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

Adam Lewis, Mercer University

Title: Pascal to the Rescue

Abstract: In the 17th century, Blaise Pascal found himself in a pickle. No matter how hard he tried, he could not figure out how to measure lengths of parabolic arcs with Euclidean coordinates. So Pascal employed an underused problem-solving technique: he decided to view these arcs from a different perspective. Instead of using Euclidean coordinates, Pascal chose to use polar coordinates. In the spirit of Pascal, we will use this same problem-solving technique to answer questions about the hemisphere model of hyperbolic geometry. Questions such as: what would mirror images look like in the hemisphere model? What would railroad tracks look like? How does one reflect a point over a line? If you're ready to answer these questions and more, prepare to learn how changing your perspective can lead to understanding relationships among the Klein disk, the hemisphere model, and Blaise Pascal himself, as well as the answer to our questions. It's time to bend your perspective of Geometry!

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

Mark Woods, Millikin University

Title: Good or Bad: Altering Admission Standards

Abstract: Entrance requirements for some colleges and universities have become more inclusive over the past several years. In this talk, we will analyze whether students who would not have been previously admitted to Millikin University are being retained long-term. Further, we will discuss how Millikin can predict the retention of similar students in the future.

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

Scott Rexford, Northern Illinois University

Title: To Construct a Hyperbolic Triangle...

Abstract: In this presentation we will discuss the motivation for defining fractal dimension and construct a fractal having a two dimensional attractor and zero measure, obtained from iterations on a solid from classical geometry. We will give a brief description of Poincare's model for hyperbolic geometry and present a construction of a triangle with arbitrary centroid given three angles having sum less than pi. We will construct a parametric curve to find a region in the plane for which a presented problem from transformational geometry is solvable. We will also briefly present a derivation of a series converging to pi.

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

David Irwin, Miami University (Oxford, OH)

Title: *d*-Nice Numbers

Abstract: *d*-Nice number is what can be expressed as sum of an Arithmetic Progression (A.P.) with common difference $d \geq 1$. We explored for $d = 1$ at last year's conference. We will present results for $d > 1$ this time.

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

Morgan Perkins, Millikin University

Title: Predicting Retention of Marginally Admitted Students

Abstract: It is a common debate whether there are benefits to a university by being more inclusive regarding their entrance standards. We decided to analyze the retention rate of the current senior class who were marginally admitted to Millikin University. Some of the characteristics considered were GPAs, ACT scores, and intended major.

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

Matthew Harris, University of Evansville

Title: Mercury Pollution Modeling Around the A.B. Brown and Gibson Generating Stations

Abstract: Mercury is a pollutant that can cause great damage to ecosystems, especially in larger concentrations, such as when it bioaccumulates in fish. In Southern Indiana, the amount of fish that can be eaten out of the Ohio River is limited because of the mercury found in the fish. For this reason, understanding the mercury emissions (e.g., from power plants) in Southern Indiana is important. The amount of mercury deposited in the soil around two power plants (A.B. Brown and Gibson Generation Stations) was physically sampled and then modeled using AERMOD. The model took into account meteorological, land, landscape, and mercury emission data. The amount of deposition around Brown was greater than the amount of deposition around Gibson, despite the fact that Gibson emits more mercury. There are three types of mercury that naturally occur when burning coal: elemental, divalent and particulate. After modeling the emissions from the two plants, it was found that different amounts of these three types of mercury found at the two power plants caused this discrepancy. In order to estimate the speciation profile for the total mercury output of each plant, two methods were used. One method, the Linear Method, showed that the speciation must be different for each plant. The other method, the Bisection Method, was used to get the modeled data to fit better to the sampled data. The final speciation profile at Brown was: 33.2% Hg(P),14.5% Hg(II), 52.3% Hg(0) and the final speciation profile at Gibson was: 4% Hg(P), 25% Hg(II), 71% Hg(0). The model that used the final speciation profile and the sample data, once normalized to have both be unitless, have similar graphs for both Brown and Gibson.

