36th Annual Mathematics Symposium - Western Kentucky University

November 11 – November 12, 2016

*= student presentation

Friday 3:30pm, Registration and refreshments begin, 1st floor of Snell Hall (SH)

Friday 3:50 pm, ROOM 1108, Welcome by Bruce Kessler, Head of the Mathematics Department and Cheryl Stevens, Dean of Ogden College

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Friday 4:00-4:50 pm, ROOM 1108

INVITED TALK

Professor Ralph Smith
(North Carolina State University)

Uncertainty Quantification for Physical and Biological Models

The quantification of uncertainties inherent to models, parameters, and experiments is critical to access the accuracy of predictions. In this presentation, we will discuss basic issues that must be addressed when quantifying uncertainties inherent to physical and biological models. This will be motivated by examples drawn from nuclear power plant design, HIV models, climate models, and the flying micro-robot Robobee. Uncertainty quantification is naturally addressed in a Bayesian framework and we will use examples to motivate recent Metropolis and propagation algorithms, which are appropriate for large scale simulation models. Finally, we will discuss the use of sensitivity analysis and active subspace construction to isolate influential model inputs. This is a new and evolving topic and open questions will be noted throughout the presentation.

PARALLEL SESSIONS, Friday

Friday 5:00 - 5:20 pm

ROOM 1101 •• **Mark Robinson** (WKU)
Some Topics in Numerical Integration

Abstract: In elementary calculus courses, students are introduced to the topic of numerical integration, including such commonly-used methods as the trapezoidal rule and Simpson's rule for approximating the definite integral of a continuous function over a closed and bounded interval. In this talk, we extend this discussion to include various topics in the area of numerical integration, including Gaussian quadrature, approximating improper integrals involving infinite discontinuities or unbounded intervals of integration, and applications to the numerical solution of differential equations.

ROOM 1102 •• **Bruce Kessler** (WKU)
Observations on the Logistic Population Model With a Non-Constant Carrying Capacity

Abstract: Most students and teachers of Calculus are familiar with the standard logistic population model with a constant carrying capacity. The differential equation is separable, and it provides a nice application of integration for beginning students. However, it is very uncommon to consider the same differential equation with a non-constant carrying capacity. This talk will explore the behavior of solutions when the carrying capacity is not constant, and will apply this condition to the density-dependent Leslie matrix model for logistic populations developed by Andrew Davis and the author

ROOM 1103 •• **Mikhail Khenner** (WKU)
Partial Differential Equation Model of the Graphene Island Growth on Copper

Abstract: Graphene, a two-dimensional layer of carbon atoms arranged in a honeycomb lattice, holds a promise of becoming the material of choice in advanced nano-electronic technologies. A 2010 Nobel Prize in physics was awarded for extraction of the graphene "from a piece of graphite such as is found in ordinary pencils", and for discovery of some of graphene's extraordinary electronic properties. In this talk I will present a model consisting of two partially coupled diffusion-type PDEs that describe evolution of the concentration of the carbon atoms and dimers during graphene growth on a copper surface. The model is used to compute growth of a graphene island. The speed of the island's edge advancement on Cu[111] and Cu[100] surfaces is computed as a function of the growth temperature and pressure. The contributions provided by the atoms and dimers to the growth speed are discussed, and the island growth in the conditions of a thermal cycling is studied.

ROOM 1108 •• **Richard Schugart** (WKU)
WKU's New Student Chapter for Industrial and Applied Mathematics with Q&A

Abstract: If you are interested in learning more about applying mathematics to industry or problems in many disciplines, then we are starting a new student chapter in the Spring 2017 to support this endeavor. The new student chapter will be through the Society for Industrial and Applied Mathematics. The chapter is open to all students - math, stats, physics, engineering, chemistry, biology, economics, etc. - as well as graduates and undergraduates. I will present a little background on the Society; provide a preview of what we initially envision the student chapter to be like; and answer any questions as a portion of the talk time will also be set up as a Question & Answer session.

Friday 5:30 - 5:50 pm

ROOM 1101 •• **Alec Brown*** (WKU)
Preliminary Analyses of the College Decision Making Process

Abstract: The purpose of this research is to investigate the relationships between the amount of financial aid awarded, as well as demographic information, and the enrollment decision of first-time, first-year students at WKU. The Division of Enrollment Management has provided a SAS dataset containing various information about all WKU students admitted from 2013, 2014, and 2015. This data will be analyzed using SAS Enterprise Guide to identify key characteristics involved in the enrollment decision at WKU. Results of preliminary analyses will be presented in this talk.

