# Rose-Hulman
# Undergraduate Mathematics Conference

April 22 - 23, 2016

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

# Welcome

Welcome to the 33rd Annual Rose-Hulman Undergraduate Mathematics Conference. This conference serves as an opportunity to highlight the research being done by undergraduate mathematicians, statisticians and data scientists. 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 continue our education 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:** Mathematics is too often viewed by society as a necessary evil which is tolerated in service to the more noble sciences. Mathematics, however, is a very powerful tool which can be wielded to the benefit of the world around us. The theme of this year's conference, *Mathematics for a Better World: Data Science and Operations Research in Humanitarian Efforts*, emphasizes the opportunities available to those in the mathematical sciences for contributing to the betterment of society. Karen Smilowitz, Professor in the Department of Industrial Engineering and Management Sciences at Northwestern University, will discuss the use of operations research for humanitarian and non-profit logistics. Lauren Haynes, Senior Project Manager at the Center for Data Science and Public Policy at the University of Chicago, will discuss the role of data science in addressing issues faced by society.

**Short Courses:** Returning this year, we are pleased to offer three short courses to our registrants. These two-hour courses will present topics in mathematics and statistics. For those who enjoy the beauty of mathematics, Dr. Mike McDaniel, Professor of Mathematics and Department Co-chait at Aquinas College, will present lead participants on a hunt for famous numbers in the everyday. Dr. Tim All, Visiting Professor of Mathematics at Wabash College, will present on the use of abstract algebra and cryptography, bridging the pure and applied side of mathematics. Dr. Mark Daniel Ward, Associate Professor of Statistics at Purdue University, will provide and introduction to data science, a rapidly growing field at the intersection of mathematics, statistics and computer science, which strives to convert data into information.

**Contributed Papers:** The focal point of the weekend is the contributed student talks. We have 33 papers being presented by students this weekend on topics ranging from topological data analysis and machine learning to fractal machines and modulated Fibonacci sequences. 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. Jameel Ahmed | Opening Remarks |
| Floyd Yager, William Branda, and the Allstate Team | Predictive Analytics Competition |
| Michelle Prather | Administrative Assistant |
| Tracy Crosby | Reservations |
| Yvonne Heiber | Hotel Representative |

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, subsidize hotel accommodations for 48 students, provide meals during the conference, and bestow monetary prizes for the *Predictive Analytics Competition*. Please keep these organizations and corporations in mind as you continue your career.

**Platinum Sponsors:**

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## 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 contact:

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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) forms the Northern border, Interstate 70 creates the Southern border, US 41 (Third Street) defines the Western edge, and State Road 46 the Eastern edge.

**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!**

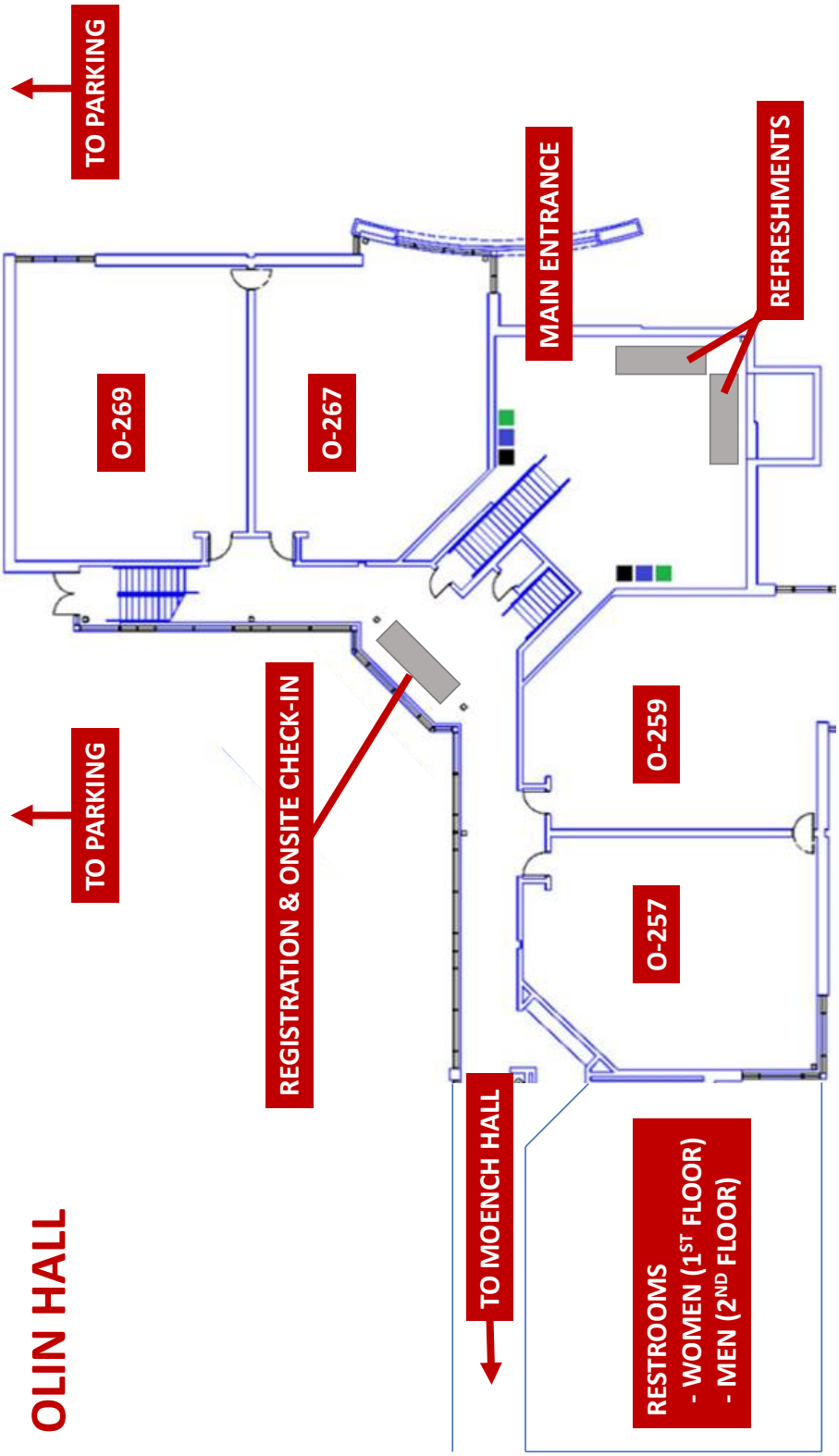
We thank you for choosing to stay at the conference hotel. Your patronage keeps housing costs lower, allowing us to subsidize the cost for many students attending the conference.

