

Michigan State University

Department of Mathematics

**11<sup>TH</sup> MSU STUDENT MATHEMATICS  
CONFERENCE**



**April 12<sup>th</sup>, 2014**

# Eleventh MSU Student Mathematics Conference

Saturday, April 12, 2014

All talks will be in C304 Wells Hall.

9:45 – 10:00 am: Continental Breakfast in C304 Wells Hall

10:00 – 10:15 am: Welcoming Remarks, Professor Yang Wang

## Session 1: 10:15 – 11:40 am

- 10:15 – 10:35     *Characterizing Landfill Data for Maximum Methane Extraction*  
Jeremy Babila, Yunyun Wei, Weicong Zhou
- 10:40 – 10:55     *Applying Group Theory to Molecular Models*  
Kenneth Plackowski
- 11:00 – 11:20     *Crash-Relevant Vehicle Parameters beyond Mass and Footprint*  
Jingyun Fan, Veronica Marth, Chad Stripling
- 11:25 – 11:40     *Group Theory Valuation of Particle Physics*  
Dewen Zhong

## Break: 11:45 – 11:50 am

## Session 2: 11:55 am – 12:55 pm

- 11:55 – 12:10     *A Predictive Modeling Approach to Option Pricing*  
James Regan II
- 12:15 – 12:30     *A Geometric Interpretation of the Frisch-Waugh-Lovell Partitioned Regression Theorem*  
Ethan Davis
- 12:35 – 12:55     *Regression Analysis of the Winter Protection Plan*  
Steve Draggoo, Dmitry Mikhaylov, Eddie Niedermeyer

## Lunch & Morning Presentation Awards in C304 WH: 1:00 – 1:35 pm

**Session 3: 1:40 – 3:00 pm**

- 1:40 – 1:55      *Precision of Mathematical Language and its Effects on Student Learning*  
Kellie Stilson
- 2:00 – 2:15      *On the Logic of Infinity*  
William Penn
- 2:20 – 2:35      *Riemann's Rearrangement Theorem*  
Christie Campbell
- 2:40 – 3:00      *Isomorphisms of Ring Extensions of Algebraic Numbers*  
Tom Gannon and Jake Landgraf

**Break: 3:05 – 3:15 pm**

**Session 4: 3:20 – 4:35 pm**

- 3:20 – 3:35      *Modeling Imaginary Exponential Functions using Polar Coordinates*  
Jeremy Kray
- 3:40 – 3:55      *Computer Science, Mathematics and Security*  
Minh Pham
- 4:00 – 4:15      *Estimating the Number of Characters in a Scanned Bar Code*  
Andrew Werner
- 4:20 – 4:35      *Deriving Parameters of Competing Poisson Processes*  
Erik Bates

**Break: 4:40 – 4:50 pm**

**Afternoon Presentation Awards and Team Problem Solving Competition: 4:55 – 5:40 pm**

**Pizza in C-304 WH: 5:40 – 6:10 pm**

## Session 1

10:15 – 11:40 am

Chaired by Professor Peiru Wu

### *Characterizing Landfill Data for Maximum Methane Extraction*

**Jeremy Babila, Yunyun Wei, Weicong Zhou**, Michigan State University

Abstract: The Landfill Gas (LFG) collection systems are designed to collect methane gas for safety as well as energy usage. With the collected data, the goal of the project is to maximize/maintain the flow of methane while reducing the presence of other gasses, such as carbon dioxide and oxygen. First data mining techniques are used to create the variables that are most useful for characterizing the wells. Once well-established characteristics are defined correlation analysis and clustering analysis are performed to group wellheads that behave similarly and single out any outliers in order to improve overall extraction of methane gas.

### *Applying Group Theory to Molecular Models*

**Kenneth Plackowski**, Michigan State University

Abstract: The behavior and properties of molecules are related to underlying theories: specifically regarding their symmetries. The most important study of these properties lies in quantum theory. To understand quantum theory is to understand chemical bonding and molecular dynamics of atoms involved. Energy levels defined for atoms and molecules are precisely determined by the symmetries of the molecule and we can explain what types of reactions and relationships are possible. Thus we can use the describing qualities of group theory to understand these rotational symmetries inherent in each molecule. We will briefly introduce the familiar properties of groups and then relate those rules to molecules. Finally, we will consider some examples in where group theory allows us to reach conclusions we would not have been able to before.

### *Crash-Relevant Vehicle Parameters beyond Mass and Footprint*

**Jingyun Fan, Veronica Marth, Chad Stripling**, Michigan State University

Abstract: The purpose of this project is to merge 2002-2008 fatality crash information from the National Highway Traffic Safety Administration (NHTSA) and crash test vehicle parameters from NHTSA New Car Assessment Program (NCAP) dataset. The NCAP data set provides crash test parameters of various makes and models. With this information, correlations between crash fatality risk of occupants and the vehicles' crash tests characteristics will be investigated using logistic regression and conclusions will be formed. These can then be used to develop a probabilistic model of the vehicle fleet that can estimate injury and fatality rates for Chrysler Group LLC. These rates will then be compared to federal regulations to determine their efficacy.

