13th Annual
Texas Undergraduate Mathematics Conference

TUMC

University of the Incarnate Word
San Antonio, Texas
October 20-21, 2017

University of the Incarnate Word
1881

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I'd like to personally welcome you to the 2017 Texas Undergraduate Mathematics Conference! The students and faculty at the University of the Incarnate Word join me in extending a warm welcome to our campus.

This conference celebrates the education of undergraduate students, a mission we hold dear at UIW. Our school had humble, but bold, beginnings in 1881 when three young French nuns traveled to San Antonio to help children orphaned by the cholera epidemic. They founded a school to educate the children, an endeavor that eventually became Incarnate Word College, then the University of the Incarnate Word. At the root of the Mission of UIW is the tenet to provide access to education and we are proud to serve not only our community, but students from all over the world.

That is why we are especially glad to welcome the TUMC conference to our campus. Engaging undergraduate students is the cornerstone to academic success and this conference helps spark that desire in budding mathematicians across Texas. The faculty here today serve as role models for these students. You are here today to showcase the wonder of mathematics. And to all the students in attendance, we applaud you for getting involved and enriching your academic journey.

This weekend's program is exciting! We will have panel discussions, math games, and a variety of presentations. We warmly thank our invited speakers, Dr. Padmanabhan Seshaiyer and Dr. Paulette Williams for joining us.

From all of us here at the University of the Incarnate Word, we thank you and welcome you.

Let the games begin!

Joleen Beltrami, Ph.D.
Chair, Department of Mathematics and Statistics
University of the Incarnate Word

Wi-Fi: Select *uiw-guests*, enter your information, you will have access for 24 hours.

Schedule of Events

Friday, October 20, 2017

3:00-7:00 PM	Registration and Welcome	Student Engagement Center—Ballroom Foyer
6:00-8:00 PM	Making Math Fun in the Classroom Dr. Padmanabhan Seshaiyer George Mason University	Student Engagement Center—Room 2031
6:00-8:00 PM	Pizza and Games	Student Engagement Center—Ballroom

Saturday, October 21, 2017

8:00-9:00 AM	Registration	Student Engagement Center Ballroom Foyer
9:00-10:55 AM	Contributed Presentations	Student Engagement Center Rooms 2030, 2031, 2032, 2034
11:00-12:15 PM	Welcome and Keynote Dr. Padmanabhan Seshaiyer George Mason University	Student Engagement Center Ballroom
12:15-1:05 PM	Lunch	Student Engagement Center Ballroom
1:10-2:05 PM	Contributed Presentations	Student Engagement Center Rooms 2030, 2031, 2032
2:10-3:05 PM	Break Out Discussions see page 6 for more information	Student Engagement Center Rooms 2030, 2031, 2032
3:10-4:00 PM	Invited Address Dr. Paulette Willis Kumon Math and Reading Center	Student Engagement Center Ballroom
4:00-4:10 PM	Closing Remarks	Student Engagement Center Ballroom

*All Texas NExT events will be held in SEC 2053

Invited Talks

Friday Night Workshop: Dr. Padmanabhan Seshaiyer, George Mason University

Title: *Enhancing pedagogical practices to improve student engagement thorough inquiry-based problem solving approaches*

Abstract: In this session, we will share how inquiry based approaches can be employed to engage students in higher-level critical thinking strategies, open-ended exploration and multiple approaches in problem solving, including technology. Specifically, the participants will learn about best practices in teaching and learn to develop mathematically rich problem solving activities and tasks that can help students to develop their algebraic habits of mind. The participants will also have an opportunity to learn about effective performance based tasks with varying cognitive demand and 21st century skills designed to help educators support their students learning progression and their mathematical understanding.

Keynote Speaker: Dr. Padmanabhan Seshaiyer, George Mason University

Title: *Undergraduate research in mathematical modeling, analysis and simulation of biological, bio-inspired and engineering systems*

Abstract: In the last decade, there have been dramatic advances in mathematical modeling, analysis and simulation techniques to understand fundamental mechanisms underlying biological, bio-inspired and engineering systems. This work will present examples of undergraduate research projects that evolved from multidisciplinary applications modeled via coupled differential equations. Some of these examples include using mathematics to understand why aneurysms rupture; understand how zika spreads; studying social dynamics and; employing mathematics to stop poaching of elephants in Africa. Mathematical analysis and computation for some benchmark model applications will also be presented. Finally, we will also discuss how such projects can provide scholarship opportunities for students at all levels to employ transformative mathematical research in multidisciplinary areas.

