SPONSORS of the 39TH ANNUAL MATHEMATICS SYMPOSIUM WESTERN KENTUCKY UNIVERSITY

WKU DEPARTMENT OF MATHEMATICS

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siam Society for Industrial and Applied Mathematics
Western Kentucky University Student Chapter

WKU AMS Student Chapter

SCHEDULE FOR 39TH ANNUAL MATHEMATICS SYMPOSIUM WESTERN KENTUCKY UNIVERSITY NOVEMBER 22-NOVEMBER 23, 2019

***Gatton Academy Student, **Undergraduate Student, ***Graduate Student**

FRIDAY, NOVEMBER 22, 2019

Registration and refreshments begin at 3 PM on 1st floor of Ogden Hall

Welcome (Friday 3:25-3:30 PM, Ogden Hall Auditorium)
Dr. Bruce Kessler, Head of the Department of Mathematics
Dr. Greg Arbuckle, Dean of Ogden College of Science & Engineering

Keynote Talk (Friday 3:30-4:20 PM, Ogden Hall Auditorium)

One Health: Connecting Humans, Animals and the Environment
Sponsored by WKU American Mathematical Society Student Chapter
Friday 3:30-4:20 PM, Ogden Hall Auditorium
Dr. Suzanne Lenhart, The University of Tennessee, Knoxville

Abstract: 'One Health' is a multidisciplinary approach to improving the health of people, animals and the environment. Environmental, wildlife, domestic animal, and human health fall under the One Health concept. Mathematical models of infectious diseases involving animals, environmental features, and humans will be presented. These models can suggest management policies and predict disease spread. Examples including La Crosse virus and Zika virus will be discussed.

General Session I (Friday 4:30-6:20 PM, Ogden Hall Auditorium)

Energies of knots
Friday 4:30-4:50 PM Ogden Hall Auditorium
Dr. Claus Ernst, Western Kentucky University

Abstract: Knots can be considered as thick-knotted tubes or a stiff thin curves. These considerations influence the shape the knots will have. We discuss the mathematics behind these ideas.

Binary Classification for Network Intrusion Detection in Drones
Friday 5:00-5:20 PM, Ogden Hall Auditorium
Sierra Wyllie*, Western Kentucky University
Mentor: Dr. Ismail Abumuhfouz, Western Kentucky University

Abstract: The technological growth of drones and other Unmanned Aerial Vehicles (UAVs) is inevitable. They are currently used in a variety of fields, but this usage is susceptible to cyberattacks; which may endanger privacy, national security, and even human life. Network Intrusion Detection Systems (NIDS) are used to monitor a network or systems for malicious activity or policy violations. The current NIDS are ineffective to protect the drones against novel attacks. This project seeks to create a binary classication NIDS to protect drones from WIFI attacks. We combine the NIDS with Machine Learning (ML) to increase previously unidentifiable attacks. Several ML-enabled NIDS already exist in different fields, but to the best of our knowledge, this is the first NIDS that is tailored specically for drones. We evaluate the performance of the ML algorithms of random forests, stochastic gradient boosting, and K-Means for binary classication on the CI-CIDS2017 dataset.

Creating Incredible Graphs Using Free Online Software Compatible with Microsoft Word
Friday 5:30-5:50 PM, Ogden Hall Auditorium
Lee Emanuel, Western Kentucky University

Abstract: It is frequently said that a picture is worth a thousand words. In my College Algebra courses, I try to utilize graphs to illustrate as well as measure concept mastery. The main problem I experienced was creating graphs that could be copied and pasted into a word processor without loss in resolution. A few years ago I found a free online software that allowed complete compatibility with Microsoft Word. In this talk, I will cover axis, basic functions in the rectangular coordinate system, parametric functions, and functions in polar form. The software is found at https://www.padowan.dk/download/

Frame as a Sum of Two Given Frames
Friday 6:00-6:20 PM, Ogden Hall Auditorium
Dr. Ghanshyam Bhatt, Tennessee State University

Abstract: Frames, linearly dependent spanning set, are more stable as compared to bases under the action of a bounded linear operator. Sums of different frames under the action of a bounded linear operator is studied with the help of analysis, synthesis and frame operators. A simple construction of frames from the existing ones under the action of such operator is presented here. It is shown that a frame can be added to its alternate dual frames yielding a new frame. It is also shown that the sum of a pair of orthogonal frames is a frame. This provides an easy construction of a frame where the frame bounds can be computed easily. Moreover, for a pair of orthogonal frames, the necessary and sufficient condition is presented for their alternate dual frames to be orthogonal. This allows for easy construction of a large number of new frames.

WKU SIAM Student Chapter-sponsored Session
(Friday 4:30-6:20 PM, Snell Hall 1108)

Semi-discrete Finite Difference Approximations of the Wave Equation Controlled Through Its Boundary
Friday 4:30-4:50 PM, Snell Hall 1108
Emma Moore, Western Kentucky University**
Mentor: Dr. Ozkan Ozer, Western Kentucky University

