Abstracts of Student Talks

Mathematical Association of America, Allegheny Mountain Section Meeting
Duquesne University, Friday April 7, 2017

7:35 – 7:50 p.m.

Tristan Hyde, *Slippery Rock University of Pennsylvania,* ***College Hall 220***

A Problem Related to the Game of Set

In a recent issue of Math Horizons, there was a problem about a game of two players which operated in a manner similar to the game of Set. In this talk, we will explore the proposed game and find a strategy for one player which will allow that player to win, regardless of their opponent's strategy.

Karen Adams, *Shepherd University,* ***College Hall 223***

A Discrete Case of Minkowski's Inequality using Induction

Mathematical Induction is a method of mathematical proof typically used to establish that a given statement is true of all natural numbers or otherwise is true of all members of an infinite sequence which will be demonstrated in this presentation.

Nicole Chris, *West Liberty University,* ***College Hall 225***

Reverse Engineering Newton's Method

Given a function and a starting point Newton's Method generates a sequence. A second, and related, sequence-generating method will also be introduced. In this talk we study the inverse problem in which a sequence is specified and we seek a function that generates it when one or both of these methods is applied. A symmetry between the methods leads to the fact that the graphs of functions generating the same sequence form families of orthogonal trajectories. This talk will use basic facts from differential equations, linear algebra, and calculus.

Donovan Ramsey, *Duquesne University,* ***College Hall 446***

Geometry -vs- Intensity in Image Denoising

Recent studies suggest that various denoising methods can be improved upon by denoising some geometric feature of a noisy image instead of processing the image directly. We have observed that while the object boundaries within an image always benefit from this approach, smooth regions do not always enjoy the same benefits. In this research we are currently exploring mechanisms within this framework for treating smooth areas and edge regions differently to generate an optimal reconstruction across the entire image.

Mary Jaskowak, *Mercyhurst University,* ***College Hall 447***

The Fourth Dimension

This talk will use rotations to show the need for higher dimensions. The development of the understanding of the fourth dimension will be explored.

Michael Wigal, *West Virginia University,* ***College Hall 449***

Online Coloring Blowups of a Known Graph

A graph coloring game of width w is played between two players, Algorithm and Spoiler. Both the graph G and width w are known to both players before the start of the game. Spoiler plays a token on a vertex of G. Algorithm then responds by coloring the token so that tokens on the same or adjacent vertices have distinct colors. Spoiler must ensure that w colors would suffice if all token positions were known prior to coloring. This is equivalent to Spoiler ensuring that the token blowup graph (in which two tokens are adjacent if and only if their distance in G is at most 1) has a chromatic number at most w. Algorithm wants to minimize the total amount of colors used while Spoiler wants to maximize the total amount of colors used. The value of the game, denoted f(G,w), is the minimum number of colors needed for an optimal Algorithm strategy. A graph G is online-perfect if f(G,w) = w. We give a forbidden induced subgraph characterization of the class of online-perfect graphs. This game is inspired by a natural coloring game on the real number line.

Bohan Qu, *University of Pittsburgh at Johnstown,* ***College Hall 553***

It Is Just a Number: 12345679 and Its Properties

The magic number 12,345,679 in Base 10 is known for some interesting properties, and it is often stated as a fun fact; yet few have done scholarly research on this number. We determine some further properties about this number that do not appear to have been observed before. In fact, there is always a similar number with similar properties in any arithmetic base b greater than 2:

1) There is always such a number $\beta=[b\text{^}(b-1)-1]/(b-1)\text{^}2$
2) When multiplying β by any number m not relatively prime to b-1 (and the greatest common divisor is d), mβ results in a number constructed by a pattern repeating itself d times.
3) When multiplying β by any number m relatively prime to b-1, mβ results in a number with no repeating digits, and using up all digits from 0 to b-1 except ((b-1-m) mod (b-1))

Note that the second and the third properties only work if $m\leq(b-1)\text{^}2$, or under modulo $b\text{^}(b-1)-1$.

