

Welcome from the Chair

Greetings and welcome back for another exciting academic year in the Department of Mathematics. 2018-2019 was a great year for us, with some impressive student and faculty accomplishments. We had three students successfully defend their honors theses, all of whom spent a year working on their research with faculty members. We had a large number of student presentations at conferences, and we even hosted our own conference at UMW with the regional MAA group. This past summer we had a new crop of students begin their research experience in the Jepson Summer Science Institute. You can read more about these people and events in the following pages.

We've also got some new additions to the curriculum taking effect this year. For one, we now have the minor in applied statistics, designed to give a solid foundation including upper-level statistics courses while also allowing for an interdisciplinary approach. We have one new course, MATH 253: Introduction to Cryptography, which supports the new major in Cybersecurity in the Department of Computer Science. This year we will be investing much time thinking about how our courses will fit into the new general education framework, scheduled to take effect in Fall 2020.

In addition to our usual offerings, we have some great elective choices planned for the spring schedule of courses. Of note, Debra Hydorn will run another section of her Problems in Industry course (MATH 361A). This course pairs groups of student researchers with external industry partners to work on real-life, relevant math and statistics problems. We will also offer Melody Denhere's course in Applied Regression Analysis (STAT 320), and Julius Esunge will give his course in the Theory of Interest (MATH 481). And don't forget, you can always craft your own independent study (MATH 491) in the topic of your choice by working one-on-one with a faculty sponsor.

We are also in the midst of planning all of our usual events for the year. This includes our fall and spring colloquium series, career night, our spring alum visitor, and our annual departmental honors defenses. These events are always interesting and a fun time, so don't be shy about coming out and networking a little. Best wishes for a fun and productive year, and don't hesitate to get in touch if you ever have any questions or great ideas.

Randall Helmstutler
Chair, UMW Department of Mathematics

Jepson SSI

Hannah Frederick worked with **Dr. Randall Helmstutler** on a research project in the area of non-commutative cryptography. In her project, Hannah devised a method of altering the well-known "suitcase with two locks" scheme so that it could be implemented with a non-abelian group of matrices. Hannah designed a way for such a scheme to work using the group of invertible matrices over a finite field, using her new method as a key exchange protocol for the Hill cipher. In order to adapt this new idea to this group of matrices, Hannah had to prove many results about the ring of circulant matrices, and she performed experimental computations to test and confirm her conjectures (and eventually prove them). Hannah won the first place award in the presentation category at the Jepson Summer Science Symposium, and she looks forward to presenting her work at external conferences this coming year.

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Jepson SSI continued

In her SSI project, **Makayla Ferrell** considered the dynamics of the Human Immunodeficiency Virus (HIV). She used both analytical and computational methods to investigate her model under the direction of **Dr. Leo Lee**. Specifically, she derived analytical solutions of some simplified versions of the model, and applied four different numerical schemes to approximate solutions to the model. Her analysis provided an interpretative diagram of how healthy cells react to HIV and how HIV spreads without treatment.

Ashley Scurlock and **Isabella Gransbury** worked with **Dr. Jeb Collins** on two separate projects this summer. Ashley investigated the properties of non-commutative number systems. In particular, she examined quaternions, a non-commutative generalization of the real and complex numbers that is four-dimensional. Ashley explored how some of the well-known functions and identities change when commutativity is taken away. She also examined an anti-commutative version of Pascal's triangle and proved a relationship to the original Pascal's triangle. Isabella's work involved solving differential equations using Bertini, a software package used to solve systems of polynomial equations. Isabella considered approximating a nonlinear boundary value problem with the finite element method with linear elements, and then solving the resulting polynomial system with Bertini. She then expanded the work by developing a similar procedure for quadratic elements, for which the complexity of the polynomial system is significantly increased. She tested each of these algorithms and compared their results to determine which is more effective.

UMW Hosts Regional MAA Meeting

Your probability of running into a mathematician on campus was significantly higher than usual November 2-3, 2018. The math department hosted the fall meeting of the Maryland-DC-Virginia section of the Mathematical Association of America (MAA), bringing 125 faculty and students from regional colleges and universities to campus. Meeting highlights included invited addresses "A mathematical art gallery tour" by Eve Torrence of Randolph-Macon College, "How much is too much? Axiom systems and reverse mathematics" by Kira Hamman of Penn State Mont Alto, and "Unexpected Zetas!" by Dominic Lanphier of Western Kentucky University. The meeting also featured contributed talks, including talks by UMW math majors **Riley Anderson** and **Makenzie Clower**. Riley presented "Implementing machine learning to improve Bertini 2.0" and Makenzie presented "Predicting parameters

for Bertini using neural networks." Both presentations were based on work done for honors projects, which you can read more about in this newsletter.