Invited Address: Dr. Paulette Willis, Owner and Director of the Kumon Math and Reading Center of Houston-Steeplechase

Title: *How to choose a career*

Abstract: Most people believe that pursuing math leads to only two options for jobs: teacher or professor. That belief is completely false. There are many exciting career paths available to mathematically inclined individuals. Dr. Paulette N. Willis will share with you her nontraditional career path as a mathematician and discuss the ups and downs of her journey. Come listen to her story and the lessons she's learned. We are sure you will gain some insight on how to choose a career you will love.

Schedule of Talks — Morning Session

	Room 2030 **Algebra** **Moderator: Jorgenson**	**Room 2031** **Numerical Analysis** **Moderator: Yang**	**Room 2032** **Graph Theory** **Moderator: Dunning**	**Room 2034** **Probably and Statistics** **Moderator: Smith**
9:00-9:15	**Andrew Soto** University of Texas at *Arlington* *Matrix Factorizations for Polynomials*	**Aser Garcia, Eric Hall** Tarleton State University *Creating a Heliocentric Lunar Forming Impact Model*	**Bianca Salinas** St. Edward's University *A Combinatorial Approach to RNA-Inspired Folds*	**Penny Phan** Southwestern University *Singapore: Model of a Savings Fund*
9:20-9:35	**Yansy Perez** University of Texas at Tyler *The Structure of the Inverse Semigroups of Self-Similar Graph Actions*	**Edwin Gonzalez, Stephen Lowe** Tarleton State University *N-body Approach to the Traveling Sales Man Problem*	**Daniel Kim** Texas Academy of Mathematics and Science @ UNT *The Devil in the Details: Spectrum and Eigenvalue Distribution of the Discrete Preisach Memory Model*	**Madison Edwards** Southwestern University *Take Your Best Shot: Optimizing Shot Selection in Basketball*
9:40-9:55	**Catherine Marin King & Asa Linson** University of Texas at Tyler *Modular Arithmetic and Cryptography*	**Victoria Gore** Southwestern University Modeling Trends in Austin Traffic	**Maria Mota** St. Edward's University *Solving 2-by-2 Scramble Squares Puzzles with Repetitions*	**Samuel Vardy** Southwestern University *The Price of Health*
10:00-10:15	**Robert Toedt** Sul Ross State University A Study on Elliptic Curves	**Bryan Pennington** University of Texas at Tyler *Pattern Avoidance on Quasi-Stirling Permutations*	**Derek Drumm** Lamar University Setting Up Scheduling Problems Through Linear Optimization and Graph Theory	**Sabrina Hetzel** Tarleton State University Computing absorption probabilities in simple finite random walks
10:20-10:35	**Richard N. Van Natta** The University of Texas at Dallas *Ordering Spaces with a "Tupling" Function using Figurate Numbers*	**Arman Maesumi** The University of Texas at *San Antonio* *Triangle Inscribed-Triangle Picking*	**Ivan Rocha** University of Houston-Downtown *Mathematical Details on the Singular Integral Equation Method*	**Kristen McCrary** Southwestern University *Math and Mancala*
10:40-10:55	**Anca Andrei** University of Texas at Austin *Some considerations on the relationships between an infinite group and its subgroups*	**Bonnie Henderson** Southwestern University *The Mathemasticks of Flower Sticks*		**Amira Mahler** St. Edward's University *American Roulette: How Long and Boldly Can You Play?*

Schedule of Talks — Afternoon Session

	Room 2030 Education Moderator: Archer	Room 2031 Topology Moderator: Hochberg	Room 2032 Differential Equations Moderator: Tek
1:10-1:25	**Jessie English** The University of Texas at Tyler *The Mathematics of SET*	**Sarah Goldrup** St. Edward's University *A new lower bound on unstable neural codes*	**Niyousha Davachi** University of Texas at Arlington *Auxiliary Conditions To The Euler-Lagrange Equations For A New Class Of Non-Standard Lagrangians*
1:30-1:45	**Maria Ornelas, Petra Reyes-Perez, Zachery Viray** University of the Incarnate Word *Pedagogy and Paper Folding*	**Jake Howell** Texas Christian University *Analyzing Personality Structure Over Time with Topological Data Analysis*	**Isaac Hopkins** *Southwestern University* *A Fluid Dynamical Approach to Modeling Traffic*
1:50-2:05	**Jocelyn Alvarado** University of the Incarnate Word *A Study of Student Performance in Middle School Mathematics Courses*	**Emily Feller** University of Dallas *Ramsey Numbers from Tiling T-tetronimos*	**Erik J. Harwell** Texas A&M University-Kingsville *Complex Matter Space (CMS) and Superluminal Particles*

