ROSE-HULMAN INSTITUTE OF TECHNOLOGY

Undergraduate Mathematics Conference

Student Speaker Abstracts

(listed according to times)

Friday 3:10 - 3:30 p.m., G219, Crapo Hall

Amber Brown, Greenville College

Title: ***Wavelet Analysis and a Computational, Time-Dependent Problems***

Abstract: Wavelets are a basis set of functions that can be used to effectively represent images or other functions. Though most commonly associated with image processing such as FBI fingerprint storage and jpeg files, wavelets have become popular in the physics and chemistry communities for solving partial differential equations (PDE's). The most notable features of wavelets are their multiresolution capabilities and good localization, which together allow for efficient representations of solutions to PDE's. The performance of two types of wavelets, symmlets and coiflets, were compared based on their efficiency and error accumulation when used to solve the quantum displaced harmonic oscillator. After a brief introduction to wavelets and their properties, specific attention will be given to how wavelets were applied to the aforementioned problem.

Friday 3:10 - 3:30 p.m., G221, Crapo Hall

Sarah Jabon, Rose-Hulman Institute of Technology

Title: Algorithmic Threshold Selection for the Peak-Over-Threshold Method

Abstract: In extreme value theory, the peak-over-threshold method is one way to model the tails of heavy tailed distributions. In this method, a generalized Pareto distribution (GPD) is fit to the data points that exceed a high threshold. Choosing an appropriate threshold is crucial, as bias and variance affect the fit of GPD when then threshold is too low or too high respectively. Currently, graphical techniques are typically employed to identify a suitable threshold given a data set, as there is no accepted standard for determining a threshold algorithmically. We compare three original algorithmic techniques that use commonly used plots, the Hill plot and the exponential quantile plot, as well as one previously proposed method from Zhou et al. in "A New Method to Choose the threshold in the POT Model." In order to compare performance, we apply each method to simulated data from the Pareto, f, Frechet, and Student's t distributions with multiple data set sizes. One method based on the Hill plot performs particularly well with regard to identifying a threshold that produces a GPD with a shape parameter close to the true value. Finally, we apply these techniques to the well-studied Danish fire data set. These algorithmic methods can aid in identifying suitable thresholds for the peak-over-threshold approach in extreme value theory.

Friday 3:10 - 3:30 p.m., G222, Crapo Hall

Lane Bloome, Millikin University

Title: Compressed Zero-Divisor Graphs of Finite Commutative Rings

Abstract: The zero-divisor graph of a commutative ring R, denoted ΓR, is a graph whose vertices are the nonzero zero-divisors of a ring, and two vertices are connected if and only if their product is zero. These graphs have been studied for a number of years in the hope that the graph-theoretic properties of ΓR can help us understand more about the ring-theoretic properties of R. We slightly alter the definition of the zero-divisor graph to obtain the compressed zero-divisor graph. In this talk, we will explore recent developments regarding these structures, including an algorithm for constructing these graphs.

Friday 3:40 – 4:00 p.m., G219, Crapo Hall

Kyla Lutz, Rose-Hulman Institute of Technology

Title: Yeast and Mathematics

Abstract: Mathematics underlies many biological problems, including the metabolism of Saccharomyces cerevisiae, or baker's yeast. The metabolic network of this organism is modeled using flux balance analysis (FBA), which incorporates linear algebra, computer science, and the chemical reactions within a cell to determine what a single cell is doing while it is in steady-state. More basic mathematics is also used for this metabolic model. Specifically, Boolean algebra is used to represent the reactions so that the experimental data can be used accurately in the model. The metabolites given to the cell initially are collectively called the environment, or medium, which can be controlled by the user in the model to mimic experimental conditions so that accurate predictions can be made. Using this tool, some questions that can be asked are "What are the minimum number of metabolites that the cell needs and what are they?" and "What are the compositions of all of the possible 'minimal media' in which the cell can survive?" These questions were addressed in Dr. Jason Papin's Biomedical Engineering laboratory over the course of an REU at the University of Virginia. Another problem that was addressed is the connectedness among all of the reactions in a cell and each metabolite with which the cell interacts. These connections can be found using a modification of the Floyd-Warshall algorithm from computer science. Mathematics played a major part in this research project and others very similar to it.