ROOM 1102 •• **Krishna Bemis* (WKU)**
The Peculiarity of Non-transitive Grime

Abstract: We begin by exploring the non-transitive dice set developed by Dr. James Grime known as Grime Dice. These dice function similar to the kids' game, "Rock, Paper, Scissors", where paper wraps rock, rock crushes scissors, and scissors cut paper. Any hand gesture can be beaten by another if a player knows what sign the other player will throw. Likewise in a set of Grime Dice, a player can always chose a die with better odds of winning than his opponent by simply choosing his colored die second. We will examine how the property of non-transitivity is applied to this dice set, the unexpected outcomes of a two and three player game, the evolution of alternative non-transitive dice sets, and the strategies used to create a set of my own.

ROOM 1103 •• **Alex Malone*** (WKU)
Analyzing the generating functions of duels on graphs

Abstract: Sequential duels between three players, or truels, are well studied games that lead to some interesting and counterintuitive results. This talk will explore generalizations of the duel and truel to iterated variants with unbounded stopping time, as well as to duel-type games on an arbitrary directed graph. In particular, we will consider the asymptotic properties of such games as the number of iterations becomes large.

ROOM 1108 •• **Makenzie Daniels*** (WKU)
Analysis of DNA Data Using Mathematica

Abstract: Scientists often use DNA restriction analysis to identify differences and similarities between genomes. This project uses Mathematica, a function-based coding system, to assist the user in analysis of data collected through DNA gel electrophoresis. The program allows the user to browse their files in order to input a gel image. The interface allows the user to crop and enhance the picture quality, choose ladder options, define separate lanes, label lanes, and edit the automatic band calls. By adjusting parameters that let the user simulate the location of the ladder elements, the program is able to provide very accurate estimates of the fragment sizes for each of the bands in the sample lanes, using an innovative algorithm created by Afshin Behesti. The program also allows the user to crop, edit, and label their gel image. At the end of the program, the user can save their image in the desired location as the desired size.

Friday 6:00 - 6:20 pm

ROOM 1101 •• **Surina Borgijin* (University of Louisville)**
A multilevel color image thresholding based on two-dimensional CHT entropy and enhanced particle swarm optimization

Abstract: Image segmentation is an important and fundamental task in many digital image processing systems. Image segmentation by thresholding is one of the simplest techniques. In this talk, we present a general technique for multilevel thresholding of digital color images based on Charvat-Havrda-Tsallis (CHT) entropy. The optimal threshold values are found by using enhanced particle swarm optimization method. The effectiveness of the proposed method will be demonstrated by using color images. This talk will be accessible to undergraduates**.**

ROOM 1102 •• **Rebecca Crouch and Richard Charnigo** (UK)
Aggregated Quantitative Multifactor Dimensionality Reduction

Abstract: We consider the problem of making predictions for quantitative phenotypes based on gene-to-gene interactions among selected Single Nucleotide Polymorphisms (SNPs). Previously, Quantitative Multifactor Dimensionality Reduction (QMDR) has been applied to detect gene-to-gene interactions associated with high measurements of quantitative phenotypes, by creating a dichotomous predictor from one interaction that has been deemed optimal. That method does not take into account cumulative effects from multiple interactions. To address this, we propose an Aggregated Quantitative Multifactor Dimensionality Reduction (AQMDR), which exhaustively considers all k-way interactions among a set of SNPs and replaces the dichotomous predictor from QMDR with a continuous aggregated score. We propose three distinct aggregated scores, which dictate the weight assigned to specific interactions based on p-values from permutation testing. We evaluate this new AQMDR method in a series of simulations for 2-way and 3-way interactions, comparing the new method with the original QMDR, and examining possible advantages of particular proposed aggregated scores. In simulation, AQMDR yields consistently smaller prediction error than QMDR when more than one interaction is present.

ROOM 1103 •• **Aynur Er*** (WKU)
Discrete Calculus on the Set of Natural Numbers

Abstract: We introduce discrete calculus with nabla operator which is defined by

$$\nabla y(t)=y(t)-y(t-1) \quad \text{for } t \in \mathbb{N}.$$

Polynomials, exponential functions, properties of nabla difference operator, sum operator will be discussed in details.

