Day is an annual workshop on computational mathematics organized by the Department of Mathematics of the University of Maryland at College Park and the Department of Mathematical Sciences of the University of Delaware (Profs. Petr Plechac and Francisco-Javier Sayas are the UD co-organizers). The workshop consists of 12 contributed talks and a keynote address. The third edition took place on Saturday, May 10, 2014, at the University of Maryland, Baltimore County (UMBC). The keynote speaker was Ragnar Winther from the University of Oslo. This year's DelMar Numerics Day took place in the U.S. Naval Academy at Annapolis, Maryland. The invited speaker was Soren Bartels from the

Winter Research Symposium

Albert-Ludwigs-Universitat Freiburg in Germany. This is an activity open to all researchers in the wide field of computational mathematics. The website of the conference is at http://delmar.math.umd.edu.

WINTER RESEARCH SYMPOSIUM 2014 AND 2015

Our 5th and 6th Winter Research Symposium were held during February 2014 and 2015 in Gore Hall 103 and the adjoining rotunda. It is a showcase of the research and scholarship of the Department of Mathematical Sciences organized by the graduate committee. In 2014, the event featured a guest lecture by our own Prof. Mokshay Madiman as well as a poster session and contributed talks by graduate students. Chris Castillo, Brooks Emerick, Isaac Harris, Zhenyu He, Aleksandr Kodess, Yan Song and Fan Yang exposed on a variety of topics ranging from ``Transmission eigenvalues and non-destructive testing of anisotropic magnetic materials with voids'' to ``Algebraic directed graphs''. More details can be found at https://https://sites.google.com/a/udel.edu/winter-research-symposium-2014/welcome.

For the 6th Winter Research Symposium the keynote talk was delivered by UD alumnus Keith Mellinger. The symposium included the presentation of the First Wenbo Li Scholarship for Graduate Research. For more information, visit the webpage https://sites.google.com/a/udel.edu/wrs2015/

Shixu Meng Selected as STEM Chateaubriand Fellowship Recipient

BY FIORALBA CAKONI

Shixu Meng, who is a fourth year graduate student, has been selected as a recipient of a 2014-2015 STEM Chateaubriand Fellowship offered by the Embassy of France in the US. The STEM Chateaubriand Fellowship program targets outstanding Ph.D. students enrolled in an American university who wish to conduct part of their doctoral research in a French laboratory. The fellows are selected through a merit-based competition. Shixu is spending January through August 2015 at the prestigious Ecole Polytechnique, Paris to pursue his research on inverse problems as part of the DeFI-INRIA team.

For ten years, the research group on Inverse Problems in the Department of Mathematical Sciences has been an international partner of INRIA, the French Institute for Research in Computer Science and Automation. This partnership, called the Project QUASI (Qualitative Approaches to Scattering and Inversion), is with the DEFI-team at Ecole Polytechnique lead by Prof. Houssem Haddar. Prof. Fioralba Cakoni was the representative of the University of Delaware group. The partnership has enabled reciprocal research visits at various levels for faculty and graduate students. In particular six graduate students from the University of Delaware Inverse Problems group, Q. Chen, F. Yang, I. Harris, S. Meng, J. Rezac, I. De Teresa Trueba, have conducted research at Ecole Polytechnique on a three-month summer research internship. This has been a transformative experience for these graduate students with long lasting effect in their future career. Unfortunately, this valuable international collaboration will end with Prof. Cakoni leaving UD. It is hoped that similar collaborative efforts can be established in the Mathematical Science Department at the University of Delaware in the not too distant future.

FEATURED GRADUATE STUDENTS

BROOKS EMERICK

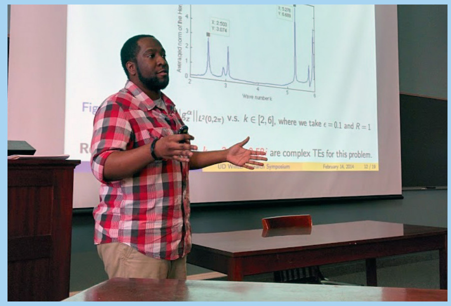
Brooks Emerick grew up in Hyndman, Pennsylvania, a small rural town of Bedford county. He graduated Summa Cum Laude with a Bachelor of Science degree in Applied Mathematics from Shippensburg University in May 2009.

As an undergraduate, Brooks worked with Dr.Luis Melara to study the classic endemic SIR model, a technique used to simulate the spread of infectious diseases, and its applications to a Rubella variant. This was a collaborative work with Dr.Alyssa Bumbaugh of the Biology Department and he wrote a senior thesis on the topic. In 2007, he worked with Dr.~Sean McCulloch during a summer REU opportunity at Ohio Wesleyan University to study the shared shortest path problem in digraphs. A paper detailing the heuristic algorithm posed to solve the problem appeared in the MCURCSM 2011 conference proceedings.

