Mathematics at UMW

a newsletter of the Department of Mathematics at the University of Mary Washington

Welcome from the Chair

We are delighted to share the remarkable work of our students and faculty with you in this unusual year. This academic year begins in the midst of a global pandemic, and it is my first year as department chair. I am most indebted to those who have served our department in this role in the past and particularly thankful to Larry Lehman, Debbie Hydorn, Keith Mellinger (Dean of the College of Arts and Sciences), and Randall Helmstutler. They have all worked hard to instill a warm and engaging student-centered culture within our department. Our hope is to build on their remarkable successes as we strengthen our program.

The confluence of the uncertainties resulting from the pandemic, the abundance of data, and the inevitability of change provides an unrivaled set of excellent opportunities for our faculty and our students. In the summer, several faculty participated in delivering an excellent talk on the pandemic and its numbers, as part of a university-wide offering dubbed *COVID in Context*. This fall, with classes happening in a mix of online and in-person, we remain committed to engaging our students with regular course offerings and a diverse set of high impact activities. In addition, more than half of our faculty are directing individual studies with students to broaden their knowledge and skills beyond the ongoing classes.

We are pleased to report the promotions of Leo Lee to Professor, and Kelly Perkins to Senior Lecturer. Thanks to action from UMW's Board of Visitors, our building is now called James Farmer Hall, in honor of former UMW professor, scholar and noted civil rights activist Dr. James Farmer. In other news, please be in the lookout for our new seminar series *the life of a mathematician/ statistician*, featuring Larry Lehman and Marie Sheckels as the inaugural speakers in the fall and spring, respectively. In addition, we hope to welcome one or two guest speakers, including an alum, alongside the noted mathematician Ken Ono. Whether in-person or virtual, our programming will maintain the cutting edge and distinction of the discipline which Gauss described as the queen of the sciences, as we strengthen our community.

With best wishes for a fantastic year,

Julius N. Esunge
Chair, Department of Mathematics, UMW

Honors Projects

Abigail Bernhardt's journey into mathematics began in **Dr. Esunge**'s Intro Stats class. As she approached her final year, she made the choice to work on a thesis project to combine her interests in biology, mathematics, and statistics. The result was an honors project in mathematical epidemiology discussing the spread of diseases. In somewhat fortuitous timing, Abigail completed her work in the midst of a global pandemic, and earned her degree with departmental distinction.

Amy Creel investigated deterministic and stochastic versions of the T, T^*, V_I, V_{NI} model for Human Immunodeficiency Virus Type 1 (HIV-1) dynamics as her independent study, under direction of **Dr. Lee**. Her project was very successful, culminating in an excellent 33-page long thesis. At the end of the year, she gave a poster presentation at UMW's research and creativity day. In addition, part of Amy's honors thesis

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where great minds get to work
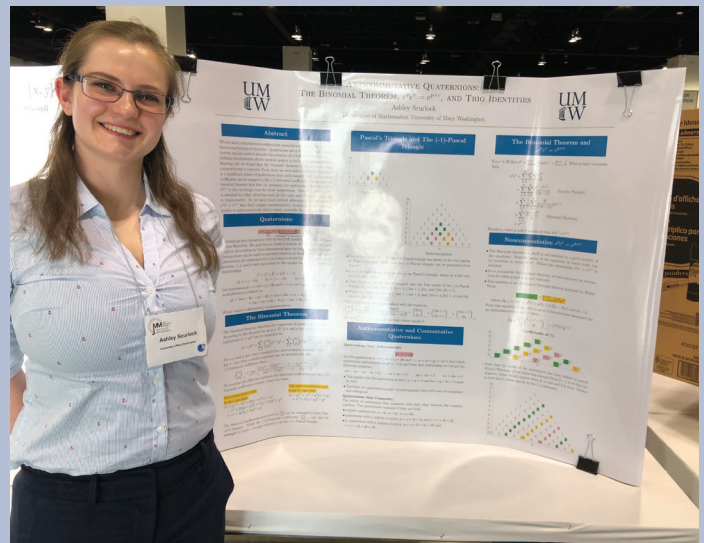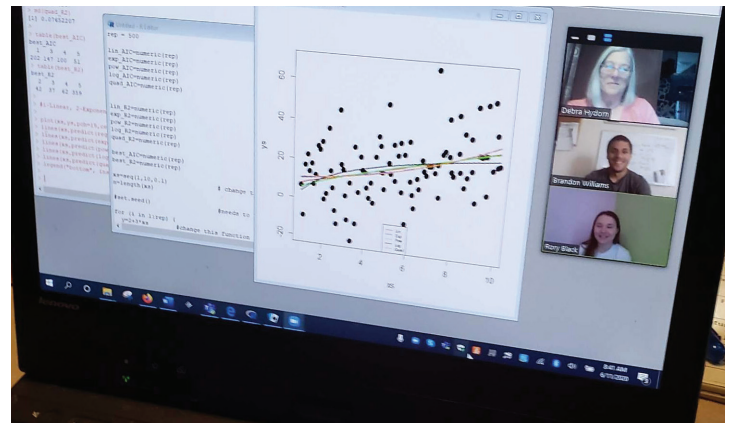
Honors Projects continued