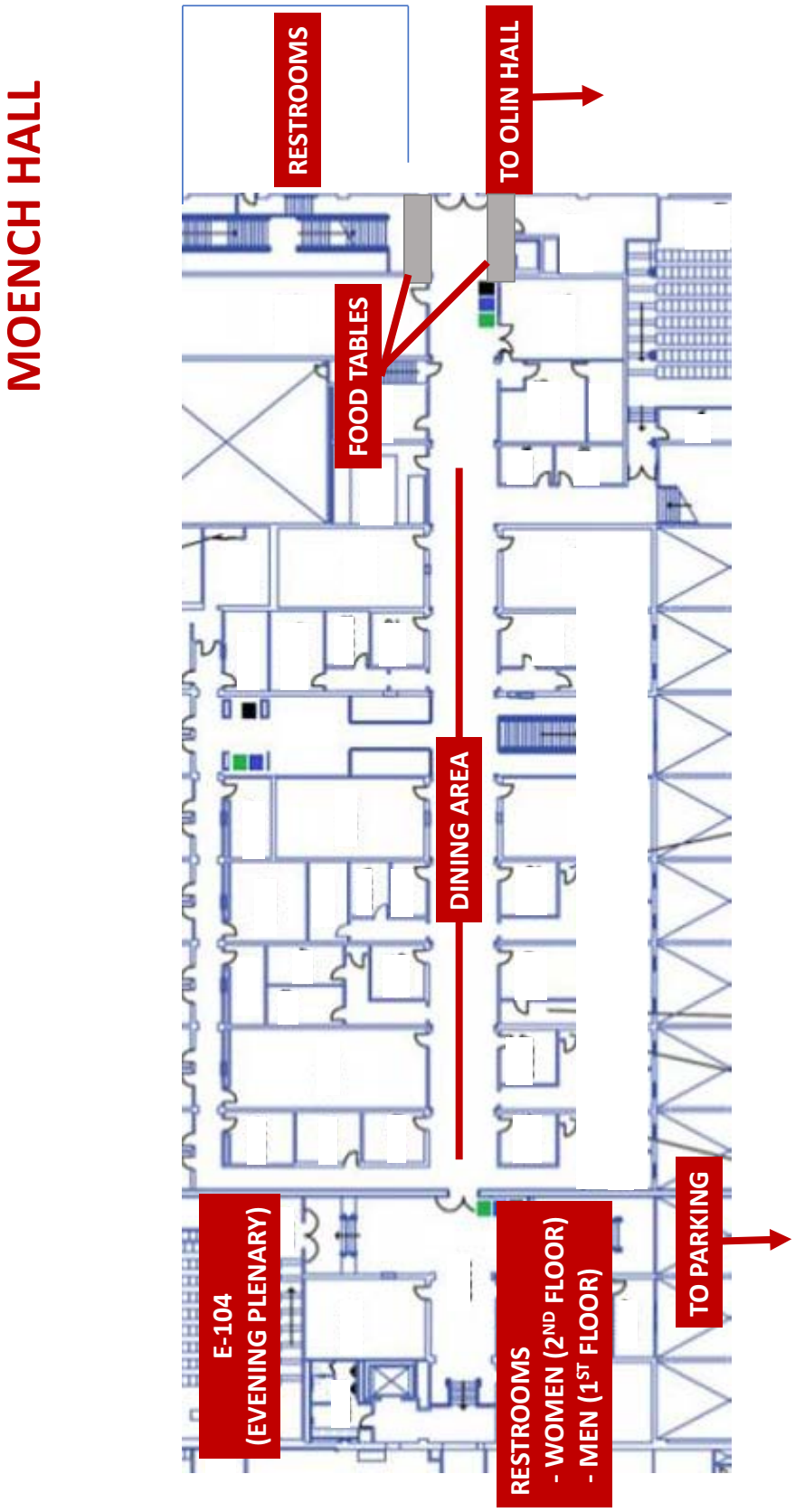
**Restuarants**
Terre Haute is home to many large chains. On State Road 46, just off Interstate 70, there are a few fast food options and a Mexican restaurant located near the Walmart complex. Downtown Terre Haute offers some local restaurants; local favorites include Mogger's and Saratoga. Third Street,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

Friday check-in and registration, as well as the short courses and contributed student talks will be in Olin Hall. Following the contributed talks, dinner and the evening plenary will be held on the top floor of Moench Hall. Please note that all academic buildings are connected so that you can move from one conference event to the next without exiting the facility. All events Saturday will take place in the Hulman Memorial Union.


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

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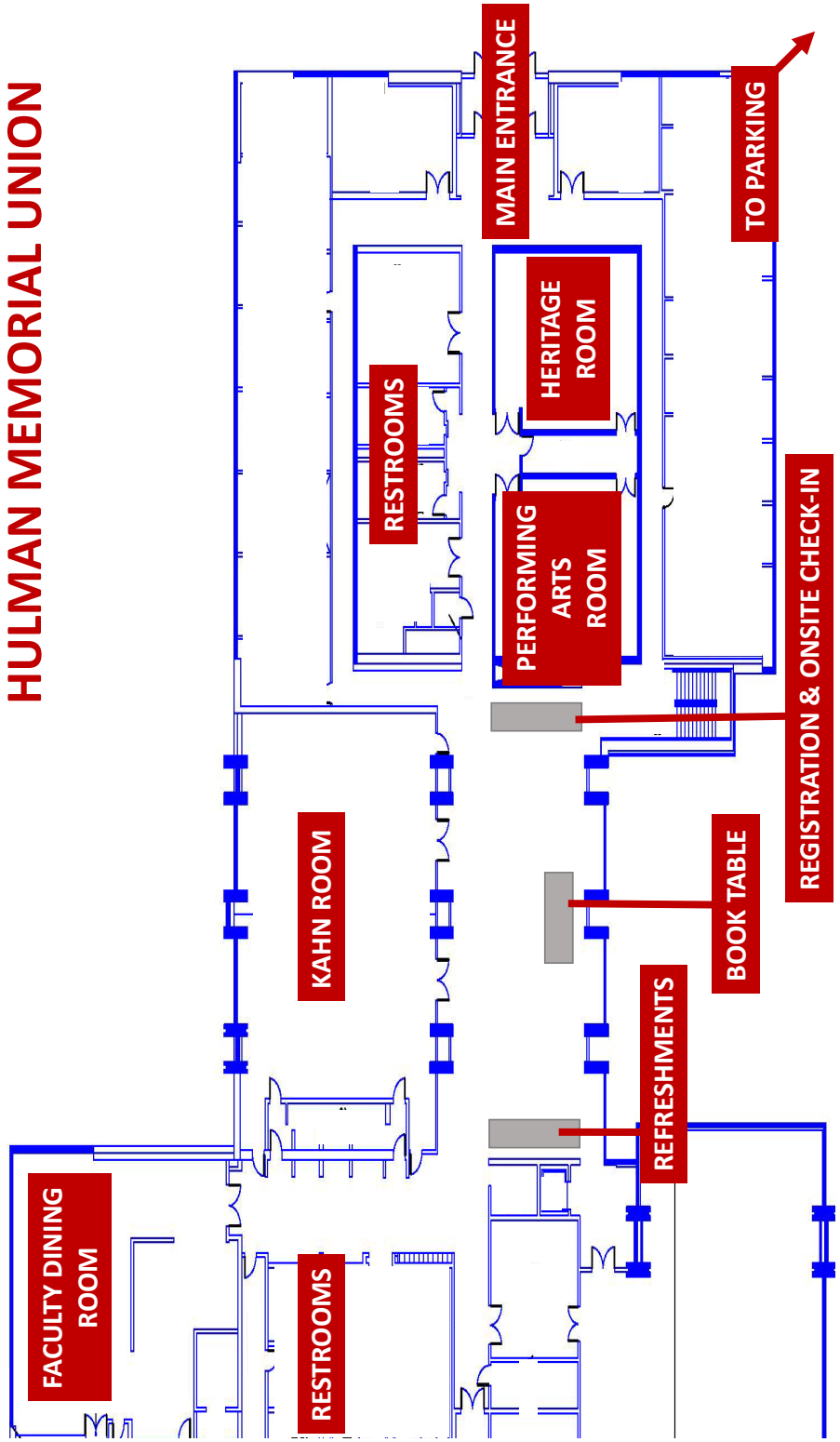
HULMAN MEMORIAL UNION
MAIN ENTRANCE
TO PARKING
HERITAGE ROOM
RESTROOMS
PERFORMING ARTS ROOM
REGISTRATION & ONSITE CHECK-IN
KAHN ROOM
BOOK TABLE
REFRESHMENTS
FACULTY DINING ROOM
RESTROOMS

