Rose-Hulman
Undergraduate Mathematics Conference

April 20 - 21, 2018

Rose-Hulman Institute of Technology
Department of Mathematics
Terre Haute, Indiana

Welcome

Welcome to the 35th Annual Rose-Hulman Undergraduate Mathematics Conference. This conference serves as an opportunity to highlight the research being done by undergraduate students which involve the use of mathematics and statistics. Students and faculty performing research across a wide spectrum are brought together by our shared interest in the mathematical sciences. This weekend is an opportunity to celebrate the accomplishments of those who are presenting, to encourage those for whom research is on the horizon, to broaden our knowledge amongst new and old friends, and to socialize with others who also have a passion for mathematics and statistics. We have a great program this weekend.

Invited Speakers: Those seeking a career in the mathematical sciences have many potential career paths. In addition to academia, mathematicians and statisticians are invaluable resources to a variety of disciplines, and are often hiding in plain site. The theme of this year's conference, *Mathematics in Unexpected Places*, highlights some of these more unique career opportunities. Hilary Parker, a data scientist at StitchFix, will discuss the use of statistics and data science within the fashion industry. Lawrence Stone, chief scientist at Metron, will reveal the role of mathematics in finding lost wreckage. Tanya Leise, head of the department of Mathematics at Amherst College, uses mathematical modeling to unlock the secrets of sleep.

Short Courses: We are pleased to offer three short courses to our registrants. These two-hour courses will present foundational topics in mathematics and statistics. For those interested in geometry, Peter Andrews (Eastern Illinois University) will offer a course on extending euclidean geometry to the complex numbers. Of special interest to faculty this year, Tim All (Rose-Hulman Institute of Technology, and local TeX guru) will offer a course on advanced editing in LaTeX. Mark Daniel Ward (Purdue University) will provide an introduction to data science.

Contributed Papers: The focal point of the weekend is the contributed student talks. We have 35 papers being presented by students this weekend on topics ranging from the mathematical modeling of biological systems, to data visualization to mathematical theory in games. Regardless of your specialty, we are certain you will find something that interests you. We are grateful to all those students who are willing to share their work with us during the conference.

We are excited to host you this weekend, and we hope you enjoy the conference!

Acknowledgments

This conference would not have been possible without the dedication and service of many. We are grateful to all those who have helped this conference come together. In particular, we would like to thank the following individuals:

Dr. Russ Warley	Dean of Faculty
Mariana Lane	Administrative Assistance
Michelle Prather	Administrative Assistance

To all those we neglected to mention above, we truly are appreciative of all the work you put into the conference.

And to all those participating in the conference, thank you for attending; you are what the conference is all about.

Sponsors

The success of this conference is due in large part to our gracious corporate sponsors. The contributions of the following organizations allowed us to waive the registration fee for those registering early, subsidize hotel accommodations for 50 students, and provide meals during the conference. Please keep these organizations and corporations in mind as you continue your career.

Rose-Hulman Undergraduate Math Journal

The Rose-Hulman Undergraduate Math Journal is devoted entirely to papers written by undergraduates on topics related to mathematics. Although the authors need not be undergraduates at the time of submission or publication, the work must have been completed before graduation. The journal is distributed freely in an electronic format (PDF) from the journal's web site.

In order to maintain a high level of exposition, each paper is sponsored by a mathematician familiar with the student's work and each paper is refereed. The editor-in-chief makes the final decision for publication. The journal is sponsored by the Mathematics Department at Rose-Hulman Institute of Technology.

To each of our presenters, we hope you will consider publishing your research. Should you choose to consider the Rose-Hulman Undergraduate Math Journal, please visit the journal's website or contact the following individuals:

Dr. Tim All **Dr. Joe Eichholz** **Dr. Josh Holden**

Dr. Tom Langley **Dr. John McSweeney**

Department of Mathematics

Rose-Hulman Institute of Technology

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Terre Haute

During your stay in Terre Haute, we anticipate you will spend most of your time on the Rose-Hulman campus. Should you decide to explore Terre Haute, for those unfamiliar, there are four key roads that form a box: US 40 (Wabash Avenue) on the North, Interstate 70 on the South, US 41 (Third Street) on the West, and State Road 46 on the East.

Accommodations
The conference hotel is the Quality Inn of Terre Haute, located at 555 South Third Street (812.235.3333). As you exit the Rose-Hulman campus, turn right onto Wabash Avenue. Proceed through downtown Terre Haute until you reach the court house; turn left on Third Street. The hotel will be on the right after a few blocks. Please remember, **the conference hotel offers a hot breakfast each morning!**

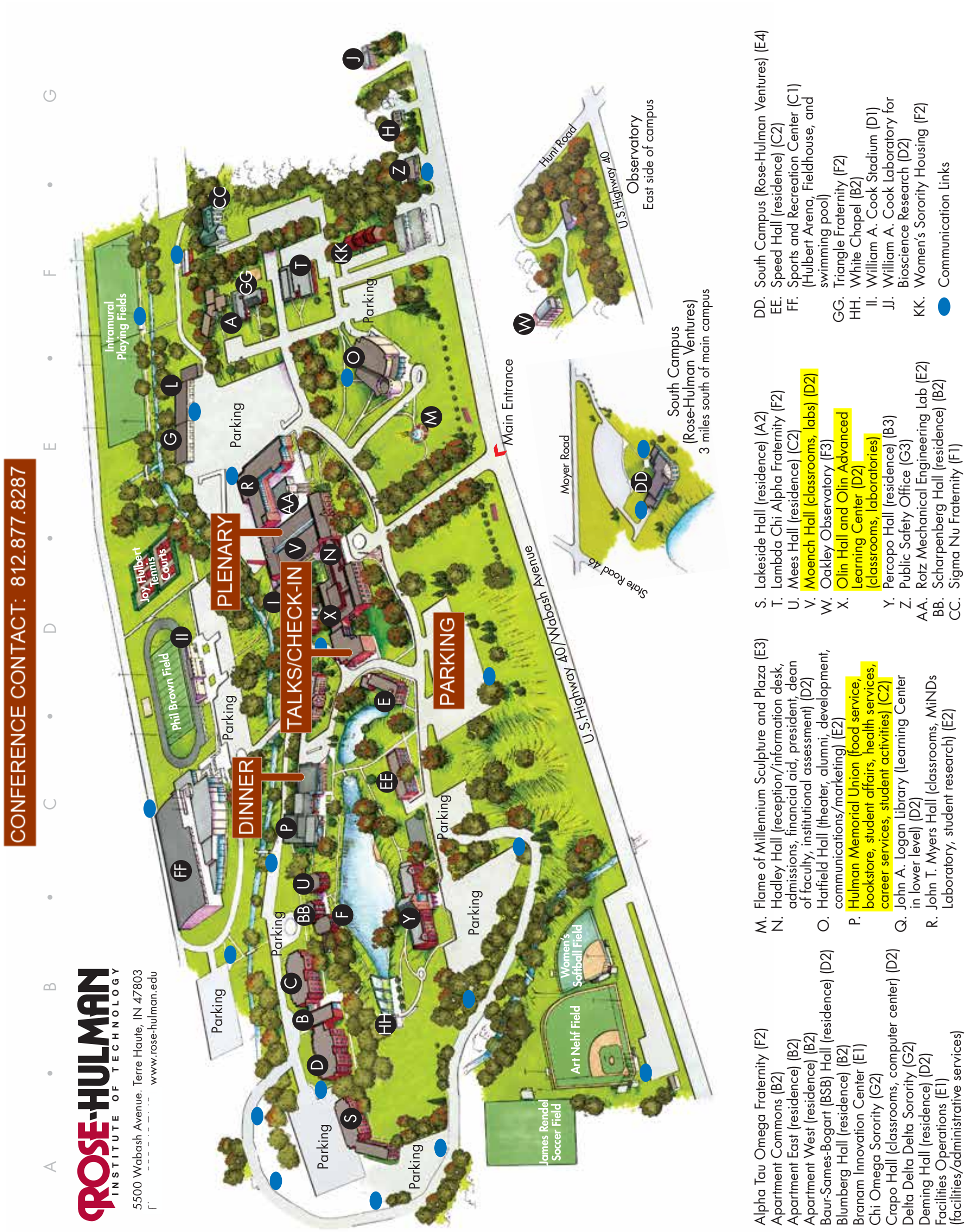
We thank you for choosing to stay at the conference hotel. Your patronage keeps housing costs lower, allowing us to subsidize the cost for many students attending the conference.

