

Abstracts of Student Talks
Mathematical Association of America
Allegheny Mountain Section Meeting
Mercyhurst College,
Friday April 13th, 2007

8:15-8:30

Sarah Orris, Behrend College

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Summation of a certain class of infinite series

Several different methods exist to find the summation of an infinite series. For a foundation to researching the method using residue theorem, we have computed summations using both Laplace transforms and Fourier series. In particular we will sum a class of series of the form $\sum_{n=1..infinity} (n^c)/(n^{d+K})^2$, n odd).

Nicole Pernischova, Duquesne University

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Convergence of Finite Approximations to the Solutions of Infinite Systems of Linear Equations

When using Fourier based solutions of differential equations on conjoined rectangular regions, an infinite system of linear equations will often be produced. The solution represents some unknown Fourier series coefficients. In practice the infinite system is truncated to a finite system in order to compute an approximate solution. The talk will demonstrate how these infinite systems are produced and discuss the numerical effect of the truncation to a finite system.

Jared W. Burns, University of Pittsburgh at Greensburg

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The Integrability of 1-Forms on R^3

This presentation will explore the topic of the calculus of differential forms on R^3 . The focus of this paper will revolve around considering the problem of integrating 1-forms and will seek to determine the following: When is a 1-form closed? When is a 1-form Exact? When is a 1-form Exact up to a multiple?

The demonstration of these topics will include an example by MAPLE.

Alison Bish and Tiffany Riggleman, West Liberty State College

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Can the Game of Craps be Simulated on a Computer?

First, the probabilities of the game of Craps were calculated, for winning before the first roll. Then a computer simulation was written in hopes of matching these probabilities. Finally, the results of many trials of the simulation were compared with the theoretical probabilities.

Bryan Bischof, Westminster College
Andrew Periello, Penn State University New Kensington

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On the Images of Non-Constant Integer Coefficient Polynomials

Following the search for a non-constant integer polynomial producing only primes, an existence proof was discovered that every one of these polynomials has a composite image. Using this proof, we present a solution and then, expanding on it, we present a proof of infinite composite images. Additionally, we will prove a fact about divisibility of prime powers into our images. Finally, using elementary number theory we prove another theorem involving divisibility and order of the prime factorization set.

Rebecca Myers, West Virginia Wesleyan College

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"Tweaking" the Fundamental Theorem

Not all definite integrals can be evaluated by standard means. I will prove a result for evaluating some definite integrals that cannot be determined through conventional methods.

8:35 - 8:50

Jesse Stimpson, Penn State Erie, The Behrend College

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A Modeling Study of Idiopathic Intracranial Hypertension (IIH) using a Starling Linear Resistor

In an attempt to better understand the unexplained disorder IIH, models display the behavior of the Cerebrospinal Fluid (CSF) when the fluids in the brain's sinuses are introduced to changes in transmural pressure—the pressure difference between interior and exterior pressures ($P_{int} - P_{ext}$). We model sinus behavior using a linear resistor as a part of a piecewise system of non-linear differential equations. The dynamics of the system can result in a partial collapse of the sinus, thus causing increased resistance to natural blood flow and hypertensive CSF pressures. We compare measures of CSF pressures from IIH patients to numeric solutions of our model and introduce possible treatment options.

Patrick Plunkett, Duquesne University

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Curvature and Torsion in Random Knots

How much curvature is in the average knotted shoelace? How twisted do they get? This talk will attempt to answer these questions, in addition to explaining how knots are randomly generated and modeled on a computer. From this, we go on to explore the notion of "average curvature" and "average torsion" of randomly generated knots, the concept of "equilibrium length," and how MCMC (Monte Carlo Markov Chain) analysis can aid in obtaining more accurate estimations.

Jesse Stratton, University of Pittsburgh, Johnstown

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Photomosaics

A photomosaic is the creation of a large picture out of many smaller pictures. The mathematics of this art includes determining a mathematical model for the problem and finding an optimal solution. A computer program will model the mathematics used in this problem and an example of a photomosaic will be produced.