# Program Summary

## Friday, April 22

| | | |
|---|---|---|
| 12:00pm - 5:00pm | **Conference Registration and Onsite Check-In** | Olin Hall (Upper Level) |
| 1:00pm - 3:00pm | **Short Courses** | Olin Hall (Upper Level) |
| | **Introduction to Data Science**<br>Mark Daniel Ward | O-259 |
| | **NTRU: How Abstract Algebra is Keeping Your Data Safe**<br>Tim All | O-267 |
| | **Mathematical Celebrity Sightings**<br>Michael McDaniel | O-269 |
| 3:30pm - 5:05pm | **Contributed Papers** | Olin Hall (Upper Level) |
| 3:30pm - 3:50pm | **Statistical Soundscape Ecology: Entropy and Phase Transition Analysis of Big Sound Data**<br>Kristen Mori and Jack VanSchaik | O-259 |
| | **Assessing the Effects of Various Farming Techniques on Nitrogen Management**<br>Andrew Yuk | O-267 |
| | **Encryption Using MIDI Files**<br>Patrick Cuthbertson | O-269 |
| 3:55pm - 4:15pm | **Glimpses of rocket science mathematics: modeling and analysis of a supersonic rocket motion**<br>Noah Turner | O-259 |
| | **Geo: A Game of Building the World**<br>Anmol Lamichhane | O-267 |
| | **Music and Modulated Fibonacci Sequences**<br>Zachary Dunlop | O-269 |
| 4:20pm - 4:40pm | **The Original Fractal Machine**<br>Qiushi Yin | O-259 |
| | **General Investigations of Chesspiece Polynomials**<br>Jacob Hiance | O-267 |
| | **Life of Forensic Analyst**<br>Nathaniel Kraus | O-269 |
| 4:45pm - 5:05pm | **Infinite Function Systems – Expanding the Fractal Machine**<br>Hongjian Shi | O-259 |
| | **Bitcoin Valuation: An Empirical Enquiry**<br>Connor Kispert | O-267 |
| | **The Perfect Lineup**<br>Brent Vaccaro | O-269 |

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|---|---|---|
| 5:30pm - 6:30pm | **Dinner** | Moench Hall (Second Floor) |
| 6:45pm - 8:00pm | **Plenary Session** | Moench Hall (E-104) |
| | **Opening Remarks**<br>Dr. Jameel Ahmed, Rose-Hulman Institute of Technology | |
| | **Winners of Allstate Predictive Analytics Competition**<br>William Branda, Allstate Insurance Company | |
| | **Doing Good with Good OR: Operations Research for Humanitarian and Non-profit Logistics**<br>Karen Smilowitz | E-104 |
| 8:15pm - 9:30pm | **Student Party** | Hulman Union (Chauncey's) |

## Saturday, April 25

| | | |
|---|---|---|
| 8:30am - 9:00am | **Conference Registration and Onsite Check-In**<br>Light Refreshments | Hulman Union (Main Lobby) |
| 9:00am - 10:00am | **Plenary Session** | Hulman Union (Kahn Room) |
| | **Using Data Science for Social Good**<br>Lauren Haynes | Kahn Room |
| 10:10am - 11:45am | **Contributed Papers** | Hulman Union |
| 10:10am - 10:30am | **Chaos Game Approximations of IFS Attractors**<br>Bryce Carter | Faculty Dining Room |
| | **An Overview of Machine Learning using MNIST Dataset**<br>Kent Gauen | Heritage Room |
| | **Enumerations of Lozenge Tilings**<br>W. Tyler Reynolds | Performing Arts Room |
| 10:35am - 10:55am | **Finding Fixed Spaces I: A Search Without Bounds**<br>Benjamin Jones | Faculty Dining Room |
| | **Variable Screening via Complete Least Squares and Distance Correlation**<br>Wenjun Kong | Heritage Room |
| | **Randomness and regularities in the leading digits of number-theoretic sequences**<br>Zhaodong Cai, Matthew Faust and Shunping Xie | Performing Arts Room |
| 11:00am - 11:20am | **Finding Fixed Spaces II: The Central Theorem**<br>Andrew Vander Werf | Faculty Dining Room |
| | **A Flow Network Approach to Laboratory Group Assignment**<br>Ian Ludden | Heritage Room |
| | **Paradoxes Of Voting: From Lincoln's Presidential Election to College Football Polls**<br>Vivek Kaushik, Aubrey Laskowski and Yukun Tan | Performing Arts Room |

| | | |
|---|---|---|
| 11:25am - 11:45am | **Measuring Infinite Distances: an Extension of the Hausdorff Metric**<br>Grant Schumacher | Faculty Dining Room |
| | **Counting solutions to discrete non-algebraic equations modulo a prime power**<br>Abigail Mann | Heritage Room |
| | **Preliminary Introduction to Topological Data Analysis**<br>Filemon Mateus | Performing Arts Room |
| 12:00pm - 1:00pm | **Lunch** | Hulman Union (Kahn Room) |
| 1:10pm - 2:20pm | **Contributed Papers** | Hulman Union |
| 1:10pm - 1:30pm | **Iterative Construction of Non-Compact Fractals**<br>Michael Peters | Faculty Dining Room |
| | **Variance of Stochastic Clusterings on Graphs**<br>Thomas Mulc | Heritage Room |
| | **Population Balance Model for DNA Methylation**<br>Alan Min | Performing Arts Room |
| 1:35pm - 1:55pm | **Predicting Advertisement Clicks Using Deep Learning**<br>Karan Samel | Faculty Dining Room |
| | **Analysis of the Model Similarity of LNA and EIGAs**<br>Jonathan Taylor | Heritage Room |
| | **Sovereign Adaptive Risk Modeling**<br>Morgan Escalera | Performing Arts Room |
| 2:00pm - 2:20pm | **Predictive Analytics Competition Winners**<br>TBA | Faculty Dining Room |
| | **Minimal Surfaces in SO(3)**<br>Luke Bohn | Heritage Room |
| | **Statistical Analysis of Mappings of the Discrete Logarithm**<br>Mitchell Orzech | Performing Arts Room |
| 2:30pm - 3:00pm | **Closing Remarks** | Hulman Union (Kahn Room) |