Abstract: Vibrations on a clamped-free string of length *L* are modeled through the following one-dimensional wave equation:

$$\frac{\partial^2 w}{\partial t^2} - \frac{\partial^2 w}{\partial x^2} = 0, \quad w(0,t) = 0, \quad \frac{\partial^2 w}{\partial x^2}(L,t) = u(t), \qquad (1)$$

where $u(t)$ is the applied boundary controller. Vibrations exist along the string, and to control them, one may to observe these vibrations through a sensor placed at the tip of the string. Our goal is to develop a reliable approximation technique for (1) via the use of standard Finite Differences. Let $\{w_j(t) \approx w(x_j,t)\}^N{}_{j=1}\}$. After carefully analyzing the spectrum of the central difference approximations with control-free boundary conditions of

$$-A_h\vec{w} = \tilde{\lambda}\vec{w}, \quad w_0 = 0, \quad w_{N+1} = w_N, \qquad (2)$$

$$-\frac{\partial^2}{\partial x^2}\vec{w} = \lambda\vec{w}, \quad w(0) = 0, \quad w_x(L) = 0, \qquad (3)$$

where $\vec{w} = [w_1, w_2, ..., w_N]$, $h = \frac{L}{N\_1}$, we show that the eigenvalues of (2) diverge away from those of (3). Moreover, the gap between two consecutive eigenvalues of (2) tends to zero as the mesh parameter h → 0, which is not case for (3). That is, one cannot distinguish one vibrational frequency from another. However, these spurious vibrations do not exist on the string and are solely caused by the blind application of the Finite Differences. Preservation of the gap condition is necessary to control the approximated model corresponding to (1). To fix this issue, one has to filter these vibrations in the approximated model. We adopt a direct filtering method, which adds a viscosity term to the equation. The results and simulations will be provided.

Visitors from the 4th-dimension: Visualizing Wavelets as Points in 4-space
Friday 5:00-5:20 PM, Snell Hall 1108
Dr. David Roach, Murray State University

Abstract: The parameterized length-four wavelets are the solution to a nonlinear system of equations where each equation represents an object in 4-space, and the wavelet solution is the intersection. In this talk, we will examine some projection models that describe the shape of these objects and animate their cross-sections as they pass through our dimension. This topic is accessible to both students and faculty.

Doc2Vec and the Relationships Between Written Information
Friday 5:30-5:50 PM, Snell Hall 1108
DJ Price, Western Kentucky University**
Mentor: Dr. Uta Ziegler, Western Kentucky University

Abstract: There currently does not exist a way to easily view the relationships between a collection of written items (e.g., sports articles, diary entries, research papers). In recent years, novel artificial intelligence learning methods have been developed which are very good at extracting semantic relationships from large numbers of documents. One of them is the (unsupervised) machine-learning model Doc2Vec, which constructs vectors for documents. The current research project uses this and other already existing algorithms to learn the relationship between pieces of text and to create a visual display of how the pieces are connected. This presentation will explain how Doc2Vec is used for document analysis and how these visualizations are created. Further analysis has been done on the documents using different text classification methods.

Semiparametric Least Squares Estimation of Mileage-based Weibull Parameters
Friday 6:00-6:20 PM, Snell Hall 1108
Dr. Jonathan Quiton, Data Scientist, Nissan North America
Michael Martin, Product Owner, Nissan North America

Abstract: The Weibull Distribution is a failure–time distribution used to project cumulative incident rates. The high appeal of the Weibull distribution is that the Weibull parameters have engineering interpretation, and the distribution is robust enough to capture various failure modes. The statistical challenge for a mileage-based Weibull estimation; however, is that we do not have the complete mileage information for all the vehicles. In this talk, we will present a solution using a semi-parametric Nelson-Aalen cumulative hazard estimator. Specifically, we use the law of iterated expectation to estimate the at-risk function $Y(t)$, where t is a specific mileage point. Finally, we plot the hazard function against mileage and generate the Weibull parameters via the least squares method. Business rules, data limitations, computing platform, visualization and the agile product development workflow will also be discussed.

Pizza dinner break begins at 6:30 PM on 1st floor of Ogden Hall

Career Panel Session (Friday 7:00-7:40 PM, Ogden Hall Auditorium)

Career Panel Session Sponsored by the WKU Society for Industrial and Applied Mathematics Student Chapter
Friday 7:00-7:40 PM, Ogden Hall Auditorium
Christina Florence, Southern Kentucky Community & Technical College
Siddharth Krishnamurthy, Data Scientist & Engineer, GEODIS
Dr. Suzanne Lenhart, Professor, The University of Tennessee, Knoxville
Dr. Jonathan Quiton, Data Scientist, Nissan North America
Jerry Shaw, Senior Operations Research Analyst, UPS
Moderator: Dr. Richard Schugart, Western Kentucky University

Abstract: A career panel session is an opportunity for students to ask questions regarding your next steps after graduation. Questions can range from, “How did you get into your current position?” to “What courses should I take to best prepare for a job in your field?” We have five great panelists: Christina Florence, an associate professor at the Southern Kentucky Community & Technical College, Siddharth Krishnamurthy, a data scientist and engineer; Dr. Suzanne Lenhart, a professor at The University of Tennessee, Knoxville; Dr. Jonathan Quiton, a data scientist at Nissan North America; and Jerry Shaw, a senior operations research analyst at UPS.

Play (Friday 7:45-8:15 PM, Ogden Hall Auditorium)

The Math is Right!
Friday 7:45-8:15 PM, Ogden Hall Auditorium

Abstract: The math is right is based on the game show “The Price is Right!” This play will require audience participation; get ready to volunteer.