Honors Projects



Emily MacIndoe completed a thesis project under the guidance of **Dr. Leo Lee**, applying the Susceptible-Infected-Virus (SIV) model to the Human Immunodeficiency Virus (HIV). In her honors thesis, she presented analytical solutions to two different deterministic models providing exact results. Then she applied numerical methods to both

deterministic and stochastic systems giving computational results. The results of her honors thesis were adapted into a research article and eventually published in the refereed *SIAM Undergraduate Research Online journal*, which is known for its very high standards.

Riley Anderson completed a departmental honors thesis this past year working with **Dr. Jeb Collins**. The title of her thesis was "Improving Bertini 2.0: Classifying Singular Polynomials with Machine Learning". For her thesis, Riley considered the question of whether a polynomial can be determined to be singular or nonsingular, that is whether or not it has a double root, based solely on its coefficients. The answer to this question can be useful in increasing the speed of a software package called Bertini, which is used to determine an approximate solution of a polynomial system. Riley used machine learning algorithms, in particular a neural network, to classify a polynomial as singular or nonsingular. This required her to first generate a data set of polynomials for which the classification is known. She then used a program called TensorFlow, developed by Google, to generate a neural network that could be trained on her data set. She also developed her own type of neural network that was specifically designed to solve this classification problem. This network was again tested on a set of polynomials

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Honors Projects continued

and found to offer better performance in certain situations. Riley currently works for the Department of Defense.

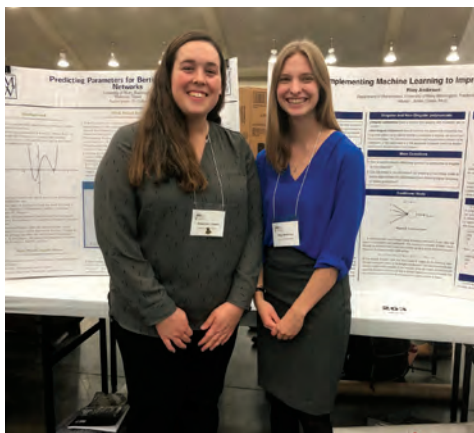
Makenzie Clower also worked with **Dr. Collins** on an honors thesis this past year. The title of her thesis is “Predicting Parameters for Bertini Using Neural Networks”. Bertini uses a homotopy continuation technique to approximate solutions to a polynomial system. Bertini uses many user-defined parameters and each can be used to fine tune the various aspects of the homotopy continuation method. Makenzie used machine learning algorithms to attempt to automatically choose the correct value for these parameters for any given polynomial, based solely on the coefficients of that polynomial. She learned how to use Bertini to generate a data set of polynomials for which the optimal parameter settings are known. This data set was then used in the machine learning algorithm to develop a neural network that could predict optimal parameter settings. Makenzie currently works at the Naval Surface Warfare Center-Dahlgren Division as a Software Test Engineer.

Darden Awards



For the first time in anyone’s memory, two mathematics majors won the Colgate W. Darden award at this year’s graduation ceremony. The Darden award is given to the graduating senior(s) with the highest cumulative GPA, and this year mathematics majors **Emily MacIndoe** and **Hollis Pultz** won the award. Not only did Emily and Hollis both finish with 4.0 GPAs, they are both double majors: Emily with Physics, and Hollis with Computer Science. And, coincidentally, both Emily and Hollis have taken positions at the Naval Surface Warfare Center-Dahlgren Division. Congrats to Emily and Hollis on their achievements!

Student Travel



In October 2018, three students traveled to James Madison University for the Shenandoah Undergraduate Mathematics & Statistics (SUMS) conference to present research from their 2018 SSI projects.

Riley Anderson

presented a talk on her work while **Makenzie Clower** and **Amy Creel** gave poster presentations.

Riley and Makenzie also attended the Joint Mathematics Meetings in Baltimore, MD in January 2019. Both students gave poster presentations and Riley also presented a talk on her work. In addition, they competed in and won Radical Dash, a competition for undergraduate students at the conference.