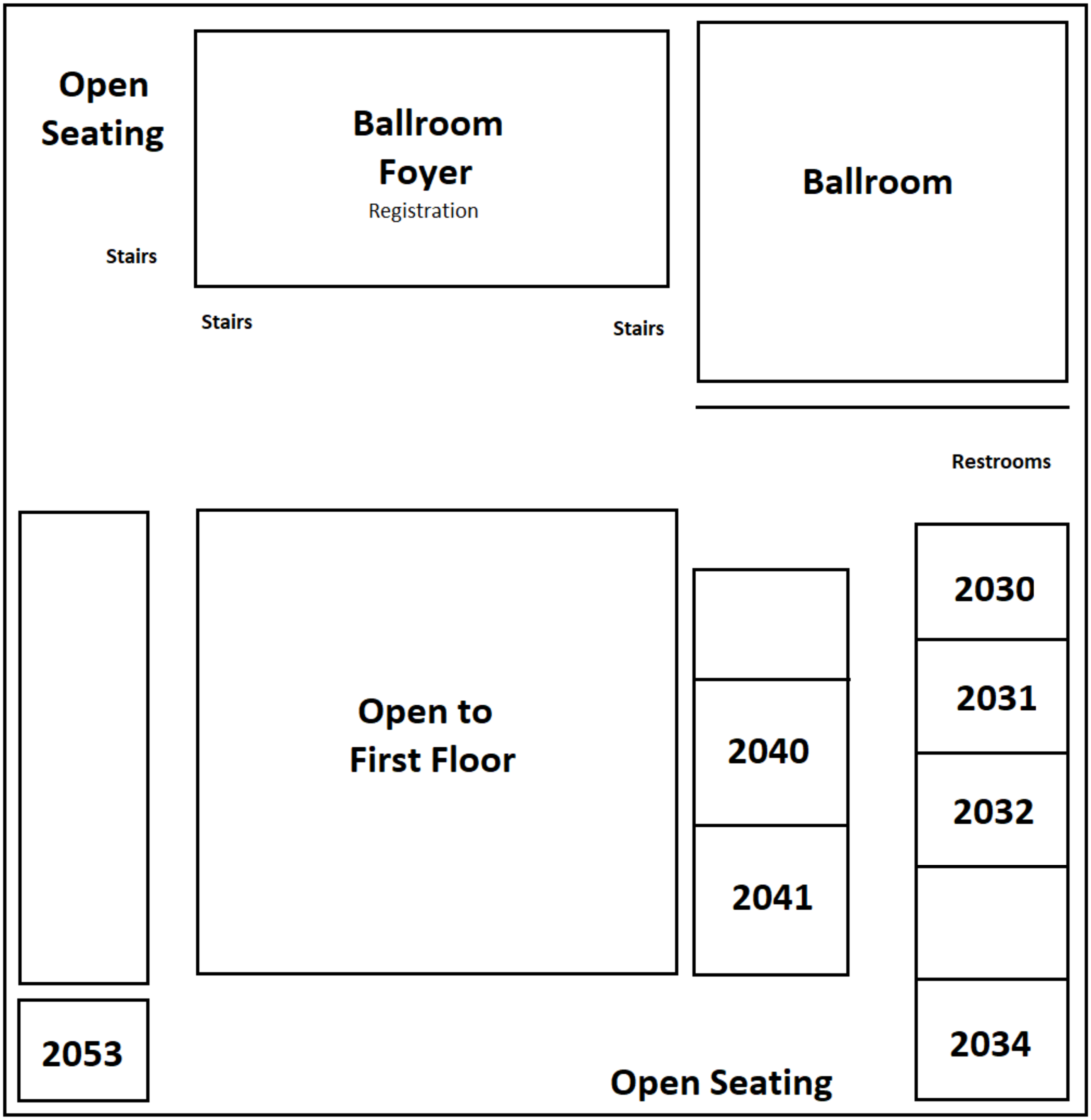
Schedule of Talks — Break Out Discussions

Students will have the opportunity to attend two of the three interactive discussions led by faculty members with significant experience in each topic.

