MAA MATHFEST

August 3-6, 2016

Abstracts of Papers

Presented in Columbus, OH

MAA 100
MATHEMATICAL ASSOCIATION OF AMERICA
CELEBRATING A CENTURY OF ADVANCING MATHEMATICS

Abstracts of Papers
Presented at
MathFest 2016
Columbus, OH
August 3 – 6, 2016

Published and Distributed by
The Mathematical Association of America

Invited Addresses

Earle Raymond Hedrick Lecture Series

Hendrik Lenstra Universiteit Leiden

Lecture 1: The Group Law on Elliptic Curves
Thursday, August 4, 10:30–11:20 AM, Regency Ballroom

The theory of elliptic curves is a showpiece of modern mathematics. Its implications are felt from the brightest parts of number theory, where it supplied the key to Fermat's Last Theorem, to the darkest corners of cyberspace, where it provides the workhorses of secret communication. How much of the theory can with lucidity and rigor be developed in an undergraduate algebra course? The lecture outlines an approach to at least establishing the group law, using no other tools than what such a course ordinarily already covers.

Lecture 2: The Combinatorial Nullstellensatz
Friday, August 5, 9:30–10:20 AM, Regency Ballroom

Noga Alon's combinatorial Nullstellensatz (1999) is a quantitative sharpening of the familiar fact that a non-zero polynomial in several variables over an infinite field defines a function that does not vanish everywhere. It has an impressive number of consequences of a combinatorial nature, and forms an excellent example of what algebra can do for the non-algebraist. As the lecture shows, the combinatorial Nullstellensatz also belongs to the algebraist's own toolbox. A characteristic application is an elegant theorem about matrices that is just one step away from one of the loveliest theorems of Galois theory: the existence of a normal basis in any finite Galois extension.

Lecture 3: Profinite Number Theory
Saturday, August 6, 9:30–10:20 AM, Regency Ballroom

What is a number? Surprisingly, one of the fundamental notions of mathematics is never given a rigorous definition. Usage determines the meaning of the word. When one refers to the typical element of some ring as a "number" , one expresses a certain familiarity with that ring. The algebraist who defines a new ring creates a new species of number, and may feel master of the universe. Profinite numbers are elements of the ring of profinite integers, an important instrument in both infinite Galois theory and arithmetic geometry. In the lecture, the world of profinite numbers with its wealth of wonders is explored for its own sake.

AMS-MAA Joint Invited Address

Thursday, August 4, 9:30–10:20 AM, Regency Ballroom

Ravi Vakil Stanford University

Understanding Geometry (and Arithmetic) through Cutting and Pasting

Euler's famous formula tells us that (with appropriate caveats), a map on the sphere with ff countries (faces), e borders (edges), and v borderends (vertices) will satisfy $v - e + f = 2$. And more generally, for a map on a surface with g holes, $v - e + f = 2 - 2g$. Thus we can figure out the genus of a surface by cutting it into pieces (faces, edges, vertices), and just counting the pieces appropriately. This is an example of the topological maxim "think globally, act locally" . A starting point for modern algebraic geometry can be understood as the realization that when geometric objects are actually algebraic, then cutting and pasting tells you far more than it does in "usual" geometry. I will describe some easy-to-understand statements (with hard-to-understand proofs), as well as easy-to-understand conjectures (some with very clever counterexamples, by M. Larsen, V. Lunts, L. Borisov, and others). I may also discuss some joint work with Melanie Matchett Wood.

MAA Invited Addresses

Thursday, August 4, 8:30–9:20 AM, Regency Ballroom

Robert Megginson University of Michigan

Mathematical Sense and Nonsense outside the Classroom: How Well Are We Preparing Our Students to Tell the Difference? Network Science: From the Online World to Cancer Genomics

"Mathematics will always be a key element of liberal education, since it promotes logical reasoning." You have likely heard this claim, or perhaps made it yourself. And we generally do a decent job of teaching our mathematics and statistics students how to avoid certain types of errors in their own deductive and inductive reasoning. But it is not so clear that we have done as good a job of preparing our students to examine critically the reasoning, mathematical and otherwise, of others who are trying to convince us to buy their product or adopt their position on an issue. In this presentation, which expands upon an invited 20 minute talk given at JMM 2013 in San Diego, the speaker will propose a three-category classification of types of fallacious mathematical arguments that have been used to try to convince the public of the wisdom of a policy decision or the safety of a new product, in the hope of starting a conversation about where and how in our school and college mathematics curricula we could better prepare students to be suspicious when presented with arguments in each category, and help them think about the questions they should ask when their suspicions are aroused. Examples will be given, several with roots in applications of mathematics to climate science, one of the speaker's interests. For those involved in teacher preparation or who are K-12 teachers themselves, some connections to the Common Core standards will be given.

Friday, August 5, 10:30–11:20 AM, Regency Ballroom

Arthur Benjamin Harvey Mudd College

Magical Mathematics

We will explore mathematical magic tricks using cards, calculations, and combinatorics! Sometimes the underlying mathematical secret is just as interesting as the magic trick itself.

Saturday, August 6, 10:30–11:20 AM, Regency Ballroom

Judy Holdener Kenyon College

Immersion in Mathematics via Digital Art

The relationship between mathematics and art has a long and rich history. Artists past and present have used mathematics in significant ways to carry out their artistic vision, and mathematicians have used formulas, algorithms and computers to produce art. In my own case, I find art to be a good medium for conveying the nature of mathematics to a wide audience. In this lecture I examine my recent venture into digital art with the creation of a mathematical artwork I title "Immersion" . The surface patterns in the piece reflect my own day-to-day immersion in mathematics, depicting patterns that relate to the content of courses I teach as well as research I have conducted with undergraduates in the area of dynamical systems. I will describe how patterns in the piece reflect the connection between two well-known mathematical objects: the Thue-Morse sequence and the von Koch curve. Additionally, I will describe how the formal mathematical meaning of "immersion" plays a role in the composition of my piece. In particular, my work highlights "Boy's Surface" , which is an immersion of the real projective plane into three-dimensional Euclidean space.

James R.C. Leitzel Lecture

Saturday, August 6, 8:30–9:20 AM, Regency Ballroom

Annalisa Crannell Franklin & Marshall College

Inquiry, Encouragement, Home Cooking (And Other Boundary Value Problems)

When you teach an abstract algebra class in a bagel shop, there's this problem: you have no chalkboards. Likewise, no chalk. Worse yet, the acoustics are lousy for lecturing, especially if you are trying to keep your voice down so you don't annoy the non-algebra bagel customers. But crossing the threshold into new physical spaces can lead to crossing metaphorical boundaries into strange and wonderful new pedagogies. In this talk we'll explore a personal approach to stumbling into inquiry-based learning. Along the way, we'll meander into developing pragmatic strategies that help us in cheerleading for our students, and of course, we'll celebrate food.

AWM-MAA Etta Z. Falconer Lecture

Friday, August 5, 8:30–9:20 AM, Regency Ballroom

Izabella Laba University of British Columbia

Harmonic Analysis and Additive Combinatorics on Fractals

A plane is flat; a sphere is curved. Both are smooth, well behaved surfaces on which one can define measure and integration. If a harmonic analyst only knows the behaviour of analytic objects associated with a given surface, for example singular or oscillatory integrals, can she tell whether the surface is curved or flat? It turns out that, yes, the geometry of the surface is indeed reflected in such analytic estimates. It might be somewhat surprising that similar phenomena have also been observed for fractals, including Cantor-type sets on the line. Some fractals behave, from the analytic point of view, as if they were flat; others display features typical of the sphere, and we have also seen additional types of behaviours that are never observed for smooth surfaces. The recent work investigating such phenomena highlights the connection to arithmetic properties of fractals, expressed in terms of "randomnes" and "structure".

MAA Chan Stanek Lecture for Students

Thursday, August 4, 1:00–1:50 PM, Regency Ballroom

Colin Adams Williams College

Zombies & Calculus: A Survival Guide

If you are reading this, then you have managed to survive the zombie apocalypse so far. Congratulations! But as the world sinks further into ruin, what additional strategies can you apply to endure the onslaught? Learn how calculus can help you to defeat the zombie hordes. The lecture room will be certified a safe haven for the duration of the talk.

Pi Mu Epsilon J. Sutherland Frame Lecture

Friday, August 5, 8:00–8:50 PM, Regency Ballroom

Robin Wilson Open University

Combinatorics - The Mathematics That Counts

How many Sudoku puzzles are there? Are there 33 Londoners with the same number of hairs on their head? Can a knight visit all the squares of a chessboard just once? And can we tile a floor with squares and regular hexagons? These are all problems in combinatorics, the branch of mathematics concerned with selecting, arranging, counting and listing things. In this talk I shall illustrate the nature and uses of combinatorics by means of a number of entertaining problems.

NAM David Harold Blackwell Lecture

Friday, August 5, 1:00–1:50 PM, Regency Ballroom

Robert Hampshire University of Michigan

Urban Analytics: The Case for Smart Parking

Parking management has been a vexing problem for cities since the invention of the automobile. One concern is excess travel, congestion, air pollution and greenhouse gas (GHG) emissions that are caused by drivers searching for available parking –an activity colloquially known as cruising. A recent study by UCLA economist and urban planner, Donald Shoup, found that in a 15-block area of Westwood, cruising for parking generates 950,000 excess vehicle-miles of travel, wastes 47,000 gallons of gas, 100,000 hours and produces 730 tons of greenhouse gas carbon dioxide per year. I present the results of an investigation of this problem using queueing theory, stochastic processes, statistics including the Rao-Blackwell theorem, optimization and machine learning. The analysis is enabled by a large dataset of sensor data, cell phone data, parking payment data, and connected vehicle data.

Presentations by Alder Awards Winners

Alder Award Session

Friday, August 5, 2:30–4:00 PM, Hayes

The MAA established the Henry L. Alder Award for Distinguished Teaching by a Beginning College or University Mathematics Faculty Member to honor beginning college or university faculty members whose teaching has been extraordinarily successful and whose effectiveness in teaching undergraduate mathematics is shown to have influence beyond their own classrooms. Each year, at most three college or university teachers are honored with this national award. The awardees are invited to make a presentation in this session. The session is moderated by Francis Su, Harvey Mudd College, MAA President.

This year's honorees are:

Dandrielle Lewis *University of Wisconsin - Eau Claire*
Jana Gevertz *College of New Jersey*
Benjamin Galluzzo *Shippensburg University*

Dandrielle Lewis University of Wisconsin - Eau Claire

Do You: How Mathematics + Mentoring + Passion = Opportunities
2:30–2:50 PM
Becoming a mathematics professor was not my lifelong dream, but experiences along life's journey changed my perspective. Mathematics, effective mentoring, and my passion to excel provided "the ticket" to sit at a table where I create opportunities for students, underrepresented populations, and women in STEM. In this talk, I will discuss my journey, how it influenced my teaching and involvement in student-centered projects and research, and why making a lifelong impact on students is important to me.

Jana Gevertz College of New Jersey

Two Human Faces of Mathematics: Students and Medicine
3:00–3:20 PM
As a mathematical biologist who works to better understand cancer dynamics, I often dream of the day that my mathematical models will be used by clinicians to help prolong or save the lives of patients suffering with cancer. Yet I accept that as hard as I will continue to work, it is a long shot that my research will vastly impact humanity by altering the landscape of cancer treatment. A more achievable goal, however, is to use my mathematics classroom and my interaction with students as a way to have a positive impact on as many individuals as possible. It is my belief, and this belief is beginning to get research support, that when a teacher exhibits genuine interest in their students' success and lives, the impact on students' motivation and learning can be significant. Admittedly, what I can accomplish in the classroom is of a different scale than my lofty goal of improving cancer care. That said, having a positive impact on the motivation, growth, and content knowledge of as many students that cross my path as possible represents another face in how mathematics can be used to impact the lives of others.

Benjamin Galluzzo Shippensburg University

Modeling Across the Curriculum
3:30–3:50 PM
Numbers matter. Numerically based statements frequently serve as the primary justification for positions on provocative topics of general interest such as politics, economics or sustainability. In this talk, we'll investigate how the math modeling process provides students, of all levels and mathematical backgrounds, with an accessible tool for deconstructing numbers they encounter on a daily basis. In particular, we'll discuss examples that motivate student engagement in curricular mathematics.

Invited Paper Sessions

Knot Theory

Part A: Thursday, August 4, 8:30–9:50 AM, Fairfield

Organizers: Colin Adams Williams College
Lew Ludwig Denison University

With the increase in undergraduate research there is also an increased need for open and accessible problems for students to tackle. Knot theory is particularly fertile ground for such problems. Each speaker in this session will introduce a topic, pose three open questions that are accessible to undergraduate research, and place the questions in context of the topic.

Colin Adams Williams College

Turning Knots into Flowers: Petal Number and related Problems

8:30–8:50 AM

Working with students, we found that every knot has a petal diagram, a projection with just a single multi-crossing and petals around it like a daisy. We will discuss past work of students and the variety of open problems about petal projections, petal numbers and the generalizations to ubercrossing number and multi-crossing number.

Jennifer McLoud-Mann University of Washington, Bothell

Knot Mathematical Fiddlestix: An Introduction to Lattice Knots

9:00–9:20 AM

This talk will be an introduction to lattice knots in the simple cubic, simple-hexagonal, face-centered, and body-centered cubic lattices. An appealing feature of working with lattice knots is their discrete nature - students get to play with stix to formulate conjectures! Examples of projects used to introduce undergraduates to mathematical research in this accessible area will be given as well as ideas for future work.

Cynthia Curtis College of New Jersey

Problems Related to Spanning Surfaces of Knots

9:30–9:50 AM

Surfaces in knot complements with boundary the knot play a large role in understanding both knots and 3-dimensional spaces. These surfaces are used in the construction of many sophisticated, modern knot invariants. Using a collection of such surfaces, we discuss three concrete, fairly combinatorial problems accessible to undergraduates which are motivated by more advanced questions in knot theory.

Part B: Thursday, August 4, 2:00–4:20 PM, Fairfield

Louis Kauffman University of Illinois, Chicago

Rope Magic and Topology

2:00–2:20 PM

In this talk the speaker will perform rope magic that appears to contradict topological theorems. Rope will be supplied to the members of the audience so that they can participate in this event. There are a number of possible outcomes for this talk. (1) Members of the audience may become convinced that basic knot theory is utterly wrong. For example, they will see a demonstration of the cancellation of the connected sum of two non-trivial knots. They will see a demonstration of the connected sum of two non-trivial knots coalescing to a single non-trivial prime knot. Knots will appear and disappear on a rope without sliding out the ends of the rope. Hands will penetrate small loops by what seems to be an access to higher dimensional spaces. (2) The lecturer may disappear into 4-space. https://books.google.com/books?id=UK8UJLpA3SgC&pg=PA99&lpg=PA99&dq=The+no-sided+professor&source=bl&ots=2Jl4F1hXW0&sig=f2LaF0I48cmBDTJ0XHICi4Rkxw0&hl=en&ei=JNGiTOLZ KdKGnQf22uWIBA&sa=X&oi=book_result&ct=result#v=onepage&q=The%20no-sided%20professor&f=false (3) The lecturer may not disappear into 4-space, but the meeting grounds of the MAA may disappear into 4-space. http://homepages.math.uic.edu/k̃auffman/CrookedHouse.pdf (4) None of the above. (5) All of the above.

Candice Price Sam Houston State University

Accessible Problems for Undergraduates in Knot Coloring

2:30–2:50 PM

This talk will include a brief discussion of two invariants for knots: Fox-coloring and N-colorability. We include various examples and conclude by posing some problems concerning these invariants that can be explored. The invariants introduced here are arithmetic and algebraic and thus provide easily attainable projects for undergraduates.

Lew Ludwig Denison University

Computer Algorithms for Counting Knot Mosaics
3:00–3:20 PM
In 2006, Lomonaco and Kauffman introduced another way to depict knots, knot mosaics, which uses 11 distinct 1x1 tiles. A relatively new topic, knot mosaics provide a treasure trove of open questions for undergraduate research. In this presentation, we will discuss my work with undergraduate students to use computer algorithms to count the number of distinct knot mosaics that can occur on square mosaic board. This presentation is intended for a general mathematical audience.

Jennifer Townsend Bellevue College

Gamifying Knot Theory
3:30–3:50 PM
Phrasing knot theory questions as games can provide inherent motivation for research, encourage creative construction of (counter)examples, and lead to unique perspectives and approaches. It also opens doors into new and approachable questions. We examine a few such questions, and discuss how a game-based approach can benefit students new to mathematical research.

Allison Henrich Seattle University

Unknotting Knots
4:00–4:20 PM
There are several ways of unknotting knots. The classical unknotting operation is the crossing change, but there are others. The delta and sharp moves are two interesting examples that were discovered in the 1980's by Murakami and Nakanishi. More recently, Ayaka Shimizu discovered another unknotting operation called the region crossing change. This new move has led us to ask classical unknotting questions in the region crossing change setting. We'll consider several of the questions that have been studied by undergraduate researchers in the last couple of years as well as related questions that have yet to be explored.

The Mathematics of Games

Thursday, August 4, 2:00–3:50 PM, Harrison

Organizer: Michael Catalano-Johnson Susquehanna International Group

Games, how to win them and how to design them, often lead to mathematical questions. Generally intractable games, such as poker, have 'toy' variants that yield to explicit mathematical analysis, while some simple 'solved' games such as tic-tac-toe become very challenging when moves are auctioned to the highest bidder. The talks in this session discuss the design considerations of games and the determination of optimal play in both games of chance and no-chance.

David Pettey Susquehanna International Group

Recent Advances in Game Design
2:00–2:20 PM
Over the past 20 years there have been noticeable advancements made in game design that have led to significantly more enjoyable games. We will highlight several of the general principles employed to improve design, and why we believe they lead to better games.

Bill Chen Susquehanna International Group

Solving Poker-Like Games
2:30–2:50 PM
We will look at how to solve 'toy' poker games, using examples from the book 'The Mathematics of Poker' by Chen and Ankenman, and what the solutions mean for real poker games.

Daniel Loeb Susquehanna International Group

Richman Games
3:00–3:20 PM
In Richman games (aka bidding games), rather than alternating moves, the two players bid for the privilege of making the next move. Players may or may not know the bankroll of their opponents. We discuss optimal strategies for players.

Michael Catalano-Johnson Susquehanna International Group

Misère Russian Roulette (with Multiple Revolvers)
3:30–3:50 PM
Two players take turns removing (without replacement) a random stone from a player selected urn, each containing known mixtures of black and white stones. A player wins as soon as he or she draws a white stone. How to play? sometimes the correct play is counterintuitive. We establish simple to calculate rules for optimal play.

Mathematics and Magic

Friday, August 5, 1:00–3:55 PM, Fairfield

Organizer: Arthur Benjamin Harvey Mudd College
Speakers will demonstrate and explain magic tricks based on interesting mathematical principles.

Irl Bivens Davidson College

Tricks You Can Count On
1:00–1:15 PM
In Spring 2016 I taught a course at Davidson College entitled "Math, Magic, and Mystery". The course satisfied a graduation requirement in "Mathematical and Quantitative Thought" and the students in the class were bright and enthusiastic, but had limited technical facility in mathematics. The first component of the course consisted of tricks built upon counting cards or coins in unusual ways. Such tricks provide a natural pathway into important mathematical concepts such as one-to-one correspondence, the pigeonhole principle, and inclusion-exclusion. In this talk I will focus upon the use of a one-to-one correspondence to help students understand a brilliant self-working card trick that Martin Gardner referred to simply as "Henry Christ's Improvement".

Steve Butler Iowa State University

Shuffling Cards and Binary Numbers
1:20–1:35 PM
Magicians (and more recently mathematicians) have worked to master the art of shuffling to manipulate cards in the deck. We will focus on one particular type of shuffling, the perfect shuffle, and look at how this can be used together with binary numbers to manipulate the location of a card in the deck.

Doug Ensley Shippensburg University

More Card Effects from the Perfect Shuffle
1:40–1:55 PM
In this presentation we will explore variations on the inverse perfect shuffle that preserve some of the properties that make perfect shuffleeffects so interesting mathematically. The corresponding small packet effects rely on invariant properties well known for perfect shuffle tricks, while allowing the flexibility of having a spectator mix the cards.

Ron Graham University of California, San Diego

Dunninger Meets DeBruijn
2:00–2:15 PM
Joseph Dunninger was one of the most famous mentalists of all time. N. G. de Bruijn was a well-known mathematician with notable contributions in analysis, number theory, and combinatorics. What links them together? Come to the talk and find out!

John Harris Furman University

Telepathy or Tele-mathy-y?
2:20–2:35 PM
"Is your number 1089?" "Are you thinking of a gray elephant from Denmark?" These are the punchlines from some classic (but simple) mathematical mind-reading tricks. In this talk, we will have a look at a fun mind-reading effect that relies on a more sophisticated concept relating to Fibonacci and the lucky number 7.

Liz McMahon Lafayette College
Hannah Gordon Lafayette College

Tricks with SET

2:40–2:55 PM

The card game SET gives rise to tricks that look quite magical. The tricks can shed light on the geometry, and modular arithmetic, that underlies the game. These tricks show how using mathematics increases the enjoyment of an already enjoyable game.

Colm Mulcahy Spelman College

Fitch Cheney's 5 Card Trick for Values of 5 Less Than 5

3:00–3:15 PM

Fitch Cheney's classic five card trick sees two mathematicians, Aodh and Bee hand out a deck of cards for mixing. Five random cards are given to Aodh, while Bee looks away. Aodh displays four of the cards in a row on the table, following which Bee inspects them. Soon Bee identifies the fifth card. It's entirely based on mathematics. This can be generalized to work if just four cards are selected at the outset and given to Aodh, three of which are then shown to Bee. It even works if we start with three cards, and amazingly, if we start with two cards. In all cases, Bee can identify one card whose face is not seen.

Heather Russell University of Richmond

This is Knot a Trick!

3:20–3:35 PM

A knot is a flexible embedding of a circle in three-dimensional space. Knot theory seeks to understand properties of knots and is particularly interested in distinguishing between different knots. In this demonstration, we will explore the concept of unknotting a knotas well as obstructions to doing so. This talk is inspired by Louis H. Kauffman's excellent repertoire of knot tricks.

Tim Chartier Davidson College
Tanya Chartier Davidson College

Stretching Your Mind with Topological Mime

3:40–3:55 PM

Tim and Tanya Chartier have performed their mime show throughout the United States and in such countries as Holland, Japan and South Korea. The presentation introduces mathematical ideas to audiences using the illusionary world of mime to visualize the often invisible world of mathematics. This talk will demonstrate mime pieces that introduce topology, from tying a tie to a human-sized Slinky. Come see how topological ideas can come alive through the silent world of mime.

Mathematics and the Life Sciences at MBI

Friday, August 5, 1:00–4:10 PM, Harrison

Organizer: Reginald L. McGee Mathematical Biosciences Institute

In this session we demonstrate how the mathematical sciences help address important and interesting questions in neuroscience, virology, cancer immunology, cellular communication, and sleep cycle dynamics. Abstract: Using mathematics to gain new insights into the biological sciences requires the use of existing techniques and also the development of new mathematics. The interplay between math and life sciences is a key component of the mission of the Mathematical Biosciences Institute (MBI). This session samples research related to several of MBI's recent and upcoming thematic programs: molecular biosciences, cancer and the immune system, network dynamics, mathematical neuro-science, and the analysis of complex data. In this session, we discuss how the mathematical sciences are utilized to make contributions to biological and biomedical questions. Theory and concepts from algebra, geometry, dynamical systems, numerical analysis, probability theory, and other areas will be presented. The math will be used to uncover symmetries in neural activity, quantify signaling dynamics inside cancerous immune cells, consider the impact of oscillations on coupled cells, investigate circadian rhythms and energy regulation, and increase the understanding of viruses and how to overcome their resistant nature.

Janet Best The Ohio State University

Why We Sleep: Math Sheds New Light on Personal Energy Conservation

1:00–1:30 PM

While sleep was long considered an energy conservation strategy, the modest calculated savings led to skepticism that energy conservation is the function of sleep, particularly given sleep's inherent costs in vulnerability. Using a mathematical model, we recalculate the energy savings due to sleep and argue that energy conservation is actually the ultimate function of sleep.

Richard L. Buckalew Mathematical Biosciences Institute

Dynamical Systems and Emergent Properties of Cell Networks
1:40–2:10 PM
The dynamics of individual cells lies at the root of much of biology, yet individual cells almost never exist in isolation. Modes of interaction between cells are usually limited to simple signals, but simple interactions at the individual level can lead to surprisingly complex behavior at the population (or organism) level. Syncytial embryos, wherein many nuclei share their cytoplasm, are fertile ground for demonstrating and investigating such behaviors. Simple interactions lend themselves well to mathematical description, and through mathematical modeling we have gained insight into the fascinating behavior of Drosophila and Xenopus embryos, both of which are syncytial.