Brooks began his graduate studies at UD in 2009 and started working with Dr.Gilberto Schleiniger in the summer of 2011 on modeling cell populations in the human colonic crypt, a gland in the lining of the colon responsible for continuous epithelial cell renewal. His work focuses primarily on the biochemical processes within the cell that influence cellular proliferation at the tissue level. Specifically, he uses mass action kinetics and perturbation techniques to describe important intracellular interactions with the APC tumor suppressor gene. He also uses numerical simulation to describe normal and abnormal colonic processes, especially those related to the initiation of colorectal cancer. This work is collaborative and useful information is provided by Dr.Bruce Boman, a professor in the Department of Biological Sciences and oncologist at the Helen F.Graham Cancer Center. With help from the department, Brooks has presented his research at several conferences including the 2013 Society for Mathematical Biology annual conference in Tempe, AZ. Brooks greatly appreciates the support and guidance from both Gilberto Schleiniger and Bruce Boman on this project.

Aside from research, Brooks has enjoyed serving as the president of the student chapter of SIAM, coordinating the Hallenbeck Graduate Student Seminar, and working as a teaching assistant and course instructor. He is extremely grateful for this opportunity to teach as his career goal is to acquire a tenure track position at a college or university that values teaching. Brooks' passion for teaching earned him the Baxter-Sloyer Graduate Teaching Award in Spring 2011. Brooks also collaborates with Dr.Abhyudai Singh of the Electrical and Computer Engineering Department on a semi-discrete approach to model host-parasitoid dynamics, which lends an interesting opportunity for future mentoring of undergraduate research. Brooks plans to continue researching and teaching such topics in applied mathematics after graduation.

Beyond math, Brooks enjoys playing ultimate frisbee, long boarding down gentle slopes, and grilling thick steaks. He would like to thank his family, friends, and the department faculty and staff for their patience and support. Lastly, he would like to acknowledge the great friendship and invaluble discussion provided by his fellow graduate students.



ISAAC HARRIS

Isaac Harris graduated from Kean University Magna Cum Laude in the summer of 2010 and started his graduate studies here at the University of Delaware in the fall of 2010. As a graduate student he has been an advocate for his colleagues here at the University of Delaware. In the Department of Mathematical Sciences he has served as the SIAM Student Chapter President and the Student Representative on the Graduate Committee. For the 2013-2014 academic year Isaac was the coordinator for the Hallenbeck Graduate Student Seminar. He was also involved with the Graduate Student Government where he served as the Parliamentarian for the 2013-14 and 2014-15 academic years.

In the spring of 2012, Isaac received his M.S. in Applied Mathematics and continued his graduate studies under the advisement of Dr. Fioralba Cakoni. He has been working on inverse problems for partial differential equations that arise in acoustic and electromagnetic scattering. The goal of this work is to detect/reconstruct defective regions in an inhomogeneous anisotropic material. He has worked on extending the factorization method to reconstruct defects in anisotropic materials. He has also worked on using the so-called transmission eigenvalues to detect cavities. In the summer of 2013, Isaac visited Ecole Polytechnique in France where he worked with Dr. Houssem Haddar on the transmission eigenvalue problem for both isotropic and anisotropic periodic media. This work has lead to three papers, two of which were published in the journal "Inverse Problems" and the third accepted to the journal "Inverse Problems and Imaging" for publication. In 2015, the work in these papers were presented at the mid-Atlantic AMS Sectional Meeting at Georgetown University, the AMS Session on Inverse Problems at the Joint Math Meetings, the Department Colloquium at Kean University, and the Numerical Analysis Seminar at Texas A&M.

Outside of his services and research Isaac has taught a multitude of courses throughout his tenure at the University of Delaware. Isaac has been a Teaching Assistant and Instructor for Analytical Geometry & Calculus A/B as well as an Instructor for Pre-Calculus. In the winter of 2013 he ran the Analysis Prelim review session and for his efforts he received the Baxter-Sloyer Graduate Teaching Award in 2014 for his excellence in teaching. All of the above experiences have helped Isaac attain a Visiting Assistant Professor at Texas A&M starting in the fall of 2015.

LONGFEI LI

Longfei Li has been a graduate student at the University of Delaware in Applied Mathematics since August 2009. He is originally from Chengdu, the capital city of Sichuan Province in Southwest China, and the home of the panda and spicy Sichuan (Szechuan) food. Longfei had spent most of his time in Chengdu before college graduation. Even though it is said to be that once you have been to Chengdu, you won't want to leave, Longfei decided to leave the city and explore the exciting world after he received his BS degree in Mathematics from Sichuan University.

