Rose-Hulman
Undergraduate Mathematics Conference

April 24 - 25, 2015

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

Welcome

Welcome to the 32nd Annual Rose-Hulman Undergraduate Mathematics Conference. This conference serves as an opportunity to highlight the research being done by undergraduate mathematicians and statisticians. 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: Over the past few years, it has become clear that there is no shortage of data. The conversation has turned to how we will leverage that data to move our society forward. New programs in Data Science have been popping up across the country. As we began planning this conference, we felt it appropriate to address this new frontier. The theme of this year's conference, *Statistics: From Big Data to Big Decisions*, stresses the need to convert data into information. Nick Lockwood, Senior Director of Brand Marketing Analytics at Catalina Marketing will describe how businesses are using data to target their marketing. We also have Amanda Cox, graphics editor at the New York Times, joining us for a webinar on Saturday morning exploring data visualization.

Short Courses: A new addition to the program, we will have three short courses available to our registrants. These two-hour courses will present topics in mathematics and statistics. Dr. Ralph Grimaldi, Professor of Mathematics at Rose-Hulman Institute of Technology, will discuss one of the most ubiquitous number sequences in mathematics, the Catalan Numbers. Dr. Thomas Mifflin, Group Manager at Metron Scientific Solutions, and Chris Overton, Data Scientist at Ayasdi, will each present a course which blends mathematics and statistics. Dr. Mifflin's talk overlays a statistical framework on random graphs and Mr. Overton's talk presents tools useful for making sense of large datasets.

Contributed Papers: The focal point of the weekend is the contributed student talks. We have 29 papers being presented by students this weekend on topics ranging from modeling in computational biology to cluster analysis using graphs to generalized linear mixed models and Bayesian inference. 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!

Sincerely,

Eric Reyes	Diane Evans	Dave Rader
Co-Organizer	Co-Organizer	Department Head

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. Rick Stamper	Opening Remarks
Lorena Maxwell	Volunteer Coordinator
Amy Kamperman, Lorena Maxwell and Natasha Tepley	Registration Desk
Alanna Nacar	Book Table
Edna Jones and Mitch Orzech	Student Party
Drs. Mark Ward, Roger Lautzenheiser and Joe Eichholz	Distinguished Paper Award
Floyd Yager, Mark Slusar, Kelly Thompson and the Allstate Team	Predictive Analytics Competition
Michelle Prather	Administrative Assistant
Mary Rose Silva	Friday Dinner and Refreshments
Janie Szabo, Alan Ward and Randy Carle	Webinar Technology
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.

In heartfelt appreciation,

Eric Reyes	Diane Evans
Co-Organizer	Co-Organizer

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 *Distinguished Paper Award* and *Predictive Analytics Competition*. Please keep these organizations and corporations in mind as you continue your career.

Platinum Sponsors:

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* Funds provided through MAA NSF-RUMC, NSF grant DMS-0846477

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 must be sponsored by a mathematician familiar with the student's work and each paper will be refereed. The editor-in-chief will make the final decision for publication. The journal is sponsored by the Mathematics Department at Rose-Hulman Institute of Technology.

Should you want to consider publishing your research in 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. You can get directions by clicking on the QR code on the right. 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.

