Abstracts of Student Talks

Mathematical Association of America, Allegheny Mountain Section Meeting
Penn State Behrend, Friday April 6, 2018

7:15 – 7:30 p.m.

Billy Mellinger, *Penn State Greater Allegheny*, ***Burke 101***

A Serious Series Problem

I showed that any convergent infinite series, with positive terms, has a subsequence of terms which adds to an irrational number.

Madison Babicka, *Washington & Jefferson College*, ***Burke 102***

So Many Primes (Proofs)!

We know that there is an infinitude of prime numbers by Euclid's original proof. We will prove this theorem by a handful of different methods, including Euclid's proof, and variations of other proofs using Fermat numbers, group theory, and ideas from topology.

Aaron Worley, *Penn State Altoona,* ***Burke 103***

Cubic Metallic Means

The metallic means (also known as metallic ratios) may be defined as the limiting ratio of consecutives terms of sequences connected to the Fibonacci sequence via the invert transform. For example, the Pell sequence (invert transform of the Fibonacci sequence) gives the so-called silver ratio, and the invert transform of the Pell sequence gives the bronze ratio. In this talk we consider the Tribonacci sequence, and will use it to introduce a corresponding family of cubic metallic means.

Augustine Fisher, *Northwest Pennsylvania Collegiate Academy*, ***Burke 104***

Optimizing Routes through a Network Containing a Speed Upgrade

We examine a generalization of the Travelling Salesman Problem in which visiting a specific city upgrades the salesman's travel speed. The location and strength of the speed upgrade significantly affect the search for an optimal route. We first provide several examples, which we then use to illustrate the speed upgrade's effect. Next, we discuss the concept of viable paths and how to count such paths. Finally, we explore connections between our problem and the original Travelling Salesman Problem.

Zack Linger, *Fairmont State University*, ***Burke 105***

Experiments Related to the Riemann Zeta Function

Our ultimate goal is to further our understanding of the Riemann zeta function by studying similarly defined functions. First, we give a brief description of how to graphically represent complex-valued functions using domain colorings. We will observe qualitative similarities between our functions and the Riemann zeta function and investigate a problem similar to the Riemann hypothesis: "Where are the poles (rather than zeros/roots) of our function?"

Chelsea Deluisio, *Edinboro University of Pennsylvania, **Burke 106***

Proof of Menelaus Theorem

A proof of the Menelaus Theorem will be presented featuring various properties of triangles.

7:35 – 7:50 p.m.

Rebecca Drucker, *Juniata College, **Burke 101***

Constructing Configurations of the Dr. Eureka Puzzle

Dr. Eureka is a recent puzzle game reminiscent of the Towers of Hanoi challenge that was designed to test children's critical thinking and fine motor skills. In this project, we take the first steps toward finding the maximum number of moves needed to obtain any of the possible configurations. We begin by counting the number of legal game states using combinatorics and using a computer. We then treat these configurations as vertices in a graph with legal moves representing the edges. Analysis of this graph by hand and by using a computer, we begin to get a sense of the number of moves needed to solve particular configurations.

Madison Lydic and Jordan Melko, *Washington & Jefferson College, **Burke 102***

Cookie Monster Problem

Given a set of k jars, each filled with a distinct number of cookies; Cookie Monster can select any number of jars and remove the same amount of cookies from them. The Cookie Monster Number, CM(S), is the minimum number of such moves needed to empty the jars. It has been shown that: $\lceil \log_2(|S|+1) \rceil \leq CM(S) \leq |S|$. In this presentation, we discuss the upper and lower bounds of CM(S), along with the restrictions affecting the Cookie Monster Number. Also, we look at instances when the jars contain cookies in the Fibonacci and Tribonacci sequences.

Chenzhang Zhou, *Penn State Altoona, **Burke 103***

ODE Solver Based on Taylor Approximation

Since most ordinary differential equations cannot be solved in terms of explicit formulas, numerical methods are required to solve them approximately. Runge-Kutta methods are the standard for this. We present a method based on quadratic Taylor expansion of the differential equation. The motivation is to improve accuracy in certain ecological models. In particular, logistic models with harvesting are solved error free by our method.