He came to Delaware following his fondness for mathematics. Since his first summer at UD, Longfei has been working with Dr. Richard Braun on formulating mathematical models for human tear film dynamics, which are then investigated by either perturbation or numerical methods. The underlying goal of his work is to theoretically explain phenomena that are experimentally observed, and provide predictions that are yet to be verified by any experiment. Moreover, he developed and analyzed several numerical methods to solve the governing system of nonlinear PDEs. A lot of his work involves collaborations. For example, he works with Dr. William D. Henshaw of RPI and Jeffrey W. Banks of LLNL on computational issues, and he collaborates with optometrist Dr. P. E. King- Smith of Ohio State University to compare the computed results with observations. He has presented his work at national and international conferences and has published the results in refereed journals. Their discoveries were reported by a press release to raise awareness among the general public and the media.

Longfei also spent about two months visiting the Institute for Mathematics and its Applications at the University of Minnesota in February and March 2014. It is from this visit that he had learned the true meaning of winter. Except for the lowest temperature he had ever experienced, Longfei enjoyed his stay at the IMA. He was so happy and grateful that his advisor Dr. Braun took him to several Chinese restaurants to try the authentic spicy Szechuan food in the Twin Cities. Somehow, Dr. Braun has developed a love of spicy food in Minnesota.

Aside from math, Longfei has served as the Vice President of the SIAM student chapter at UD. He likes watching movies and sports games in his spare time. He likes playing soccer and basketball, and he likes swimming, too. His current goal is to swim freestyle nonstop for 1000m.

Longfei loves the math department at UD very much. He feels sad because it's time for him to graduate and leave the department. He wants to take this opportunity to thank his parents, his wife, Xiaohan, and all his fellow graduate students, especially his officemates Brooks and Zhenyu, and his former roommate Lei, for their support and encouragement during graduate school. Most of all, he would like to thank Dr. Braun for his great support and guidance.

YAN SONG

Yan Song is originally from Qiqihar, a small city in northeast China. She completed her undergraduate studies at Jilin University (a top ten university in China) in May 2009 with a Bachelor of Information and Computational Sciences degree in Mathematics.

She focused on the field of applied mathematics, and won two prizes in the mathematical modeling competition during her four years' college study. One of her favorite professors encouraged her to go abroad to continue to study in the area of computational and applied mathematics. Thus, she decided to continue her studies at the University of Delaware to pursue a Ph.D. in applied mathematics.

In the summer of 2010, she decided to broaden her knowledge in the field of Direct and Inverse Acoustic Scattering problems. Under the supervision of

Dr. David Colton, Dr. Fioralba Cakoni, and Dr. Peter Monk, she learned some relevant theorems in this field and successfully obtained a theoretical proof and numerical evidence for identifying the radius and density of a two dimensional plate from a scattered signal. Meanwhile, she has taken the most advanced courses in the math department to gain a deeper understanding in the field of Probability and Stochastic Processes and prepare for future research opportunities.

In February 2011, she began working with Dr. Petr Plechac as a research assistant, studying pattern formation in many particle stochastic systems, especially the classic lattice-system of the Ising model. Under the supervision of Dr. Petr Plechac, She applied Markov Chain Monte Carlo method, more specifically the Metropolis-Hastings algorithm, to study and compare the equilibrium properties of pattern formation of stochastic lattice systems with competing short and long range interactions represented by different control parameters. She discovered different parameter regimes and constructed phase diagrams in spin flip dynamics with an external field. Furthermore, she exploited the coarse-graining algorithms, and applied Nonlinear Laplacian Spectral Analysis (NLSA), in order to obtain the main characteristics of the equilibrium of the stochastic lattice models. Meanwhile, she attended several summer school programs to broaden her perspective in the field of stochastic lattice dynamics, and shared her latest work with peers. Aside from research, Yan has also served as the GSS senator at University of Delaware in 2011, and shared opinions toward the benefits and lives of the Graduate Students.

In her personal life, Yan enjoys dancing, and has performed at the Chinese Spring Festival Gala several times. She also loves going to the gym, especially running and zumba. Besides sports, Yan also loves reading and watching movies. Her motto is "Tomorrow is anther day", coming from the famous movie, \emph{Gone With The Wind}. Yan greatly appreciates the support and guidance from Dr Plechac throughout her graduate studies, and is especially grateful for the opportunities and support from the department. Yan also would like to thank all the other faculty and staff in the department for their tremendous help through the past five years.

YU SUN

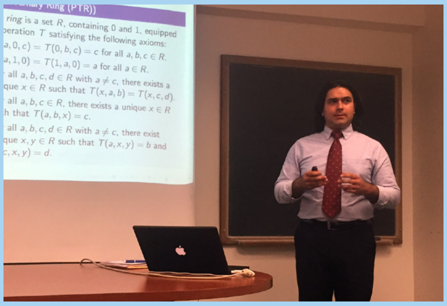
Yu Sun grew up in Shenyang, a northeastern city in China and did her undergraduate work at nearby Dalian University of Technology. She majored in Mathematics with a focus on its computational aspects. After receiving her Bachelor of Science degree in June 2010, she became a graduate student in the Department of Mathematical Sciences at the University of Delaware.