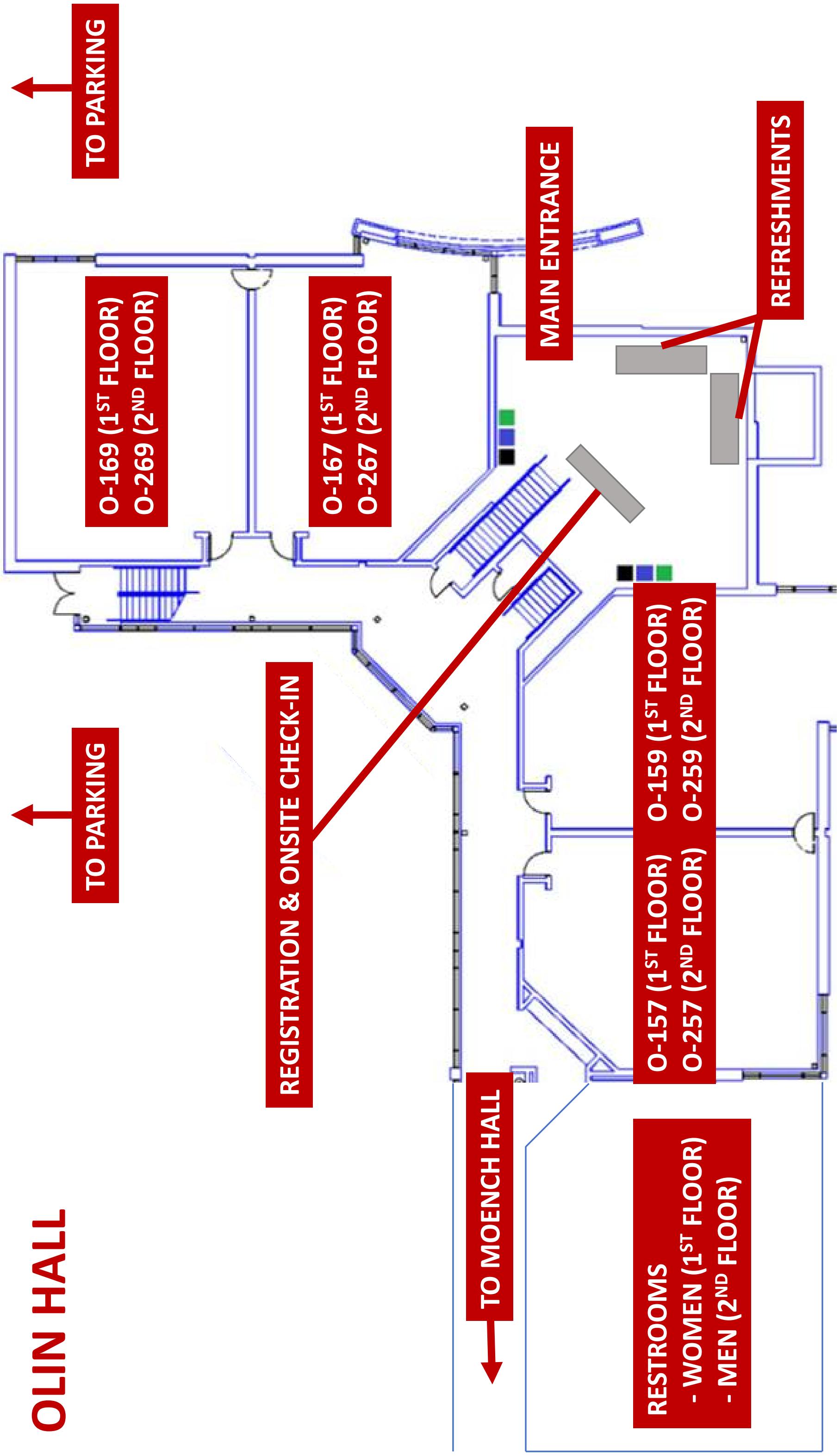
Restuarants
Terre Haute is home to many large chains. On State Road 46, just off Interstate 70, there are a few fast food options and a Mexican restaurant located near the Walmart complex. Downtown Terre Haute offers some local restaurants; local favorites include Mogger's and Saratoga. Third Street, near Interstate 70 and the Honeycreek Mall offers a plethora of options including fast food and larger chains.

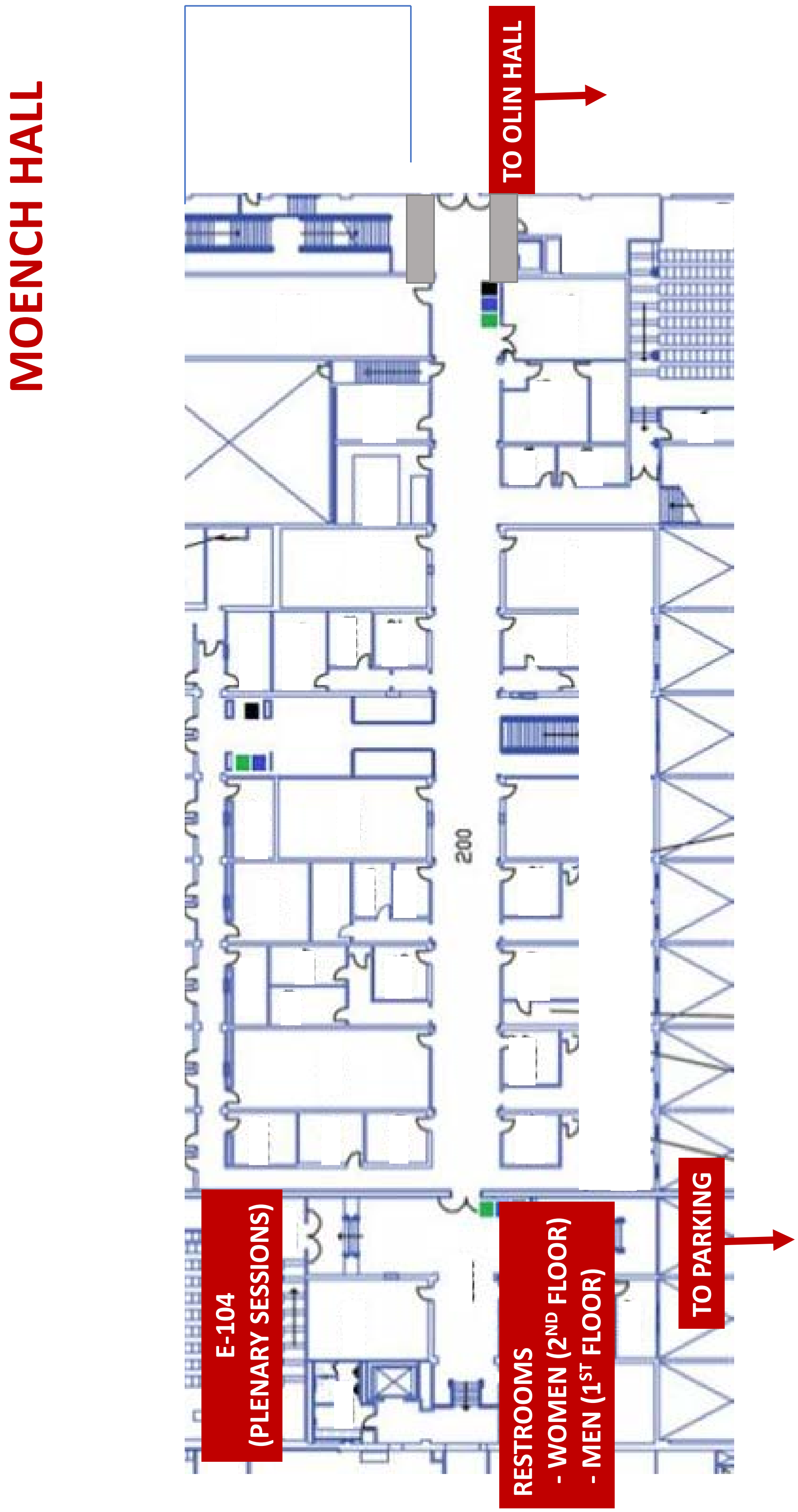
While the conference is providing dinner on Friday evening and lunch on Saturday afternoon, conference attendees are responsible for lunch on Friday and breakfast Saturday morning. The conference hotel will provide breakfast on Saturday morning for those staying at the Quality Inn. If you are not staying at the conference hotel, there are several breakfast options (Bob Evans, Cracker Barrel, Denny's, McDonald's, etc.) on Third Street. The conference will provide light refreshments on Saturday morning.

Floor Plans

Check-in and registration, as well as the short courses and contributed student talks will be in Olin Hall. Following the contributed talks, dinner will be held in the Lake Room within the Hulman Memorial Union. The plenary sessions and panel discussion will take place on the top floor of Moench Hall.