Wasim Jamshed, *Penn State York, **Burke 104***

MHD Flow and Heat Transfer of Casson Nanofluid with Slip Conditions, Thermal Radiation and Variable Thermal Conductivity

In the present research a simplified mathematical model is considered in the form of non-uniform unsteady stretching surface. The flow is induced by a non-uniform stretching of the porous sheet and the uniform magnetic field is applied in the transverse direction to the flow. The non-Newtonian Casson fluid model is used along with slip boundary conditions. Moreover the high temperature effect of thermal radiation and temperature dependent thermal conductivity are also included in the present model. The mathematical formulation is carried out through a boundary layer approach and the numerical computations are carried out for Cu-water and TiO2-water nanofluids. Results are presented for the velocity, temperature and entropy generation profiles as well as the skin friction coefficient and Nusselt number and the discussion is concluded on the effect of various governing parameters on the motion, temperature variation, velocity gradient and the rate of heat transfer at the boundary.

Carl Wahler and Anna Westfall, *Fairmont State University*, ***Burke 105***

Using Monte Carlo Methods to Predict Satellite Directional Stability

In this talk, we will recount the project we did for NASA IV&V in which we used Monte Carlo methods, machine learning algorithms, and statistics visualization techniques to predict the stabilizing behavior of an orbiting satellite. We will also discuss the value of using randomly generated data to solve real-world problems.

Rachael Troutman, *Edinboro University of Pennsylvania*, ***Burke 106***

Alice's Adventures in Mathematical Madness

Alice's Adventures in Wonderland by Lewis Carroll is a popular childhood story with themes revolving around imagination, curiosity, and nonsense. However, "Lewis Carroll" is a pseudonym used by mathematician and logician, Charles Lutwidge Dodgson. The implementation of a mathematical lens reveals the truth behind the "nonsense" and "madness" embedded within Alice's Adventures in Wonderland. Mathematical concepts such as the continuity principle, rules of inference, and the fourth quaternion will be analyzed and explored throughout this presentation.

Dylan Langharst and Marco Nunez, *Penn State Behrend*, ***Burke 204***

Deriving the Schrödinger Form for Various Orthogonal Polynomial Sequences

Quantum mechanics is written in the language of functional analysis, and hinges on solutions to the Schrödinger equation, which models a quantum state. Every beginning student of quantum mechanics encounters the harmonic oscillator, whose solutions are the Hermite orthogonal polynomials. In general, an orthogonal polynomial sequence follows a three-term recurrence relation, which is valid over some domain. An important aspect of orthogonal polynomial sequences is that the inner-product between any two terms of the polynomial sequence is 0 if the terms are different or some finite value if the terms are the same. This study has successfully created a model for deriving an associated Schrödinger form for several different orthogonal polynomial sequences, and arrived at a new conjecture concerning these forms: the components used to derive the associated Schrödinger form, themselves derived from the orthogonal polynomial sequence, are discontinuous at the boundary of the sequence's domain.

7:55 – 8:10 p.m.

Stephanie Ringer, *Juniata College*, ***Burke 101***

Finding the Optimal Math Homework Review Method

With the ever-growing push toward student achievement, class time is becoming all the more valuable. Time spent on reviewing homework during class takes up a significant amount of the school day. Mathematics homework has been shown to be effective for students' academic achievement, and we strive to find a way to review it that is just as productive. We explore different feedback techniques that include variations in time use, peer involvement, and timing of feedback. During student teaching, this research focused on students in a rural high school in their math courses. With the goal to determine which strategy is most practical in various situations, we used qualitative and quantitative data from comprehension questions and student surveys to assess individual confidence, preference, and daily growth.

Michael Wigal, *West Virginia University*, ***Burke 102***

Characterization of Subexponential Posets for First-Fit

Given a finite partially ordered set (poset) of width w, Dilworth's theorem gives an existence and minimality of a chain partition of size w. First-Fit is an online algorithm for creating a chain partition of a poset. Given a linear ordering of the points of the poset, $v_1, \cdots, v_n$, First-Fit assigns the point v_i to the first available chain in the chain

partition of the points $v_1, \cdots, v_{i-1}$. It is a known fact that First-Fit has unbounded performance over the family of finite posets of width 2. We give a complete characterization of the family of finite posets in which First-Fit performs with subexponential efficiency in terms of width. Joint work with Dr. Kevin Milans.

Matt Bruno, *Edinboro University of Pennsylvania,* ***Burke 103***

An Overview of Elliptic Curve Cryptography

Cryptography is imperative in the digital age. Elliptic curve cryptography is one of the most secure and compact options for encrypting data. It is beneficial to be conscious of and to at least partly understand what transpires behind our screens. This presentation serves to introduce the concepts of elliptic curves over finite fields and how elliptic curves are applied to cryptography. Furthermore, this presentation highlights how elliptic curves connect abstract algebra and number theory.

