The Department of Mathematical Sciences

Presents

Student Scholarship Day

Friday, April 26, 2024

Appalachian
STATE UNIVERSITY

❖❖ Schedule of Events ❖❖

1:00 p.m. (WA 103A): 3-Minute Thesis Competition

- *Using Math to Teach Financial Literacy*, **Amber Mellon, M.A.**
- *I use RBFs to Solve PDEs on ES.*, **Jacob Blazejewski, Ph.D.**
- *The Risch Algorithm: Exploring the Integrability of Functions in Terms of Elementary Functions*, **Brody Miller**
- *How Smart Bucks and Math Merge: Empowering Students with Financial Literacy*, **Silva Keohulian**

2:00 p.m. (Outside WA 103A): Poster Session with Refreshments

- *Mapping Maternal Health Care Access Disparities: A Fine-Scale Geospatial Analysis in North Carolina*, **Caroline A. Fehlman**
- *Overview of Interpolation using Radial Basis Functions and Runge Phenomena*, **Lucas Jimenez**
- *The Risch Algorithm: Exploring the Integrability of Functions in Terms of Elementary Functions*, **Brody Miller**

3:00 p.m. (WA 103A): Master's Directed Research Presentations

- *How Smart Bucks and Math Merge: Empowering Students with Financial Literacy*, **Silva Keohulian**
- *Plato, Poincaré, & Pythagoras: an initiation into esoteric mathematical astronomy*, **James Watkins**

4:00 p.m. (WA 103A): Undergraduate Talks

- *Heuristics (and also Biases) in the Insurance Context*, **Dattasai Sagili**
- *Monte and Quasi-Monte Carlo Method for Integration*, **Seamus Flaherty**
- *Quaternionic Cryptography*, **Hank Ewing**

4:00 p.m. (WA 103B): Undergraduate Talks

- *Katherine Johnson's Formulation and Calculation of the Azimuth Angle at a Spacecraft's Burnout Position*, **Ethany Payne**
- *Exploration of Stochastic Differential Equations and Their Simulation*, **Joey Seevers**
- *Defining trajectories from recursive pairing between zeros and critical points of derivatives of random polynomials*, **Nickolos Monk**

5:00 p.m. (WA 103A): Prize Drawing – attend talks for tickets! *Thanks to* **Mint Indian Cuisine**, **Stick Boy Bread Company, Espresso News Cafe and Roastery,** *and* **The Department of Mathematical Sciences** *for generous prize donations!*

❖❖ Graduate Student Directed Research Abstracts ❖❖

How Smart Bucks and Math Merge: Empowering Students with Financial Literacy

Silva Keohulian

Silva’s directed research illustrates the idea of incorporating Financial Literacy in Introductory Mathematics courses. Apart from her research evincing the importance of such integration, she wrote a complimentary guide that provides a comprehensive framework for App State students to effectively manage their expenses, cultivate financial literacy, and make informed financial decisions during their academic journey, ultimately contributing to their long-term financial well-being and success. Mentored by Dr. Quinn Morris.

Plato, Poincaré, & Pythagoras: an initiation into esoteric mathematical astronomy

James Watkins

An investigation into the development of Western mathematics from Pythagorean ideals. The focus is on relating maths’ position in the dichotomy of art/science through mathematical astronomy. We explore the philosophical trajectory of universal gravitation, aesthetics in maths, and the ubiquity of deduction. In particular, we want to answer if the Music of Heavens conjecture is in fact true. Mentored by Dr. Tracie Salinas.

❖❖ Undergraduate Talk Abstracts ❖❖

Heuristics (and also Biases) in the Insurance Context

Dattasai Sagili

Standard economics makes a powerful assumption that people will make rational financial decisions that will maximize their utility. But behavioral economics finds out that people make suboptimal decisions that don't maximize their utility. What I will present today is a summary about the suboptimal decisions carried out by finance professionals, like actuaries who calculate the price of insurance, and individuals who buy insurance. I will delve into the extensive literature that studies these suboptimal decisions and the innate biases that play a role in carrying out these decisions. The summary will be divided into the following parts: First the differentiation between biases and heuristics, examples of heuristics and biases seen in actuaries, an explanation of prospect theory and its significance, examples of heuristics and biases with individuals buying insurance, and finally a conclusion describing the benefit this knowledge has and potential application to ameliorate the decisions of both professionals and individuals alike in the context of insurance.

Monte and Quasi-Monte Carlo Method for Integration

Seamus Flaherty

The Monte Carlo Method for Integration uses pseudo-random numbers to estimate the value of integrals. This method has flaws, mainly the slow convergence rate and variance between points. By using pre-determined sequences of numbers (Quasi-Random Numbers), the variance is reduced and the Quasi-Monte Carlo Method is born. I will go over the curse of dimensionality, both methods, a common sequence of pseudo-random numbers (The Halton Sequence), and examples of accuracy and convergence.

Quaternionic Cryptography

Hank Ewing

Classical methods of cryptography rely on commutative mathematical structures. However, the emergence of quantum computing poses a threat to these classical cryptographic systems because of the Hidden Subgroup Problem. Therefore there has been research into the use of noncommutative algebraic structures, such as the quaternions, in cryptographic systems. We will explore a cryptographic system proposed by Mariana Durcheva and Kristian Karailiev that utilizes the quaternions. The talk will perform a demonstration of this protocol. The material in this handout is drawn from my final project presentation from MAT 4010 in December 2023.