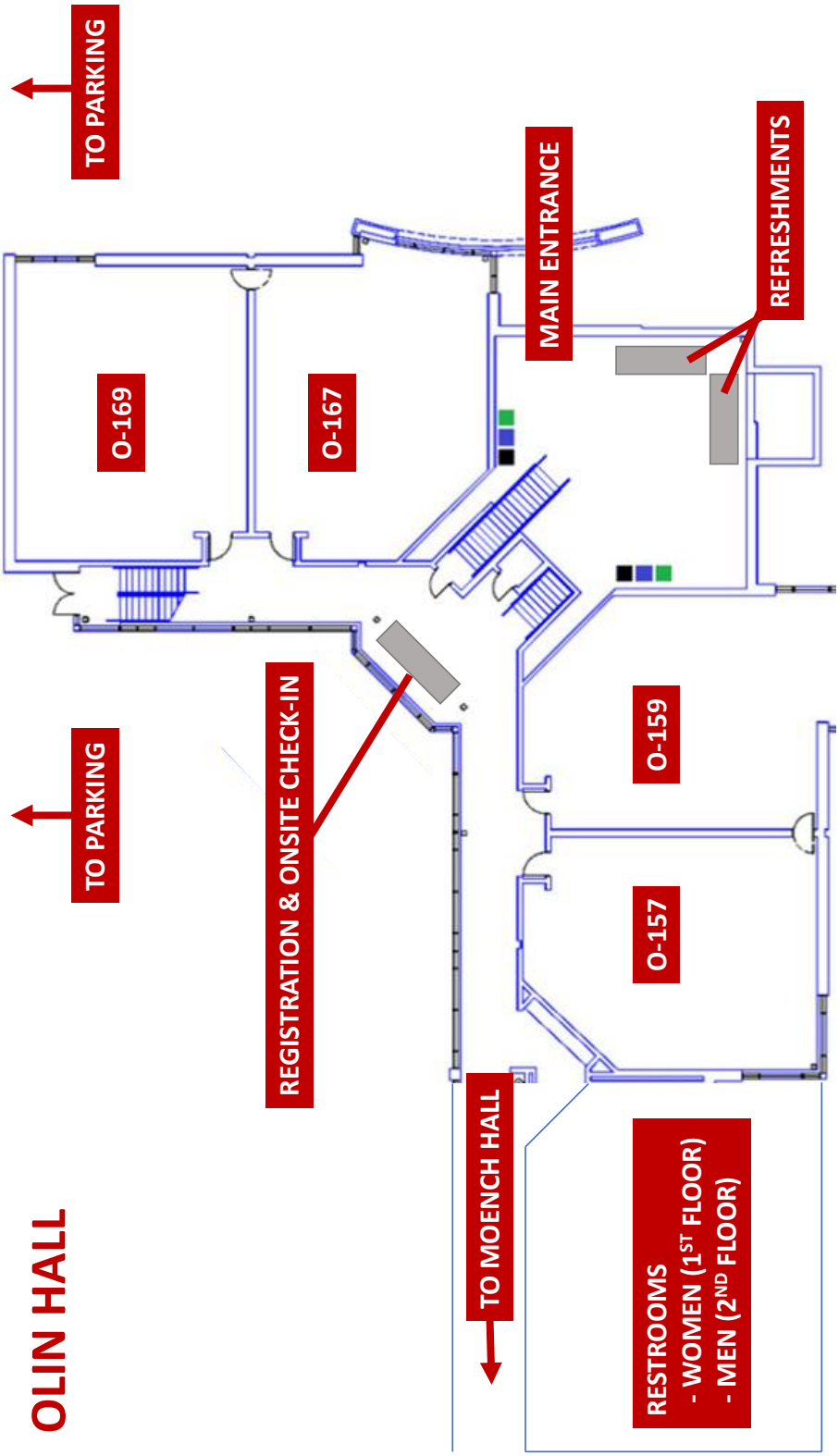
Restuarants

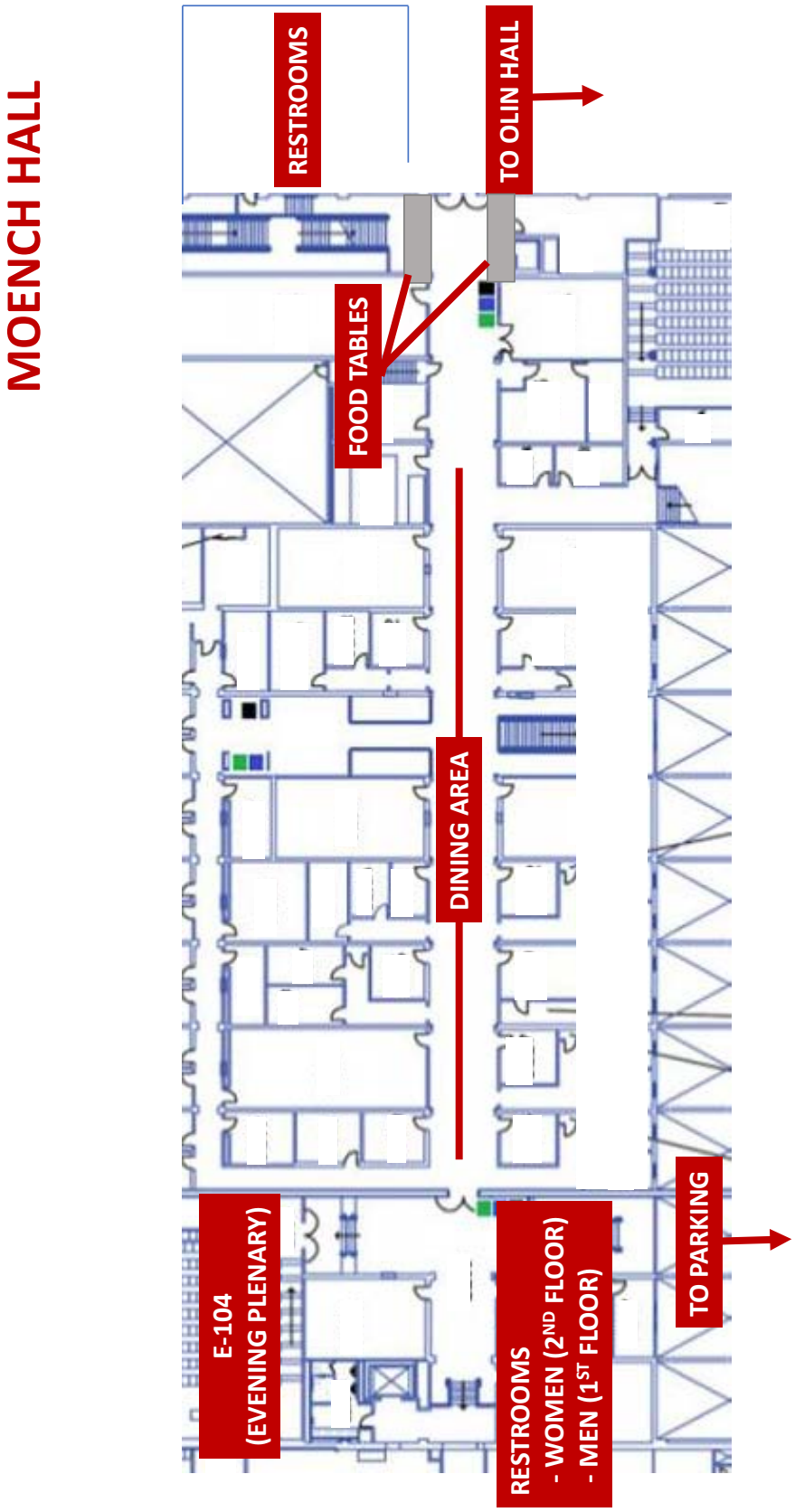
Terre Haute is home to many large chains. On State Road 46, just off Interstate 70, there are a few fast food options and a Mexican restaurant located near the Walmart complex. Downtown Terre Haute offers some local restaurants; local favorites include Mogger's and Saratoga. Third Street, near Interstate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

The conference begins in Olin Hall; check-in and registration, as well as the short courses and contributed student talks will be hosted here. Following the contributed talks, dinner will be held on the top floor of Moench Hall. The evening plenary will follow dinner in E-104, located in Moench Hall. All of the Saturday events take place in the Hulman Memorial Union.


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



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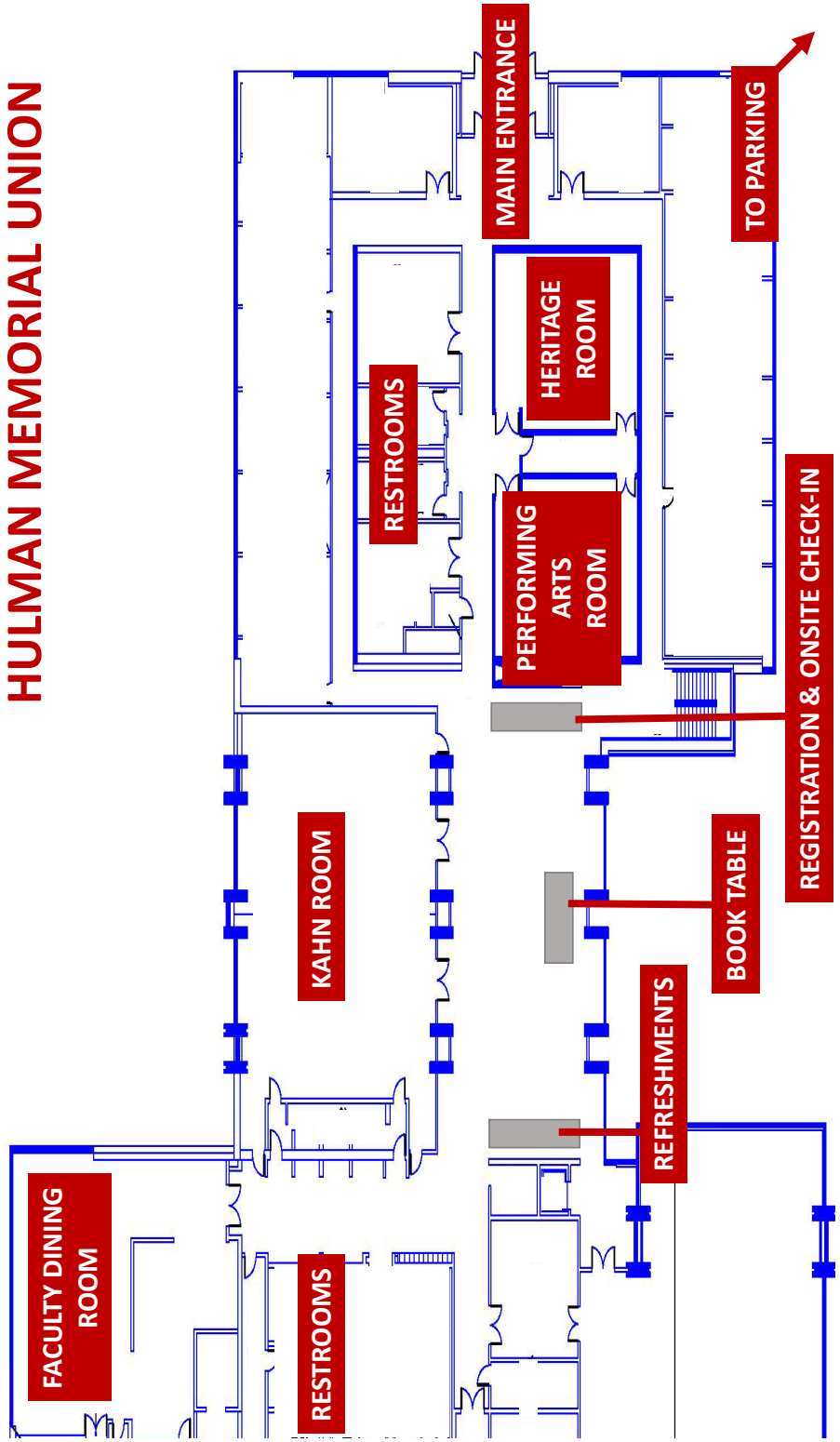
HULMAN MEMORIAL UNION
MAIN ENTRANCE
TO PARKING
HERITAGE ROOM
RESTROOMS
PERFORMING ARTS ROOM
REGISTRATION & ONSITE CHECK-IN
KAHN ROOM
BOOK TABLE
REFRESHMENTS
FACULTY DINING ROOM
RESTROOMS