SATURDAY, NOVEMBER 23, 2019

Registration and refreshments begin at 7:45 AM on 1st floor of Ogden Hall

Knots Session (Saturday 8:25-11:20 AM, Ogden Hall Auditorium)

Drawing Knots in Mathematica
Saturday 8:25-8:45 AM, Ogden Hall Auditorium
Eamon O'Connor*, Western Kentucky University
Alec Ramos*, Western Kentucky University
Mentor: Dr. Claus Ernst, Western Kentucky University

Abstract: Drawing knots by hand may be fun, but drawing knots computationally is more practical. Utilizing a knot's planar diagram code and its shadow, we can represent a knot in $\mathbb{R}^2$ in a newer, faster program-compared to other drawing solutions in *Mathematica*.

Virtual Reality Meets Knot Theory
Saturday 8:50-9:10 AM, Ogden Hall Auditorium
Nathaniel Gillispie*, Western Kentucky University
Mentor: Dr. Claus Ernst, Western Kentucky University

Abstract: This talk will show some of the infinite applications of 3D and computer graphics with special attention on knot theory. We will cover some of the widely available options for modeling and viewing in 3-dimensions.

A Representation of Flypes in Seifert Diagrams and Graphs
Saturday 9:15-9:35 AM, Ogden Hall Auditorium
Nathan Jones*, Western Kentucky University
JT Reagor*, Western Kentucky University
Mentor: Dr. Claus Ernst, Western Kentucky University

Abstract: Our research in the field of knot theory is analyzing the applicability of Seifert graphs and diagrams toward identifying flypes in knot diagrams. We have determined what we believe to be general representations of both antiparallel and parallel flypes in Seifert diagrams. We are currently determining the possibility of using Seifert graphs to identify flypes.

Break 9:40-9:55

Manipulating Link Diagrams using Flypes
Saturday 10:00-10:20 AM, Ogden Hall Auditorium
Lukas Negron*, Western Kentucky University
Mentor: Dr. Claus Ernst, Western Kentucky University

Abstract: Knot theory is the study of mathematical knots. A knot is a one-dimensional closed curve in 3-space. A knot diagram is a two-dimensional representation of a knot, similar to a shadow of it. A link is the union of multiple knots, each of which is called a component of the link. All minimal diagrams of an alternating link can be found through some series of flypes performed on a single minimal diagram of that link. My project involved creating code in Wolfram *Mathematica* that can perform a flype on an alternating link.

Determining the Braid Index of Alternating Links
Saturday 10:30-10:50 AM, Ogden Hall Auditorium
Caitlin Cook*, Western Kentucky University
Grace McClurg*, Western Kentucky University
Mentor: Dr. Claus Ernst, Western Kentucky University

Abstract: In knot theory, a *knot* can be thought of as a two-dimensional string twisted around itself with its endpoints connected. A *link* is a set of one or more knots that may be intertwined; an alternating link is a link that can be drawn in such that tracing around each component in the link alternates between over- and under-passes. A *braid* is a set of one or more distinct strands that are intertwined. When the strands of a braid are conjoined at their ends, a link is created. The least number of strands in a braid that represents a link is the *braid index* of that link. We show how the braid index can be computed for some alternating link families.

A Complete List of Minimal Diagrams of an Alternating Knot
Saturday 11:00-11:20 AM, Ogden Hall Auditorium
DJ Price, Western Kentucky University**
Mentor: Dr. Claus Ernst, Western Kentucky University

Abstract: A knot is an embedding of a circle in 3-space. A knot can be represented by tangling some string and then fusing the ends of the string together. Given some knot in 3-space, a diagram *D* of that knot is obtained by shining a light on the knot and observing the shadow of that knot on the plane. Places where this shadow intersects itself are called crossings. The lines that form these crossings are called strands; we do not allow for three or more strands to compose a crossing, only two. We call two-knot diagrams equivalent if we can stretch and compress the strands in the first diagram in such a way that we are able to recreate the second diagram. However, we do not tear or cut any strands in this process. When viewing a diagram, the strand that is on top in a crossing is called the overstrand. The other strand is the understrand. A knot diagram is called alternating if when traversed, the strands constantly alternate between over and under. A tangle *T* in a knot diagram *D* is a region *R* bounded by a simple closed curve that intersects *D* at exactly four points that are not crossings themselves. A flype is a move whereby *T* is flipped 180 degrees such that if there were a crossing on one side of *T*, it is moved to the other side of *T*. A reduced diagram of a knot is a diagram that has the least number of crossings possible. All alternating diagrams are inherently reduced. By the Tait-Flyping Conjecture, two reduced diagrams of an alternating knot can be transformed to each other through a finite series of flypes. Consequently, given a reduced diagram of a knot, it is possible to generate all other reduced diagrams of that through performing all possible flypes on it and continuing this process recursively until all diagrams have been found. The programming languages used include PHP, C, and *Mathematica*. The software used includes Ubuntu 18, Ubuntu 14, and Docker.