The UD Groups Exploring the Mathematical Sciences (GEMS) program, a program that is open to first year graduate students, determined her to focus on research about large swarms with covert leaders. Swarming dynamics studies the collective behaviors of a group of agents interacting with each other without a central control. Under the supervision of her advisor Prof. Louis Rossi, she has successfully constructed a model to describe the dynamics of a large swarm with covert leaders. With her model, she analyzed properties such as the stability of the system, the behavior of the swarm with the presence of a multiple leaders with different goals and techniques for identifying covert leaders in swarms. She has presented her results at two international conferences.

During her graduate studies at UD, Yu has participated in several workshops, modeling camps, and summer schools. The intense "Collective Behavior Summer School" held in Sweden was very beneficial for her research in this field and has broadened her knowledge about the applications of her research. The workshops and the modeling camps held by UD, RPI, and IMA gave her the opportunity to apply mathematics to solve real life problems. These experiences and her interest in real life problems helped Yu decide to pursue a career in industry.

Outside of research, Yu has enjoyed her life at UD by traveling, drawing, and playing a variety of sports including bocce, a department tradition.

Yu is grateful to her advisor, Dr. Rossi, for his guidance, support, and education. Yu would also like to thank the department faculty and staff for their generous help.



CHRIS CASTILLO

Chris Castillo grew up in Baltimore, Maryland and graduated from Towson University in May 2008 with a bachelor's degree in mathematics and a minor in music performance on tuba. While at Towson, he spent two years working in the Applied Mathematics Laboratory developing crime mapping algorithms and software to aid law enforcement in locating serial criminals. After working for the Boy Scouts of America in Baltimore, Chris arrived at UD in September 2009. In the years since, he has taught Discrete Mathematics (Math 210) several times and all of the courses in the Calculus sequence.

His research focuses on permutation polynomials over finite fields, under the supervision of Prof. Robert Coulter. Using interpolation, he developed a method for constructing groups of permutation polynomials over finite fields. Not only did this method lead to discovering new families of permutation polynomials, but the underlying representation theory shows that there is some amount of structure inherent in the permutation polynomials that are produced. As an application, he generalized the construction method to produce bivariate polynomials which can be used to coordinatize certain finite projective planes.

Beyond mathematics, Chris was very active with the Graduate Student Government (GSG) at UD, serving as the Senator representing the mathematics program, as Secretary for the 2011-2013 academic years, and as President from December 2013 through May 2015. GSG is an organization that focuses on programming for and advocacy on behalf of the graduate student community. Programming included the annual Graduate Research Forum, GSG's flagship event, a one-day conference each spring where graduate students from across the university share their research, in addition to many formal and informal social and networking opportunities at The Speakeasy, a graduate student and faculty pub, located in the basement of 44 Kent Way. On the advocacy side, he worked very closely with the Office of Graduate and Professional Education, served on the Faculty Senate and the Graduate Studies Committee, wrote the graduate education planks of Delaware Will Shine (UD's new strategic plan), and worked to combat sexual violence on campus as a member of the Faculty Senate's Commission on Sexual Assault and Harassment.

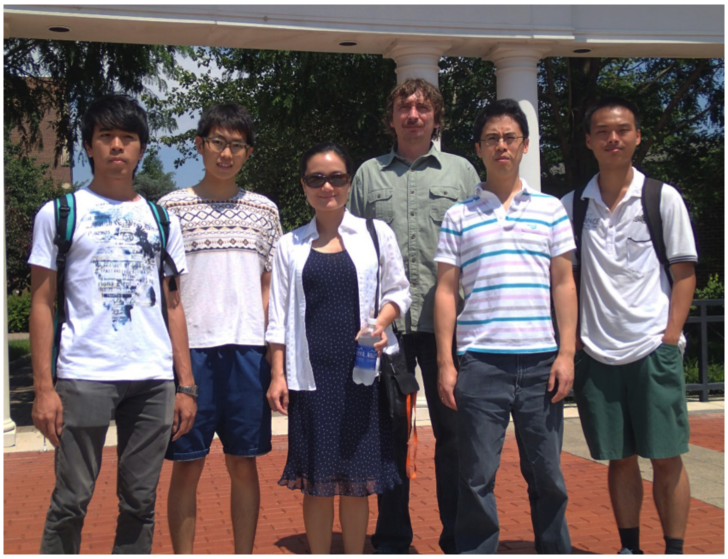
Outside of UD, Chris remains active with the Boy Scouts in Baltimore through various youth and adult leadership training courses as both a staff member and organizer.