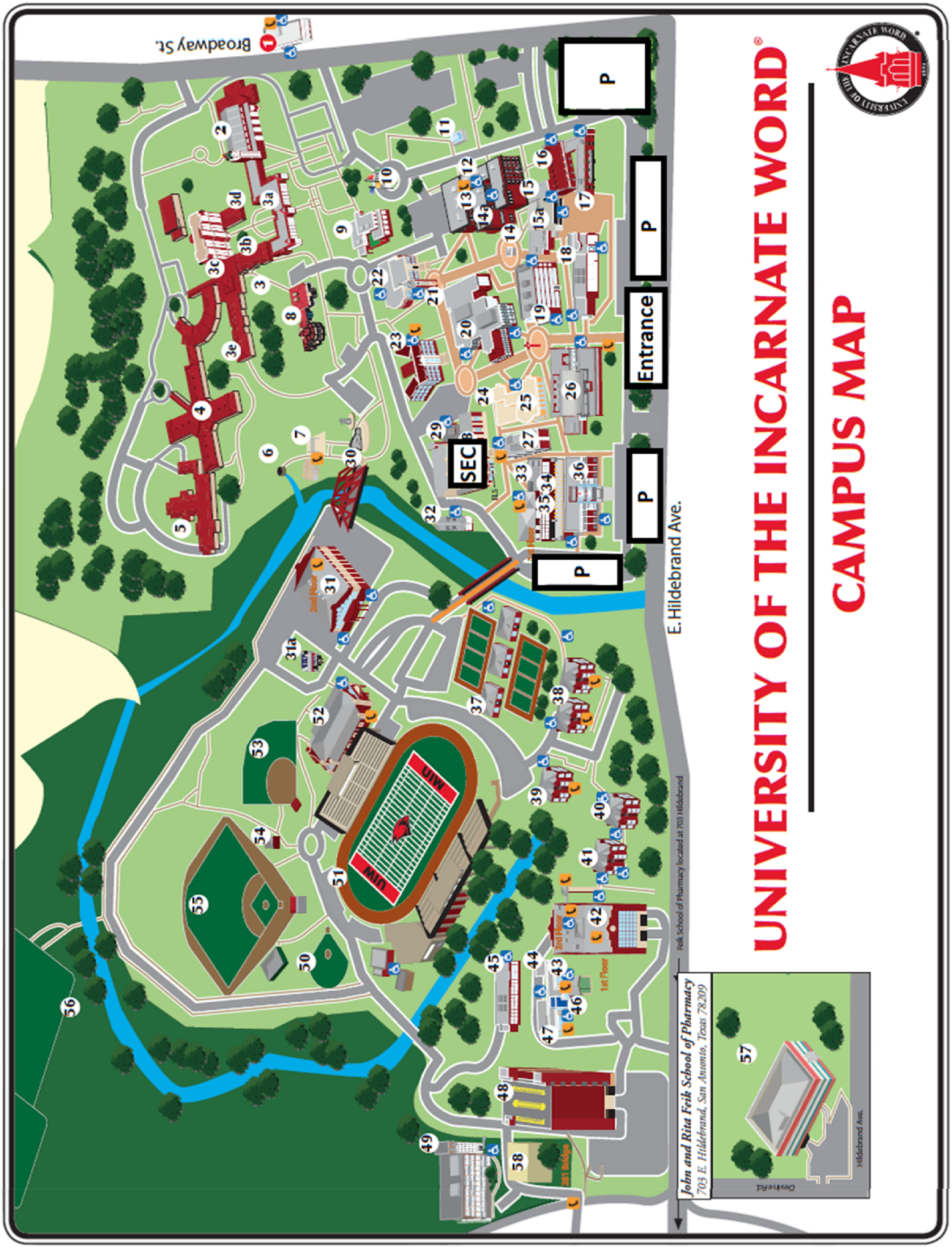
	Room 2030	Room 2031	Room 2032
2:10-2:40	**Applying to Graduate School: Process, Necessary Documents, and Advice** Dr. Eileen Faulkenberry Tarleton State University	**Summer Research Opportunities: REU's, Research Internships** David Milan, PhD University of Texas at Tyler	**What Can You Do With a Math Degree? Jobs Outside of Academia** Kevin E Kalinowski, PhD, MPH, CPH UIW School of Osteopathic Medicine
2:45-3:15	**Applying to Graduate School: Process, Necessary Documents, and Advice** Dr. Eileen Faulkenberry Tarleton State University	**Summer Research Opportunities: REU's, Research Internships** David Milan, PhD University of Texas at Tyler	**What Can You Do With a Math Degree? Jobs Outside of Academia** Kevin E Kalinowski, PhD, MPH, CPH UIW School of Osteopathic Medicine

Map — Student Engagement Center

Second Floor



Map — University of the Incarnate Word



Abstracts—Alphabetical Order

Jocelyn Alvarado
University of the Incarnate Word

A Study of Student Performance in Middle School Mathematics Courses

In this presentation, we will discuss performance of middle school students in mathematics courses. In particular, we study data on how gender, availability of home support systems and other additional school support systems effect failure rates.

Anca Andrei
University of Texas at Austin

Some considerations on the relationships between an infinite group and its subgroups

Group theory has been studied for centuries by many researchers. In the case of finite groups, Lagrange proved that the cardinality of any subgroup of a given finite group is an integer divisor of the cardinality of that group. This paper defines a new concept related to both finite and infinite group theories and their subgroups, called pseudo-partitions of a group. The main result of our paper proves that the set of elements obtained from removing a subgroup from a pseudo-partition of a(n) (in)finite group cannot be a subgroup of the given group.