OLIN HALL
TO PARKING
TO PARKING
O-169 (1ST FLOOR)
O-269 (2ND FLOOR)
O-167 (1ST FLOOR)
O-267 (2ND FLOOR)
MAIN ENTRANCE
REFRESHMENTS
REGISTRATION & ONSITE CHECK-IN
O-159 (1ST FLOOR)
O-259 (2ND FLOOR)
O-157 (1ST FLOOR)
O-257 (2ND FLOOR)
TO MOENCH HALL
RESTROOMS
- WOMEN (1ST FLOOR)
- MEN (2ND FLOOR)


MOENCH HALL
TO OLIN HALL
200
E-104
(PLENARY SESSIONS)
RESTROOMS
- WOMEN (2ND FLOOR)
- MEN (1ST FLOOR)
TO PARKING

Program Summary

Friday, April 20

Time	Event	Location
12:00pm - 5:00pm	**Conference Registration and Onsite Check-In**	Olin Hall
1:00pm - 3:30pm	**Short Course**	Olin Hall (Upper Level)
	Introduction to Data Science Mark Ward	O-259
1:30pm - 3:30pm	**Short Courses**	Olin Hall (Upper Level)
	Making Euclidean Geometry More Complex Peter G Andrews	O-267
	Upping your LaTeX Game: Class Files, Scripting, and Graphics Tim All	O-269
3:55pm - 5:30pm	**Contributed Papers**	Olin Hall (Upper Level)
3:55pm - 4:15pm	**Comparison of Statistical Procedures to Identify Technicians with Terminal Digit Preference in Blood Pressure Measurements** Amber Young	O-259
	Optimizing Credit Card Fraud Detection with Limited and Imbalanced Data Samuel Showalter	O-267
	A Real Variable Equivalence of the Riemann Zeta Hypothesis Using Step Functions Jack VanSchaik	O-269
4:20pm - 4:40pm	**Past vs. Present Comparison of The Relative Age Effect Reversal Among Canadian-Born NHL Hockey Players** Jesse Stires	O-259
	Data Mining Graduate School Admissions Hao Qiu, Pengyu Chen, Ruorong Yin	O-267
	Measurements for the Construction of Nested Hyperbolic Squares Thomas Westrick	O-269
4:45pm - 5:05pm	**Negative Binomial Generalized Linear Mixed Models and Practical Applications in R** Sydney Benson	O-259
	Can you hear the shape of data? Zach Eisenreich	O-267
	Mathematical Modeling of Growth of Internal Cracks in Pipelines Georgia Warnock, Jerry Magana	O-269
5:10pm - 5:30pm	**Programming Across MS Office Products Using VBA** Krysten Schultz	O-259
	Bootstrap-based Non-parametric ANOVA Bochuan Lyu	O-267

	TSP Meta-Learning Using Deep Neural Networks Adam Gastineau	O-269
5:45pm - 6:45pm	**Dinner**	Hulman Memorial Union (Lake Room, Lower Level)
7:00pm - 8:15pm	**Plenary Session** **The Statistics Behind a Personalized Look** Hilary Parker	Moench Hall (E-104)

Saturday, April 21

8:30am - 9:00am	**Conference Registration and Onsite Check-In**	Olin Hall
9:00am - 10:00am	**Plenary Session** **Bayesian Search for Missing Aircraft, People, and Ships** Lawrence D Stone	Moench Hall (E-104)
10:15am - 11:25am	**Contributed Papers**	Olin Hall (Lower Level)
10:15am - 10:35am	**Reclassification of Protein Families through Uncertain Data Envelopment Analysis** Casey Garner	O-157
	kth-Order Fibonacci-like Polynomials Alexandra Embry	O-159
	Big Data Visualization: HoloLens Transforms Users to Data Scientists Dylan Martin	O-167
	Noise-Induced Stabilization of Perturbed Hamiltonian Systems Anthony Coniglio	O-169
10:40am - 11:00am	**Modeling acute blood flow responses to a major arterial occlusion** Erin Zhao	O-157
	The Square-Sum Problem Isaac Dragomir	O-159
	Using Time and Location to Analyze the Effectivity of Machine Learning Algorithms Cailey Farrell, Meera Haridasa	O-167
	The Mathematics of Poker: Extending the Nash-Shapley Model Tanner Corum, Ajay Dugar, Kevin Grosman, Haoyu Wang	O-169
11:05am - 11:25am	**Mathematical Modeling of Novel Bio-Active Nano Coatings of Dental Implants** Chasen Campbell, Nathan Clement, Jerry Magana	O-157
	Definability in Expansions by a Generalized Cantor Set Yuanqi Li	O-159

	Using Boosted Regression Trees to Predict Invasive Species Richness Namaluba Malawo	O-167
	The Cantor Set and Hyperbolic Geometry Sean Douglas	O-169
11:35pm - 12:05pm	**Panel Discussion: Career Paths in Mathematics**	Moench Hall (E-104)
12:05pm - 12:35pm	**Lunch**	Olin Hall (Main Lobby)
12:40pm - 1:50pm	**Contributed Papers**	Olin Hall (Lower Level)
12:40pm - 1:00pm	**Smoking Dynamics with Health Education Effect** Zeyu Zhang	O-157
	On the Computation of Wilf Partitions Simon Langowski	O-159
	An Optimal Strategy for simplified yahtzee Han Wei	O-167
	Using Dynamic Programming to Optimize Formula-Style Race Cars Evelyne Maquelin	O-169
1:05pm - 1:25pm	**Cell Data Mining and Phenotypic Classification Using Image Analysis of Epigenetic Modifications** Chris Bryan	O-157
	Classification and Visualization of Poisson Structures in Low Dimensions Oscar Araiza Bravo, Jessica Bai, Leonardo Rodriguez, Jordan Stempel	O-159
	Variants of the Monty Hall Problem and Battleship Sean Russell	O-167
	A Search for Exotic Gravity Haley Drabek, Josh Apanavicius	O-169
1:30pm - 1:50pm	**Redefining the Biomass Growth Equation in the FBA Model** Ariel Bohner	O-157
	The Uniform Distribution of Farey Fractions Lee Trent	O-159
	A Proof of the "Magicness" of the Siam Construction of a Magic Square Joshua Arroyo	O-167
2:00pm - 3:00pm	**Plenary Session** **Clocks in Mice and Flies and Bears, Oh My!** Tanya Leise	Moench Hall (E-104)
3:00pm - 3:15pm	**Closing Remarks**	Moench Hall (E-104)

Program | Short Courses

Introduction to Data Science

Mark Daniel Ward
Associate Professor of Statistics, Purdue University
Time: Friday, 1:00pm - 3:00pm
Location: O-259

We will have a hands-on overview of some of the tools that data scientists use for working with data, including large data sets. The workshop topics can be slightly flexible and open to discussion, depending on the interests of the participants. At a minimum, we will introduce students to R and RStudio, data visualization, and perhaps some tools for scraping and parsing XML directly from the web and processing the scraped data in R. All participants are encouraged to bring a laptop...and to be excited to learn about some of the introductory nuts and bolts of data science. No computational background is needed for this workshop.

Making Euclidean Geometry More Complex

Peter G Andrews
Professor of Mathematics, Eastern Illinois University
Time: Friday, 1:30pm - 3:30pm
Location: O-267

The goal of this course is to explore how complex numbers can be used to describe classical analytic geometry in the plane. We will start with a review of complex numbers including the definition and geometry of the basic operations – addition, multiplication, and conjugation. This will lead to complex versions of classical notions such as perpendicularity, parallelism, lines, and circles . We will develop complex proofs of a few classical Euclidean theorems and conclude by classifying all isometries of the plane – in complex terms, of course. A fleeting familiarity with complex numbers will help, but really all that will be needed to follow the material is knowing how to describe a straight line in the plane and what perpendicular and parallel mean in ordinary Euclidean geometry.

Upping Your LaTeX Game: Class files, scripting, and graphics

Timothy All
Assistant Professor of Mathematics, Rose-Hulman Institute of Technology
Time: Friday, 1:30pm - 3:30pm
Location: O-269

LaTeXis the de facto standard when it comes to typesetting mathematics and scientific documents. In this workshop, we aim to give an overview of some of the more advanced features available in LaTeX. Specifically, we will explore the following:

- the creation of custom packages and document classes to avoid those mile-long preambles,
- other TeX engines with specific emphasis on LuaLatex which includes Lua as an embedded scripting language. This allows for a host of useful applications (e.g., creating custom assignment classes that auto-populate a table of scores or an answer key, or that randomly generate similar problems upon compiling),
- the various tools and add-ons available for creating high-quality 2D and 3D vector graphics in LaTeX.