My Research Experience at UD

BY HAORAN TANG

Thanks to the support from my department, I was able to participate in a summer research project in Department of Mathematical Sciences, University of Delaware. The project lasted for 2 months and it was more rewarding than any regular course I took before.

My mentor, Prof. Plechac, guided me through the process of identifying, planning, studying and presenting a geometry problem in applied math. It was a variant of a classical problem, but with more challenging features. We had a very clever idea at first, but we could not make a breakthrough without carefulness and patience. It took us a month to fix a small mistake and to get reasonable outputs from the program I wrote.



All participating CUHK students and UDel professors. From the left: Wai-Yip Chan, Weining Xin, Prof. M. Y. Ou, Prof. P. Plechac, Prof. P-W Fok, Haoran Tang.

The outputs were exciting, but still far from what we want. We spent another month approaching the desired result, until the available computing power was almost exhausted.

During the process, Prof. Plechac gave me very useful advice and encouragement. His friend Prof. Jiri Matousek (of ETH Zurich and Charles University Prague) provided insightful methods to tackle the problem. And I was fortunate to be helpful on the programming side. It was the first time I realized that math research required close cooperation.

I would like to thank Prof. Plechac and other UDel professors who gave CUHK students the chance to perform real research. I also suggest that undergraduates interested in science participate in a summer project. The experience could be more interesting than you expected.

Alumni Updates & Achievements

OUR UNDERGRADUATES GO ON TO A VARIETY OF CAREERS AFTER EARNING THEIR DEGREE WITH US. WE CONTACTED A SMALL SELECTION OF RECENT GRADUATES TO FIND OUT WHAT THEY ARE DOING, AND HOW WE HELPED THEM PREPARE FOR THEIR JOB. HERE ARE THEIR ANSWERS (LIGHTLY EDITED!)

CATHERINE MONK

Graduated in 2012. She took advantage of the Dean's Scholar program to design her own degree in ``Mathematics and Finance'' ultimately graduating with a B.S. from our department.

How would you describe your current job?

I currently work for BNP Paribas on the Short-term interest rate trading desk. Our desk trades short dated US government treasury notes and bills and repurchase agreements for US treasuries, US agency debt, and mortgage backed securities. Our basic responsibilities are to provide liquidity for our clients, and facilitate flows as a financial intermediary. We also are in charge of the funding needs for US rates trading, and must manage and hedge the risks for the desk.

How does math help you at your job and how much math do you do in your job?

Math is deeply important to the financial industry. All of the theoretical models for movements of stocks and bonds are based off of stochastic calculus and random paths. A solid foundation of probability and calculus are necessary for understanding these models.

We also use a lot of regression techniques in my job to establish patterns and decide the optimal trading strategy. We use basic regression as well as time series and machine learning to help make trading decisions for the desk.

Any other information you would like to include about your past and current achievements and time at the University?

I was a math and finance major at UD, and this was integral to help me get into Carnegie Mellon to pursue a dual Masters in Computational Finance (MSCF) and MBA. Within the MSCF program, UD gave me a great foundation in both Math and Finance to help me excel in the program. Some of the classes that especially helped me were advanced calculus, basic probability and statistics, and the matlab based classes. It was excellent to be able to start the program with a well rounded background in math and computing, and it helped me to develop my knowledge of quantitative finance.

Professor Gilberto Schleinger was a major reason that I was able to complete my two degrees, and was a strong advocate for me. He was an amazing adviser and I wouldn't be here without him!

> UD gave me a great foundation in both Math and Finance to help me excel.

PATRICK DEVLIN

Patrick graduated UD in Winter 2010 with a BS and MS after just five semesters.

How would you describe your current job?

Following graduation from UD, I was accepted for math graduate work at Rutgers University, where I am currently finishing my fourth year as a PhD student. I expect to remain at Rutgers for another one or two years before graduating with my doctorate. I am studying discrete mathematics at Rutgers University under my advisor Jeff Kahn, and I am exceedingly happy to be doing so. My plan is to pursue a career as a math professor.

How did the University of Delaware and the Mathematics Department help you to get where you are now?

It helped a lot. Obviously, I wouldn't have been able to get into graduate school without the instruction, mentorship, and support from the UD math department. There are really too many people and friends to mention, but

> The department was extremely creative and dedicated in all the many ways they helped.

allow me a poor attempt.

- **Influence from Wenbo Li**
  The most important influence on me as a mathematician at UD was the mentorship and encouragement I received. This came most notably through Wenbo Li, whom I was extremely fortunate to know. Even though I was just a know-nothing freshman, Wenbo agreed to mentor me through many undergraduate research projects. He then encouraged me to apply for the prestigious Goldwater scholarship, which---with his help---I won. He gave me academic advice encouraging me to pursue my studies diligently and reach for goals beyond myself, and with his support I was able to graduate from UD after only five semesters and because of all the graduate-level courses I had taken, I was simultaneously awarded a master's degree as well.