Niyousha Davachi
University of Texas at Arlington

Auxiliary Conditions to the Euler-Lagrange Equations for a New Class of Non-Standard Lagrangians

A new class of non-standard Lagrangians that explicitly depend on the special functions of mathematical physics is discovered and this requires adding some auxiliary conditions to the Euler-Lagrange equations. Several examples with applications of the new non-standard Lagrangians are presented and discussed. Moreover, the relationships between the obtained results and Lie algebras and Lie groups are also briefly addressed.

Derek Drumm
Lamar University

Setting Up Scheduling Problems through Linear Optimization and Graph Theory

Scheduling problems are commonplace in the industrial world of today. As such, being able to solve these scheduling problems serves an important role in increasing efficiency of society. Finding the solutions to these scheduling problems involves knowledge of linear optimization and graph theory. This presentation will focus on the setup of these scheduling problems in both a linear optimization and graph theory environment.

Madison Edwards
Southwestern University

Take Your Best Shot: Optimizing Shot Selection in Basketball

Basketball is a multi-faceted game, the outcome of which is determined by many different components. One of these components is the concept of “shot selection,” which is a major offensive focus of basketball teams and coaches. Shot selection refers to the types of offensive attempts made by a team towards the basketball goal. Good shot selection can be defined as shot attempts that have a high probability of resulting in points and give a team some type of advantage over its opponent. This mathematical model determines a function for optimal shot selection and then uses statistical data from games participated in by the Southwestern University Women’s Basketball team to compare the team’s points per possession to the points per possession that would be expected if the team abided by the optimal shot selection function.

Jessie English
The University of Texas at Tyler

The Mathematics of SET

SET is a card game which requires cognitive, logical, and spatial reasoning skills to complete a set. A set is a group of three cards which are either all the same or all different in four distinct features: shape, shading, number, and color. The game of SET has connections to a variety of topics in mathematics, including counting, probability, modular arithmetic, and geometry. We will discuss some of these connections while improving our own game strategy."

Emily Feller , Elizabeth Derdeyn
University of Dallas

Ramsey Numbers from Tiling T-tetronimos

The ordinary van der Waerden number W(k, l) is the least positive integer W such that any k-coloring of the initial segment of positive integers [W] contains a monochromatic arithmetic progression of length l. In this paper we consider tilings of rectangles by T-tetrominos, and ask when arithmetic progressions (AP) of tiles must occur, that is, tiles that are equally spaced and all in the same orientation. Define T(4, k) to be the least T such that in any tiling of a 4xT rectangle by T-tetrominos, a k-term AP must appear. And let the notation (M,N) → k mean that any tiling of an MxN rectangle by T-tetrominos must contain a k-term AP. When evaluating T(4, 2) and T(4, 3), the combinations of tilings can be sorted out by hand. As the sizes increase, the tilings get longer and the computer becomes useful to sort through the millions of tilings in order to find or avoid APs. We will present exact values of T(4, k) for some small k, and characterize those pairs (M, N) for which (M, N) → 3. Our initial results show that there is a suprisingly tight correlation between our tiling numbers and the ordinary van der Wearden numbers for the coloring of the integers.

Aser Garcia, Eric Hall
Tarleton State University

Creating a Heliocentric Lunar Forming Impact Model

To date, researchers investigating lunar forming impacts have only considered the impactor and proto-Earth in their simulations. This project aims to incorporate the effects of the Sun on lunar forming impact studies. The Sun makes up 99.8 percent of the solar systems mass. Hence, any valid study must include the effect caused by such a massive body. We have incorporated data from NASA's "Horizons" system at JPL to produce the correct initial conditions for the impactor and proto-Earth—relative to the Sun. The solar gravitational effect was added to complete this heliocentric model. Currently we are investigating the effect the Sun has on lunar forming impacts and comparing this with data from existing models. We hope to use this knowledge to create a more complete theory of how our Moon was formed.

Sarah Goldrup
St. Edward's University

A new lower bound on unstable neural codes

Neural codes, represented by binary strings, encode neural activity and show relationships between stimuli, like distance between locations in an environment. Certain neurons, called place cells, have shown experimentally to fire in convex regions in space. An open convex code is a code that can be realized as open convex sets. It was initially believed that all open convex codes can also be realized with closed sets; however, counterexamples with six neurons show that this is not the case. Codes that are open convex but not closed convex are called unstable neural codes. In this talk, we will show that five neurons is the minimal number of neurons necessary to construct unstable neural codes, as well as discuss common elements of such codes.