Jeremy Glasner and Josh Hnat, *Washington & Jefferson College,* ***Burke 104***

Expressing Polynomials with Binomial Coefficients

The first order difference sequence of a sequence a=(a_n): a_0,a_1,…,a_n,… is the sequence Δa=(Δa_n): Δa_0,Δa_1,…,Δa_n,... where Δa_n=a_(n+1)-a_n. The n-th order difference sequence Δ^(n)a is defined inductively by Δ^(n)a =Δ(Δ^(n-1)a) and Δ^(0)a = a. We explore the linearity of the operator Δ and elaborate on the difference sequence defined by polynomial functions. Following this, we use difference tables to illustrate difference sequences and show how, by using the zero diagonal of the difference table, the original sequence can be determined. Finally, we show that all polynomial functions can be expressed as sum of binomial coefficients.

Dawn Sargent, *Fairmont State University,* ***Burke 105***

Characterizing the Behavior of a Spring Pendulum with Monte Carlo Methods.

We want to identify the conditions that result in a spring pendulum's chaotic behavior. Using normally distributed initial conditions and physical parameters with the known equations of motion for the system, we use a Monte Carlo simulation to collect the data. We then implement machine learning and data mining techniques to analyze the data. To do this, we identify a performance metric and classify each run as being chaotic or not. We then apply kernel density estimates to determine the possible influential variables on an individual basis, and we investigate the accuracy of applying a k-nearest-neighbor classification prediction model to study the possible influential variable combinations.

Ava Hoag, *Westminster College,* ***Burke 106***

A Glimpse at Space Around Black Holes

We are able to visualize how objects move near black holes by constructing and studying embedding diagrams. Embedding diagrams allow us to visualize two dimensions of the non-Euclidean geometry of general relativity by embedding them into three dimensions of Euclidean geometry. These diagrams can be difficult to interpret because we are used to the Euclidean geometry of the world around us. By examining the geometry of four-dimensional general relativity two dimensions at a time, we are able to piece together an understanding of how objects move through space and time near a black hole.

Landon Han, *Penn State Behrend,* ***Burke 204***

Optimal Forcing Location in Arrays of Coupled Oscillators

This research project studied the chains of coupled oscillators which are connected at several points with no closed loops. The goal of this project is to allow for any configuration (closed loops are acceptable) and to identify optimal

locations in these arrays. Using differential equations, we were able to identify the optimal location for entrainment and introduce more loops to the original system, forming a tree-like system with several small loops. We were able generate the function of any tree like system and determine how the new loop will affect the characteristic of the entire system.

8:15 – 8:30 p.m.

Jared Mountan, Matthew Adams, Bogdan Bordean, and Cy Milko, *Pennsylvania State University,* ***Burke 101***

Neural Networks in Artificial Intelligence

Neural Networks are widely used in many modern day artificial intelligence applications. The purpose of our study was to isolate the traditional neural network structure and both seek to understand it as well as build such a structure to read handwritten digits. All neural network structures are similar in the sense that they are constructed from a net of decision making gates called sigmoids. Sigmoids, as they are a model of human neurons, take information through differently weighted or biased inputs, and output information to the next series of sigmoids. The weights and biases that aid in correct decision making for the network must be trained using a standard set of information. During the length of this study, we studied these aspects of a tradition neural network and used C++ to write a program that would train a traditional network to recognize handwritten numbers. In this presentation, we will be explaining these elements of a traditional network further and going over backpropagation and other similar algorithms that are necessary to train the network. As a live application, we will be running examples of code to show our results.

Peter Conley, *Gannon University,* ***Burke 102***

Inverse Domination: Search for a Counterexample

In the context of simple graphs, the first part of this talk will outline inverse domination values (γ'), independence values (α), and the open problem relating the two: this problem asks whether or not it is true that $\gamma'(G) \leq \alpha(G)$ for all graphs, G. An approach for finding a counterexample will then be discussed. Various properties have been discovered that a counterexample would have to exhibit if one exists, and so this talk will look at a few of these properties in particular. As part of this exploration, a property L(G) is defined and it will be shown how graphs of exploded paths carry significant results with regards to this property and the open problem in question. Finally, thoughts about further exploration into a possible counterexample will be given.

Alison Pearce, *Edinboro University of Pennsylvania,* ***Burke 103***

The Median Concurrence Theorem

This talk will provide the audience with a formal proof of the Median Concurrence Theorem. This theorem states that all three medians of a triangle are congruent. This proof will be done using the Crossbar Theorem and the Parallel Projection Theorem. The proof will be divided into four main sections. The first will discuss how we use the Crossbar Theorem to prove that any two of the medians must intersect. The second and third sections will use the Parallel Projection Theorem, and the final section of this proof will conclude the proof by showing that all three medians must intersect.