  More than that, Wenbo has taught me how to think like a researcher and given me a wonderful example of a teacher. I'm certain I will always remember the looks of joy on his face when he was proud of me, and he is surely missed.

- **Becoming a "mathematician"**
  I remember taking the UD 'perspectives on math course'. One day Professor Lazebnik was invited to talk about pursuing a career as a pure mathematician. This was the first time I had ever seen him, and I remember sitting in that room and listening to this man with a soft voice and funny foreign accent.

  He spoke quietly in front of the class, and I can still remember nearly everything he said that day. At on point, he cut himself off saying, "by the way, I notice in this country that mathematics students are very hesitant to call themselves mathematicians. They believe that to be a mathematician you need to have some job at a university, and even then maybe not yet. This is such a strange concept to me because when I was growing up, my friends and I would meet together and discuss various mathematical problems and ideas; and even then, we called ourselves mathematicians. And that's what a mathematician is: a person who loves and enjoys mathematics. And so, right now you are all mathematicians—and you can call yourselves that—as long as you love and enjoy doing mathematics."

  That was a very formative moment for me, and at that point, I felt indoctrinated into this ancient and lasting community of mathematicians.

- **UD discrete math group**
  The members of the UD discrete math group were also highly influential on me—professors Lazebnik, Ebert (since retired), Cioaba, Xiang, and Coulter. Their weekly undoubtedly sparked my interest in discrete math, which will be the topic of my doctoral dissertation.

  Gary Ebert was also quite influential, and in many office hour visits and the like, he helped introduce me to many wonderful worlds of abstraction.

  David Bellamy is unique to say the least, but boy was he helpful to me. Like Socrates, Bellamy was a wonderful gadfly, which I mean in the best possible sense. He really helped me develop a view that doing mathematics is like an adventure into the unknown. By rarely (if ever) telling students if a statement is true or false, he developed the skill of viewing a problem from both ends at the same time [not knowing which is correct], which is indispensable as a researcher. This sort of approach is one that I strive to incorporate into my teaching style.

- **The department as a whole**
  It was really fantastic to have the support and help from the various administrative and organizational people in the department. I recall many emails to Dr. Pelesko (then director of the graduate program) with special permission requests and the like, and everyone was so open-minded and accommodating. Ultimately, I was able to graduate in just five semesters at UD, and when I graduated I simultaneously earned a master's degree. Neither of these features represent the "typical" academic plan, but the department was extremely creative and dedicated in all the many ways they helped.

ROBERT SHEEHAN

Robert graduated in 2011 with a B.S. in ``Quantitative Biology'' from our department.

How would you describe your current job?

I am currently a graduate student pursuing my PhD in Computational Biology in the Carnegie Mellon - University of Pittsburgh Joint Program in Computational Biology. I work in the lab of Dr. James Faeder in the Department of Computational and Systems Biology at Pitt, where I work on building mathematical models of cell signaling systems. I have two current collaborations, working with Dr. Sarah

Gaffen in the Department of Medicine, Division of Rheumatology and Clinical Immunology and Dr. Penelope Morel in the Department of Immunology at Pitt, where we are working on modeling the IL-17 receptor and T cell receptor signaling pathways, respectively. These collaborations have allowed me to combine wet lab experimental work with mathematical modeling to explore new biological hypotheses.

How does math help you at your job and how much math do you do in your job?

I work on ordinary differential equation models of our systems of interest, calibrating them using Bayesian parameter estimation techniques. This require a strong background in math to build and troubleshoot the models, and to analyze their behavior. I spend roughly ¾ of my time working on these models, with the remaining ¼ dedicated to experimental work. This modeling time requires reading literature in computational biology and related fields, writing code, and doing analysis, all skills that require a strong grounding in math which I started developing in the Mathematics Department at Delaware.

How did the University of Delaware and the Mathematics Department help you to get where you are now?

Completing my degree in Quantitative Biology within the Mathematics Department was hugely important in shaping my academic interests and landing me in my current PhD program. I was able to develop a strong background in differential equations and statistics, which is now critical to my modeling work, while also being free to pursue undergraduate research in biology, allowing me to merge my interests and develop a unique and marketable skill set. Receiving a thorough introduction in mathematical modeling through the Introduction to Systems Biology course (MATH460), led by Dr. Prasad Dhurjati and Dr. Gilberto Schleiniger, both sparked my first interest in pursuing my current career path, and perfectly prepared me for it.

In terms of achievements, I recently had two publications accepted.

MICHAEL TAIT

Michael graduated in 2011 with a BS in mathematics.

How would you describe your current job?

I am currently a graduate student in the math department at UC San Diego. I will finish my degree next year. I would say that my job consists mostly of doing research, teaching undergraduates, and traveling to conferences. My area of study is extremal combinatorics.