### *Group Theory Valuation of Particle Physics*

**Dewen Zhong**, Michigan State University

Abstract: Group theory has, historically, been applied to many problems in quantum physics. Quantum mechanics showed that matter is made up of particles, such as electrons and protons. Since given two identical particles, one cannot be distinguished from another (i.e. we cannot distinguish one proton from another), symmetry in their arrangement is exact, not approximate as in the macroscopic world. In all cases, symmetry can be expressed by certain operations on the system concerned, which have properties revealed by group theory. The special unitary  $SU(N)$  group is often used in the Standard Model of particle physics, especially  $SU(1) \times SU(2)$  in the electroweak interaction and  $SU(3)$  in Quantum Chromodynamics (QCD). QCD is a type of quantum field theory in which the analog of electric charge in Quantum Electrodynamics (QED) is a property called "color" and gluons are the force carrier of the theory. Based on QCD, we have a useful tool, called "color-flow", which provides great help in data analysis of Higgs research. We will briefly introduce the properties of a unitary group, such as  $U(2)$  and  $SU(3)$ , and then show how it could be used in combining quarks wave-function and introduce the idea of color and the application of  $SU(3)$  in QCD. Finally, we will show the application of "color-flow" in the experimental physics research of Higgs particle.

## Session 2

**11:55 am – 12:55 pm**

**Chaired by Professor Emiliano Valdez**

*A Predictive Modeling Approach to Option Pricing*

**James Regan II**, Michigan State University

Abstract: The Black-Scholes pricing model is ubiquitous in option pricing theory. However, it relies on certain assumptions that empirically do not appear to hold in real-world option markets. This talk examines predictive modeling techniques that can be used to model implied volatility of a certain stock option. I will be applying both ordinary-least squares regression and support vector regression to the Practitioner Black-Scholes pricing scheme and model implied volatility. With an estimated model for implied volatility, we can price our options more accurately to what is currently going on in the market instead of according to historical data. We can also use our model to forecast what implied volatility will be in the future, so we can estimate what this option will go for in the future as well.

*A Geometric Interpretation of the Frisch-Waugh-Lovell Partitioned Regression Theorem*

**Ethan Davis**, Michigan State University

Abstract: The FWL Partitioned Regression Theorem is a result in econometrics regarding a linear regression model whose explanatory variables have been partitioned into two subsets, where the parameter coefficients for one set of variables are of interest. The theorem states that the least squares estimate of the coefficients for the subset of variables of interest obtained from the block-partitioned linear regression model can be obtained identically from the regression where the explained variable and explanatory variables of interest have been detrended from those variables not of interest. Mathematically this is achieved by projecting the vector of y-data and matrix of x-data of interest into the orthogonal complement of the space spanned by the x-variables not of interest and results in a lighter computation. This presentation interprets both estimation methods using Euclidean geometric arguments to illustrate visually why both approaches to regression are identical.

*Regression Analysis of the Winter Protection Plan*

**Steve Draggoo, Dmitry Mikhaylov, Eddie Niedermeyer**, Michigan State University

Abstract: The goal of this project is to assess the Winter Protection Plan offered by Consumers Energy and evaluate its effectiveness. The plan protects low-income and senior customers from shut-offs during cold months by leveling the utilities expenses. A linear regression model based on the data collected for several consecutive years determines the likelihood that a participant will complete all payments based on their demographic information. Specific recommendations are made in order to improve the program.

### Session 3

1:40 – 3:00 pm

Chaired by Professor Christel Rotthaus

*Precision of Mathematical Language and its Effects on Student Learning*

**Kellie Stilson**, Michigan State University

Abstract: Suppose a teacher instructs a student to remember that when reporting the area, they have to write “square units”, or ask, “Then did you get rid of the 3 on both sides?”, or tell them to “flip it upside-down and multiply” to eliminate a fraction in the denominator. As math teachers focus more and more on teaching procedural computations in class, students lose more and more understanding of the procedures. Of course, they may be able to replicate the solution or rote memorize a proof, but by having a shallow understanding, they lose much of the thinking behind mathematics and rely solely on the machinery. While teachers must change many things in order to amend this “plug and chug” trend, I argue that using precise mathematical language and appropriately analyzing student understanding can have a positive effect on student understanding. For motivation, I will reference my own teaching and observing experiences of different grade levels, focusing primarily on measurement and geometric visualization – though my comments can be adapted and applied more generally across other areas of mathematics.

