SCHEDULE FOR 37TH ANNUAL MATHEMATICS SYMPOSIUM WESTERN KENTUCKY UNIVERSITY NOVEMBER 17-NOVEMBER 18, 2017

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

FRIDAY, NOVEMBER 17, 2017

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

Welcome (Friday 3:25-3:30 PM, ROOM 1108)
Bruce Kessler, Head of the Department of Mathematics
Ken Crawford, Associate Dean of Ogden College of Science & Engineering

Keynote Talk (Friday 3:30-4:20 PM, ROOM 1108)

Collections of Points and Lines
Friday 3:30-4:20 PM, ROOM 1108
Ed Pegg, Wolfram Research

Abstract: A line, circle, plane, parabola, sphere, conic section, and cubic curve can be defined by 2, 3, 3, 4, 4, 5, and 9 points. The points can be represented in Cartesian, polar, complex, barycentric, or powered coordinates. If 16 2D points are in a unit square, what is the largest possible smallest triangle? What patterns are there in triangle centers? Can 25 points make 18 lines of 5 points? Can 27 points be arranged to make 81 unit distance lines? Can a point be a rational distance from the corners of a square? If 16 3D points have maximal distance 1, what is the greatest volume they can contain? Can 19 3D points be arranged so that all distances are powers of a given constant? How can the 95 points and lines of the Hexagrammum Mysticum be represented? Beyond those, what are some unsolved problems involving points and lines, and what methods might be useful for solving them?

SIAM Student Chapter Sponsored Session (Friday 4:30-6:50 PM, ROOM 1108)

The Neglected Discrete Distribution
Friday 4:30-4:50 PM, ROOM 1108
Melanie Autin, Western Kentucky University

Abstract: In probability courses, students are often exposed to a variety of discrete probability distributions. Consider randomly selecting items from a population that contains two types of objects: successes and failures. Suppose that a fixed number of items are selected from the population, and the number of successes selected is observed. If selections are made with replacement, this is a binomial random variable; however, if selections are made without replacement, this is a hypergeometric random variable. Suppose, instead, that the desired number of successes is fixed, and selections are made until that number of successes is achieved. If the selections are made with replacement, this is a negative binomial random variable. What if the selections are made without replacement? Then which distribution should be used? This situation, which is rarely covered in probability courses, will be explored in this talk!

The Mathematics of Artificial Neural Networks and the Quest to Understand Our Language
Friday 5:00-5:20 PM, ROOM 1108
Harrison Froedge*, Western Kentucky University

Abstract: Since their recent success in image recognition and other fields, Artificial Neural Networks (ANNs) have sprung to the forefront of public attention as they increasingly begin to resemble the artificial intelligence systems of sci-fi novels. Their rise has proceeded at an incredible rate - this year, an ANN defeated the world champion of Go (a board game often likened to chess), a feat, which has taken traditional algorithms decades to even approach. To some, the incredible results these networks provide make them an intimidating object of study. However, like any other computer program, they can be broken down into a logical set of mathematical steps. In this presentation, we will discuss the inner workings of ANNs, and how they are helping the WKU Semantics Laboratory classify the trustworthiness of the statements we make in our collaboration and competition with each other.

Challenges and Opportunities for Math-Based Solutions and Careers in the Automotive World
Friday 5:30-5:50 PM, ROOM 1108
Jonathan Quiton, Nissan North America

Abstract: In this talk, I will first "paint" the "big data" landscape in the automotive world in general and at Nissan North America in particular. This growth comes with the challenges of finding meaningful information in an increasing, massive pile of data, requiring advanced math/statistical algorithms and a robust Hadoop (big data) cluster-computing environment. I will describe some of the exciting data science problems we are tackling, our current big data analytical platform, opportunities for collaborative work via the Nissan Summer Internship Program and potential career in Data Science.

What, like it's hard? The logical transition from studying math to studying law
Friday 6:00-6:20 PM, ROOM 1108
Samantha McKean, Vanderbilt University

Abstract: Samantha McKean, third-year law student at Vanderbilt, will discuss her journey from being a mathematics major to law school. She will focus on how being a math major can set you apart in the legal field, from the admissions process to the job search and beyond.

Data Analytics and Actuarial Science
Friday 6:30-6:50 PM, ROOM 1108
Andrew Page, BPS&M, LLC

Abstract: In this talk, I will give a general overview of the growing demand for data analytics and how students with strong math and analytical skills are in very high demand. From there I will provide a close up view of my chosen career as an actuary. I will provide information on the steps that are needed to become an actuary as well as examples of the types of work that we perform at one of the nation's leading Pension Actuary Firms.

Algebra and Linear Algebra Session (Friday 4:30-6:50 PM, ROOM 1101)

Generate and Order: Dihedral Groups
Friday 4:30-4:50 PM, ROOM 1101
Jeremiah Bush, Western Kentucky University**

Abstract: We investigate the probability of generating the dihedral group when choosing exactly two random elements in the group. We also determine the average order of the elements of the dihedral group. Various interpretations of both topics are discussed.

