TUMC 2025 – Abstracts of Contributed Talks

Morning Talks (9:00-9:55am)

Alkek 101

- (9:00-9:15am)
  Alejandro Lopez, Rice University
  Illuminating Finite Cities

  In the finite city of Jorp, the city planning committee is trying to determine how to place street lamps so that every neighborhood is well-lit. Unable to agree on a light-source arrangement, the committee decided to have a randomized polynomial dictate the light placement for them! Unsurprisingly, this almost never works—but surprisingly, when it does, the solution is almost always…trivial? This talk will discuss joint work with Bella Villarreal, Ren Watson, and Jaedon Whyte from the 2023 MathILy-EST REU.

- (9:20-9:35am)
  Asher Grizzaffi, University of Texas at Dallas
  Constructing and Exploring the Hypernatural Numbers

  The usual construction of the hyperreal numbers begins by assuming the real number system then utilizing real sequences with a nonprincipal ultrafilter equivalence relation to extend them. Alternatively, it is possible to conduct a similar process on the natural numbers to form the hypernaturals. Afterwards, the construction of the hyperintegers, hyperrationals, and hyperreal numbers follows in a way analogous to the construction of the integers, rationals, and reals from the naturals. This talk features the construction of the hypernatural numbers and highlights several of their interesting properties.

- (9:40-9:55am)
  Tyler Trujillo, University of Texas at Arlington
  Inside Free Resolution: Exploring the Limits of Polynomial Factorizations

  A matrix factorization consists of breaking apart a scalar matrix of the polynomial f into two square matrices S and T such that $ST = TS = fI$, where I is the identity matrix. We looked to expand on the Trujillo Theorem (2024) by finding which polynomials can be factored with something smaller than $2^{d-1} \times 2^{d-1}$ matrix factorization, where d is the number of variables. We believe that going deeper and finding another proof for the Trujillo Theorem 2024 will increase its applications in any field that uses matrices. The major new theorem (Trujillo Theorem 2025) that complements the Trujillo Theorem (2024) is that the number m of non-constant terms also determines the size of a matrix factorization. Either theorem can be advantageous depending on if m or d is smaller. We used David Eisenbud's method to give an alternate proof of the Trujillo Theorem (2024). The ranks of free modules are given by Pascal's triangle, and adding up all the even and odd ranks for the free resolution in d variables, we get

$2^{d-1} \times 2^{d-1}$ for S and T. This means we took half of Pascal's Triangle to form the sizes of our matrix factorizations, which is exactly what the Trujillo Theorem (2024) suggests.

Alkek 102

- (9:00-9:15am)
  Tanner Klein, Southwestern University
  A Different Type of Circuit: Exploring Graph Theory in Mario Kart World

  This talk focuses on exploring the ins and outs of Mario Kart World's map using concepts of graph theory. The game has thirty tracks and over two hundred routes to travel, so finding a way to connect them all can be a daunting task. We can represent the tracks as nodes and routes as edges to discover information about the whole graph. Using properties of Hamiltonian (all nodes are included) and Eulerian (all edges are included) circuits and paths, it can be shown whether connecting all of these routes together is possible. It has been found that creating any circuit around the entire world map is not possible due to the presence of a sink in the graph. Additionally, more than two of the nodes on the graph have an odd degree, meaning that no Eulerian path exists on the graph. Instead, we can shift our focus to finding the largest subgraphs that contain these paths and circuits.

- (9:20-9:35am)
  D. Blake Hopkins, University of Texas at Tyler
  On the Gonalities of Kneser Graphs

  The Kneser graphs $KG(n,k)$ are a classically studied family of graphs. One less well-known invariant of $KG(n,k)$ is gonality (also called divisorial gonality), which is the minimum degree of a rank 1 divisor on the graph.

  Using known bounds on gonality, one may obtain that for $KG(n,k)$ gonality is bounded above by the number of vertices of the graph minus the independence number of the graph, which equals $\binom{\mathrm{n}-1}{\mathrm{k}}$. In 2021, Liu, Cao, and Lu showed that by using treewidth, a lower bound on gonality for $KG(n,k)$ is $\binom{n-1}{k} - 1$ when n is greater or equal to $4k^2 - 3k + 2$.