Program Summary

Friday, April 24

12:00pm - 5:00pm	**Conference Registration and Onsite Check-In**	Olin Hall (Lower Level)
1:00pm - 3:00pm	**Short Courses**	Olin Hall (Lower Level)
	Understanding Data: From Math (Probability) to Statistics to Machine Learning, and Back to Math (Topology) Chris Overton, Ayasdi	O-157
	The Catalan Numbers Dr. Ralph Grimaldi, Rose-Hulman Institute of Technology	O-159
	Detection Theory on Random Graphs Dr. Thomas Mifflin, Metron Scientific Solutions	O-167
3:30pm - 5:05pm	**Contributed Papers**	Olin Hall (Lower Level)
3:30pm - 3:50pm	**The Effect of Regulation on Bitcoin** Connor Kispert	O-157
	Blocking Sets in Finite Projective Planes Brian Bowmaster	O-159
	Working with Data Sets in Maple, Part I Daniel Skoog	O-167
3:55pm - 4:15pm	**The Stock Price Effect of Apple Keynotes** Ethan Petersen	O-157
	Paper Folding Fractals Will Klausler	O-159
	Working with Data Sets in Maple, Part II Daniel Skoog	O-167
4:20pm - 4:40pm	**Big Data: From Stocks, to Poverty, to Policy** Sharanya Pillai	O-157
	Finding Roots of a Non-Linear Function using The Brown-Johnson Method Dillon Brown	O-159
	PSM and ODEs Abby Schendt	O-167
4:45pm - 5:05pm	**Assessing the Sustainability of the Cost of Government and Health Care in the United States** Jacob Rich	O-157
	The F-Signature Function: A New Computation Michael Perlman	O-159
	Representations by Ternary Quadratic Forms Edna Jones	O-167

5:30pm - 6:30pm	**Dinner**	Moench Hall (Second Floor)
6:45pm - 8:00pm	**Plenary Session**	Moench Hall (E-104)
	Opening Remarks Dr. Rick Stamper, Rose-Hulman Institute of Technology	
	Winners of Allstate Predictive Analytics Competition Mark Slusar, Allstate Insurance Company	
	Marketing with Big Data: The Power of Analytics Nick Lockwood, Catalina Marketing	
8:15pm - 9:30pm	**Student Party**	Hulman Union (Chauncey's)

Saturday, April 25

8:30am - 9:00am	**Conference Registration and Onsite Check-In** Light Refreshments	Hulman Union (Main Lobby)
9:00am - 10:00am	**Plenary Session**	Hulman Union (Kahn Room)
	Data Visualization at the New York Times Amanda Cox, New York Times	
10:10am - 11:45am	**Contributed Papers**	Hulman Union
10:10am - 10:30am	**Extending the DESeq software package for use in multi-step differential gene expression testing procedures*** Ciaran Evans	Faculty Dining Room
	Collaboration Graphs and Cluster Analysis Xinwei Li, Jing Mu and Jiarui Xu	Heritage Room
	Stochastic Protein Alignment and Data Compression Alex Zellner	Performing Arts Room
10:35am - 10:55am	**Generalized Linear Mixed Models for Putting Performance on the PGA TOUR*** Scott Manski	Faculty Dining Room
	Modeling on an Open Limestone Channel David Wolfe	Performing Arts Room
11:00am - 11:20am	**Improved Adjoint Sensitivity Analysis: Mathematical Model of Vicodin Abuse** Luke Settles	Faculty Dining Room
	The Broken Stick Problem in Higher Dimensions: From a Classic Puzzle to Modern Distance Geometry Alexander Page, Yuliya Semibratova and Yi Xuan	Heritage Room
	Points Configurations Maximizing a Thomson-like Potential Dena Zhu	Performing Arts Room
11:25am - 11:45am	**Skin Deep Choices** Aaron Brown	Faculty Dining Room

	Fractals, patterns, and randomness in number theory and mathematical physics: Unraveling the mysteries of number-theoretic Fourier series Jia Yu and Yu Fu	Performing Arts Room
12:00pm - 1:00pm	**Lunch** *Birds of a Feather* Roundtable Discussions	Hulman Union (Kahn Room)
1:10pm - 2:45pm	**Contributed Papers**	Hulman Union
1:10pm - 1:30pm	**Bayesian estimation in autoregressive models using reversible jump Markov chain Monte Carlo*** Nathan Rogers	Faculty Dining Room
	Squaring the Circle in Bent Space Noah Davis and Kyle Jansens	Heritage Room
	Modeling the Relationship between Employment Levels and Gross Domestic Product Growth Angela Hanson and Andrew Kipp	Performing Arts Room
1:35pm - 1:55pm	**Analysis of Power Output of a Laser using a Bayesian Approach** Wenjun Kong	Faculty Dining Room
	Computations on Cube Complexes Alexander Gilbert	Heritage Room
	Distance Covariance as an Omnibus Test Against Trends from Stationarity Andrew Kipp	Performing Arts Room
2:00pm - 2:20pm	**Evaluating Gender Bias in Jury Selection** Lorena Maxwell	Faculty Dining Room
	Harmonic Polynomials Hunter Jackson	Heritage Room
	2-state Automata on a Hyperbolic Plane Cormac Slade Byrd	Performing Arts Room
2:30pm - 3:00pm	**Allstate Predictive Analytics Competition Panel** Discussion with winning teams	Hulman Union (Kahn Room)
3:00pm - 3:30pm	**Closing Remarks and Awards**	Hulman Union (Kahn Room)