Friday 3:40 – 4:00 p.m., G221, Crapo Hall

Alicia DeHart, Northern Michigan University
Title: ***Modified Fibonacci Sequence***
Abstract: The Fibonacci sequence is often described with a population model, where the population exists under the most ideal conditions. If a change is made in the conditions, how does the sequence change? Is there a formula we may use to generate this new sequence? These questions, and more, will be answered in this presentation.

Friday 3:40 – 4:00 p.m., G222, Crapo Hall

Darrin Weber, Millikin University
Title: ***A Preliminary Look at Compressed Zero-Divisor Graphs and Zero-Divisor Lattices***
Abstract: The zero-divisor graph of a commutative ring *R* is a graph whose vertices are the nonzero zero-divisors of a ring, and two vertices are connected if their product is zero. These graphs have been studied for a number of years in the hope that the graph-theoretic properties can help us understand more about the ring-theoretic properties of *R*. We slightly alter the definition of the zero-divisor graph to obtain the compressed zero-divisor graph. Also, we look to expand on the idea of zero-divisor graphs of rings into lattices on those rings. We take the zero-divisors of a ring, examine their annihilator sets, assign an order to them, and then place these annihilators into a lattice structure. We take a preliminary look at the relationships between the zero-divisor graph, compressed zero-divisor graph, and the zero-divisor lattice.

Friday 4:20 - 4:40 p.m., G219, Crapo Hall

Joseph Gasper, Kent State University
Title: ***If Knot Theory and Knot Invariants, Then What?***
Abstract: We will give a brief introduction to Knot Theory with consideration of Knot Invariants and examples.

Friday 4:20 - 4:40 p.m., G221, Crapo Hall

Tim Ekl, Rose-Hulman Institute of Technology
Title: ***Local Warming***
Abstract: Much attention has been given recently to the validity of global warming claims. We present a model-based look at local weather data in an attempt to identify whether global warming exists on a much smaller, local scale. We use a linear model and statistical analysis to find the amount of "local warming," if any, that exists in and around Terre Haute, IN.

Friday 4:20 - 4:40 p.m., G222, Crapo Hall

Taole Zhu, Illinois Wesleyan University
Title: ***B-coloring in regular graphs***
Abstract: A b-coloring is a vertex coloring in which every color class contains a vertex that has a neighbor in all other color classes. The b-chromatic number b(G) of a graph G is the largest integer k such that G has a b-coloring with k colors. We discuss various approaches to a conjecture on b-coloring in regular graphs and prove that for any d-regular graph with girth = 5, the b-chromatic number is at least floor((d + 1)/2).

Friday 4:20 - 4:40 p.m., G317, Crapo Hall

David Irwin, Miami University Middletown
Title: ***Nice Numbers***
Abstract: Find the number of Representations of Nice numbers as sum of consecutive integers.

Friday 4:50 - 5:10 p.m., G219, Crapo Hall

Nathan Poirier, Aquinas College
Title: ***Alhazen's Billiard Problem in Hyperbolic Geometry***
Abstract: Alhazen's billiard problem gives points A and B inside a circle and seeks an inscribed isosceles triangle with a given point on each leg. In our summer research, we found a bijection between Euclidean solutions and hyperbolic solutions. The constructible Euclidean cases pair up with the constructible hyperbolic cases. We will prove the bijection and give some examples.

Friday 4:50 - 5:10 p.m., G221, Crapo Hall

Jonathon Strauser, Rose-Hulman Institute of Technology
Title: ***Protein structure alignment and classification using dynamic programming***
Abstract: Biological molecules called proteins are compared on the basis of the three-dimensional folds that define their shape and function. A mathematical description of a protein's fold is created so that proteins can be aligned. A dynamic programming algorithm is used to compare proteins in a data set consisting of 300 proteins of known family classification. The algorithm has been optimized for both speed and accuracy.