Counting SL_2C-invariant polynomials
Friday 5:00-5:20 PM, ROOM 1101
Christopher Seaton, Rhodes College

Abstract: *Polynomial Invariant Theory* is a classical topic in mathematics and active area of research in algebraic geometry and commutative algebra; it plays a role in many areas of algebra, geometry, and mathematical physics. The typical starting point in invariant theory is a *group representation*, a set of matrices representing linear transformations from a fixed vector space to itself. One then studies the polynomial functions on this vector space that remain unchanged, or *invariant*, when composed with each of these matrices. This collection of *invariant polynomials* can be very difficult to compute or completely describe, even in relatively simple examples. Hence, one often seeks to describe properties of the set of invariants. For example, the *Hilbert series* of a set of invariants is a function that tells you how many invariant polynomials there are of each degree.

I will give a brief introduction to the basic notions of invariant theory with a focus on Hilbert series and invariants of a binary form. I will then present some recent results computing the Hilbert series of the invariants of a reducible representation of SL_2C, the group of 2 x 2 matrices with complex coefficients and determinant 1.

A New Characterization of Principal Ideal Domains
Friday 5:30-5:50 PM, ROOM 1101
Ryan Gipson*, University of Louisville**

Abstract: We introduce a new description of integral domains, namely, those integral domains whose every proper 2-generated ideal is contained in a proper principal ideal. We call this the principal containment (PC) condition, and we compare it with similar

conditions previously considered and show that it is indeed more general. Finally, we will prove that every integral domain *R* that satisfies the (PC) condition is, in fact, a PID.

Analysis of weight matrices that induce 2-principal and stable torus actions
Friday 6:00-6:20 PM, ROOM 1101
Yi Song, Rhodes College**

Abstract: Symplectic manifolds arise as geometrical representations of classical mechanical systems. We focus on the study of symplectic quotients, which are quotients of symplectic manifolds by symmetries of the system. The simplest quotients are by finite groups of symmetries and are known as orbifolds. However, it has been observed that more complicated symplectic quotients can sometimes but not always be identified with orbifolds. In fact, previous work by Herbig-Schwarz-Seaton has shown that if the group action of a torus on a complex space has certain properties, called 2-principal and stable, then there does not exist a symplectomorphism between the symplectic quotient and a linear symplectic orbifold. My research focuses on determining a necessary and sufficient condition for inducing a 2-principle and stable action only in terms of the weight matrix associated to the group action. We will present progress towards determining such a condition relating to the weight matrix.

Construction of finite frames as deterministic sampling matrices with low mutual coherence for the recovery of a sparse signal
Friday 6:30-6:50 PM, ROOM 1101
Ghan S Bhatt, Tennessee State University

Abstract: The recovery of a sparse signal is possible even if the number of measurements is far less than actually required in principle. The traditional sampling techniques use random sampling matrices, which satisfy the requirements with a fairly high probability. However the deterministic sampling are preferred for many applications. The sampling matrices are required to have low mutual coherence for applications. The shrinkage methods, namely shrinking the entries of the gram matrix, for construction of frames with low coherence has been proposed in literatures. We use their method to construct finite frames as deterministic sampling matrices with low mutual coherence.

Computational Session I (Friday 4:30-6:50, ROOM 1102)

N-Body Simulator in Wolfram Mathematica
Friday 4:30-4:50 PM, ROOM 1102
Brock McDaniel*, Western Kentucky University
Harper Sewalls*, Western Kentucky University

Abstract: The "three-body problem" is an intricate physics and classical mechanics puzzle that, unlike its simpler "two-body" variant, has no closed-form solution. *N*-body simulators, an integral component of research into orbital dynamics, model the motion of an "*N*" number of point masses under the effects of gravity. This *N*-Body simulator approximates the propagated motion of a user-specified number of point masses under the influence of other points' gravity. Using Newtonian mechanics propagated over discrete time steps, the algorithm models systems of up to 80 bodies. The program's interface allows a user to control visualization options such as zoom, pan, velocity arrows, and trails.

Optimizing the Time Spent Mowing by Analyzing Mowing Patterns
Friday 5:00-5:20 PM, ROOM 1102
Andrew Thomerson, Western Kentucky University**

Abstract: The aim of this work is to analyze different mowing patterns of an m x n plot and then model these patterns based on (a) costs associated with time spent on stopping the mower, and (b) cost of time per degree in turning the mower using the basic push lawn mower. From comparison of each model, it can be concluded moving at a constant rate, to optimize mowing a lawn by reducing the amount of time spent mowing, the simple back and forth method overall reduces the time of mowing.