7:55 – 8:10 p.m.

Nevena Kulina, *Edinboro University of Pennsylvania,* ***College Hall 220***

Mathematics of Tennis

Probability of success in the game of tennis.

Sarah Roberts, *Juniata College,* ***College Hall 223***

Patterns in Fractals: The Multibrot & Julia Sets

The Mandelbrot and Julia sets are some of the world's most famous fractals, formed by iterating z^2+c, varying c and z, respectively. The shape of a Julia set, which depends on the constant c, can be predicted based on the location of c in the Mandelbrot set. The bulbs of which can be described by a period, given by the Farey sequence. We explore high-order variations of the Mandelbrot set called the Multibrot set which iterates z^n +c. We look for patterns that carry over from the Mandelbrot set and search for new ones by investigating the Julia sets associated with points in the Multibrot set.

Brady Sheehan, *Duquesne University,* ***College Hall 225***

Geometry in Patch Based Non-Local Denoising Algorithms

Techniques for denoising natural images have seen incredible advances over the past several decades, with the current state of the art using non-local patch based algorithms. Recent studies of denoising techniques have shown that we are not likely to do much better than the current state of the art when using image data alone. One way to improve image quality is to incorporate image geometry into the denoising algorithm. We present empirical evidence suggesting that properly incorporating geometry within these non-local algorithms shows great potential for improving the current state of the art non-local denoising algorithms.

Nico Gabriel, Vivien Chang, Anthony Galante, Angela Hoeltje, Mary Johnson, Stephen Kandrack, Michael Leasure, Ethan Shuffelbottom, Betsalel Williamson, *University of Pittsburgh,* ***College Hall 446***

ER Data Analysis

Utilizing health-care data to track the prevalence of syndromes and disease that could affect public health is paramount in medical preparation. The reported data suffers from inaccuracies. Our talk will focus on filtering bad data and utilization of the SARIMA model to replace unreliable data in project-based mathematics class environment.

Aysha Nuhuman, *Washington & Jefferson College,* ***College Hall 447***

Counting Rectangles, Squares, Blocks and Cubes

Counting the number of rectangles and squares in a grid seems easy if the grid is small. However, we can't simply count our way through a general m x n grid using brute force. In this presentation, we show how to count them systematically and use some simple identities to help us reach the end goal. It is surprising that counting squares are more difficult than counting rectangles. We then extend these concepts to counting blocks and cubes in a general rectangular block. Furthermore, we employ similar techniques to count the number of different rectangular shapes in a given grid. The combination of these methods can lead to simply beautiful formulas, and emphasizes the very basics of counting.

Mark Leadingham, *West Virginia Wesleyan College,* ***College Hall 449***

An Introduction to Chaotic Behavior

Chaos Theory is the study of systems that are highly dependent on their initial conditions. Any seemingly insignificant change will create completely different results than those expected. Deterministic Chaos focuses on

strange results occurring from seemingly predictable systems. The applications are apparent in computer science, physics, and astronomy. Astronomical objects called pulsars may exhibit chaotic behavior in the emission of their radio pulses. We will discuss famous attractors (Lorenz & Rossler) as well as the methods of describing these phenomena, such as building models, dimensional mapping and phase space, the fourth-order Runge-Kutta Method, and the concept of embedding dimensions.

Man Wing Chan & Erica Flanders, *Gannon University,* ***College Hall 553***

Purple Martin Die-Off Rates in 2014 and 2015

We investigated the difference in death rates for young Purple Martins in Pennsylvania, Ohio, and New York for 2014 and 2015. We focused on the differences in the weather for those two years. We will present our conclusions and directions for further study.

8:15 – 8:30 p.m.

Alexander Michels, *Westminster College,* ***College Hall 220***

Repeated Play Games

Game Theory is the study of how to make decisions when the outcome is dependent on not just your decision, but also the decisions of other 'players.' Games can be played once or many times in a row. Repeated games are common in business, biology, and many other fields, where we see sets of players repeatedly play the same game. We explored the best strategies to play these games when our opponent is similarly playing based on game-theoretic principles and wanted to know how one could take advantage of play that deviates from these principles.