  Using scramble number, another lower bound on gonality, we involve calculus techniques to improve this polynomial bound and show that the gonality of $KG(n,k)$ is exactly $\binom{n-1}{k}$ for more strict polynomial bound, and conjecture and even stricture polynomial bound using the uniform edge scramble.

- (9:40-9:55am)
  Avery Weatherly, Southwestern University
  Pip Pip Hooray! A mathematical exploration of Pips, a New York Times Game

  We will explore the New York Times game Pips. A pip is a dot on a domino that indicates the numeric value of that domino face. In the game of Pips a certain collection of dominoes is given and the player arranges them in such a way that the dominoes fit a specific shape and arithmetic rules similar to KenKen. The dominoes range in pip faces 0 to 6 and each domino is unique (no repeats of dominoes). In this project, I will be looking at the number of pip boards of a certain size and shape that correspond to a unique solution.

Alkek 103

- (9:00-9:15am)
  Dhruv Ajmera, University of Texas at Austin
  An $O(n)$ Space Construction of Superpermutations

  A superpermutation is a sequence that contains every permutation of n distinct symbols as a contiguous substring. For instance, a valid example for three symbols is a sequence that contains all six permutations. This paper introduces a new algorithm that constructs such sequences more efficiently than existing recursive and graph-theoretic methods. Unlike traditional techniques that suffer from scalability and factorial memory demands, the proposed approach builds superpermutations directly and compactly. This reduces space complexity to linear in the number of symbols, enabling the construction of larger sequences previously considered impractical under the factorial growth typical of other approaches.

- (9:20-9:35am)
  Natalie Huang, University of the Incarnate Word
  From Data to Prevention: Predicting Bone Fractures in Diabetic Men Over 60

  This project uses exploratory data analysis and predictive modeling to examine fracture risk among diabetic men over 60 in San Antonio, TX. Our research focuses on how vitamin D, calcium, A1C, testosterone, smoking status, and insulin use relate to fracture outcomes. Logistic regression and random forest classifiers achieved strong overall accuracy, showing that these features are effective in characterizing lower-risk patients while also underscoring the challenge of predicting rare fracture events in imbalanced datasets. Overall, this study demonstrates how machine learning and clinical insight can be combined in order to strengthen risk assessment and support preventative strategies for bone health in aging diabetic populations.

- (9:40-9:55am)
  Adedeji Kuforiji, Prairie View A&M University
  Leveraging Machine Learning and the All of Us Research Program to Predict the Occurrence of Uterine Cancer

  The Centers for Disease Control and Prevention (CDC) reports that uterine cancer is the most common gynecologic cancer in the United States. It includes two main subtypes: the more prevalent endometrial carcinoma and the rarer uterine sarcoma. The American Cancer Society projects that approximately 69,120 individuals in the U.S. will be diagnosed with uterine cancer in 2025. Early detection plays a pivotal role in improving treatment outcomes. Established risk factors include advanced age, obesity, and a family history of uterine, colon, or ovarian cancer. This study aims to identify novel risk factors associated with uterine cancer and to develop and evaluate three supervised machine learning models for predicting its occurrence. The models utilized data from the All of Us Research Program, which offers a wide range of clinical, demographic, environmental, biological, behavioral, and social variables. Propensity score matching was used to construct two datasets. In the first dataset, each uterine cancer case was matched to a single control (n=82); in the second, each case was matched to three controls (n = 164), with matching based on age and race. Logistic regression models were developed using four feature selection strategies: (1) Inclusion of all available features, (2) Selection of features highly correlated with the target variable using Kendall's Tau, (3) Univariate Feature Selection and (4) Recursive Feature Elimination. Each model was evaluated for predictive performance. Across both datasets, models utilizing features selected via Kendall's Tau correlation achieved the highest performance, with an accuracy of 88%. Machine learning models show strong potential for identifying novel risk factors and improving predictive accuracy for uterine cancer. Future work will focus on implementing and evaluating more advanced algorithms, such as Random Forest and XGBoost, to further enhance model performance and interpretability.