Applications Session (Saturday 8:25-11:20 AM, Snell Hall 1108)

Three Computational Techniques for Analyzing a Mathematical Model of Patients with Diabetic Foot Ulcers Using Individual Patient Data

Saturday 8:25-8:45 AM, Snell Hall 1108

Michael Belcher, Western Kentucky University**
Gloria Huang*, Western Kentucky University
Mentor: Dr. Richard Schugart, Western Kentucky University

Abstract: A mathematical model for the healing response of diabetic foot ulcers was developed using averaged data (Krishna et al., 2015). The model contains four major factors in the healing of wounds using four separate differential equations with 12 parameters. The four differential equations describe the interactions between matrix metalloproteinases (MMP-1), tissue inhibitors of matrix metalloproteinases (TIMP-1), the extracellular matrix (ECM) of the skin, and the fibroblasts, which produce these proteins. A global sensitivity analyses was conducted to determine which parameters are most influential across all patients. The two most sensitive parameters were used to visualize the three-dimensional geometry of this parameter subspace to see how these factors affect individual patients. A second technique introduces mixed modeling effects on the growth parameters in the model. Mixed effects modeling is an analytical tool useful for the repeated measurement of data with subjects, patients, etc. that have random effects that deviate from a specified norm. A third approach uses an optimal design technique to identify which times are ideal for gathering clinical data. This part of the project seeks to combine these last two techniques by introducing parameter values from mixed effects modeling into a Standard Error (SE) optimal-design algorithm and then comparing the results with the original parameter values. Finally, other optimal-design techniques were used with and without the parameters measured using mixed effects modeling to see if another technique is better than the SE optimal-design algorithm.

Travelling Waves with Oscillating Speeds in Integro-Difference Models
Saturday 8:50-9:10 AM, Snell Hall 1108
Michael Nestor, University of Louisville**
Mentor: Dr. Bingtuan Li, University of Louisville

Abstract: In population biology, integro-difference equations are used to model the growth and dispersal of a single species throughout space. It is well-known that when the growth function is monotone and exhibits a strong Allee effect, there exists a traveling wave with a unique constant speed. We explore the case where the growth function has a stable equilibrium at zero and is non-monotone with a stable 2-point cycle near carrying capacity, and thus displays both a strong Allee effect and overcompensation. We show analytically the existence of a traveling wave with a period-2 speed when the growth function is a piecewise constant function. We present numerical simulations to demonstrate that solutions with initial compact support have alternating spreading speeds and travelling waves have alternating shapes.

PDE Models of the Dynamics of Surface Instabilities of a Thin Solid Film
Saturday 9:15-9:35 AM, Snell Hall 1108
Dr. Mikhail Khenner, Western Kentucky University

Abstract: I will present an introduction to mathematical modeling of thin solid films. In a high temperature and stress environment that is typical to the operation of a thin film-based nanoelectronic device, a surface of such films changes shape due to diffusion of the atoms in the surface layer. In a worst-case scenario, the amplification of surface perturbations may lead to the loss of the structural integrity of a film and thus to the device degradation or loss. The modeling is based on a strongly nonlinear evolution PDE for the film height (thickness) function $h(x,t)$. The PDE is analyzed using the perturbation methods and computations.

Break 9:40-9:55

Modeling and simulating earthquake-induced structural vibrations on a multi-story building through the Wolfram's Demonstration Project
Saturday 10:00-10:20 AM, Snell Hall 1108
Jared Parker, Western Kentucky University**
Mentor: Dr. Ozkan Ozer, Western Kentucky University

Abstract: The effects of an earthquake on a multistory building were investigated by modeling a building as a large spring-mass system. Upon the application of Newton's Second Law, it is possible to model the displacement of any given floor of a building through a system of linear second order differential equations. The solution is determined using the Laplace transformation. Several simulations were conducted through the *Wolfram*'s Demonstration Project using this model to emulate various earthquake frequencies and the building's stiffness between floors. The model was then modified to consider the use of damping devices in the building. Open problems and future work will be discussed.

Spectral Analysis and Lack of Uniform Observability for the Finite Difference Space Discretization of the Beam Equation
Saturday 10:30-10:50 AM, Snell Hall 1108
Sydney New, Western Kentucky University**
Mentor: Dr. Ozkan Ozer, Western Kentucky University

Abstract: Bending profile $w(x,t)$ on a hinged fully-elastic beam of length L is modeled through the Euler-Bernoulli beam equation:

$$(*)\quad \begin{cases} \frac{\partial^2 w}{\partial t^2} - \alpha \frac{\partial^4 w}{\partial x^2 \partial t^2} + K \frac{\partial^4 w}{\partial x^4} = 0, & (x,t) \in (0,L)\times\mathbb{R}^+ \\ w(x,t),\ \frac{\partial^2 w}{\partial x^2}\Big|_{x=0,L} = 0, & t \in \mathbb{R}^+ \\ w(x,0) = w_0(x),\ \frac{\partial w}{\partial t}(x,0) = w_1(x) & x \in (0,L) \end{cases}$$

This equation also describes the bending profile of smart piezoelectric devices, which have the ability to convert mechanical energy to electrical energy, and vice versa. Therefore, these devices are used for both actuators and sensors. Vibrations exist along the beam, and to control them, one has to observe these vibrations through a sensor placed at the tip of the beam. Our goal is to develop a reliable approximation technique for (*) via the use of standard Finite Differences. Even though it is well-known that all vibrations on the beam are exactly observable by measuring the shear force at the tip of the beam, $w'''(L,t)$, the approximated model lacks exact observability with the same measurement.

The lack of observability is crucial in control theory, simply because, the sensors are designed based on the reduced model in practice. Based on the observed data, the control action is taken accordingly. However, in this case, the sensor gets numb to vibrations existing on the beam at that moment in time. In fact, these vibrations travel on the beam, but cannot be recovered or observed by the sensor. So, they are coined the term ghost vibrations. The goal of the research is to construct one of these vibrations in order to prove the lack of exact observability for the Euler-Bernoulli Beam Equation when blindly using Finite Differences.