Reginald L. McGee Mathematical Biosciences Institute

Singled Out: Using Single-Cell Data to Identify Signaling Trends in Leukemia
2:20–2:50 PM
Mass cytometers can record tens of features for millions of cells in a sample, and in particular, for leukemic cells. Many methods consider how to cluster or identify populations of phenotypically similar cells within cytometry data, but there has yet to be a connection between cell activity and other features and these groups or clusters. We use differential geometric ideas to consider how cell cycle and signaling features vary as a function of the cell populations. This consideration leads to a better understanding of the nonlinear relationships that exist in the cytometry data.

Farrah Sadre-Marandi Mathematical Biosciences Institute

An Insight to Viral Assembly through Normal Model Analysis
3:00–3:30 PM
Normal mode analysis, also known as harmonic analysis, is applicable to many fields. It identifies the natural, resonant movements of a physical object, such as a building, guitar string or molecule. In this talk, I will demonstrate how to apply normal mode analysis to proteins. Specifically, this analysis will be applied to predict how proteins move during HIV viral assembly.

Marty Golubitsky Mathematical Biosciences Institute

Binocular Rivalry and Symmetry Breaking
3:40–4:10 PM
Binocular rivalry discusses how a subject perceives images when different images are shown to the subject's left and right eyes. More generally, rivalry addresses the question of how the brain deals with contradictory information. This talk will discuss a generalized model for rivalry proposed by Hugh Wilson and show how rigid phase-shift synchrony in periodic solutions of coupled systems of differential equations can help understand the surprising results of several binocular rivalry experiments. This is joint work with Casey Diekman

Numbers, Geometries, and Games: A Centenarian of Mathematics

Saturday, August 6, 1:00–3:10 PM, Fairfield

Organizers: Steve Butler Iowa State University
Barbara Faires Westminster College

Born nearly at the same time as the MAA, Richard Guy has had a tremendous impact on mathematics through his (continuing) work in number theory, geometry, and game theory. This session brings together friends an colleagues to talk about these mathematical areas, to celebrate Richard's achievements, and to mark his transition to his second century.

Ron Graham University of California San Diego

Sums of Unit Fractions
1:00–1:20 PM
In this talk I will describe a number of results and open problems dealing with so-called Egyptian fractions, i.e., representations of rationals as sums of unit fractions with distinct denominators. These occur in some of the earliest known mathematical manuscripts (approxapprox1650 B.C) and were a favorite topic of the late Paul Erdős. These are also covered in Richard Guy's Unsolved Problems in Number Theory and, in particular, it was the references there which were responsible for the most recent paper of Erdős (published within the last year).

Jeffrey Lagarias University of Michigan

Products of Farey Fractions
1:30–1:50 PM

The Farey fractions of order N are the rational fractions in the unit interval which in lowest terms have denominators at most N. Farey fractions have generally been studied additively, as in Problem F11 in Richard Guy's book, Unsolved Problems in Number Theory. We describe results arising from an REU project that studies them multiplicatively: How do products of all (nonzero) Farey fractions of order N behave, as a function of N? This work was done with Harsh Mehta (now a grad student at U. South Carolina).

Steve Butler Iowa State University

Some Tiling Problems
2:00–2:20 PM

Many interesting mathematical problems arise from and can be related to problems involving tiling. We discuss a tiling problem with connections to well known integer sequences and also consider a result of tiling which blends geometry and number theory.

Elwyn Berlekamp University of California Berkeley

Fibonacci Plays Billiards, Again
2:30–2:50 PM

One version of the classic traveling salesman problem seeks to determine whether or not, in any given graph, there exists a "Hamiltonian path" which traverses every node exactly once. In the general case, this problem is well-known to be NP Hard. In one interesting subclass of this problem, the nodes are taken to be the first N integers, $\{1, 2, 3, \ldots, N\}$, where there is a branch between J and K if $J + K$ is in a specified set $S = \{S[1], S[2], S[3], \ldots, S[M]\}$. Or, given S, for what values of N does a Hamiltonian path exist? How fast can the elements of S grow such that there exist solutions for infinitely many N? The answer to the second question turns out to be a close relative of the Fibonacci numbers, for which we construct solutions by observing the path of a billiard ball which travels at 45 degree angles to the sides of its table. Using the same billiard ball methodology, we also find some particular solutions when S is the set of squares or the set of cubes.

Richard Guy University of Calgary

Remarks
3:00–3:10 PM

Undergraduate Research Projects in the Mathematical Sciences

Saturday, August 6, 1:00–3:20 PM, Harrison

Organizers: Pamela E. Harris Williams College
Alicia Prieto Langarica Youngstown State University

The undergraduate mathematics curriculum continues to evolve from expository classes to students working on original research projects. This curriculum change has created a need in the mathematical community for more REU programs and for faculty to develop accessible research projects for students at their respective institutions. For new faculty, developing such projects may be challenging, as their particular expertise might require extensive background and is hence not suitable for an undergraduate audience. Fortunately, faculty programs, such as The Center for Undergraduate Research in Mathematics (CURM) Mini-Grants, Preparation for Industrial Careers in Mathematical Sciences (PIC Math) Preparing Undergraduates Through Mentoring toward PhD's (PUMP), Project NExT (New Experiences in Teaching), and Research Experience for Undergraduate Faculty (REUF), have an impressive track record of helping faculty develop and promote accessible research projects at the undergraduate level. In this session, past CURM, PIC Math, PUMP, Project NExT, and REUF faculty participants present the mathematical results of their student's original mathematical research and share tools they learned and used to develop these projects. In addition, speakers will provide early-career faculty with information related the respective faculty programs and open problems that are accessible to undergraduate students. Mathematical topics are broad and include number theory, graph theory, applications of PDEs, and industrial mathematics.

Naiomi Cameron Lewis & Clark University

Counting Dessins
1:00–1:20 PM

In this talk, I will discuss an undergraduate research agenda which originated at a 2012 AIM REUF Workshop. The objective of the research is to contribute to the efforts to better understand the Galois orbits of dessins through combinatorial, topological, geometric and/or arithmetical points of view. I will describe the motivation and outcomes of two undergraduate research experiences that have resulted from this agenda. In the first, an eight-week experience over the summer of 2014, the research group explicitly computed Belyi maps for trees with passports of size 1 or 2. In the second, a semester long experience over the spring of 2016, the research group tackled the problem of enumerating dessins whose passport is given by a triple of partitions.

Michael Dorff Brigham Young University

PIC Math: A Course for Undergraduate Students to Do Research on Actual Problems from Industry

1:30–1:50 PM

PIC Math is a new program to prepare undergraduate students in the mathematics and statistics to succeed in careers in business, industry, and government (BIG). Funded by a $2 million NSF grant, this program strives to (a) increase awareness among faculty and students about non-academic career options, (b) pro- vide undergraduate research experience using problems from industry, and (c) pre- pare students for industrial careers. The program includes a 3-day faculty summer training workshop, a spring semester course in which students learn skills and work on research problems from industry, and an end-of-program research conference at which the students present. For the semester course, we have developed a set of educational and informative videos and prepared materials for the course such as sample syllabi, set of sample research problems from industry, sample student solutions to industrial research problems, and sample videos of student presenting their research. During the 2015-2016 academic year we have math departments at 50 different institutions with over 500 students participating.

Cynthia Flores California State University, Channel Islands

Constructing Solutions to Truncated Moment Problems and Applications to PDE; a PUMP Undergraduate Research Group

2:00–2:20 PM

This presentation outlines an investigation of the synergy between truncated moment problems and their wide applications in the theory of partial differential equations (PDEs). For instance, some PDEs display a special time evolution of the moments up to a finite order, such as in the case of the Benjamin-Ono equation, a model for long internal gravity waves. As part of this project, undergraduate student participants study how to derive useful measures with prescribed moment properties. In this talk, we discuss the motivation of the project, the undergraduate student involvement, as well as the mathematical results.

Aparna Higgins University of Dayton

Undergraduate Research in Pebbling

2:30–2:50 PM

Since it was introduced in 1989, the topic of pebbling on graphs has been a source of interesting and accessible problems for researchers, including undergraduates. Given a connected graph G and a distribution of non-negative integers on its vertices, a pebbling move on G is defined as the removal of two pebbles from one vertex, followed by the placement of one of those pebbles on an adjacent vertex. The pebbling number $f(G)$ of a graph is the minimum number of pebbles needed such that, given any distribution of $f(G)$ pebbles on G, one pebble can be placed on any specified but arbitrary vertex through a sequence of pebbling moves. The talk will describe results by undergraduates on pebbling and on some of its variations. We will also show, via the example of pebbling, some general ideas on how to create problems that may be tractable for engaging undergraduates in research at one's own institution.

Thomas Wakefield Youngstown State University

Research Collaborations in the Public Sector

3:00–3:20 PM

As part of the PIC Math (Preparing for Industrial Careers in Mathematics) program offered by the MAA, Youngstown State offered students the opportunity to work on research problems originating from the Youngstown Police Department and other agencies under my direction. Although originally planned for one semester, the students' work on the YPD project extended throughout the summer and into the next academic year. We will discuss the project, address the benefits and challenges of such partnerships, and offer tips for finding such partnerships.

Themed Contributed Paper Sessions

Inviting All Students to Do Mathematics – Engaging Courses, Projects, and Activities for Liberal Arts Students

Part A: Thursday, August 4, 8:30–10:05 AM, Union B

Organizers: Jennifer Nordstrom Linfield College
Suzanne Doree Augsburg College
Sarah Mabrouk Framingham State University
Victor Piercey Ferris State University
Curriculum Renewal Across the First Two Years (CRAFTY) Committee

All students should have the opportunity to do mathematics in a meaningful way for the sheer fun of it. Such experiences, if well designed, improve students' effective thinking skills, increase their appreciation of the beauty and utility of mathematics, and prepare them to be mathematically-literate members of society. This session invites talks on how we can engage the liberal arts student through courses specifically designed for them. We welcome presentations on innovative course design, pedagogy, projects, or activities, as well as talks on tools used to assess such courses. Presentations should include a research basis for the design or pedagogical choices, a report on outcomes in student learning or attitude, or other evidence of success. Papers about programs demonstrating success engaging students who enter the course reluctant to engage in mathematics are especially encouraged. We also welcome talks on first year seminars or other experiences that engage first year students in doing mathematics as well as Honors courses in mathematics that incorporate the liberal arts.

Philip Hotchkiss Westfield State University

Pascal, Rascals and Inquiry

This year several of us from the *Discovering the Art of Mathematics* project have had some remarkable student results while exploring Pascal's Triangle and the Rascal Triangle in our Mathematics for Liberal Arts (MLA) courses. Our students made several discoveries: a new number triangle related to both Pascal's Triangle and the Rascal Triangle, a simpler rule, as well as some equivalent rules (all of which were heretofore unknown), for generating the Rascal Triangle as well as several patterns within the Rascal Triangle. This inquiry has resulted in a wonderful level of engagement and excitement in mathematics for these students, many of whom have been disenfranchised by their previous mathematical education.

Brandy S. Wiegers Central Washington University

Mathematics Around Central Field-Trips

Mathematics around Central is a new one hour weekly seminar that orchestrates weekly field-trips to locations around our university campus and reveals the mathematics hidden across campus. Some field-trip locations included campus exhibitions at the art gallery, cultural museum, and the green house. Other locations included existing campus projects such as walking the scaled solar-system model spanning across campus and visiting physic's Foucault pendulum. A combination of math and liberal art majors in the course provided the opportunity for engaged in-class discussion of the connections between the field-trips and mathematics. Some connections were obvious (the art gallery had an exhibit on quantitative painting) while other field-trips provided the opportunity to connect mathematical concepts of patterns, symmetry, and sequences. Students especially appreciated the opportunity to learn about geocaching and at the end of class the students created a photo book that talks about the math at each of these experiences to share with future students. This was shared in the new geocache which was created by the students to commemorate their seminar experience.

Pamela Peters San Juan College
Lisa Ruffier San Juan College

How I Spent My Summer Vacation or How to Plan and Organize a Math Study Abroad

In the summer of 2015, we led a very successful study abroad trip to Italy for students at our two year college, with the title, "Da Vinci, Scientist and Mathematician" . We believe that Study Abroad is an excellent way for students to broaden their horizons and enhance their world view. It also makes them more competitive in the job market where companies are becoming increasingly more global. Unfortunately, when we started working on this project, we found that there are no commercially available study abroad trips with any kind of a math emphasis. So we jumped into the deep end of the pool to organize our own Study Abroad trip. We will share our challenges, insights and recommendations gained from this fun and interesting endeavor.

Bahman Kalantari Rutgers University

Making Polynomials Fun for All Via Polynomiography

Supported by numerous experiences with *Polynomiography*, I believe there is convincing evidence that polynomials could be turned into fun objects for all: not only K-16 students and educators, but the general public, even children. Polynomiography stands for algorithmic visualization in solving polynomial equations. Its underlying concepts and techniques, together with its software and apps help associate a kind of visual beauty to polynomials that offers numerous applications in STEM, fine art and more. It gives rise to numerous colorful images, not just fractal ones. More importantly, not only Polynomiography inspires students into learning diverse mathematical and algorithmic concepts, it promotes creativity and innovative applications of polynomials, far beyond the ordinary and dry applications in math and science. At Rutgers I have taught Polynomiography through Honors courses, First-Year Seminars, and undergraduate research programs. I have also collaborated with middle and high schools in New Jersey and elsewhere in designing related activities. In this talk I will describe several related experiences and activities. I will also invite educators into collaborations that would help them and their students experience the power and beauty of Polynomiography.

Edmund A. Lamagna University of Rhode Island

Puzzles + Games = Analytical Thinking

Puzzles and games provide a rich environment for acquiring critical mathematical thinking skills through active learning. The presenter designed and teaches a liberal arts math course using puzzles and games. Most students enrolled are non-STEM majors using the class to fulfill a general education requirement. Puzzles and games provide a way to ”level the playing field” among students with vastly different mathematical backgrounds. Importantly, students enjoy mathematical puzzles, and will put more effort into them than routine exercises. The course is taught without lectures. Students spend most of a class period working in small groups (2-4 individuals) solving several related puzzles or playing a game with a mathematical theme. Toward the end of class, students present and discuss their solutions with guidance from the instructor. Students individually write solutions to selected problems, often including ones not solved in class. Good writing and careful presentations are expected. The solutions are revised based on feedback, and compiled into a solutions manual submitted at the end of the term. The in-class group work and presentations, and the writing assignments help students to sharpen their reasoning and develop an ability to communicate mathematical ideas. Topics studied include sequential movement puzzles, probability, mathematical logic and deduction, basic number theory, summation and proofs without words, algorithms, recursion and induction, and graphs. The talk includes examples of several class activities, and discusses the critical reasoning they cultivate.

Part B: Friday, August 5, 8:30–9:45 AM, Union C

Angela M. Brown Sul Ross State University

Bringing the Arts Into a LIberal Arts Math Course

At Sul Ross State University, all Bachelor of Science Majors are required to take College Algebra, Statistics, or higher level courses to meet their math requirement. This leaves those getting a Bachelor of Art degree as the students in Contemporary Mathematics, our liberal arts mathematics course. This being said, we try to bring creative components into this course. For my sections, this includes hands on activities that build these students' critical thinking skills and final projects that bring their creativity into play. We will discuss some of the aspects of how this course is taught at Sul Ross and how students have reacted to mathematics that most of them have not seen before.

Douglas Shier Clemson University
Marilyn Reba Clemson University

Puzzles and Paradoxes: Engaging the Interests of Both the Willing and Reluctant

We describe a course on puzzles and paradoxes created to entice students to an appreciation of unifying mathematical concepts. Originally taught for students in the Honors College at Clemson University in 2008, this course was successfully modified in 2014 as a special critical thinking section of our liberal arts mathematics course. Both courses present a progression of puzzling situations and illustrate how mathematical formulation can be used to aid comprehension and generalization. Moreover, this approach links together seemingly unrelated situations by use of a common set of representations and solution strategies. In this talk we specifically illustrate the power of mathematical representation with examples drawn from biology, sports, gambling, and voting.

Jason Molitierno Sacred Heart University

Mathematics Without Calculations - It's a Beautiful Thing!

"Mathematics Without Calculations - It's a Beautiful Thing!" is a first year seminar course for non-math majors which focuses on writing about various concepts in mathematics rather than on rigorous calculations. By writing about mathematics, the non-math oriented student gains an appreciation for what mathematics is really like, and at the same time, improves his/her writing and speaking skills. In this talk, several creative writing projects will be presented along with the overall structure of the class which also includes research presentations. Projects pertaining to the infinitude of prime numbers, different levels of infinity, three-dimensional solids, four-dimensionality, fractional dimensions, and graph theory will be discussed.

Margaret Boman Harrisburg Area Community College-Lebanon Campus

Projects for Poets

Engaging the diverse set of students come to a Liberal Arts Math course is a challenge. I will discuss the challenges and successes I have had integrating projects on geometry, set theory, voting and probability into a community college Liberal Arts Math course.

Part C: Friday, August 5, 1:00–6:15 PM, Union C

Dan C. Kemp South Dakota State University

Using the History of Mathematics to Invigorate Honors Calculous

To make Honors Calculus 'honorable' I attempted to follow Abel's advice "*It appears to me that if one wishes to make progress in mathematics, one should study the masters and not the pupils.*" Our friends in the Humanities apparently have great success with this model, but I quickly discovered that our freshman don't even know mathematics has 'Masters'. Many claim never to have heard of Euclid! To get over this hurdle I began having my student read a very introductory mathematics history text, *The Story of Mathematics* by Richard Mankiewicz, and submit reflection papers over their reading. This turned out to be popular and I will discuss the reading of history of mathematics in more detail. Reading mathematics written by masters for beginning calculus students seemed too ambitious, but writing Projects for them based on the works of masters did work. These projects, over topics related to the subject currently being studied, were assigned to groups of three or four students to be done outside of class. The result is a word processed paper. Added benefits include socialization of the students and them beginning to learn how to write mathematics. Examples of Projects will be given along with some student responses. One of my favorite projects begins by discussing the history of the problem of determining sum of the reciprocals of the squares of all positive integers and one of Euler's remarkable proofs that the sum equals pi squared divided by six. Then the students work through a modern elementary proof that uses integration by parts, partials sums of series, and the squeeze theorem, all topics that they are currently studying.

Ximena Catepillan Millersville University of Pennsylvania

A course on the mathematics of the pre-Columbian Americas

This presentation addresses the need and rationale for the creation of a course for non-STEM students on the mathematics of pre-Columbian Americas. Sample lessons for in-class work and projects with exercises also are included.

Aaron Trocki Elon University

Grounding Calculus Learning in the History of Mathematics

The study of Mathematics is integral to a liberal arts education and often includes a first course in Calculus. A challenge facing Calculus I instructors is that of connecting the content of Calculus to other pillars of a liberal arts education such as history, writing, and communication. A typical Calculus I course is content heavy leaving little time for supplemental activities and projects. A need then exists for course designs and projects that connect Calculus to other aspects of liberal arts while simultaneously contributing to the achievement of content goals. This presentation delineates one project and implementation that may work to meet this need for all Calculus learners. The project is entitled *Giving a Historical Context to Calculus*, and its purpose is to provide students an opportunity to familiarize themselves with the origins and archetypal problems of Calculus that led to our current conception of the field. Berlinghoff and Gouvea explain, "Learning about math is like getting to know another person. The more you know of someone's past, the better able you are to understand and interact with him or her now and in the future" (p. 1, 2002). The project takes the form of a short paper and brief presentation. Project details and implementation are shared along with student work samples and reactions to the experience.

Filippo Posta Grand Canyon University
Ben Vanderlinden Grand Canyon University

Integration of Faith and Learning in the Mathematics Curriculum

There are more than 1,000 religiously affiliated Colleges and Universities in the United States. These schools are chosen by learners not only for their academic standards, but also because of their focus on religious and spiritual values. The mission statements at these Academic Institutions include words regarding integration of faith and learning (IFL) in the curriculum. However, how to apply IFL in a Mathematics classroom can be a daunting and uncomfortable endeavor. We present different approaches that vary in nature and effort. From motivational speeches aimed at creating a positive classroom atmosphere, that promotes student tenacity and limits math anxiety. To synchronous and asynchronous activities, that help relate abstract and isolated mathematical procedure to spiritual and social contexts, that are dear to our (and your) learners. We will discuss the evidence that we gather. We will show what worked and what to avoid.

Jacqueline Brannon Giles HCC Central College/Texas Southern University/S.H.A.P.E. Community Center

Mathematics in Ministry, Money and Movies

The presenter will discuss creative examples of the use of mathematics in many aspects of our daily activities. Two year college students suggested three focus areas: ministry, money, and movies. The Faith Equation will be discussed and examples from numismatics and movies will be shared. The expected outcome for students and participants will be to inspire students from all echelons of society to Do mathematics, and to see that mathematics is in everything.

Cristina Gomez Ithaca College
Osman Yurekli Ithaca College

Divination: Using Excel to Explore Ethnomathematics

This presentation will provide an outline of an introductory liberal arts mathematics course where students will develop different methods of understanding mathematics as a human creation through looking at the development of mathematical ideas in different cultures at different times. Students experience various social activities such as divination and marking time. They learn how to reflect on broader ideas about how we discover and create mathematical knowledge and understand the world around us. As a demonstration of our ideas, we will present a divination process that originated in Madagascar centuries ago and is still practiced there to this day. We will then discuss how to model this divination using a spreadsheet program (Microsoft Excel).

G. Gerard Wojnar Frostburg State University

Teaching Proofs to Gen Ed-Lib Arts Learners—Leapfrogging Basic Skills Deficits While Building Learner Self-Confidence

Sadly, many general education-liberal arts students are in college math-phobic and with horribly inadequate basic math skills. These students are intelligent but suffer from poor self-images when it comes to math. Nevertheless, their general intelligence equips them to grasp various basic proofs with a sense of mastery, providing positive and authentic experiences of mathematics. Two such proofs are the infinitude of the primes, and the infinitude of the harmonic series.

Pat Devlin Rutgers University
Nora Devlin Rutgers University

Math as a Creative Art: Reflections on an honors proofs class for liberal arts majors

In the words of Paul Halmos, 'it saddens me that educated people don't even know that my subject exists. There is something that they call mathematics, but they neither know how the professionals use that word, nor can they conceive why anybody should do it.' To this end, we designed an honors-level course geared towards liberal arts majors to provide a taste of (and ideally appreciation for) 'math as a creative art' (i.e., proofs). The mathematical content spanned many topics including (as two examples) combinatorial game theory and Cantor's diagonalization argument. Students were also exposed to social aspects of the discipline including its history, culture, and modern-day issues (e.g., under-representation of certain demographic groups). In this talk, we discuss an implementation of this course giving an overview of the structure chosen and the progression of student opinions towards the subject as a whole. We pay special attention to which activities and other pedagogical choices were (and which weren't) particularly effective in engaging students to think mathematically. In all, we found that the chosen format worked quite well, and in fact many students were themselves surprised to realize how much they were getting out of it.

Jonathan Hulgan Oxford College of Emory University

Graph Theory: Non-Quantitative Mathematics for Liberal Arts Students

The 100-level course *Graph Theory and Math Models* was designed to give all interested students a glimpse of mathematical research without regard for each student's particular mathematical background. For the first two-thirds of the semester, students explored fundamental topics in graph theory through guided inquiry activities. The last segment of the course saw students working to understand a classic paper in the field as well as develop a list of questions or conjectures inspired by these results and proofs. I will share how this course seemed to have a positive impact on students' attitudes towards mathematics, as evidenced through comments from regular student reflections as well as course evaluation data.

Samuel Luke Tunstall Michigan State University
Richard Edwards Michigan State University
Jeff Craig Michigan State University
Andy Krause Michigan State University
Vince Melfi Michigan State University

Quantitative Literacy at Michigan State University: Present Successes and Challenges

Effecting curricular change at a large public institution is a nontrivial endeavor. In this presentation we discuss the creation of Math 101 and 102–each entitled Quantitative Literacy–at Michigan State University. The course fulfills a component of the University's general education mathematics requirement; its curriculum is context-driven, and its assessment is non-traditional. All of this was done while keeping in mind that students in the course may have mathematics anxiety and have faced challenges in previous mathematics courses. We begin with a brief outline of the course's development, then the bulk of the presentation will focus on curriculum (including example content and assignments), pedagogy, and assessment (both short- and long-term).

Rebecca Walker Guttman Community College

Building quantitative reasoning through interdisciplinary theme-based first-year courses

At Guttman Community College, a new community college that is part of the City University of New York, the first-year experience for all students, the majority of whom are liberal arts intending and have not yet demonstrated basic algebra proficiency, includes a year-long exposure to quantitative reasoning as part of two interdisciplinary courses that explore contemporary urban issues. In these City Seminar courses, social science, English, and mathematics faculty work collaboratively to develop and implement integrated projects that the students complete over the course of the semester. Through these projects and related class activities, we are able to address a range of developmental mathematics topics and help students see how mathematics and quantitative reasoning can be used to explore critical issues such as gentrification and immigration and how they can help support a thesis. In this talk, I will share the skill spines that serve as the basis for the course and examples of student-centered class activities and integrated projects. The challenges of allowing flexibility of City Seminar topics depending on faculty interest and expertise while maintaining consistency of quantitative reasoning development from section to section will also be discussed.