Alkek 104

- (9:00-9:15am)
  Joseph Medina, Texas A&M University - San Antonio
  Weighted Voting and the U.N. Security Council

  The European Economic Community in 1957 was a weighted voting system. Under Math and Politics, is the U.N. Security Council, a yes-no voting system, also a weighted voting system? There must be a set of weights and a quota, q, among the 5 permanent and 10 nonpermanent members. The goal for this information is to observe the effect of veto power on a yes-no voting system as well as to question the resulting power asymmetries in the U.N. Security Council. Assuming the unknown weight of the 5 permanent members to be x, and the weight of the nonpermanent members to be 1, and that 9/15 of votes are required for a resolution to pass, while accounting for the 5 permanent members' veto power, we get the following inequalities: $4x + 10 < q$ and $q \leq 5x + 4$. Resulting in $6 < x$, so through convention, we let $x = 7$, which justifies $38 < q \leq 39$. This weight and quota fulfill the applied situation but raises the question of whether all yes-no voting systems are also a weighted voting system.

- (9:20-9:35am)
  Nicholas Galus and William Paipa, St. Mary's University
  When Will It Thaw? Coupling surface energy balance and permafrost thaw

  We investigate possible coupling mechanisms between a heat transfer model of permafrost thaw through a vertical soil column and the Budyko energy balance model, which represents the balance of atmospheric energy fluxes across latitudes. We simulate solutions to the permafrost component of the model using a finite difference method and Budyko's energy balance model using the Euler method. We propose two possible coupling terms between the equations and discuss the merits of each. As a result we can simulate the coupled models and from this we determined that only one of the coupling functions was suitable.

- (9:40-9:55am)
  Rick van Iterson, Lamar University
  Fairy Chess and the Problem of Nonattacking Nightriders

  There are many famous chess problems in mathematics. For example, the N-queens problem asks how to place N queens so that none attack one another, and the knight's tour problem involves moving a knight to visit every square on the board exactly once. For years, enthusiasts have been creating fairy chess pieces. These are often variants of traditional chess pieces, and offer interesting twists to classical problems. In this talk, we explore the nightrider, which can make any number of knight moves along one direction. Specifically, we delve into the problem of placing nonattacking nightriders on N x N boards. We find solutions using integer programming, highlight interesting patterns in those solutions, and present a proof for a subset of boards. Lastly, we present open questions and ideas for future work.

Alkek 105

- (9:00-9:15am)
  Olivia Aubone, University of Texas at San Antonio
  Infinitary Logic, Forcing, and the Omitting Types Theorem

  The method of forcing was first introduced in 1963 by Paul J. Cohen to show that the Continuum Hypothesis and the Axiom of Choice are independent of Zermelo-Fraenkel set theory. In 1973, H. Jerome Keisler presented a model-theoretic approach to forcing from which he proved the Omitting of Types Theorem. This theorem ensures that under certain conditions, we can construct a model that omits a given set of types.

- (9:20-9:35am)
  Sam Ward and Andy Zhang, University of Texas at Austin
  Knots in Triangulated 3-Spheres

  We describe an original algorithm which, given a planar diagram code for a knot, produces a triangulation of the 3-sphere with the given knot embedded in the 1-skeleton. This algorithm is designed for usage with the software package Regina.

- (9:40-9:55am)
  Joshua Hamilton, University of Texas at San Antonio
  Ultraproducts in Model Theory

  A topological construction known as the ultrafilter gives rise to a tool called the ultraproduct which is used primarily in logic and set theory. In model theory, the semantic study of mathematical logic, the Polish mathematician Jerzy Łoś used models to construct mathematical structures that reveal hidden truths about everything from the naturals to logical compactness. Furthermore, ultraproducts give us a valuable test for the first order axiomatizability of a class of structures.

Alkek 108

- (9:00-9:15am)
  Jonathan Leung, University of North Texas
  Fractals and Function Equations: Revolving Sequence Representation of Lévy's Dragon Curve

  Self-similar fractals are structures that replicate their overall form at every scale, revealing intricate patterns found throughout nature, art, and mathematics. In this talk, we explore a particularly striking example: Lévy’s Dragon Curve—a self-similar curve notable for its ability to tile the complex plane.

  Approaching the curve through the lens of functional equations, we show that every point on the curve admits a natural representation as a complex power series. This representation is characterized by a special revolving sequence, offering new insight into the curve’s algebraic structure and deepening our understanding of its mathematical properties.