Edwin Gonzalez, Stephen Lowe
Tarleton State University

N-body Approach to the Traveling Sales Man Problem

The Traveling Salesman Problem (TSP) is a classical NP-hard problem in Optimization Theory that has been around since 1930. The problem is defined as follows: "Given a list of cities, what is the shortest possible route that visits each city exactly once and returns home?" The process to find the exact solution is straightforward: start with a city, then go to the next city, until all cities have been visited once and return to the initial city. Do this for all possible tours and choose the shortest tour. The difficulty lies in the fact that there are (n+1)!/2 possible tours. To understand the situation, imagine a TSP that contains 25 cities. If the first living biped (4.9 million years ago) had a super computer that could calculate 2 billion tours per second, the computer would just now finish calculating. Since finding an exact solution is not feasible, efficient approximation methods are needed. In this work, we utilize an N-body approach to extrude an accurate approximation to the TSP. The rate of complexity of an N-body problem grows at the rate of n^2 which is a vast improvement over n!

Abstracts (continued)

Victoria Gore
Southwestern University

Modeling Trends in Austin Traffic

"We analyze yearly traffic accident data in Austin, TX in order to reveal trends in traffic accidents. We apply multiple methods in order to determine how the number of traffic accidents varies based on the hourly time of day and day of the week. We also analyze fatal and non-fatal accidents.

Erik J. Harwell
Texas A&M University-Kingsville

Complex Matter Space (CMS) and Superluminal Particles

Complex Matter Space (CMS), Antiparticles, Wave functions, and Tachyons. The Special Theory of Relativity cannot recognize velocities faster than the speed of light. However, there are phenomena that do appear to transmit data and maybe energy much faster than the speed of light. New assumptions will be postulated that two of matter's intrinsic components, 1) mass, and 2) charge, are a single complex quantity: $M=m+iq$. The mass will be measured by real number system and the charge on the imaginary axis. We will review the history of Complex Matter Space, introduce complex numbers, vectors, and vector spaces, then explain how momentum and energy are reformulated in Complex Matter Space, and finally, use the Complex Matter Space concept to help explain antiparticles and to conjecture the existence of tachyons which are implied by CMS and may help explain how the wave functions of entangled particles collapse so quickly.

Bonnie Henderson
Southwestern University

The Mathemasticks of Flower Sticks

We will present a mathematical model of the motions of juggling flower sticks. We will use motion capture technology and digitization to find equations that represent the paths of the sticks and to find the rates of change in the Cartesian coordinate and angular positions.

Sabrina Hetzel
Tarleton State University

Computing absorption probabilities in simple finite random walks

In this talk, I will develop a classic formula for computing the probability of absorption in simple finite random walks with absorbing boundaries. I will also discuss the potential application of such computations to applied settings, including modeling of response times in behavioral experiments.

Isaac Hopkins
Southwestern University

A Fluid Dynamical Approach to Modeling Traffic

We analyze a mathematical model for traffic based on fluid dynamics and, specifically, hyperbolic conservation laws. These conservation laws are a set of partial differential equations which define the dependency between changes in traffic density and traffic flux. We investigate the theoretical relationship between these fundamental traffic variables.

Abstracts (continued)

Jake Howell
Texas Christian University

Analyzing Personality Structure Over Time with Topological Data Analysis

Personality psychologists often apply clustering techniques on questionnaire data to model personality structure. Inspired by this work, we apply techniques from topological data analysis (TDA) to understand the structure of this data. The data comes from Cattell's Sixteen Personality Factor Questionnaire (collected by Bell, Rose, & Damon in 1972). Subjects were 969 adult male volunteers divided into three age groups: 25 to 34, 35 to 54, and 55 to 82. We use persistent homology (a TDA tool) to cluster the data and identify that personality structure is slightly different between the age groups. It is also curious to note that data from the youngest age group appears to have a topological "hole", which raises questions of the psychological significance. This work suggests that additional research, including applying TDA tools to other questionnaire data sets can provide insights to the study of personality. Preliminary work on current research will also be included.

Daniel Kim
Texas Academy of Mathematics and Science @ UNT

The Devil in the Details: Spectrum and Eigenvalue Distribution of the Discrete Preisach Memory Model

The Preisach model is a well-known input-output model that was originally proposed for magnetic hysteresis, characterizing transitions between magnetic dipole states as a function of the system's previous states. This dependence of a system on its history of possible states has been extended beyond magnets to obtain suitable mathematical models for a variety of hysteresis phenomena in engineering, physics, and economics applications. Transitions between 2^N states of the discrete Preisach model can be described by a directed graph Γ. We consider an adjacency matrix A_N associated with a random walk on this graph. Alternatively, this matrix is associated with the random evolution of an inventory under the "Last In, First Out" (LIFO) inventory management rule. By relating the self-similar nature of LIFO directed graphs to the recursive nature of Chebyshev polynomials, we are able to obtain explicit formulas for the spectrum and eigenvectors of the non-symmetric adjacency matrix A_N . This work was done in collaboration with A. Amann, D. Dmitrii, T. Kalmar-Nagy.