Templates and/or minimal working examples will be provided for those who wish use or otherwise tootle around with those demos used in the workshop.

Program | Plenary Sessions

The Statistics Behind a Personalized Look

Dr. Hilary Parker
Data Scientist, Stitch Fix
Time: Friday, 7:00pm - 8:00pm
Location: E-104, Moench Hall

Stitch Fix is an ecommerce site that delivers personalized recommendations to customers, helping them discover what they love. Behind that effort are almost 80 data scientists from a large variety of backgrounds. As a team, we work on myriad problems which include optimizing our styling algorithm that acts as a first pass through our inventory, perfecting our stylist-facing interface for our unique "human in the loop" problem, analyzing changes to our site using A/B testing, and accurately modeling demand. In this talk, I will discuss the various roles on the team, as well as the foundational skills that can be taught to set students up for success.

About Hilary: Hilary Parker is a Data Scientist at Stitch Fix and co-founder of the Not So Standard Deviations podcast. She focuses on R, experimentation, and rigorous analysis development methods such as reproducibility. Formerly a Senior Data Analyst at Etsy, she received a PhD in Biostatistics from the Johns Hopkins Bloomberg School of Public Health. Hilary can be found on Twitter at @hspter.

Bayesian Search For Missing Aircraft, People, and Ships

Dr. Lawrence D. Stone
Chief Scientist, Metron
Time: Saturday, 9:00am - 10:00am
Location: E-104, Moench Hall

In recent years there have been a number of highly publicized searches for missing aircraft such as the ones for Air France flight AF 447 and Malaysia Airlines flight MH 370. Bayesian search theory provides a well-developed method for planning searches for missing aircraft, ships lost at sea, or people missing on land. The theory has been applied successfully to searches for the missing US nuclear submarine Scorpion, the SS Central America (ship of gold), and the wreck of AF 447. It is used routinely the by U. S. Coast Guard to find people and ships missing at sea. This talk presents the basic elements of the theory. It describes how Bayesian search theory was used to locate the wreck of AF 447 after two-years of unsuccessful search and discusses how it was applied to the search for MH 370. A crucial feature of Bayesian search theory is that it provides a principled method of combining all available information about the location of a search object. This is particularly important in one-of-a-kind searches such as the one for AF 447 where there is little or no statistical data to rely upon.

About Lawrence: Dr. Stone joined Metron in 1986. He became Chief Operating Officer in 1990 and Chief Executive Officer in 2004. In 2010 he returned to primarily technical work as Chief Scientist at Metron.

In 1986, he produced the probability maps used to locate the S.S. Central America which sank in 1857, taking millions of dollars of gold coins and bars to the ocean bottom one and one-half miles below. He was one of the primary developers of the U. S. Coast Guards Search and Rescue Optimal Planning System (SAROPS) used by the Coast Guard since 2007 to plan searches for people missing at sea. In 2010 he led the team that produced the probability distribution that guided the French to the location of the underwater wreckage of Air France Flight AF447. He coauthored the 2016 book Optimal Search for Moving Targets. He continues to work on a number of detection and tracking systems for the United States Navy and is coauthor of the 2014 book, Bayesian Multiple Target Tracking 2nd Ed.

Clocks in Mice and Flies and Bears, Oh My!

Dr. Tanya Leise
Chair of the Department of Mathematics, Amherst College
Time: Saturday, 2:00pm - 3:00pm
Location: E-104, Moench Hall

Most creatures on earth have internal circadian clocks that regulate our daily rhythms of activity and sleep. Like mechanical clocks, these biological clocks keep regular, precise time and can be reset to match external time, for instance, adjusting to changes in time zone. Well take a look at analysis of circadian clock oscillations in behavioral and molecular records of mice, fruit flies, and brown bears, employing a variety of methods ranging from autocorrelation to wavelet transforms. In mice and flies, we can track expression of a key clock gene, while in brown bears we have records of activity and body temperature rhythms. Our data for these noisy biological oscillators often include relatively few cycles, so that reliable estimation of period can be quite challenging. The phase relationships between different rhythms in the same organism, e.g., between temperature and activity or between intracellular calcium levels and clock gene expression, are also of interest, as well as transient changes in relative phase following a disruption, potentially yielding insight into how such rhythms might be coupled.

About Tanya: Tanya Leise has been teaching in the Department of Mathematics & Statistics at Amherst College since 2004, and currently chairs the department. Her courses focus primarily on applied mathematics, including multivariable calculus, applied linear algebra, differential equations, mathematical modeling, and Fourier and wavelet analysis. Tanya's research on biological oscillators focuses on circadian rhythms in mammals and is highly interdisciplinary in nature. She works with colleagues in neuroscience and biology to study the physiological mechanism of the circadian clock at the cellular and tissue levels in a variety of organisms. She utilizes a mix of mathematical modeling and wavelet-based time series analysis to gain insight into the circadian clock.

Program | Contributed Papers

Abstracts of contributed papers are listed below.

3:55 PM to 4:15 PM

Comparison of Statistical Procedures to Identify Technicians with Terminal Digit Preference in Blood Pressure Measurements

Amber Young, Purdue University
Location: O-259

Reducing systemic error is essential in any experiment to produce accurate and repeatable results. However, error is intrinsic to any measurement taken by humans. In a recent experiment involving the effect of diet on blood pressure, a quality control procedure was sought to ensure that the technicians taking the blood pressures did not show any error or bias in their measurements. In particular, the procedure would focus on the terminal digits of the blood pressure measurements to determine if any of the technicians showed a terminal digit preference (i.e. consistent rounding off to zero). An expert on the project created an algorithm to identify technicians with serious digit preference based on the percentages of each terminal digit. To guarantee identification of these technicians, the proposed algorithm was compared with other statistical tests. Properties of the tests considered in this comparison were type I error, type II error, power, and sensitivity to sample size. These test properties were analyzed using a simulation created to generate terminal digit data from its probability distribution. This project discusses which test — or quality control procedure — would minimize errors, maximize power, and be accurate with a small sample size.

Optimizing Credit Card Fraud Detection with Limited and Imbalanced Data

Samuel Showalter, DePauw University
Location: O-267

The past decade has given rise to a multitude of statistical and computational fraud detection methods. Of note, machine learning has automated much of the initial screening process, notifying banks of – or even blocking –potentially fraudulent transactions instantly. However, fraud methods are continuously evolving, and an enormously small amount of transactions are fraudulent relative to total purchases. This imbalance starves traditionally trained machine learning models of the content necessary to detect fraud. Regardless, recent surveys have found credit card fraud alone costs companies billions every year, underscoring the importance of overcoming data imbalance.

This study examines three separate factors of fraud detection via statistical analysis and machine learning. First, it assesses the potential for different sampling methods – under-sampling and SMOTE (Synthetic Minority Oversampling Technique) – to improve algorithm performance.

Additionally, several supervised machine learning algorithms used in fraud detection (Support Vector Machine, Random Forest, Logistic Regression, Gaussian Naive Bayes, and K-Nearest Neighbors) are evaluated based on total fraud-cost savings in addition to traditional performance metrics.

Finally, a genetic algorithm is implemented to identify if an ensemble of these algorithms can outperform its individual components. This study utilizes fraud transactions published by an unnamed European bank or banks that occurred over two days in September 2013. For privacy purposes, data was transformed using Principal Component Analysis before being posted by Kaggle.com.

A Real Variable Equivalence of the Riemann Zeta Hypothesis Using Step Functions

Jack VanSchaik, Purdue University
Location: O-269

Prime numbers are an important concept in both applied and pure math. In 1859, Bernhard Riemann published a paper hypothesizing that prime locations are related to the zeros of a certain analytic function, the Riemann zeta function. This idea, now referred to as the Riemann hypothesis, has evolved into perhaps the most famous unsolved problem in mathematics. As mathematicians, we must be willing to look at the Riemann hypothesis through a different lens. We introduce a class of real step functions, which will lead to several identities linking staircase functions to the Riemann zeta function in unexpected ways. We discuss a reformulation of a real variable equivalence of the Riemann hypothesis: the Nyman-Beurling density statement. The density of step functions in the context of Nyman-Beurling is discussed, leading to some new insights.