“See”PS
Saturday 11:00-11:20 AM, Snell Hall 1108
Maunil Mullick*, Western Kentucky University
David Suarez*, Western Kentucky University

Abstract: Given a certain prescription, our project outputs images simulating a person’s vision without the use of corrective lenses. Through the use of various concepts in optics, “See”PS attempts to address the development and implementation of an algorithm to convolute the color value of pixels in an image based on a set of prescription input values (sphere, cylinder, and axis). The program displays a prompt asking the user to input their prescription and choice of image to be distorted. After the program’s execution, the left and right eye images are displayed. Different prescription inputs necessarily result in different image outputs, with the distortion being accordingly scaled to the prescription inputs.

Algebra and Analysis Session (Saturday 8:00-11:20 AM, Snell Hall 1101)

What does the Fibonacci Array count?
Saturday 8:00-8:20 AM, Snell Hall 1101
Lee-Lee Knupp*, Western Kentucky University
Mentor: Dr. Molly Dunkum, Western Kentucky University

Abstract: The Fibonacci Array is derived by taking the elements in the “shallow diagonals” of Pascal’s Triangle and arranging them into a right triangular numerical array. The entries in each row are enumerated by two types of sequences - Odd-Even (OE) and Adjacency-Free (AF). By replacing the entry ‘1’ in row 0 of the Fibonacci Array with α, we generalize the array. Generalizing the array calls for a generalization of the definitions of OE and AF Sequences. We were successful in finding the sequence definitions-including general exclusion principles-as well as a bijection between the two.

Fibonaccian Lattices and Some Curious Triangle-shaped Integer Arrays
Saturday 8:25-8:45 AM, Snell Hall 1101
Dr. Molly Dunkum, Western Kentucky University
Dr. Rob Donnelly, Murray State University

Abstract: In recent work with students, we have found what we think are some attractive and new connections between some Fibonacci-related distributive lattices, triangular integer patterns, and one-variable sign-alternating polynomials. In this talk, we'll present some of these objects and explore some of their interconnections.

Visualizing Representations of Fibonacci and Catalan Lattices
Saturday 8:50-9:10 AM, Snell Hall 1101
Sasha Malone*, Western Kentucky University**
Mentor: Dr. Molly Dunkum, Western Kentucky University

Abstract: There exists a natural correspondence between representations of complex semisimple Lie algebras and certain families of distributive lattices. In this talk, two such families of lattices (whose vertex cardinalities correspond to well-known integer sequences) will be introduced and computationally visualized.

The Condition for a Quaternary Cyclic Code to be LCD
Saturday 9:15-9:35 AM, Snell Hall 1101
Seth Gannon*, University of Louisville**
Mentor: Dr. Hamid Kulosman, University of Louisvlle

Abstract: A linear code with complementary dual (LCD code) is a linear code C whose dual satisfies $C \cap C^{\perp} = \{0\}$. These codes are of importance for not only theory, but for application as well. LCD codes give an optimum linear coding solution for a two-user binary adder channel and they simplify the maximum-likelihood decoding problem. In 1993, Yang & Massey produced a condition for a cyclic code over a Galois Field to have a complementary dual. It will be shown that a necessary and sufficient condition for a cyclic code C over $\mathbb{Z}_4$ of odd length N to be an LCD code is that $C = (f(x))$, where f is a self-reciporocal monic divisor of $X^N - 1 \in \mathbb{Z}_4[X]$.

Break 9:40-9:55

Geometric Ramsey Theory
Saturday 10:00-10:20 AM, Snell Hall 1101
Dr. Attila Por, Western Kentucky University

Abstract: In Ramsey theory, given a finite structure, we want to find a “large” substructure with some (homogeneous) property. In graph theory, given a (hyper)graph G and a coloring of its edges with k color, find a subset X of the vertices V such that every edge contained in X has the same color. Let $f(n, k, r)$ be the least number, such that given a k-coloring of the edges of the complete r-uniform hyper-graph on $N = f(n, k, r)$ vertices, then there exists an n element subset X of the vertices such that all the edges in X are monochromatic. It is known that $f(n, k, r)$ is asymptotically a tower function of n, k of height $r - 1$. By replacing graphs with geometric structures, like order type, the height of the tower is reduced by 1.

Controllability and Observability of Linear Time-invariant Nabla Fractional Discrete Systems
Saturday 10:30-10:50 AM, Snell Hall 1101
Tilekbek Zhoroev*, Western Kentucky University**
Mentor: Dr. Ferhan Atici, Western Kentucky University

Abstract: In this presentation, we study linear time-invariant nabla fractional discrete control systems. The nabla fractional difference operator is considered in the sense of Riemann-Liouville definition of the fractional derivative. We first give necessary and sufficient rank conditions for controllability of the discrete fractional system via the Gramian matrix and controllability matrix. Then we obtain rank conditions for observability of the discrete fractional system. We illustrate main results with some numerical examples. Then we state that the rank conditions for the dynamic systems on time scales, continuous fractional systems, and discrete fractional systems coincide. Finally, we examine the controllability and observability of the three-compartment model of digoxin distribution.