Friday 4:50 - 5:10 p.m., G222, Crapo Hall

Mark Bissler, Kent State University
Title: ***Group Theory Applications to Rubik's Cubes***
Abstract: We will speak on elementary group theoretics applied to the coolest toy known to man.

Friday 4:50 - 5:10 p.m., G317, Crapo Hall

Gina Luciano, Millikin University
Title: ***Using Data Mining to Determine Academic Success in College***
Abstract: Data mining is the process of finding useful patterns in data. A data mining program called Rattle was used to analyze admission data for Millikin University. The purpose of analyzing this set of data was to find patterns that could determine the success of students who were academically at risk at the time of their application. An original data set of variables was processed and analyzed to find characteristics of students who thrive academically at Millikin although they were "at risk" when they applied. The results could also determine if an academically at risk student would remain at risk and potentially transfer throughout their college career. The findings were relayed to the Office of Admission to help them more effectively reach out to students to at risk students.

Saturday 10:10 - 10:30 a.m., G219, Crapo Hall

Brian McDonald, Carmel High School
Title: A formula for the integral of an inverse function in terms of the integral of the function.
Abstract: Most calculus texts give a formula for the derivative of an inverse function in terms of the derivative of the function. They do not give a corresponding result for the integration of inverse functions. We derive the integral formula by looking at the graph of the function. Our derivation does not depend on integration by parts.

Saturday 10:10 - 10:30 a.m., G221, Crapo Hall

Michael Pridal-LoPiccolo, Rose-Hulman Institute of Technology
Title: ***Analysis of Keccak, a SHA-3 Finalist***
Abstract: Hash functions are cryptographic primitives used in a variety of important applications. Recent attacks against the industry standard functions have motivated the search for new, more secure functions. This presentation focuses on the security of one candidate algorithm, Keccak.

Saturday 10:10 - 10:30 a.m., G222, Crapo Hall

Matthew Grimm, Kent State University
Title: ***Minkowski Length of 3-D Polytopes***
Abstract: The Minkowski sum of two polytopes is the set pairwise sums of their points. We will look at the Minkowski length L(P) of a lattice polytope P. We will explain an algorithm for computing L(P) and look at indecomposable polytopes. Our result extends a previously known result with polygons. Our methods are substantially different from those used in the two-dimensional case.

Saturday 10:40 - 11:00 a.m., G219, Crapo Hall

Xin Ma, Trinity University
Title: ***Estimating bacterial lag phase: a branching process approach.***
Abstract: Before a population of bacteria (or other cells) starts growing exponentially, there may also be an initial phase, the lag phase, when the bacterium adjusts to a new environment. Accurate estimation of the lag phase is important in the field of predictive food microbiology.

Saturday 10:40 - 11:00 a.m., G221, Crapo Hall

Jack Pringle, Rose-Hulman Institute of Technology
Title: ***Secret Sharing Schemes: An Application of Projective Geometry***
Abstract: We will introduce secret sharing schemes. Then we will discuss finite projective geometries and other useful properties associated with them. Then we will show how to use finite projective geometry to construct a secret sharing scheme. Finally, we show why this construction is superior to other secret sharing schemes.

Saturday 10:40 - 11:00 a.m., G222, Crapo Hall

Scott Rexford, Northern Illinois
Title: ***An overlooked reference from the last book of Euclid's Elements.***
Abstract: Did Euclid suggest an alternate construction for the pentagon in the 13th book of elements? It would seem so. In this talk the construction will be presented, and its correctness will be proven. We will also give a brief definition of the affine geometric transformation known as circle inversion. This will lead up to a posed problem involving an infinite summation of circles packed within an arbelos.