4:20 PM to 4:40 PM

Past vs. Present Comparison of The Relative Age Effect Reversal Among Canadian-Born NHL Hockey Players

Jesse Stires, Sienna Heights University
Location: O-259

The relative age effect that is associated with cut-off dates for hockey eligibility has been a continuous debate within the academic, athletic, and popular media circles. This effect can primarily be seen in Canadian Major Junior Hockey League. In this league there is a disproportionate amount of young players with birthdays that fall in the first three months of the year. However, when the rosters from the National Hockey Association are analyzed for Canadian born players with a similar trend in birthdays, the pattern is not as prevalent. Using research done by Gibbs, Jarvis, and Dufur (2011), it is seen that the relative age effect described by Gladwell (2008), is moderately high for the average Canadian National Hockey League player and reverses when examining the most elite professional players (All-Star and Olympic rosters). Gibbs, Jarvis, and Dufur (2011) came to the conclusion that there is a surprising relative age effect reversal that occurs from the junior leagues to the most elite level of hockey play. Using the same research methods and data collection methods as Gibbs, Jarvis, and Dufur (2011) of present day rosters, a comparison will be conducted to see if this trend of a reverse relative age effect still holds true.

Data Mining Graduate School Admissions

Hao Qiu, Pengyu Chen, Ruorong Yin, University of Illinois
Location: O-267

Students applying to graduate programs naturally would like to know, as precisely as possible, their chances of getting admitted at a particular school. Is Northwestern harder to get into than Wisconsin for an applicant to a Math PhD program? Is UC Santa Barbara harder to get into than Cornell for an applicant to a Physics PhD program? We seek to answer such questions by analyzing admission results posted by applicants to Math and Physics PhD programs at online forums. Each record includes complete GRE and GPA scores of the applicant, as well as lists of schools at which the applicant has been accepted or rejected. Using statistical and machine learning techniques, we seek to predict the admission outcome, and the rank of a school at which a student is likely to get accepted. We also use the user-reported admission outcomes, along with matrix-based ranking methods, to rank schools in terms of their relative difficulty of getting admitted, and we compare this "empirical" ranking to well-known rankings such as those of US News and World Report.

Measurements for the Construction of Nested Hyperbolic Squares

Thomas Westrick, Aquinas College
Location: O-269

In the Poincaré disk, hyperbolic squares have sides with hyperbolic lengths dependent on the angle size of the square. The Euclidean lengths, however, depend on location. The constructions for these squares turn out surprisingly simple, considering these size constraints. Participants will produce nested hyperbolic squares of their own using compass and straightedge.

4:45 PM to 5:05 PM

Negative Binomial Generalized Linear Mixed Models and Practical Applications in R

Sydney Benson, University of St. Thomas
Location: O-259

Linear models — a statistical modeling staple since the beginning — have been generalized to account for non-normal response variables in generalized linear modeling and correlated data in linear mixed modeling. These models have been combined to produce generalized linear mixed models. Our research expands on the abilities of the R package glmm, which creates generalized linear mixed models, to include the ability to model relationships with a response following a negative binomial distribution and utilize parallel computing to increase the speed of calculations. Prior to our work, the package had the functionality to model relationships with response variables following Poisson and binomial distributions and had the capability of utilizing a single core for data processing. In this session, I will introduce generalized linear mixed models and explain the utility of negative binomial modeling. Additionally, I will illustrate the more rapid processing abilities of the package.

Can you hear the shape of data?

Zach Eisenreich, Westminster College

Location: O-267

Manifold learning has ascended to a prominent role in the fast-developing field of Data Science. In this talk, we will discuss a particular method for dimension reduction and data representation using Laplacian Eigenmaps. Techniques from spectral graph theory are applied to optimize the embedding of a lower-dimensional data manifold into a higher-dimensional ambient space. The connections between the choice of weights for the graph and the heat kernel are also explored. Time permitting, we will indicate possible numerical investigations.

Mathematical Modeling of Growth of Internal Cracks in Pipelines

Georgia Warnock, Jerry Magana, University of North Georgia

Location: O-269

In this research, we solved integral and differential equations to obtain a resulting equation which models the growth of the radius of a crack. Pipelines are used in many countries to transport precious fuels and materials. However, pipelines are susceptible to tiny cracks, or fractures, due to pressure, stress, and other factors. These fractures start small, but grow over time, causing leaks and spills of expensive substances and small catastrophes. We conducted research to learn more about the factors behind the cracks and to model the growth of the fractures. We found the equation for the growth of the radii of inner cracks to be dependent on time. Likewise, our results show that the radius of an internal crack grows at a constant rate as a function of time. This rate of growth can be modeled mathematically. These results have been confirmed by experiments.

5:10 PM to 5:30 PM

Programming Across MS Office Products Using VBA

Krysten Schultz, Sienna Heights University

Location: O-259

This project outlines what I have learned with regards to programming in VBA for MS Office products during my internship. The purpose of this project is to explain both what I have accomplished and what is possible to do using VBA code.

Bootstrap-based Non-parametric ANOVA

Bochuan Lyu, Rose-Hulman Institute of Technology

Location: O-267

A large set of statistical problems exist where we cannot make stringent assumptions on the underlying random process within the data. The bootstrap is a computer-intensive method which we might employ to solve these types of questions. For example, ANOVA is a classical method for factorial data analysis where variance is partitioned by factors. The contribution of each factor is traditionally assessed by an F-statistic. However, it is not always possible to meet the assumptions for F-test. The challenge of this problem is intensified by the hierarchal nature of these models when more than 1 factor is presented. Bootstrap techniques are one nonparametric solution for such scenarios. During the talk, I will introduce the ideas of bootstrap and how to implement bootstrap in 2-way ANOVA. A new R function will be employed to demonstrate the technique in an analysis.

TSP Meta-Learning Using Deep Neural Networks

Adam Gastineau, Rose-Hulman Institute of Technology
Location: O-269

The Traveling Salesperson Problem (TSP) is a classically difficult combinatorial optimization problem, often taking immense computational time to find an optimal solution. Heuristics and meta-heuristics (heuristics designed for heuristics) are therefore commonly used to find quality solutions (though not provably optimal) in a short period of time. Since different heuristics can produce different solutions and there is no general ¡U+0093¿best heuristic¡U+0094¿ for all instances, meta-heuristics can be used to choose the optimal heuristic to run. In this talk we present preliminary results that use Deep Neural Networks to create a learning meta-heuristic, identifying which heuristics are best to run on various TSP instances.

10:15 AM to 10:35 AM

Reclassification of Protein Families through Uncertain Data Envelopment Analysis

Casey Garner, Rose-Hulman Institute of Technology
Location: O-157

Proteins are classified into functionally similar families. A protein's structure closely associates with its function; therefore, understanding how proteins are structurally related is essential for predicting a protein's possible task in a cell. Uncertain Data Envelopment Analysis (uDEA) is a computational tool that is being adopted to see if proteins could be members of multiple families. uDEA accomplishes this task by computing the minimum amount of uncertainty necessary in a protein's atomic coordinates to achieve the highest adherence to the structure of the proteins in a given family. For example, let Protein A be a member of Family I. If Protein A is not structurally similar to the proteins in Family II, then a high amount of uncertainty would be needed of Protein A's atomic coordinates for it to appear similar to the proteins of Family II. However, if Protein A was not overly disjoint from the proteins in Family II, then a small amount of uncertainty would be needed for Protein A to have a high correspondence with the proteins in Family II. A model of efficiency evaluates how well proteins fit into their respective families, and how well they disassociate with proteins from other families. The main goal of this research is to locate the familial overlaps that exist for various proteins in the hope that this added knowledge will aid biologists in their pursuits of protein understanding.

kth-Order Fibonacci-like Polynomials

Alexandra Embry, Indiana University

Location: O-159

The well-studied Fibonacci polynomials are described by $F_n(x) = xF_{n-1}(x) + F_{n-2}(x)$ with $F_0 = 1$ and $F_1 = x$. We extend this recursive polynomial sequence to $G_n^{(k)}(x) = xG_{n-1}^{(k)}(x) + G_{n-k}^{(k)}(x)$ and further to $H_n^{(k)}(x) = xH_{n-1}^{(k)}(x) - H_{n-k}^{(k)}(x)$ with initial conditions $G_0^{(k)} = G_1^{(k)} = \cdots = G_{k-1}^{(k)} = 1$ and $H_0^{(k)} = H_1^{(k)} = \cdots = H_{k-1}^{(k)} = 1$. When $k = 2$, the $G_n^{(k)}$ polynomials are the Fibonacci polynomials with altered initial conditions. When $k = 3$ and $x = 1$, the $G_n^{(k)}$ polynomials describe Narayana's Cow Sequence. In this talk, we present a closed form for these polynomials from which we derive a class of significant integer sequences. We also study some interesting analytic properties of these polynomials, especially concerning the behavior of their roots. We establish that the minimal real roots of $G_n^{(k)}(x)$ converge uniformly to some number $-3 < r^{(k)} < -1$, and the maximal real roots of $H_n^{(k)}(x)$ converge uniformly to 2. MATLAB simulations show that the roots of $G_n^{(3)}$ are rational for only $n = 3, 5, 6, 10$, and 19, and those of $H_n^{(3)}$ are rational for only $n = 3$ and 12. Computer-assisted curve fitting using MATLAB suggests that the relative rates of convergence of the minimal real roots of $G_n^{(k)}$ and the maximal real roots of $H_n^{(k)}$ are of exponential order.

