Abstracts for Contributed Paper Presentations

Susan Abernathy
Louisiana State University

Knots and a Special Type of Chord Diagram

Abstract: Usually we study knots via knot diagrams, but we may also obtain information about knots from related objects called chord diagrams. Our approach uses a special type of chord diagram, which we call a circumtext. In addition to a brief introduction to knots, we define circumtexts and discuss the relationship between these diagrams and knots.

John Alford
Sam Houston State University

Mathematical Models of Dispersal in Ecology

Abstract: I will discuss mathematical models of animal movement. These are differential equations which describe the position of an individual animal as it depends on time (Lagrangian model) or the density of a population as it depends on space-time (Eulerian model). Ecological applications (snakes and flies) will be presented.

Curtis Balusek, Casey Hartnett, and Kristen Pelo
Sam Houston State University

Mathematical Models for Invasive Aquatic Vegetation

Abstract: A dynamical model is formulated to describe the competition between two aquatic plants by using a mixture of Turchins regrowth model and the classical Lotka-Volterra model. This model is a system of differential equations that accounts for the belowground biomass, herbivory, and interspecific competition. There are two types of competing vegetation; one that is completely submerged with significant belowground biomass and the other which emerges from the water, but has negligible below ground biomass. The model was analyzed in order to determine the relative parameter values where one species out competes the other.

Brian Beavers
Stephen F. Austin State University

Going Uphill Both Ways: How Math Just Keeps Getting Easier AND Harder

Abstract: Humans have been doing math for both fun and practical purposes for thousands of years. We have made much progress in making types of problems easier to solve, but we keep finding harder questions to wrestle with. In this talk, we will look at stories and examples to get a overview of the bloody and beautiful story of "The Queen of the Sciences."

Angela Brown
University of Texas at Arlington

An Introduction to Finite Geometries and Semifields

Abstract: In this talk we will give a brief introduction to finite geometries and discuss where we are headed with our research in semifields.

Leah Childers
Louisiana State University

Simply Intersecting Pairs in the Mapping Class Group

Abstract: The Torelli group, $\mathcal{I}$, is the subgroup of the mapping class group consisting of elements that act trivially on the homology of the surface. There are three types of elements that naturally arise in studying $\mathcal{I}$: bounding pair maps (BP-maps), separating twists, and simply intersecting pair maps (SIP-maps). Historically the first two types of elements have been the focus of the literature on $\mathcal{I}$, while SIP-maps have received relatively little attention until recently, due to an infinite presentation of $\mathcal{I}$ introduced by Andrew Putman that uses all three types of elements. We will discuss all these elements and state results about the SIP group, including that it is an infinite index subgroup of $\mathcal{I}$.

Scott Clark, Lauren Mondin, Courtney Weber, and Jessica Winborn
Sam Houston State University

Invterval Estimates for Predictive Values in Disease Testing

Abstract: In disease testing, patients and doctors are interested in knowing the estimates for positive predictive value (ppv) and negative predictive value (npv). The ppv of a test is the probability that given a positive test result, the patient actually has the disease. Similarly, the npv of a test is the probability that given a negative test result, the patient actually does not have the disease. These are generally estimated using clinical trial data. By calculating interval estimates of these numbers, using confidence intervals and credible sets, we were able to measure with 95% confidence the true ppv, npv, and in certain cases the unsure predictive value (upv). We used various schools of thought to calculate these intervals: the classical approach using the Delta Method and Agresti-type adjustments and the Bayesian approach using non-informative priors. We compared the performance of these intervals using coverage and width programs written in R, a statistical analysis p! rogram.

Alexander Diaz
Sam Houston State University

The Linear Independence of Algebraic Curvature Tensors

Abstract: The set of all algebraic curvature tensors denoted $\mathcal{A}(V)$ is spanned by the set of all algebraic curvature tensors defined by symmetric bilinear forms. This leads to the question: given $\varphi_1, \ldots, \varphi_k$ symmetric bilinear forms, when is the set $\{R_{\varphi_1}, \ldots, R_{\varphi_k}\}$ linearly independent? Provided certain basic rank requirements are met, we establish a converse of the classical fact that if A is symmetric, then R_A is an algebraic curvature tensor. This allows us to establish a simultaneous diagonalization result in the event that three algebraic curvature tensors are linearly dependent. We use these results to establish necessary and sufficient conditions that a set of two or three algebraic curvature tensors be linearly independent.