Program | Short Courses

Understanding Data: From Math (Probability) to Statistics to Machine Learning, and Back to Math (Topology)

Chris Overton
Data Scientist, Ayasdi Inc.
Time: 1:00pm - 3:00pm
Location: O-157

In this session, we will survey a variety of techniques for modeling, forecasting, and discovering patterns in uncertain data. We will present and critique examples using probabilistic models, regression, hierarchical clustering (along with map-reduce), and finally the topological mapper algorithm. For each of these techniques, we discuss a high-level theoretical overview, practical implementation and benefits, as well as demonstrations of what they fail to detect. Data science is now recognized as an important subject, but it is evolving rapidly, and people use the term in very different ways. By providing historical and interdisciplinary background, we hope to help students plan better for how to develop expertise in this challenging area. In particular, needed CS skills are also evolving rapidly. Though this is a small part of the talk, we survey current tools (flat-file etl, sql db's, data frames, Hadoop, Spark) and suggest ways to avoid getting trapped in "data munging" so that one is able to proceed to data science. We close by discussing and showing visualizations of the mapper algorithm, which is used by Ayasdi to help customers in several industry verticals make new sense of their "big data."

The Catalan Numbers

Dr. Ralph Grimaldi
Professor of Mathematics, Rose-Hulman Institute of Technology
Time: 1:00pm - 3:00pm
Location: O-159

One of the most ubiquitous number sequences in mathematics, the Catalan numbers arise in problems dealing with lattice paths, trees, balancing parentheses, compositions, data structures, pattern avoidance, graph theory, coin arrangements, and other areas. In this minicourse we shall investigate some of these applications and also look at some of the properties satisfied by these numbers.

Detection Theory on Random Graphs

Dr. Thomas Mifflin
Group Manager, Metron Scientific Solutions
Time: 1:00pm - 3:00pm
Location: O-167

After the attacks on September 11th, 2001, military and intelligence communities used link analysis to attempt to localize key individuals that masterminded the attack. Link analysis represents relationships among individuals as a graph. Immediately before and after the attack our adversaries took great care into blending into the background of the societies where they resided. The technical question became can we distinguish between the "noise" of relationships in normal societies from the "signal" of the structure of terrorist organizations? This mini-course will show how classical detection theory based on the Neyman-Pearson lemma from statistics (likelihood ratio) can be applied to models of signal and noise in certain classes of random graphs. The course concentrates on the simplest model of random graphs, the Erdos-Renyi model, $G(n, p)$, where n is the number of vertices in the graph and p is the probability that any two vertices are linked with an edge. The course ends with showing selected results from other random graph models, such as the random bipartite projection (Kevin Bacon) model.

Program | Plenary Sessions

Marketing with Big Data: The Power of Analytics

Nick Lockwood
Senior Director of Brand Marketing Analytics, Catalina Marketing
Time: Friday, 6:45pm - 8:00pm
Location: E-104

Data analytics has unquestionably changed the way we shop and has become increasingly critical for everyday items such as grocery, household, and health and beauty products. Retailers in these industries operate on high volumes and razor-thin profit margins, so analytics is leveraged to increase sales whenever possible. One of the most powerful data sets a marketing professional can have is that of actual purchase behavior (i.e., shopping transactions). In this session, we will explore a variety of ways in which companies are utilizing analytics with transactional data to drive sales and provide value to retailers, manufacturers, and consumers alike.

About Nick Lockwood: Nick Lockwood is currently Senior Director of Brand Marketing Analytics at Catalina Marketing, a personalized digital media company with the largest shopper purchase history database in the world. Nick works with client brand teams to uncover strategic insight from Catalina's data and identify optimal purchase-based targets for marketing campaigns. He received a BS in Computer Science and Mathematics from the University of Illinois at Urbana-Champaign before pursuing an MBA from Southern Illinois University Edwardsville. He then attended Indiana University Bloomington for a PhD in Information Systems and worked as an Assistant Professor at Missouri University of Science and Technology before leaving to work at Catalina. Nick's diverse background of programming, data infrastructure, statistics, research methodology, business, and teaching experience has served him well in the field of analytics, and he is enthusiastic about sharing this experience with students interested in a business analytics career.

Data Visualization at the New York Times

Amanda Cox
Graphics Editor, New York Times
Time: Saturday, 9:00am - 10:00am
Location: Hulman Union, Kahn Room

Amanda will discuss the lessons she has learned about data visualization from working with news graphics. In particular, she will discuss the importance of looking at the entire distribution instead of only summary measures (like averages), a lot of good songs have back up singers, and that the annotation layer is very important. She will also discuss current challenges in the field of data visualization including how to represent uncertainty and how to create charts that play well with words.

About Amanda Cox: Amanda Cox is a graphics editor at the New York Times, where she makes charts and maps for the paper and its web site. Before joining the Times in 2005, she earned a master's degree in statistics from the University of Washington. She received the Excellence in Statistical Reporting Award from the American Statistical Association in 2012 and was part of a team that won a National Design Award in 2009.

Program | Contributed Papers

Abstracts of contributed papers are listed below. An asterisk (*) indicates the paper is a finalist for the Distinguished Paper Award.

Friday, 3:30PM to 3:50PM

The Effect of Regulation on Bitcoin

Connor Kispert, Rose-Hulman Institute of Technology
Location: O-157

This paper builds off the connection between China's introduction of new regulations on cryptocurrency and the sharp, negative change in the trend of Bitcoin's value. A time series trend analysis establishes both linear and exponential trends for 6 different regulation events to predict the price of Bitcoin in a small 21 day window surrounding a new government regulation. The paper finds that there is a significant change in trend exactly one day after the introduction of a new regulation on the cryptocurrency. Building on these results a similar analysis was done on volatility of Bitcoin relative to expected volatility to see if its unpredictability was likewise spiking in response to the same set of government regulations. However, similarly suggestive results were not found in volatility's reaction to regulation.

Blocking Sets in Finite Projective Planes

Brian Bowmaster, Rose-Hulman Institute of Technology
Location: O-159

We discuss blocking sets in finite projective planes. Informally, a blocking set, $\mathcal{S}$, is a collection of points in the plane that have the property that all lines in the plane contain at least one of the points in $\mathcal{S}$. We discuss the existence of blocking sets for planes of small order, and then examine blocking sets from a graph theoretical point of view. We show that a blocking set from a geometric point of view can have a well-defined structure but in a graph theory setting, any particular blocking set can have a variety of characteristics.