Saturday 11:20 - 11:40 a.m., G219, Crapo Hall

Andy Milluzzi, Rose-Hulman Institute of Technology
Title: Lego: The Intersection of Art and Engineering
Abstract: Everyone has played with LEGO Bricks, but what happens when you take it to the next level? There is a thriving community of adult fans that use those plastic bricks as much more than a toy. From models of the White House to robotic arms, LEGO mixes art and engineering in a way that captures the inner child in everyone.

Saturday 11:20 - 11:40 a.m., G221, Crapo Hall

Steven Hayman, Illinois Wesleyan
Title: ***Tabulating Irreducible Polynomials over GF(2)***
Abstract: This focus of this presentation is the tabulation of irreducible polynomials over GF(2). The last tabulation was up to degree 5,000. The goal for my research project was to tabulate up to degree 100,000.

Saturday 11:20 - 11:40 a.m., G222, Crapo Hall

Bill Karr, IUPUI
Title: ***Level density and level-spacing distributions of random, self-adjoint, non-Hermitian matrices***
Abstract: We investigate the level-density $\sigma(x)$ and level-spacing distribution $p(s)$of random matrices $M = AF \neq M^{\dagger}$ where F is a (diagonal) inner-product and A is a random, real symmetric or complex Hermitian matrix with independent entries drawn from a probability distribution $q(x)$ with zero mean and finite higher moments. Although not Hermitian, the matrix M is self-adjoint with respect to F and thus has purely real eigenvalues. We find that the level density $\sigma_{F(x)}$ is independent of the underlying distribution $q(x)$, is solely characterized by F, and therefore generalizes Wigner's semicircle distribution $\sigma_{W(x)}$. We find that the level-spacing distributions $p(s)$ are independent of $q(x)$, are dependent upon the inner-product F and whether A is real or complex, and therefore generalize the Wigner's surmise for level spacing. Our results suggest F-dependent generalizations of the well-known Gaussian Orthogonal Ensemble (GOE) and Gaussian Unitary Ensemble (GUE) classes.

Saturday 11:50 a.m. - 12:10 p.m., G219, Crapo Hall

Kelly Ruder, Siena Heights University
Title: ***Mathematics Vocabulary and Comprehension***
Abstract: Some say mathematics has a language all its own, while others say that math is the universal language. If, indeed, "Mathematics has a language all of its own" and "Mathematics is the universal language", then students should be able to comprehend and apply the vocabulary of the discipline. Mathematics vocabulary however, can present a major challenge to many learners, and even though vocabulary is stressed in the elementary grades, this practice is not typically continued in the secondary grades. The issue of vocabulary can also lead to an increase in mathematics anxiety, which discourages many students to continue taking math courses. Thus, this research questions stems from these ideas: Does developing a working vocabulary in statistic students increase comprehension and decrease math anxiety? This presentation will detail the approach that will be taken.

Saturday 11:50 a.m. - 12:10 p.m., G221, Crapo Hall

Eric Crockett, Rose-Hulman Institute of Technology
Title: ***Algebraic Solutions to Non-Linear Systems***
Abstract: Many cryptographic algorithms such as AES rely on the difficulty of solving non-linear systems of equations over a finite field, which is NP-hard in the general case. When the system is overdetermined, it is sometimes possible to find a solution in polynomial time. We examine two algorithms for solving non-linear systems which work by finding new linearly independent equations and using them to solve the system. We will also discuss the implications of these algorithms on modern cryptography.

Saturday 11:50 a.m. - 12:10 p.m., G222, Crapo Hall

Tyler Foxworthy, IUPUI
Title: ***Explicit representations of characteristic polynomial coefficients associated with an n-by-n symmetric matrix***
Abstract: We obtained explicit representations of the zeroth and the first order coefficient of the characteristic polynomial associated with an n-by-n symmetric matrix, E^{∞}. It is the asymptotic limit of a matrix associated with fitting data at regular intervals to a sum of exponentials. Through functional iteration with these coefficients, one can find estimates for the largest and smallest eigenvalues of the symmetric matrix. In this presentation computational results and motivational examples will be given to highlight the significance of such problems.