Nick Duplan
Lamar University

The Stationary Distribution of a Bonus-Malus System

Abstract: The Bonus-Malus System rewards insurance holders with a discount, or bonus, for filing no claims, and it adds a penalty, or malus, to the policyholder for filing claims. There are several classes of rates in the Bonus-Malus System, and the stationary distribution gives an estimated percentage of people in each class after the system has been run for a long time. From a given Bonus-Malus System, we will calculate the transition matrix and use it to calculate the stationary distribution, and we will explain what it means.

Luiz Faria
Texas A&M University

Annuli Bounds for the Roots of Sparse Polynomials

Abstract: We examine the roots of univariate polynomials with real coefficients with the intent of obtaining annuli bounds for clusters of roots. We examine in more detail roots of trinomials and show that they are well approximated by roots of certain convexly defined binomials. We compare the annuli bounds obtained by this method to classical annuli bounds, showing that for sparse polynomials, the bounds obtained using our methods are significantly better.

Karleigh Frederick, Samantha Hilker, Megan Savage
Sam Houston State University

Constructing Cube Knots

Abstract: Knot theory is a branch of topology that studies mathematical knots. Our specific area of research this past summer was in cube knots, mathematical knots made out of cubes. Our presentation will explain the process of creating cube knots, compare our findings to the best known cube numbers found in literature, and we will give many examples of our findings.

Rebecca Garcia
Sam Houston State University

The Mathematical Magic of Benjamin Franklin

Abstract: Circa 1752, Benjamin Franklin constructed several *ultra-magic* squares, but precisely one *ultra-magic* circle, which we will dub *the* Franklin magic circle. In this talk, we will focus on Benjamin Franklin's unique magic circle and discuss its many fascinating properties. Using relatively modern techniques in computational algebraic combinatorics and enumerative geometry, we will discuss the answers to the standard questions related to these mathematically magic objects: enumeration, construction and symmetry operations.

Suzi Gearhart and John Owen
Sam Houston State University University

The Relative Gain Array of Cayley Graphs

Abstract: The relative gain array (RGA) is a matrix function which has applications to chemical engineering. When one explores iterates of this function, one of four things will occur. If the input matrix A is singular the RGA(A) = 0. If A is nonsingular then in some rare cases, A is xed by the relative gain array. In other cases, iterates of the function RGA converges to a xed matrix. And nally, in some cases, iterates of the RGA display chaotic behavior. A Cayley graph is a graph with a sharply transitive automorphism group. We explore the RGA of various Cayley graphs. Using both Mathematica and Groups Algorithms and Programming (GAP), we observe the four di?erent behaviors of the RGA. We analyze the dening set S in an attempt to predict the behavior of the relative gain array. We compare the action of the RGA on a Cayley graph with the action of the RGA on the complementary graph. We are especially interested in cases in which either the adjacency algebra of a graph or its complement is closed under the Hadamard product.

Jillian Hamilton
Lamar University

$\mathbb{G}$-Planar Groups

Abstract: For a group G with generating set $S = \{s_1, s_2, \cdots, s_k\}$, the $\mathbb{G}$-graph of G, $\Gamma(G, S)$, is the graph whose vertices are distinct cosets of $\langle s_i \rangle$ in G. Two distinct vertices are joined by an edge when the set intersection of the cosets is nonempty. A group G is $\mathbb{G}$-planar if there exists a generating set S such that the graph, $\Gamma(G, S)$, is a planar graph. In this talk, we classify the $\mathbb{G}$-planar groups.

Ashli Lawson
University of Mary Hardin-Baylor

Applications of Advadnced Calculus to Blood Flow Analysis

Abstract: Just like other fluids, blood can be represented by vector components, but unlike some fluids, blood flow influences and is influenced by the elasticity of the vessels encapsulating it. In order to balance the internal and external pressures on the blood vessel, the vessel itself must have an elastic component. Ottesen, Olfusen, and Larsen (authors of Applied Mathematical Models in Human Physiology) analyzed the tangential and normal vector components acting on the vessel and this project considers the assumptions made to derive their equations. The project examines mathematical explanations of transmural pressure, requirements for the assumed linear relationship between arterial stress and strain, and the Landlau Lifshitz Theory of Elasticity.