- (9:20-9:35am)
  Colten Snyder and Carly Waldal, LeTourneau University
  Coarse Geometry of lp Spaces

  This talk will investigate the difference between linear and coarse embeddings in the context of the lp spaces. It is known that lp coarsely, but not linearly, embeds into lq for $p<q$. We present an example of a new and simple map from l1 to l2 and discuss potentially generalizing that map to lp for $p>1$.

- (9:40-9:55am)
  Hannah Hamrin, Dallas College
  Rocket fire

  This project details the design, physics-based calculations, and construction of a PVC rocket with the objective of achieving a horizontal flight distance of 80 feet. The rocket was built using 1.338-inch PVC pipe, a simple PVC end-cap for the nose, and trapezoidal fins for stabilization. To ensure aerodynamic stability and controlled flight, the rocket's center of mass was strategically positioned ahead of its center of pressure, which was located using the shadow method.

  Using a launch angle of 45 degrees, the necessary initial velocity was calculated via ballistic equations to be 50.73 ft/s, resulting in a flight time of 2.23 seconds. Further calculations determined the maximum altitude would be approximately 20 feet and that the launcher would perform 54.11 Newton-meters of work. By equating this work to the rocket's gravitational potential energy at its maximum height, the required mass for the rocket was found to be approximately 1.98 pounds. In summary, this report demonstrates that a stable, 8-inch-long rocket with a mass of 1.98 pounds, equipped with trapezoidal fins, can successfully travel the required distance of 80 feet when launched with given force 60psi.

Afternoon Talks (1:40-2:55pm)

Alkek 101

- (1:40-1:55pm)
  Ren Watson, University of Texas at Austin
  Left and Right Quotient Sets in Non-Abelian Groups

  For a finite subset A of a group G, we define the right quotient set and the left quotient set of A, respectively, as the sets $AA^{-1}$and $A^{-1}A$. While the right and left quotient sets are equal if G is abelian, subtleties arise when G is a nonabelian group, where the cardinality difference between the left and right quotient sets may take on arbitrarily large values. Using the results of Martin and O'Bryant on the cardinality differences of sum sets and difference sets in the integers, we prove in the infinite dihedral group, every integer difference is achievable. Further, we prove that in the free group on 2 generators, an integer difference is achievable if and only if that integer is even, and we explicitly construct subsets of the free group on two generators that achieve every even integer. We further determine the minimum cardinality of A a finite subset of G so that the difference between the cardinalities of the left and right quotient sets is nonzero, depending on the existence of order 2 elements in G. To prove these results, we construct difference graphs D_A and $D_{\mathrm{A}^{-1}}$ which encode equality, respectively, in the right and left quotient sets. We observe a bijection from edges in D_A to edges in $D_{A^{-1}}$ and count connected components in order to obtain our results on cardinality differences between the left and right quotient sets.

- (2:00-2:15pm)
  Nathan Collins, Sam Houston State University
  Formalizing Yablo's Paradox with Turing Machines

  Yablo's paradox, a non-self-referential variation of the liar paradox, presents an infinite sequence of statements, each asserting the falsity of all subsequent statements. This talk will explore a formalization of this paradox using the theoretical framework of Turing machines. We will construct an infinite sequence of Turing machines where each machine is designed to search for a proof within Peano Arithmetic (PA) that the next machine in the sequence will never halt and will halt if it finds such a proof. This construction reveals that for any given machine in the sequence, PA can neither prove that it halts nor that it never halts, assuming PA is consistent. This result mirrors the paradoxical nature of Yablo's statements and provides a concrete computational analogue.

- (2:20-2:35pm)
  Kacy Miller, Southwestern University
  Path-finding and Patterns in Free Flow

  This talk will explore the mathematics behind the number of valid solutions in the game Flow Free. In this context, a flow is defined as a continuous path that connects two dots of the same color placed on the grid. A valid solution occurs on an nxn grid when every square in the grid contains some part of a flow and no flows cross. As the grid size n grows and more flows (or colors, c) are introduced, the number of possible solutions increases and becomes more difficult to determine. For this project, I will look at all unique solutions for 2×2 grids, 3×3 grids, and 4×4 grids as the number of colors increases. From found solutions, I will highlight any similarities or patterns that appear between different grids and consider connections to other known mathematical objects and concepts.