Planetary Creation
Friday 5:30-5:50 PM, ROOM 1102
Maggie Cook*, Western Kentucky University
Morganne Williams*, Western Kentucky University

Abstract: Using *Mathematica*, we developed an educational and interactive experience that enables users to learn about how life came to be on our planet while using logic and problem solving skills to create a planet as similar to Earth as possible. This game is more focused on the user learning about their surroundings than actually creating life, as the game aims to increase appreciation and wonder as well as general knowledge about life as we know it. The user is given 4 pre-created solar systems where they can place a planet in the predetermined field. If their planet is habitable, based on distance from the sun and orbital paths, they will be allowed to create a planet with traits like:

geography, atmosphere, plate tectonics, available minerals, and potentially life. The calculations for habitability stem from correlated astronomical and biological equations. The user's selected inputs are used as parameters for the equations, and the results are used to alert and inform the user of miscalculations, as well as the general similarity of their created planet to our own.

Using Computational Bayesian Statistics to Analyze Parameters in a Differential Equation Model
Friday 6:00-6:20 PM, ROOM 1102
Jacob Menix, Western Kentucky University**

Abstract: The purpose of this project is to use Bayesian statistics to analyze values of parameters for a previously developed system of ordinary differential equations, which describes the healing process of diabetic foot ulcers. The model describes the relationships between matrix metalloproteinases, their inhibitors, and extracellular matrix. A Bayesian approach is used when the availability of data is sparse, as it is in this case. Delayed Rejection Adaptive Metropolis (DRAM), a MATLAB implementation of a Metropolis-Hastings algorithm, is used to estimate parameters. Using this approach with the individual patient data allows us to refine the parameter estimates, find associated confidence intervals using parameters' posterior distributions, and compare pairwise plots of parameters. This will help improve the wound-healing model in order to better predict wound-healing outcomes for individual patients.

Tank Trouble
Friday 6:30-6:50 PM, ROOM 1102
Arjun Kanthawar*, Western Kentucky University
Benjamin Kash*, Western Kentucky University

Abstract: We sought to re-create a popular online game called Tank Trouble. In this game, two tanks are placed in a maze and the goal is to destroy the other tank. The tanks are able to move around and launch bullets that rebound off walls. Using *Mathematica*, we implemented both a one-player and a two-player version of this game. Unlike in the online version, our game enables the users to customize their tanks and each game board is randomized. Elements of the Java programming language were used to allow for simultaneous keyboard input. The A.I. in our one-player version moves along a graph that is determined by the board setup, and the A.I. has its own strategy for destroying the user's tank.

General Session I (Friday 4:30-6:50 PM, ROOM 1103)

Extreme Value Theorem and Applications
Friday 4:30-4:50 PM, ROOM 1103
Christian Lowe*, Western Kentucky University**

Abstract: A very useful tool in Calculus and Real Analysis is the Extreme Value Theorem (EVT). We will be using an extension of the EVT called The Interior Extremum Theorem which states that "*Let c be an interior point of the interval I at which f : I* → R *has a relative extremum. If the derivative of f at c exists then* $f'(c) = 0$." We will first prove the Interior Extremum Theorem and study how it is applicable, which includes the following: optimization, proving Rolle's Theorem, and more interesting problems.

The Golden Beauty
Friday 5:00-5:20 PM, ROOM 1103
Leah Shartzer, Western Kentucky University**

Abstract: The golden ratio is a reoccurring event that happens in both nature and human artwork. There have been cases where the golden ratio has applied in nature. Since human artwork is influenced by both nature and the golden ratio, I will investigate the use of the golden ratio during two different time periods of art.

Parameter Estimation and Control of a Model for Lupus Nephritis
Friday 5:30-5:50 PM, ROOM 1103
Peter Agaba*, Western Kentucky University**

Abstract: System Lupus Erythematosus (SLE) is a chronic inflammatory autoimmune disorder that affects many parts of the body including skin, joints, kidneys, brains and other organs. Lupus Nephritis (LN) is a disease caused by SLE. Given the complexity of LN, we establish an optimal treatment strategy based on a previous developed mathematical model. As in Budu-Grajdeanu et al., (2010), our model variables are: Immune Complexes (I), Pro-inflammatory mediators (P), Damaged tissue (D), and Anti-inflammatory mediators (A). The analysis in this research project focuses on analyzing therapeutic strategies to control damage using both parameter estimation techniques (integration of data to quantify any uncertainties associated with parameters) and optimal control with the goal of minimizing time spent on therapy for treating damaged tissue by LN. Our simulated results for LN model will be presented in our talk.

An Introduction to Discrete Time Linear State-Space Models
Friday 6:00-6:20 PM, ROOM 1103
Duc Nguyen*, Western Kentucky University**

Abstract: Advances in science and technology have always stemmed from our desire to control things. In fact, one might say how advanced we are as a species is measured by how well we control the world around us. Before we can discuss how to control something, however, we must first be able to represent the system of interest by some sort of "model". In the real world, many problems can be handled by investigating the first-order discrete time-invariant linear equations:

$$\Delta y(t) = Ay(t) + Bu(t)$$

$$z(t) = Cy(t)$$

where Δ is the *difference operator*: $\Delta y(t) = y(t+1) - y(t)$, and A, B, and C are constant matrices. After a brief introduction into discrete calculus, we will talk in more details about this particular system of equations, and take a look at two important properties of control systems: *controllability* and *observability*. Examples in the form of practical problems will also be provided to help explain these concepts.