ROOM 1108 •• **Aaron Kirtland* and Caleb Stickney*** (WKU)
The Particulars of Pac-Man

Abstract: Developed in 1980, Pac-Man is now regarded as one of the most influential video games of all time, as it was the first to introduce now-standard features including power-ups, iconic characters, and stealth components. These features were implemented at a time when resources were limited and computation was expensive. In this project, we implement Pac-Man using Mathematica. At any given time, each ghost is in one of three states: chase, scatter, or frightened. Furthermore, the behavior of each ghost is distinct due to different objectives. These algorithms combine to create complex behaviors suitable for machines without today's large processing capabilities. In our project, we compare the heuristic algorithms of Pac-Man with modern day pathfinding algorithms possible with today's technology.

Friday 6:30 - 6:50 pm

ROOM 1101 •• **Andrea Jenkins*** (WKU)
Estimating a Probability Using Geometric Samples

Abstract: In this paper, we are trying to estimate the number of primes from integers L to U. We use the geometric distribution found from our geometric sample to derive three confidence intervals. These intervals give a more precise interval for the proportion of primes in this interval than using the traditional methods of finding an unknown probability.

ROOM 1102 •• **Josh Price*** (WKU)
How to run an optimal race

Abstract: In this talk I will present a mathematical model of a runner, and deduce an optimal strategy to complete a race in the shortest amount of time.

ROOM 1103 •• Matthew Riggle* (WKU)
Expected Number of Trials Required for a Run of n Identical Outcomes

Abstract: Suppose we repeatedly flip a coin which comes up heads with probability p and tails with probability $q = 1 - p$, and we wish to observe a run of n consecutive heads or a run of n consecutive tails. We obtain a formula for the expected number of flips required to observe such a run using a recursive technique. We verify this formula using simulation, and apply the result to Wald's Identity in order to determine the average final height of a random walk.

ROOM 1108 •• Ayush Prasad*, Karthik Boyareddygari*, Rachel French*, Carson Price*, Jacob Menix*, Rachel Turner*, Nigar Karimli*, Arjun Kanthawar*, Nikhil Krishna*, Stefan Stryker* (WKU)
Can We Use Student Research in Mathematics to Heal All Wounds?

Abstract: In this talk, students in Dr. Schugart's research group present snapshots of what they have been working on this semester through electronic posters and 3-minute presentations. The work encompasses mathematical modeling in wound healing for two different projects. The first project uses patient protein data and wound areas with a differential-equation model to analyze healing responses. The second project incorporates optimal control theory to study the removal of a bacteria infection using hyperbaric oxygen therapy.

Friday 7:00-7:30pm Food and Refreshments!

Friday 7:30 - 8:00 pm

ROOM 1108 •• **Panel Session: Careers in Mathematics**

Panelists: Cameron White (Fruit of the Loom), Rebecca Crouch (Statistical Consulting Company), Rob Sparkman (Oil Investment Company), Hannah Keith (Teacher, Logan County) and Elizabeth Forrester (Volunteer State Community College)

Friday 8:00 - 8:30 pm

ROOM 1108 •• **Mathematical Play:**

"Professors Hugh S. Less Calculus"

Authors: Z. Bettersworth, M.El-Farrah, C. Ernst, A. Malone, U. Ziegler

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Friday 8:30 pm-

Our Department Head is hosting the Aftermath at Pots Place on the downtown square, between the Capital Arts Center and 440 Main restaurant.

Saturday from 8:00 am - Registration and Refreshments, Third Floor of Snell Hall (SH)
REGISTRATION continues until 11:30am SATURDAY

PARALLEL SESSIONS, Saturday

Saturday 8:30 - 8:50 am

ROOM 4114 •• **Caroline Boone* and Patricia Thompson*** (WKU)
MyMathematicaLab

Abstract: MyMathematicaLab is a Calculus tutoring and studying program. Based on the user's professed area of study, the program displays randomized math problems in that area and grades the user correct or incorrect on their inputted answer. The program additionally includes a statistical analysis to aid the user in identifying their areas of struggle.
The program opens a menu that prompts the user to choose one of three areas in calculus. It also prompts the user to choose the number of questions they want to answer. After the user continues to the questions, the program conducts a selection from a list of base problems within that area of Calculus. These have randomly generated coefficients to allow the user to retain retake value. The program contains a learning algorithm that tracks average correct or incorrect answers to increase or decrease the probability of given types of questions being chosen based on the user's needs. The program does not compare the answers directly to the stored answer, but simplifies both expressions to their lowest form, then compares them. On a given question, the program displays a problem with the coefficients and constants of the problem randomized. The user has the option of seeing the timer in the corner to see how long they have spent on a particular problem. They also have the option of watching a tutorial video on the subject or checking the instructions.
After the user has completed their question set, the program runs statistical significance tests: a t-test, z-test, and outliers. It displays graphs of current and previous data (that is collected by exporting to a file specific to the user). It also returns to the user which areas they seemed to struggle with the most, based on correctness and the amount of attempts.