Big Data Visualization: HoloLens Transforms Users to Data Scientists

Dylan Martin, Purdue University

Location: O-167

Large amounts of data are created and stored daily, and it is no wonder that scientists are seeking innovative, meaningful mediums through which to display their impactful analyses. Data scientists are now asked to find new ways to visualize large quantities of data in ways that engage an audience and effectively inform without overwhelming them. In this research, I intend to explore the developing technology of Augmented Reality through the Microsoft HoloLens as a means to display heterogeneous datasets that vary in size, variety, and formats. I will construct an application for the HoloLens that acts as a framework to embed various analyses of datasets in a three-dimensional environment. Such a framework will more easily enable visualization of statistical models on large datasets. Visualization is the process of transforming disparate, often complex data into a visual representation that is easy to understand. Users will be able to manipulate statistical analyses at will, encouraging deeper understanding and inspiring an interest in data analysis and visualization. This material is based upon work supported by the National Science Foundation under Grant No. 1246818.

Noise-Induced Stabilization of Perturbed Hamiltonian Systems

Anthony Coniglio, Indiana University
Location: O-169

Noise-induced stabilization is the phenomenon in which the addition of randomness to an unstable system of ordinary differential equations results in a stable system of stochastic differential equations. With stability defined as global stochastic boundedness, Hamiltonian systems can never be stabilized by the addition of noise that is constant in space. In this talk, we investigate how to deterministically perturb a class of unstable Hamiltonian systems in such a way that the qualitative behavior is preserved, but that enables the systems to exhibit noise-induced stabilization.

10:40 AM to 11:00 AM

Modeling acute blood flow responses to a major arterial occlusion

Erin Zhao, IUPUI
Location: O-157

Peripheral arterial disease (PAD) is a serious illness in which major arteries become blocked, causing reduced blood flow to peripheral tissues. In some cases, the body can effectively compensate after an arterial occlusion, but often PAD results in severe pain and possible limb loss. Improved diagnoses and treatments for PAD require a more complete understanding of the changes that occur in vascular segments both proximal and distal to the site of occlusion; such information can be investigated using mathematical modeling. Here, a mathematical model of the vasculature of the rat hindlimb is developed to predict the immediate (acute) changes in vessel diameters and smooth muscle tone following femoral arterial occlusion. Vascular responses to changes in pressure (myogenic response), shear stress, and metabolic levels are modeled, and both resting and exercising conditions are simulated. The preliminary results suggest that after occlusion, despite significant dilation of collateral arteries, the oxygen saturation and blood flow to tissues in the calf are still significantly reduced. In this project, the model is calibrated to additional experimental data and will be used to assess the relative importance of changes in the diameters and numbers of different vessel types on restoring flow to its pre-occlusion levels.

The Square-Sum Problem

Isaac Dragomir, Trinity International University
Location: O-159

On January 11, YouTube channel Numberphile featured Matt Parker discussing an intriguing problem from his 2014 book "Things to Make and Do in the Fourth Dimension": "Arrange the numbers 1 to 15 in such a way that if you add each adjacent pair of numbers you always get a square number" (p. 48). This presentation's titular problem asks if such an arrangement is possible for all n, where n is the largest integer in the arrangement. We shall explore the interesting history of this problem — ¡U+009D¿including a possible proof — ¡U+009D¿and offer conjectures on its generalization.

Using Time and Location to Analyze the Effectivity of Machine Learning Algorithms

Cailey Farrell, Meera Haridasa, Purdue University

Location: O-167

Large amounts of data are sent and received every day. Therefore, computers need faster working algorithms to analyze data more efficiently. Today, machine learning algorithms only use an original training data set on different methods which can amount to hours of labor. Purdue University¡U+0092¿s CAM2 (Continuous Analysis of Many Cameras) team is investigating how to eliminate this step, by using time and location of the real-time images to train the methods more efficiently known as context learning. CAM2 has access to networking cameras all over the world and the goal is to eliminate human labeling. As a team, have manually labeled thousands of images to teach the machine how to do so on its own. We have also used several testing models, to see the difference between using trained data sets, versus time and location. Preliminary results suggest that using other methods may lessen the amount of human labor, creates better structured algorithms to handle large data analytics. CAM2 team is led by Professor Yung-Hsiang Lu along with Phd Student Kirubel Tadesse. This material is based upon work supported by the National Science Foundation under Grant No. 1246818.

The Mathematics of Poker: Extending the Nash-Shapley Model

Tanner Corum, Ajay Dugar, Kevin Grosman, Haoyu Wang, University of Illinois

Location: O-169

In 1938, John von Neumann proposed his now-famous mathematical model of poker. Over the years, other poker models have been proposed and studied by mathematicians (Borel, Bellman, Blackwell), economists (Kuhn, McAdams), and even professional poker players (Chris Ferguson). However, all of these models focus on the two-player case. It was not until 1950 that the first three-player poker model was proposed by John Nash and Lloyd Shapley, who derived optimal probabilistic strategies for each of the players. Their model remains one of the only mathematical poker models involving more than two players. The Nash-Shapley model assumes there are only two kinds of cards, high and low. At the beginning of the game, each player is dealt a card, chosen at random from the two kinds. The game then proceeds for up to five rounds of betting or passing actions. Nash and Shapley derived optimal betting probabilities for each player and each round of this game.

We implemented the Nash-Shapley model in Mathematica in order to have the ability to extend the model in new directions. In particular, we explored different player profiles (Random, Optimal, Semi-Optimal, Naive, Tight/Loose, Contrarian) in an effort to uncover the effects of different strategies on player profits. We did so by running simulations, as well as working out the relevant probabilities and expected values theoretically.

11:05 AM to 11:25 AM

Mathematical Modeling of Novel Bio-Active Nano Coatings of Dental Implants

Chasen Campbell, Nathan Clement, Jerry Magana, University of North Georgia
Location: O-157

The focus of this research is to determine a mathematical model for the bond strength of a novel bio-active nano coating onto a titanium dental implant. Osseointegration is the process of bone growing onto a bio-active coating. Initial research on bio-nano materials has shown potential for an improved rate of Osseointegration and improved bond strength. Since the discovery of Osseointegration, scientists have searched for ways to make the process more efficient and long lasting. Our research has focused on mathematical modeling of processes of Osseointegration, to create the tools to calculate the factors that affect Osseointegration and possible ways to improve the process. Our final goal is to mathematically determine the strength of the bond of the bio-nano coating with the implant surface. We calculated this strength through Density Functional Theory as well as Molecular Dynamics simulations. First step, we minimized a functional that describes the energy of a system in terms of electron density. The density functional is $E[\rho] = \int V(r)\rho(r)dr + (1/2)\int dr \int dr'[(\rho(r)\rho(r'))/|r - r'|] + Exc[\rho]$. That is a quadratic functional with respect to the electron density function, and we used the gradient method to minimize it. On the second step, of the Molecular Dynamics simulations, we also solved a series of partial differential equations to find new positions of the nuclei $MR'' = -jEmin(R)$. During calculations we calculated the bond strength for different types of coatings with different thicknesses, temperatures, and with various initial distances from the implant. In the future, that will allow us to give different recommendations on how to improve the quality of the implants.

Definability in Expansions by a Generalized Cantor Set

Yuanqi Li, Rose-Hulman Institute of Technology
Location: O-159

Definability is a central topic in first-order logic. We study the sets which are definable in expansions of the ordered additive group of real numbers. The middle-thirds Cantor set could be generalized for arbitrary base r¿=3, and define a non-empty set K which denotes the removed digits in the set building iterations. Consider the ordered additive group of real numbers expanded by a generalized Cantor set predicate, which decides whether an element is in the set. It is known that such structure has the same definable sets as the ordered additive group of real numbers expanded with predicate W(x,d,n), which gives description of the digits of base r expansion. We generalized this result to add a more generalized Cantor set predicate: for example, there are different sets of digits removed in alternate Cantor set building iterations.