- (2:40-2:55pm)
  Oleg Marenkov, University of Texas at Dallas
  Grazing bifurcation of spiking oscillations in resonate-and-fire neurons

  Experimental evidence shows that spikes in resonate-and-fire neurons occur at specific phases when the membrane potential variable reaches its maximum. We introduce a straightforward mathematical neural model that exhibits spikes near the peak of membrane potential. This novel approach is based on a degenerate grazing bifurcation of an asymptotically stable impulsive limit cycle from a center and reduces to the study of stability of fixed point of a one-dimensional Poincare map. This is a joint work with Marianne Bezaire and Michael Hasselmo (Boston University).

Alkek 102

- (1:40-1:55pm)
  Olivia Payne, Stephen F. Austin State University
  The Chromatic Symmetric Function of Plankton Graphs

  We consider graphs with a small number of vertices and analyze the coefficients of hook partitions of their chromatic symmetric function, which is a generalization of the chromatic polynomial of a graph. Some of these coefficients can hold information about the graphs themselves and, in this research, we find a combinatorial formula for coefficients of hook partitions. This research is motivated by Stanley’s Tree Conjecture.

- (2:00-2:15pm)
  Sebastian Loder, Southwestern University
  Snakes and Snowmen: Exploring new classes of graphs within the Game of Cycles

  The Game of Cycles is a game played on a planar graph where two players take turns directing edges until either the last legal move is played or a cycle is completed. In this game, sources and sinks at any point on the graph are not allowed. The Game of Cycles was originally introduced by Francis Su in the book Mathematics for Human Flourishing. In a follow-up paper, the modified mirror reverse strategy is introduced. This strategy is where players mark either direction on any self-involutive edge until there are no more of said edges, then players mark across the axis of symmetry in the opposite direction on the same cycle. This strategy gives the player who is mirror-reversing an advantage. In this talk, we explore some of the further questions asked by the authors of the paper ``Playing Games With Cacti" by exploring multiple other classes of graphs where the modified mirror reverse strategy is ideal.

- (2:20-2:35pm)
  Tabitha Williams, Sam Houston State University
  Triangle-Free Modal Graph Theory

  Modal logic offers expressive power beyond first-order logic, particularly in model theory. Building on work by Hamkins and Woloszyn, which shows that modal model theory can express properties such as two-colorability, connectedness, finiteness, countability, and cardinality constraints for general graphs, our research investigates whether these properties can also be expressed for triangle-free graphs. We construct modal sentences to capture each of these properties specifically within the class of triangle-free graphs. Our results demonstrate that modal logic can indeed express all the aforementioned properties in this restricted graph class.

- (2:40-2:55pm)
  Kristian Duddridge, Southwestern University
  What's magical about hexagonal tiling?

  Rhombi-trihexagonal tiling is a way of filling a two dimensional space with no empty places. This pattern is used in the game of Kensington. Each hexagon is surrounded by six triangles, and six squares. A hexagon shares two triangles and one square with every adjacent hexagon. By assigning values to the squares and triangles, we can investigate if the tiling can have magic properties, and determine how large such a magic tiling can be.

Alkek 103

- (1:40-1:55pm)
  Egor Makarenkov, Allen High School
  Design of basic lattice-spring systems with minimal fabrication cost and optimal multi-functional properties

  We consider a problem of the design of lattices of elastoplastic current conducting springs with optimal multi-functional properties and minimal fabrication cost. In the previous work [1], we used a technique of inequalities to reduce the number of variables of the associated nonlinear optimization problem and to compute the minimal cost of a prototypic lattice of 4 springs for fixed parameters of the multi-functionality constraint. In this presentation we consider lattices of 2 and 3 springs (which can be building blocks of larger systems) and classify optimal configurations in the entire 2-dimensional space of parameters of the multi-functional constraint. In the space of parameters, we discover curves of interesting shape separating different optimal configurations. This is a joint work with Sakshi Malhotra (University of Texas at Dallas, now Montgomery College, Maryland) and Yang Jiao (Arizona State University).