Bingliang Lu, *Washington & Jefferson College,* ***Burke 104***

The Unimodality of Binomial Coefficients and Northeastern Lattice Paths

This paper is inspired by mathematician Miklós Bóna and his work on combinatorics. It aims to provide an overview of the unimodality property of binomial coefficients and its relative proofs using different methods. More specifically, a bijective proof using northeastern lattice paths will be discussed in detail. The presence of unimodality in other areas of mathematics is also investigated.

Si Chen and Tiantian Liu, *University of Pittsburgh,* ***Burke 105***

Indicators of Pointed Hopf Algebras of pq Dimension over Characteristic p

Let p, q be two distinct primes. We consider pointed Hopf algebras of pq dimension over an algebraically closed field of characteristic p. We compute higher Frobenius-Schur indicators of these Hopf algebras through the associated graded Hopf algebras with respect to their coradical filtrations. The resulting indicators are gauge invariants for the monoidal representation categories of these algebras.

Tyler Heintz, *Westminster College,* ***Burke 106***

Finding Unimodular Roots of Complex Polynomials

In this talk, we examine complex-valued polynomials of the form $p(z) = z^n+z^j+z^k-1$, where n, j, and k are distinct integers greater than or equal to one. We will give a formula for locating roots of p of modulus one. Such roots are called unimodular roots. This work was motivated by a question asked in a 2014 College Mathematics Journal article entitled "Locating Unimodular Roots," by Michael Brilleslyper and Lisbeth Schaubroeck.

Kade Kolheffer, *Penn State Behrend,* ***Burke 204***

Horse Racing Analysis

This talk will focus on the proficiency of the free sections of racingdudes.com and equibase.com in picking the winners of horse races. I will explain the wagers you can make and then compare the results between the two websites. I will be focusing on any possible statistical trends that could favor one website over the other.

8:35 – 8:50 p.m.

Zeph Turner, *Juniata College,* ***Burke 101***

Estimating the Sources of Metagenomic Data using Bayesian Statistical Methods

In a study of knockout mice, we want to determine whether or not bacteria from the gut are migrating through the gut lining and entering the bloodstream. We have samples of taxa found in the mouse's gut and in its blood. How can we tell what proportion of the blood sample consists of taxa originating in the gut, and what proportion comes from other, unknown sources? In general, given a sample of taxa along with samples from several possible sources, how can we determine how the sources are mixed in the sink? I will introduce two implementations of a Bayesian hierarchical statistical model used to solve this problem: the open-source software SourceTracker2 and my implementation of the model in JAGS. I will discuss details of the model before comparing the two implementations with results from a simulation study.

Shulai Yang, *Washington & Jefferson College,* ***Burke 102***

The Catalan Numbers and its Applications

We look at the Catalan numbers and its history in combinatorial mathematics. Additionally, we investigate two different approaches of deriving the formula for the Catalan numbers: the first one is through path drawing of n by n grid, and the second one is through triangulation of an n-gon using generating function. Finally, we will look at other applications of the Catalan numbers.

Hong Xin, *Penn State Behrend,* ***Burke 103***

Bridge Tournament Arrangement

Scheduling a Bridge Tournament might involve various challenges. A group of twenty-four players participating in a tournament met weekly for six consecutive weeks. In many cases, two players might be scheduled to meet more than during the six-week tournament. This is problematic because this project addresses and tackles this problem to avoid grouping players with repetition, using various complex concepts. To make arrangements for every around, our research group divided twenty-four players into six groups, with each group containing four players. In order to better explore these concepts and discover the pattern of the players' schedules, we examined sixteen players' schedule which can be found by trying different combinations. We then scheduled twenty players, which cannot be arranged by trying combinations. A former student researcher was inspired by the pattern of Latin Square, who thus manipulated this pattern and created a particular template that can be used as a guide to group twenty players for five around of tournament without repetition. However, the twenty-four players arrangement are not found. Inspired by the former student research, the current student researcher applied Latin Squares and Combinatorics concepts, and designed a special arrangement that can compromise sixteen, twenty and twenty-four players. After introducing a color coding chart to keep track of repetition, we have proved our arrangement guarantee to find at least five around for groups of sixteen, twenty and twenty-four players. This method solves the original Bridge Tournament scheduling problem of repetition, helping to make scheduling more efficiently. This method also provides further implications for exploring the bases of DNA and gene duplication.