# Program | Short Courses

### Introduction to Data Science

**Dr. Mark Daniel Ward**
Associate Professor of Statistics, Purdue University
Time: 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.

### NTRU: How Abstract Algebra is Keeping Your Data Safe

**Dr. Tim All**
Visiting Professor of Mathematics, Wabash College
Location: O-267

Cryptography has been with us for some time. Julius Caesar was known to have encrypted his private correspondence by replacing each letter in his message with a letter some fixed distance down the alphabet. For modern cryptographic needs, ciphers such as Caesar's aren't sufficient. After all, if Amazon tells everyone to encrypt their credit card numbers by simply shifting the digits by some fixed amount, we'd be in a heap of trouble. In the modern era, we need public-key cryptosystems. The main feature of these systems is the construction of key pairs called the public-key and private-key. The public-key is used for encryption while the private-key is used for decryption. What makes a public-key cryptosystem secure is the relative difficulty in computing the privately held private-key from the publicly available public-key. Amazingly, mathematics that was originally explored for aesthetic or foundational purposes is now being applied to construct these public-key cryptosystems. This mini-course will focus on NTRU, a relatively new public-key cryptosystem whose back-bone is built on ring theory and, unlike RSA and systems based on the theory of elliptic curves, NTRU is not known to be vulnerable to quantum-computing. We plan to discuss the background material needed to understand how the encryption/decryption process works, and the security of the system or lack thereof in some circumstances.

## Mathematical Celebrity Sightings

**Dr. Michael McDaniel**
Professor of Mathematics and Department Co-char, Aquinas College
Location: O-269

When a research mathematician runs into famous numbers unexpectedly, the research gains excitement. In this session, we will find famous numbers when counting chord diagrams, when calculating HOMFLYPT weights of chord diagrams (two problems from knot theory), and in calculations of hyperbolic length and hyperbolic area (two problems from hyperbolic geometry.) The participants will get introduced to the relevant knot theory and geometry. Dr. McDaniel will then give the research questions to the participants and the hunt is on. Like paparazzi at the Oscars, participants will see celebrities. Except they're mathematical celebrities. And you'll need a calculator to see them.

# Program | Plenary Sessions

## Doing Good with Good OR: Operations Research for Humanitarian and Non-profit Logistics

**Karen Smilowitz**
Charles Deering McCormick Professor of Teaching Excellence
Professor of Industrial Engineering and Management Sciences, Northwestern University
Time: Friday, 6:45pm - 8:00pm
Location: E-104

This talk will discuss opportunities and challenges related to the development and application of operations research techniques to transportation and logistics problems in humanitarian and non-profit settings. Much research has been conducted on transportation and logistics problems in commercial settings where the goal is either to maximize profit or to minimize cost. Significantly less work has been conducted for non-profit applications. In such settings, the objectives are often more difficult to quantify since issues such as equity and sustainability must be considered, yet efficient operations are still crucial. This talk will present several research projects that introduce new approaches tailored to the objectives and constraints unique to non-profit agencies, which are often concerned with obtaining equitable solutions given limited, and often uncertain, budgets, rather than with maximizing profits.

**About Karen**: Karen Smilowitz is a Professor in the Department of Industrial Engineering and Management Sciences at Northwestern University and holds a joint appointment with the Northwestern University Transportation Center. Dr. Smilowitz is currently a Charles Deering McCormick Professor of Teaching Excellence. Dr. Smilowitz studies modeling and solution approaches for logistics and transportation systems in both commercial and non-profit applications, working with transportation providers, logistics specialists and a range of non-profit organizations. She is currently leading the Northwestern Initiative on Humanitarian and Non-Profit Logistics. Dr. Smilowitz received a CAREER award from the National Science Foundation and a Sloan Industry Studies Fellowship. She received her Ph.D. in Civil and Environmental Engineering from the University of California, Berkeley and her BSE in Civil Engineering and Operations Research from Princeton University.

## Using Data Science for Social Good

**Lauren Haynes**
Senior Project Manager
Center for Data Science and Public Policy, University of Chicago
Time: Saturday, 9:00am - 10:00am
Location: Hulman Union, Kahn Room

The biggest corporations in the world are using data science and machine learning to drive their business - why aren't we using the same approach to solve the world's biggest problems? Learn how different non-profits and government agencies are using data to make their programs more efficient and effective. In this talk, we will cover case studies from education, healthcare, environment, and criminal justice. We'll answer questions such as what skills are necessary to be a data scientist for social good and what kinds of problems can (and cannot) be solved with data science?

**About Lauren**: Lauren Haynes is Senior Project Manager at the Center for Data Science and Public Policy at the University of Chicago, where she serves as a translator between data scientists and non-profit and government agency personnel. Before joining DSaPP, Lauren was Product Manager at GiveForward, supporting an agile team of 12 developers and designers. She was previously IT Manager and interim CIO at the Ounce of Prevention Fund, a non-profit focused on early childhood education and advocacy with 250 staff and a $50 million operating budget. She was a consultant with Accenture's Technology Labs where her projects focused on Healthcare, Knowledge Management, and Collaboration while working with clients including Shell and DuPont. Lauren is vice-chair of the Board of Directors for Break Away, a national nonprofit focused on service learning trips for college students. Lauren also sits on the Board of Directors for El Hogar del Nino and the Board of Trustees for the University YMCA at the University of Illinois at Urbana Champaign. In her spare time, Lauren travels to Lindy Hop dance events. She holds a BS in General Engineering from UIUC, where her secondary field was in Human Computer Interaction.

# Program | Contributed Papers

Abstracts of contributed papers are listed below.