Hao Hu, *University of Pittsburgh,* ***College Hall 223***

Computing Indicators of Radford Algebras

In this talk, we will be discussing the higher Frobenius-Schur indicators of Hopf algebras. We find the sequence of indicators of the Radford algebra R(p) via concrete computation. Our result verified, in the case of the Radford algebra R(p) , a theorem by Shimizu on the periodicity of the higher FS indicators over positive characteristic. Moreover, we find the minimal polynomial of this sequence of indicators and its expression in binomial coefficients.

Andrea Sajewski, *Duquesne University,* ***College Hall 225***

Linear Transforms and Sparse Representations for Processing Medical Image Data

Functions, signals, and images can be more effectively analyzed or processed when viewing them as elements of a vector space and choosing an appropriate representation, or spanning set, for them. In this talk, we will explore several ways to represent image data that use the Fourier transform, wavelets, and algorithms that exploit self-similarity. Specifically, these representations will be used in different image processing techniques that will be applied to medical image data.

Veronica Kirchner, *Juniata College,* ***College Hall 446***

Random Forest Models for Microbial Communities

The decision tree method is a machine learning algorithm that generates a model resembling a flowchart, and is thus suitable for high-dimensional data analysis. Decision trees have practicality in the medical field because the method is analogous to human decision-making. Advantages of decision trees over other regression and classification techniques include the easily interpretable results in the form of a simple graphical display of a "tree". A random forest model involves the generation of a collection of decision trees, whereby combining multiple trees improves prediction accuracy. In this study, random forest modeling was applied to four datasets to predict chemical concentration of contaminated water systems, hypertension status of human patients, and fracking activity of streams. Results from one of these analyses will be discussed.

Victoria Jakicic, *Indiana University of Pennsylvania,* ***College Hall 447***

Magic Polygons and Their Properties

Magic squares are square arrays, where the sum of each row, each column, and both main diagonals is the same. The concept of a magic square with 3 rows and 3 columns is generalized to encompass regular polygons. These magic polygons have the same sum on each edge, as well as each of the diagonals. Construction of these magic polygons, as well as their existence, will be discussed.

Brandon Eschborn, *Edinboro University of Pennsylvania,* ***College Hall 449***

History of Number Systems

How people have depicted numbers has changed numerous times throughout the millennia. This talk discusses the various number systems used over written history, from bases 2 to 60.

Derek Prijatelj & Daniel Watson, *Duquesne University,* ***College Hall 553***

Analysis of the Implementation of Ensemble Methods in Automated Stylometry

Stylometry is the of study of linguistic style to attribute a written work to its author. It has important applications in law, journalism, and scholarly research. The significance of stylometry in these fields naturally demands reliability and statistical validity. In our research, we explore common methods of automated stylometry and, using these methods as classifiers, discuss the use of an ensemble of classifiers for document classification. An ensemble of classifiers is generally more reliable than any single classifier, but assembling an ensemble intelligently is no trivial task. Our process involves taking both individual performance and statistical behavior between linguistic analysis methods into account to estimate a given ensemble's performance on a dataset. This process is accomplished by modeling method's results on a training set as a random multivariate binary distribution which can be sampled to give an approximation of overall accuracy. These approximations are used in selecting an ensemble. For comparison, we examine the naive approach, where an ensemble is chosen from the analysis methods with the best individual performance, and compare this to the ensemble chosen by our process. To compare the separate approaches, we utilized a corpus of English mystery and science fiction novels and use our ensemble construction approach to suggest an optimal ensemble of linguistic analysis methods for authorship attribution.

8:35 – 8:50 p.m.