Catherine Marin King & Asa Linson
University of Texas at Tyler

Modular Arithmetic and Cryptography

Construction of a cryptosystem generally requires the system to be relatively easy to solve in one direction but difficult to solve in the reverse. For example, modular multiplication is easy but modular division can be difficult. To assist in modular arithmetic, factoring methods such as Pollard's p-1 factoring algorithm can be used. An overview for the types of encryption methods are given to introduce a basic cryptosystems. With this foundation, we will present a cryptosystem based on the theory of elliptic curves.

Arman Maesumi
The University of Texas at San Antonio

Triangle Inscribed-Triangle Picking

Given a triangle ABC with area Δ, the average area of an inscribed triangle RST whose vertices are uniformly distributed on AB, BC, and CA, is proven to be one-fourth of the area of ABC. The second and third moments of the area are shown to be $\frac{\Delta^2}{12}$ and $\frac{5\Delta^3}{144}$ respectively. A general formula for the n-th moment of the area is derived. Additionally, a Monte Carlo simulation, as well as a Maxima program, confirm the theoretical results. We experimentally verify that the Monte Carlo method has a $1/\sqrt{N}$ convergence where N is the number of samples.

Amira Mahler
St. Edward's University

American Roulette: How Long and Boldly Can You Play?

American Roulette is a casino game in which players place various types of bets on subsets of 38 numbers. A wheel is then spun to determine the winning number; players who bet on this number win their bet amount plus a payout multiplier specific to each type of bet while players who did not bet on this number lose their bet amount. Previous research uses Markov chains to compute probabilities of players accumulating a desired amount of money ("success") or losing all their money ("ruin") for each type of bet. We use Markov chains to compute the probabilities of success and ruin for new betting strategies based on bold gambling and find that these strategies yield higher probabilities of success. We also use Markov chains to compute the expected game lengths until success or ruin for all betting strategies.

Kristen McCrary
Southwestern University

Math and Mancala

We will present a mathematical model of the game Mancala, a sequential two-player board game consisting of "pits" and "stones." Considering that the goal of the game is to capture the most stones, we will investigate various strategies and their effects on the outcome of the game.

Maria Mota
St. Edward's University

Solving 2-by-2 Scramble Squares Puzzles with Repetitions

A Scramble Squares puzzle consists of nine square pieces with half of an image on each edge. To solve the puzzle the nine pieces are arranged in a 3-by-3 grid so that edges on adjacent pieces form a complete image. A repetition is a half-image that appears more than once on a puzzle piece. Previous research uses a graph-theoretical approach to establish necessary and sufficient conditions for solutions without repetitions to 2-by-2 Scramble Squares puzzles. We use a similar approach to establish necessary and sufficient conditions for solutions with repetitions to 2-by-2 Scramble Squares puzzles.

Maria Ornelas, Petra Reyes-Perez, Zachery Viray
University of the Incarnate Word

Pedagogy and Paper Folding

Origami is the art of paper folding to construct a sculpture from a square. This art usually results in the paper having many shapes and patterns which we intend to use to explain mathematical concepts. We will go over TEKS from the primary level and use origami as a manipulative to teach them.

Bryan Pennington
University of Texas at Tyler

Pattern Avoidance on Quasi-Stirling Permutations

Pattern avoidance was first developed by Donald Knuth in 1973, while studying stack-sortable permutations. He needed a way of distinguishing which permutations on the set $S_n=\{1, 2, \dots , n\}$ could be sorted from least-to-greatest using a stack-sorting algorithm. During our research, which was done as part of the REU at the University of Texas at Tyler, we studied pattern avoidance on quasi-Stirling permutations, which are permutations on the multi-set $\{1, 1, 2, 2, \dots , n, n\}$. Our focus was on avoiding combinations of patterns from S_3.

Abstracts (continued)

Yansy Perez
University of Texas at Tyler

The Structure of the Inverse Semigroups of Self-Similar Graph Actions

We discuss a recently discovered class of inverse semigroups called the inverse semigroups of self-similar graph actions. To describe this class, we characterized the idempotents, ideals, and other properties common to inverse semigroups in general. Furthermore, we provide conditions that ensure a self-similar graph action is fundamental or 0-disjunctive and, more generally, when it satisfies properties of inverse semigroups relevant to the study of C-algebras.