was written as a research article for publication, and it was submitted to a mathematics journal.

Hannah Frederick completed her honors thesis titled Conjugation by Circulant Matrices in Non-commutative Cryptography under the direction of **Dr. Helmstutler**. Hannah's thesis extended the results of her work in the 2019 Jepson Summer Science Institute. In her research Hannah developed an encryption system that conceals secret matrices by a chain of conjugations by special matrices known as circulants. To formulate and analyze her scheme, Hannah had to establish numerous results on the algebraic structure of the ring of circulant matrices over an arbitrary finite field. She was also able to generate and analyze data on the number of keys in such schemes, eventually proving a conjecture on an exponential lower-bound on such counts. Hannah is now a student in the master's program at the School of Data Science at the University of Virginia.

Ashley Scurlock completed a departmental honors thesis this past year working with **Dr. Collins**. The title of her thesis was "Anticommutative Associative Algebras and the Binomial Theorem". Ashley's work, which began in the 2019 Jepson Summer Science Institute program, involved considering number systems for which commutativity of multiplication does not necessarily hold. In particular, she looked at numbers where changing the order of multiplication introduces a negative sign. She examined how well-known theorems change when this change to basic arithmetic is introduced. She looked at the Binomial Theorem and then at a basic property of exponentials. In her thesis work, she developed a new formula to describe how this basic property of exponentials changes when considering anticommutative numbers. Ashley is now pursuing a degree in Data Science at the University of Virginia.

Stephen Tivenan did a yearlong independent study and honor's project with **Dr. Lehman** on Galois Theory. In his honor's thesis, he developed a practical method of testing whether a degree five polynomial is solvable by radicals, constructing all examples of those polynomials with small integer coefficients. This data led to some unexpected conjectures on the number of real roots and certain other characteristics of solvable quintic polynomials.

Check out our website
cas.umw.edu/math
view our page devoted to our alumni and, better yet, email Dr. Esunge at jesunge@umw.edu to get yourself included!

Jepson SSI

This summer **Rory Black** and **Brandon Williams** worked with **Dr. Hydorn** to investigate using nonlinear regression to find best-fit curves to simulated data. Their goal was to evaluate how well two goodness-of-fit measures, the coefficient of determination (R2) and Akaike Information Criterion, perform in identifying the correct curved model. They wrote R code to experiment with different sized samples, different degrees of curvature, and different amounts of random variation.

Lynne Shermann and **Caitlin Holt** worked on projects involving the applications of Markov chains under the guidance of **Dr. Esunge**. Lynne focused her efforts on basic models for weather forecasts, while Caitlin applied the techniques to design pricing matrices for auto insurance.

Remote Research Experience
by Paige Beidelman
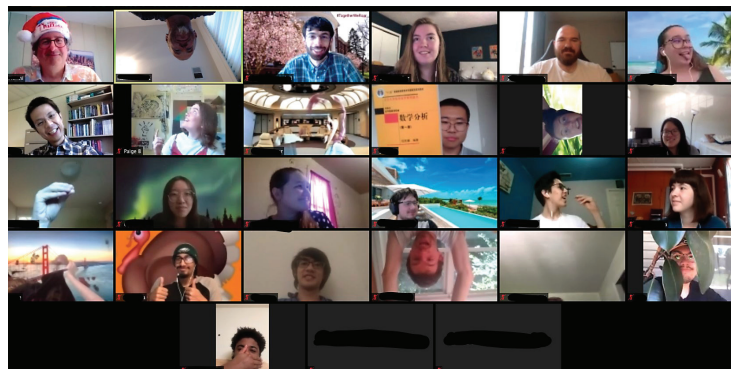
Over the summer, I participated in a virtual REU (Research Experiences for Undergraduates) with Moravian College in computational and experimental mathematics. With collaboration between students around the country and mentoring professors Caitlin Owens from DeSales University