  [1] E. Makarenkov, S. Malhotra, Y. Jiao, A dimension reduction procedure for the design of lattice-spring systems with minimal fabrication cost and required multi-functional properties, https://arxiv.org/abs/2501.05430

- (2:00-2:15pm)
  Sebastian Marcano, Lone Star College
  Simulating Particle Motion on Unstructured Mesh Using Inverse Isoparametric Mapping and Bilinear Interpolation

  Numerical simulations are vital for modeling particle transport in ocean currents; applications like oil-spill dispersion and contaminant transport depend on their predictive capabilities. Open-source software on unstructured meshes removes access and modification barriers, enabling accurate tracking across diverse flows. This study investigates the effectiveness of applying bilinear interpolation of time-dependent velocity fields defined on an unstructured mesh to approximate the expected final positions of advected particles within a specified error tolerance. We integrate trajectories using a second-order Runge–Kutta (RK2) scheme. To locate particles in quadrilaterals, we first use a barycentric test on two triangulations; candidates are then mapped back via Newton's method to invert the nonlinear bilinear map defined by Lagrange shape functions on the reference element update. The shape functions facilitate bilinear interpolation to evaluate particle velocities within the mesh. Vertex coordinates and velocity data come from Julia's Trixi.jl, with simulations implemented in Python. Future work may explore neighbor-based search algorithms to lower computational cost.

- (2:20-2:35pm)
  Alessandra Martinez, University of Texas Rio Grande Valley
  Mathematical Framework for Modeling Non-Genetic Heredity in Vesicle Systems

  The emergence of life on Earth remains one of the biggest unanswered questions in science. One of the most prominent hypotheses is the metabolism-first hypothesis, which suggests that life began with self-sustaining chemical networks that allowed for the growth and inheritance of traits via molecular composition. The simplicity of membrane-bound vesicles makes it a suitable model for the study of the growth, division and non-genetic heredity of early cellular structures. We developed and analyzed ordinary and partial differential equation models to simulate vesicle membrane and populations dynamics incorporating parameters such as lipid intake, outlet, growth and division. These models provide insights into the conditions needed for inheritance of membrane traits across generations. By implementing experimental data into our models, we aim to find the foundational elements that permit Darwinian evolution to operate in the earliest stages before genes emerged.

- (2:40-2:55pm)
  Kierra Vigil, Sam Houston State University
  Bridge Cost Optimization

  This talk presents a mathematical model for minimizing bridge material costs. Using calculus, we derive an optimal relationship between the number of columns and span length, incorporating a cost elasticity parameter. The analysis identifies critical points and confirms a minimum cost solution, providing a framework for efficient bridge design.

Alkek 104

- (1:40-1:55pm)
  Carina Yleana Vlaun, St. Mary's University
  From Incarceration to Integration: A Community Based Systems Dynamics Model of Reentry Support at the Dayton Foodbank

  As of October 1st , 2025, there are approximately 45,603 incarcerated individuals in Ohio. When leaving incarceration, many returning citizens lack support for accessing public resources. This has an extreme negative impact on returning citizens and leads to higher rates of people returning to incarceration. We are using a community-based system dynamics approach, in partnership with the Dayton Foodbank, to construct a model identifying key factors for reducing reincarceration rates. The Dayton Foodbank uses equitable hiring practices, including disregarding many disqualifying criminal offenses in the decision-making process. They are nationally known for developing support systems for equitable access to public resources as well as a thriving work culture that meets employees' needs for their social determinants of health. We conducted preliminary interviews of the Dayton Foodbank administrators and employees. Based on these interviews, we identified possible ways the Foodbank's equitable benefits and work culture have impacted the re-entry process by constructing possible causal loop diagram models, which take the form of networks with both balancing and reinforcing feedback. We aim to revise the "Cost of Recidivism" stock and flow model to continue this modeling process to show how equitable hiring can lead to a statewide reduction of recidivism. We will discuss possible interpretations and understanding gained from our findings.

- (2:00-2:15pm)
  Schadrack Karekezi, St. Edwards University
  HafiCare: An AI-Driven Platform for Symptom Analysis and Healthcare Access in Underserved Communities

  Access to timely and accurate healthcare remains one of the most pressing challenges in many low-resource settings, where limited medical infrastructure and shortages of healthcare professionals often delay diagnosis and treatment. HafiCare is an AI-powered healthcare platform designed to bridge this gap by combining machine learning, data science, and intelligent search techniques to improve how patients understand symptoms, connect with doctors, and locate essential medical services.