## Friday, 3:30pm to 3:50pm

### Statistical Soundscape Ecology: Entropy and Phase Transition Analysis of Big Sound Data

**Kristen Mori** and **Jack VanSchaik**, Purdue University
Location: O-259

Soundscape ecology explores the health and changes of the environment through analysis of regular recordings of the biological, geological, and anthropogenic sounds that compose the ecosystem. Ecologists can extract acoustic indices from the recordings that quantify aspects of biodiversity from a time-series representation of the data. A desire for statistical methods for large-scale data analysis motivates this project. A primary goal is to optimize data collection techniques through reduction of hard drive space use and time spent in the field.The study aims to minimize overall recording time through a running analysis of the entropy of amplitude distributions of the frequency domain of recordings. This method can analyze temporal dynamics of distribution entropy, as well as detect phase transitions, which are points in time at which the overall mean or variance of a time series changes. Identifiable through outlier detection, phase transitions can be caused by seasonal cycles or 'triggers,' which are events, such as fire, human intervention, or atypical weather, that alter the soundscape's diversity and may indicate critical events in an ecosystem.

### Assessing the Effects of Various Farming Techniques on Nitrogen Management

**Andrew Yuk**, Rose-Hulman Institute of Technology
Location: O-267

Nitrogen is one of the most essential elements for successful crop growth. However, excess nitrogen can cause a variety of economic and environmental issues. Using data provided by the ITSD, this study aims to assess the effects of various farming practices on stalk nitrogen rates to determine changes that can lead to more optimal rates.

### Encryption Using MIDI Files

**Patrick Cuthbertson**, Siena Heights University
Location: O-269

The purpose of this research project is to develop a program that can encrypt a message into a MIDI (Musical Instrument Digital Interface) file so that a melody is generated by the program in the form of a MIDI file that contains the encrypted message. The program must also be able to decrypt and extract the message from the MIDI file so that another user can acquire the message if he has the same key with which the message was encrypted. The program went through various

stages of development and, ultimately, can do everything that was set forth for it to accomplish. Further research could be done so that the program would allow for other file formats than MIDI. This program could be used in any situation where a person would want to encrypt a message and send it to another person who can then decrypt it and use the message.

## Friday, 3:55pm to 4:15pm

### Glimpses of rocket science mathematics: modeling and analysis of a supersonic rocket motion

**Noah Turner**, Western Connecticut State University
Location: O-259

A project is aimed at analyzing the flight and performance of a supersonic rocket. It is a multi-disciplinary endeavor requiring the use of mathematics, physics, and electrical engineering. The focus of this presentation is on the mathematical modeling and analysis of the rocket motion. Motion with variable mass, first stage of the rocket motion, is modeled by a Riccati equation that is solved analytically as opposed to conventionally used numerical treatment. Engineering aspects of the project including calculation of the stability parameter, so called center of pressure, and the autonomous on-board control will be briefly addressed. The presentation includes visualizations of the computational results and evidence of a launch of a similar supersonic rocket previously built by the presenter.

### Geo: A Game of Building the World

**Anmol Lamichhane**, Earlham College
Location: O-267

Geo is a game of building the world. Different member cards combine to form various ecosystem cards which again combine with other ecosystem or member cards, carrying higher point value, to ultimately obtain the world card, which has the highest point value. The theme of the game hides the mathematics behind it. Member cards represent various geometry axioms and ecosystem and world cards represent various geometry theorems. Different combinations of axioms create different theorems, and different combinations of theorems and axioms create more complex theorems. Thus, when we translated such tree of axioms and theorem combination to the given theme, we were able to create the game, Geo. This research project was funded by the Ford/Knight Collaborative Research fund at Earlham College.

### Music and Modulated Fibonacci Sequences

**Zachary Dunlop**, Siena Heights University
Location: O-269

The basis of my project is using modulation on different sequences to find out if I can map the sequences to scalar notes and then see if music follows. My plan is to begin by taking one sequence and seeing if I can continually modify it in order to create music or something that does not sound

like a cat walking on a piano. I want to focus on the Fibonacci sequence to see what kind of modifications I can make to it and the effects that those modifications will make on the musical mapping.

## Friday, 4:20pm to 4:40pm

### The Original Fractal Machine

**Qiushi Yin**, Indiana University
Location: O-259

1. Contractive mapping theorem 2. Hausdorff Distance 3. Fractal Machine

### General Investigations of Chesspiece Polynomials

**Jacob Hiance**, Rose-Hulman Institute of Technology
Location: O-267

When studying combinatorics, you soon encounter the problem of counting with restrictions. For example, you may want to count the number of ways to assign professors to courses while avoiding assigning a professor to a class they dislike. This problem can be reduced to counting the number of ways to place rooks on a chessboard so that no rook attacks another. In this talk, we will discuss a solution technique and generalize it to other chesspieces. We will then discuss patterns that arise from our technique to help make our computations easier.

### Life of Forensic Analyst

**Nathaniel Kraus**, Siena Heights University
Location: O-269

My senior projects consists of my objectives, intern duties, and experiences with my internship opportunity given to me in the summer of 2015. I was assigned to work under Detective Sergeant Ben Gonzalez, of the Michigan State Police Computer Crimes Unit located at the State Police Headquarters. With this opportunity I hoped in the end it would help me determine what job I would like to pursue in my future career. This senior project will be a representation of the experiences I had during my internship with the Michigan State Police. Coming into this internship I had developed multiple goals involving familiarizing myself with different types of software, imaging hard drives and most importantly, determining if I would like to spend my career after college with the Michigan State Police or a different occupation. With this unique internship opportunity I was able to experience situations and events that most people would not be lucky enough to experience.

## Friday, 4:45pm to 5:05pm

### Infinite Function Systems – Expanding the Fractal Machine

**Hongjian Shi**, Indiana University
Location: O-259

Hutchinson (1981) showed that that an IFS (or finite set of contractions) on the complete metric space $X$ has a unique nonempty compact invariant (fixed) set $S$, which can be obtained by iterating the system. Our aim is to determine under what conditions we may allow our IFS to contain infinitely many functions. As a teaser, it turns out to be important that the collection of functions itself is (in some sense) compact!

### Bitcoin Valuation: An Empirical Enquiry

**Connor Kispert**, Rose-Hulman Institute of Technology
Location: O-267

This paper develops a standard model for valuation of bitcoin using supply and demand fundamentals. We will also analyze the relationship of dollar and gold alternatives relative to bitcoin price and how this these assets may affect its value. The period we analyze will run from 2011 to 2016 including three sub-samples before, during and after the alleged bitcoin bubble of 2013. The changes in estimated coefficients across these samples give some indication of how the market for bitcoins has structurally changed since its beginning. Our estimates support a significant substitution effect between bitcoin and the value of both gold and the dollar. We also find that variables measuring market thickness are highly correlated with the price of bitcoin and as market activity increases the value of bitcoin is driven up by a demand side shock. These findings extend to moving average estimations as well as results in the most recent sub-sample and also show that the model developed for bitcoin price is both robust and significant in the post-crash timeframe.

### The Perfect Lineup

**Brent Vaccaro**, Siena Heights University
Location: O-269

How do experts rank MLB players? Everyone debates who the best players are in the world each and every day, and baseball is no different. I shall use Minitab to shed a bit of light on a statistical reasoning for how these players are ranked.