ROOM 4145 •• **Will Johnson*** (WKU)
Linear Stability Analysis and Numerical Approximation of Thin Metal Film Thickness

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Abstract: Thin films are part of our daily lives. They are used in the semiconductors in our cell phones, in the light emitting diodes of our televisions, and in solar cells that help power our world. The process to create thin films is extremely challenging due to the conditions under which they are made. It can require temperatures over 1000°C and pressures on the order of MPa. The physical mechanisms that underlie the manufacturing of thin films are not well understood. As the name implies, the thickness of these films is on the order of nanometers to micrometers. Due to the microscopic thicknesses, the films can be unstable under certain conditions. The diffusion of adsorbed atoms and molecules can create ridges and valleys in the thin film. If the valleys become too deep, the film material will no longer be touching and electrical conductivity will be lost. In order to understand the conditions that cause instability, the diffusion model was linearized and a stability analysis was performed. When the results were plotted, it became clear which parameters effected the instability. Once the stable and unstable regions were found, a numerical solution to the governing PDE was found.

Saturday 9:00 - 9:20 am

ROOM 4114 •• **Ayush Prasad*** (WKU)
Using Individual Patient Data to Quantify a Mathematical Model for the Interactions of Matrix Metalloproteinases and Their Inhibitors in a Wound

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Abstract: Because the medical treatment of diabetic foot ulcers remains a challenge for clinicians, a quantitative approach using patient data and mathematical modeling can help researchers understand the physiology of the wounds. In this work, we extend a previously developed mathematical model describing the interactions among matrix metalloproteinases, their inhibitors, extracellular matrix, and fibroblasts (Krishna et al., 2015). In the previous work, the model was curve-fitted to the averaged data of patients with diabetic foot ulcers from Muller et al. (2008), and the model parameters were estimated using ordinary least-squares. The model and parameter values were then analyzed using global and local sensitivity analyses, which were used to describe how sensitive each parameter value of the model was to changes in the system. This work uses the individual patient data obtained from Muller for curve-fitting a modified model using similar techniques from the previous work. The goal of this work is to quantify and understand differences between patients in order to predict future responses and individualize treatment for each patient.

ROOM 4115 •• **Courtney George*** (WKU)
Magic Sierpinski Triangles

Abstract: A magic square is a square divided into smaller, equal squares, each containing an integer such that the sum of the integers in every column, row, and diagonal equals the same number. I have investigated the concept of magic squares and applied the idea to the geometry of Sierpinski Triangles. In doing this, I have formed a set of restrictions for the placement of the integers and created a new model for the notion of magic squares. This presentation will begin with a historical background on magic squares before moving onto how "Magic Sierpinski Triangles" work, the rules that govern them, and how to find a solution.

ROOM 3110 •• **Van Pham*** (WKU)
Loop numbers of knot diagrams

Abstract: We count the number of loops created when traversing along a regular diagram of a knot. What can we say about such numbers?

Saturday 9:30 - 9:50 am

ROOM 4114 •• **Mia Weaver* and Jessica Williams *** (WKU)
Break the Ice

Abstract: Using Mathematica, we recreated a game from the children's website Club Penguin called "Thin Ice". In this game, the user has a red character that he/she moves around a board made up of square tiles. Some of these tiles are free spaces where the character can move. These tiles are white and they represent thin ice, or breakable blocks. Other tiles are obstacles, meaning they are inaccessible to the user.

From where the user starts, the user must get to the door/exit on the board. Every time the user makes a move off of a free square tile, the tile "breaks" and becomes water, and it is therefore inaccessible to the user. Because of this, it is possible for the user to back him/herself into a corner and be trapped on all sides by water and/or obstacles.

The main objective of the game is for the user to collect, or "break", as many ice tiles as possible by moving over them before reaching the exit and moving onto another level.

What sets our game, Break the Ice, apart from the original game is the randomization of the board our game implements. "Thin Ice" has a series of predesigned levels. You start on the same level each time you start the game, having to beat the current level to move on to harder levels. Instead of having a series of preset levels that have been predesigned to be solvable, our game randomly generates the location of the start point, the exit point, and the obstacles, all while ensuring that the board is solvable each time.