Rachael Elliott, *Westminster College,* ***Burke 104***

An Application of k-modes Clustering to Institutional Advancement Data

Data mining is a technique that combines skills from several disciplines, including computer science, mathematics, and domain expertise of the information recorded in the database. Machine learning and database studies come from computer science; mathematical and statistical modeling from mathematics. In this project, data mining techniques were applied to a database maintained by the office of Institutional Advancement, a non-profit organization, at Westminster College. This database consists of records of every person or organization who has donated to the college, along with all of those who have graduated from the college. The database was examined, and data was extracted to identify factors, or characteristics of a donor, that might indicate level of donation. This talk will discuss the results of the data mining k-modes clustering algorithm. This will include discussion of the grouping of similar constituents from the algorithm and their relation to level of donation to the college.

Joseph Datz and Connor Stout, *University of Pittsburgh,* ***Burke 105***

Leveraging Machine Learning to Model Hospital Patient Readmittance

With anonymized data about a patient's health information, we address if it is possible to determine which factors predict a patient's re-admittance within 30 days using statistical and supervised learning techniques. This work is part of a project for Craneware, Inc.

Jacob Simmons, *Edinboro University of Pennsylvania,* ***Burke 106***

Ciphers and Their Relation to Polynomials and Modular Arithmetic

A cipher is an algorithm for performing encryption or decryption. In other words, a cipher is a series of steps that can be followed to encode or decode a secret message. This project will explore different ciphers that employ modular arithmetic and various polynomials to encode any message. To this end, different polynomials will be explored to discover the relationships with modular arithmetic that allow certain polynomials to be used in ciphers and why other polynomials cannot be used. Along with ciphers being used to encrypt messages, we will investigate how to decrypt messages using these ciphers and how to recognize specific ciphers, such as the Caesar cipher, and Affine cipher. Once the premise behind these ciphers are understood, a program can be written that will quickly code or decode any message for a given cipher.

8:55 – 9:10 p.m.

Lewis Dominguez, *Indiana University of Pennsylvania, **Burke 101***

Finite Sum Representations of Elements in *R*

In February 2017, a number theoretic problem was posed in Mathematics Magazine by Souvik Dey, a master's student in India. The problem asked whether it was possible to represent a real number by a finite sum of elements in an open subset of the real numbers. Specifically, the open subset must contain one positive and one negative number. This talk will showcase a solution and extension to this problem.

Kashmir Sainiak, *Washington & Jefferson College, **Burke 102***

Plus and Equals

The plus and equals signs are two of the most common mathematical operations, but are not often described as special or surprising. This talk will discuss some occurrences of + and = as operations and symbols, both inside and outside the world of mathematics. We will show the uses of + and = in the Pythagorean Theorem, Fibonacci Numbers, and infinite sums – finding some surprising results along the way.

Lulu Liu, *Penn State Behrend, **Burke 103***

Different Ways to Sum Zeta(2)

Zeta(2) is a popular p-series study in typical calculus II class. However, we will not talk to how to sum the popular Basel problem. In this talk I will present several different methods to sum zeta(2).

Trevor Arrigoni, *Westminster College, **Burke 104***

On Inverse Semigroups of Self-Similar Graph Actions

Inverse Semigroups are like groups in that they are sets with an associative multiplication and an "inverse" operation. This type of algebraic structure is useful in understanding the symmetries of quasi-crystal structures and the theory of partial isometries on a vector space. In this presentation, we discuss the structure of Inverse Semigroups of Self-Similar Graph Actions where we investigate ideas such as Idempotents, Natural Partial Order, and Congruences. This research was done as part of the NSF-funded REU at the University of Texas at Tyler in the summer of 2017.

Brian Gentry, *University of Pittsburgh, **Burke 105***

Predicting High-Volume Prescribers of Life-Saving Medical Devices

A practical application of machine learning is in the prediction of product sales. ZOLL, a company based in Pittsburgh, Pennsylvania, produces LifeVests, which are wearable cardiac defibrillators that continually monitor cardiac activity and deliver a shock when abnormal activity is detected. ZOLL provided us with past sales data so that we could predict the number of LifeVests a doctor would sell in the next two-week period. Utilizing machine learning techniques to select relevant data and time series analysis to discover historical trends, we developed scripts in R to accurately predict the number of LifeVests a doctor will prescribe.

Brandon Eschborn, *Edinboro University of Pennsylvania, **Burke 106***

Perfect Numbers in Other Bases

Perfect numbers have fascinated mathematicians for hundreds of years. However, there are properties that may not be as well known. This talk will explore three properties for even perfect numbers if expressed in a different number system.