Alexander G. Atwood Suffolk County Community College

Introducing Fermi Problems and the Art of Reckoning to Liberal Arts Students

The art of calculating informed estimates using minimal information, as done by the physicist Enrico Fermi, can be effectively taught in a Mathematics class for Liberal Arts Students. Although many students are initially hesitant in making back-of-the-envelope estimates and calculations, they can become progressively much stronger. I will share my experiences of what works and what doesn't work in nurturing students' powers of guesstimation, and I will share my Fermi Problems that I use in the classroom.

Michael Weingart Rutgers University

Innovations in a Liberal Arts Probability Course

This talk will discuss recent innovations in both the format and content of the undergraduate probability course at Rutgers taken by a general liberal arts audience, much of which is decidedly math-phobic. The format innovation is to teach in a hybrid, flipped classroom model. The results have been positive, especially for the substantial population of international students in the course; they have performed significantly better in the flipped version. The content innovations include teaching expected value in a new way, inspired by cognitive science research on understanding natural frequencies, and restructuring the course plan so that what had been isolated topics are now recurring themes throughout the course. A series of exercises ask students not only to solve problems, but also to make their own individual decisions informed by (but not determined by) expected value computations, and keep track of their total "score" as the course goes on.

Catherine A. Robinson University of Rhode Island

Introductory Statistics - Group Project in a Large Class

Many students are required to take a first course in introductory statistics, and many of them are fearful or apprehensive as they see statistics as a foreign language. Having a group project in an introductory statistics class that is discussed in the very first class of the semester and due near the end of the semester is one way to help engage students, foster collaborative student efforts, and promote active learning throughout the course. The lecture class provides the necessary basic statistical concepts and a (smaller) recitation class provides weekly opportunity for students to work on practice exercises to reinforce the material presented in lecture, as well as for student groups to discuss and work on project deadlines. The first project related recitation exercise is to divide into self-selected student groups of 2-4 and discuss ideas for a project topic based on the students' interests. Information on existing data sets is provided, as well as ideas on data collection. The grading rubric is provided at the onset of the semester, as well as the guidelines on the final project report preparation. Each week there is time devoted in recitation to another aspect of the group project. A project proposal (template is provided to students) is submitted mid-semester including the group's topic, objectives, and variables to be utilized, as well as information regarding the analyses the group anticipates will be performed.

The instructor provides feedback and guidance for each group project. Recitation instruction includes usage of statistical software to run analyses and creation graphs, tables, and charts. The final project report is due late in the semester.

Hope Essien Malcolm X College (one of the City Colleges of Chicago)

The Impact of Academic Presentations on Students Understanding of Mathematical Concepts in General Education Mathematics

Encouraging an active learning environment for any group of students may pose challenges, particularly in a mathematics classroom. Recent curriculum recommends cognitive mathematical learning tasks for all students to utilize multiple modes of communication. The goal of this project was to create a mathematics learning space that facilitates activities and foster connections that enhanced student learning through collaborative work. Within that context, we investigated the impact of academic presentations on students understanding of mathematical concepts in a general education mathematics classroom. According to Huddle (McNamara, et al., 2010). "Poster preparation allows students to become active learners and encourages deeper learning" . Additionally, posters can be defined as "multimodal communicative genre, with text, graphics, color, speck, and even gesture used to convey meaning" (Kress & van Leeuwen, 2001). Participants included sophomore students in a Midwest, urban, public two-year community college, consisting predominantly of students of color during a 16-week semester. Analysis of the result demonstrates that students effectively analyzed and solved complex mathematical problems and explained their procedures when responding to probing questions. This investigation concludes that there is a relationship between academic presentation (active learning) techniques and students understanding of mathematical concepts. It affirms that poster utilizes students centered learning style that permits students to be deeper learners, encouraging students to reflect on materials covered using active learning, research skills and numeracy which is demonstrated during presentation.

Lorraine F. Dame University of Minnesota Rochester
Aminul Huq University of Minnesota Rochester
Bijaya Aryal University of Minnesota Rochester
Xavier Prat-Resina University of Minnesota Rochester

Revitalizing College Algebra and Pre-Calculus through Curricular Collaboration and Team Teaching with Partner Disciplines in a Liberal Education Program

In the Center for Learning Innovation at the University of Minnesota Rochester (UMR), mathematics and partner discipline faculty are collaboratively engaged in re-envisioning the pre-calculus curriculum and its delivery to addresses specific needs of students in a Liberal Education program. Our new pre-calculus curriculum consists of two integrated three-credit courses, College Algebra with Physical Concepts and Pre-calculus with Physical Concepts. At their core, each of these courses has assessable learning objectives from mathematics, biology, chemistry and physics in a ratio of approximately two parts math to one part physical concepts. We are modifying curriculum delivery to include multi-disciplinary team teaching in which faculty from partner disciplines introduce related foundational physical concepts at key points in the delivery of the math curriculum. Our goals in modifying the curriculum and its delivery include: increasing the efficacy of transfer of pre-calculus knowledge to partner discipline courses; addressing the needs of students identified as struggling with mathematics upon entry to a health sciences program; and increasing motivation for students to develop pre-calculus skills. Preliminary evidence collected includes qualitative student & faculty interview results, student grade information, and before/after assessment using the Basic Skills Diagnostic Test developed by Dr. Jerome Epstein. In this talk we will discuss the successes and struggles thus far in designing and implementing the new pre-calculus curriculum and its delivery. We will also discuss future curriculum development plans for pre-calculus at UMR by our highly collaborative faculty.

CAMP: Calculus Applied Mathematics Projects

Thursday, August 4, 1:00–3:55 PM, Franklin A

Organizers: Ellen Swanson Centre College
Emek Kose St. Mary's College of Maryland

Teaching mathematics includes not only helping students learn the material but also appreciating the utility and applicability of those skills in better understanding the world. One technique in achieving this appreciation is through the use of projects which also strengthens inquiry, collaboration, reasoning and communication. However, there are currently limited curricular materials readily available to instructors of single and multivariable calculus. We invite you to come to CAMP with us by offering innovative applied mathematics project ideas that can be used in the Calculus sequence.

Ellen Swanson Centre College

Travel Inspired Projects

Bringing world experiences into the classroom excites students to better understand material being discussed. We will discuss a project inspired by traveling to Stockholm, Sweden. The 17th century war ship sank within 1500m of land during its maiden voyage. The recovery of this ship, in the 1950s, required a well developed plan. This project crosses the interdisciplinary boundaries of history, physics, and mathematics.

Jared Warner Guttman Community College

The Calculus of New York City's Subways

What time of day is the height of rush hour at the 5th Avenue stop on the 7 train? How many total riders enter (or exit) the Times Square stop at 42nd Street on your average Tuesday afternoon? The New York City Metropolitan Transportation Authority freely releases both static and real-time data feeds for public use that can help a first-semester calculus student answer questions like these. This talk will describe a very substantial, five-part project that makes use of this data to perform a calculus-based analysis of rider traffic through the New York City subway system. The project guides students in the use of technologies such as Microsoft Excel, Desmos, GeoGebra, and WolframAlpha to research various quantitative questions about their most frequented subway stops. Within the project students find real-world applications for a very broad range of calculus concepts including secant and tangent lines, local and global extrema, L'Hopital's rule, and the fundamental theorem of calculus. We will discuss our implementation of the project at an urban community college in Manhattan and provide resources for instructors of calculus who may be interested in adapting this project for use in other cities.

Brian Winkel Emeritus, US Military Academy, West Point NY and Director, SIMIODE

Complex, Technology-Based Problems in Calculus Equations

We revisit a rich set of problems for calculus involving applications to reality using technology at http://www.rose-hulman.edu/Class/CalculusProbs/. These include an inverse problem in geology, design of fair ball park, time for ant to build a tunnel, cutting bread evenly, highway to the mall, determine the depth of a well - kerplunk, tracking with cameras, stopping fluid flow with plug in pipe, and many more. We also visit a community for end game calculus applied problems at SIMIODE - Systemic Initiative for Modeling Investigations and Opportunities with Differential Equations (www.simiode.org).

Stepan Paul UC Santa Barbara

Using group projects to extend coverage

In this talk, I will share experiences using group projects and presentations in calculus classes as a way of extending the coverage of the class. While many inquiry-oriented approaches to teaching have a perceived association with sacrificing class material, group projects have the potential to do the opposite. By assigning different groups different topics on which to write and present, students are given the opportunity engage deeply with one particular topic of their choosing, while also gaining exposure to a wider range of topics, all with minimal commitment of class time. Student feedback indicates that this project structure sparks interest and curiosity in the topics covered, builds confidence, and reinforces the major themes of the course. I will share some representative project assignments from differential equations and multivariable calculus (some original and some inspired by or adapted from other sources), along with lessons learned about how to structure group projects intended to extend coverage.

Stacy Hoehn Franklin College

Cookies and Cars in Calculus

One engaging project that can help students truly come to grips with business optimization problems in calculus is to ask them the simple question, "How much should the Girl Scouts really charge per box of cookies to maximize their profit on our college campus?" To investigate this question, the students first complete a market survey to gather data about the cookie-buying preferences of their peers; this is easy and fun data to collect since most students love Girl Scout cookies! After analyzing this data using a combination of technology and calculus, the students are always amazed by how closely their result mirrors the true price charged by the Girl Scouts. Later in the semester when discussing the idea that the area under a velocity curve gives the total displacement of a moving object, even the best students get excited by another project in which they are given a glimpse into the "secret" life of their professor. Here, the students are given their professor's actual speedometer readings recorded every 30 seconds on a weekend outing, and based on only these readings and ideas from calculus, they must find a plausible description of the professor's journey as well as her final destination. How well do these sleuths do at determining where the professor went? Come and find out!

Melissa A. Stoner Salisbury University

Calculus in Clinical Medicine: Using the Campus Simulation Center to Motivate and Apply Calculus

How can we utilize the medical simulation center on campus to enhance learning in mathematics class? Based on a student project, we have designed a differential equations model of the mechanical lung used in respiratory care. In collaboration with the respiratory therapy program, we have run simulations on the mathematical model comparing results to the model lungs in the simulation center. We then discuss the design of a project for the Differential Equations course regarding the mechanical lung, as well as the integration of the simulations in Calculus I to motivate the use of derivatives in medicine.

Christina Selby Rose-Hulman Institute of Technology

Removing Distortion in Star Images with Calculus

Calculus students often encounter optimization problems such as maximizing the area of a region a farmer can enclose with a given amount of fencing material. While such applications have their merits, students may not realize how optimization can be applied to more technical domain areas. A "real-world" optimization application based on personal NASA experience has been developed into a Calculus I project, and could be expanded into a Calculus III project. The goal of the project is to determine system parameters that accurately model the distortion of a lens in a given imaging system. This project incorporates the use of data in a mathematical model, computational tools (Maple or Matlab), and technical writing.

Jerry D. Schermerhorn Owens Community College

Gravity With First Year Calculus

First year calculus and physics students often expect to learn how Newton invented calculus to explain that an inverse-square theory of gravity predicts Kepler's elliptical orbits, yet surprisingly no physics textbook at entry level gives a derivation, much less with the calculus required as a course prerequisite (none ... not Halliday, Resnick, & Walker nor Sears & Zemansky not even Feynman). Newton's Principia seems bewildering with his non-rigorous geometry based calculus Method of Fluxions - nothing like what is taught in the modern first year calculus course. This in-class project to do that task connects some history with modern notation by illustrating thought processes to derive only from Newton's three laws and first year calculus tools not only Kepler's first law but also as a result, not a starting point, conservation of momentum which is in essence Kepler's second law of planetary motion. Multi-variable vector calculus or quaternions are not used.

Victor Piercey Ferris State University

The "Force" of Interest

The "force" of interest is a concept based on an exponential approximation to a function. This lends itself to an interesting theoretical comparison to the traditional derivative as a linear approximation that also provides practical applications in understanding the accumulation of interest at non-constant rates. I will describe this concept along with a potential outline for a related project that could span a full single-variable calculus sequence.

Fostering a Problem-Solving Culture for Students

Thursday, August 4, 1:00–4:15 PM, Taft A

Organizers: J. Lyn Miller Slippery Rock University
Ron Taylor Berry College
Robert Vallin Lamar University

All of us have experienced what George Pólya describes as "the tension and triumph of discovery" that comes from solving a difficult problem. This is something numerous faculty endeavor to bring to their students. The purpose of this session is to share ideas for extracurricular activities involving problem-solving events that occur regularly. These can range from Problem of the Day/Week/Month to forming a Problem Solvers Group that meets often to an Annual Inter-Collegiate Problem Contest, and so on. Let us share what worked, what can be improved, and how you entice students to participate. Our desire is for inclusivity, so these events should be open to all students, not just your best math majors. Talks in this session address specifically the aspects of establishing and maintaining a practice of extracurricular problem solving among students and not single undergraduate research projects. We also want to know if these led to more student engagement such as GRE Study clusters, journal problem-solving groups, Putnam involvement, teams for the Mathematical Contest in Modeling, or something else.

Heidi Hulsizer Benedictine College

Creating a Culture of Engagement

The focus of this talk will be the interplay of several departmental activities that help to create a culture of discovery and problem-solving. For example, departmental problems of the month culminate in a year-end presentation and prize to the top student. Departmental colloquia encourage engagement for all levels of students and national high-level competitions challenge the brightest students. Required write-ups of these events also force students to reflect upon their experiences. The discussion will focus on a small liberal arts campus environment, but some ideas could extend to other campuses. The key to success is a department that works together to support an interactive, positive culture.

George T. Yates Youngstown State University

Undergraduate Involvement in Problem Solving at Youngstown State University.

Youngstown State University (YSU) has a long standing tradition of involving undergraduate students in extracurricular activities in mathematics. Activities such as a problem of the week, a problem solving seminar, integration bee and many others are described and illustrate how they foster student participation in the Putnam Competition, Mathematical Contest in Modeling, regional and national conferences such as MathFest, various outreach programs and much more. The Center for Undergraduate Research in Mathematics (CURMath) at YSU helps coordinate these and other events.

Elizabeth A. Peitz University of Central Florida

The Great Escape: Undergraduate Problem Solving for Freedom

As John Lennon said, "There are no problems, only solutions" . Although John Lennon was not referring to the infinite problem solving world that is Mathematics, he is right that there are solutions as long as we have mathematicians searching for them. At the University of Central Florida, we have put emphasis on getting mathematics students of all levels to participate in problem solving activities such as Problem of the Week questions at our popular club the Collegiate Mathematical Society, encouraging students in classes as early as Calculus I to join our Putnam and Mathematical Modeling teams, and creating fun activities that we encourage students that are not majoring in mathematics to join such as a "Math Escape Room" where teams work to solve math problems in order to "escape" the Mathematical Sciences building. This paper will show how these activities increase undergraduate participation in problem solving. A survey of the students who participated in these activities will be used to decide what aspects of these activities were most enjoyed and what can be improved to have a greater amount of participation in the future. Using the survey, there will be presented ideas of how to encourage more problem solving among undergraduates as well as proposals for alternative types of activities.

Ron Taylor Berry College
Robert Vallin Lamar University

Dead Poets Society

In this talk we describe an exemplar for extracurricular mathematical engagement that combines aspects of journal problem solving groups, Putnam competition teams, math clubs, and community service organizations. This model is based around creating a collaborative setting where people can focus on having fun while interacting with both mathematical questions and other people who enjoy mathematics. The activities of this group provide a safe place for students, and faculty, to experience some camaraderie and have some fun thinking about interesting problems while comparing/discussing alternative solutions. This allows for an atmosphere that is communal without being as passive as listening to a lecture and also intellectually stimulating without being as solitary as working alone on contest problems. Additionally, there is flexibility to shape the group to a best-fit scenario for individual schools.

Andrew Penland Western Carolina University

Reflections on a Puzzle-Themed Scavenger Hunt

Inspired by his experiences with the Cicada 3301 and Austin Bridge Cipher puzzles, the author organized a nontraditional, multimedia "scavenger hunt" for the 2016 Pi Month celebration at Western Carolina University. This talk will discuss the content and format of the puzzles, the response they generated, and some ideas on the logistics of running such an event.

Julie Barnes Western Carolina University

Student Problem Solving at Math Club Meetings: You Don't Have To Do It Alone

In this talk, we will discuss how we have provided a variety of problem solving opportunities during weekly math club meetings. Activities range from a review of tricky integrals, a collection of logic puzzles from the Internet, some old Putnam exams, and practice Math Jeopardy questions. In addition, students also tested out some hands on classroom activities to see how well they worked. Several faculty members as well as the math club officers have been involved in problem selection, so nobody had to do too much.

J. Lyn Miller Slippery Rock University

Evolution of a Problem-Solving Culture: One Department's Experience

We describe various efforts over 15 years to foster student participation in extra-curricular mathematical problem-solving at a rural, public regional university. Our activities have broadly targeted mathematics majors and minors at all levels in our program, which until 2016 was bachelor's-granting only. This talk will identify elements that have been especially successful for us - including our ongoing Dead Poets Society, - and we'll conjecture about what may have made other efforts fizzle. This analysis of our history may help faculty at other institutions to adapt their own activities more successfully.

Greg Oman University of Colorado, Colorado Springs

How to create it, how to solve it, and what to do with it: a problem-posing primer

I have published 30+ problems in various MAA journals over the years, and have had several folks ask me how I've come up with the problems I've posed (this group includes both students and faculty). I created a problem specifically for this talk which I will use as a template to give partial answers to the following questions: 1) How does one come up with a good problem? 2) How does one solve the problem? 3) What does one do with the finished product? This talk should be accessible to all faculty and most mathematically mature undergraduates.

Laurie Zack High Point University

Designing an Introductory Seminar To Encourage Problem Solving In Mathematics

In an effort to encourage freshman and sophomore mathematics majors and minors in the department in their mathematical thinking and to spark some interest in embarking on a math research project, we created a 1-credit problem solving course. There were many goals of this course including introducing students to various topics of math research within the department and providing an opportunity to work on interesting problems in various math disciplines. Other goals of the class were to expose students to the power of different computer algebraic systems and to create an environment where students could learn the value of success and failures. In this talk, I will give an overview of the class and outline the types of topics and problems we posed to our students plus touch on some of the responses from the students.

Nicholas Long Stephen F. Austin State University

What I Learned and What I Hope Students Learned from Running a Problem Solving Seminar

This talk will discuss a seminar for math majors and minors aimed at improving students' problem solving abilities for applied and non-routine problems. Problems were taken from previous Mathematical Contest in Modeling as well as introductory problems from other sources. Some problems took several weeks while others came and went in a single meeting. In exit interviews for our math majors and minors, this seminar was noted as providing a different and enlightening environment in which to use math and problem solving, as well as a great way for students to talk about math in job interviews and other settings. We will discuss several important activities, what I learned from these experiences, and how some of these elements became formalized in other courses while other elements dropped away.

My Favorite Math Circle Problem

Thursday, August 4, 1:00–4:55 PM, Franklin C

Organizers: Katherine Morrison University of Northern Colorado
Philip Yasskin Texas A&M University
SIGMAA MCST

A math circle is an enrichment activity for K-12 students or their teachers, which brings them into direct contact with mathematically sophisticated leaders, fostering a passion and excitement for deep mathematics in the participants. Math circles combine significant discovery and excitement about mathematics through problem solving and exploration. Talks in this session will address a favorite problem or topic that was successful with a math circle audience.

Judith Covington LSU Shreveport

Tiling with Pentagons

As Math Teachers' Circle leaders we are always looking for new ideas for problems for our meetings. When I heard that a 15^{th} pentagon had been found that would tile the plane I knew there was a session idea involved! I will share how I took the newly discovered tiling and created a hands-on activity for the North Louisiana Math Teachers' Circle. The teachers enjoyed the session so much they decided that the pentagon tiling should be part of our new t-shirt.

Mary Garner Kennesaw State University
Virginia Watson Kennesaw State University

The Check is in the Mail

One of our favorite math circle problems comes from *Exploratory Problems in Mathematics* by F.W. Stevenson. As with all the problems from this book, the author presents the problem in such a way that there is a guaranteed entry point, and a series of questions that definitely requires problem-solving stamina. There is also the potential to engage a wide range of mathematical principles, from very basic to more advanced. The specific problem is titled "The Check is in the Mail" and it is concerned with 12 checks and 12 envelopes and how many of the checks are in the correct envelopes. In this session, we'll discuss our experience with middle-grades math teachers and examine what several math circles have published about problems involving derangements. We'll also mention one other favorite problem from the book - the Josephus problem in disguise.

Chris Bolognese Columbus Academy
Raj Shah Math Plus Academy

Measuring Up: Perfect Rulers

Is it possible to measure all possible integer lengths on a ruler without marking every integer on that ruler? In particular, can you construct the most efficient ruler that can measure all integer lengths from 1" to 36" on a yardstick using the least number of marks? And if so, what is the minimum number of marks needed and where should they be placed? A trivial solution would be to mark the ruler at one inch and simply measure objects by moving the ruler along the object one inch at a time. So, we constrain this exploration to using the ruler without moving it along the object. This problem was investigated by our local area mathematics teachers' circle. Participants at the circle started by analyzing a 6" ruler and found that marks at 1" and 4" produced a perfect ruler (that is, one with the least marks that can still measure all the lengths as before). Exploring this problem further, participants developed a number of conjectures, such as key locations to place marks, and how symmetry could be used to find other possible solutions. Participants also developed digital tools to help in the analysis using Javascript and Ruby code. The perfect rulers task served as an exemplary circle topic since it was easy to access and extend and promoted collaboration and discussion.

Diana White University of Colorado Denver, NAMC
Brandy S. Wiegers Central Washington University, NAMC

First survey of National Association of Math Circles

Math Circles have spread rapidly over the past 15 years and through their growth we have seen the development of broader informal mathematical outreach efforts. The National Association of Math Circles (NAMC, http://www.mathcircles.org/) has done the first attempt to survey this growing group and learn more about their contribution to the national picture of mathematical outreach and enrichment. The initial data collection occurred over the spring of 2016, when the NAMC administered a basic information gathering survey to the more than 180 Math Circle programs across the country who have registered on the NAMC website. This talk will summarize the information we learned. In addition, we will provide information on future NAMC initiatives and plans with regard to training, resources, evaluation and research, and partnerships with other informal learning groups.

Sandra Richardson National Science Foundation

Using Tools to Communicate in a Math Teachers' Circle

This session will highlight manipulatives and tools used to foster communication among middle and high school mathematics teachers in a Math Teachers' Circle (MTC). Examples of how participants effectively communicate mathematical concepts, representations, and approaches in reasoning through favorite MTC problems will be shared.

Robert Sachs George Mason University

Making Infinitely Many Mistakes Deliberately – Iteration

A Math Circle session devoted to iterative approximation went really well and focused on some important and beautiful mathematics. The "hook" is to ask how the Babylonians might have found the highly accurate approximation to the square root of 2 found on YBC 7289. The topic lends itself to many variations depending on the group and can branch in many ways and be approached at various levels of sophistication.

Douglas B. Meade University of South Carolina

Fractals: Theory, Application- and Business Cards?

Fractals are everywhere, and involve beautiful and accessible mathematics. The presentation was originally prepared for use in a Math Teachers' Circle for middle school teachers. The material is easily adapted for use with teachers of other levels – or for a traditional Math Circle for students. The presentation includes a balance of theory (geometry, self-similarity, sequences, series, recurrence relations), application (graphical, 3D printing), and hands-on construction (origami). To participate in the origami component, bring 12 business cards to build a level 0 Menger sponge (a cube) or 192 cards to build a level 1 Menger sponge.

Alessandra Pantano University of California, Irvine

Stimulating math curriculum for students from challenging socio-economic backgrounds.

In this talk, we address the transition of our math circle from a program for talented youth, serving the mathematical elite, to a program with a stronger community outreach objective, serving socio-economically disadvantaged students and their parents. Shifting gears in scope and audience required substantial curriculum modifications, with the obvious challenge of designing mathematically stimulating problems for students who often lack mastery of even the most basic fundamental concepts. Given that our audience is also generally under-educated in a number of other subjects, our team has recently decided to try to broaden the educational value of our program by designing a mathematically challenging curriculum that addresses topics of high societal impact (e.g., water conservation, environmental protection, health care). The overarching goal is developing an appreciation for mathematics as a truly trans-disciplinary field.

Li Feng Albany State Univrsity
Janis T. Carthon Albany State Univrsity
Courtney L. Brown Albany State Univrsity

Visualize the Two Conjugate Complex Roots for Quadratic Equations

An quadratic equation can have two distinct real roots, or one repeated real solution, or two conjugate complex solutions. The first two cases can be visualized by looking at the x-intercept(s) of the graph of the corresponding quadratic function. In the case when there are two conjugate complex solutions, its graph does not have any x-intercepts. So we cannot use the x-intercept to locate the complex roots. In this paper, we will use a new approach to visualize the two complex roots. We will use a special circle and look at the intersection points of circle and the axis of symmetric of the quadratic function. We pointed out those intersection points are the two conjugate complex roots and hence it provides us a way to visualize the complex roots.