Using Discerning to Axiomatically Characterize Approval Voting
Friday 6:30-6:50 PM, ROOM 1103
Trevor Leach*, University of Louisville**

Abstract: In 2013, Conal Duddy & Ashley Piggins published a paper on Collective approval using a new axiom they refer to as "Discerning" to axiomatically characterize the Mean Based rule. We will use Discerning to axiomatically characterize the Approval Voting rule.

Pizza dinner break begins at 7 PM on 1st floor of Snell Hall

Career Panel Session (Friday 7:30-8:10 PM, ROOM 1108)

Career Panel Session
Friday 7:30-8:10 PM, ROOM 1108
Hannah Keith, Mathematics Teacher
Samantha McKean, Vanderbilt University
Andrew Page, BPS&M, LLC
Jonathan Quiton, Nissan North America

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 a job in your field?” We have four great panelists: Hannah Keith, a mathematics teacher; Samantha McKean, a law student at Vanderbilt University; Andrew Page, an actuary at BPS&M, LLC; and Jonathan McKean, a statistician at Nissan North America.

Play (Friday 8:15-8:45 PM, ROOM 1108)

Solving Math Problems
Friday 8:15-8:45 PM, ROOM 1108

Abstract: Following the success of comedic plays developed in recent years for the WKU Math Symposium, the WKU faculty and students have again put together another play. This year’s play-ful rendition is titled, “Solving Math Problems.”

SATURDAY, NOVEMBER 18, 2017

Registration and refreshments begin at 7:30 AM on 1st floor of Snell Hall

Analysis Session (Saturday 8:30-10:20 AM, ROOM 1108)

A Spectral Analysis of the Caccetta-Häggkvist Conjecture
Saturday 8:30-8:50 AM, ROOM 1108
Andrew Davis, Western Kentucky University**

Abstract: The Caccetta-Häggkvist conjecture asserts that there are small cycles in digraphs with large minimum out-degrees. However there are only proofs of some special cases of the conjecture. This talk will describe a spectral analysis of digraphs using the Perron-Frobenius theorem in an attempt to better understand cycles in digraphs. Using this analysis, it will give qualitative criteria so that relatively small cycles exist in the digraph.

Using the Putzer Algorithm to Calculate A^t for 2x2 and 3x3 Matrices and Some Trigonometric Identities in Discrete Calculus
Saturday 9:00-9:20 AM, ROOM 1108
Sarah Angelle, Western Kentucky University**

Abstract: Discrete calculus is the study of finite sequences or differences. A sequence in discrete calculus could be a finite sequence from a data source or an infinite sequence from a discrete dynamical system. On the surface, it may appear that properties and applications of discrete versus continuous calculus are essentially the same. Our differential comprehension of the world has been largely based in continuous calculus, and so we often use differential modeling to predict and fit curves to real-world data. However, since this data is given discretely in complex physical systems, and since the digital age we live in limits our ability to model these infinite, smooth curves using computers, mathematicians are slowly but surely unearthing a gap between theoretical and applied mathematics. Discrete calculus serves to close this gap by providing a simpler way to define and develop computations with real-world data that mathematicians, computer scientists, and physicists can use. Discrete mathematics is more straightforward and easy to use when working with real data, and often provides a better fit to the real data. My research involves researching using the Putzer Algorithm to calculate A^t for certain 2x2 and 3x3 matrices, as well as researching the discretization of trigonometric identities for a matrix A using discrete calculus to test whether the properties of these identities, such as sin(A) for a matrix, still hold.

Derivation and Analysis of the Bigraded Hilbert Series of a Circle Action
Saturday 9:30-9:50 AM, ROOM 1108
Saad Khalid, Rhodes College**

Abstract: Let G be the circle group. Consider the weight vector $(a_1, \ldots a_n, -a_1, \ldots, -a_n) \in Z^{2n}$ describing an action of G on C^{2n} with coordinates $(z_1, \ldots z_n, w_1, \ldots, w_n)$. We call a weight vector of this form *cotangent lifted*. A polynomial $f(z_1, \ldots z_n, w_1, \ldots, w_n)$ is invariant under this action if $f(z_1, \ldots z_n, w_1, \ldots, w_n) = f(t^{a_1} z_1, \ldots t^{a_n} z_n, t^{a_1} w_1, \ldots, t^{a_n} w_n)$, where t is any element of the circle group. The Hilbert Series is a power series that counts the elements of a ring. The ring in our case is the polynomials invariant under a circle action, and so the Hilbert Series allows us to count the polynomials invariant under a given circle action.