> The math department at the University of Delaware played a huge part in getting me to where I am right now.

As a math graduate student, of course, I spend lots of time doing math! I would say 95% of my working hours are spent on mathematics (everything besides some administrative things that have to get done).

How did the University of Delaware and the Mathematics Department help you to get where you are now?

The math department at the University of Delaware played a huge part in getting me to where I am right now. I started doing research as an undergraduate at Delaware with Felix Lazebnik and Sebastian Cioaba, and Sebi became my advisor when I continued at UD to do my M. Sc. Felix is an expert in extremal graph theory and Sebi is an expert in spectral graph theory, and my current research is very strongly influenced by both of them. The tools that they taught me have been invaluable. In addition, both of them have worked with my current advisor at UCSD, and so they were each able to give me a strong, personal letter of recommendation that helped me get into the program.

Any other information you would like to include about your past and current achievements and time at the University?

I'd just like to encourage the math majors at UD to start exploring research as soon as possible. Many of the faculty are happy to work with undergraduates and it is an experience that I feel really helped my career. I'd also like to give a shout out to all the grad students who I spent one year with at Delaware.

Patricia Miller Overdeer: An Educator and Alumna

BY FELIX LAZEBNIK

In March 2015 I met with a distinguished alumna of our department, Mrs. Patricia Miller Overdeer, who asked me to address her just as Pat, ``as that is what everyone calls me". I very much enjoyed the conversation and wish to share what I learned.

Born in California, Mrs. Overdeer (maiden name Miller) crossed the country five times before she was six years old to visit grandparents in Pennsylvania. Eventually her family moved back East. Pat grew up in a 'science oriented household', as she put it. Her father was an electrical engineer and her brother was a short-wave radio operator. Her grandmother graduated from Swarthmore in 1885, majoring in Elocution. There was never any question about her going to college.

In 1940 Mrs. Overdeer began studying at West Chester University, but when her family moved to Montclair, New Jersey, she transferred to Montclair State University, graduating in 1943 with a B.A. in Education. She majored in Science with a minor in Mathematics. She remembers "too many labs" in her Chemistry courses.

After teaching in Public school for a year she married Earl Spraberry and had a son, Lynn. Mr. Spraberry was killed during World War II. Mrs. Overdeer then decided to return to school for a graduate degree. She applied to several graduate schools and was excited when in June 1945 she was admitted to the University of Delaware by Dr. Carl Rees, the head of the Mathematics Department. She remembers with gratitude that Carl and Eleanor Rees invited her to dinner. ``Eleanor found a wonderful woman" who took care of Pat's son Lynn on a farm very close to town. The first summer session Mrs. Overdeer took Calculus I with Dr.

Rees as instructor (she never took Calculus for her B.A.). In the second session she took Calculus II and III concurrently. That fall with the ending of WWII, many veterans arrived on campus. Mrs. Overdeer and the two other graduate students, Harry Smith and Carl Nelson, became teaching assistants. The Mathematics Department was located in Hullihen Hall and the library was in Memorial Hall which was the division between the Men's College to the North and the Women's College to the South. It was about that time that the two colleges were combined as one University. The football games were played at a stadium in Wilmington. Pat took several courses with Dr. G. Cuthbert Webber who became her Master thesis advisor. She graduated in 1949 with an M.A. and her thesis was titled ``On the non-existence of odd perfect numbers of the form $N=\rho^{\alpha}\rho^{2/1}\rho^{2/2}\cdots\rho^{2/r}q^{4/1}q^{4/2}$, and was based on the work of L.E. Dikson and G.C. Webber. (The existence of odd perfect numbers is still an open problem). The only other name of the faculty she remembers is that of Dr. Truman Botts.

After graduation she was accepted by the University of West Virginia for a Ph.D. program in Mathematics. Instead she chose to marry Robert Overdeer who had been a student in the first class she had taught. He graduated from the University of Delaware in 1950 with a B.S. in Engineering and went on to Lehigh University for a Masters in Engineering. He was employed by the Philco Corp. in Philadelphia. The family moved first to Elkins Park, PA and, finally in 1955 settled in Jenkintown, PA. Their three children Lynn, Nancy and Louise graduated from Jenkintown High School.