## Saturday, 10:10am to 10:30am

### Chaos Game Approximations of IFS Attractors

**Bryce Carter**, Indiana University
Location: Faculty Dining Room

Given any IFS, we have a few ways (both deterministic and non-deterministic) of drawing the image of its attractor. In this talk, I introduce and prove the chaos game method for strictly contractive (and more generally, "contractive on average") function systems. To finish, I'll give examples of function systems whose attractors can be generated by these methods.

### An Overview of Machine Learning using MNIST Dataset

**Kent Gauen**, Purdue University
Location: Heritage Room

Machine learning is a powerful tool used in a wide breadth of applications including quality control, image classification, and self-driving cars. We will give a broad summary of many fundamental machine learning models, so that the reader may gain an intuition behind their formulation. In this paper, we use the MNIST data-set to demonstrate the mechanisms of machine learning models. Three learning paradigms will be discussed in detail: supervised, unsupervised, and representational learning. Each of the learning paradigms will be separated into individual methods, and each of the methods will be further separated into three sections: the problem formulation, a brief overview of the algorithm, and the result on the MNIST data-set. In conclusion, we will discuss the implications of our results and briefly cover some interesting applications of the introduced models.

### Enumerations of Lozenge Tilings

**W. Tyler Reynolds**, Eastern Illinois University
Location: Performing Arts Room

It is known that the lozenge tilings of a triangular subregion of a triangular lattice are enumerated by the permanent of a corresponding matrix. Taking the determinant of this matrix yields a signed enumeration of these lozenge tilings, which may be distinct from the standard enumeration. Closed formulas for these signed enumerations are known for some regions, but not for every region. Using a connection to families of non-intersecting lattice paths, we establish closed formulas for the signed enumerations of lozenge tilings of three specific regions given in two parameters. This talk is based on joint work with Erin Bossen done under the supervision of Dr. David Cook II.

## Saturday, 10:35am to 10:55am

### Finding Fixed Spaces I: A Search Without Bounds

**Benjamin Jones**, Indiana University
Location: Faculty Dining Room

The compact fractal theorem determines that there is a unique compact fixed set of an iterated function system. However, there are a potentially (uncountably) infinite number of unbounded fixed sets of a given IFS. It is possible to generate these sets by examining the fixed sets of the component functions of the IFS. Given that one can generally find the unbounded fixed sets of a single function, this talk will cover the method for finding spaces that contain a fixed set of a multifunction IFS by examining its fixed points.

### Variable Screening via Complete Least Squares and Distance Correlation

**Wenjun Kong**, Rose-Hulman Institute of Technology
Location: Heritage Room

Feature selection filters out irrelevant variables. However, when the size of predictors gets much larger than the sample size these selection techniques give noisy and unreliable results. An initial screening step can improve their performance. We developed a screening procedure based on distance correlation and complete least squares (DC-CLS). We compared DC-CLS to sure independence screening (SIS) proposed by Fan and Lv (2008) and a variant which relies on distance correlation (DC-SIS) proposed by Li, Zhong and Zhu (2012). While our model showed promise in a proof of concept example, our simulation reveal it is not competitive for general use.

### Randomness and regularities in the leading digits of number-theoretic sequences

**Zhaodong Cai**, **Matthew Faust** and **Shunping Xie**, University of Illinois at Urbana-Champaign
Location: Performing Arts Room

If you pick a Fibonacci number at random, what is the probability that it begins with a 1? Surprisingly, the answer is not 1/9 as one might expect. In fact, around 30.1% of Fibonacci numbers begin with a 1, about 17.6% begin with a 2, and only around 4.6% begin with 9. This peculiar first-digit distribution is known as Benford's Law. Persi Diaconis proved that Benford's Law holds for a large class of arithmetic sequences, such as the Fibonacci numbers, the powers of 2, and the factorials. Is there a way to distinguish these sequences by examining only the leading digits? In research performed at Illinois Geometry Lab, we seek to answer such questions, both experimentally and theoretically.

## Saturday, 11:00am to 11:20am

### Finding Fixed Spaces II: The Central Theorem

**Andrew Vander Werf**, Indiana University
Location: Faculty Dining Room

A continuation of Finding Fixed Spaces I: A Search Without Bounds, Ben Jones' results on unbounded fixed sets of iterated function systems are given rigorous justification. In particular we show that the classic fractal machine extends to include unbounded fixed sets that can be obtained by iteration.

### A Flow Network Approach to Laboratory Group Assignment

**Ian Ludden**, Rose-Hulman Institute of Technology
Location: Heritage Room

The maximum-flow problem for a flow network has a well-known, efficient algorithm, namely, the Ford-Fulkerson augmenting-path method. Due to the simplicity and flexibility of flow networks and the Ford-Fulkerson method, they can be applied to solve many practical optimization problems, including scheduling airline routes and determining when baseball teams are mathematically eliminated from the playoffs. My research models a laboratory group assignment problem for a sequence of Chemical Engineering courses at Rose-Hulman as a series of flow network problems. The goal is to generate solutions that meet a variety of constraints, including professor and student preferences and availabilities.

### Paradoxes Of Voting: From Lincoln's Presidential Election to College Football Polls

**Vivek Kaushik, Aubrey Laskowski and Yukun Tan**, University of Illinois at Urbana-Champaign
Location: Performing Arts Room

How does the winner of an election depend on the voting methods used? In US politics, we use a plurality system in which each voter chooses a single candidate, but this is not the only possible method. One example is the Borda Count Method used in college football polls. Tabarrok and Spector studied how the outcome of the 1860 US Presidential election would have changed using other voting methods. We performed a similar analysis using data from recent AP college football polls. We found many instances of known paradoxes, such as cyclic majorities (i.e. situations in which team A is ranked above team B by the majority of voters, team B is ranked above team C by the majority of voters, and team C is ranked above team A by the majority of voters).

## Saturday, 11:25am to 11:45am

### Measuring Infinite Distances: an Extension of the Hausdorff Metric

**Grant Schumacher**, Indiana University
Location: Faculty Dining Room

We define a space P that captures "how infinitely far" sets in a metric space X can get from each other. This set has an algebraic structure that provides a nice perspective on finding fixed sets of an IFS. We conclude by defining a family of pseudometrics on P that is compatible with the algebraic structure and which shows promise in the creation of analytic methods to characterize fixed sets of IFSs.

### Counting solutions to discrete non-algebraic equations modulo a prime power

**Abigail Mann**, Rose-Hulman Institute of Technology
Location: Heritage Room

As society becomes more reliant on computers, cryptographic security becomes increasingly important. Current encryption schemes include the ElGamal signature scheme, which depends on the complexity of the discrete logarithm problem. It is thought that the functions that such schemes use have inverses that are computationally intractable. In relation to this, we are interested in counting the solutions to a generalization of the discrete logarithm problem modulo a prime power. This is achieved by interpolating to p-adic functions, and using Hensel's lemma, or other methods in the case of singular lifting, and the Chinese Remainder Theorem.