Thomas Clark Dordt College

Projective Geometry Hidden Inside: Can you Spot it!?

In this talk I'll share about a Math Teachers' Circle session I recently ran centered around the children's game Spot it! This game has some very interesting mathematics behind it and naturally begs to be explored with inquiry. I'll describe the way I led teachers to ask questions about the game, the way the teachers then explored the topic, and the mathematics behind it all. Materials available.

Crystal Lorch Ball State University
John Lorch Ball State University

The Mathematics of Shidoku

A *Sudoku puzzle* is a 9 X 9 grid, divided into nine 3 X 3 subsquares, in which some of the cells already contain numbers (called *clues*) from the symbol set $\{1, 2, ..., 9\}$. To solve the puzzle one must fill the remaining cells with symbols such that no symbol is repeated in any row, column, or subsquare. "How many sudoku solutions are there?" and "What is the fewest number of clues that can be used to determine a unique Sudoku solution?" are among the natural questions about Sudoku. Answers to both questions are known (6670903752021072936960 and 17, respectively) though the second question stood open until 2012 and currently can only be verified by an exhaustive and time-consuming computer search. In the Yorktown Middle School Math Circle we investigated these questions by considering a smaller version of Sudoku, called *Shidoku*, in which one uses symbols $\{1, 2, 3, 4\}$ and a 4 X 4 grid divided into four 2 X 2 subsquares. Students used the ideas of multiplicative counting, relabeling, symmetry, and equivalence classes (the latter we called "teams"; these were represented by "team captains") to show that there are 288 Shidoku solutions and that four is the fewest number of clues that can be used to determine a unique Shidoku solution. In this presentation we describe how students were introduced to the ideas listed above and the activities that led them to their results about Shidoku.

Angie Hodge University of Nebraska Omaha

Pirate Zombie Math

This Math Circle session gives the standard river crossing problems a fun new twist with pirate zombies. In this session, I'll explain how to run the session, provide helpful tips on how to make this session run smoothly, and also give a sampling of the problems used in this circle. Be ready for audience participation!

Novel Introductions to Non-Euclidean Geometry

Thursday, August 4, 1:00–2:55 PM, Union A

Organizer: Sarah L. Mabrouk Framingham State University

This session invites presenters to share interesting ways in which to introduce undergraduate students to non-Euclidean geometry. These "tastes" of geometry may be demonstrations, in-class activities, projects, proofs, or ways in which to guide undergraduates to explore and to learn about non-Euclidean geometries. but not those related to differential geometry or (low-level) graduate courses. Those discussing demonstrations or in-class activities are encouraged to share key portions. Presenters should discuss the facets of their approaches which highlight the differences between the geometry being explored and the Euclidean geometry with which undergraduates are familiar. Information regarding prerequisite topics and related areas with which students have difficulty should be discussed as should follow-up topics and problems, if any, experienced when using this approach. Presenters are invited to discuss how they have modified their approaches over time and to share information about successes, failures, and student reaction. Abstracts should include the type of geometry being examined, a brief description of the aspects of this geometry which are introduced, the theorem, if appropriate, the software or application, if any, which may be used, and what makes this approach a unique introduction to non-Euclidean geometry. Those whose presentations are dependent upon software or tablet explorations must provide their own laptop or tablet.

Thomas Q. Sibley St. John's Universtiy, College of St. Benedict

Bending Students' Intuition

Physical models enable students to expand their geometrical intuition from Euclidean geometry to spherical and hyperbolic geometries. In particular, in less than a class period drawing and measuring on saddle shaped surfaces, my students consistently make several conjectures. As we develop hyperbolic geometry, they are able to prove these conjectures. I find this approach a more successful initiation than analytical models, such as the Poincare disk model. (Later I do introduce analytic models.)

Michael Hvidsten Gustavus Adolphus College

Concrete Conics and Pencils in Projective Geometry

Students often have difficulty in conceptualizing properties of Projective Geometry. Many of the concepts, such as pencils of lines and points, seem to have no intuitive connection to student's perception. This is unfortunate, as Projective Geometry is one of the most beautiful and elegant ideas in mathematics. This talk will demonstrate a project that is used in the presenter's geometry class where students investigate how pencils of lines naturally lead to conic sections in Euclidean Geometry. By extending this investigation to the circle model of Euclidean Geometry, students see how all conic sections are essentially the same in Projective Geometry. This investigation makes apparent how the idea of pencils of points and conics arise naturally in Projective Geometry.

Ruth I. Berger Luther College

Explorations using Cinderella

Cinderella is an easy to use dynamic software program which allows for constructions in Euclidean, Hyperbolic, and Elliptic geometries. Hyperbolic geometry uses the Poincare disk model. In Elliptic geometry the screen shows a transparent sphere where, because a "point" consists of a pair of antipodal points, the user sees the other part of their constructions on the back side of the sphere. The menu selection in Cinderella is similar to Geometer's Sketchpad: plot points, lines, segments, midpoints, drop perpendicular from P to l, measure segments and angles, ... and of course dynamically move your construction around. Cinderella also has a built in calculator. My course focusses on proofs, but almost every week I have an exploratory Cinderella lab, so students can get a feeling for these other geometries and make conjectures. Well known Euclidean results are verified while students get used to the menu items needed in the construction, then they explore the same constructions in the other geometries. Lab activities include: Measure the angles of a triangle and compute the angle sum. Measure the sides of a right triangle and check if $c^2 = a^2 + b^2$. Do the perpendicular bisectors of a triangle always intersect? If so, what is the relevance of that point? What about the angle bisectors? Construct an equilateral triangle for a given adjustable side length, measure the angles. Construct a rectangle (quadrilateral with 4 right angles). Measure the angles and the sides of a Saccheri quadrilateral. Do parallel (non-intersecting) lines exist? If so, do they have equidistant points, or a common perpendicular? The non-pro version of Cinderella is sufficient for my classroom use, it can be downloaded for free at Cinderella.de

Roberto Salgado U. Wisconsin La Crosse

Introducing Spacetime Geometry: Relativity on Rotated Graph Paper

The Minkowski Spacetime Diagram is an essential tool for understanding Special Relativity. However, its non-euclidean geometry makes it difficult to interpret. Since the circle is replaced by a hyperbola asymptotic to the light cone, displacements of equal size in Minkowski geometry do not look equal and directions that are perpendicular in Minkowski geometry do not look perpendicular. To help students see these features, we present an approach that allows us to draw and calibrate a Minkowski spacetime diagram using ordinary graph paper rotated by 45 degrees. The boxes in the grid (called "clock diamonds") represent units of measurement corresponding to the ticks of an inertial observer's light clock. We show that many quantitative results from special relativity can be read off a spacetime diagram simply by counting boxes, with very little algebra. We demonstrate this using visualizations created with GeoGebra.

Recreational Mathematics: Puzzles, Card Tricks, Games, Gambling, and Sports

Part A: Thursday, August 4, 1:00–3:55 PM, Taft C

Organizers: Paul R. Coe Dominican University
Kristen Schemmerhorn Concordia University Chicago
Sara B. Quinn Dominican University

Puzzles, card tricks, board games, game shows, gambling, and sports provide an excellent laboratory for testing mathematical strategy, probability, and enumeration. The analysis of such diversions is fertile ground for the application of mathematical and statistical theory. Submissions to this session are encouraged that look at new problems as well as novel solutions to old problems. Submissions by undergraduates or examples of the use of the analysis in the undergraduate classroom are encouraged.

Stephen Adams Cabrini University

Using Algebra to Solve Two Popular Puzzles That Aren't Sudoku

Kakuro (also known as Cross Sums) is a grid of white and black squares similar to a crossword puzzle. An integer between 1 and 9 is written in each white square such that the sum of the numbers is equal to a given value with the constraint that no numbers may be repeated in each sum. SCRABBLEgrams is a puzzle consisting of four racks of seven letters. A word is made from each of these racks and is scored according to the normal point values in Scrabble. The goal is to maximize the total score of all four words. In this talk we demonstrate how elementary algebra can be used to find solutions to these popular puzzles.

Ying Zhou Rhode Island College
Walter G. Gall Rhode Island College

Locker Lotto

The classic Locker Problem has been used in K-12 textbooks to simulate student interest in number multiples and probability. We extend the problem by modifying the rules of game and adding properties to the lockers. These variations have been used in teaching Number Theory and undergraduate research projects. There are various approaches to solve the problem. CS students would calculate the probability by running simulations, while math students use combinatorics. In either way, it is a fun game to learn from. One version of the extended game was used in a student's senior honor project. One day before practice, a sports team of 20 players is divided into two groups, red and blue, with 10 players each. Each player is given a bag of the corresponding color for his belongings. The players are in a hurry, so they quickly stuff their bags and randomly place them among 20 lockers labeled 1 through 20. During the practice, a player from the red group needs to find his bag, but he has no recollection of which locker was his. The janitor comes over and says to him, "Let's play a game. You can open any single locker: if you find your bag you win, and otherwise I win." The player doesn't like games with the odds stacked so high against him, so he negotiates, "How about giving me a bonus pick if open a locker with a red bag in it that isn't mine? So I can keep choosing new lockers so long as the bags inside them are red." The janitor agrees and says, "Fine. If you win, I'll give you seven dollars. If I win, you just give me a dollar." The player pauses and thinks whether he should take on this game. In general, if a total of n players split into a two groups of k red and (n-k) blue, what is the probability of winning the game? Further what if the players split into three groups, what would be the chance?

Anne Quinn Edinboro University of PA

Mathematical Strategies for the Game of SET®

SET® is a popular, fast-paced game which I have used to study mathematics with people of all ages (from middle schools to college math clubs to professionals). The game is very addictive and leads students of all ability levels to discover many areas of mathematics in their search for strategies. Numerous mathematical topics will be discussed (such as combinations, permutations, probability, expected value, divisibility, modular arithmetic, and mathematical proof) as we search for the best strategies for winning. Results will include my solutions (some of them published in the Mathematics Teacher in 1999 and on the SET Research page in 2011), undergraduates' solutions, ideas for the classroom, and some further questions for study. For basic information on the game: Each card can be identified by four attributes, each of which has three values: number (1, 2, 3), color (red, green, purple), symbol (diamond, oval, squiggle), and shading (open, striped, solid). An introduction to the game and some basic questions are available at www.setgame.com .

Gordon A. Swain Ashland University

An Analysis of *Sorry!*

Games where moves are determined by chance can be modeled as a Markov process, and analysis can determine the expected length of a game. A single player, single pawn, version of *Sorry!* is open to this analysis; however, moves in *Sorry!* are determined by selections from a deck of cards rather than dice or a spinner, and some cards give the player options. We determine strategies to optimize the length of the game. Additionally, Markov chain results are compared to average game lengths generated by a computer simulation.

Darren Glass Gettysburg College
Jonathan Needleman LeMoyne College
Stephen Lucas James Madison University

Chutes and Ladderless

In this talk, we will consider the effect that the size of the spinner has on the expected length of a game of Chutes and Ladders. In particular, using both computational techniques and a Markov Chain analysis, we will consider what size spinner will allow a game on an n-square board with no chutes or ladders to end as quickly as possible, and we will consider questions of how placing chutes and ladders on the board will affect this length.

Flavia Sancier-Barbosa Antioch College

Risk and War: Is a good offense the best defense?

We compare the probabilities of conquering territories in the board games "Risk" and "War". War is a Brazilian variant of Risk in which the defense uses the same number of dice as the attack, three instead of two. Dice odds in the game Risk have been thoroughly investigated, corrected, and extended by others. We use a similar set of mathematical and statistical tools, such as Markov Chains and Order Statistics, to extend dice odds to the case of three defense dice. The conquering probabilities offer insight on the main difference between these two games, and whether aggressive or conservative strategies work best in each game.

Kimberly Jordan Burch Indiana University of Pennsylvania
Rachelle Bouchat Indiana University of Pennsylvania
Derek Hanely Indiana University of Pennsylvania
Mitchell Ponchione Indiana University of Pennsylvania
Aaron Werner Indiana University of Pennsylvania

Strategic Placement in *Ticket to Ride*©

Ticket to Ride© is a board game in which players complete train routes connecting cities throughout North America. In this talk, the game board is represented by a graph, with the cities corresponding to vertices and the connections viewed as edges. We present a weighting of the graph's edges which identifies the most valuable routes in the board game. Both offensive and defensive strategies are analyzed that utilize the routes identified by our weighting.

Bradley Forrest Stockton University
Kara Teehan Rutgers University

The Topology of Knight's Tours on Surfaces

The Knight's Tour problem is a classical chess puzzle and a mainstay of recreational mathematics and graph theory. There are many generalizations of the problem, Knight's Tours have been studied on varying board sizes, shapes, and dimensions. In this talk, we discuss closed Knight's Tours on cylinders and tori. Each such tour realizes an element of the fundamental group of the surface. We will give a characterization of the sizes of cylinders and tori that admit nullhomotopic Knight's Tours. We will also give a characterization of the sizes of cylinders that admit a tour that realizes a generator of the fundamental group, and an analogous characterization for tori.

Sarang Aravamuthan Tata Consultancy Services

Two-Player Games on Arithmetic Expressions, Graphs and Checkerboards

e-Valuate is a game on arithmetic expressions. The players have contrasting roles of maximizing and minimizing the given expression. The maximizer proposes values and the minimizer substitutes them for variables of his choice. When the expression is fully instantiated, its value is compared with a certain minimax value that would result if the players played to their optimal strategies. The winner is declared based on this comparison. We use a game tree to represent the state of the game and show how the minimax value can be computed efficiently using backward induction and alpha-beta pruning. The efficacy of alpha-beta pruning depends on the order in which the nodes are evaluated. Further improvements can be obtained by using transposition tables to prevent reevaluation of the same nodes. We propose a heuristic for node ordering. We show how the use of the heuristic and transposition tables lead to improved performance by comparing the number of nodes pruned by each method. We describe some domain-specific variants of this game. The first is a graph theoretic formulation wherein two players share a set of elements of a graph by coloring a related set with each player looking to maximize his share. The set being shared could be either the set of vertices, edges or faces (for a planar graph). An application of this is the sharing of regions enclosed by a planar graph where each player's aim is to maximize the area of his share. Another variant is a tiling game where the players alternately place dominoes on a 8 X 8 checkerboard to construct a maximal partial tiling. We show that the size of the tiling x satisfies $22 \leq x \leq 32$ by proving that any maximal partial tiling requires at least 22 dominoes.

Part B: Friday, August 5, 1:00–4:15 PM, Taft C

John Bonomo Westminster College

Winning a Football Pool is Harder than You Thought

A confidence pool is one where a unique confidence value is placed on the outcome of a series of games (for example, college football bowl games) and each contestant's score is the some of the confidence values for correctly predicted games. After a certain number of games have been played it is often desirable to know whether or not you still have a chance to win the pool, given the results of the games already played and the confidence values placed on the remaining games by you and the other contestants. We show that this problem is NP-complete, meaning that with very high probability there is no fast solution to determine its answer.

Russell E. Goodman Central College

Goals in Context: an Analysis of Iowa Conference Goal Scorers

In soccer, a simple tabulation of goals scored does not tell the story of the *value* of the goals a player has scored. This presentation will offer the results of an analysis of goal-scoring in the 2015 Iowa Intercollegiate Athletic Conference (IIAC) soccer season. The analysis attempts to quantify the context and value of goals scored, to determine a method to produce a more value-oriented goal-scoring leaderboard. Full disclosure: the presenter is an assistant coach for one of the teams in the IIAC.

Paul Fonstad Franklin College
Justin Armbruster Franklin College

Non-transitive Swim Meets

Inspired by the scoring system used in NCAA Division III dual swim meets and based on an undergraduate research project, this talk will examine if one of these meets can have a non-transitive finish; that is, can team A beat team B, and team B beat team C, but team C beats team A, all in the same swim meet? The journey toward an answer and beyond will be a glimpse into the realms of probability, voting theory and even abstract algebra, as conditions are discovered for when these finishes are possible.

Jon Stadler Capital University

Sequences related to bounded juggling

A siteswap is a sequence on nonnegative integers, each term representing the length of time a ball is in the air. The formula for the number of b-ball siteswaps of length n is known, yet a formula for the number of sideswaps in which the throw heights are bounded is quite challenging to produce. Nevertheless, there are numerous well-known sequences lurking in this collection of numbers. We will discuss some of these and some lesser-known sequences related to bounded juggling.

Ryan Fox Belmont University

What's up with Countdown?

I have used an activity similar to the numbers game in the British game show *Countdown* for mathematically interested middle school students and pre-service elementary teachers. For portions of the game, contestants are given six numbers from the numbers one through ten, 25, 50, 75, and 100 and are expected to use some or all of the numbers, including their partial sums and products, to get a three-digit number. I run the game for middle school students much like the game show itself. However, with future elementary teachers I modified the game for them to use in their future classroom: use only one-digit numbers and have students or contestants reach a two-digit target number. I will refer to this as the modified game. In presenting the modified game to both future teachers as a course assignment and to practicing school teachers as presentations for state and regional mathematics teacher conferences, I very rarely noticed a puzzle that did not have a solution. I am bringing in college students interested in mathematics to support my conjecture about the likelihood of a solution to each puzzle in my modified game. Two goals for my presentation are to introduce an additional audience to the game for the purposes of collecting feedback and to encourage undergraduate students' work with mathematics outside of the usual classroom experiences. The undergraduates in this presentation will provide explanations for results from generalizing the modified game. Opportunities for student presentation and audience participation exist in the current setting: for what collection of one-digit numbers would there be no solution for a two-digit number in this modified game?

Anthony DeLegge Benedictine University

The Probability of Joining the *Monopoly Millionaires' Club*

Monopoly Millionaires' Club was a weekly game show that aired from March 2015 to April 2016, featuring lucky lottery winners from across the country competing to win large cash prizes. The show's final game of the night was always "Go for a Million", where one contestant risked all of his/her winnings to try and win a million dollars. To play, the contestant rolled a pair of dice and tried to make it around the Monopoly game board in five rolls or less. If he/she was able to do so and land exactly on "Go", then he/she won a million dollars. However, even if he/she was unsuccessful, tens of thousands of dollars in prizes could still be won as consolation. In this talk, we will study the "Go for a Million" game in depth and discuss the answers to two key questions: What is the probability a contestant can win the million dollar prize, and is it worth the contestant risking his/her potentially substantial earlier winnings to "Go" for the million?

Robert W. Vallin Lamar University

Waiting for a Sequence in Roulette

In an experiment of flipping a coin three times, each of the eight possible outcomes is equally likely to occur. However the possible results of three tosses have different wait times for an outcome's first appearance in a string of coin flips. In this talk we apply this idea to a roulette wheel, where the player can choose Red or Black, and analyze the wait time for three outcome choices (such as Red/Black/Red) to appear in a run of spins under different green square (0 and 00) interpretations. This is all related to Penney's Game, a non-transitive two-player game that first appeared in 1969.

Mark Bollman Albion College

Penny Keno and Integer Programming

Keno is a casino game with a long history and a notoriously high house advantage. *Penny Keno* is a new video keno game which allows players to play hundreds of virtual tickets at 1 cent each. Tickets are based on patterns within alphabetic letters on a keno ticket. This talk will examine the possibilities for winning a Penny Keno bet, and will explore how attempting to find the maximum possible win leads to a simple problem in integer programming.

Jeff Rosoff Gustavus Adolphus College

Arbitrarily Unfair Card Decks and a Conjecture of Artin

Cheating at cards has long been a source of fascination. Various forms of cheating involving sleight of hand, hidden cards and marked decks have been immortalized music, in countless movies, and of course on velvet. A more subtle form of unfairness in cards involves simply the number of cards in a deck. In this talk we provide a measure of fairness of a card deck based on shuffling, and use a bit of calculus and group theory to show that there are decks that achieve any specified degree of unfairness simply because of their sizes. These ideas lead in a natural but surprising way to a famous conjecture in number theory.

Richard D. Neidinger Davidson College

A Fair-Bold Gambling Function is Simply Singular

What are the chances of achieving a goal in Vegas as a function of how much you start with? Repeatedly play a simple game with the odds against you, but bet boldly toward your goal. The probability of reaching your goal continuously increases as a function of your initial stake. Amazingly, the function never has a positive derivative, it's zero almost everywhere, called singular. If you play with a friend instead of Vegas, you could make it "fair" by alternating the odds of house and client. Now the probability of reaching your goal is a strange new singular function. We exploit its fractal structure to characterize the derivative at each point. Such pointwise characterization has been elusive for singular functions.

Encouraging Early Career Teaching Innovation

Part A: Friday, August 5, 1:00–4:55 PM, Union A

Organizers: Susan Crook Loras College
David Failing Quincy University

Faculty are eager to offer activities in the classroom that foster student success, but many are not formally trained in pedagogy. Junior faculty in particular may feel overwhelmed with adjusting to a new position, and the need to create an impressive tenure portfolio. This session will consist of presentations of effective and innovative We hope that this session will allow junior faculty in particular to be exposed to new, successful techniques that have been vetted by experienced faculty. We would also encourage presenters to be open to being contacted by attendees with questions about implementation, addressing any possible barriers to implementation, etc..tips, techniques, and tricks that experienced faculty members have used. Talks will address the reasoning behind, design, and implementation of their resource. While these activities may be whole course techniques, we also seek presentations on activities that can be dropped into an existing class to bolster student learning and reflection. Such activities may include exam wrappers, question stems, and IF-AT scratch off cards. Techniques do not have to be original to the presenter, but sources should be credited and proof of success (or failure and redesign) should be given.

Magdalena Luca MCPHS University

Teaching Tips and Tricks I Wish I Knew 25 Years Ago!

How do we measure student success? By their grades or by high evaluation scores at the end of the semester? I believe that student success is measured by how well students *retain, connect and reuse* the concepts taught in a course in their future learning and throughout their entire life. This presentation will address innovative teaching methods that help science students succeed in Precalculcus, Calculus and/or Statistics courses. I will give concrete examples of activities and ideas that work well in all mathematics courses and examples that are tailored to a specific course. These activities have been successfully developed, utilized and improved throughout the years to promote a deeper, conceptual understanding of mathematics, improve complex cognitive skills and engage students in the learning process and in higher-level discussions during class. The teaching tips and tricks I will share in my presentation will expose junior faculty to effective pedagogy and stimulate a discussion with the audience.

Sarah Wolff Denison University

Preludes: A question-based approach to linear algebra

One of the most important aspects of teaching vector space linear algebra to students who have taken nothing other than calculus is to get them to engage with the material and start asking their own questions. This year, I taught linear algebra both terms and in the second term was funded by a Pedagogy Practice Project along with Lew Ludwig at Denison to introduce 'preludes' into our classroom. My 'prelude' was to introduce each new topic with a series of leading questions, then to frame class as a discussion around those questions that began to push at definitions and general ideas. This approach really created a discussion environment in the classroom that I had never experienced before- by the middle of the semester I could go in, put one or two definitions on the board, and receive enough questions to have an entire 50-minute discussion. In this talk I will give examples of the 'preludes', talk about the change in classroom environment over the semester, compare it with the previous semester of teaching the same class, and welcome feedback on how to grow and develop these ideas further.

Roger Wolbert University at Buffalo and Edinboro University of PA

Posing Problems Using the "What-if-not" Strategy in a Geometry Class

Students in an introductory geometry class are typically exposed to proofs of common theorems such as the Pythagorean Theorem. They are also exposed to problems centered on common theorems, formulas, or definitions. However, students probably have not explored types of problems where the conditions of a theorem are not met, e.g., what happens if $a^2 + b^2 \neq c^2$. In this session, we will review how George Pólya's ideas of formulating new problems from an existing problem can lead to discoveries new to students. We will extend Pólya's ideas using Stephen Brown and Marion Walter's "What-if-not" strategy for posing new problems. Studies show that students who reflect on the new problems after using the "What-if-not" strategy have a deeper understanding of the solution to the original problem. Participants are encouraged to bring a geometric problem or topic to the session to discussed and explore using the "What-if-not" strategy.

Ashley Johnson University of North Alabama

A Flipped College Geometry Course

In this talk, I will discuss the nuts and bolts of my flipped College Geometry course for secondary teachers. In short, the course is group worked based with students completing reading guides ahead of class. I will also include student reactions and suggestions to the set up of the course, and I how I have adapted it over the past three years.

Donna Flint South Dakota State University

Easy Innovations in Real Analysis

Easy Innovations in Real Analysis Real Analysis is a difficult course to teach. Besides the obvious complexity of the topics and proofs (which makes it quite easy to give long, complicated, boring lectures), there is the issue of student prior experience. For many students, this is a first or second foray into the fascinating world of theoretical mathematics. Without careful guidance, too many students tend to spend class time frantically taking notes, confident it will all become clear later while they are studying alone... between social media postings ... with their music on... late at night. This talk presents activities for a class designed to help students understand the ideas of Real Analysis while developing skills in reading proofs, writing proofs, conjecturing, and formalizing mathematical ideas. Development and use of these and similar activities will make your class time more interesting and more productive and have the nice side effect of allowing you to work *with* your students instead of *for* your students.