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

Lane Bloome, Millikin University

Title: Connections between Central Sets and Cut Sets in Zero-Divisor Graphs of Commutative Rings

Abstract: The zero-divisor graph of a commutative ring with unity, denoted G(R), is a graph that has a vertex for every nonzero zero divisor of R, and vertices *a* and *b* are connected by an undirected edge in the case that $ab = ba = 0$. These structures have been the subject of much algebraic and graph theoretic investigation for the past 15 years. Recently, there has been undergraduate research focused on investigating cut-structures in these graphs. A cut vertex of a graph is a vertex that disconnects the graph upon removal, and a cut-set of a graph is a minimal set of vertices that disconnects a graph upon removal. This talk looks at the relationship between the center of G(R) and the cut-sets of G(R).

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

Trenton Tabor, Rose-Hulman Institute of Technology

Title: Building Predictive Models in Absence of Theory: An Application of the LASSO Variable Selection Technique to Student Persistence

Abstract: Because of the nature of some processes, it is problematic to generate a theoretical model that is complete enough to describe and predict behavior in the process. For these types of problems, building a predictive model typically involves regressing against all of the available observed characteristics of the process. However, when the number of observable characteristics is large compared to the number of observations, these models may be difficult or impossible to generate. One method of analysis in these situations is the Least Absolute Shrinkage and Selection Operator, which can be used to generate sparse and parsimonious models, this method is discussed in relation to an application of predicting student persistence rates. By analyzing past student success and failure, a model is created to relate student persistence probability to a number of easily observed characteristics.

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

Trent Tabor, Chase Mathison, James Folberth, Rose-Hulman Institute of Technology

Title: Hortonian Scaling of Maximum Flow in Non-idealized River Basins

Abstract: River basin flow models typically involve thousands of non-linear, coupled ordinary differential equations. We used the results of R. Mantilla et al. to model the flow in the Clear Creek and Big Bear Creek watersheds using various assumptions about the impact of friction on the velocity of the flow. The Horton order of a link (river) in a basin is a natural number that describes how many other links feed into the link. Using our model, we empirically verified Mantilla's results that mean peak flow scales with Horton order.

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

Aaron Davis, Southwest Baptist

Title: Statistical Analysis of Prime Factors

Abstract: This presentation will report the results of an investigation of the prime factors of the positive integers 2 through *n* as *n* gets large. Tools used in the investigation include means, variances, and standard deviations. Computer programs were used to investigate these measurements to see if they yield any discernible pattern(s) including if there is a limit associated with means, variances, or standard deviations as *n* gets large. This is mainly a computational approach rather than a theoretical approach.

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

Jill Shuman, Rose-Hulman Institute of Technology
Title: Optimizing Beam Selection in Radiotherapy
Abstract: Radiotherapy is used in the treatment of approximately 50% of cancer patients. One of the main components of radiotherapy is the selection of angles along which the radiation is delivered to the tumor. As the tumor is treated, more dose is delivered to the target as well as the surrounding critical structures. In order to minimize the amount of damage to critical structures, and maximize the amount of damage to the tumor, we have developed an optimization technique to alleviate high doses in the critical structures. We use dynamic programming to decide if we should reoptimize the angles during the course of daily treatments.

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

Andrew Harris, Rose-Hulman Institute of Technology
Title: A Mathematical Model for the Baking Process – A Phenomenological Approach
Abstract: In this talk, I will present a mathematical model for the baking process of a cake and/or bread. The model is based on basic physical principles including diffusion, elasticity, and thermodynamics. I will explain the modeling process from these first principles to partial differential equations. The final model then consists of a coupled system of seven nonlinear partial differential equations that specify the temperature, moisture content, vapor content, pressure, and deformation in the dough. This is solved numerically to produce a reasonable representation of the baking process.

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

Meagan Ryan, Saint Mary of the Woods College
Title: Understanding Coulomb Potential: An Unproven Array of Points
Abstract: In this presentation, we will discuss the use of the Coulomb potential to find the minimal energy configuration of n charges located on a thin circular conductor. Some history and mathematical background will be presented, highlighting the motivation behind finding solutions for the unsolved problem. Some simple mathematical cases will be illustrated and explained, while a comparison between the energies using the Coulomb potential and logarithmic potential will be discussed.