Tumor Growth Model with Fractional *h*-difference equations
Saturday 11:00-11:20 AM, Snell Hall 1101
Kamala Dadashova*, Western Kentucky University**
Mentor: Dr. Ferhan Atici, Western Kentucky University

Abstract: We study the pharmacodynamics (PD) models of tumor growth and effects of monotherapy against cancer on discrete fractional calculus. The model consists of three fractional *h*-difference equations. First, we introduce some preliminary definitions, theorems and lemmas on discrete fractional calculus on $h\mathbb{N}_0$ to give explicit solutions to the PD model. Subsequently, we focus on phramacokinetic (PK) model. We solve the model using definition of *h*-nabla operator and Putzer algorithm.

General Session II (Saturday 8:00-11:20 AM, Snell Hall 1102)

Fluid Mechanics for English Majors
Saturday 8:00-8:20 AM, Snell Hall 1102
Patrick O'Boyle*, Western Kentucky University
Lukas Negron*, Western Kentucky University

Abstract: Fluid Mechanics for English Majors (FMEM) was a MATH/CS 371 final project at Western Kentucky University. FMEM illustrates basic principles from fluid mechanics and allows the user to build their own pipe network from the bottom-up. The user first defines the network structure and inserts components, such as valves, gates, and reservoirs. Then, the user can modify the pipe network they created by transferring fluid and changing part states. Properties such as fluid velocity and differential pressure can be observed at different stages in the simulation. This presentation will focus on recursive model used for the representation of the pipe network.

The Differentiation Differentiator
Saturday 8:25-8:45 AM, Snell Hall 1102
Gabriella Lynn*, Western Kentucky University
John Thornhill*, Western Kentucky University

Abstract: Using *Mathematica*, our project improves the user's differentiation skills. At the beginning of the program, a user is given a diagnostic test, with questions ranging from basic derivatives to advanced techniques. Based upon answers to these questions, the user is assigned a skill level, and lessons are created for the user. As the user's skill is increased, so is the difficulty of the questions. The questions have variable numbers so that the user is not asked the same question multiple times, making sure that they do in fact learn the process, not the answer. Various help mechanisms, such as videos and step-by-step solutions, are available in the program as resources for the user. The user can save their progress and resume later.

Summing Sums of Powers of Sums
Saturday 8:50-9:10 AM, Snell Hall 1102
Dr. Dominic Lanphier, Western Kentucky University

Abstract: Formulas for the sums of powers of the first few positive integers are often encountered by undergraduates. General formulas, however, require Bernoulli numbers and Bernoulli polynomials. Estimating sums of non-integer powers even require the Riemann zeta function. We review these results, and give natural multivariable generalizations. Along the way, we introduce Bernoulli-Barnes numbers and Barnes zeta functions, which are needed for the new formulas.

Generating Chemical Compounds for Naming Using Algorithms
Saturday 9:15-9:35 AM, Snell Hall 1102
Belle Begley*, Western Kentucky University
Mentor: Dr. Uta Ziegler, Western Kentucky University
Mentor: Dr. Sarah Edwards, Western Kentucky University

Abstract: Chemical nomenclature is a set of rules used to make systematic names for chemical compounds. This is a topic that students in introductory chemistry courses typically struggle in. With this issue in mind, a chemical nomenclature tutor was created with the hope of aiding student success in this area. The tutor, coded in *Mathematica*, can be used to practice chemical nomenclature as it gives the user the name of a compound and asks for the corresponding formula or vice versa. The program utilizes a series of algorithms, which have the ability to create tens of thousands of chemical compounds for naming. Therefore, it gives students an endless amount of compounds to practice with.

Break 9:40-9:55

Continental Drift: A Computational Problem Solving Project
Saturday 10:00-10:20 AM, Snell Hall 1102
Laurel Philpott*, Western Kentucky University
Hazel Traw*, Western Kentucky University

Abstract: We created a simulation of continental drift consisting of three main parts. The first is an educational description of plate tectonics that helps provide background information to users. The second part is a simulation using Manipulate to show the movement of the continents over time from Pangea to modern day. We took the coordinates of the continents from *Mathematica*'s database and then wrote code to translate these points to a coordinate plane system in order to display and translate the points more easily. The third component is an interactive game in which the user can try to piece together modern day from Pangea and from Gondwana and Laurasia, and even try to create the future supercontinent Pangea Proxima. Our hope was to create a project that helps to convey geological information in an interesting, hands-on way, bridging the gap between computer programming and earth sciences.

Black Box: A Computational Problem Solved
Saturday 10:30-10:50 AM, Snell Hall 1102
Margot Hare*, Western Kentucky University
Licia Henneberg*, Western Kentucky University

Abstract: In the program *Mathematica*, we created a computer version of the game "Black Box." The object of the game is to find hidden "atoms" in a board by shooting "light" through it. Based on how the light reflects off the atoms and where it exits the board, atoms can be located. The user plays by clicking on the outer perimeter of the board to get feedback and clicking the center of the board to place guesses about the locations of atoms. Our final product changed the original two-player game to a single player version with hints, scoring, and other features. The player is able to puzzle out a computer-generated game that is both challenging and entertaining. We discuss our methodology and final product in our presentation.