### Preliminary Introduction to Topological Data Analysis

**Filemon Mateus**, Westminster College
Location: Performing Arts Room

The notion of persistent homology has been a quite powerful tool in topological data analysis. This talk surveys a preliminary discussion on the applications of computational algebraic topology to problems of feature detection and shape recognition in data. The primary mathematical tool considered is homology theory for point-cloud data sets, i.e. persistent homology, and a novel representation of this algebraic characterization through barcodes. We exemplify an application of these techniques by computationally estimating the topological features of different shapes based on point-cloud data sets and persistence. No prior algebraic topology knowledge is assumed.

Background: None.

## Saturday, 1:10pm to 1:30pm

### Iterative Construction of Non-Compact Fractals

**Michael Peters**, Indiana University
Location: Faculty Dining Room

The classic (Hutchinson) Fractal Machine Theorem stipulates that a compact fixed set exists for any iterated function system (IFS). In an effort to broaden these results to include non-compact fixed sets, we discuss a method by which any fixed set of an affine-linear IFS may be extended to create a new fixed set which is "infinitely far away" under the Hausdorff metric. In particular, this method takes any bounded fixed set to an unbounded fixed set, and so provides a simple mechanism for the creation of non-compact fractals. This method can also be shown to produce a strictly increasing hierarchy of fixed sets under the subset relation. We discuss the application of this method to the characterization of fixed spaces of the given IFS.

### Variance of Stochastic Clusterings on Graphs

**Thomas Mulc**, Rose-Hulman Institute of Technology
Location: Heritage Room

A clustering on a graph is simply a partition of the vertices. Most clustering algorithms are deterministic, but we examined one that was stochastic. The consistency of the algorithm was quantified by forming a measure of spread for a collection of partitions. The Rand Index was used as a metric for the distance between two clusterings. An alternate form of variance for a collection of numerical data was used to quantify the spread of a collection of clusterings on the same graph.

### Population Balance Model for DNA Methylation

**Alan Min**, Purdue University
Location: Performing Arts Room

DNA Methylation is a process by which methyl groups are attached to DNA strands on the cytosine base pair using DNA Methyltransferase enzymes (DNMT). Methylation patterns are associated with bodily processes such as aging, tumor suppression, and Retts syndrome. DNMT and methyl donors are located in the cytoplasm of the cell and can be transferred to the DNA. Thus a population balance model has been developed to model the diffusion of DNMT. The model hypothesizes that during the methylation process, enzymes diffuse along the DNA to attach a methyl group to cytosine. The model has been extended to consider varying levels of enzyme in the cell, and a framework to consider cells in a population have been created. The predictions of the model have been compared to methylation data that is given from the MethDB methylation information database.

## Saturday, 1:35pm to 1:55pm

### Predicting Advertisement Clicks Using Deep Learning

**Karan Samel**, Purdue University
Location: Faculty Dining Room

This paper will cover building prediction models to estimate click through rates for various advertising platforms. Given a dataset from advertisers containing information whether targeted users clicked or ignored an advertisement, data for each advertiser is parsed individually. Following this, the variables are formatted to be read by a deep learning model to predict a click probability for each example. This involves parsing, cleaning, and separating variables to indicators to be used for training. A Convolutional Neural Network (CNN) is used to find features within the data that indicate if a user is going to click an advertisement. Since CNNs are used traditionally for image data, model parameters are changed within the convolution layers to account for the fact that we are working with textual data. Initial results indicate that CNNs provide better click estimation compared to conventional logistic regression methods used for prediction. By parsing more data and tweaking the convolution layers, CNN's testing scores continue to increase.

### Analysis of the Model Similarity of LNA and EIGAs

**Jonathan Taylor**, Rose-Hulman Institute of Technology
Location: Heritage Room

The Protein Folding problem attempts to determine whether or not two proteins share some amount of structural similarity that implies that they have the same functional or evolutionary group. Our work was to compare two algorithms that attempt to solve this problem, Lagrange Norm Alignment (LNA) and Eigen-decomposition Alignment with the Spectrum (EIGAs). These algorithms share a dynamic programming (DP) step and have both shown to be quite successful. As such we have analyzed the decision making process of each in order to attempt to infer some amount of model similarity.

### Sovereign Adaptive Risk Modeling

**Morgan Escalera**, Rose-Hulman Institute of Technology
Location: Performing Arts Room

In the wake of the 2008 financial crisis, the FSB (Financial Stability Board) and the BCBS (Basel Committee on Banking Supervision) created a list of Globally Systematically Important Banks with the intention of determining which financial institutions were important enough to the global market that their failure would result in total systemic collapse. The purpose of this research paper is to use econometrics and statistical analysis to create a mathematical model that generalizes the BCBS's five criteria that define the financial institutions and apply these measures of systemic risk to governmental bodies. These five criteria are size, interconnectedness, cross-jurisdictional activities, complexity, and substitutability. The model utilizes weighted directed graphs to simulate default scenarios of central banks in the system as well as creating a 'market valuation' of each

country based on their five-year bond yields and a regard for their individual CDS spread. The original application of the model was a time series going back 3 years tracking the troubled economy of Greece in the Eurozone, comparing its systemic risk to the other member states of the monetary union.

## Saturday, 2:00pm to 2:20pm

### Predictive Analytics Competition Panel

**TBA**

Location: Faculty Dining Room

The winners of the Allstate Predictive Analytics Competition will discuss their approach to the posed problem.

### Minimal Surfaces in SO(3)

**Luke Bohn**, Rose-Hulman Institute of Technology

Location: Heritage Room

Classical minimal surface theory can be thought of as examining the shapes of soap films stretched across wire loops in Euclidean space $R^3$. For my research, I have examined analogous structures in an abstract three-dimensional space, the Lie Group SO(3). This is the space of possible rotations in $R^3$, where each rotation is expressed with three angles: two to indicate the axis of rotation and one to indicate the amount of rotation. The properties of the space SO(3) make constructing minimal surfaces more complicated, as they must be constructed in ways consistent with both the curvature and the group structure of the space. The result is minimal surfaces that behave differently from those in $R^3$.

### Statistical Analysis of Mappings of the Discrete Logarithm

**Mitchell Orzech**, Rose-Hulman Institute of Technology

Location: Performing Arts Room

The increased use of cryptography to protect our personal information makes us want to understand the security of cryptosystems. The security of many cryptosystems relies on solving the discrete logarithm, which is known to be relatively difficult. Therefore, we focus on the statistical analysis of certain properties of the mapping of the discrete logarithm. We discovered the expected value of a certain property of the mapping and compare it to experimental data. Our finding did not coincide with our intuition of the data following a Gaussian distribution given a large sample size. Thus, we found the theoretical distributions of certain properties of the mapping.