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

Jacki Simon, Rose-Hulman Institute of Technology
Title: Robustness Test for a Protein Alignment Algorithm
Abstract: Proteins, the basic building blocks of many biological molecules, can be compared by three dimensional folds that dictate structure and function. Many efficient, accurate algorithms have been determined that take a mathematical description of a protein's folds and use dynamic programming to align its structure with that of other proteins. As proteins are not usually static molecules, a method of studying an algorithm's robustness under perturbations of the data has been developed and used to test the stability of one of the dynamic programing alignment algorithms.

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

Chelsey Barron, Saint Mary of the Woods College
Title: Breaking Down the Riemann Hypothesis
Abstract: The problem popularly referred to as the Riemann Hypothesis was first posed in 1859. Since then there have been many attempts to solve this problem (some "solutions" can readily be found online). This talk will examine the Riemann Hypothesis by providing a brief history of the problem, mentioning some of the mathematical stumbling blocks to completing the proof, and explaining the problem's relevance (and the solution's relevance) to present-day applications.

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

Jackie Buhrman, Millikin University
Title: The U.S. Life Insurance Industry: Time Series Analysis
Abstract: The life insurance industry is an important part of our financial sector, providing a variety of services to its customers, including term or permanent life insurance, investment annuities, and mutual funds. Life insurance is an integral component of many financial portfolios; about 70% of American households have some type of life insurance. However, there have been very few recent studies on the growth or health of the life insurance industry. My research attempts to answer questions such as "What is the current trend in the health of the life insurance industry, and how does that compare to the current trend in GDP?" and "Which major economic events have had an effect on the life insurance industry, and what has that effect been?", among others. To accomplish this, I have selected variables to represent the health of the industry, chosen a group of life insurance companies to represent the industry, and then used those variables to model the health of the life insurance industry over a period of time.

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

Joseph Gasper, Kent State University
Title: An Introduction to Object Oriented Design Principles and Their Benefit to Mathematicians
Abstract: I will be taking you through the design and evolution of an Application Programming Interface for abstract strategy board games, detailing road blocks and how they were overcome with the use of object oriented design principles, then describing the benefits of said principles to the mathematician and mathematical community with examples.

Saturday 11:20 – 12:10 p.m., G219, Crapo Hall

Michael Fitzpatrick, Trenton Schirmer, University of Iowa; Greg Zynda, Indiana University; Brian Shroud, University of Notre Dame

Title: Graduate Student Panel

Abstract: This new session added to this year's conference aims to be a resource for undergraduates in mathematics who are starting to ask questions, such as "*what's next?*" Four panelists with various mathematical backgrounds will talk about their experiences in making decisions about graduate school, and answer your questions about choosing the right school for you, selecting an advisor, obtaining funding, the graduate school application process, and anything else you've wanted to know (but have been unable to ask). After the panelists introduce themselves and talk about how they came into their current positions, they will take questions from the audience.

Saturday 11:20 – 12:10 p.m., G221, Crapo Hall

Brad Jones, Consulting Actuary, Actuarial Services, McCready and Keene, Inc.

Title: Q&A about a Career in Actuarial Science

Abstract: Our own Rose-Hulman alumnus Brad Jones (Class 2005) will answer questions related to a career in actuarial science. If you want to know more about actuarial science, Brad will tell us how he chose this career and what activities are part of his daily routine. Also, he will explain the actuarial testing process.

Saturday 11:20 – 12:10 p.m., G222, Crapo Hall

Andrew Rourke, Maplesoft

Title: Stick With It! (Why math matters now more than ever)

Abstract: Let's face it: studying mathematics is hard, but in today's increasingly tech-filled world, mathematics is playing a larger and larger role in everyday life. At the heart of much of our modern society is mathematics, and in the coming years great rewards will go to those who possess mathematical knowledge and skills (and an ability to apply them). This talk will focus on examples from everyday life where mathematics - sometimes hidden, sometimes not - plays an important role, and how Maplesoft - through products like Maple and MapleSim - is committed to helping students both succeed in their studies today and prepare for their careers of tomorrow.