A Mathematical Summer

by Paige Beidelman

This summer has been full of new experiences, amazing people, and of course math! I spent half my summer participating in a prep research opportunities for undergraduate students (PREU) at Clemson University and the other half



traveling to Hungary, observing mathematical teaching methods. My research at Clemson involved studying the solvability of networks with interference sending messages. Many of the ideas related to these networks stem from graph theory, abstract algebra, and linear algebra. While the results overall were negligible, the experience of waking up every day to work through problems, ask new questions, and explore different concepts in the field of mathematics was exciting. There were twelve other students participating in math research at Clemson as well as graduate assistants, who guided us through the research. Clemson and the PREU program was essential in my journey to discovering the importance of math.



Hungarians believe mathematics is very important, but they also believe it to be a very creative subject full of problem solving and abstract thinking. For six weeks, I participated in the Budapest Semester in Mathematics Education (BSME), where I took math and education classes as well as observed a middle school math camp for advanced students. In the camp, math topics were taught through a series of riddles and problems. This method of teaching students to think like a mathematician by exploring and posing new questions is called the Pósa Method. Many famous mathematicians are from Hungary because schools teach multiple math concepts at once and make connections between the different concepts. In addition to the mathematical work, I was able to travel around Hungary, Slovakia, and Austria. I was able to climb the highest mountain in Hungary, crawl through the hidden caves under the city, and swim in the numerous hot spring baths. I learned enough of the language to buy fresh peaches and paprika at the open markets, say good morning to the neighbors of my flat, and get a ticket for the villamos. There was always something to do in the city, but the countryside was peaceful and beautiful with fields and fields of sunflowers. Hungary was a wonderful place to dive into the importance of mathematics!

Faculty Notes

Yuan-Jen Chiang had two research articles published including “Equivariant Biharmonic Maps between Manifolds with Metrics of Signature” in the Journal of Geometry by Springer. She also delivered a presentation, “Exponentially Harmonic Maps between Surfaces”, at the Joint International Meeting of the American Mathematical Society and Vietnam Math Society in Quy Nhon, Vietnam.

Jeb Collins was elected At-Large Executive Committee Member for the Maryland-DC-Virginia MAA section. He also organized a minicourse on mastery grading at MathFest in Cincinnati, OH.

Julius Esunge was invited to the 39th Infinite Dimensional Analysis and Quantum Probability Conference in Levico Terme, Italy in October 2018. He also organized a special session at the January 2019 Joint Math Meetings in Baltimore, MD and was co-PI on a successful conference grant from the NSF.

Randall Helmstutler travelled to the regional MAA meeting in Frederick, MD in April to give the talk “Circulant Matrices in Non-commutative Cryptography.” He also consulted with the American Canoe Association in order to devise a multi-faceted scoring system to rate competitive kayakers as they train to qualify for Olympic events.

Janusz Konieczny published three research articles, appearing in Theoretical Computer Science (coauthored), Algebra Colloquium, and Asian-European Journal of Mathematics.

Leo Lee attended an international U.S. – Korea Conference (UKC) in Queens, NY, where he presented his recent results about solving multi-objective optimization problems using the domain decomposition method. In addition, he has been serving as the mathematics, applied mathematics, and statistics symposium chair for UKC 2019 that will be held in Chicago. UKC is the biggest conference between the United States and South Korea that covers math, statistics, science, technology, and engineering.

Larry Lehman had his book, *Quadratic Number Theory: An Invitation to Algebraic Methods in the Higher Arithmetic*, published in the Dolciani Mathematical Expositions series of AMS/MAA Press. The book includes several notational innovations developed through several independent studies and a topics course in algebraic number theory taught by Prof. Lehman at UMW.

Marie Sheckels and **Suzanne Sumner** presented the workshop “Birds of a Feather: Folding Paper and Weaving Ribbon” for the Mathematics of Various Entertaining Subjects Conference hosted by the National Mathematics Museum and the City University of New York in New York City in August.



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Left: The department welcomed another baby girl this year. Shamiso, born in April, is the daughter of **Dr. Melody Denhere**.

Bottom: A group of math majors in **Dr. Randall Helmstutler**'s Cryptology class traveled to the National Cryptologic Museum in April.