The aim of this project is to generalize existing computations of the univariate Hilbert Series, $H(x)$, for cotangent lifted circle actions to the bivariate case, $H(x_1,x_2)$. This results in the ability to distinguish between polynomials in $(z_1, \ldots z_n)$ and $(w_1, \ldots, w_n)$ when counting, leading to more precise information about the invariant polynomials. This is in contrast to only being able to specify the degree of a monomial as a whole in the

univariate case. For example, the univariate Hilbert series may tell us that a group has 3 invariants of degree 2. This means that there are 3 invariant monomials in the form z_i^2, z_iw_j, or w_j^2. Using the bivariate expansion, we could find that there are exactly two invariants of the form z_i^2 and one invariant of the form z_iw_j. We also aim to generalize computations of something called the *Laurent coefficients* of the Hilbert series, which are the coefficients of the series expansion of the Hilbert series at a singularity, specifically at $(x_1,x_2) = (1,1)$, $(1,0)$, and $(0,1)$. Finally, we generalize an algorithm for the computation of a univariate Hilbert Series of a circle action to the bigraded case.

Homogenization with soft inclusions and interior Lipschitz estimates at every scale
Saturday 10:00-10:20 AM, ROOM 1108
Chase Russell*, University of Kentucky**

Abstract: In this talk, we will discuss recent work in establishing interior Lipschitz estimates at the large-scale (via a Campanato-type iteration) and at the small-scale (via a layer potential argument) for solutions to systems of linear elasticity with ε-periodic coefficients and Dirichlet boundary conditions in domains periodically reinforced with soft inclusions of size ε and magnitude δ by establishing H^1-convergence rates. In particular, we consider the variational problem

$$\int_\Omega k_{\delta^2}\left(\frac{x}{\varepsilon}\right) a_{ij}^{\alpha\beta}\left(\frac{x}{\varepsilon}\right)\frac{\partial u_{\varepsilon,\delta}^{\beta}}{\partial x_j}\frac{\partial \varphi^\alpha}{\partial x_i}\,dx, \text{ for each } \varphi = \{\varphi^\alpha\} \in H_0^1(\Omega;\mathbb{R}^d)$$

and $u_{\varepsilon,\delta} - \mathrm{f} \in H_0^1(\Omega;\mathbb{R}^d)$, where $A = \left\{a_{ij}^{\alpha\beta}\right\}$ is uniformly elliptic and 1-periodic. The function k_δ is also 1-periodic, where

$$k_\delta(y) = \begin{cases} \delta \in [0,1], & \text{for } y \in \mathbb{R}^d \backslash \omega \\ 1, & \text{for } y \in \omega \end{cases}$$

and ω denotes an unbounded, connected, periodic substrate.

The homogeneous Dirichlet boundary value problem models relatively small elastic deformations of composite materials reinforced with soft inclusions (*e.g.*, light-weight aggregate concrete, rubber tyre reinforced bitumen) subject to zero external body forces and with a prescribed boundary deformation. We will mostly provide a background to periodic homogenization and present optimal interior regularity results and convergence rates for the case of soft inclusions. Time permitting, we will discuss interesting aspects of the proofs.

Mathematical Biology Session (Saturday 8:00-10:20, ROOM 1101)

Using Gaussian Quadrature to Study Pig Cartilage

Saturday 8:00-8:20 AM, ROOM 1101

Richard Schugart, Western Kentucky University

Abstract: A method for numerical solution of the continuous spectrum linear biphasic poroviscoelastic (BPVE) model of articular cartilage is presented. The method is based on an alternate formulation of the continuous spectrum stress-strain law that is implemented using Gaussian quadrature integration combined with quadratic interpolation of the strain history. For N time steps, the cost of the method is $O(N)$. The method is applied to a finite difference solution of the one-dimensional confined compression BPVE stress-relaxation problem. For a range of relaxation times that are representative of articular cartilage, accuracy of the method is demonstrated by direct comparison to a theoretical Laplace transform solution.

Accurately Modeling the Healing Process of Chronic Wounds

Saturday 8:30-8:50 AM, ROOM 1101

Arjun Kanthawar*, Western Kentucky University
Nigar Karimli*, Western Kentucky University**
Nikhil Krishna*, Western Kentucky University

Abstract: In order to formulate a mathematical model that accurately represents the physiology of a wound, the model and its parameters must be identifiable when given actual data. Practical identifiability is a method used to determine whether parameters in a model can be uniquely determined given actual data. This work uses a differential equation model that describes the interactions among matrix metalloproteinases, their inhibitors, the extracellular matrix, and fibroblasts (Krishna *et al.*, 2015). A singular value decomposition technique with a QR factorization combined with a correlation analysis is used to find an identifiable subset of parameters. Subsets are analyzed through model prediction intervals and parameter Markov chains and posterior densities. An SE-optimal design (standard-error optimal-design) method, which calculates optimal observation times for collecting clinical data, is used to estimate model parameters more efficiently and accurately. The goal of this work is to formulate a model that can accurately predict the healing process for individual patients.