Jacqueline Jensen-Vallin Lamar University

Teaching students to read their textbook

In an ideal world, students will read the textbook to understand new concepts, look for examples similar to assigned problems, and to preview new material. It doesn't take long for new faculty to learn that many students do not use their text this way. Reading quizzes (first suggested to me by Ryan Higginbottom) with focused questions can encourage and support these skills. Introducing this practice in freshman level courses help students as they progress through mathematics classes, and enhance their learning experience. We will discuss the implementation and effectiveness of these reading quizzes.

Michael Janssen Dordt College

Improving proof-writing with reading guides

One of the barriers in the transition advanced mathematics is that the proofs and ideas in even the best mathematics texts must be read more carefully than many students are accustomed to. Yet in order to learn to write proofs well, one must learn how to read proofs well. Borrowing an idea from Lewis Ludwig, I flipped my introduction to proofs (discrete structures) course in Spring 2016 with the use of reading guides. Each day, students were responsible for reading a section of the text and completing a worksheet that highlighted the main points, asked students to create their own examples of the concepts introduced, and probed the inner workings a proof or two in depth. These reading guides then formed the basis for classroom discussion. I will share examples of the reading guides I created and discuss student reactions.

Maria Fung Worcester State University

Writing Assignments for Math Courses

In this talk we will describe a variety of writing assignments for the mathematics classroom. We will consider informal assignments (both short and long), formal assignments (with different audiences in mind), and creative writing assignments (larger projects or capstones). Why use writing? We will present evidence of improved understanding and learning.

Nicholas Long Stephen F. Austin State University

It's the Little Things that Matter: Assignments that Go Somewhere

While innovation in teaching should be holistic, it is often the little things that you do (or don't do) that can make for lasting change in students. I will talk about using technology to reinforce sense-making rather than answer-getting, and using free-writing assignments to engage students in a discussion of education and their role in it. I will discuss assignments that form the prelude to transformative experiences like undergraduate research. Key to all of my successful (and unsuccessful) attempts at teaching innovation have been an environment where trying something new is encouraged (or at least, not discouraged) and a focus on improving student learning and experiences, not just covering more content.

Kristin Lassonde Klamath Community College

Foster Student Understanding with Formal Test Corrections

How often do students miss problems on a test and then continue to make the same errors test after test throughout the course? All too often students miss concepts covered on a course test and never spend the necessary time required to correct those errors. After studying the best they feel they can, students feel defeated when they still miss concepts. They often chalk it up to bad luck or not being able to learn everything. They move on to the next unit in the course, leaving behind that concept and hoping to never see it again. Instructors unintentionally perpetuate this issue by providing test solutions, which are frequently looked over for a few seconds and then discarded. Instead, consider fostering student understanding with formal test corrections. Force students to face their own mathematical misconceptions by using a formal test corrections process. It is strongly recommended to make this a required assignment in the course. Decrease the likelihood of students repeating the same errors on future tests by requiring students to face their own errors now! When students spend time correcting and reflecting on test errors, both their own understanding and accountability for their own learning is strengthened.

Caroline Maher-Boulis Lee University

Effective Techniques to Get Students Engaged

In the first years of my teaching career I was faced with the problems of disengaged and disinterested students. This was particularly so in the lower level classes and mathematics courses for non-science majors. Through the years I have learned, used and developed several techniques for the classroom. The activities resulted in very dynamic and engaging classes as evidenced by peer evaluation and students' course evaluations. In this talk I will present some of these techniques and point out the ones that have worked best.

Christopher T. Sass Young Harris College

Techniques for Fostering Community, Engagement, and Inquiry in Lower Level Classes

Many new faculty members find it challenging to teach lower level courses populated in significant proportions by students who may not expect to find the mathematics interesting, but enrolled only to satisfy degree requirements. In this talk I will first outline broad practices for fostering community and engagement in these classes. I will then make specific recommendations for experimenting with new teaching techniques by incorporating inquiry-based learning modules at certain stages of material development and coverage. Finally, I will share examples of such modules from College Algebra, Precalculus, and Calculus I.

Part B: Saturday, August 6, 9:30–11:45 AM, Union A

Suzanne I. Dorée Augsburg College, Minneapolis

At the bell: designing, implementing, and assessing entrance quizzes

Entrance quizzes are an important tool in any professor's toolkit. They give students (and the professor) frequent feedback on their learning, create teachable moments to reinforce key ideas, can help build student self-efficacy, provide a launching point for the day's lesson, and encourage students to be on time for class. Well designed quizzes can test core concepts or memory of key facts in ways that online (or any open book) homework cannot. For several decades I have used entrance quizzes in a variety of classes with great success. In this talk I'll describe some key features to writing a good quiz, including examples from abstract algebra, linear algebra, multivariable calculus, precalculus, and developmental algebra. I'll explain how I have students self-correct their work, with just a little quick oversight from me, making these quizzes super quick to grade. I'll also share how I build these quizzes into the course grade in a way that does not artificially inflate course grades and yet builds student confidence.

Dawn Archey University of Detroit Mercy

Authentic Applied Problems: like story problems only less stupid

Students want to know when they will use math in real life, but complain when asked to do story problems. This is because story problems are hard without being meaningful. Meanwhile, employers want to hire people who can take an ambiguously stated problem, decide what mathematical techniques to apply, and present their conclusion in a clear and convincing fashion.* Traditional story problems, do not really reach the point of doing this either. One solution to both the students' complaint and employers' desire is to create and use Authentic Applied Problems (AAPs). For example, instead of computing the height of a tree by measuring its shadow, students are asked to estimate the height of mountains on Pluto based on the lengths of shadows in pictures taken by the New Horizons craft in its fly by. Adding AAPs to a class is a teaching innovation that is well suited to a beginning faculty member because one is not committed to anything for the whole term, rather one can create as many of these as time allows. The speaker tries to add one or two new AAPs to each course every semester until the course has enough. For additional examples of AAP's see http://blogs.udmercy.edu/archeyde/ *Based on interviews with employers at a Universiy Carreer fair.

Justin Dunmyre Frostburg State University

Quick and easy random groups

Two frequently talked about components of active classrooms are group work and student presentations. This talk will focus on the logistics of how one might manage in-class group work and presentations. There are many ways one might decide to form groups. Should they be based on GPA? Should the students choose their own groups? In my classes, I randomize the groups for each class meeting. We will discuss the relative merits of this choice and a quick method that can be used to form groups while minimizing in-class organization time. Once the logistics of forming the groups are discussed, we will briefly discuss the types of work you might collect from groups. Finally, we will turn to address the logistics of student presentation of group work and some easy adjustments that I have made that have made a big difference.

Michelle Cordier Wheeling Jesuit University

Using Microsoft OneNote for Lesson Plans

Go paperless, save time, and stay organized using Microsoft OneNote. I found in the past that I would spend too much time filing through papers, recreating exams, and finding files. Using OneNote, I am able to create lesson plans, view past exams, and keep files organized. In particular, I will discuss my OneNote notebooks I used for Calculus II and Complex Variables classes.

Roberto C. Soto California State University, Fullerton

Knowing our Students

As a new high school teacher in the Los Angeles metropolitan area I quickly learned that the earlier I memorized my students' names the easier it would be to manage my class. In the years that followed I also learned that the more I knew about my students' prior knowledge the more effective I became as an educator. In the past eight years I have been modifying my "high school tricks" in college classrooms in Iowa and southern California with success and would like to share the various ways that I gather valuable information regarding my students, which then informs my practice. This information allows me to tailor my classes to create a learner-centered environment and thus become a more effective educator! In this talk we will discuss easy to implement yet effective strategies that will allow us to better serve our students and simple modifications that can make them work for you. Samples of student work and other resources will be provided.

Brian Katz Augustana College

Me and My Shadow: Teaching students about Pedagogy

The biggest change in my first decade of teaching comes down to this claim: students can learn to understand how teaching and learning work. In this talk, I will briefly describe my journey to this claim and then share some classroom activities and reflection assignments that I use to teach my students about pedagogy, techniques I feel are particularly important for young faculty using active learning pedagogies. I expect to share activities from the first day of class and the middle of the term as well ideas for weaving this learning into ongoing course structures.

Erin Moss Millersville University of Pennsylvania

Using Video to Prompt Reflection in Mathematics Courses for Prospective Elementary Teachers

Mathematics courses for prospective elementary teachers are often taught by professors with a limited background in K-6 education. A major challenge facing an instructor who is new to these courses is getting students to think deeply about fundamental mathematics while making explicit the relevance to their future careers in the classroom. Short videos of students sharing their mathematical thinking can meet the goal of mathematical depth while increasing preservice teachers' buy-in to the course. They also provide a way for an instructor to start to break free from traditional lecture-based pedagogy. A series of video clips of elementary-aged children solving and discussing problems, produced as part of the federally-funded Integrating Mathematics and Pedagogy (IMAP) project, is publicly available online. Instructors can use these videos during class time to prompt small-group and whole-class discussion; as a way to teach key mathematical concepts; as a form of assessment to gauge students' understanding of elementary mathematics; and/or as an impetus for an individual or group capstone project. During this presentation, I will share several ways that I have used these videos in my instruction, sample assignments that might be paired with the video clips, and excerpts from student work. Participants will also receive a handout with other video resources that are useful for designing lessons or assignments.

Formative Assessment Techniques for Undergraduate Math Courses

Part A: Friday, August 5, 1:00–4:35 PM, Union B

Organizers: Jarod Hart University of Kansas
Alyssa Armstrong Wittenberg University
Katie Haymaker Villanova University
Mike Janssen Dordt College
Austin Mohr Nebraska Wesleyan University
Jessica Stewart Christopher Newport University
Jessica O'Shaughnessy Shenandoah University
Amanda Harsy Lewis University

Recent trends indicate that formative assessment encourages a growth mindset, reduces test anxiety, and improves student gains in math classrooms. The purpose of this session is to disseminate new approaches to student evaluation that use assessment as a learning experience and help students overcome challenges that disproportionately affect students in math classes, including test anxiety, insufficient prerequisite knowledge, or lack of confidence. Examples of formative assessment include mastery-based testing schemes, feedback on rough drafts of student work, peer review of coursework, and oral exams. The focus of the session is on pedagogical rationales for formative assessment tools, their practical implementation, and their impact on the aforementioned challenges facing students. Speakers should talk about formative assessment techniques they use in these contexts, and provide evidence of how they encourage student success in math courses. In addition, speakers are encouraged to share their experiences and their advice for educators planning to incorporate formative assessment in their classes.

Frank Savina The Charles A Dana Center, University of Texas at Austin
Stuart Boersma Central Washington University
Rebecca Hartzler Seattle Central College

Formative Assessment in the new STEM Prep Pathway

The New Mathways Project (NMP) from the Charles A. Dana Center at the University of Texas at Austin has designed a mathematics pathway that prepares students beginning at the elementary algebra level to succeed in college-level calculus. The pathway consists of two courses: Reasoning with Functions I and II that are designed with an inquiry guided instruction structure that frees the instructor to work with groups of students during class assessing their understanding on a continuous basis. Each course has approximately 90 lessons and each lesson has three components: 1) a *Preview* assignment which prepares students for the upcoming in-class lesson while simultaneously requiring students to self-assess their understanding of these pre-requisite skills ; 2) an in-class inquiry guided *Lesson*; and 3) a set of *Practice* problems which extend beyond the Lesson. Preview assignments ask students to rate their own competence and encourage them to seek additional resources in preparation for class. In-class Lessons are designed for students to share their strategies and reflect on their progress. Additionally, the

curriculum intentionally integrates three levels of Constructive Perseverance into the student experience. Detailed instructor notes for each lesson guide instructors on the type of formative assessment that is appropriate for each level of Constructive Perseverance and provide support for choosing the level of instructor-student interaction and the type of formative inquiry that would be most helpful. The authors will share specific examples from the curriculum which illustrate all these formative assessment techniques.

Jenna P. Carpenter Campbell University

A Formative Assessment Approach to Teaching Integration Techniques

With effort, students can master the intricacies of calculus integration techniques, but determining when to use which one is often the bigger challenge. One can show students the "10,000-foot view" of the problem landscape, together with the structural properties that different techniques exploit. Still, students need to practice the associated analytical strategies under test conditions to be prepared for an exam. We do this through the use of integral recognition quizzes, which present students with ten integrals and require them to identify, in 5 minutes or less, the correct integration technique required to work each one. Students are not required (nor do they have time) to work the integrals, just identify the correct techniques. By focusing students on "getting started" and removing the crutch of knowing which problem came from which section of the book, students must rely on analytical strategies. Timing the quizzes forces students to learn to apply the analytical strategies fast enough to finish the actual exam. Quizzing students at least 3 times before the test exposes them to a range of integrals and provides the opportunity to learn from mistakes on previous quiz(zee). This formative assessment approach results in noticeably better-prepared students (with minimal negative impact on course grade) and much-imrpoved test grades (with minimal impact on faculty time). It also drags students' attention away from the details of individual techniques to the overarching analytical skills that often get overlooked in homework. Recognition quizzes can also be used with other topics, such as solving equations or factoring, that require students to develop analytical skills in order to correctly select from multiple solution strategies.

Jeanette Mokry Dominican University

Preparation Assignments and Student Success

In many disciplines it is typical to have students come to class having read over material that will then be further discussed. In mathematics part of being prepared is coming to class with certain prerequisite knowledge so it can be recalled and built upon in a new context. Short assignments which focus on this prerequisite material allow students to be better prepared for class. They also inform the instructor what misconceptions, if any, need to be addressed and what are the areas of weakness that require more in-class review. Several examples from Calculus II will be provided, as well as student and instructor feedback on how they affected the course. Additional examples from Calculus I and Trigonometry/Precalculus will also be provided.

Timothy Boester Wright State University

Using Oral Exams to Reinforce Calculus Concepts

Assessment techniques should be aligned with the pedagogy and mathematical content of a course. In the case of an undergraduate calculus class that specifically emphasized explanations of conceptual understanding, oral exams were used so that students could demonstrate their knowledge in lieu of traditional problem solving. Examples of oral exam problems and grading rubrics will be discussed. In addition, connections between exam questions and activities introducing course content as well as students' reactions, exam preparation strategies, and outcomes will be shared.

Mary Nelson George Mason University

Oral Reviews: Formative Assessment that Results in Improved Grades, Understanding and Retention

Failure rates in introductory mathematics and science courses often result in discouragement and even the dropping of a STEM major. The gatekeeper of most STEM majors is Calculus, and the national failure rates are about 40% for first semester calculus. More troubling is the fact that many rural and inner city high schools are unable to provide high level mathematics courses that are available to students in the suburbs. Hence some students begin STEM majors at a distinct disadvantage. Our study showed strong correlations between the use of oral reviews and a leveling of the playing field for mathematically under-prepared students. Orals are discussion-based review sessions that take place before written exams. They are voluntary and ungraded one hour sessions. A group of 5-6 students discusses important concepts with each other and a knowledgeable facilitator. They elucidate concepts to be covered on upcoming written exams, and they draw graphs and diagrams to clarify important ideas. Students gain a more conceptual understanding of course materials through the interactive feedback and the opportunity for increased discourse. The incorporation of these reviews has been shown to be highly correlated to improved exam scores and to a decrease in DFW rates. At the University of Colorado at Boulder, for example, a ten year average failure rate of 31% for Calculus I was dropped to a five year average of 22% after the introduction of oral reviews.

Sarah L. Mabrouk Framingham State University

Re-Think and Re-Do: A Learning Opportunity

During the past few years, I have included a learning opportunity in connection with examinations and some assignments. This learning opportunity is designed to guide to students to reconsider and revise their work as well as to enable them to reflect on their efforts throughout the course. For this opportunity, students determine and describe what was incorrect or incomplete in regard to their analysis, solutions, and/or proofs, discuss the changes that must be made and relate these to relevant information about the topics, methods, and theorems being used, and completely redo each problem or proof correctly. In this presentation, I will discuss the requirements for this learning opportunity, its use in various courses from introductory courses such as quantitative reasoning and college algebra to calculus and courses for mathematics majors such as Euclidean geometry and numerical methods, the grade benefits to the students, and the effect on student morale and confidence as well as the continued benefits throughout the semester and on the final examination.

Anil Venkatesh Ferris State University

Mastery-Based Assessment: An Implementation with Reflective Writing

Mastery-based assessment has been shown to improve student confidence and achievement. However, promoting mastery by allowing revision of graded work can result in untenable instructor workload in larger classes. In this talk, we share results from a semester-long study of mastery-based assessment in mid-size sections of intermediate algebra, calculus, and linear algebra (enrollment approximately 30). We present on the practical implementation of the study, including sample assignments and assessment techniques. We also offer quantitative and qualitative evidence of student success in mastering course content and building reflective learning practices. We conclude with a discussion of the obstacles encountered in the study and propose measures to address these obstacles.

Austin Mohr Nebraska Wesleyan University

Mastery-Based Exams Are Self-Evidently Better Than Traditional Exams

A mastery-based examination is one in which students receive credit only for completely correct solutions, but they are given many attempts throughout the semester to display mastery. A brash assistant professor claims that this simple shift in perspective results in an assessment technique that is necessarily superior to traditional examination. Increases in student perseverance, growth-orientedness, and depth of understanding are among the many virtues we will observe from our armchairs. Survey data attesting to positive student outcomes at six different institutions will be provided for the staunch empiricists in the audience.

John E. Foster Walla Walla University

Mastery Grading in Calculus

Awarding partial credit for poor performance has notable drawbacks: It is time-consuming, it is arbitrary, and it gives little motivation for students to revisit material they have not mastered. This year I used a mastery grading system in the calculus sequence in an attempt to address these issues. I will describe my experience in implementing the system, share the effects I observed in student learning, and summarize student feedback concerning their motivation and stress levels.

Amanda Harsy Lewis University

Comparing Mastery-Based and Traditional Assessment in Calculus II Courses

We will present preliminary results from a two-year study comparing traditional assessment with a more formative assessment model called "mastery-based testing." In mastery-based testing, students are given early feedback which enables them to reevaluate and retest concepts they have missed on exams. This talk will compare qualitative and quantitative data collected from five Calculus II classes.

Derek Thompson Taylor University

A Journey Towards Specifications Grading

This talk will chronicle my experience with mastery-based testing, how that framework evolved into embracing specifications grading, and pitfalls to avoid with those assessment techniques.

Part B: Saturday, August 6, 1:00–3:35 PM, Union B

Gary MacGillivray University of Victoria

Using in-class assignments in a first proofs course

UVic Math 122, Logic and Foundations, is a first proofs course. Students study fundamental mathematical topics like sets, functions and integers, and learn the basic proof methods. For the past several years we have incorporated short, low-stakes, in-class assignments into the classroom time as part of a strategy to improve student success in the course. The emphasis is on providing a safe environment for practice, learning and mathematical communication, rather than on evaluation. The feedback from both students and instructors has been highly positive. Outcomes have included a more positive student experience, and a reduction of about 50% in the failure rate in most terms. We will discuss the overall strategy, implementation of the in-class work, observed outcomes, and measured outcomes. The latter is supported by data from the last 5 years.

Katie Anders University of Texas at Tyler

Improving and evaluating proof writing in a first abstract algebra course

We will discuss strategies used for evaluating students' proofs in an abstract algebra course. The goal of these methods is to provide constructive feedback both early and often so that students have the opportunity to improve and implement needed changes on a weekly basis. Our discussion will include student feedback and reviews of the methods.

Alison G. Lynch California State University, Monterey Bay

Using Technology to Provide Effective and Efficient Feedback for Proof-Writing

When learning to write proofs, students benefit from opportunities to receive feedback on their drafts and to revise their work. As an instructor, however, the logistics of providing this feedback can be challenging, especially for large classes. How will you collect and return work? How will you provide meaningful feedback quickly? How will you manage the paper load? In this talk, I will discuss some of the technology available that can help streamline this process while maximizing impact on student learning.

Amy Cohen Rutgers

Instructor-led workshops provide formative assessment

Formative assessments give instructors promptly useful information about their students' progress and about particular obstacles to their learning. In some courses at Rutgers, there have been weekly required workshops coached by the faculty member teaching the course or a teaching assistant working closely with the faculty member. Implementations in calculus for the mathematical and physical sciences and in elementary real analysis will be described. The instructor creates a workshop problem set on which students work in small groups. At the end of the period, one problem is assigned for a written report including numerical, graphical, and symbolic work surrounded by an explanatory exposition in good mathematical English. The goal is to improve understanding and communication as well as computation. There is also a weekly set of procedural drill exercises. It is very informative for instructors to observe students struggle to combine lecture material and sample solutions to approach the mathematically richer workshop problems - and to communicate their ideas and their questions. Coaching workshops corrects the optimistic view that clear lectures with well-constructed solutions of sample problems can substantially ease the work of learning. However, coaching does allow us to address inaccurate conceptions in real time and to provide generally applicable scaffolding for problems. In these ways, workshops do provide formative assessment.

Dave Klanderman Trinity Christian College
Sarah Klanderman Michigan State University

Reading, (W)Riting, Reflecting, and Reviewing: The Four "R's" of Formative Assessment in Mathematics

While almost all undergraduate level mathematics classes claim that reading the textbook or other materials is important, relatively few of these classes include appropriate formative assessment methods to maximize both the percentage of students who complete the reading and the value of the reading process. Our session focuses on innovative assessment methods used in a wide variety of mathematics courses, including calculus, math for teachers, math methods, statistics, abstract algebra, and history of mathematics. Methods discussed will include student syntheses of assigned readings with potential discussion questions (used in a modified flipped classroom model), student reading panels, individual and small group student guest mini-lectures, partner explorations and labs, individual and partner reading quizzes of several formats, student-generated review questions with answer keys, and peer reviews of class presentations. Summary data from a survey of over one hundred students enrolled in some of these courses validates the impact of these approaches to formative assessment.

Gizem Karaali Pomona College

Formative Assessment with a Purpose: From Philosophical Considerations to Pragmatic Implementation

Students, parents, and policymakers want to know why we teach the mathematics we teach. Even though we often dismiss it, I claim that this question is neither trivial nor irrelevant. On the contrary it is central to our role as instructors. In this paper I explore the philosophical underpinnings of mathematics education and then propose some implications for the reflective use of formative assessment in mathematics education. I then discuss my experiences with formative assessment in a diverse selection of courses (ranging from calculus to introduction-to-proofs) in this purpose-driven framework. Finally I offer some take-away ideas and adaptable templates for instructors. (This work was partially supported by a grant from the National Endowment for the Humanities.)

Allen G. Harbaugh Boston University

Considering Influence of Mathematics Students' Characteristics on Successful Use of Formative Assessments

Formative assessment aims to (1) change students' epistemic beliefs regarding the nature of knowledge and learning in the math classroom, (2) provide students self-regulatory skills and strategies to address the affective nature of learning, and (3) increase self-efficacious beliefs about doing mathematics as this is most strongly related to improving students' grades and overall passing rates in mathematics classes. However, as the population of undergraduate students being served is far from homogeneous, one might expect different levels of epistemic beliefs, anxiety levels, established self-regulated learning skills, and self-efficacy beliefs among our mathematics students. Furthermore, different formative assessments may require students to possess different skill sets or ability levels to effectively and efficiently use these self-evaluation protocols to progress them toward the desired goals. This paper presents findings on an extensive cross-sectional study of over 4,000 community college students in courses spanning the full spectrum of the first two years of the college-level mathematics curriculum. The findings suggest that there are indeed different characteristics of students at different levels, and this work begins to suggest how various formative assessments may operate differentially in the various cohorts.

Chandra Kethi-Reddy University of Central Florida

The Open Problem Curriculum and the Future of Calculus

An Open Problem Curriculum is only possible when we believe that education must be seen as training others to produce and apply knowledge to solve the problems they will face. We must teach students about unsolved problems. We should not force them to mechanically consume and regurgitate solutions to solved problems, while threatening to take away their grades, which are directly connected to their economic opportunities and, thus, their survival. The stress from the threat of failure significantly detracts from the quality of a student's education by prioritizing test performance over actually developing skills to interpret, create, and apply knowledge. We should increase our standards for students while lowering the consequences for failure. In order to encourage creativity and critical thinking, I outline an experimental syllabus for a Calculus I class, based on alternative epistemological grounds, where knowledge is considered as remnant byproducts of creative practice. This class is distinguished because it trust students with the unknown. By taking advantage of free, online resources like Khan Academy, teachers are free to talk about topics of their interest. Students will be tasked to responsibly edit a chosen calculus-relevant Wikipedia article as well as to demonstrate their understanding of open problems by producing original individual or group research, tailored to their interests. Collaboration and interdisciplinary work should be encouraged. Students who produce exceptional work should be helped to get into conferences, so they can directly impact and advance the field.

Programming in Mathematics Classes and Mathematics for Programming

Saturday, August 6, 1:00–5:15 PM, Union A

Organizer: Jacci White Monika Kiss, and Brian Camp, Saint Leo University

This session invites participants to reflect upon their use of computer programming and/or computer algebra systems within their upper-level mathematics curriculum. Implementations using SAGE, Maple Mathematica or other programming/computer algebra environments are welcome. The purpose of this session is to explore the outcomes of different aspects of programming in mathematics education while providing tools and/or examples for anyone that is interested in incorporating more programming into their own curriculum. Presenters will describe the tools used, lessons developed, and examples of student outcomes.