  At its core, HafiCare uses natural language processing (NLP) and classification algorithms to analyze user-reported symptoms and return a list of likely medical conditions. Based on this predictive layer, the system then recommends specialized doctors and nearby healthcare facilities, using semantic search and graph-based data modeling to match patients with the most relevant care options. The platform further integrates geolocation and pharmacy databases to guide users toward available medicines and treatment resources in their area.

  This project demonstrates how mathematical modeling, graph theory, and machine learning can be combined to solve real-world public health challenges. Beyond its technical contributions, HafiCare highlights the potential of AI-driven tools to expand healthcare access, particularly in under-served regions, by transforming raw health data into actionable insights. Future development aims to enhance diagnostic accuracy, integrate appointment-scheduling agents, and deploy the platform at scale in East Africa and similar contexts.

- (2:20-2:35pm)
  Lev Rachinskiy, University of Texas at Dallas
  Estimation of survival probabilities based on missing data: A case study

  This talk presents a nonparametric statistical framework for estimating survival probabilities when survival time data is partially missing. Traditional survival analysis methods, such as Kaplan-Meier estimation, often ignore incomplete records, resulting in biased conclusions. Building on the methodology developed by Dr. Sam Efromovich and Lirit Panovska, we apply a Fourier series expansion combined with inverse probability weighting to recover the survival density and hazard functions under covariate-dependent missingness. The approach models the probability that a survival time is observed, then uses cosine basis functions to estimate the underlying distribution without assuming a fixed parametric form. A case study illustrates the significance of this correction in real-world settings, showing how ignoring missing data can lead to substantial overestimation of survival. This work highlights the value of flexible, mathematically rigorous tools for uncovering accurate survival dynamics in both contemporary and historical datasets.

- (2:40-2:55pm)
  Mrinal Kanti Roychowdhury, University of Texas Rio Grande Valley
  Constrained Quantization and Conditional Quantization for Probability Distributions

  Constrained quantization for a Borel probability measure involves approximating the given probability measure by a discrete probability measure with finitely many support points restricted to lie on a specified set, referred to as the constraint. When no such restriction is imposed, the process is called unconstrained quantization, which is the classical notion of quantization found in the literature. The concept of constrained quantization was introduced by Pandey and Roychowdhury. Its introduction has led to a natural classification of quantization into two categories: constrained and unconstrained. In addition, we have introduced another branch of the theory, termed conditional quantization. With the advent of constrained and conditional quantization, the scope of quantization theory has expanded significantly, offering a wide range of potential applications in real-world contexts. Further details can be found in my preprints and publications. I will talk about it.

Alkek 105

- (1:40-1:55pm)
  Wildaniel Cortes, Sam Houston State University
  Pattern-Based Distinctions of Twisted–Torus Knots

  We distinguish twisted torus knots by performing algebraic calculations of the Jones polynomial associated with twisted torus links of type $T((p,q),(2,s))$.

- (2:00-2:15pm)
Arseny Mingajev, Trinity University
Ricci flow of homogeneous spaces with two equivalent isotropy summands

  Ricci flow is a process that gradually deforms the shape of a space in a way that is similar to how heat flow smooths out temperature. We present a complete qualitative analysis of the behavior of the normalized (volume-preserving) Ricci flow on the homogeneous manifold Spin(8)/G_2. As a consequence, we prove that any invariant metric on this manifold will be smoothly deformed via Ricci flow to have positive Ricci curvature. In general, the Ricci flow is given by a PDE, which is quite difficult to analyze. For homogeneous manifolds, symmetries allow us to reduce the PDE to a system of ODEs, where the variables are the components of the metric tensor. For the associated system of ODEs on Spin(8)/G_2, we accomplished the following: found all the singularities of the system (these singularities correspond to Einstein metrics); identified curves along which solutions to the system converge toward or diverge from the singularities in closed algebraic form; proved that any initial condition is taken by the flow to the forward-invariant region with positive Ricci curvature in finite time. This work was carried out under the mentorship of Dr. Lawrence Mouillé at Trinity University, sponsored by the Semmes Distinguished Scholars in Science Program.