Katherine Johnson's Formulation and Calculation of the Azimuth Angle at a Spacecraft's Burnout Position

Ethany Payne

Born in an age of segregation, Katherine Johnson worked diligently to achieve her position in the Flight Research Division at NASA. Using her strong foundation in mathematics that mentors began to construct during her high school years, Johnson became instrumental in generating the information, equations, and textbooks that would be used to establish new regulations regarding air traffic, launching manned spacecraft into orbit, and tracking the flight path of the spacecraft. Despite her involvement in the development of this information, Johnson was forbidden from including her name on the publications of the information because she was a woman. Katherine Johnson and Ted Skopinski's technical note titled "Determination of Azimuth Angle at Burnout for Placing a Satellite Over a Selected Earth Position" was the first exception to this rule. Given preselected longitude and latitude coordinates, Johnson and Skopinski's technical note, in which Johnson did most of the work, provided the mathematical formulas for approximating the azimuth angle at which a spacecraft would need to have at its burnout point for the spacecraft to land in a designated location. In Appendix B of her paper, Johnson provided the formulas that she created and used to calculate the azimuth angle of a spacecraft at its burnout position, as well as two examples where she used the formulas to calculate the azimuth angle for a spacecraft at its burnout position given specific initial conditions. Analysis of Katherine Johnson's story and contributions to mathematics reveals that the study of mathematics is not relegated to a certain gender or race, but to those who desire to spend their time grappling with the mathematical information they know and have available to identify how real-world phenomenon can be modeled and calculated using mathematics.

Exploration of Stochastic Differential Equations and Their Simulation

Joey Seevers

This project was an exploration of stochastic differential equations, with the goals of building up enough of the theory around the field to eventually begin producing simulations of them to better understand their behavior. Specifically looking at their behavior when their initial value is near points of bifurcation, and how to visualize that behavior. Mentored by Dr. Quinn Morris.

Defining trajectories from recursive pairing between zeros and critical points of derivatives of random polynomials

Nickolos Monk

Given a random, complex-valued, degree-n polynomial p_n, we propose a polynomial-time algorithm, motivated by a classical proof of the Gauss–Lucas theorem, to precisely define a collection of "trajectories" of zeros of the derivatives $p_n^{(k)}$, $0 \leq k < n$, of p_n that transport individual roots of p_n to their arithmetic mean. We present a preliminary investigation, via simulation, into the behavior of these trajectories. Mentored by Dr. Noah Williams.

❖❖ Poster Session Abstracts ❖❖

Mapping Maternal Health Care Access Disparities: A Fine-Scale Geospatial Analysis in North Carolina

Caroline A. Fehlman (presenting author), Margaret M. Sugg, Sarah E. Ulrich, Dennis Guignet; Jennifer Tyson, Shishir Shakya

Maternal mortality and morbidity rates continue to rise despite advances in maternal health care and the success of simple interventions like prenatal care. Rises in maternal mortality and morbidity are occurring parallel to decreasing maternal healthcare accessibility as hospitals discontinue their OB services and provider shortages escalate in rural and underserved communities. In this study, we examine the accessibility of maternal health care by providing the first fine-scale geospatial analysis of maternal health care at the census tract level in North Carolina. We use the National Provider Identifier (NPI) database to obtain geocoded coordinates of all maternal health care providers (e.g., OBGYN, Midwives, Family Practitioners, and Doulas). Geocoded coordinates of providers are linked with contextual information of rurality, poverty, structural racism, and income segregation to identify which communities have minimum maternal health care access. Results suggest a strong divide in maternal healthcare access, with rural communities with high-income segregation experiencing the least amount of service. Our work is transformative as it provides the first sub-county analysis of maternal health care access for the state of North Carolina, with direct implications for public health policy and future research examining how access to maternal health care impacts maternal and fetal health.

Overview of Interpolation using Radial Basis Functions and Runge Phenomena

Lucas Jimenez

Interpolation is a method of estimating unknown values in a given data set. For example, interpolation techniques are used to construct brain surfaces, predict temperature in between weather stations, and create elevation maps from limited measurement sites. Our research focuses on using radial basis functions (RBFs) for interpolation. We will discuss the process of interpolation using the Gaussian RBFs and present error plots that map the L-infinity norm over varying RBF shape parameters. Additionally, we will explore how varying the shape parameter impacts the Runge phenomenon, which is observed as oscillations of the interpolated function towards the outer edges of its graph. Mentored by Dr. Jacob Blazejewski.

The Risch Algorithm: Exploring the Integrability of Functions in Terms of Elementary Functions

Brody Miller

Within the standard calculus sequence, we are taught how to integrate a wide class of functions. However, while we traditionally learn how to integrate certain functions in these courses, we don't discuss exactly when and why certain functions are integrable by hand while others aren't. In fact, finding antiderivatives in terms of what we call "elementary functions" is a question of mathematical interest commonly referred to as the problem of integration in closed form. The Risch Algorithm, which has been partially implemented in some computer algebra systems (CAS), can tell us whether the integral of a function has a closed form expression in terms of elementary functions or not. We will discuss some introductory differential field theory and the two approaches the algorithm takes to find a closed expression.