and James Hammer from Cedar Crest College, we investigated two problems. We tried maximizing the minimum distance between symbols in adjacent cells of a Latin square and then we added restrictions such as being a Sudoku Latin square or pandiagonals Latin squares. In a separate problem, we researched edge coloring such that a there exists a shortest path between every vertex with no adjacent edges colored the same. We applied this strong proper coloring to different classes of graphs and graph operations. Every week of the REU, our group presented to the other students in the math REU and we had the wonderful opportunity to hear about their projects on polyominoes, cographs, Fibonacci sequence, parasitoids, and many other interesting projects. I appreciated the smooth adaptation to holding the REU virtually through Zoom meetings, providing students with appropriate technology, and creating fun events like game nights and music trivia. I enjoyed the amazing group of students and professors as well as the interesting research!

Student Travel

In October of 2019, five of our students traveled to James Madison University to attend the Shenandoah Undergraduate Mathematics & Statistics conference (SUMS). **Benjamin Ahren**, with **Corinne Rydgren**, delivered a presentation "Minimal Surfaces and Their Geometric Interpretations Using Mathematica", based on research done during two independent studies led by **Dr. Chiang**. Also at the SUMS conference, **Ashley Scurlock**, **Isabella Gransbury**, and **Hannah Frederick** all presented their research from the 2019 Jepson Summer Science Institute.

In January 2020, Ashley, Isabella, Hannah, and **Paige Beidelman** traveled to the Joint Mathematics Meetings in Denver CO. Ashley, Isabella, and Hannah gave poster presentations of their SSI research. With the group from her Summer 2019 pREU at Clemson University, Paige presented on solvability, or the ability to send a message through a

communication network with interference. The group's work classified unsolvable networks by subgraphs, preformed transformations of the adjacency matrices of solvable networks, and found the maximum messages that can be send through a communication network. The Joint Mathematics Meetings is the largest mathematics conference in the country, with thousands in attendance.

Faculty Notes

Yuan-Jen Chiang published three research articles this year in various journals. She also served as a reviewer of Mathematical Reviews, an AMS publication.

Julius Esunge attended 2019 Joint Mathematics Meetings as the host of a special session and participant at the AMS workshop for department chairs. He also saw three papers with different co-authors appear in print and received an NSF grant which enabled him to revise the delivery of STAT 180.

Debra Hydorn had the paper "Tools for Modern Mathematics: A Course to Introduce Experimental Mathematics" published in the proceedings of 15th Conference of the Mathematics Education for the Future Project, held in Maynooth Ireland. She also gave presentations at both the Joint Statistics Meetings and the AAC&U PKAL Conference for Transforming STEM Higher Education.

Janusz Konieczny co-authored a research article, "Conjugacy in inverse semigroup," which was published in the Journal of Algebra. He also gave an invited talk at the AMS Special Session on "Recent Trends in Semigroup Theory," at the Joint Mathematics Meetings.

Leo Lee published "A Domain Decomposition Algorithm for Optimal Control Problems Governed by Elliptic PDEs with Random Inputs" in the journal Applied Mathematics and *continued on page 4*

Faculty Notes continued

Computation. In addition, he attended an international U.S. – Korea Conference, where he presented his research on solutions of the HIV model as an invited speaker and served as the mathematics, applied mathematics, and statistics symposium chair.

Larry Lehman attended MAA Mathfest, held in Cincinnati, August 2019, and gave a talk on *Seeding Polynomials for Quadratic Congruences Modulo Prime Powers* at a session entitled My Favorite Number Theory Proof.

Suzanne Sumner's chapter "*The Mathematics of Chaos* as a First-Year Seminar" was accepted for publication in the MAA Volume *Mathematical Themes in a First-Year Seminar*. She also supervised Noah Carpenter's Honors Capstone thesis titled "Elephant Population Models."

Are you a member of our Facebook group? Look up UMW Mathematics and join today!

Future Mathematician

Dr. Collins and his wife Deb welcomed their son, Ethan, in May 2020.