RaceTracker
Saturday 11:00-11:20 AM, Snell Hall 1102
Karis Littlepage*, Western Kentucky University

Abstract: This project was created as an easy way to teach new people how to score a dirt bike race. In order to do this efficiently, the problem was broken down into a few smaller pieces: how to define a track, how to create riders and make them go around the track smoothly, and how to allow a user to score a race with multiple levels of difficulty. Using basic line and circle functions in Wolfram's *Mathematica*, a default track was created in a stadium shape. In an attempt to make the program more accurate and adaptable to any live race, the pieces of the default track were separated and set as buttons so that the user could build their own track to score. Similarly, the user is able to decide how many riders are on the track at a time, as well as how many laps they would like to score and how fast the riders will go. The riders are designated as different colored dots on the track with a number in the middle corresponding to the number in which they should be scored as. A digital score sheet is provided for the user to click which rider finishes where. At the end of the race, the program will give feedback for the user's score sheet. Due to *Mathematica* not being a coding program for simulators and the sheer number of data points the program deals with, the project could use work in terms of its efficiency and graphics.

Computational Session (Saturday 8:00-11:20 AM, Snell Hall 1103)

Visualization and Analysis of Solutions to Systems of Differential Equations
Saturday 8:00-8:20 AM, Snell Hall 1103
Dr. Mark Robinson, Western Kentucky University

Abstract: In this presentation, several autonomous systems of differential equations are examined, both linear and nonlinear and in both two and three dimensions. Visualization of solutions using direction fields and phase portraits, the nature of the solutions, and identification and classification of critical (or equilibrium) points are considered.

Authorship attribution using occupancy-problem-type indices
Saturday 8:25-8:45 AM, Snell Hall 1103
Chandra Kundu*, Western Kentucky University**
Mentor: Dr. Lukun Zheng, Western Kentucky University

Abstract: In this talk, I propose a new methodology for authorship attribution based on a profile of indices related to the occupancy problem, called occupancy-problem indices. The occupancy problem has a long history and is an important example in standard textbooks like Feller (1971). Balls are thrown independently at K boxes according to a probability distribution $\{p_k\} = \{p_k;\ 1 \leq k \leq K\}$ with the probability p_k of hitting the k-th box. This process is repeated for m times and the number H_m of nonempty boxes is recorded. Calculating the probability distribution of H_m is generally referred to as the occupancy problem. This methodology is based on the function words. A testing procedure is established by constructing a confidence band of the occupancy-problem indices using the sampling distribution of H_m. To validate the proposed methodology, I used several writing samples whose authorship is known. I then apply this methodology to explore the question of who wrote the 15th Oz book, which has a disputed authorship between Lyman Frank Baum (1856–1919) and his successor, Ruth Plumly Thompson (1891–1976), on the Oz series.

Tricky Triangle
Saturday 8:50-9:10 AM, Snell Hall 1103
Jack McCoun*, Western Kentucky University
Ashley Wright*, Western Kentucky University

Abstract: For a project in Computational Problem Solving, we wrote a computer program in *Mathematica* to simulate the knick-knack table game, Tricky Triangle. We used graphics to create a dynamic interface that a user can interact with that followed all of the rules of the physical game. We also used recursive math to create a solver to serve as a helper to a player who has gotten stuck. We combined our knowledge of computational mathematics with programming to write a game that was capable of running itself with minor user supervision.

Recreating Scrabble
Saturday 9:15-9:35 AM, Snell Hall 1103
Elizabeth Morgan*, Western Kentucky University
Saee Patwardhan*, Western Kentucky University

Abstract: We used the computational capabilities of Wolfram *Mathematica* to recreate the popular game *Scrabble*. *Scrabble* is a crossword game where players place letter tiles onto a 15 x 15 board to form words. Players attempt to earn the most points until no more tiles are remaining or there are no more possible moves. We created two versions of the original game: Single and Multi-Player. Both versions are designed to improve the user's skill level by recommending words.

Break 9:40-9:55

A Comparative Study between different Recommendation Systems
Saturday 10:00-10:20 AM, Snell Hall 1103
Ashwini Lokesh*, Western Kentucky University**
Mentor: Dr. Huanjing Wang, Western Kentucky University

Abstract: Recommendation Systems or Recommend-er Systems have become widely popular due to surge of information at present time and customer-centric environment. Researchers have looked into a wide range of recommendation systems leveraging a wide range of algorithms. This study investigates three popular recommendation systems in existence, collaborative filtering based, content-based filtering and hybrid recommendation system. The famous MovieLens dataset was utilized for the purpose of this study. The evaluation looked into both quantitative and qualitative aspects of the recommendation systems. We found that both in both the aspects, a hybrid recommendation system performs better than standalone collaborative filtering or content-based filtering recommendation system.

Exploring Dots and Boxes Endgame Strategies through Monte Carlo Tree Search
Saturday 10:30-10:50 AM, Snell Hall 1103
Dalton Richardson*, Western Kentucky University
Elijah Whittle*, Western Kentucky University
Mentor: Dr. Uta Ziegler, Western Kentucky University

Abstract: Monte Carlo Tree Search (MCTS) is a heuristic search algorithm used in artificial intelligence systems that has been adapted to accomplish many difficult tasks which could not be completed by more traditional AI means, such as defeating the world's champions of the strategy game Go. Our project applies MCTS to the deceptively complex children's game Dots & Boxes. Using this pen-and-paper game, we can look into the strategies and techniques behind this adaptive algorithm. One property of Dots & Boxes that has caught our attention is its unique endgame strategy. Our current investigation takes two approaches to the end game: A non-adaptive algorithmic approach and an adaptive, MCTS-learning approach. This talk explains what we have learned so far and how it might be used to improve the current MCTS-based Dots & Boxes player.