Using Boosted Regression Trees to Predict Invasive Species Richness

Namaluba Malawo, Purdue University
Location: O-167

Invasive species have become a major problem in the US, but our understanding of invasion patterns and key drivers are still limited. Using a powerful tool in predictive biogeography, Boosted Regression Trees (BRTs), we created models which can predict exotic species distribution for the Eastern United States at a high resolution. BRTs build on binary decision trees and combine them to create a linear combination of many trees. This leads to a more accurate model of invasion prediction and allows us to better identify key underlying variables that drive the observed patterns. Ultimately, we were able to create a model with many trees and low deviance that could predict invasive plant species richness patterns for the Eastern United States. The data measures many different variables, including soil characteristics, biotic variables, and anthropogenic drivers. The results of our work will help us better understand drivers of invasion by quantifying the relative contribution of each variable. Additionally, the results from our studies can then be used by policy makers and practitioners to manage invasions of species with more proactive measures and preventative actions. This presentation builds on work previously presented. This work is supported by NSF grant DMS #1246818.

The Cantor Set and Hyperbolic Geometry

Sean Douglas, Greenville University
Location: O-169

We build the Cantor Set and determine what kind of points it contains using its ternary representation and also take a look at its length. We then give a brief introduction to hyperbolic geometry before introducing the Poincaré Disk Model and how points and lines are interpreted, as well as how distance is defined. The rest of the talk merges these topics as we build hyperbolic Cantor-like sets in the Poincaré Model and determine their topological properties as well as measure. The Cantor Function is then used as a counter example to provide motivation for the need to show that the hyperbolic Cantor-like sets have measure zero despite having a homeomorphism with the Cantor Set.

12:40 PM to 1:00 PM

Smoking Dynamics with Health Education Effect

Zeyu Zhang, University of Evansville
Location: O-157

This talk provides a mathematical study for analyzing the dynamics of smoking population with health education campaigns involved. The the local stability of smoking-free equilibrium is derived by the basic reproduction number. The global stabilities of both smoking-free equilibrium and smoking-present equilibrium are proved by using Lyapunov functions.

On the Computation of Wilf Partitions

Simon Langowski, Purdue University
Location: O-159

Wilf Partitions are a subset of partitions with the property that each number in the partition appears a unique number of times. While this is a hard concept to express in math notation, it lends itself to computing fairly easily, using techniques such as digital trees and dynamic programming. In this talk I will discuss the methods and patterns that can be used to compute large numbers of Wilf Partitions quickly, in particular focusing on the count of Wilf Partitions that subdivide a particular number. This material is based upon work supported by the National Science Foundation under Grant No. 1246818

An Optimal Strategy for simplified yahtzee

Han Wei, Rose-Hulman Institute of Technology
Location: O-167

Solitaire Yahtzee is a dice game with a number of rounds. There are five six-sided dice in the game. In each round, a player has three chances for rolling dice. On the first roll, the player need to roll all five dice. On the other rolls, the player can keep any dice they want and re-roll the other ones. In general Solitaire Yahtzee, there are thirteen rounds and the scorecard contains thirteen different score boxes. In each round, after the last roll, a player has to choose a score box. The score for the current round will be calculated based on the rule of that score box and will be put into that box. The final score is the sum of scores in all score boxes.

These is a example of score boxes: Large Straight: the player can get 40 points for five sequential dice or 0 point otherwise.

There are various cases during a Yahtzee game and the optimal strategy is not obvious. A single round of Yahtzee game can be modeled by Markov decision process. And then entire Yahtzee problem can be simplified with dynamic programming algorithm.

The presentation will provide the basic background introduction about Markov decision process and dynamic programming algorithm. The optimal strategy for a simplified yahtzee with 3 score boxes will be discuses.

Using Dynamic Programming to Optimize Formula-Style Race Cars

Evelyne Maquelin, Rose-Hulman Institute of Technology
Location: O-169

Lap Time Simulation, the translation of vehicle parameters into theoretical track times, is an integral part of the design and testing of motorsport vehicles. As such, Rose-Hulman Grand Prix Engineering (GPE) has developed their own lap time simulation tool.

The problem with current software is that it makes a lot of assumptions about what the best driver decisions at any one point could be. To get more accurate results, my senior thesis research revolves around objectively determining the optimal driver behavior around a given track. Due to the sequential and state-based nature of the problem, dynamic programming is a convenient way to accomplish this.

With dynamic programming we can model complex behaviors such as shifting, degree of acceleration, braking, etc. and find what sequence of driver actions leads to the fastest track time, most points, or other optimal criteria. This has incredible value during the GPE competition season.

This talk will show how to translate racing vehicle behavior into a dynamic programming problem, as well as the preliminary results of my research.

1:05 PM to 1:25 PM

Cell Data Mining and Phenotypic Classification Using Image Analysis of Epigenetic Modifications

Chris Bryan, Purdue University
Location: O-157

Epigenetics is the study of heritable changes in cells that do not involve DNA sequence. Mechanisms such as methylation and histone modifications can have large effects on the transcription levels of genes, and aberrant epigenetic changes are often associated with diseases such as cancer. These modifications can be quantified in live cells using fluorescent probes. Using image analysis software, complex visual measurements of the cell such as nucleus area and intensity can be extracted and analyzed using statistical software. Using machine learning algorithms such as principal component analysis, linear discriminant analysis, and support vector machines, cells can be classified according to their phenotype, cell line, or treatment group. We hope to use this research to gain insight into the role of epigenetic modifications on cellular processes such as resistance to cancer-treating drugs. This document is based upon work supported by the National Science Foundation under Grant No. 1246818.

Classification and Visualization of Poisson Structures in Low Dimensions

Oscar Araiza Bravo, Jessica Bai, Leonardo Rodriguez, Jordan Stempel, University of Illinois
Location: O-159

The study of Poisson manifolds arises from the interest in understanding conserved quantities for classical mechanical systems. In order to understand the dynamical flow of a physical system, our presentation focuses on the symplectic foliation prescribed by two and three dimensional bivectors satisfying the Schouten-Nijenhuis equation. In two dimensions all bivectors are Poisson and the linear ones are linearly isomorphic to the constant or affine Poisson structures. Although a general classification of Poisson bivectors in three dimensions is more challenging, we present a class of Poisson structures described in terms of a governing smooth function where the foliation coincides with the level sets of the function. Moreover, for two and three dimensional Lie algebras, the symplectic foliation can be realized as orbits of the co-adjoint action of the group on the dual of its algebra. We present a visualization of the (co)-adjoint orbits of both two and three dimensional Lie groups as well as an interactive calculator of polynomial Poisson brackets, and the Hamiltonian flows for two dimensional quadratic Hamiltonians.

Variants of the Monty Hall Problem and Battleship

Sean Russell, University of Evansville
Location: O-167

In this talk, we explore a few variants of the Monty Hall Problem. We created a program that allows a player to play or run simulations on various versions of the problem. We will focus on a few recent variations that add a component of propositional logic to the classic problem. First, we show that our simulations confirm the results from a paper on this variation. Then, we discuss a few additional variants. Finally, we talk about a new variant of the classic game, Battleship. We will conclude with a look at results from simulations on different strategies for this new version of Battleship.

A Search for Exotic Gravity

Haley Drabek, Josh Apanavicius, Indiana University
Location: O-169

The gravitational constant (commonly called 'Big G') is one of the most important fundamental constants in nature. It's used in calculations such as the mass of the earth to the orbit of planets. However, there's quite a big issue, the current accepted value of G is only known to 3 orders of magnitude: a horrific disgrace to modern experiment. The most modern experiments do not come within acceptable, or verifying, range of G. We explore improvements on modern G experiments, including how Gauge Theory can help us verify G, potentially approaching experiment where gravity can be shown to be an exotic phenomenon.

1:30 PM to 1:50 PM

Redefining the Biomass Growth Equation in the FBA Model

Ariel Bohner, Rose-Hulman Institute of Technology
Location: O-157

Flux Balance Analysis (FBA) is widely used in mathematical and computational fields for modeling metabolic systems, and its predictive efficacy to identify essential genes is over 90 percent. This precision depends on an accurate biochemical description of an inferred reaction that produces biomass, but the coefficients of this reaction are biologically and numerically suspect. This research seeks to prove whether FBA is as accurate as possible, and if not, whether the biomass coefficients and their bounds can be adjusted to better match experimental data. The method presented seeks provide a better biomass definition that works to eliminate false predictions of gene knockouts. The primary mathematical and computational tools that underlie our improvements are Theorem of the Alternatives, Vector Calculus, optimization, and iterative solving.