Patrick Davis Central Michigan University

Using Python in an Introductory ODE Course

Since its release in 1991, Python has increasingly become a valuable tool for the applied mathematics community. Packages like NumPy, SciPy, and Matplotlib provide the functionality needed to perform scientific computing; and front ends like IPython/Jupyter make using Python straightforward. Moreover, Python distributions like Anaconda (provided by Continuum Analytics) are free and open source - making Python a viable alternative to traditional propriety programs. In this talk, we will discuss the benefits and drawbacks of using Python in an introductory ordinary differential equations course as part of a teaching internship completed in the Fall 2015 semester under the mentorship of Dr. Leela Rakesh. In particular, we will examine the course structure as it relates to using Python, review samples of student work, and take a look at some student feedback. We will also provide insight towards improvements that can be made.

Mihai Caragiu Ohio Northern University

Computational number theory - quest and discovery in the undergraduate classroom

We will discuss several experiments in computational number theory (involving MAPLE, MATLAB and Julia) that attracted students (mainly at the undergraduate, but also at the graduate, level) by immersing them in a process of discovery involving recurrent sequences with primes. Our initial "hero" was the greatest prime factor function. It was used to generate recurrent "GPF sequences" in which any term is the greatest prime factor of a linear combination of a fixed-size set of preceding terms, with coefficients that are natural numbers. The "GPF conjecture" states that any such sequence is ultimately periodic. While we know that the GPF conjecture is true for "GPF-Fibonacci" sequences (every term is the greatest prime factor of the sum of the previous two terms), in most cases it remains unproven. We believe that the GPF conjecture is in the same family of problems that contains the "3x+1" problem or Conway's "subprime" Fibonacci sequences. However, several interesting variations on the original theme of the GPF conjecture, discovered by computer-aided experiments, were ultimately proved, particularly interesting being a Ducci game analogue of the GPF sequences and an analogue of the classical Gilbreath conjecture, both analogues holding true. A computational analysis of analogues of GPF sequences in two or more dimensions offer a glimpse in a special type of complex systems. In the author's experience, these problems are received very well by undergraduate students (especially, but not exclusively, by those with some exposure to an upper-level course on abstract algebra or number theory) and constitute an ideal and very efficient introduction to the excitement offered by the interface between pure and experimental mathematics.

Klaus Volpert Villanova University

Explorations in Financial Mathematics with Fathom

Fathom is an almost-free, ingenious, statistics software that is ideally suited for, among other things, Monte Carlo type explorations of random walks, the Central Limit Theorem, derived distributions, the pricing of options, both vanilla and exotic, and more. Such explorations nicely complement analytic solutions like the Black-Scholes Formula. The advantage of Fathom over R and other software is that it is easy to learn and the graphical interface is just brilliant. We'll demonstrate with some examples from our course on financial mathematics

Boyan Kostadinov City Tech, CUNY

Creating Art Patterns with Math and Code

In this talk, we present computational and visualization projects, which we have developed for our STEM students interested in coding. The projects are designed to mix programming, mathematics, experimentation, and engage students' creativity by appealing to their artistic side for creating art patterns inspired by mathematics and their imagination. The mathematics behind the projects makes use of finite weighted sums of complex exponentials, out of phase logarithmic spirals to visualize galactic arms in spiral galaxies, 2D and interactive 3D Lissajous figures, the Mandelbrot set and other fractal systems, and contour projections of 2D surfaces superimposed over heat-maps for creating complex art patterns. All projects are designed for implementation using the high-level, open-source and free computational environment R, a popular software in industry and academia for data analysis, simulations and visualizations. We hope that familiarity with R could improve students' chances of getting internships and full-time jobs. This project is supported by a MSEIP Grant from the Department of Education.

Chrissy Safranski Franciscan University of Steubenville

Maple and Mathematica for March Madness

I was inspired by the work of Tim Chartier at Davidson College to have students in a one-semester Linear Algebra class use a computer algebra system to set up and solve the Colley and Massey systems of equations to find ratings for NCAA Division 1 basketball teams. They then used those ratings to fill out brackets and evaluate the performance of their rankings. I will describe how I used this as part of my course, and share the programming that I and my students did in Maple or Mathematica to accomplish this. The amount of programming required by students can be adapted to the course - more from the students and less from the instructor, or more from the instructor and less from the students.

Shirley Yap California State University East Bay

Inter activity with Processing

Processing is a programming language and environment geared towards creating static, moving, and interactive images. Its built-in mouse functionality allows users to be part of the creative process and encourages exploration and play. I this talk, I will share ways in which to engage students in Linear Algebra and Calculus with Processing.

Brian Heinold Mount St. Mary's University

Using Python in a Numerical Methods Course

This talk will cover the ways I have used Python for in-class demonstrations, homework problems, and projects in a Numerical Methods course. Python reads almost like pseudocode, so it provides nice way to present many numerical methods. It also provides an environment to explore things like roundoff error and stability of solutions. Programming exercises can be used to test students' understanding of the methods because it usually takes a solid understanding of something in order to program it. Projects, such as graphically simulating a physical system by numerically solving a differential equation, can be done easily in Python and can give students something concrete to take away from the course.

Jean Marie Linhart Central Washington University
Adam Larios University of Nebraska Lincoln
Josef Sifuentes University of Texas Rio Grande Valley

Programming and Problem Solving: Getting Started on the Right Foot.

Programming and mathematics can go hand-in-hand, yet students often fear or resist learning to program. Even once started, students often think they require help when their code doesn't work, but simple problem solving would allow them to debug their code on their own. Initial assignments have a huge impact on students' later approaches and confidence. We will share our best practices for getting students started using a computer algebra system and programming in mathematics classes such as differential equations and mathematical modeling.

Jan Hlavacek Saginaw Valley State University

Using Julia via SageMathCloud in an Introductory Matrix Algebra Course

In Winter 2015, SVSU started offering an introductory Matrix Algebra course, intended mainly for pre-computer science and computer science majors. Although the emphasis of the course is on mathematical theory and applications, rather than algorithms and computation, we felt that including a computing component will help students with their understanding of the theory, and will allow us to include more interesting applications. In Winter 2016, we included a computing component as a required part of the course. The component consisted of several in class examples, and a series of guided homework assignments, delivered in the form of Jupyter notebooks on SageMathCloud. The examples and assignments used Julia programming language. We will discuss our experience with the computing component, Julia, Jupyter notebooks, and the SageMathCloud homework system, including our plans for future improvements.

Kevin Murphy Saint Leo University

Using Technology to Implement Discovery Learning in the Classroom

In this talk, I'll share and discuss Mathematica labs that I've used in my Differential Equations courses that allow students to build familiarity with Mathematica. The labs are designed to not only stress how to use Mathematica to solve the few specific problems of the current assignment, but to gain a comfort level in which they can find their own answers to any questions they might have as well.

Saúl A. Blanco Indiana University

A Games and Puzzles Class with Programming

We designed a course that explores mathematical ideas of two-person games with perfect information, both impartial such as Nim, and partizan such as tic-tac-toe, connect-four, and chess. Other topics included constraint satisfaction problems such as sudoku, group theory and Rubik's cube, and games of chance. The class was designed for juniors and seniors who had taken an introductory programing class and an introductory discrete mathematics class where proofs were introduced. The class assignments were designed with both written and a programming parts (in Python). The course culminated in a major final project, in which most students implemented games not covered in class and designed heuristics for the computer to play them, some used artificial intelligence ideas such as alpha-beta pruning and Monte Carlo tree search. At the end of the semester, we held a public poster session where students presented their projects. In this talk, we will discuss this class, the learning outcomes, and show some of the work that students completed.

Manmohan Kaur Benedictine University

Maple Implementations in a Cryptology Course

Cryptology, the science of sending and receiving secret messages, is at the intersection of mathematics and computer science, and encompasses every aspect of modern life - online financial transactions, digital signatures, cloud computing; the list goes on. In an undergraduate course in Cryptology, we use the computer algebra system Maple to implement various cryptosystems like Enigma, RSA, Diffie-Hellman Key Exchange, etc. These cryptographic methods are easily accessible to undergraduates, and can help kindle their long term interest in mathematics and its applications. Their Maple implementations add to the excitement in the classroom, as the students can see encryption and decryption done efficiently, in real time. They are also an attempt to bridge the gap between theoretical Cryptography, whose main concern is security, and practical cryptography, which is guided by efficiency. In this presentation, we will describe these Maple implementations, how they are used in the classroom, and student outcomes.

Brian Camp Saint Leo University
Monika Kiss Saint Leo University

The mathematician as a programmer

Mathematics is closely related to the field of computer science and programming is increasingly an important part of its curriculum. How are these programming skills acquired by today's mathematicians. It may be the case that programming is learned from a traditional computer science course on programming. This talk aims to explore how programming skills can be taught using computer algebra systems. To this end we will talk about how to design a mathematics course whose goal is to teach programming using CAS.

Undergraduate Research Activities in Mathematical and Computational Biology

Saturday, August 6, 1:00–2:15 PM, Taft A

Organizers: Timothy D. Comar Benedictine University
BIO SIGMAA

This session is dedicated to aspects of undergraduate research in mathematical and computational biology. First and foremost, this session would like to highlight research results of projects that either were conducted by undergraduates or were collaborations between undergraduates and their faculty mentors. Of particular interest are those collaborations that involve students and faculty from both mathematics and biology. Secondly, as many institutions have started undergraduate research programs in this area, frequently with the help of initial external funding, the session is interested in the process and logistics of starting a program and maintaining a program even after the initial funding expires. Important issues include faculty development and interdisciplinary collaboration, student preparation and selection, the structure of research programs, the acquisition of resources to support the program, and the subsequent achievements of students who participate in undergraduate research in mathematical and computational biology.

Ted Theodosopoulos Worcester Academy
Patricia Theodosopoulos Worcester Academy

Investigating the dynamics of self-catalyzing reaction networks

The authors designed and have been teaching a course on Mathematical Biology as an interdisciplinary elective to advanced high school students. One segment of this course focuses on metabolic closure and its role in the origins of life. The students are led through a series of activities that help them design self-catalytic reaction networks. Each student proceeds to investigate the dynamics of their resulting "protocells" . They use a computational environment in MATLAB to study and compare the steady-state behavior of their networks.

Daniel Hrozencik Chicago State University

Using Stochastic Leslie Matrix Models to Investigate Stage-Structured Populations Under Changing Environmental Conditions

Standard Leslie matrix models are used to investigate the long-term viability of stage/age-structured populations under conditions where fecundity and survival rates remain fixed. To investigate such populations under changing environmental conditions, the authors develop stochastic Leslie matrix models by selecting fecundity rates from various distributions and then numerically investigating their long-term viability. The development of such models as well as several student projects implementing these ideas will be discussed.

Timothy D. Comar Benedictine University

The Dynamics of Impulsive Models

This talk focuses on results we have obtained with undergraduate students researchers on the dynamics of pulse vaccination epidemic models and integrated pest management (IPM) models. All of these models use impulsive differential equations. In the case of pulse vaccination models, a pulse vaccination strategy periodically provides a fraction of the population with vaccination against a particular disease. Results for which the disease free solution is globally attractive and for which the disease persists are presented. For the IPM models, we provide analogous results for which the pest eradication solution is globally asymptotically stable and for which the system is permanent, and thus maintains all populations between positive upper and lower bounds. We also discuss how the students are prepared to conduct this work and provide avenues for future projects appropriate for undergraduates.

Caleb Adams Radford University
David DeLara Radford University

Dynamics of a two-vector, two-pathogen, single-host model

In this talk, the speaker will present recent theoretical results from the dynamics of a two-vector, two-pathogen, single host model. A system of system of ordinary differential equations is used to model the dynamics of two vector-borne pathogens (*Rickettsia parkeri* and *Rickettsia amblyommii*) that are increasingly found within tick populations of Virginia spread by two species of ticks (*Amblyomma maculatum* and *Dermacentor variabilis*), within a single host system. Three methods of transmission are included in the model: vector-borne, transovarial, and co-feeding. Results of numerical simulations are presented and determine a range of parameter values which lead to coexistence of the two pathogens and values which lead to the extinction of one pathogen and persistence of the other.

General Contributed Paper Sessions

Organizers: Gizem Karaali Pomona College
John Wilson Centre College

Geometry

Thursday, August 4, 8:30–10:25 AM, Union D

Adam Coffman Indiana-Purdue Fort Wayne
Jiří Lebl Oklahoma State University

Perturbing isolated points of algebraic space curves

Two surfaces in real 3-space, implicitly defined by polynomial equations $P(x, y, z) = 0$, $Q(x, y, z) = 0$, generally meet along a curve, but in some cases, the intersection contains an isolated point A. Is it always possible to make small changes to P and Q so that the perturbed surfaces no longer meet in a neighborhood of A? Or is there a counterexample? This problem will be stated in a precise way and generalized to other dimensions.

Genghmun Eng FFRDC Retired Scientist

Deriving Formulas for the Perfect 19-Sided Enneadecagon

A. M. Gleason [Amer. Math. Monthly **95**(3), 1988] derived formulas for the perfect heptagon and triskaidecagon, by first solving a helping quadratic, which sets a special angle, whose trisector (a cubic equation) gives the final $[2\,\cos(2\pi/7)]$ or $[2\,\cos(2\pi/13)]$ length. The regular enneadecagon is the first polygon whose construction requires two trisections. We show that one must now first solve a helping cubic, which specifies the first trisection: (1a) $\mathcal{L}(s) = s^3 + 1s^2 - 6s - 7 = 0\,,$ (1b) $\mathcal{L}(s) \equiv (s - \Lambda_A)\,(s + |\Lambda_B|)\,(s + |\Lambda_C|) = 0\,,$ (1c) $\Lambda_A > 0\,,\, \Lambda_B < 0\,,\, \Lambda_C < 0\,;\ (\Lambda_A + \Lambda_B + \Lambda_C) = -1\%$. Standard cyclotomic polynomial analysis then gives this quintic (!): (2) $0 = 1y^5 - 4y^3 + 1y^2 + 2y - (\Lambda_A + 2)\,.$ One has to next recognize that this quintic is itself the product of a irreducible quadratic and a new cubic that is also solvable using a trisection. It allows Eq. (2) to be factored as follows: (3) $0 = [1y^3 + |\Lambda_B|\,y^2 - (\Lambda_A + 1)\,y - (\Lambda_A + 2)]\,[y^2 - |\Lambda_B|\,y + 1]$. Our presentation derives these formulas. The actual construction is left for a future MathFest.

David M. Clark SUNY New Paltz

Geometry through Guided Inquiry

Axiomatic geometry, properly presented, can offer students an ideal context to solve problems and prove theorems on their own. My text , "Euclidean Geometry: A Guided Inquiry Approach", is published by AMS/MSRI in the Math Circles Library to offer undergraduates, preservice teachers and motivated high school students this kind of presentation. It is written in an active learning format, providing instructors a direct avenue into this innovative form of teaching that is overwhelmingly supported by current educational research. Secondary school teachers with this background will be in a prime position to successfully implement the Common Core goals.

Jeff Johannes SUNY Geneseo

Take a ride on the parallel transport

I recently had the opportunity to discuss the concept of parallel transport in distinct contexts. In this talk we will consider the idea starting with the simple interpretation of streets on the earth. We discuss ways the concept appears in a visual geometry course and then compare this to roles in other situations - ranging from elementary school geometry to differential geometry. Along the way we will see good reason to view the concept of parallel transport as being more fundamental and practical than other notions of parallelism.

Stephen Andrilli La Salle University

Deriving the Finite Geometry of Pappus from a Simpler Set of Axioms

While a few college geometry textbooks contain a treatment of finite geometries, only a handful mention the finite geometry of Pappus (9 points, 9 lines). This geometry is derived from the classic collinearity theorem of Pappus in Euclidean geometry concerning 9 points: If A, B, C lie on one line, A', B', C' lie on another line, $AB' \cap A'B = D$, $AC' \cap A'C = E$, and $BC' \cap B'C = F$, then D, E, F are collinear. The axiom set for the Pappus Geometry presented in the classic texts of Eves, Cederberg, and Smart includes both a "parallel postulate" as well as its "dual" postulate. Here, a slightly simpler set of axioms for the Pappus Geometry will be presented, along with a demonstration that these axioms precisely determine the Pappus Geometry.

Richard G. Ligo University of Iowa

Defining the Energy of a Knot

In order to better study knots, mathematicians have defined a variety of knot-specific statistics, called energies. The Möbius energy is one of the most useful of these quantities. In this talk, we will define Möbius energy of a knot and describe its fundamental properties.

Peter Connor Indiana University South Bend

Special polynomials and minimal surfaces

When using Traizet's regeneration technique to construct minimal surfaces, the simplest nontrivial configurations are given as the roots of polynomials that satisfy a hypergeometric differential equation. The reason for this is unknown. We exhibit examples of simple minimal surfaces exhibiting the same behavior.

David Richeson Dickinson College

A Trisectrix from a Carpenter's Square

In 1928 Henry Scudder described how to use a carpenter's square to trisect an angle. We use the ideas behind Scudder's technique to define a trisectrix—a curve that can be used to trisect an angle. We also describe a compass that can be used to draw the curve.

Linear & Abstract Algebra

Thursday, August 4, 8:30–10:25 AM, Union E

Aaron M. Montgomery Baldwin Wallace University

A Useful Shortcut for Computing (Some) Matrix Determinants and Inverses

Given a general matrix, the problem of computing either its determinant or its inverse is usually practically difficult and computationally expensive, particularly if the matrix is very large. However, if the matrix is additively "close" to another matrix whose determinant or inverse is known, then it is sometimes possible to exploit this knowledge to expedite the relevant calculation for the original matrix. We will discuss the lemmas which permit this exploitation and provide some examples of how to apply them. (This talk is intended to be accessible to undergraduates.)

Jonathan Lopez Canisius College
Terrence Bisson Canisius College

A classification of small operators using graph theory

Given a real $n \times m$ matrix X, its operator norm is defined by $\|X\| = \max_{\|v\|=1} \|Xv\|$. We consider a matrix "small" if it has non-negative integer entries and its operator norm is less than 2. These matrices correspond to bipartite graphs with spectral radius less than 2, which can be classified as disjoint unions of Coxeter graphs. Our goal here is to see these known results as part of a general program of classification of "small" objects, as in https://en.wikipedia.org/wiki/ADE_classification.

Andrew K. Greene Manhattan College

Matrix Differential Equations: Noncommutative Variation of Parameters

Given a derivation on a matrix algebra, we define a matrix differential equation in a fashion analogous to ordinary differential equations. Matrices replace functions and commutators replace derivatives. In this talk, a purely algebraic and noncommutative version of the method of variation of parameters will be discussed.

Irawati Irawati Institut Teknologi Bandung

The structure of a polynomial ring $R[x]$ and $R[x, \sigma, \delta]$ relative to the structure of R

We explore if we can have the sructure of the polynomial ring $R[x]$, $R[x, \sigma]$, $R[x, \sigma, \delta]$ if we know the structure of the ring R.

Chad Awtrey Elon University
James Beuerle Elon University
Michael Keenan Elon University

When is a polynomial isomorphic to an even polynomial?

Let $f(x)$ be an irreducible polynomial with integer coefficients, and let $K/\mathbf{Q}$ be the number field it defines. If $g(x)$ is irreducible, call f and g isomorphic if the number field defined by g is isomorphic to K. In this talk, we focus on the question: if the degree of f is even, when is f isomorphic to an even polynomial g? We discuss a simple method that answers this question and constructs such a polynomial g if it exists. We end with an application to computing Galois groups of polynomials of even degree.

Tracy Robin University of Louisiana at Lafayette

Density of a normal subgroup of the invertibles in certain multiplier algebras

We define a C*-algebra and give some basic examples of C*-algebras. We investigate the normal subgroup structure of the general linear group of certain unital C*-algebras. If $\mathcal{A}$ is a nonunital simple C*-algebra, and $G \subseteq GL(M(\mathcal{A}))$ is a noncentral normal subgroup of the group of invertible elements of the multiplier algebra of $\mathcal{A}$. Then G contains a nonscalar positive element. We also study the strict topology closure of G under certain conditions.

Lee Raney University of North Alabama

Permutation Groups and Sliding Disk Puzzles

A sliding disk puzzle is a graph-generalization of Sam Loyd's famous 15-puzzle. Here, we discuss the arrangement group, a finite permutation group which controls the collection of legal arrangements of a sliding disk puzzle. We summarize results from an undergraduate research project on the structure of arrangement groups such puzzles, including constructions and a conjecture affirmed by a 1974 theorem of Richard Wilson.

Charles Buehrle Franklin & Marshall College

Pancake words

The pancake problem is concerned with sorting a permutation (a stack of pancakes of different diameter) using only prefix reversals (spatula flips). Although the problem description belies simplicity, an exact formula for the maximum number of flips needed to sort n pancakes has been elusive. Here we present a different approach to the pancake problem, as a word problem on the symmetric group. Pancake flips are considered as generators for a presentation of the symmetric group. At present the full list of relations for this presentation are not known. Many relations are exposed, though, by looking at the Coxeter matrix of the generators.

Applied Mathematics

Thursday, August 4, 1:00–4:55 PM, Union D

Israel Ncube Alabama A & M University

Mathematical and computational modelling of anaesthetic-induced neural oscillations

Mechanisms underlying how different anaesthetics act at various targets in the central nervous system to produce altered states of arousal are currently poorly understood. Employing a combination of mathematical modelling and numerical simulations, we study how some specific anaesthetic agents may be interacting with particular neural circuits to generate signature oscillations seen clinically in the electroencephalogram and experimentally in the local field potential.

Leslie Jones University of Tampa
Bridgette Froeschke University of Tampa

A Spatial Model for the Conservation of Sheepshead (*Archosargus probatocephalus*)

We use long-term, fisheries-independent bag seine surveys and otter trawls conducted in Tampa Bay, Florida, from 1996-2014 to develop a spatiotemporal environmental model for sheepshead, *Archosargus probatocephalus*. Relationships between environmental predictors and sheepshead distribution were investigated using boosted regression trees (BRT). Results showed good model performance and suggested that, in relation to environmental factors, sheepshead distribution was most closely linked to gear type, month and year of collection, and salinity. Spatial patterns were also evident. The development of spatially explicit models allows for prioritization and conservation of areas in a region that has great potential for human disturbance and climate change impacts.

Narasimha S. Malladi Malladi Academy

Unified, Simpler and Time Saving Solution of a Polar Vector Equation by the Method of Vector Rotation.

In solving the two unknown forces in a system of three forces in a relationship, the well known Lami's Theorem or the Law of Sines is applied. However if the system contains more than three forces, X and Y Component Equations are obtained to form two Simultaneous Equations needing six calculations, for the four coefficients and two constants. Then the two unknowns can be solved using Cramer's Rule needing 5 more calculations involving three determinants and two divisions. Thus a typical student usually does 11 calculations of varying difficulty for the solution of two unknowns. However if all the vectors in the system are rotated clockwise by the known polar angle of an unknown vector, the chosen unknown vector is along X axis and its magnitude is eliminated in the Y Component Equation of the rotated system. The other unknown magnitude can be easily solved with one calculation. This process is repeated with the original polar angle of the solved vector. Thus only two calculations are needed to solve the two unknowns. This simple process of elimination is named as Vector Rotation Theorem stated as below. Vector Rotation Theorem. "In solving a Polar Vector Equation, an unknown magnitude is directly eliminated, by subtracting its polar angle from all polar angles, thus rotating all vectors clockwise equally and obtaining the Y Component Equation using the sines of the resulting polar angles." In execution it is simply "Subtract the Elimination Angle and Take the Sines." This Theorem is simpler to employ even where Lami's Theorem and Law of Sines are usually applied. Thus theTheorem offers unified, computationally efficient and time saving solutions, free from cumulative errors, in Applied Mathematics like Planar Statics, Kinematics and Kinetics.

Patrick M. Lank University of Massachusetts - Lowell

Gödel Metric & the Penrose Interpretation of Gravitizing Quantum Mechanics

We start by posing the question, what are the consequences of an observable traversing on a world-line directed backwards in time while an observer makes observations along a world-line directed forward? As trivial as the solutions may be in a given problem or domain of discourse, we add a constraint by allowing the observable to traverse the observer's unique closed time-like curve. From this prescribed constraint, our discussion carries onto the Penrose Interpretation and proving that it is satisfiable in a Gödel spacetime. Furthermore, we then form an implicit conformal equivalence relation with the Gödel metric and Kerr metric. Afterwards, we briefly investigate this conformal relation to its applications in our analysis. The domain of discourse presented here utilizes set theory, casual set theory, first-order logic, and group theory- a unique mathematical physics analysis of quantum mechanics and the collapse of a wave function.