Kevin Zhang, *University of Pittsburgh,* ***College Hall 220***

Predicting MLB Success

As quality data and computational power became more accessible, the field of athletic scouting moved from qualitative evaluations to quantitative valuations. More frequently, Major League Baseball clubs are employing sophisticated data analysis methods to better predict the potential of amateur players. For teams without unlimited budgets, such data analysis is crucial for approximating player value and subsequently finding undervalued players. Posed with the open-ended problem of predicting MLB success, given college and scouting statistics, we attempted several modeling techniques to find a workable player valuation metric.

Tyler Gaona, *Duquesne University,* ***College Hall 223***

Primes in Arithmetic Progression: A Taste of Analytic Number Theory

Around 300 BC, Euclid established that there are infinitely many prime numbers. In the 18th century, Euler showed that the divergence of the harmonic series implies the same result. Euler's insights marked the beginning of a new subject, analytic number theory. In 1837, Dirichlet expanded on Euler's ideas to prove that there are infinitely many primes in the arithmetic progression an + b if a and b are relatively prime. While Dirichlet's proof is too technical for a 15 minute talk, we will discuss his main ideas and give an example of how to solve an easier, related problem in analytic number theory.

Paul LeVan, *Gannon University,* ***College Hall 225***

An 'Anti'-Waring Problem

Waring proposed a problem in 1770 asking whether every natural number is expressible as the sum of at most r kth powers of natural numbers. We consider the opposite direction in expressing natural numbers as the sum of r or more kth powers of distinct natural numbers. We will discuss improved bounds on finding the smallest number past which this property always holds and potential future connections that may be made in the explicit solution of the problem.

Avishkar Khanal, *Indiana University of Pennsylvania,* ***College Hall 446***

Optimal Mean and Variance Portfolio Selection

Optimal Portfolio Selection has been an important aspect of modern Investment Management. Computer programming can help to study real-time data. Our goal in this topic is to use R programming to find mean vector and variance-covariance matrix of daily return calculated from daily asset prices, finding the Efficient Frontier optimizing our Portfolio using our own objective function and our own restrictions from up to date data analysis. We have studied Optimal Portfolio as a stochastic process, and our goal can be extended to Optimize our Portfolio dynamically with time.

Luke Mariotti, *Penn State Erie, The Behrend College,* ***College Hall 447***

Students' Conceptions of Limit in High School versus College Calculus

This talk will describe the results of a study that investigated instruction of the limit concept in a high school versus college calculus class. Findings related to the classroom norms and the emphasis of mathematical limit content through class examples, formal assessments, and homework will be discussed. Results will be analyzed in terms of their importance for teachers at both academic levels as we support students in transitioning from high school to college calculus.

Rachael Troutman, *Edinboro University of Pennsylvania,* ***College Hall 449***

Nine-Point Circle Theorem

Using Euclidean geometry, this talk will demonstrate a proof of the Nine-Point Circle Theorem. This theorem states the following: If $\triangle ABC$ is any triangle, then the midpoints of the sides of $\triangle ABC$, the feet of the altitudes of $\triangle ABC$, and the midpoints of the segments joining the orthocenter of $\triangle ABC$ to the three vertices all lie on a single circle.

Jacob Coleman, *West Virginia Wesleyan College,* ***College Hall 553***

Distributive Embeddings of Groups into Monoids of Binary Operations

This work was inspired by a paper by Gregory Mezera, in which he describes a method for embedding groups into a monoid of binary operations on a set; also he says that finding minimal embeddings would be an interesting problem in itself. We explore this question of minimality by first doing small case-wise analysis. We then prove several structural properties that distributive binary operations must possess and use that information to narrow down the set of operations enough so that a computer may be used to find the sets suitable for the distributive embeddings of groups. We then describe explicit embeddings of groups into the set of binary operations of sets with various size and conclude by describing future work with larger sets as well as the possibility of working with infinite sets.

8:55 – 9:10 p.m.