Working with Data Sets in Maple, Part I

Daniel Skoog, Maplesoft
Location: O-167

Maple 18 introduced many new features for statistical analysis and probability modeling. In this two-part talk, we discuss how to work with data sets in Maple, including incorporating data from Quandl.

Friday, 3:55PM to 4:15PM

The Stock Price Effect of Apple Keynotes

Ethan Petersen, Rose-Hulman Institute of Technology
Location: O-157

We analyzed the volatility of Apple's stock beginning January 3, 2005 up to October 9, 2014, then focused on a range from 30 days prior to each product announcement until 30 days after the announcement. Product announcements were filtered; announcements whose 60 day range was devoid of other events were analyzed in addition to the entire population. This filtration was chosen to isolate the potential cross-effect between events. Analyzing the data within these ranges, there was a clear trend prior to Day 0 and significantly different trend after the event. To explore any confounding effects, a comparison to the VIX was made to determine if the changes in trends were simply following the market or were truly deviating from a trend. Again, these results showed significant activity around Day 0. We believe the findings from this study may raise concerns with the Efficient Market Hypothesis, providing an insight on how strongly this idea relates to activity surrounding Apple keynotes.

Paper Folding Fractals

Will Klausler, Rose-Hulman Institute of Technology
Location: O-159

Beginning with the origins of the Heighway dragon, we will explore the various fractals developed from from paper-folding and those from stepping out of the pattern's initial parameters.

Working with Data Sets in Maple, Part II

Daniel Skoog, Maplesoft
Location: O-167

Maple 18 introduced many new features for statistical analysis and probability modeling. In this two-part talk, we discuss how to work with data sets in Maple, including incorporating data from Quandl.

Friday, 4:20PM to 4:40PM

Big Data: From Stocks, to Poverty, to Policy

Sharanya Pillai, Indiana University
Location: O-157

Big data, from its very inception, has carried with it the power to transform information as we see it. From its roots in cloud computing to its many modern applications such as biostatistics, we are still in the process of unraveling this enigma and attempting to understand not only its depth, but also its possibly unending utility in different domains of study. Here, I would like to focus on one particular area: Financial Economics. This is a field particularly characterized by its pure reliance on statistics for econometrics, and has been revolutionized by the introduction of big data that has made possible the introduction of exotic products, and an outreach never seen before. I would also like to venture out to a related area: Poverty & Development, and try to integrate these two by finding a (relatively) unexplored common thread: statistics. I will finish by possibly (time permitting) linking this to how our society, and the world can be transformed with policy based on the pursuit of data analysis in these fields. This will be done vastly through drawing on prominent individuals in the field and their work.

Finding Roots of a Non-Linear Function using The Brown-Johnson Method

Dillon Brown, Saint Francis University
Location: O-159

The Brown-Johnson Method was developed by combining aspects of the following methods: Bisection Method, Newton's Method, and Secant Method. Secant and tangent lines are used to restrict the range that the root could lie within, and then the Bisection Method is used to approximate the root. The Brown-Johnson method converges at almost the same rate as Newton's method, and also guarantees convergence when given an appropriate initial interval.

PSM and ODEs

Abby Schendt, Rose-Hulman Institue of Technology
Location: O-167

Picard's iteration serves as a simple device for proving existence/uniqueness of ODEs, and is usually dismissed as impractical as an actual approximation technique. If the vector field generating the ODE is polynomial, suddenly Picard's iteration becomes a feasible tool. Converting nonlinear systems to autonomous polynomial vector fields is easy, and application of Picard's is easy to code and an accurate approach to handle a wide range of ODEs. A priori error bounds are possible which do not involve higher order derivatives of the vector field.

Though the Maclaurin polynomials are easy to handle for typical cases, problems exist in which terms become burdensome on any machine, slowing down processing. Also, Maclaurin polynomials lose their high levels of accuracy as one moves away from the center. To fix both problems, a method to remove extraneous terms and reset the center as one moves away from the initial point of data

has been proposed, dubbed PSM.

This talk will give an overview of the PSM approach in theory and application. Numerical simulations for a test case involving a time dependent frequency will be presented.

Friday, 4:45PM to 5:05PM

Assessing the Sustainability of the Cost of Government and Health Care in the United States

Jacob Rich, Eastern Michigan University
Location: O-157

The accumulation of debt in the United States has reached unprecedented levels, yet, little has been done by the U.S.'s policy makers to stanch this slide into the abyss. Furthermore, no attention appears to have been paid towards the true total debt of the U.S., which includes the unfunded liabilities of Social Security ($9.6t), Medicare ($38.6t), benefits for federal employees and veterans ($6.3t), and benefits for state and local employees ($7.1t). This paper outlines the feasibility for the U.S. to honour the adjusted $79 trillion debt (or at a minimum, sustain it) and concludes if the current behaviour regarding government spending and health care expenditure in America is sustainable. The analysis is free of political ideology and includes an actuarial evaluation of the implications of the U.S.'s behaviour, as if it were to operate like a family or business. Four separate models were employed with hopes that each method would support the latter and ensure integrity amongst the conclusions; which they have. Unfortunately, every model suggests a conclusion regarding the sustainability of the cost of government and health care in the U.S. that is far from optimistic.

The F-Signature Function: A New Computation

Michael Perlman, University of Illinois at Chicago
Location: O-159

The roots of a set of polynomial equations correspond to geometric objects called algebraic varieties, the fundamental objects of study in algebraic geometry. I study singularities of these varieties, which are points where the variety fails to be smooth. The F-signature function is a characteristic p invariant of these singularities designed to encode information related to the Hilbert-Kunz multiplicity and the F-signature, two invariants that measure singularities. In all known cases, the F-signature function of a polynomial limits to a piece-wise polynomial as p goes to infinity. However, this behavior is not well-understood and this function is notoriously difficult to compute. For example, it is not known whether the F-signature of the polynomial $f = x^3 + xy^3$ limits to a piece-wise polynomial. In this talk, I will introduce algebraic varieties and the F-signature function, and then I will discuss this example, which I have computed for my capstone project.

Representations by Ternary Quadratic Forms

Edna Jones, Rose-Hulman Institute of Technology
Location: O-167

How can you represent integers by ternary quadratic forms? For example, can the integer 2015 be represented as a sum of a square plus three times a square plus five times a square? A few kinds of representations over the integers (such as global representation and local representation) will be discussed. To better understand these representations, we count how many solutions there are to congruences involving ternary quadratic forms using quadratic Gauss sums and Hensel's Lemma.