Marsida Lisi
University of Houston - Downtown

Mathematical Modeling of the BMP4 and FGF Signaling Pathways during Neural and Epidermal Development in Xenopus

Abstract: During embryonic development, ectodermal cell fate in *Xenopus laevis* is determined by the mitogen-activated protein (MAP) kinase and bone morphogenetic protein-4 (BMP-4) signaling pathways. In an attempt to further understand the interactions between these two pathways, a mathematical model consisting of coupled, nonlinear ordinary differential equations has been developed. Linear stability analysis and bifurcation theory are used to describe the properties of this model. Numerical computations, including bifurcation studies have been carried out to elucidate the interaction between the two signaling pathways.

Antonio Lopez
University of Texas at Arlington

Mathematical Aspects of Photonic Crystals

Abstract: Photonic crystals have become an area of high research interest due to their ability to affect the propagation of electromagnetic waves. Photonic crystals are nanostructures exhibiting the interesting behavior that light at certain frequencies cannot travel through them, whereas at other frequencies it can. The mathematical aspects of photonic crystals are investigated in this work. Due to the periodic nature of the refractive index, light or electromagnetic waves at some frequencies cannot travel in a photonic crystal and such frequencies are known as forbidden frequencies. On the other hand, if light at a particular frequency is able to travel in the crystal, then that frequency is known as an allowed frequency, and all allowed frequencies are said to make up the spectrum of the crystal. The goal is to discover a systematic way to determine all the allowed and forbidden frequencies when the periodic structure of the refractive index of the photonic crystal is known. Fo! r this purpose, Maxwell's equations, which describe the electromagnetic wave propagation of the photonic crystal, are investigated. The partial differential equations obeyed by the electric field and magnetic field are written in the frequency domain in a way that the frequency appears as a spectral parameter. Bloch's theorem is then used to determine all the allowed frequencies. Various cases of periodic refractive indices are considered such as a layered medium in which the refractive index is a function of one spatial variable only and where that refractive index is approximated by a piecewise constant function of location.

Laura McCormick
Louisiana State University - Shreveport

Square Products of Punctured Sequences of Factorials

Abstract: The following problem is solved: for a positive integer n, for what m is $(\prod_{k=1}^{n} k!)/m!$ a perfect square $(1 \leq m \leq n)$? All solutions for even n will be presented. For odd n it will be demonstrated that no solution exists. Additionally, J. Nagura's under-appreciated improvement on Bertrand's Postulate will be highlighted, as it helped facilitate the completion of these proofs.

Charles Nguyen
University of Texas at Arlington

A Review of Human Adiposity and Climate Change

Abstract: This research challenged the conclusion of people with higher body mass index impacting the climate. This was explored through statistical simulations and parameter adjustments to what the scientists assumed. The presentation is geared towards a general math audience.

Jessica Nguyen
Lamar University

The Probability of Rocking the Ehrenfest Urn Model

Abstract: The Ehrenfest urn model is a special type of model, in that; it is a non-regular ergodic Markov Chain. Ergodic Markov chain means that it is possible to move from every state to every state. However, it is only considered regular, if it is possible to move from any state to any state in exactly n steps. We can compare a non-regular Ergodic Markov chain to a maze. Once a path is taken a new set will appear and upon taking a new path it becomes impossible to go straight from that current path to the entrance without retracing our steps. The Ehrenfest urn model describes the probability of going from one state to the next state using this matrix. N equaling to total number to steps. P= 1/N * [0 N 0 0 0 0 0 1 0 N-1 0 0 0 0 0 0 2 0 N-2 0 0 0 ..... 0 0 0 0 N-1 0 1 0 0 0 0 0 0 N 0]

Duy Nguyen
Texas Christian University

Energy of Graphs and Matrices

Abstract: Let G be a finite, undirected, and simple graph. If $\{v_1, \cdots, v_n\}$ is the set of vertices of G, then the adjacency matrix $A(G) = [a_{ij}]$ is an *n-by-n* matrix where $a_{ij} = 1$ if v_i and v_j are adjacent and $a_{ij} = 0$ otherwise. The energy of a graph, $E(G)$, is defined as the sum of the absolute values of eigenvalues of $A(G)$. The concept of energy originates in chemistry and was first defined by I. Gutman in 1978. It has been generalized recently as follows: For a graph G on n vertices, let M be a matrix associated with G. Let $\mu_1, \cdots, \mu_n$ be the eigenvalues of M and let $\bar{\mu}$ be the average of $\mu_1, \cdots, \mu_n$. The more general M-energy of G is then defined as:

$$E_M(G) = \sum_{i=1}^{n} |\mu_i - \bar{\mu}|.$$

In this paper we present our results on graph energy when M is the Laplacian matrix, the signless Laplacian matrix, or the distance matrix. In particular we give bounds for energy of different graph classes and study the effect of edge deletion.