# Conference Attendees

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|---|---|
| Jonathan Adams | Greenville College |
| Ty Adams | Rose-Hulman Institute of Technology |
| Tim All | Wabash College |
| Elizabeth Alzate | Rose-Hulman Institute of Technology |
| Michael Amat | Rose-Hulman Institute of Technology |
| Jacob Bellis | Rose-Hulman Institute of Technology |
| Mohamed Benbourenane | California University of PA |
| Cheris Black | Greenville College |
| Luke Bohn | Rose-Hulman Institute of Technology |
| Aaron Brehm | Purdue University |
| Amanda Burcroff | University of Michigan |
| Lindsay Burton | Greenville College |
| Zhaodong Cai | University of Illinois at Urbana-Champaign |
| Sylvia Carlisle | Rose-Hulman Institute of Technology |
| Bryce Carter | Indiana University |
| Ruying Chen | Rose-Hulman Institute of Technology |
| Nathan Chenette | Rose-Hulman Institute of Technology |
| Madeline Crews | Rose-Hulman Institute of Technology |
| Patrick Cuthbertson | Siena Heights University |
| Michael Dalrymple | Purdue University |
| Emily Damone | Purdue University |
| Casey Dant | Rose-Hulman Institute of Technology |
| Andrew Davis | Western Connecticut State University |
| Noah Davis | Aquinas College |
| Madison Denning | Purdue University |
| Jordan Disch | Greenville College |
| Sheng Dong | Rose-Hulman Institute of Technology |
| Sheng Dong | Rose-Hulman Institute of Technology |
| Sean Douglas | Greenville College |
| Sara Doyle | Saint Mary's of the Woods |
| Zachary Dunlop | Siena Heights University |
| Elizabeth Duteau | Indiana University |
| Morgan Escalera | Rose-Hulman Institute of Technology |
| Diane Evans | Rose-Hulman Institute of Technology |
| Matthew Faust | University of Illinois |
| Felix Francidco-Sanchez | Purdue University |
| Brian French | Purdue University |
| Casey Garner | Rose-Hulman Institute of Technology |
| Kent Gauen | Purdue University |
| Richard Gorbett | Purdue University |
| Dave Goulet | Rose-Hulman Institute of Technology |

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|---|---|
| Ralph Grimaldi | Rose-Hulman Institute of Technology |
| Ryan Grossman | Ivy Tech Community College |
| Xinghong Guo | Rose-Hulman Institute of Technology |
| Croix Gyurek | IUPUI |
| Katy Gyurek | |
| Bob Han | Greenville College |
| Lauren Haynes | Center for Data Science and Public Policy |
| Jacob Hiance | Rose-Hulman Institute of Technology |
| A J Hildebrand | University of Illinois |
| Joshua Holden | Rose-Hulman Institute of Technology |
| Jen Hurst | Greenville College |
| Vincenzo Isaia | Rose-Hulman Institute of Technology |
| Benjamin Jones | Indiana University |
| Jeffrey Kallenbach | Siena Heights University |
| Vivek Kaushik | University of Illinois at Urbana-Champaign |
| Teresa Kennelly | Purdue University |
| Samreen Khan | University of Texas |
| Connor Kispert | Rose-Hulman Institute of Technology |
| Wenjun Kong | Rose-Hulman Institute of Technology |
| Nathaniel Kraus | Siena Heights University |
| Anmol Lamichhane | Earlham College |
| Mariana Lane | Rose-Hulman Institute of Technology |
| Tom Langley | Rose-Hulman Institute of Technology |
| Aubrey Laskowski | University of Illinois |
| Katherine Lothrop | Purdue University |
| Ian Ludden | Rose-Hulman Institute of Technology |
| Sameer Manchanda | Purdue University |
| Abigail Mann | Rose-Hulman Institute of Technology |
| James Marshall Reber | Purdue University |
| Filemon Mateus | Westminster College |
| Emmett McDaniel | Aquinas College |
| Michael McDaniel | Aquinas College |
| Rebecca Medina | Rose-Hulman Institute of Technology |
| Mikaela Meyer | Purdue University |
| Alan Min | Purdue University |
| Chang In Moon | Purdue University |
| Matthew Moon | Rose-Hulman Institute of Technology |
| Kristen Mori | Purdue University |
| Thomas Mulc | Rose-Hulman Institute of Technology |
| Dean Netzler | Ivy Tech Community College |
| Mitchell Orzech | Rose-Hulman Institute of Technology |
| George Peters | Greenville College |
| Michael Peters | Indiana University |

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|---|---|
| William Pierce | Purdue University |
| Jackie Preston | Rose-Hulman Institute of Technology |
| David Rader | Rose-Hulman Institute of Technology |
| W. Tyler Reynolds | Eastern Illinois University |
| Christine Ringwald | Purdue University |
| Thomas Rotter | Purdue University |
| Brendan Ryder | Purdue University |
| Karan Samel | Purdue University |
| Zach Sanford | Greenville College |
| Kennedy Schnieders | Rose-Hulman Institute of Technology |
| Grant Schumacher | Indiana University |
| Christina Selby | Rose-Hulman Institute of Technology |
| Elle Shaw | Greenville College |
| Hongjian Shi | Indiana University |
| Alec Sills | Rose-Hulman Institute of Technology |
| Karen Smilowitz | Northwestern University |
| Wyatt Smith | Rose-Hulman Institute of Technology |
| Jacob Soehren | Rose-Hulman Institute of Technology |
| Christa Stackhouse | Greenville College |
| Tristan Tager | Indiana University |
| Yukun Tan | University of Illinois at Urbana-Champaign |
| Isaac Tat | Purdue University |
| Jonathan Taylor | Rose-Hulman Institute of Technology |
| Laura Troyer | Greenville College |
| Xinlu Tu | University of Illinois |
| Noah Turner | Western Connecticut State University |
| Brent Vaccaro | Siena Heights University |
| Andrew Vander Werf | Indiana University |
| Jack VanSchaik | Purdue University |
| Jiawen Wang | Rose-Hulman Institute of Technology |
| Xiaomo Wang | Rose-Hulman Institute of Technology |
| Mark Daniel Ward | Purdue University |
| David Womble | Sandia National Laboratories |
| Alex Wong | Rose-Hulman Institute of Technology |
| Yinan Wu | Indiana University |
| Abigale Wynn | Rose-Hulman Institute of Technology |
| Shunping Xie | University of Illinois |
| Qiushi Yin | Indiana University |
| Andrew Yuk | Rose-Hulman Institute of Technology |
| Ruinan Zhang | Rose-Hulman Institute of Technology |
| Muqing Zheng | Rose-Hulman Institute of Technology |
| Man Zhu | University of Illinois at Urbana-Champaign |
| Yuhe Zhu | University of Illinois |