Saturday, 10:10AM to 10:30AM

Extending the DESeq software package for use in multi-step differential gene expression testing procedures*

Ciaran Evans, Pomona College
Location: Faculty Dining Room

Recent improvement in the expense and speed of high-throughput sequencing of genetic material has allowed its use to become widespread in a range of scientific research. In particular, high-throughput sequencing is used in RNA-Seq experiments to investigate gene expression levels under different conditions, such as varying concentrations of a specified protein. Differential gene expression analysis attempts to determine whether observed differences in expression levels are statistically significant, using a variety of statistical and computational tools. This involves performing many hypothesis tests, generally at least one for each gene under investigation, and hence differential expression tools must be mindful of both error control and statistical power. I examine the false discovery rate (FDR), which is the standard error rate controlled in RNA-Seq experiments, as well as a multi-step hypothesis testing procedure designed to boost statistical power while maintaining error control. I then use a Monte Carlo sampling procedure to develop a new extension to the commonly-used differential expression software package DESeq to allow its use in this multi-step procedure.

Collaboration Graphs and Cluster Analysis

Xinwei Li, **Jing Mu** and **Jiarui Xu**, University of Illinois at Urbana-Champaign
Location: Heritage Room

With the goal of analyzing the database of jointly authored papers by members of a mathematical network called GEAR, we visualize the relationship of authors as a graph with a vertex for each author and with edges indicating joint authorship. Our objective is to detect the community structure in the graph and to see how the authors from different subcommunities of GEAR collaborate with each other. Using clustering algorithms such as spectral clustering and a fast algorithm by Newman based on the modularity of the graph (a measure of the strength of division of a network into clusters), combined with a graph drawing algorithm by Fruchterman-Reingold, we demonstrate how to display our clustering results in an attractive and informative way. Our method can also be generalized to other networks.

Stochastic Protein Alignment and Data Compression

Alex Zellner, Rose-Hulman Institute of Technology
Location: Performing Arts Room

The study of proteins is preeminent in the field of computational biology, and substantial amounts of mathematical and computational effort are being employed to investigate their structure, function, and creation. One of the landmark problems is to compare proteins to identify functionally similar families. We approach such comparisons by studying proteins as stochastic entities, and in particular, we posit the question, Can a protein's innate random variation identify a (small) subset of information sufficient to conduct pairwise comparisons?

Saturday, 10:35AM to 10:55AM

Generalized Linear Mixed Models for Putting Performance on the PGA TOUR*

Scott Manski, Kalamazoo College
Location: Faculty Dining Room

In golf, putting is considered to be the single most important aspect of the game. For many years, measuring putting performance has been restricted to simply measuring putts per round. In this paper, we concentrate on quantifying the various factors that contribute to putting performance. A series of generalized linear models and generalized linear mixed models using the logit link function were used in this analysis. The response variable used was whether or not the putt finished in the hole, making the logit link function ideal for this analysis. The BIC and McFadden's R squared model selection criteria were used for model comparison. The best model consisted of fixed effects; Distance and Putt.For, and random effects; Year within Player and Hole within the Course. An analysis of the best linear unbiased predictors (BLUPs) also provides insight into the conditions for which putting performance is at its best. Additionally, a generalized linear mixed model was fit for the 2014 season and the BLUPs were used as a ranking system for putting performance. The results were compared to the rankings provided by strokes gained putting and the ranking systems showed moderate consistency.

Modeling on an Open Limestone Channel

David Wolfe, Saint Francis Univeristy
Location: Performing Arts Room

Acid mine drainage (AMD) is the outflow of acidic water from metal mines or coal mines. When exposed to air and water, metal sulfides from the deposits of the mines are oxidized and produce acid, metal ions and sulfate, which lower the pH value of the water. An open limestone channel (OLC) is a passive and low cost way to neutralize AMD. A mathematical model has been created to numerically determine the change in pH of the water and the concentrations of species from the dissolution of calcium on the surface of the limestone into the acidic water. The model is used to predict the conditions in which a OLC would be an effective solution for AMD. Effective ranges are determined for the concentrations of calcium and iron, as well as the temperature and velocity of the water.

Saturday, 11:00AM to 11:20AM

Improved Adjoint Sensitivity Analysis: Mathematical Model of Vicodin Abuse

Luke Settles, Southern Illinois University Edwardsville
Location: Faculty Dining Room

Vicodin is the most commonly prescribed pain reliever in the United States, and about two million Americans are currently abusing it. The goal of this research is to reevaluate the previous sensitivity analysis done by Caldwell et. al. on the models they introduced. Through the incorporation of a terminal payoff term, a more streamlined and accurate method of determining the normalized sensitivity indices is derived. The outcomes of this new method are the same for the parameters but provide new insight for the sensitivity with respect to the initial populations.

The Broken Stick Problem in Higher Dimensions: From a Classic Puzzle to Modern Distance Geometry

Alexander Page, **Yuliya Semibratova** and **Yi Xuan**, University of Illinois at Urbana-Champaign
Location: Heritage Room

If a stick is broken up at two random points, what is the probability that the three pieces will form a triangle? This question, called the broken stick problem, first appeared about 150 years ago in an examination at Cambridge University. It attracted the interest of 19th century French probabilists, and more recently was popularized by Martin Gardner.

In this presentation, we consider the generalization of this problem to three (or more) dimensions. In particular, if a stick is broken up at five random points, what is the probability that the six pieces will form a tetrahedron? Questions of this type arise in the field of distance geometry, which has connections areas such as wireless sensor networks and molecular biology.

This is joint work with Rui Eva Zhang, carried out at the Illinois Geometry Lab (IGL).

Points Configurations Maximizing a Thomson-like Potential

Dena Zhu, University of Illinois at Urbana-Champaign
Location: Performing Arts Room

The Thomson Problem deals with the maximization of the electric potential of electrons restricted to a sphere. This problem has been solved numerically for various numbers of particles. However there have been results about this behavior that have been shown rigorously. This has led to large interest in studying spinoffs of the problem and various potentials. In this talk we consider a potential determined by the sum of the distance squared between each particle as well as a subtracted term that grows with particle distance from the origin. We do not restrict the particle positions at all.

Using elementary techniques, we obtain a geometrically appealing result that when this potential is maximized when the space we consider has dimension $n > 2$, all points lie on a $(n-1)$-sphere centered at the origin with radius determined by two given parameters with the center of mass of the points is also located at the origin. Furthermore, we give a partial analysis of the critical points which do not correspond to absolute maxima - the most interesting of these occur when all points are collinear. We conclude by remarking on a few ways in which these results can be generalized.

Saturday, 11:25AM to 11:45AM

Skin Deep Choices

Aaron Brown, Rose-Hulman Institute of Technology
Location: Faculty Dining Room

The strategy of holding a diversified portfolio has always made sound economic sense in terms of stocks and bonds. When economic shocks occur, instead of the entire portfolio tanking, a well-diversified portfolio would experience much less loss or even gains. We want to see if this idea of diversification also translates to the financial standings in Major League Baseball (MLB). We base our economic analysis on over a decade's worth of data concerning MLB demographic makeup, revenues, and game attendance. We also consider some National Football League demographic makeup and revenues to gain further insight on the sports industry in general.