Increased accuracy in population modeling using density-dependent Leslie matrices with steady-state distribution control

Saturday 9:00-9:20 AM, ROOM 1101

Bruce Kessler, Western Kentucky University

Abstract: Leslie matrices provide a discrete population model that allows for age-group

tracking, although it is basically an exponential model. Leslie provided a means of adjusting that model for use on populations with carrying capacities, as long as the same dominant eigenvalue (steady-state age-group distribution) is used throughout the model. The authors have generalized this result so that the initial Leslie matrix dominant eigenvalue can be changed to a different steady-state age-group distribution as the total population nears the carrying capacity. This allows for greater modeling accuracy in our trials.

In this presentation, we will describe how we generated out test data, how we found a nearly-best fit to the data using Leslie's original adjustment, and how we have demonstrated that we can get better results by allowing for a different steady-state age-group distribution than the original Leslie matrix.

Density Dependence and Multiple Matings Lead to Sexual Conflict in Territorial Migratory Songbirds
Saturday 9:30-9:50 AM, ROOM 1101
Sharee Brewer*, Fisk University

Abstract: Breeding strategies in conspecific territorial migratory songbirds vary between sexes and play a crucial role in reproductive success. We employ a game theoretic model to determine the effect of various mating strategies on fitness. Males first play a priority game, where the costs of early arrival are based on male quality. Males who arrive sooner obtain the best available territory, but incur an early-arrival cost. The best territory is the one with the most surrounding territories, or sides, which increases the opportunity for extra pair copulations (EPC). The female game theoretic model consists of strategies for choosing a territory that are based on a male quality and female population density. Concern for male quality may increase the number of offspring resulting from a single mating. However, concern for female population density may enable a female to avoid competition. The model finds that, whether or not all females play the same strategy, sexual conflict occurs.

Investigating Correlations in Intermitotic Time Variability
Saturday 10:00-10:20 AM, ROOM 1101
Christian Mark Devine*, Middle Tennessee State University
John Ford*, Middle Tennessee State University

Abstract: The initiation of cellular replication varies among individual cells, so that the time it takes for a cell to divide (or intermitotic time (IMT)) is highly variable. To learn more about IMT variability and the mechanisms behind it, correlations in the IMTs of related cells can be studied. The current research investigates how inheritance influences the distribution of IMTs within a population. We process data that tracks cell

lineages in order to compute correlations between the IMTs of related cells and develop and test models for explaining the correlations that we observe.

Computational Session II (Saturday 8:00-10:20 AM, ROOM 1102)

Balloon Fight
Saturday 8:00-8:20 AM, ROOM 1102
Bronson McQueen*, Western Kentucky University
Daniela Zieba*, Western Kentucky University

Abstract: Video game development has rapidly evolved - hardware limitations restrict developers less and less every day, while video game development tools have constantly evolved to accommodate growing needs and diverging requirements. Our project, Balloon Fight, recreates the classic NES game of the same name using *Mathematica*. Between the birth of the original game and the completion of our version, video games have undergone massive overhaul in design paradigms thanks to the changes in hardware and software capabilities.

The game's basic goal is to progress through stages by defeating enemies, which is accomplished when the player steps on enemies to represent popping their balloons. Balloon Fight allows for three game modes: 1-player mode, 2-player mode, and Balloon Trip. Unlike the other two game modes, Balloon Trip involves dodging randomly generated sparks to earn points. The various modes test the parallelized computational capabilities and boundaries of *Mathematica*, and design considerations involved the need to create efficient algorithms accomplishing tasks such as rudimentary enemy artificial intelligence and successful collision detection for maps that are not hardcoded into the game. Our presentation briefly discusses video game design history as well as our versions of various algorithms in our game.

Embedding binary trees into the square lattice
Saturday 8:30-8:50 AM, ROOM 1102
Uta Ziegler, Western Kentucky University

Abstract: This presentation discusses an algorithm to embed (= draw) a binary tree in the plane requiring resources (*e.g.*, area, line segments) linear in the number of edges in the tree. The algorithm uses a divide-and-conquer approach: the problem is divided into smaller and smaller sub-problems, and the solution to the overall problem is created by combining the solutions to the sub-problems. Such embeddings are used for example to describe how a computation can be executed on a standard parallel computer architecture or for describing area-efficient patterns for VLSI design.

Straight Skeletons of Simple Polygons
Saturday 9:00-9:20 AM, ROOM 1102
Natalie Reed*, Western Kentucky University

Abstract: The fold-and-cut problem was first discovered in 18th century Japan. This problem consists of the idea that, for any shape, a fold pattern can be created that will allow for the shape to be cut out by making one straight line cut across the folded paper. The theorem to develop these fold patterns was proven by Eric Demain in 1999. This talk will cover the steps that need to be taken to create the fold pattern and an explanation of the implementation of the first part of this process as a computer program, which relies mostly on the manipulation of triangles.