Dennis G. Collins UPR-Mayaguez

Toward Generalized Gravity

Generalized gravity can consider how masses and different entities besides masses can be pulled together or appear to be pulled together, for example words can attract different meanings to themselves, or cities attract more population , via Zipf's law. Mathematically the different entities can be considered as Gaussian pulses, and properties of their normalized sum f, such as Fisher information (Fisher1 = integral of $(f_x)^2 + (f_y)^2)/f$ in two dimensions) can be computed. Here it is shown that the Fisher information goes from a maximum to a minimum back to the SAME maximum as the scale of the configuration goes to zero, wherein the minimum would represent the clumping due to gravity. This procedure avoids the singularities usually involved with gravitational potentials, in this case V = MAX - Fisher1. As a consequence there is an equivalence of generalized gravity = min Fisher information = maximum entropy = maximum covered sides = evolution = maximum emergy. As an example the function V is calculated for 4 pulses in the form of a square by the FindFit command in Mathematica programming. This talk extends a talk at Purdue North Central Indiana MAA Section meeting Oct. 2015.

Lisa Holden Northern Kentucky University

Investigations in Star Formation: A Model to Consider in a First Course in Partial Differential Equations

It is often difficult to find partial differential equation models that are both interesting and accessible to students. However, during a recent sabbatical leave, I became acquainted with a particular diffusion model from the field of astrophysics that can serve as the basis of a project for a course in partial differential equations. Stars begin their life in molecular clouds: areas of dense gas in the interstellar medium that are threaded by turbulent magnetic fields. Within these molecular clouds, the gas is distributed unevenly resulting in denser regions known as cores. Star formation is thought to begin when a core loses support from its magnetic field. As the magnetic field diffuses in a process known as ambipolar diffusion, material from the core begins to "fall in" and the core becomes even denser. Once this overdense region of gas has formed, collapse is inevitable and a young star is formed. Focusing on the ambipolar diffusion process, and adopting simple geometries, one can write down a system of partial differential equations that can be analyzed both analytically and numerically by students. Today, I'll give a brief overview of how this might be accomplished and what students might take away from such an investigation.

Barry C. Husowitz Wentworth Institute of Technology

Project Based Learning via Density Functional Theory

Density Functional theory in statistical mechanics is a powerful tool to study various phase phenomena. In my previous work, I used density functional theory to study nucleation in confined systems such as cylindrical pores and in-between two disks. Confinement effects induced nucleation phenomena that are not observed in more open systems. Density functional theory allows us to systematically study the effect of a variety of geometric and interaction parameters on the properties and behavior of various systems. Although more sophisticated, but computationally more demanding, theoretical approaches can be used, it provides fundamental physical insight into the behavior of real systems and creates a solid basis for the development of more sophisticated studies. In order to solve problems based on Density Functional theory, numerical methods need to be implemented. In this talk, I will present how Density Functional theory can be used as a tool for project-based learning in an undergraduate introduction to numerical analysis class. I will present a project that my students investigated using Density Functional theory in my intro to numerical analysis class. The students final project involved using a simple van der Waals density functional with the square gradient approximate to find the equilibrium liquid vapor interface at different temperatures. The results of this project will be presented and discussed.

Lopamudra Chakravarty Kent state university

An Optimal Domain Decomposition Algorithm for Non-symmetric Problem

The linear system of algebraic equations that arises from the finite element discretization of advection-diffusion equation is considered here. A hybrid Schwarz domain decomposition algorithm is applied to solve this non-symmetric system. This method works in both symmetric and non-symmetric cases. Algorithm shows multiplicative nature among local and coarse spaces where local spaces are treated in additive manner. Among three spaces used here one is global coarse space developed for elliptic problem. Between two local spaces one is non-overlapping subdomain and other is overlapping ring shaped subdomain. Numerical experiment shows that this algorithm is optimal in the sense that the rate of convergence is independent of the mesh size and the number of subdomains.

Ozkan Ozturk Missouri University of Science and Technology
Elvan Akin Missouri University of Science and Technology

Nonoscillatory Solutions of Two Dimensional Nonlinear Dynamical Systems with Delay

We study the classification schemes for nonoscillatory solutions of a class of nonlinear two dimensional systems of first order delay dynamic equations on time scales. Necessary and sufficient conditions are also given in order to show the existence and nonexistence of such solutions and some of our results are new for the discrete case.

Matthew A. Morena Young Harris College

"*You've Never Heard of the Millennium Falcon?*": Steering Han Solo's Spacecraft Using Chaos Control

Prideful words, but ones that Han Solo famously lived up to after successfully navigating his spaceship through an assortment of galactic obstacles. Meanwhile, on planet Earth, spacecraft steering has long been a focus of many engineering applications and is generally known as "targeting." This describes how dynamical systems may be directed as efficiently as possible either along optimal paths or to desired locations in phase space. Thanks to the development of sophisticated control techniques, targeting has become feasible for chaotic systems via small, inexpensive controls. Most chaos control methods take advantage of the properties that make chaotic systems notoriously difficult to study, such as exhibiting a hypersensitivity to perturbations or admitting an infinite set of periodic orbits around their attractors. In this talk, I will describe one particularly effective control technique that when combined with shortest path algorithms allows for the efficient exploration of chaotic attractors. As a demonstration, we will simulate Solo's famous navigation of the asteroid field.

Johnson A. Osilagun University of Lagos

Improved Laplace Decomposition Method For Solving Nonlinear Initial Value Problems

Abstract: In this paper, we apply an improved algorithm of Laplace decomposition technique to develop a fast an accurate algorithm for solving nonlinear initial value problem. This improved algorithm does not require discretization and massive computations. This algorithm does not involve the usage of special polynomials, yet gives results that are relatively accurate and easily implemented when compared to known results in the literature therein.

Denver Stahl Washington & Jefferson College

Considering the Circular Cascade

Consider a cascade of tanks connected in series, such that the output of one tank becomes the input of the next. This is a fairly common mixture problem in differential equations. However, what if the tanks are connected circularly, so that the last tank feeds its output into the initial tank? Using Laplace transform, we can solve a system of differential equations that allow us to analyze the amount of mixture contained in each tank. By doing so, we find expected trends along with some surprising conclusions.

Champike Attanayake Miami University

An immersed interface flux recovery method for parabolic equations

In this study, we consider the immersed interface finite element method for solving one dimensional Pennes' bioheat transfer equation in a domain with an interface across which the thermal parameters in the bioheat equation are discontinuous. Convergence properties of the semi discrete and fully discrete schemes are investigated in L^2 and energy norms. By using the computed solution from the IMF method, a flux recovery technique is employed to approximate flux in the whole domain. This simple method guarantees continuity of the flux across the elements and captures flux exactly at all nodes and at the interface. Optimal order convergence is proved for the solution of the Pennes' equation and the approximated flux.

Jesus A. Pascal American University of Afghanistan

Constructing a solution for the dynamic programing equation

This work uses the dynamic programming approach to construct the candidate value function for a singular stochastic optimal control problem with controls taking values in a closed cone in R. We show that the constructed function is a solution for the dynamic programming equation, a second order nonlinear partial differential equation (PDE) that provides relevant information to solving optimal control problems, and consists of a pair of differential inequalities, called a variational inequality, of the form, $\max[F^1(x; v(x); v^0(x); v^{00}(x)); F^2(x; v(x); v^0(x))] = 0$; for all x in $R : 1$.

Brian Winkel Emeritus, US Military Academy, West Point NY and Director SIMIODE

SIMIODE A Community for Teaching Modeling First Differential Equations

SIMIODE - Systemic Initiative for Modeling Investigations and Opportunities with Differential Equations (www.simiode.org) is a community of teachers and learners who believe that modeling can motivate and engage students in learning differential equations. We present the SIMIODE community, offer rich examples of this approach using data, videos, and realistic scenarios, and discuss how faculty can contribute their own materials for a peer- reviewed online publication. Examples will come from engineering, physics, chemistry, and life sciences.

William R. Fuller Ohio Northern University
Nathan Knodel Ohio Northern University

An Exact Solution for the Cubic-Quintic Duffing Oscillator

The Duffing oscillator is currently of active interest in nonlinear science. Most often the effects of the nonlinearities are treated using approximations and/or simulations. In this talk we will present an exact solution for the free cubic-quintic Duffing oscillator in terms of hyper-Jacobi functions. We will provide the definitions of these functions and indicate some of their fundamental properties, including identities, derivatives, and anti-derivatives. Some of this work has been done as part of the co-author's Senior Capstone research.

Teaching Calculus

Thursday, August 4, 1:00–4:55 PM, Union E

Houssein El Turkey University of New Haven
Salam Turki Rhode Island College

Implementing pre-class readings in Calculus

In this talk, I report on preliminary results and remarks from a comparative study on four sections of Calculus II. In this study, two instructors were teaching four sections of Calculus II which spanned from Integration to Power Series. The instructors typed summarized notes (1-page) for each section from the textbook and assigned it to two classes as a pre-class reading while the other two classes had access to these notes after class. I will discuss instructors' observations and results from a survey given to students.

Kimberly Roth Juniata College
Henry Escuadro Juniata College

Reviewing Precalculus in Calculus: Integrated vs. Beginning of Course

Calculus textbooks typically start with a precalculus review at the beginning of the book. At Juniata it was typical to start the course with these sections. In the last several years, Kim replaced the precalculus review material with a combination of a review quiz with retake, a review homework assignment, and review of particular concepts as they appear as part of the calculus material. This integrated review technique allows for a review when it is most needed and frees up some time in the class schedule to spend on difficult topics later in the course. However, students can find the review quiz and assignment intimidating and we are unsure if the integrated review leads to a more effective use of the skills when they do show up in the course material compared to the regular review. So we conducted an experiment where both Kim and Henry taught two sections of Calculus in a semester, one with the Precalculus review at the beginning and one with integrated review with some common exam questions that involve precalculus skills. We will discuss the design of the experiment and its results.

Robert Rogers SUNY Fredonia
Eugene Boman Penn State - Harrisburg

Flipping the Calculus Course (Not the Class!)

The typical calculus sequence presents foundational material in the beginning of the courses (limits, continuity, Riemann sums, etc.) before delving into applications. This is historically inaccurate, as the foundations were solutions to foundational issues that arose from the application of calculus. We will present how a calculus sequence can teach students the applications before delving into foundational issues in a natural way, and still cover the same material.

Kara Teehan Rutgers University

Flipping the Calculus Classroom-Blended Learning as an Instructional Approach

Flipping Calculus-Blended Learning as an Instructional Approach Teaching calculus in the high school advanced placement setting requires a fast pace and rigorous instructional methods. Students cannot hope to fully conceptualize calculus concepts without diligent and active involvement in their own learning. A lot of the exploratory aspects of learning calculus require some amount of direct instruction, along with practice, repetition, and development of abstract calculus ideas and theoretical understanding. Time is an issue, so how does one maximize time available to provide valuable instruction that allows students to concretize calculus time, while working under the constraint of a normal high school instructional schedule? In this talk, we will discuss an answer to this question by describing a blended learning environment, where students' traditional classroom learning experiences are "flipped", allowing for in-class engagement and exportation, with passive absorption of theorems and rules happening outside the classroom prior to teacher facilitated instruction. Taking a "flipped" approach means that students watch instructional videos at home, or pre-read while taking detailed notes on the topics that will be explored in the subsequent class. This allows students to have a foundational grasp on the concepts, or at least have written down and absorbed the notation and theorems that they will be dissecting in class. In this talk, we will discuss the "flipped classroom" instructional design model in a calculus context, with specific examples and instances of the success for differential and integral calculus learning.

Karen McCready King's College

Going deeper: an interactive approach to studying calculus (or other math)

A great way to gain a thorough understanding of a concept is to try to explain it to someone else. In this talk we will look at how this idea can be integrated into a calculus class, giving students the opportunity to help each other understand the material at a deeper level in class, as well as motivating students to practice problems outside of class.

Louis Freese DeVry University

Faculty Chair

Abstract I present a method of learning for the mathematics classroom grounded in adult learning theory but it can be used and adapted for secondary classrooms as well. In this method students are asked to use discovery and experiential techniques to explore and learn mathematical material rather than simply download it from their instructor via lecture. Students are given a set of activities, before any lecture takes place, through which they discover the rules, formulas, and concepts in Calculus. This allows the student to derive their own understanding of how to solve mathematical problems. It increases problem solving skills and the ability to think mathematically. Students are encouraged to work in groups and to record what they have learned. This allows for the dialog, both external and internal, that is needed to solidify the learning process. The instructor is enabled to observe and then respond to student learning. Lecture becomes a tool to elaborate on, reinforce, and apply the skills and ideas students have developed on their own.

Rachel Weir Allegheny College

Highlighting Mindset and Self-Regulation in Calculus

It is a pervasive belief in our society that only "math people" can be successful in math courses or when using or discussing math. Unfortunately, this belief creates a unnecessary barrier to student success at all levels. In an attempt to counter this, I introduced the notion of growth mindset to my Calculus I students this semester. I also required them to complete self-regulation assignments throughout the semester to give them insight into the habits and skills required for effective learning. In this talk, I will describe these interventions and reflect on the successes and challenges.

Linda Becerra University of Houston-Downtown

A Course Innovation Initiative Proposal For Our Calculus I

Because of a low student success rate, Calculus I is considered a barrier course at our campus. The Cal I faculty decided to collectively address improving student learning in the course through a university supported Course Innovation Initiative proposal, which includes supplemental instruction, time compressed sections and a nonstandard incentive system. In this talk, I will present the elements of our proposal and give a progress report on its on-going implementation.

Philip B. Yasskin Texas A&M University

Introducing MYMathApps Calculus

MYMathApps Calculus is a calculus text, under development, which is totally online. As such, it includes: (1) randomly generated tutorials and exercises in addition to the standard static text, examples and exercises, (2) user-controllable animations in addition to the standard static graphics (3) hyperlinks to material both internally within the text and externally to related resources on the web (In particular, on the exercise pages, there are links back to the pages where the material for each exercise is discussed.) and (4) pop-up notes, for things like proofs, which do not obstruct the flow of the text but are available to those students who wish to learn more. These features will be demonstrated in this talk. This text has grown out of two sources: (1) the WebCalc project involving the author, Don Allen and Mike Stecher at Texas A&M University, which developed an online first semester calculus text (So far, the MYMathApps Calculus text only covers second and third semesters of calculus.) and (2) the Maplets for Calculus project involving the author and Doug Meade at the University of South Carolina, which developed a collection of randomly generated tutorials. The text is being written in HTML5, Javascript and MathJax so it is available on all devices. The work is supported in part by NSF DUE TUES-2 grant 1123255.

Bart Snapp The Ohio State University

Calculus with Ximera: Building an open-source interactive calculus textbook with LaTeX

In the Autumn of 2015 and Spring of 2016, The Ohio State University Mathematics department offered experimental sections of Calculus 1 and 2 that used a free, open-source, online interactive textbook. This textbook was developed by faculty at OSU using Ximera (NSF Grant DUE-1245433). In this talk we will discuss the development of this textbook and its impact on student learning outcomes. In addition, we will share how faculty at other institutions can utilize these resources as they are, how faculty at other institutions can modify these resources, and how faculty can create new resources using the same tools.

James Quinlan University of New England

Using SageMathCloud Worksheets to facilitate computational thinking and collaboration in Calculus

SageMathCloud (SMC) is an online service that provides a computational mathematics framework in which mathematics can be done collaboratively. SMC worksheets can be assigned to initially step students through the process or develop a concept (e.g., definition of derivative). After students have become proficient with SMC syntax, students are encouraged to formulate the problem and generate an algorithm to solve a general class of problems. SMC contains course management functionality and can be used to assign, collaborate, edit, and collect Sage worksheets. Worksheets can be viewed by teachers to provide instruction and feedback as well shared peer-to-peer for potential collaboration.

Lee N. Collins County College of Morris

Newton's Square Roots of Power Series Functions

Once a familiar hand calculation in grade school mathematics, the division-like algorithm used for extracting square roots is virtually nonexistent in classrooms today. In this talk, we discuss the common algorithm for extracting a square root of a number and how Newton applied it to a power series function in his posthumously published *Method of Fluxions*. By extending Newton's argument, we show it is possible to find any nth root of a power series function by hand.

Yanping Ma Loyola Marymount University
Christina Eubanks-Turner Loyola Marymount University

The attitudes of students in calculus of life science toward Mathematics in their careers

The purpose of this study was to develop an instrument to help identify the degree to which Calculus students' value mathematics skills in their prospective careers. There are five aspects measured, including positive attitude towards the importance and relevance of mathematics/calculus towards their future career, as well their level of confidence, anxiety and enjoyment about mathematics/calculus. This type of tool would support the quantitative tracking of attitudinal changes on students in Life Science over time and attitudinal comparisons across various subpopulations, including effects based on modifications of pedagogy. Factor analysis on the pilot population (Loyola Marymount University undergraduate students taking Calculus I for Life Science) will be done to test whether this instrument may accurately measure the five constructs. We will report the accuracy of this instrument in the meeting.

Stacy Musgrave California State Polytechnic University, Pomona
Marilyn P. Carlson Arizona State University

Preparing future faculty to teach mathematics meaningfully

This presentation will share research stemming from an intervention being used to support mathematics graduate teaching assistants (GTAs) to teach precalculus and calculus meaningfully. Investigations into the GTAs' meanings for ideas foundational to precalculus and calculus (e.g., angle measure, average rate of change, exponential growth) reveal that even mathematically sophisticated individuals often have impoverished meanings for these ideas. Foci of the intervention include supporting the GTAs in developing richer and more connected understandings of the content, as well as developing fluency in discussing these ideas. Data collection pre-, mid-, and post-intervention suggest that such transformations are possible, but interesting issues arose for discussion and further investigation.

Gregory V. Bard University of Wisconsin—Stout

A New Application of the Markowitz Optimal Portfolio Theory and its Efficient Frontier

The Markowitz Optimal Portfolio Theory, published in 1952, is well-known, and was often taught because it blends Lagrange Multipliers, matrices, statistics, and mathematical finance. However, the theory faded from prominence in American investing, as Business departments shifted from techniques based on mathematics, finance, and statistics, to focus instead on leadership, public speaking, advertising, etc... The author proposes a new application of Markowitz's Theory: the detection of a fairly broad category of financial fraud (called "Ponzi schemes" in American newspapers) by looking at a particular inequality derived from the Markowitz Optimal Portfolio Theory, relating volatility and rate of return. For example, one recent Ponzi scheme was that of Bernard Madoff, uncovered in December 2008, which comprised fraud totaling 64,800,000,000 dollars. The objective is to compare investments with the "efficient frontier" as predicted by Markowitz's theory. Violations of the inequality should be impossible in theory, therefore in practice violations might indicate fraud.

Serge Yaskolko Department of Mathematics, South University
Genady Ya Grabarnik Department of Mathematics and Computer Science, St. John's University, Queens, NY
Luiza Kim-Tyan Department of Mathematics, Department of Mathematics, MIS&S, Moscow, RF

Cross countries comparison of the Calculus education for STEM students

The recent study by MAA outlined main points for improving the Calculus education for STEM students. In our study, we work on expanding this approach to multiple countries. We start by comparing two countries with traditionally different education systems. We study differences and similarities of content, pedagogy and socio-economics, evaluate an international comparison system developed by Organization for Economic Cooperation and Development for high school education and outline our work on culture-independent comparison methods with a goal to improve or adjust Calculus education. We suggest a three-stage study program: a) identify the set of countries and universities for initial study and an assessment system that is independent of both country and culture, b) test the assessment, adjust it, and build a statistical model, c) run the assessment on wide set of universities, choose the best cross countries teaching practices. We have chosen the US and the RF (Russian Federation) education systems for the initial comparison as they represent two opposite approaches to education, both carrying high merits. The US system implies minimum restrictions allowing almost complete freedom, with the only restrictions being the required core classes and prerequisites, the RF system offers a rigid schedule system, not allowing any changes or modifications of such schedules. We ran a detailed analysis of both systems, identified differences and suggested an assessment as a mixture of "understanding concepts" and "in-depth" questions. We outlined socio-economic effects and we will be using them for adjusting the study's surveys. The next steps are to run the assessment in a wider range of countries to test it and fine-tune the weighting of its parts.

Graph Theory and Other Topics

Friday, August 5, 8:30–11:40 AM, Union E

Ji Young Choi Shippensburg University of PA

Digit sums on vertex-weighted graphs

For a given graph, can we assign a weight to each vertex so that the weight of each vertex is the same as the sum of the digits of all the weights on every adjacent vertex? This talk will discuss the possibility and present a strategy to assign weights on the possible graphs.

William Higgins Wittenberg University
Aparna Higgins University of Dayton
Karrolyne Fogel California Lutheran University
John Villalpando California Lutheran University
Vesta Coufal Gonzaga University
Robert Ray Gonzaga University
Kathie Yerion Gonzaga University

Trees for Values of the Span and Icaps for L(2, 1) - colorings

An L(2,1)-coloring of a graph is a labeling of the vertices using non-negative integers such that adjacent vertices differ in label by at least 2 and distance two vertices differ in label. The invariant span, denoted by λ, is the smallest integer such that for a given graph there exists an $L(2,1)$-coloring of the graph using only non-negative integers less than or equal to λ. An $L(2,1)$-coloring of a graph is irreducible if reducing the label on any vertex violates an $L(2,1)$-coloring condition. The invariant icaps, denoted κ, is the least number of color classes required to create an irreducible $L(2,1)$-coloring on a given graph. We determine if there exist trees for each pair of possible values of span and icaps.

Natacha Fontes-Merz Westminster College

Counting Euler Circuits

How many Euler circuits are there in the complete graph on n vertices? In this talk, we will derive some known values for small n and count the number of Euler circuits in other types of graphs as well.

Mary Shepherd Northwest Missouri State University

Snake's Path Quilts and Graph Theory

The folk art of quilting includes some beautiful mathematics. Most quilt blocks, the building blocks of quilt tops are squares and involve straight line seams. An interesting variety of quilts are ones with portions of circles and have seams that are not straight lines. A Truchet tile (Smith, 1987) is a square with two quarter circles of annuli joining midpoints of adjacent sides. This Truchet tile block is considered a variation of the Drunkard's Path block. I found a quote about a specific quilt in the pattern called "Snake in a Hollow Maze" that used the Truchet tile block. The quote stated the directions for setting the blocks in a maze pattern were carefully hoarded and passed from quiltmaker to quiltmaker (Cory, 1991). In this maze pattern the quilt blocks are arranged in such a manner that there appears to be a single path starting at one edge of the quilt and ending at another. This talk will show how graph theory can be used to demystify creations of the maze patterns using a Truchet tile block.

Muhammad A. Khan University of Calgary

Contact graphs for packings of convex bodies

Given a packing of translates of a convex body, the contact graph of the packing is the simple graph whose vertices correspond to the packing elements and any two vertices are joined by an edge if and only if the corresponding packing elements touch each other. The contact number of the packing is then defined to be the number of edges in the contact graph. The problem of finding the largest contact number of n translates of a given convex body K is highly interesting as it generalizes Newton's classical kissing number problem and is equivalent to Erdős' repeated shortest distance problem in normed spaces. Moreover, the contact number problem finds applications in the science of self-assembling materials, such as colloidal matter. In this talk, we present some of our new results on contact graphs and largest contact numbers of translative packings of convex bodies in general, and Euclidean balls in particular. (Joint work with Károly Bezdek.)

Donna Beers Simmons College
Mary Goodloe Belmont University
Maurino Bautista Rochester Institute of Technology

Who is really in charge? Connecting graph and network theory to analyzing social networks.

Have you ever wondered who is really in charge? Who is at the center of whatever is trending? Who influences policy decisions? Who motivates groups that bring about change? Leaders, whether in business, government, or education, are interested in who is at the heart of all that is happening, whether those central individuals are considered to be trendsetters, revolutionaries, or the superspreaders of a contagious disease. In this talk we provide a brief introduction to network analysis and to the graph theory tools and techniques for detecting the key actors within a social network. With these tools we will show how to find out who was really in charge among the revolutionaries prior to the American Revolution as well as among the individuals behind 9/11. We will provide examples of projects where students may discover "who is in charge" by applying graph theory and computational tools to analyze social networks.

Jeffrey Clark Elon University

Exploring the Fibonacci Word

The Fibonacci word is an infinite sequence of two symbols (usually 0 and 1) whose definition is similar to the definition of the Fibonacci numbers. It contains the properties of the Fibonacci numbers in terms of counting how many 0's and 1's occur in finite prefixes, but with the added complexity of the order of the digits it affords many other interesting properties. The Fibonacci word is relatively unknown and a fount of research questions for interested undergraduates and faculty. This talk will explore its definition and some of its more easily discovered qualities.

David Xiang Westwood High School
Amber Lu Texas Academy of Math and Science
Eric Li Clements High School

Signed Path Matrices and Oriented Hypergraphic Generalizations

Every hypergraph can be represented by some matrices. By studying these matrices, we solve several problems in data structure analysis and provide combinatorial interpretations of these results. Previously, a path counting theorem was known for k-regular graphs. In this paper we generalize and extend the theorem to count paths in all oriented hypergraphs, and consequently show its applicability for both signed and unsigned graphs. We explore the bipartite model of a hypergraph and study the relationships between the adjacency, incidence, and Laplacian matrices of the aforementioned graphs. In the process we show the ubiquity of the square root of the Laplacian matrix, and use the combinatorial interpretation of this result to introduce the idea of a fractional walk. We also analyze and provide an interpretation of the matrix-tree theorem in the context of hypergraphs, and explore the methods of counting trees in signed graphs. Our path counting theorems allow efficient computation of the minimum number of connections needed to guarantee a majority of positive connections between nodes. This gives our results immediate applications in many fast growing fields such as social networking, mobile computing, and data analysis. Furthermore, it has applications in structural design, such as in VLSI systems and neurological modeling, as hypergraphs are ideal for modeling large, complex technological and social systems where multi-relationships are prevalent.