History of the Platonic Solids

This presentation was created to accompany a research paper done in a history of mathematics course. It summarizes Euclid's Proof of the existence of only five Platonic Solids as well as their specific properties including duality. It then summarizes Plato's "Theory of Everything" as it relates to his in depth study of the Platonic Solids. Details are given as to how deeply Plato's imagination went with the solids and how close he was to understanding great mathematical ideas such as commensurability. Finally, it demonstrates how the Platonic Solids were used in other realms such as the arts and sciences, particularly in the works of Johannes Kepler, Leonardo Da Vinci, and M.C. Escher.

Curtis Yenyo, Westminster College

The Dimension of the Coast of Westminster's Lake Britain: A Look at Fractal Dimensions

Fractal dimensions of objects, which are non-integer dimensions, differ from the standard Euclidean whole number dimensions. The fractal dimensions can be found in many different ways: the Hausdorff method, compass setting method, and the box-counting method are just a few. So, what kind of a fractal dimension does Lake Britain of Westminster College have? This is explored through looking at other fractals and fractal dimension methods, and the use of GPS and mapping software.

Shauna Knarr, Penn State DuBois Campus

A Digit Shifted, Sums of Digits Sequence

These sequences produce multiple limit cycles of various lengths for different bases. For example in base ten there are two possible cycles of length four ranging from two to three digits:

918 183 123 63 92 112 43 72 92,

and

919 193 133 73 102 33 62 82 102.

In base seven there is one cycle of length five ranging from two to three digits:

666 243 123 63 122 53 112 43 102 33 62 112.

We will prove that these sequences converge to a limit cycle and show that the cycles' length, number of possible cycles and number of digits are the only possibilities.

8:55 - 9:10

Joe Pleso, Penn State Behrend

The Game of Go and Surreal Analysis

The focus of this talk will be the application of surreal analysis to the game of Go. Similar analyses have been conducted on Go before, specifically the later stages of the game; however, this research will employ surreal analysis on earlier parts of the game by extrapolating the current theory. Motivated by the lack of a superior computer algorithm, this technique will allow a larger class of positions to be analyzed. It is believed that with a better understanding of more positions, a more advanced artificial intelligence (AI) can be constructed. Thus, this research aims to improve existing Go algorithms by extending the surreal analysis of Go. The results of this technique will be presented and explained. This talk is intended for a general audience.

Morphological Image Processing

Logical operators have proven to be an effective tool in image processing through the field of mathematical morphology. In this talk we will discuss the formulation of the morphological operations, dilation, erosion, opening and closing and their applications to boundary extraction and removal of salt and pepper noise. We will also look at some more current applications of these processes, namely the watershed transformation.

Partial Differential Equations for Image Decomposition

Partial differential equations have proven to be a useful tool in image processing. In this talk, we will discuss how images are defined as both continuous and discrete mathematical objects, how PDEs can be used to decompose images into 'meaningful' parts, and some applications of these models to real world problems.

A Simple Finite Element Example: Shape functions in one and two dimensions and solving a one dimensional heat equation.

We will describe the calculation of shape functions for a finite element mesh in one and two dimensions and then show the weak formulation and implementation of one dimensional shape functions for the heat equation.

Continued Fractions and the Fermat-Pell Equation

In this talk I will be using finite and infinite continued fractions to solve Fermat's Equation.

Determining Recommended Levels of Harvest on Pacific Halibut

Using data on catch and effort for Pacific halibut provided by the International Pacific Halibut Commission, we created a logistic growth model representative of six regions off the coast of Alaska. The model was adjusted to include harvest for each year. We explored the effect of making changes in fishing gear, density-dependent catchability, migration patterns, and carrying capacity within our model. Parameter estimates were determined using maximum likelihood techniques and model comparison was done using the Akaike's Information Criteria. After the best model is discovered, maximum sustainable yield was determined for the model. Suggestions for the maximum sustainable yield are then available to determine the maximum amount of halibut that can be caught without crashing the population. We bootstrapped the residuals to assess the uncertainty in our recommendations.