- (2:20-2:35pm)
Megan du Preez, University of Texas at Tyler
Relationships between common slice obstructions and the Eisermann ribbon obstruction

  An n-component slice link is a smooth embedding of n disjoint circles into S^3 that bounds n disjoint, smoothly embedded disks in B^4. A ribbon link is a slice link that bounds n disks in S^3 whose only self-intersections are ribbon singularities. In 2008, Eisermann showed that all ribbon links with n components have Jones polynomials that are divisible by the Jones polynomial of the n-component unlink. We prove that this holds for all 2-component slice links. We also conjecture that Eisermann's ribbon condition follows from the Alexander module having maximal rank, a well-known necessary condition for topological sliceness. We prove that this conjecture holds for all links whose prime factors each have at most 14 crossings. We will also briefly mention that this conjecture holds for several families of links.

- (2:40-2:55pm)
Mesut Altiyev, University of the Incarnate Word
Exploring Differential Equations through Visualization and Simulation with Calculus Tools

  As a high school senior with a 5 on the AP Calculus AB exam and additional self-study, I set out to see how far basic calculus and visualization could go in understanding differential equations. Using slope fields, I explored the qualitative behavior of models such as RC circuits and logistic population growth. I then extended this by running simple numerical simulations in Python and Desmos to compare visual predictions with approximate solutions. Even without advanced mathematics beyond calculus, this approach revealed key ideas such as stability, equilibrium points, and the role of parameters. My project shows that high school–level calculus can already open doors to the kinds of modeling and analysis often seen in undergraduate mathematics and engineering courses.

Alkek 108

- (1:40-1:55pm)
  Alexa Smith, University of Mary Hardin-Baylor
  The Psychological Basis for the Benefits of Studying Mathematics

  We relate the fields of psychology and mathematics by discussing the benefits of a Mathematical Mindset on neuroplasticity to promote greater learning abilities, critical thinking skills, and self-efficacy. This talk will explore the neuroscience behind the cognitive and behavioral growth that results from building these skills on a developing brain.

- (2:00-2:15pm)
  Ryan Arif, University of Texas at Arlington
  Understanding Mathematics Identity and Belonging in an Undergraduate General Education Terminal Mathematics Course

  With the goal of enhancing student engagement and equity in undergraduate general education terminal mathematics courses, Homp et al (In Progress) devised instructional strategies, focused on highlighting the contributions of historically minoritized mathematicians. As a part of this multi-sectioned course, the students wrote four biographical assignments about the previously mentioned minoritized mathematicians. A pre- and post-survey adapted form Hazari et al (2020) revealed a significant increase the feeling of belonging of the students in the broader mathematical community. Using Guiterrez' (2012) equity in mathematics education dimensions of access, achievement, identity and power, we examine for each student three of their biography assignments and thematically analyze how the views on mathematics, mathematicians, and their connection to themselves evolved over the semester. Our findings indicate that early in the semester, students initially focused on the achievements of their selected mathematicians, and as the semester progressed, students found more human ways in which they connected with the mathematicians. This suggests the instructional tasks described here, which are relatively simple and inexpensive to implement, can have a significant impact on improving mathematical identity for students in a general education mathematics course.

- (2:20-2:35pm)
  Anna Knickel, Trinity University
  Lessons from Developing and Implementing a Poster Project Presentation in a Business Math Course

  This presentation describes and evaluates the implementation of changes to a Math for Business and Economics Course at Trinity University. To better tailor the course towards students, we have modified the course content, emphasized collaborative learning, and added a major poster project and presentation. The poster project asked students to solve a real-world problem (related to business, economics, or finance) using mathematics skills learned during the semester. The students then presented their findings to a group of faculty and high-school students. In this presentation, we detail the design of the poster project and examine students' reactions to it. We then share practical ideas for individuals interested in implementing a similar project at their own institution. We include project materials, rubrics, example projects, and other resources.

- (2:40-2:55pm)
  Dane Dune, Stephen F. Austin State University
  Swarm Behaviors and Optimization Methods

  In nature we observe animals working in large groups to perform complicated tasks that no single individual of the group could perform alone. We call this "swarm intelligence". This swarm intelligence works by having each individual of the group only performing basic tasks following very simple rules. The corroboration of the whole allows for very complex tasks to be formed. In this study we aimed to model these behaviors by giving the same simple instructions to particles. We also show how swarm intelligence can be used to solve optimization problems, particularly with a numerical algorithm called Particle Swarm Optimization (PSO), which minimizes a function of n variables.