ROOM 4115 •• **Andrew Davis*** (WKU)
Density-Dependent Leslie Matrix Modeling for Logistic Populations with Steady-State Distribution Control

Abstract: The Leslie matrix model allows for the discrete modeling of population age-groups whose total population grows exponentially. Many attempts have been made to adapt this model to a logistic model with a carrying capacity, with mixed results. This presentation describes a new model for logistic populations that tracks age-group populations with repeated multiplication of a density-dependent matrix constructed from an original Leslie matrix, the chosen carrying capacity of the model, and a chosen steady-state age-group distribution. The total populations from the model converge to a discrete logistic model with the same initial population and carrying capacity, and growth rate equal to the dominant eigenvalue of the Leslie matrix minus 1.
Keywords: Leslie matrices, discrete population models, exponential population model, logistic population model

ROOM 3110 •• **Claus Ernst** (WKU)
What is the probability that a random triangle is obtuse?

Abstract: This problem goes back to a book a "Pillow Problems" by Lewis Carroll (1895, the author of Alice's Adventures in Wonderland). We will give several different answers to this question.

ROOM 1108 •• **Molly Dunkum** (WKU)
Group theory in the bedroom

Abstract: To maximize the life of your mattress, it is recommended that you rotate and/or flip it every three to six months. How many ways can a rectangular mattress be rotated or flipped? We will use this idea to motivate an introductory discussion of group theory and symmetry with examples from art, architecture, nature, and games. No proofs but lots of pictures**.**

Saturday 10:00 - 10:20 am

ROOM 4114 •• **Peter Agaba*** (WKU)
Mean Value Theorem and its Applications

Abstract: One of the most applicable theorem in Calculus and Real analysis is the Mean Value Theorem (MVT). The general MVT states that "Suppose that real valued functions f and g are continuous on a closed interval [a, b] and differentiable on an open interval (a, b), then there exists at least one point $c \in (a, b)$ such that$(g(b) - g(a))f'(c) = \big(f(b) - f(a)\big)g'(c)$." We first prove the general MVT and study its applications which include the following: estimations of numbers, proving $L'H\hat{o}spital'$s rule, and the proof of the Fundamental Theorem of Calculus.

ROOM 4115 •• **Laura Schoeppner*** (WKU)
A Study by Scenario of the Factors Influencing the Power and Probability of Type I Error

Abstract: In the problem of testing the equality of two population means in statistics, the Rule of Thumb is often used to determine if one should assume population variances are equal or unequal. However it is uncertain if using this Rule of Thumb could increase the probability of committing type I and type II errors with two-sample-t-tests. As such this study looks to test through scenario by usage of mathematical software program R and recording the probabilities of committing type I and type II errors. The study will account for various factors such as sample size, mean, variance and compare the results when using the Rule of Thumb and when automatically assuming that the population variances are unequal.

ROOM 3110 •• **Uta Ziegler** (WKU)
Combinatorial adventures: From building (random) bridges to growing trees

Abstract: Using only up-steps and down-steps, how can a (random) bridge be built which connects two separated locations (e.g. a bridge over an abyss)? How many different bridges exist and how can one be built randomly? How do the building constructions have to be changed if the random bridge needs to cross a river – and nobody wants to get wet feet going over the bridge? How many such river-bridges exist and how can one be built randomly? The last part of the talk outlines how the bridge-building idea was used in research to generate random binary trees and knots.

ROOM 1108 •• **Dominic Lanphier, Magannah El-Farrah** (WKU)
Subgroups of cyclic groups and values of the Riemann zeta function

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Abstract: If we select an element at random from a large cyclic group, what should we expect the order to be? More generally, if we select k elements at random, what should be the order of the subgroup generated by those k elements? The average order of the elements of a cyclic group have been well-studied in recent years. In this talk we study the above questions by considering the average order of the subgroups of a cyclic group which are generated by a fixed number of elements. Interestingly, values of the Riemann zeta function arise in the study of these and similar questions.

Saturday 10:40 - 11:40 am, Room 3110

INVITED TALK

Colin Adams
(Williams College)

Blown Away: What Knot to Do When Sailing

Being a tale of adventure on the high seas involving great risk to the tale teller, and how an understanding of the mathematical theory of knots saved his bacon. No nautical or mathematical background assumed!

Saturday 11:45 - 12:15 pm, ROOM 3110

Tutorial Session

Colin Adams (Williams College)

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