The Uniform Distribution of Farey Fractions

Lee Trent, Rose-Hulman Institute of Technology
Location: O-159

The Farey sequence of order n is the increasing sequence of reduced rational numbers between 0 and 1 inclusive whose denominator is at most n. These sequences are consequently a fairly natural way to enumerate the rational numbers. While they exhibit lots of very simple and intuitive properties due to their symmetry and order, they also exhibit more subtle and intricate properties which can produce interesting results about themselves, other rational numbers, and the real numbers in general. In particular, in 1946, Neville showed the density of the rational numbers in the Farey sequence of order n is “roughly uniform”¡U+009D¿ throughout the interval between 0 and 1 inclusive. In this largely expository talk, we will introduce Farey sequences and elaborate on Neville’s uniformity result. Time permitting, we will discuss possible generalizations in future guided research.

A Proof of the ”Magicness” of the Siam Construction of a Magic Square

Joshua Arroyo, Rose-Hulman Institute of Technology
Location: O-167

A magic square is an n x n array filled with n^2 distinct positive integers $1, 2, \ldots, n^2$ such that the sum of the n integers in each row, column, and each of the main diagonals are the same. A Latin square is an $n \times n$ array consisting of n distinct symbols such that each symbol appears exactly once in each row and column of the square. Many articles dealing with the construction of magic squares introduce the Siam method as a “simple” construction for magic squares. Rarely, however, does the article actually prove that the construction yields a magic square. In this paper, we describe how to decompose a magic square constructed by the Siam method into two orthogonal Latin squares, which in turn, leads us to a proof that the Siam construction produces a magic square.

Conference Attendees

Ty Adams	Rose-Hulman Institute of Technology
Anthony Aguilar	IUPUI
Joshua Apanavicius	Indiana University
Oscar Araiza Bravo	University of Illinois
Joshua Arroyo	Rose-Hulman Institute of Technology
Jessica Bai	University of Illinois Urbana-Champaign
Adam Baker	Rose-Hulman Institute of Technology
Elizabeth Bell	Purdue University
Sydney Benson	University of St. Thomas
Avni Bhalgat	Purdue University
Aaradhana Bharill	Rose-Hulman Institute of Technology
Andrew-David Bjork	Sienna Heights University
George Black	Greenville College
Ariel Bohner	Rose-Hulman Institute of Technology
Logan Bradley-Trietsch	Purdue University
Hannah Bredikhin	Purdue University
Ben Brubaker	Rose-Hulman Institute of Technology
Chris Bryan	Purdue University
Chasen Campbell	University of North Georgia
Sylvia Carlisle	Rose-Hulman Institute of Technology
Shreeya Chandra	Temple University
Cynthia Chang	Purdue University
Pengyu Chen	University of Illinois
Yifei Chen	Rose-Hulman Institute of Technology
Maggie Christy	Purdue University
Anthony Coniglio	Indiana University
Jess Corso	Rose-Hulman Institute of Technology
Tanner Corum	University of Illinois
Madeline Crews	Rose-Hulman Institute of Technology
Hope Cullers	Purdue University
Anna DeFries	Rose-Hulman Institute of Technology
Sean Douglas	Greenville College
Haley Drabek	Indiana University
Isaac Dragomir	Trinity International University
Ajay Dugar	University of Illinois
Riley Dunnagan	Rose-Hulman Institute of Technology
Joe Eicholz	Rose-Hulman Institute of Technology
Zach Eisenreich	Westminster College
Alexandra Embry	Indiana University
Cailey Farrell	Purdue University
Luke Francisco	Purdue University

Casey Garner	Rose-Hulman Institute of Technology
Adam Gastineau	Rose-Hulman Institute of Technology
William Green	Rose-Hulman Institute of Technology
Brittany Griggs	Purdue University
Ralph Grimaldi	Rose-Hulman Institute of Technology
Kieran Groble	Rose-Hulman Institute of Technology
Kevin Grosman	University of Illinois
Croix Gyurek	IUPUI
Katy Gyurek	
Kelsey Hall	Aquinas College
Matthew Hamilton	Westminster College
Meera Haridasa	Purdue University
Jordan-Taylor Harris	Purdue University
Daniel Havern	Purdue University
Megan Heyman	Rose-Hulman Institute of Technology
A J Hildebrand	University of Illinois
Rachel Hill	Greenville College
Joshua Holden	Rose-Hulman Institute of Technology
Allen Holder	Rose-Hulman Institute of Technology
Leanne Holder	Rose-Hulman Institute of Technology
Draven Houser	Greenville College
Thaddeus Hughes	Rose-Hulman Institute of Technology
Cobi Illian	Rose-Hulman Institute of Technology
Mark Inlow	Rose-Hulman Institute of Technology
Hailey Jack	Aquinas College
Carlyn Johannigman	Rose-Hulman Institute of Technology
Jeff Kallenbach	Sienna Heights University
Kali Lacy	Purdue University
Mariana Lane	Rose-Hulman Institute of Technology
Jayla Langford	Purdue University
Tom Langley	Rose-Hulman Institute of Technology
Simon Langowski	Purdue University
Thomas Leinart	Purdue University
Kevin Lewis	Rose-Hulman Institute of Technology
Weite Li	Rose-Hulman Institute of Technology
Yuanqi Li	Rose-Hulman Institute of Technology
Rafael Lovas	Purdue University
Sara Lynch	Purdue University
Bochuan Lyu	Rose-Hulman Institute of Technology
Ming Lyu	Rose-Hulman Institute of Technology
Namaluba Malawo	Purdue University
Evelyne Maquelin	Rose-Hulman Institute of Technology
Nicholas Marien	IUPUI

James Marshall Reber	Purdue University
Dylan Martin	Purdue University
Michael McDaniel	Aquinas College
John McSweeney	Rose-Hulman Institute of Technology
Aaron Minard	Greenville College
Igor Minevich	Rose-Hulman Institute of Technology
Michael Miron	Sienna Heights University
Garrett Mulcahy	Purdue University
Jonathan Myers	Rose-Hulman Institute of Technology
Tyler Netherly	Purdue University
Dean Netzler	Rose-Hulman Institute of Technology
Tucker Osman	Rose-Hulman Institute of Technology
Walt Panfil	Rose-Hulman Institute of Technology
Timothy Park	Purdue University
George Peters	Greenville University
Mary Petersen	Rose-Hulman Institute of Technology
Anna Poznyak	Purdue University
Hao Qiu	University of Illinois
Dave Rader	Rose-Hulman Institute of Technology
Ryan Rakers	Greenville College
Pradeep K. Ranaweera	Sienna Heights University
Emily Ray	Rose-Hulman Institute of Technology
Eric Reyes	Rose-Hulman Institute of Technology
Manda Riehl	Rose-Hulman Institute of Technology
Leonardo Rodriguez Gutierrez	University of Illinois
Sean Russell	University of Evansville
Kice Sanders	Rose-Hulman Institute of Technology
Zachary Schafer	Rose-Hulman Institute of Technology
Krysten Schultz	Sienna Heights University
Nate Schwindt	Rose-Hulman Institute of Technology
Phillip Shepard	Rose-Hulman Institute of Technology
Kathleen Shepherd	Monroe County Community College
Yosi Shibberu	Rose-Hulman Institute of Technology
Samuel Showalter	DePauw University
Jose Smokowski	Rose-Hulman Institute of Technology
Jacob Soehren	Rose-Hulman Institute of Technology
Jordan Stempel	University of Illinois
Michael Stiles	IUPUI
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Sarthak Suri	Rose-Hulman Institute of Technology
Dustin Swarm	Greenville University
Seiji Takagi	Rose-Hulman Institute of Technology
Wayne Tarrant	Rose-Hulman Institute of Technology

Andrew Thomack	Greenville College
Trang Tran	University of California, Riverside
Lee Trent	Rose-Hulman Institute of Technology
Madison Trout	Purdue University
Laura Troyer	Greenville College
Jack VanSchaik	Purdue University
Haoyu Wang	University of Illinois
Songyu Wang	Rose-Hulman Institute of Technology
Mark Daniel Ward	Purdue University
Georgia Warnock	University of North Georgia
Lauren Washington	Purdue University
Coleman Weaver	Rose-Hulman Institute of Technology
Han Wei	Rose-Hulman Institute of Technology
Thomas Westrick	Aquinas College
Tracy Weyand	Rose-Hulman Institute of Technology
Brenna Wiens	Greenville College
Robert Williams	Rose-Hulman Institute of Technology
Jennifer Wohlpart	Rose-Hulman Institute of Technology
Zhixin Wu	DePauw University
Pengcheng Xiao	University of Evansville
Ruorong Yin	University of Illinois
Amber Young	Purdue University
Zeyu Zhang	University of Evansville
Erin Zhao	IUPUI
Muqing Zheng	Rose-Hulman Institute of Technology