Penny Phan
Southwestern University

Singapore: Model of a Savings Fund

In Singapore, the Central Provident Fund (CPF) serves as the national savings system. Singaporean and permanent workers are required to contribute part of their wages to a compulsory savings account to fund their retirement, healthcare and housing needs. We model the CPF based on data including workforce participation and annual income by age group.

Ivan Rocha
University of Houston-Downtown

Mathematical Details on the Singular Integral Equation Method

During the span of our research we studied the singular integral equation method (SIEM) that has been used in the paper “The Crack Problem for a Nonhomogeneous Plane”, by F. Delale and F. Erdogan. Compared to other numerical methods (finite element, finite difference, or finite volume), SIEM is a semi-analytical method; it provides very accurate results in solving crack problems. Despite the fact that SIEM is an accurate method used in the solid mechanics community, due its heavily mathematical derivation, only a limited school of researchers are using it. Our goal in this research is to break down the mathematical details of SIEM so that more researchers can understand and use the method. We also implemented the numerical part to obtain the crack displacement profiles and the stress intensity factor (SIF) at crack tips.

Bianca Salinas
St. Edward's University

A Combinatorial Approach to RNA-Inspired Folds

RNA is a single-stranded molecule whose function depends on how it folds onto itself. Biologically, the folding is given by Watson-Crick Base Pairs. We consider a combinatorial abstraction of RNA where the bonding relations are given by a connection graph, instead of Watson-Crick base pairs, and foldings are represented by non-crossing matchings. Using this model, we were able to categorize graphs that guarantee a connected move graph, which is how foldings transform into one another.

Abstracts (continued)

Andrew Soto
University of Texas at Arlington

Matrix Factorizations for Polynomials

Irreducible polynomials are by definition not factorable in the conventional sense, so having another method to factor these polynomials is important. The factorization method we discuss in this paper uses matrices, and was first introduced by David Eisenbud in 1980. The method is called matrix factorization, and works whether the polynomial is irreducible or not. Regarding the question of the existence of matrix factorizations, we prove that it suffices to show every homogeneous polynomial has a matrix factorization. We then show that every homogeneous polynomial does in fact have a matrix factorization. These results have been obtained by starting with polynomials of one term and working up from there. When factoring polynomials in the conventional sense, there is one and only one way to factor them. However, using matrix factorizations, more than one factorization is possible. These factorizations will look different, so we need a precise notion of equivalence. We discuss two definitions of equivalence, Eisenbud's and homotopy equivalence, and show one implies the other, but not vice versa. Results include a theorem showing the conditions required for a polynomial to be factored using a two by two matrix, a theorem and a proposition that shows how to make a matrix factorization for a given polynomial and homogenize it for the homogenization of the polynomial, and a theorem that shows how to make an arbitrary factorization homogeneous for a homogeneous polynomial."

Robert Toedt
Sul Ross State University

A Study on Elliptic Curves

Applications of elliptic curves include solving Fermat's Last Theorem, cryptography, and integer factorization. Using the Weierstrass equation for elliptic curves $y^2=x^3+Ax+B$, with the condition $4A^3+27B^2$ not equal to 0 is equivalent to there being no singular points on the curve allowing for a well-defined tangent line at each point. The Addition Law (or Group Law) for adding points on an elliptic curve demonstrates that (rational) points on elliptic curves form a group. This addition involves a "tangent and secant" method, which can be used to find additional rational points on a curve if one knows at the outset at least one rational point on the curve. These points, as well as the coefficients of the elliptic curve must be in a field, so this Addition Law is applied in the case where the curve is defined over a finite field. Elliptic curves can be implemented to factor an integer N, in order to determine if N is composite or prime, by reducing their coefficients and the rational points on the curve modulo N.

Richard N. Van Natta
The University of Texas at Dallas

Ordering Spaces with a "Tupling" Function using Figurate Numbers

We construct a family of polynomial bijections between N and N^m for any m in N. The family of bijections is based on the figurate numbers of recursively generated gnomons shaped like simplices. A beautiful advantage of this approach over simply recursively folding tuples down to a single number by chaining Cantor's pairing function is that this approach is significantly easier to reason about due to its geometric foundation. This technique also produces polynomial bijections from N^m to N of degree m, which for odd m, is lower than using Cantor's. An example application in Computer Science, iterating through infinite spaces in "list comprehensions," is lightly discussed.

Samuel Vardy
Southwestern University

The Price of Health

In the past fifteen years, the healthcare system and cost of healthcare in the United States has become increasingly more complicated and more expensive. We examine data on the National Healthcare Expenditure (NHE) and analyze the relationship between other variables and NHE. The analysis includes linear regressions that model healthcare costs. Specifically data on the cost of different sectors in the healthcare system is used. These include prescription drugs, hospital visits, personal healthcare, GDP, and population.

Notes