*On the Logic of Infinity*

**William Penn**, Michigan State University

Abstract: In resolving a paradox, specifically the paradoxes of the infinite (Zeno’s paradoxes, the set theoretic paradoxes, etc.), there are three options available. Given a typical argument with premises P, inferences F, and conclusion C, if C is paradoxical, then one can either reject P (or one member of P), reject F (or one member of F), or accept C. I claim that in responding to a paradox of the infinite, the third solution is preferable because it comes with far less conceptual and utilitarian cost than the other two.

I shall argue that the proponent of logic revision retains the power of metaphysics at the cost of deductive power, and the proponent of ontological revision sacrifices the power of metaphysics to preserve logic, while the third option retains the full power of metaphysical intuition and logic at a much lower cost: the revision that certain logical principles (specifically the law-of-excluded-middle) are quasi-valid, not valid simpliciter.

I shall focus my discussion to the specific case of the set theoretic paradoxes (generated by the axiom of unrestricted comprehension) and I shall argue that, since these typify paradoxes of the infinite, my solution can be properly generalized to include other paradoxes of infinity.

*Riemann’s Rearrangement Theorem*

**Christie Campbell**, Michigan State University

Abstract: Riemann’s Rearrangement Theorem states that, given a conditionally convergent series, we can rearrange the terms of that series, to create a new series that will converge to any real number  $c$ . The fact that there exists a permutation, and not just a sub-selection of the original series, is what makes this a much more challenging and interesting result. The details of this proof and the relevance of infinite series will be discussed during this presentation.

*Isomorphisms of Ring Extensions of Algebraic Numbers*

**Tom Gannon and Jake Landgraf**, Michigan State University

Abstract: We investigate the equality of rings of the form  $R[\sqrt{2}, \sqrt{3}]$  and  $R[\sqrt{2} + \sqrt{3}]$ , where  $R$  is a subring of the complex numbers. We prove that, when  $R = \mathbb{Q}$ , these two rings are equal and when  $R = \mathbb{Z}$  these two rings are not equal. We generalize the argument to show  $\mathbb{Q}[\sqrt{p}, \sqrt{q}] = \mathbb{Q}[\sqrt{p} + \sqrt{q}]$  for all distinct primes  $p, q$ .

#### **Session 4**

**3:20 – 4:35 pm**

**Chaired by Professor Russell Schwab**

*Modeling Imaginary Exponential Functions using Polar Coordinates*

**Jeremy Kray**, Michigan State University

Abstract: One well-known property of exponentials is that any nonzero number to the power of 0 equals 1. Researching how this works with negative numbers by using square roots revealed an imaginary exponential function that can be easily modeled by a polar function. It is possible to generalize this polar function for any imaginary exponential function. The content of this presentation will include the proof of this concept as well as the derivation of the generalized polar equation. Other outcomes of this proof will also be analyzed, including finding the set of all  $n^{\text{th}}$  roots of any complex number and the strategy for finding generalized formulas for  $\sin(nx)$  and  $\cos(nx)$ .

*Computer Science, Mathematics and Security*

**Minh Pham**, Michigan State University

Abstract: Cryptography has been around for almost 4000 years. How do contemporary cryptographic systems compare to those of 4000 years ago? In this presentation, we will discuss the role of mathematics in the field of cryptography, as well as an old encryption method and compare it to the RSA algorithm, the most widely used cryptographic algorithm for e-commerce.

*Estimating the Number of Characters in a Scanned Bar Code*

**Andrew Werner**, Michigan State University

Abstract: When a one-dimensional bar code is scanned, a laser shines back-and-forth across the bar code. Due to ambient light and scanner distance, the scanning process results in measured data that is blurred and noisy. My talk will discuss my efforts to develop an algorithm that takes in such measured data and then estimates the correct number of bars in the bar code that generated it (when the bar code is allowed to have an arbitrary number of bars, as in Code 128). My proposed solution method uses both edge detection, and a modified clustering approach.

*Deriving Parameters of Competing Poisson Processes*

**Erik Bates**, Michigan State University

Abstract: Suppose one counts the number of times an event occurs, and suppose the times elapsed between consecutive occurrences are independent. This stochastic counting procedure is known as a Poisson process, and the waiting times between occurrences all follow a single exponential distribution. A natural question is, "How long does one expect to wait between occurrences?" The answer is well-known to be the mean of the exponential distribution. But what if one observes competing Poisson processes, each of which obeys a different average waiting time? Given observations of only how the sum Poisson process behaves, how does one determine the average waiting time of each process acting independently? I will answer this question after first introducing Poisson processes and their relationship to exponential distributions.

#### **Team Problem Solving Competition**

**4:55 – 5:40 pm**

**Chaired by Professor Bob Bell**

Sharpen your problem solving skills and have fun racing to figure out the solutions to a variety of mathematical problems and puzzles. Form a team of 2-3 students and join us for an end of the day spirited competition. You and your teammates will race to a series of problems, each with a 4 minute time limit. The top scoring teams will be awarded prizes, and fun will be had by all!