Using Mixed Modeling Effects for a Mathematical Model of Wound Healing
Saturday 9:30-9:50 AM, ROOM 1102
Rachel French, Western Kentucky University**

Abstract: Because the medical treatment of diabetic foot ulcers remains a challenge for clinicians, a quantitative approach using de-identified patient data and mathematical modeling can help researchers understand the physiology of the wounds. Previously, an ODE model was developed to illustrate how these wounds heal. In this work, we plan to use nonlinear mixed effects modeling to attribute wound healing variability to either fixed effects, parameters that are more likely to remain constant for all patients, or random effects, parameters that vary from patient to patient. We aim to identify these random effects to make sure these parameters are taken into special consideration when treating patients with chronic wounds, especially diabetic foot ulcers. This approach will help to more accurately represent the complex interactions that occur in the diabetic foot ulcers.

A Brief Introduction To The Iterative Solution Of Linear Systems
Saturday 10:00-10:20 AM, ROOM 1102
Mark P. Robinson, Western Kentucky University

Abstract: In linear algebra courses, students typically learn about direct methods for solving linear systems of equations, such as Gaussian elimination. An alternative to such methods is provided by iterative methods, in which a sequence of approximate solutions is produced, which converges to the solution of the system. Iterative methods are particularly useful for large, sparse systems that arise in many applications. In this presentation, the two most basic of these iterative methods, the Jacobi and Gauss-Seidel methods, are discussed. Numerical examples are included.

General Session II (Saturday 8:00-10:20 AM, ROOM 1103)

Intermediate Value Theorem
Saturday 8:00-8:20 AM, ROOM 1103
Ruchini Mendis*, Western Kentucky University**

Abstract: The Intermediate Value Theorem (IVT) is one of the most applicable theorems in Calculus and Real analysis. The IVT states that "Let I be an interval and let f be a real valued function continuous on I. If $a,b\in I$ and if $k\in R$ satisfies $f(a) < k < f(b)$, then there exists a point $c\in I$ between a and b such that $f(c) = k$." We prove the IVT and discuss its applications. In addition, the intermediate Value Theorem for differentiable functions will be discussed.

Taylor's Theorem and a Survey of Its Applications, Including One in Finance
Saturday 8:30-8:50 AM, ROOM 1103
Richard Applin*, Western Kentucky University**

Abstract: Some literature on mathematics education argues that Calculus sequences tend to fall short in terms of surveying applications in business, finance, and economics relative to the numerous applications often covered relating to engineering and the (non-social) sciences. This paper proposes one topic in which some business-related applications may be introduced regarding the approximation of functions via their k^{th}-order Taylor Polynomial. In doing so, a review of Taylor's theorem and its proof is presented along with a survey of the typical applications of Taylor's theorem - such as, numerical estimation, derivation of inequalities, finding extreme values, and determining convexity. Afterwards, an introduction to some of the ways Taylor's Theorem is utilized in finance is provided. In particular, discussion includes an example relating to bond duration.

Copula Functions and the Housing Crisis
Saturday 9:00-9:20 AM, ROOM 1103
David Zimmer, Western Kentucky University

Abstract: Prior to the housing crisis, the normal distribution was widely used to calculate the riskiness of mortgage-backed securities. But the normal distribution imposes asymptotic independence such that extreme events appear to be unrelated. This restriction might be innocuous in normal times, but during extreme events, such as the housing crisis, the normal distribution might be inappropriate. This talk uses copula functions to show that the degree to which housing prices are linked is far larger than what is implied by the normal distribution.

Analyzing the Properties of a set of *m* x *n* Pixels
Saturday 9:30-9:50 AM, ROOM 1103
Sam Durham*, Western Kentucky University

Abstract: The study of computer graphics suggests many questions about sets of pixels in an *n* x *m* grid. A connected set in an *n* x *m* grid of pixels is one, which is all in one piece. Formally, *A* is a connected set if for any two pixels *p* and *q* in *A*, there is a sequence of adjacent pixels in *A* connecting *p* with *q*. We are addressing combinatorial counting problems to determine how many connected subsets an *n* x *m* grid has, and how many of those connected subsets have connected complements.

We have created a *Mathematica* program that analyzes these numbers for any *n* x *m* that is input, and we are now taking these numbers and trying to further identify any relations between them. This includes recursion formulas to determine the number of connected complimentary subsets for any 2 x *m* set. We have also found interesting connections to both the numerators and denominators of the continued fraction of $\sqrt{2}$. We are continuing to examine further connections of any 2 x *m* set and will hopefully expand this to other *n* x *m* sets.