Fractals, patterns, and randomness in number theory and mathematical physics: Unraveling the mysteries of number-theoretic Fourier series

Jia Yu and **Yu Fu**, University of Illinois at Urbana-Champaign
Location: Performing Arts Room

In the 1980s, mathematical physicists discovered intriguing spiral-like features while investigating certain classes of curves that arise in the study of diffraction of light. In this presentation we report on research performed at the Illinois Geometry Lab on similar - and to date unexplained - phenomena observed with a very different class of curves, associated with Fourier Series arising in number theory. Our goal is to investigate these curves in a systematic manner, and to develop a theory to explain the mysteries observed.

This is a joint work with Ryan Grady, and Yuda Wang, carried out at the Illinois Geometry Lab (IGL).

Saturday, 1:10PM to 1:30PM

Bayesian estimation in autoregressive models using reversible jump Markov chain Monte Carlo*

Nathan Rogers, University of Illinois at Chicago
Location: Faculty Dining Room

In most real applications, there is uncertainty about the statistical model to be considered. In this paper, we consider a particular class of autoregressive time series models where the order of the model—which determines the dimension of parameter—is uncertain. A common approach for model selection is to balance model fit with model complexity using, say, an AIC criterion. However, such an approach provides no meaningful measure of uncertainty about the selected model. A Bayesian approach, on the other hand, which treats the model and model parameters as random variables, can directly accommodate model uncertainty. The challenge is that the Bayesian posterior distribution is supported on a union of spaces of different dimensions, which makes computation difficult. We consider a reversible jump Markov chain Monte Carlo method for sampling from the posterior, and apply this method to provide a Bayesian analysis of simulated and real data.

Squaring the Circle in Bent Space

Noah Davis and **Kyle Jansens**, Aquinas College
Location: Heritage Room

We can construct squares and circles with the same hyperbolic area. The method was presented at last year's conference. To complete the set of Euclidean (impossible), hyperbolic and elliptic geometries, this talk presents the elliptic construction and a sketch of its proof. Everyone should know how this 2300 year-old story ends.

Modeling the Relationship between Employment Levels and Gross Domestic Product Growth

Angela Hanson and **Andrew Kipp**, Rose-Hulman Institute of Technology
Location: Performing Arts Room

The purpose of this research is to form an approximate optimization model for gross domestic product (GDP) and then to determine if there is a level of U-3 unemployment or civilian employment-to-population ratio which maximizes percent growth in GDP. We use both these ratios rather than just unemployment rate because of previously unsatisfactory results from evaluating solely unemployment. Our models examine the relationship between variables like tertiary education, investment rate, exports and imports of goods and services, and gross domestic savings. Each contributor to change in GDP listed above is given a value to proportionally weight its effects. To improve accuracy of the model, we attempt to include squared and interaction terms as well. The data gathered is from various time spans in the United States.

Saturday, 1:35PM to 1:55PM

Analysis of Power Output of a Laser using a Bayesian Approach

Wenjun Kong, Rose-Hulman Institute of Technology
Location: Faculty Dining Room

A Gaussian beam is a beam that has its intensity profile following a Normal distribution. A red Helium-Neon lase is usually used in a laser laboratory due to its small power consumption and its stable power output overtime.

Always assuming that it has a stable power output, we started to wondering if there is a trend for the fluctuation of the power output. Therefore, we conducted a study on the laser power output overtime and obtained a results that the power output had a decreasing trend with a rate of 2.92×10^{-5} (mW/s) with a credible interval of $(-4.631 \times 10^{-5}, -1.144 \times 10^{-5})$, which would give a significant effect (i.e. the laser dies) after days.

Computations on Cube Complexes

Alexander Gilbert, University of Illinois at Chicago
Location: Heritage Room

The Virtually Haken Conjecture, one of the most important open questions in low-dimensional topology, was proved in 2012 by Ian Agol. The events leading up to the discovery of this proof included a key Conjecture made by Dani Wise, and Agol's verification of this conjecture proved The Virtually Haken Conjecture as a consequence. Wise's conjecture involved "cube-complexes". Cube complexes are built from basic unit cubes glued together along their faces by isometries. Just like graphs these cube complexes can be defined purely combinatorially which lends them to be easily understood and interpreted by a computer. In this talk we will explore how computer programs can help us gain a better understanding of these complexes. I have developed software that can perform the following algorithms; calculate the fundamental group of a cube complex, check whether or not

a cube complex is non-positively curved, and determine if a cube complex is special, a key property in Agol's proof. I will present this software and some calculations.

Distance Covariance as an Omnibus Test Against Trends from Stationarity

Andrew Kipp, Rose-Hulman Institute of Technology
Location: Performing Arts Room

An important aspect of a data generating process is whether or not it is stationary. Tests of stationarity, which test whether or not the data's distribution is constant over time, can be used to determine if a process is performing properly. We developed an omnibus test of stationarity which uses the distance covariance measure developed by Maria L. Rizzo and Gabor J. Szekely. We compared our omnibus test with three popular tests used in quality methods: the runs test, the zone test, and the correlation test. Our test compares favorably with all three procedures.

Saturday, 2:00PM to 2:20PM

Evaluating Gender Bias in Jury Selection

Lorena Maxwell, Rose-Hulman Institute of Technology
Location: Faculty Dining Room

The selection process for juries has been questioned as biased on numerous occasions. In 1969, the pediatrician Dr. Benjamin Spock was brought to trial after being charged with conspiracy to violate the Military Service Act. The jury selected was chosen after two rounds. A panel of 350 persons was originally selected by the clerk. Of the 350, 102 were women, despite the fact that 53% of the eligible jurors in the district were female. During the next stage, the judge chose 100 people. Of this number, 9 were women. In this talk, we use a Bayesian hierarchical model to determine whether the judge behaved biased.

Harmonic Polynomials

Hunter Jackson, University of South Florida
Location: Heritage Room

In this paper, we study properties of complex polynomials that are harmonic in the plane. This includes how, by applying the Fundamental Theorem of Algebra and Bezout's Theorem, one could seek a sharp bound for a number of solutions to a harmonic polynomial.

From there, we will study the orientation of harmonic polynomials as well as the properties that could lead to determining the number of roots for a canonical example of a harmonic polynomial including contour and caustic plots. Finally, we will discuss the open questions currently being studied and will answer the question: Is the Fundamental Theorem of Algebra still true for Harmonic Polynomials?

2-state Automata on a Hyperbolic Plane

Cormac Slade Byrd, Walter Payton

Location: Performing Arts Room

We consider what happens when we translate conways game of life from the euclidean plane to the hyperbolic plane. To tile the hyperbolic plane so we use a [5,4] pentagonal tiling. We initially tried to prove that there is no 2-state sum of neighbor rule on this plane that would result in the rule being universal, however we were only able to prove that of all the possible rules, the only rules that could be universal had to include at least one of born zero neighbors, born one neighbor, or born three neighbors. Additionally we then considered Bring's Curve, a genus four surface, which we can finitely tile with only 24 pentagons. We then were able to compute the end behavior of ever possible starting configuration of alive and dead cells with the born three, stay alive two and three rule. We then proved that any finite still life on the infinite tiling that can be translated to Bring's Curve is not a still life on Bring's Curve. Finally we observed the behavior and classified ever possible end behavior of the 2^{24} possible initial configurations.