Adam Anthony, *Juniata College,* ***College Hall 220***

Fairness of Skewed Dice

Dice are a staple in tabletop games, injecting an element of randomness. We intuitively believe that a cube or dodecahedron are fair dice, and near as makes no difference, our intuition is validated. The fairness of a die can be tested by treating it as a random number generator and testing the sequence of rolls for randomness. This is done using established tests for randomness, such as Marsaglia's diehard tests. We will present results from testing the fairness of a skewed 12 sided die.

Kevin Shuman, *Edinboro University of Pennsylvania,* ***College Hall 223***

Properties of Cut Points in Point-Set Topology

A cut point y in a set X is a point such that when y is removed from X, the set X without y is disconnected. Using this definition and topological principles, it will be shown that every point in the real line is a cut point, cuts points are preserved under a homeomorphism between two sets, and every point in the subspace ((-1,0] X {0}) U {(x,y) ϵ R^2 : 0 < x < 1, y = sin(1/x)} of R^2 is a cut point.

Trevor Arrigoni, *Westminster College,* ***College Hall 225***

Computational Analysis of Dyck Path Characteristics

Named after 19th century German Mathematician Walther von Dyck, Dyck Paths are a special lattice path that are famous for their relationship with the Catalan Numbers. Even today, Dyck Paths are being researched in the field of Combinatorics. In 2003, Dr. James Haglund of the University of Pennsylvania conjectured three statistics on Dyck Paths: Area, Bounce, and Diagonal Inversion (Dinv). When fixing the Area and Length of a Dyck Path, Haglund proved that Bounce and Dinv created equal multisets. In this presentation we will look at an open problem that stems directly from Haglund's result.

Trevor Williams, *West Virginia Wesleyan College,* ***College Hall 446***

Properties of Elementary Cellular Automata

Using an elementary cellular automata simulation we explore various properties that occur. We explore the group structure of ECA, bijective function between inverse seeds, and random seedings.

Meghan Sunners, Ben Turner, Robin Hwang, & Everardo Tellez, *University of Pittsburgh,* ***College Hall 447***

BIG Problems: Return on Investment Calculator

Our project in the BIG problems class at Pitt was to develop a return on investment calculator to help support the sales team at Compunetix, a conference calling technology company. The main goal of the calculator is to provide the sales team with the best estimate of customer savings over several years. As we lacked customer data, we combined programming and mathematics to generate a model for customers' needs, to use as input to our calculator.

Denver Stahl, *Washington & Jefferson College,* ***College Hall 449***

Using the Laplace Transform to Determine Equilibrium of a Circular Cascade

A common problem in differential equations is a problem involving a cascade of tanks connected such that the output of one becomes the input of the next. In this talk, we consider the situation in which the final tank in the cascade feeds back into the first tank, and introduce a theorem regarding the equilibrium values of the tanks of such a cascade.

Matthew Sobocinski, *Duquesne University,* ***College Hall 553***

TAPS (Typing Analysis Password System): Multi-Factor Biometric Authentication via Keystroke Dynamics

As more and more sophisticated computer attacks are developed, the demand for security in the world of information technology is rapidly increasing. For every convenience granted to us by the ubiquity of computers, an opportunity for a malicious attack is born. Almost every secured system makes use of passwords, as they are simple, costless, and tend to be relatively effective at blocking potential intruders. As computing power increases and the advent of quantum computers quickly approaches, more effective security measures need to be implemented. An ideal verification system is one that is inconspicuous to the user, silently providing an added layer of security. TAPS (Typing Analysis Password System) uses mathematical analysis of keystroke data to perform password hardening and seeks to introduce a new methodology into the field.

9:15 – 9:30 p.m.