Strategies for Finding the Vertical Asymptotes of Solutions to First Order Differential Equations
Saturday 10:00-10:20 AM, ROOM 1103
Davis Deaton, Belmont University**
Jordan Sawdy, Belmont University**

Abstract: Though numerical methods are often the tool of choice for solving complicated differential equations in physical applications, finite difference approximations can fail to reproduce subtle behaviors of some differential equations. In particular, numerical methods may occasionally skip over asymptotes, producing nonsensical and physically unrealistic approximations for solutions. If, however, the location of asymptotes is known, approximations can be applied with much more confidence. Finding the asymptotes of differential equations whose solutions are known is relatively trivial; however, finding the asymptotes of a differential equation whose solution is unknown or does not exist in closed form is significantly more complicated. Using power series representations, we are able to translate first order differential equations into difference equations of varying complexity where the asymptotes of the differential equation are described by the end behavior of the difference equation. This allows solving for the exact location or a lower bound of the asymptotes of a solution in many cases.

Keynote Talk (Saturday 10:30-11:20 AM, ROOM 1108)

Pseudo-Transient Continuation
Saturday 10:30-11:20 AM, ROOM 1108
Tim Kelley, North Carolina State University

Abstract: The convergence theory for Newton's method says that either the iteration will converge rapidly to a solution from a given initial iterate, or fail in one of two easy-to-detect ways. The failure modes include (1) convergence to an incorrect (*i.e.*, non-physical or dynamically unstable) solution, (2) divergence to infinity, and (3) stagnation at a singularity of the Jacobian. The classic theory will count (1) as a success, but shouldn't.

Pseudo-transient continuation is a way to enforce dynamic stability of the solution of a nonlinear equation and thereby increase the chances that the limit of the Newton iteration is a useful solution. This approach can also help one avoid stagnation. In this talk we will describe the method and some of the recent convergence results. We will also discuss some of the many applications, and show how non-smooth analysis can connect theory and practice.

Tutorial Session (Saturday 11:30 AM-12:20 PM, ROOM 1108)

Mathematica Tutorial for Collections of Points and Lines
Friday 3:30-4:20 PM, ROOM 1108
Ed Pegg, Wolfram Research

Abstract: Following Ed Pegg's opening Keynote Talk, he has graciously offered a tutorial in *Mathematica* for some of the interesting results that he presents in his talk, as well as some other results not included in the talk, as time permits. All members in the audience are encouraged to bring a computer with *Mathematica* on it. However, even if you don't have a computer, you can still come and learn more about the computational aspects of his research.

Friday

3:30-4:20 **Room 1108** **Keynote Talk: Ed Pegg**				
	SIAM Student Chapter Sponsored Session **Room 1108**	**Algebra and Linear Algebra Session** **Room 1101**	**Computational Session 1** **Room 1102**	**General Session 1** **Room 1103**
4:30-4:50	Melanie Autin, WKU	Jeremiah Bush**, WKU	Brock McDaniel*, Harper Sewalls*, WKU	Christian Lowe***, WKU
5:00-5:20	Harrison Froedge*, WKU	Christopher Seaton, Rhodes College	Andrew Thomerson**, WKU	Leah Shartzer**, WKU
5:30-5:50	Jonathan Quiton, Nissan	Ryan Gipson***, U Louisville	Maggie Cook*, Morganne Williams*, WKU	Peter Agaba***, WKU
6:00-6:20	Samantha McKean, Vanderbilt U	Yi Song**, Rhodes College	Jacob Menix**, WKU	Duc Nguyen***, WKU
6:30-6:50	Andrew Page, BPS&M, LLC	Ghan S Bhatt, Tennessee State U	Arjun Kanthawar*, Benjamin Kash*, WKU	Trevor Leach***, U Louisville
7:00-7:30: Break - Dinner				
7:30-8:10: Career Panel Session **Panelists: Hannah Keith, Samantha McKean, Andrew Page, Jonathan Quiton** **Room 1108**				
8:15-8:45: Play, Title: Solving Math Problems **Room 1108**				

Saturday

	Analysis Session Room 1108	**Mathematical Biology Session Room 1101**	**Computational Session II Room 1102**	**General Session II Room 1103**
8:00-8:20		Richard Schugart, WKU	Bronson McQueen*, Daniela Zieba*, WKU	Ruchini Mendis***,WKU
8:30-8:50	Andrew Davis**, WKU	Arjun Kanthawar*, Nigar Karimli***, Nikhil Krishna*, WKU	Uta Ziegler, WKU	Richard Applin***, WKU
9:00-9:20	Sarah Angelle**, WKU	Bruce Kessler, WKU	Natalie Reed*, WKU	David Zimmer, WKU
9:30-9:50	Saad Khalid**, Rhodes College	Sharee Brewer**, Fisk U	Rachel French**, WKU	Sam Durham*, WKU Chair:
10:00-10:20	Chase Russell***, U Kentucky	Christian Mark Devine**, John Ford**MTSU	Mark Robinson, WKU	Davis Deaton**, Jordan Sawdy**, Belmont U
10:30-11:20 Room 1108 Keynote Talk: Tim Kelley				
11:30-12:20 Room 1108 Tutorial Session: Ed Pegg				

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