Christina Nieuwoudt
Sam Houston State University

Some identities for $\sin x$ which resulted from medical imaging

Abstract: Some identities for $\sin x$ which resulted from medical imaging We will discuss several new identities for the sine function originating from the research done by Peter Kuchment and Sergey Lvin (Texas A&M) on computerized tomography. We will look at the identities established from the differential equations: 1.) $Du = \delta u$ 2.) $D^2u = \delta^2 u$ and will examine how these identities change as the value of δ varies through both real and complex, zero and non-zero values.

Kevin Oakley
Lamar University
Efficient In My Work

Abstract: A bonus-malus system is used to figure out the cost of a premium of say car insurance. One way to see if a bonus-malus system is reasonable is to calculate the efficiency of it. This is a way of seeing if the risk outweighs the reward. An ideal system has your risk premium equal to your mean premium. This would give us an efficiency value of 1. Values can vary usually between 0 and 1, but might sometimes have values greater than 1. With values greater than 1, you have an overly efficient system, and values between 0 and 1 you have change in premium being less than your change in claim frequency.

Heather Pierce
University of Texas at Tyler
An Introduction to the Jones Polynomial

Abstract: We will discuss some basics of knot theory and how to determine if a knot is truly knotted. We will introduce the Jones Polynomial, and show how this works to distinguish knots.

Tia Pilaroscia
University of Houston - Downtown
Fungal Population Dynamics along Buffalo Bayou

Abstract: We are trying to determine effects of environmental factors such as pH, soil elements, and location of fungal communities along the Buffalo Bayou.

Ken Smith
Sam Houston State University
The LURE grant: past, present and future

Abstract: The Longterm Undergraduate Research Experience is a program funded by the National Science Foundation which supports students and a faculty mentor for two consecutive summers. The students (primarily sophomores and juniors) work in small teams for 24 months on a research project in the mathematical sciences. The first round of this grant has involved approximately 80 students at five universities. Fourteen of those students (in 4 teams) have been at Sam Houston State University. I will present some initial results of this program, including recent assessment of the grant, along with some thoughts about enhancing undergraduate research. In addition, I will discuss the future direction(s) of this program and the intent to extend the grant to other Texas universities.

Sarah Spielvogel
Sam Houston State University

Causality: Understanding the world via statistics, algebra, and graph theory

Abstract: Human beings see the world in terms of causes and effects. Fundamental questions, such as "What effects do our actions have?" or "What would happen if the past were different from what it is?" have been asked by human kind throughout the ages. Philosophers and other social and behavioral scientists have formalized these ancient questions using modern mathematics and statistics. A graphical model is a representation method based on combinatorial graphs and probability theory used to formalize a variety of causal queries as certain types of probability distributions. A central problem in graphical models is the analysis of identification. A model is identified if it only admits a unique parametrization to be compatible with a given set of observed data. In this talk, I will present how the identification problem can be solved using tools of graph theory and computational commutative algebra.

Nicole Williams
Sam Houston State University

Computerized Tomography and Some Mathematics Behind it

Abstract: Computerized Tomography is a technology that enables one to see inside of a non-transparent body. The basic problem in computerized tomography is the reconstruction of a function f, describing for instance a particular organ or a tumor, based on some partial information which is values of integrals over a set of lines, planes, or circles . Some methods involved in reconstructing this function include interpolation, Radon transforms, and Fourier transforms. Applications of these processes can be found not only in medicine but also astronomy, electron microscopy, seismology, radar, and plasma physics.

Cynthia Willis
Lamar University

Jumping Off the Financial Skyscraper: Exploring Absorbing Markov Chains

Abstract: The fundamental matrix can be derived from the canonical form of an absorbing Markov Chain. With this new matrix, one can determine the number of steps until the chain is absorbed as well as the probability that the matrix will be absorbed in a particular state. This study will present a real world example displaying the functionality of the fundamental matrix.