Conference Attendees

Bryan Andrews	Eastern Michigan University
Stephen Bowling	Southwest Baptist University
Brian Bowmaster	Rose-Hulman Institute of Technology
Peter Boyd	Purdue University
Steve Bradlow	University of Illinois at Urbana-Champaign
Allen Broughton	Rose-Hulman Institute of Technology
Aaron Brown	Rose-Hulman Institute of Technology
Dillon Brown	Saint Francis University
Matt Buckner	Rose-Hulman Institute of Technology
Max Buot	Xavier University
Nathan Chenette	Rose-Hulman Institute of Technology
Ryan Coffman	Rose-Hulman Institute of Technology
Andon Crisp	Southwest Baptist University
Kiattipong Damrongwet	Rose-Hulman Institute of Technology
Danielle Dattilio	DePauw University
Sarah Davidson	Xavier University
Noah Davis	Aquinas College
Christina DeSantiago	Purdue University
John Diorio	Eastern Michigan University
Casey Edgar	Eastern Michigan University
Joe Eichholz	Rose-Hulman Institute of Technology
Ciaran Evans	Pomona College
Felix Francisco-Sanchez	Purdue University
Manjie Fu	Purdue University
Yu Fu	University of Illinois at Urbana-Champaign
Patrick Gallagher	Purdue University
William Ge	Rose-Hulman Institute of Technology
Alexander Gilbert	University of Illinois at Chicago
Jayme Gonzales	Purdue University
Dave Goulet	Rose-Hulman Institute of Technology
Ryan Grady	University of Illinois at Urbana-Champaign
William Green	Rose-Hulman Institute of Technology
Ralph Grimaldi	Rose-Hulman Institute of Technology
Ryan Grossman	Ivy Tech Community College
Katie Gyurek	
Angela Hanson	Rose-Hulman Institute of Technology
Sijun He	Rose-Hulman Institute of Technology
A J Hildebrand	University of Illinois
Sebastian Hoar	Xavier University
Allen Holder	Rose-Hulman Institute of Technology
Leanne Holder	Rose-Hulman Institute of Technology

Haojian Hong	University of Illinois at Urbana-Champaign
Fang Huang	Rose-Hulman Institute of Technology
Vincenzo Isaia	Rose-Hulman Institute of Technology
Hunter Jackson	University of South Florida
Kyle Jansens	Aquinas College
Abigael Johnson	Purdue University
Andrew Johnson	Saint Francis University
Edna Jones	Rose-Hulman Institute of Technology
Brian Kidd	Purdue University
Andrew Kipp	Rose-Hulman Institute of Technology
Connor Kispert	Rose-Hulman Institute of Technology
Will Klausler	Rose-Hulman Institute of Technology
Wenjun Kong	Rose-Hulman Institute of Technology
Zhijie Kong	University of Michigan
Brady Kornrumpf	Southwest Baptist University
Georgios Kydonakis	University of Illinois at Urbana-Champaign
Tom Langley	Rose-Hulman Institute of Technology
Richard Layton	Rose-Hulman Institute of Technology
Mingyu Li	University of Illinois at Urbana-Champaign
Xinwei Li	University of Illinois at Urbana-Champaign
Ying Li	Saint Francis University
Lily Liu	Pomona College
Robert Lombrana	Eastern Michigan University
Joe Longo	Holy cross
Ruth Luo	University of Illinois at Urbana-Champaign
Emily Malek	Purdue University
Scott Manski	Kalamazoo College
Emily Martin	Purdue University
Lorena Maxwell	Rose-Hulman Institute of Technology
Michael McDaniel	Aquinas College
Mitchell McDaniel	Aquinas College
Thomas Mifflin	Metron Scientific Solutions
Cameron Mooney	IUPUI
Jing Mu	University of Illinois at Urbana-Champaign
Erik Norlin	Purdue University
Bailey O'Malley	Purdue University
Blaise Onyiaike	Southwest Baptist University
Mitch Orzech	Rose-Hulman Institute of Technology
Chris Overton	Ayasdi
Yuri Overton	
Alexander Page	University of Illinois at Urbana-Champaign
Zehua Pan	University of Illinois at Urbana-Champaign
Mark Panaggio	Rose-Hulman Institute of Technology

Michael Perlman	University of Illinois at Chicago
Ethan Petersen	Rose-Hulman Institute of Technology
Ashley Peterson	Purdue University
M Tip Phaovibul	University of Illinois
Weston Phillips	Purdue University
Sharanya Pillai	Indiana University
Brittany Porter	Southwest Baptist University
David Rader	Rose-Hulman Institute of Technology
Jenna Reno	Purdue University
Jacob Rich	Eastern Michigan University
Christine Ringwald	Purdue University
Nathan Rogers	University of Illinois at Chicago
Tyler Russ	Eastern Michigan University
Rei Rutkowski	Purdue University
Abby Schendt	Rose-Hulman Institute of Technology
Anna Scott	Rose-Hulman Institute of Technology
Yuliya Semibratova	University of Illinois at Urbana-Champaign
Luke Settles	Southern Illinois University Edwardsville
Erin Simmons	Eastern Michigan University
Cormac Slade Byrd	Walter Payton
Mark Slusar	Allstate Insurance Company
Spencer Smith	Southwest Baptist University
Melissa Sovak	California University of Pennsylvania
Danielle Sponseller	University of Illinois at Urbana-Champaign
Ryan Stadtfeld	Eastern Michigan University
Jonathan Taylor	Rose-Hulman Institute of Technology
William Trice	Eastern Michigan University
Bogdan Vajiac	Saint Mary's College
Christopher Vincent	Purdue University
Abigail Vorhies	Purdue University
Miao Wang	University of Michigan
Xueqi Wang	University of Illinois at Urbana-Champaign
Yilin Wang	Rose-Hulman Institute of Technology
Mark Daniel Ward	Purdue University
Han Wei	Rose-Hulman Institute of Technology
David Wolfe	Saint Francis University
Konrad Wrobel	University of Illinois at Urbana-Champaign
Jiarui Xu	University of Illinois at Urbana-Champaign
Yi Xuan	University of Illinois at Urbana-Champaign
Lake Yoke	Purdue University
Jia Yu	University of Illinois at Urbana-Champaign
Alex Zellner	Rose-Hulman Institute of Technology
Christine Zhang	Purdue University

Tengji Zhang	Rose-Hulman Institute of Technology
Yang Zhang	Rose-Hulman Institute of Technology
Ran Zhou	University of Illinois at Urbana-Champaign
Dena Zhu	University of Illinois at Urbana-Champaign