Parallelization and Backpropagation Techniques for Monte Carlo Tree Search
Saturday 11:00-11:20 AM, Snell Hall 1103
Mina Ryumae*, Western Kentucky University
Caedan Whitaker*, Western Kentucky University
Mentor: Dr. Uta Ziegler, Western Kentucky University

Abstract: High strategy games that have complex rules can be difficult to solve mathematically. In these cases, it can be beneficial to employ computational search methods to create a computer model with a deeper understanding of the game. The Monte Carlo Tree Search (MCTS) technique has been proven to be beneficial in games with a large computational burden due to the number of available player actions. As opposed to previous algorithms which reduce the game tree through pruning techniques, MCTS works by building a tree of moves that are determined to be important for the success of the game and records the benefit of each move through a process called backpropagation. In this way, the entire game tree isn't necessarily searched, and the depth of learning is directly dependent on the number and depth of paths explores. Moves are selected to be tested by simulations based on characteristics such as the number of times the move has been tested and the overall benefit the move had. Our research group focuses on applying the MCTS algorithm to the two-person, zero sum, children's game of Dots and Boxes. We will discuss two methods of improving the Dots and Boxes player by: (i) finding the areas of high computing strain in our implementation of the MCTS algorithm which can be computed in parallel and (ii) updating the approach to move selection and backpropagation by observing multiple paths that lead to the same state.

Keynote Talk (Saturday 11:30AM-12:20 PM, Ogden Hall Auditorium)

How Mathematics Helps Feed the World: Examples of Innovations in Agriculture
Sponsored by the WKU Society for Industrial and Applied Mathematics Student Chapter
Saturday 11:30 AM-12:20 PM, Ogden Hall Auditorium
Dr. Laura Potter, Syngenta

Abstract: Curious to learn how you can apply your math and analytics skills to help farmers feed the growing population? In this talk I will share examples of how modeling and computation enable the design and placement of new and enhanced seed products to help improve crop yields.

Beginning at 12:45, the Women In Science & Engineering Club will host a panel discussion with Dr. Suzanne Lenhart and Dr. Laura Potter in Snell Hall 1101.

Friday

3:30-4:20 **Keynote Talk: Dr. Suzanne Lenhart, The University of Tennessee, Knoxville** **Sponsored by WKU AMS Student Chapter** **Ogden Hall Auditorium**		
	General Session I **Ogden Hall Auditorium**	**WKU SIAM Student Chapter-sponsored Session** **SH 1108**
4:30-4:50	Dr. Claus Ernst, WKU	Emma Moore**, WKU
5:00-5:20	Sierra Wyllie*, WKU	Dr. David Roach, Murray St U
5:30-5:50	Lee Emanuel, WKU	DJ Price**, WKU
6:00-6:20	Dr. Ghanshyam Bhatt, Tennesee St U	Dr. Jonathan Quiton, Michael Martin, Nissan
6:30-7:00: Break – Dinner **Ogden Hall**		
7:00-7:40: Career Panel Session Sponsored by the WKU SIAM Student Chapter **Panelists: Christina Florence, Siddharth Krishnamurthy, Dr. Suzanne Lenhart, Dr. Jonathan Quiton, Jerry Shaw** **Ogden Hall Auditorium**		
7:45-8:15: Play **The Math is Right!** **Ogden Hall Auditorium**		

***Gatton Academy & Undergraduate Student, **Undergraduate Student, ***Graduate Student**

Saturday

	Knots Session Ogden Hall Auditorium	Applications Session SH 1108	Algebra & Analysis Session Sponsored by AMS Student Chapter SH 1101	General Session II SH 1102	Computational Session SH 1103
8:00-8:20			Lee-Lee Knupp*, WKU	Patrick O'Boyle*, Lukas Negron*, WKU	Dr. Mark Robinson, WKU
8:25-8:45	Eamon O'Connor*, Alec Ramos*, WKU	Michael Belcher**, Gloria Huang*, WKU	Dr. Molly Dunkum, WKU, Dr. Rob Donnelly, Murray St U	Gabriella Lynn*, John Thornhill*, WKU	Chandra Kundu***, WKU
8:50-9:10	Nathaniel Gillispie*, WKU	Michael Nestor**, U Louisville	Sasha Malone***, WKU	Dr. Dominic Lanphier, WKU	Jack McCoun*, Ashley Wright*, WKU
9:15-9:35	Nathan Jones*, JT Reagor*, WKU	Dr. Mikhail Khenner, WKU	Seth Gannon***, U Louisville	Belle Begley*, WKU	Elizabeth Morgan*, Saee Patwardhan*, WKU
9:40-9:55: Break					
10:00-10:20	Lukas Negron*, WKU	Jared Parker**, WKU	Dr. Attila Por, WKU	Laurel Philpott*, Hazel Traw*, WKU	Ashwini Lokesh***, WKU
10:30-10:50	Caitlin Cook*, Grace McClurg*, WKU	Sydney New**, WKU	Tilekbek Zhoroev***, WKU	Margot Hare*, Licia Henneberg*, WKU	Dalton Richardson*, Elijah Whittle*, WKU
11:00-11:20	DJ Price**, WKU	Maunil Mullick*, David Suarez*, WKU	Kamala Dadashova***, WKU	Karis Littlepage*, WKU	Mina Ryumae*, Caedan Whitaker*, WKU
11:30-12:20 Keynote Talk: Dr. Laura Potter, Syngenta Sponsored by the WKU SIAM Student Chapter Ogden Hall Auditorium					

***Gatton Academy & Undergraduate Student, **Undergraduate Student, ***Graduate Student**