Malorie Winters, Penn State Erie, The Behrend College**207**

Hopf Bifurcations on a Scavenger/Predator/Prey System

The basis of this research is to determine the dynamics of a system when a scavenger is introduced onto a Lotka-Volterra predator/prey model. Using Routh-Hurwitz analysis, we found conditions that guarantee the existence of a Hopf bifurcation. Bifurcation diagrams were then used to find parameter values for which the system exhibits two stable structures simultaneously (a stable limit cycle and a stable fixed point). This represents a biologically relevant model because it displays extinction and persistence of all three species for various parameter values.

Jeromy Sivek, Duquesne University**212**

Non-Euclidean Metrics in Gaussian Process Models

Gaussian processes represent a rich class of spatial models that are used to predict spatial attributes at specific locations. These models require the use of a correlation function, which describes how quickly the dependence of two measurements decreases as a function of the distance between the locations of the measurements. Correlation functions must satisfy certain conditions in order to produce a valid Gaussian process model. These conditions are all satisfied when the function uses Euclidean distance, as is traditional. However, this metric does not account for possible barriers through which the measurable cannot travel. This study focuses on the conditions under which geodesic distance, which accounts for these barriers, yields a valid Gaussian process model.

Jeremy Sopko, Penn State Behrend**213**

A Coupled Oscillator Model Applied to the Spinal Cord of a Sea Lamprey

This research will expand upon recent research done on pattern formation of coupled oscillators. This project will seek to model the neuron electric activity in a sea lamprey spinal cord. This will expand on current models that involve linear chains of neurons with external forcing only occurring at the ends of the chain. The research will allow for forcing along any neuron in the spinal cord and allow variable coupling and intensity among the neurons, rather than nearest neighbor coupling that previous models used. We will then analyze the stable structures of resulting differential equations, in the attempt to find Hopf bifurcations in the model. To carry out this research relevant biological data will be received. With a system as large and as variable as this, we will only analyze unique cases that arise from the data to find relevant results.

Jerime Pichler, Penn State**214**

A Simple Finite Element Example: Simplified coding for a 1D heat equation and a 2D example using LISA a FEA code.

We describe our simplified coding for a one dimensional heat equation solution and show some simple modeling results from LISA a Finite Element Analysis code.

Finding the Best Seat

A common maximum and minimum problem from calculus is to maximize the viewing angle subtended by the movie screen to a viewer in the theater. This talk shows how to find a solution without using calculus and then generalizes the solution to allow the viewer to be positioned on a continuous curve rather than on the floor of a typical movie theater.

9:35 - 9:50

Sam Marvit, The Pennsylvania State University

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Stabilizing the population dynamics of a host-parasite system by host immigration

A soil-dwelling parasitic worm has recently been shown to infect two hosts—the ghost moth and a beetle species. We are interested in modeling the dynamics of this system. Since field studies are extremely difficult, we formulated a hybrid discrete-continuous model. Our model alternates between two phases—an ordinary differential equations phase and a difference equation phase. A case exists in which chaotic host dynamics occur given there is low infectivity rate of the ghost moth. Moreover, the host population size cycles through extremely small amounts as well as large amounts. This means the host may become extinct by stochastic fluctuation when its population size is very small. For this case, we show the host population size is stabilized with immigration of the beetle.

Dylan Hower, Duquesne University

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Mathematical Methods in Grain Boundary Detection

Properties of crystalline metals can be obtained by studying their grain boundary networks at the nanoscale level. This data can be collected by imaging thin films of the metals using a transmission electron microscope. Current techniques for detecting the boundaries are both labor and time intensive due to noise, low contrast, bending of the film, and other factors that arise in the imaging process. In this presentation, I will discuss some mathematical methods for automating the grain boundary detection process based on anisotropic diffusion, gradient-based edge detection, and image segmentation using Gabor filters.

Amy Brem, Penn State Erie, The Behrend College

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A Statistical Breakdown of NFL Betting Lines and Outcomes

I am attempting to look at the association, if any, of opening and closing lines of the NFL Bets based on the 2006 NFL season and looking at any patterns in wins/losses within division, conference, home and away while getting an understanding of Excel and MINITAB in the process.