Oliver Miles, *Penn State Erie, The Behrend College,* ***College Hall 220***

Bridge Tournament Scheduling Problem

Originally viewed as an opportunity to tease out an interesting solution, the Bridge Tournament Scheduling Problem is its own puzzle and is so much more than an interesting question. The problem, based on the idea of a 6-night tournament with 24 players, asked: is it possible for each night to have wholly unique teams of players such that no single person ever plays with someone they have already played with before? Every night 6 groups, each consisting of 4 players, meet to play. Within each group teams of 2 form and, during the course of the night, all possible team combinations compete. Thus, each member of a group was considered to have played with every other member of the group. In an attempt to narrow the scope of the problem, permutations of the 24 player problem were considered. Maintaining 4 player groups, as a facet of bridge, was required and led to considering 16 player and 20 player tournaments. As a person in a 16 player tournament can at most play with the 15 other persons and with 3 other persons per night, the maximum number of unique potential nights is 5 for a 16 player tournament. Compared to 6 nights for 20 players or 7 nights for 24 players, this shrinking of complexity is why smaller tournaments were considered. Ultimately, several 5 night solutions for the 16 player problem were found using a variety of techniques. These strategies include: Latin squares, geometry, tracking allowable pairings of players, bicycle lock assignments, option trees, and the template approach. The template approach, in particular, seems to contain aspects of all these techniques. Understanding and explaining the template approach has been the most investigated avenue to solving higher order problems. Additionally, despite limited success in the 20 and 24 player problems, a 5 night solution was found, via Latin squares, for the 20 player problem. This solution seems to be the optimal solution pattern and, potentially, indicates that there may not, as previously thought, be a 6 night solution for the 20 player problem. This problem has proven to be non-trivial in both scale and complexity. In the presentation, the process by which 16 player solutions were generated will be explained with focus on the template approach and on Latin squares.

Bradley Wolfe, *Edinboro University of Pennsylvania,* ***College Hall 223***

The Zariski Topology

Let P be a polynomial in n real variables, and denote its solution set as Z(P). Then the complements of solution sets form a basis for a topology on Rn. This topology is called the Zariski Topology. First, it will be shown that the solution sets form a basis for a Topology. Second, it will be shown that the Zariski Topology is not Hausdorff. Finally, it will be shown that every finite set is closed.

Xueyi Lei & Shulai Yang, *Washington & Jefferson College,* ***College Hall 225***

Lill's Method

We look at Lill's method of visually finding real roots of polynomials of any degree with real coefficients. Additionally, we investigate the history of Lill's method as well as several extensions of this method such as successive roots, derivation of the quadratic formula using Lill's Method, reversed coefficients, etc.

Joshua Baktay, *Duquesne University,* ***College Hall 446***

The Multivariate Gaussian Distribution and Spatial Data Analysis

Spatial data arise when values of a variable of interest are measured at specific coordinates, such as when water surface temperatures are taken at various locations across a body of water, or when the concentration of a soil contaminant is measured at select locations across a field. This talk investigates how the multivariate Gaussian distribution can incorporate spatial data to predict the variable of interest at unsampled coordinates, and demonstrates the flexibility of the multivariate Gaussian in doing so. Of key focus is estimation of the variogram, which defines the nature of the spatial dependence structure through the variance-covariance matrix of the multivariate Gaussian distribution. Future research paths and challenges in variogram estimation are identified.

Annie Small, *Juniata College,* ***College Hall 447***

The Mathematics of the Flip and Horseshoe Shuffles

The flip shuffle and the horseshoe shuffle are newly explored ways of shuffling cards. Both shuffles are performed by splitting a deck of cards into two piles. The bottom pile is flipped over and the cards are interlaced in an alternating pattern. The flip shuffle cares whether the cards are face up or face down, whereas the horseshoe shuffle does not. We use several new representations for these shuffles to explore the following questions: How many flip or horseshoe shuffles does it take for a card to return to its initial position? What is the minimum number of shuffles to get a card to the top of the deck? What properties are unique to decks of size 2^k? What are some relationships between the flip shuffle and the horseshoe shuffle?

Emma Everett, *University of Pittsburgh,* ***College Hall 449***

Szemerédi Regularity Lemma Illustrated

We introduce this deep result in graph theory through pictures and examples. We also mention several of the numerous applications of the lemma including the recent work of Green and Tao on arithmetic progressions in the primes.