From one of her bridge partners she learned about an open position in Mathematics at a nearby college and she decided to apply. ``That is how I came to Penn State". Mrs. Overdeer began teaching at the Pennsylvania State University in Abington, PA, a suburb of Philadelphia, in 1956. The campus had about 400 students, some of whom were older veterans just back from service in the Army and Navy. ``That was a delightful group of students, though having three children, often I had to stay up until 3am preparing for my classes." After five years she shifted to administration and served half time as Dean of Women and Admissions Counselor. ``But I found that I preferred teaching" and she returned to full time teaching. She regularly went to the University Park campus as a Senator representing the campus in the University Senate. During this period she served as Secretary and then Vice President of the University Senate. She also served on the University Council and on the University Promotion and Tenure committee. There were regular meetings with the Mathematics Department. ``I think students should enjoy the learning process but this does not mean that a teacher has to make everything fun. You have to challenge your classes. Your own enthusiasm for your subject is an extremely important factor." One of her students said, with appreciation, that ``she was the first instructor who admitted in class if she made a mistake." In 1973 Mrs. Overdeer was named the recipient of the Ogontz Campus Award for Outstanding Teaching. Around 1979 she took nine credits towards a Master Degree in the Computer Science Department at Villanova University. One of her instructors was a member of the team which worked on the ENIAC at the University of Pennsylvania. Along with the teaching, Pat supported programs for young girls to encourage them to get interested in Science and Math. ``This is now called the STEM program". She also spoke to high school classes on Escher's work and showed them how to make repeated patterns using simple translations. Mrs. Overdeer taught until her retirement in 1983 as a Professor Emerita. That year she was the Campus Commencement speaker and was able to hand her daughter, Louise, her diploma.

After retiring from teaching, Mrs. Overdeer worked briefly in the computer section of a local book store. Then she volunteered at the Franklin Institute in Philadelphia, supporting its computer program for kids. This was followed by volunteering with the Red Cross, supporting a computer program tracking the activity of volunteers. She served on the Jenkintown School board for 13 years. At present, Pat is in a book club, volunteers at the local library and enjoys spending time with her four grandchildren and one great grandchild.

Mrs. Overdeer says she will always appreciate the fine training she received at the University of Delaware and those that made it possible, as it provided her with a very rewarding career. She has been a loyal donor to the Department of Mathematical Sciences, and we are grateful for her support.

Faculty Grants Received Since Fall 2013

PI / CO-PI	AGENCY	TITLE	AMOUNT/ DURATION
Colton/Cakoni, Monk	AFOSR	*New Directions in the Qualitative Approach to Inverse Scattering Theory*	$841K / 3Y
Katugampola	DOD	*Can fractional order models do more justice to anomalous Behavior than Familiar Classical Order Models do?*	$300K / 4Y
Plechac	DOD	*UMN/ DOD MURI: multi-scale mathematical modeling and design realization of novel 2d functional materials.*	$950K / 5Y
Plechac/Vlachos	DOE	*Mathematical Foundations for Uncertainty Quantification in Materials Design*	$901K / 3Y
Pelesko, Manon	DOEd	*Delaware K-12 Mathematics Partnership Project*	$1.1M / 2Y
Driscoll/ Schleiniger	NIH	*Delaware INBRE I: Data Driven Mathematical Modeling of the Hypoplastic Left Heart Syndrome*	$44K / 1Y
Driscoll/ Schleiniger	NIH	*Delaware INBRE II: Data Driven Mathematical Modeling of the Hypoplastic Left Heart Syndrome*	$66K / 2Y
Cioaba	NSA	*Young Investigator: Problems in Algebraic and Extremal Graph Theory*	$40K / 2Y
Bacuta	NSF	*Advances in Multilevel Methods for Saddle Point Problems*	$150K / 3Y
Berk/Hiebert	NSF	*Understanding the Effects of Mathematics Teacher Preparation on the Quality of Classroom Teaching and Students' Learning*	$1M / 3Y
Braun/ Driscoll	NSF	*Collaborative research: Tear film dynamics: modeling, blinking and computation*	$385K /3Y
Cakoni	NSF	*New Directions in the Qualitative Approach to Inverse Scattering Theory*	$220K / 3Y
Cirillo	NSF	*Career: Proof in secondary classrooms: decomposing a central mathematical practice*	$874K / 5Y
Cook/Andreasen, Doty, Sawyer	NSF	*ADVANCE Institutional Transformation*	$3.3 M/ 5Y
Edwards / Zhuang	NSF	*Optimizing Biosensor Measurements for Multicomponent Reactions*	$250K / 3Y
Flores/ Park, Shipman	NSF	*Integrated Science and Mathematics Education: A Model Course for Pre-Service Teachers*	$200K / 4Y
Madiman	NSF	*Career: An integrated probabilistic approach to discrete and continuous extremal problems via information theory*	$393K / 3Y
Ou	NSF	*Inverse problems for poro-elastic composites with applications in bone health monitoring*	$207K / 3Y
Rakesh	NSF	*Inverse Problems For Hyperbolic PDEs*	$88K / 3Y
Rossi/Edwards	NSF	*Expanding Links with Industry through Collaborative Research and Education in Applied Mathematics*	$74K / 3Y
Bhatnagar	SLOAN	*Fluctuations of longest increasing subsequences in random permutations and reconstruction in in trees and random graphs*	$50K / 2Y
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