John C. Wierman Johns Hopkins University

Improved percolation threshold bounds for Archimedean lattices.

In the bond percolation model, a random graph is obtained by retaining each edge of an infinite graph G independently with probability p_c. The percolation threshold is the edge retention probability parameter value p above which the random graph contains an infinite connected component. The exact percolation threshold is known for only a few graphs, and rigorous bounds for unsolved graphs are rather poor. The substitution method provides improved bounds for several of the eleven Archimedean lattices, which are vertex-transitive tilings of the plane by regular polygons.

Duk-Hyung Lee Asbury University

Math and Music of Recuerdos De La Alhambra

Recuerdos De La Alhambra, composed for classical guitar by Francisco Tarrega (1852 1909), is a musical memory of the famous Alhambra Palace in Granada, a magnificent relic of the splendor and grace of court life during the Moorish occupation of Spain. This piece has been delighting concert audiences for the past century, and teachers and students of music have long recognized the aesthetic value of this composition. In addition to briefing the musical techniques and structures involved in, the presenter will investigate some mathematical aspects of this delicate piece of classical guitar music.

Kurt Ludwick Salisbury University

Musical Applications of Generalized Fibonacci Polynomials

One of the earliest known applications of Fibonacci numbers was counting all distinct *rhythms* of a specified length consisting of one or two temporal units - or, in musical terms, one beat (quarter notes) or two beats (half notes). In this talk, we will demonstrate an analogous application of generalized Fibonacci polynomials, which will allow us to find the number of distinct *melodies* of a specified length consisting of quarter or half notes selected from a given set of pitch classes. In addition, we will also consider variations on this problem, in which we allow our melodies to include a greater variety of note lengths and/or rests.

David Calvis Baldwin Wallace University

Reaping the Benefits of Technology Without the Frustration

This talk will address the problem of technology use crowding out important material in calculus, differential equations and other undergraduate courses. Student use of CAS and related tools presents wonderful opportunities. Yet without careful handling, it can easily produce frustration and compete for time and focus with the very mathematical topics it was intended to highlight. This approach relies on carefully-crafted out-of-class assignments that teach the student just enough about the computer system to allow an important mathematical point to be illustrated. Over the course of a semester the students become reasonably familiar with the system while acquiring the desired mathematical insights. Thus the instructional potential of the computer is realized with a minimum of distraction.

Michael Posner Villanova University
Meghan Buckley Villanova University

Should we prepare students for our tests or for the workforce?: Evaluating long-term retention in introductory statistics

Students often leave statistics classes with poor attitudes. While this is demoralizing for us and bad for our profession, how important is it really? Shouldn't we only care about whether they know statistics and whether they retain content knowledge long-term? I think the answer to this is no, but... show me the data! This study examines long-term retention of students. Three years after taking an introductory business statistics course, students were given an attitude and content survey. Factors associated with different attitude subscales and content mastery were evaluated and courses taken during this time were included in the models. We show that students who liked statistics at the end of the course and completed the survey were more likely to retain more material. The details and implications of these findings will be discussed.

Teaching Introductory Level Mathematics and Assessment

Friday, August 5, 8:30–11:40 AM, Union D

Mary B. Walkins The Community College of Baltimore County

A Freshman Transition Program Experience

The Freshman Transition Program, a collaboration between the Community College of Baltimore County (CCBC) and Towson University (TU), started in 2008. Since then, the success has been phenomenal, as the Towson students successfully transitioned into and were well-acclimatized to the university experience. In the program, CCBC instructors teach on the TU campus. The Towson University FTP students experience guaranteed housing, specialized support and participation in TU events and some clubs. Their classes are relatively small, so instructors can give one-on-one attention to students as needed. The students are very self-motivated and persevere to ensure their success in each course. I will share my FTP experience, as a CCBC instructor, teaching a developmental mathematics course at TU.

Gowribalan A. Vamadeva University of Cincinnati

Strategies to energize a Developmental Mathematics Class.

Developmental Mathematics students will be better served by a requirement to complete projects outside of class time in a group environment. Although projects are universal at the Pre Calculus andCalculus courses and above, there has not been much effort by educators, to promote the completion of appropriate projects to successfully complete a developmental Math curriculum. If we increase the rigor of our classes within the restrictions of the adopted curriculum, I feel in the long haul, students will learn and appreciate mathematics better. Completion of projects would involve deeper thinking and would better develop their critical thinking abilities, along with a better preparation for the workforce with success in a team environment. To better promote and motivate students in learning developmental mathematics, we must do more than teach the same material over and over again. Although changing of delivery methods and styles could positively affect these students learnings' it is not sufficient. Getting them to think more than what they believe they can do, will help them become successful in learning Mathematics in general. Projects will encourage them to think independently and using cooperative learning methods will be a valuable learning experience for all.

Kenneth A. Parker NYC College of Technology

Learning Without Lectures: A Tablet-Based Approach to Developmental Mathematics

Every year, some students enter college without meeting fundamental criteria in mathematics, and it's not for lack of exposure to the content. This talk will tackle the question of how students can be re-introduced to familiar content through a combination of tablets and WeBWorK. This particular approach reimagines the learning of arithmetic with an eye towards algebra without a single minute of lecture. [Based on an experimental workshop, with results appearing in iJMEST.]

Sunil Chetty College of Saint Benedict and Saint John's University

The effects of calculator use: research from psychology and education

When teaching a course for future elementary school teachers, should one discourage the use of calculators with young students? We explore the research literature from psychology and education which informs the issue of calculator use in developmental mathematics. We also discuss the calculator dilemma that may be faced in developmental courses at the collegiate level.

Najeem Lateef University of South Africa

The development and promotion ofconstructivist-learning environment to facilitate learning design on learnerswith learning barriers in Mathematic

The development and promotion of constructivist-learning environment to facilitate learning design on learners with learning barriers in Mathematic Abstract The incorporation of constructivist and critical traditional facilitating learning theory perspectives on the special learner with need in the classroom environment led to the development and uses of the Constructivist Learning Environment Survey (CLES). CLES empower the research Scholars, Educator and some stake holders in the education fraternity to observe facilitating learning approaches and to address key restraints to the development of constructivist classroom environment. CLES promotes either student or teacher perceptions of maximizing human potential to be fully immense, Uncertainty, Shared Control, moral ethics and Critical Voice was established in small-scale classroom of 35 learners which runs for twelve weeks based qualitative studies and its statistical annova table were validated in large-scale studies conducted at a special school for disable learners in Gauteng area in South Africa.

Filippo Posta Grand Canyon University
Ben Vanderlinden Grand Canyon University

Productive failure in the modern college algebra classroom

This is a preliminary report on the use of a productive failure approach within the context mathematics in secondary education. The study focuses on the delivery and assessment of a single competency within a general education Algebra course. Pedagogical success in math classroom is often associated with the ability to create a strong work ethic among the students in the classroom. Developing this work ethic may result in learners that focus on procedural memorization rather than true understanding. This is particularly true in general education Mathematics where assessment is delivered through on-line platforms that are very efficient at creating and grading assessment pieces, but lack the depth to promote true understanding. To alleviate this issue pedagogical techniques such as productive failure are used in the classroom. These techniques require students to brainstorm and then use various approaches to solve a mathematical problem until a solution is achieved rather than have the instructor give the series of steps needed to solve the problem ahead of time. The instructor acts as a facilitator, making sure that the learners persevere through the problem solving process. This is a preliminary report on the use of a productive failure approach within the context mathematics in secondary education. The presentation focuses on the delivery and assessment of a single competency within a general education Algebra course.

Jhemson C. Elis Department of Education
Elizabeth M. Ebora Department of Education
Aurea P. Ocon Department of Education
Teresita L. Culla Department of Education

Instructional Games in Teaching Algebra Among High School Students: Basis for Instructional Intervention

Our world is full of numbers, shapes, and figures that illustrate the wholeness of a thing. Indeed, this statement signifies that Mathematics is everywhere. Mathematics in its broadest sense helps people in their everyday life that is why in education it is a must to be taken by the students as a subject. The study aims to determine the profile of the respondents, performance of the respondents in the pre and posttest, impact of the instructional game used, significant difference between the level of performance of the respondents, and instructional intervention can be proposed. The descriptive method was utilized in this study. Certain approach was used to the main objective of this research. Instructional game was used as instructional intervention in teaching algebra for high school students. There were 30 students served as respondents with equal size of 15 each. Female and male teacher respondents were 7 or 70 percent and 3 or 30 percent respectively. The study recommended that mathematics teachers should conceptualized instructional games for the students with fun and enjoyment while learning through the guide of mathematics education program supervisor so that students must be given time to have fun at the classroom. *Key Words: Instructional Game in Algebra, Mathematical Intervention, Joyful, Successful*

Jesse Prince-Lubawy University of North Alabama

A Reward System for General Education Math Courses

Attendance and grades go hand in hand, and, as we all know, it is sometimes difficult to motivate college students to come to class. To account for this, we examine the use of a token economy in general education math classes. As defined, a token economy is a system of behavior modification based on the systematic reinforcement of target behavior. We use this system to encourage 100% attendance rates from all students and examine the pros and cons of the system.

Michelle L. Younker Owens Community College

Ohio Mathematics Initiative: Re-visioning Post-Secondary Mathematics

The Ohio Mathematics Initiative works to propose and revise policies and practices to improve post-secondary mathematics. Changes include: creation of a definition of college-level mathematics, development of a statewide quantitative reasoning course, updates to statewide learning outcomes, and recommendation of three mathematics pathways.

Perry Y. Lee Kutztown University of Pennsylvania
Padraig McLoughlin Kutztown University of Pennsylvania

An Assessment Study Across Multi-Sections of 'Large' College Algebra Classrooms and a 'Small' College Algebra Classroom: A Preliminary Report

During the past two academic years (2014/15 and 2015/16), an assessment study was conducted to obtain student-learned outcome data to multi-sections College Algebra classrooms (both 'large' and 'small'). The lead author incorporated the Flipped (or inverted) and the Inquiry-Based Learning (IBL) approaches (or the F/IBL method) into each of his 'large' and 'small' classrooms, and other 'large' College Algebra classrooms were taught predominantly using the traditional lecture-style methods. In these classrooms, student scores were collected by administering the assessments twice during each of the semesters: the pre-assessment and the post-assessment using Educational Testing Service's (ETS) standardized Elementary Algebra Skills Assessments (EAS). For the first time and during this past Spring 2016 semester, pre-assessment and post-assessment scores for the 'small' College Algebra using the F/IBL approach were also obtained. The presentation will address how this F/IBL method is implemented and managed into his College Algebra classrooms. Also, a summary of assessment data based on student-learned outcomes from these multi-sections of College Algebra classrooms (both 'large' and 'small') is presented.

Jeff Holt University of Virginia
John Jones Arizona State University

WeBWorK Open Problem Library

The WeBWorK Open Problem Library provides over 33,000 problems for use in courses for mathematics and related subjects through WeBWorK, a free web-based homework system. We describe work carried out over the past several years to improve the problem library, and new features teachers will find when accessing it through WeBWorK.

Rachel Frankel UC Blue Ash College

Guided Post Assessment Reflection for Student Success

This talk will address the issue of post-assessment analysis via prompted reflection to help students take responsibility for their learning and instructors to improve their teaching. Often a student takes an exam, performs poorly, and repeats the cycle throughout the semester, ultimately failing the course. Or, a student will do poorly on an exam, visit the instructor, and say "but I studied, why did I fail?" Students need guidance after each exam to self-assess factors such as their study habits, organizational skills, use of resources, distractions, their processing of the material, and their level of mastery of the material. Targeted questions on a self-reflection/prompted reflection worksheet can help students analyze their performance on the exam and set short-term achievable goals to succeed on subsequent exams. Post assessment is not limited to student self-reflection: it can also be a venue for instructor self-reflection. Instructors can solicit student feedback on the exam questions and on the style of teaching in order to improve student learning before the next assessment. In this talk I will present examples of my self-reflection worksheets and the rationale behind the questions as well as student responses and results.

Steven M. McKay Brigham Young University

Grading on a Tablet: Solutions, Experiences, and unintended pedagogical benefits.

A method for grading exams and papers on a tablet is presented which allows for automatic marking of exams and creation of a spreadsheet containing grades. Some unforseen benefits of this system for students and for instructors will be discussed.

Teaching Advanced Level Mathematics

Friday, August 5, 1:00–5:10 PM, Union E

Chad Wiley Emporia State University

Running an Online Mathematics Graduate Program

The M.S. program in mathematics at Emporia State University began as a traditional on-campus program. It transitioned to offering classes online for local teachers some years ago. There proved to be a significant demand for online graduate math courses, and now the program has hundreds of students and is available completely online. In this talk I will discuss some of the details of our program, some of the challenges we have had to overcome, and some that we still face.

Patricia S. Costello Eastern Kentucky University
Lisa W. Kay Eastern Kentucky University
Shane P. Redmond Eastern Kentucky University

The Master's Degree: The Forgotten Middle Child of College Mathematics Education

Inspired by regular reports on the state of undergraduate and doctoral education, the authors undertook a nationwide survey of master's degree programs in the mathematical sciences. We believe this to be the first comprehensive study of the master's degree in mathematics in over 100 years! The authors will share some of the highlights of their 2013 survey on the nature, practices, and composition of master's degree programs across the United States.

Padraig McLoughlin Kutztown University of Pennsylvania

An Argument for Broadening the Definition of Undergraduate Research in Mathematics To Include Authentic Inquiry-Based Endeavours

The Committee on the Undergraduate Programme in Mathematics (CUPM) is charged with making recommendations to guide mathematics departments in designing curricula for their undergraduate students. The latest CUPM Guidelines (2015) specifically defines undergraduate research to *not* include "situations in which undergraduate students are working on difficult problems whose solution is not known to the students but have been solved by someone in the mathematical community." Such is an oddly and particularly restrictive definition. Such a restrictive definition may deny forms of authentic inquiry which can lead to new ways to prove established results or create new insights into supposedly 'closed' questions. Moreover, the benefits of inquiry-based research over and above a result of the research produced by a student seem to have been ignored. Demoting inquiry-based projects to a category other than undergraduate research seems problematic at best and might affect the topics that student research may be focused upon. The purpose of this paper is to present a cogent and efficacious argument that a broader definition of undergraduate research is necessary to recognise the authentic kinds of research that do not fit within that restrictive definition. We submit both pedagogical and practical considerations that - hopefully - support the contention that an authentic and broader definition of undergraduate research benefits students and faculty. We outline why, in specificity, inquiry-based research should be included in the canon of that which constitutes meaningful mathematical undergraduate research.

Laura K. Gross Bridgewater State University

Teaching mathematical writing in an upper-level elective

In this how-to presentation, we introduce a paradigm for teaching mathematical writing in an upper-level elective. In particular, the assignments alternate between traditional problem sets and formal write-ups of problems from the previous problem set. Scaffolding includes modifying LaTeX templates, typing a few pages of class notes, considering conventions of mathematical discourse, discussing in-text citation, and giving and receiving peer feedback. The final writing assignment requires applying writing techniques to the content of other courses and considering a different audience. In this talk, we provide an overview of course materials and resources, as well as links to the documents and sites in question.

David Easdown University of Sydney

The role of proof in teaching and learning mathematics

One of the most difficult learning thresholds for students of mathematics is the concept of proof. The difficulty manifests itself in several ways: (1) appreciating why proofs are important; (2) the tension between verification and understanding; (3) proof construction. This talk will explore important issues through case studies, and attempt to relate them to the theory of threshold concepts (Meyer and Land, 2005), the SOLO taxonomy (Biggs and Collis, 1982), and other novel principles and phenomena, such as the Plateau Principle, the Principle of Reflected Blindness and the Einstellung Effect. A seminal example is the Smale proof of the Fundamental Theorem of Algebra, linking Newton's Method to complex number arithmetic, arguably, in the speaker's opinion, a paradigm for what an advanced mathematical proof should aspire to become, in an undergraduate classroom setting.

Eugene Boman Penn State, Harrisburg Campus
Robert Rogers SUNY, Fredonia

Teaching Real Analysis: Logical vs. Chrono-logical Approach

Real Analysis is traditionally taught in a highly logical manner. That is, we first build the real numbers from the rationals and then examine their properties, giving particular attention to those areas where the reals are different from the rationals, and proceeding in a more or less linear fashion. This is an entirely valid approach but for better or worse it has become the dominant paradigm for teaching real analysis. We suggest that a chronological approach is an equally valid paradigm, and has certain advantages. That is, since analysis evolved from the attempt to address the foundational issues posed by Calculus we begin by examining how analytical ideas emerged in historical context. Only after the need for resolving the foundational problems is clear do we introduce the highly non-intuitive concepts of modern real analysis. We then show how these concepts and definitions settle the foundational issues. This approach is not as "clean" as the traditional, logical, approach but it does have the pedagogical advantage that the need for a concept or definition is demonstrated before it is introduced. For

example, building the real numbers is traditionally the first topic taught in real analysis. In our approach it necessarily comes last because the student must first see the need for building the real numbers.

Michael C. Fulkerson University of Central Oklahoma

An extension of the Lusin-Privalov radial uniqueness theorem

In this talk we investigate certain aspects of the boundary behavior of holomorphic functions on the unit disc and the unit ball. In particular, we extend to higher dimensions a result of Lusin and Privalov. Connections to measure theory and Baire category are also explored.

Huseyin Cakalli Maltepe University

Beyond the Cauchy sequences

A subset E of the set of real numbers, $\mathbb{R}$ is compact if and only if any sequence of of points in E has a convergent subsequence whose limit is in E. Boundedness of a subset E of $\mathbb{R}$ coincides with that any sequence of points in E has either a Cauchy subsequence, or a quasi-Cauchy subsequence. Forward quasi-Cauchy sequences and backward quasi-Cauchy sequences provide with the conditions for the cases below boundedness and above boundedness. We prove that below (resp. above) boundedness of a subset E of $\mathbb{R}$ coincides with that any sequence of points in E has a forward (resp. backward) quasi-Cauchy subsequence. We also give continuity type theorems. It turns out that the set of uniformly continuous functions includes not only the set of the functions which preserve forward quasi-Cauchy sequences on below bounded sets, but also the set of the functions which preserve backward quasi-Cauchy sequences on above bounded sets.

Hudson Akewe University of Lagos

Hybrid Iterative Sequences of Jungck-type and Common Fixed Point Theorems

Let E be a Banach space and Y a nonempty set such that $T(Y) \subset S(Y)$ and $S, T : Y \to E$ satisfying the generalized contractive-like operators (Olatinwo [24]). In this paper, a modified Jungck-Mann hybrid iterative sequence is introduced and the scheme is used to approximate the unique common fixed point of S and T for generalized contractive-like operators defined by the author [24] in a Banach space. We establish strong convergence of Picard-Mann, Picard iterative scheme for single map T as corollaries. An example is taken to illustrate the applicability of iterative sequence. Our theorem generalizes and improves multitude of results in the literature, including recent hybrid schemes.

Clement B. Ampadu Boston, MA

Higher Order Multiplicative Contraction Principle for Self-Maps

If $\frac{d\varphi}{dt}|_{t=m(x,y)} = m(x,y)$, where $\varphi : [1,\infty) \mapsto [1,\infty)$ is such that $\frac{d\varphi}{dt}|_{t=\epsilon} > 1$ for each $\epsilon > 1$, and $m(x,y)$ is a multiplicative metric, then Theorem II.31 (https://www.asuswebstorage.com/navigate/s/031D62C7D5504A44AB7D1E6B2CE9A3564, Ampadu Clement et.al (2015): Fixed Point Theorems Using Multiplicative Contractive Definitions with Application to Multiplicative Analogue of C-class Functions, Unpublished) gives the multiplicative version of the higher-order contraction principle. In this talk we give an alternate characterization of this principle.

Toheeb A. Biala Sule Lamido University

Fractional Numerov's type methods for two dimensional space-time fractional differential equations

This work is concerned with the numerical integration of two dimensional space-time fractional differential equations. The approach is based on finite difference method for space and fractional linear multistep method for time. The interpolation and collocation technique is used to construct a continuous Numerov type method (LMM) from which the discrete fractional Numerov type method is derived as well as several discrete by-products. The partial derivatives with respect to the spatial variables are discretized using finite difference approximations to obtain a large system of ordinary differential equations (ODEs) of fractional order in the temporal variable. This system of ODEs is then approximated using the derived discrete schemes. The conditions under which the developed schemes converge are established. Numerical examples are also given to show the high accuracy of the scheme.

Leon Kaganovskiy Touro College Brooklyn Campus

Teaching Applied and Bio-Statistics with R package

It is very important to have flexible and easily available Statistical Software tool for teaching higher level courses and R by far is the best such free tool. It helps to teach courses at various levels and allows to create codes which provide efficient, hands-on Scientific Computing experience to enhance students' learning of Statistics concepts and real world Data Analysis. In this presentation, I discuss teaching Intermediate and Applied Statistics as well as Bio-Statistics courses over the years. Among the topics considered are graphical Data Analysis plots, Multiple regression, ANOVA, ANCOVA, Tree Models, repeated measures and mixed design, etc...

Timothy Lucas Pepperdine University

Slopes: An Interactive App for Exploring Differential Equations

A proper study of differential equations requires that students visualize solutions and analyze plots related to the structure of the equations. Although there is mathematical software such as Maple, Matlab, or Mathematica that performs these functions, these programs are expensive and students must invest a significant amount of time to learn the functions and proper syntax. *Slopes* is an interactive app that I have developed with a research team of faculty and students at Pepperdine University that allows students to explore numerical methods and graphical solutions to differential equations. The name of the app originates from the fact that the derivative can be interpreted as the slope of the function and most activities revolve around plotting slopes. The advantage of using an iPad application is that iPads are highly portable and feature large touch screens that allow students to view and manipulate content easily. Research based on observations of mathematics courses at Pepperdine University has shown that students are more willing to collaborate and share their results when using a tablet such as the iPad (Fisher, Lucas and Galstyan 2013). The intuitive interface of *Slopes* invites students to fully immerse themselves in the world of differential equations so that they can understand the concepts from not only algebraic, but also graphical and numerical perspectives.

Kevin Rao Texas Mathworks
Hans Li Texas Mathworks
William Liu Texas Mathworks

A Combinatorial Proof for the Rank-Unimodality of Poset Order Ideals

Posets are sets with ordering relations between some of its elements. This construction is a central topic in combinatorics and lattice theory, and posets also serve as versatile models for the distribution and prioritization of tasks, thus making them important in parallel computing. Our research deals with order ideals of the product of linear posets called $chains$ (denoted $n_1 \times n_2 \times n_3 \dots$). An *order ideal* is a set of elements and all elements less than them. The poset of all order ideals of a poset P is denoted $L(P)$, and is arranged in levels. We aim to show that these levels, or the structure of $L(n_1 \times n_2 \times n_3 \dots)$, are rank unimodal (the size of each level increases to a single local maximum and then decreases). We began our research by improving a standard poset algorithm and demonstrating rank unimodality in novel infinite families of posets. From our data, we gained insight on the structure of higher dimensional posets. Then we found an ingenious bijection between $L(n_1 \times n_2 \times n_3 \dots)$ and $W_1(n_1 \times n_2 \times n_3 \dots)$, which is the first proof that holds for all possible products of chains. Applying our bijection, we proved our second result that the product of any three chains is rank-unimodal, making the biggest breakthrough since O'Hara's 1990 proof of two-chain posets. Finally, we extended all of these results to outline a proof for the rank unimodality of infinite dimensional posets.

Emma Wright Plymouth State University

Taking Abstract Algebra O.E.R.

Students often feel a disproportionate amount of stress about the costs of their textbooks. The Open Educational Resources (O.E.R.) library provides many free educational resources, including texts, and many of these resources are malleable. In Abstract Algebra, I found an open source text that my students and I adapted. With a "pay it forward" mentality, we created a book that should better serve my next generation of Abstract Algebra students. This presentation will include a brief overview of O.E.R., the benefits of using an evolving text, and the schedule of the class. Additionally, after the semester, students were asked to reflect upon their experience using and adapting the text, and their evaluations and suggestions will be included in the presentation.

Lindsey Bosko-Dunbar Spring Hill College

Alternative Assessment in a Cryptography Course

From the general population, many people view college mathematics as the following sequence of courses: precalculus, Calculus I, Calculus II, Calculus III, etc. Even math majors may not experience a course beyond the calculus spectrum during their first year in college. As such, my department implemented a special topics course to introduce students to upper level mathematics earlier in their college career. The talk will not only elaborate on the success of teaching a Cryptography course with only a perquisite of Calculus II, but also how a poster session organized during the final week of the course gave students a unique experience to explore an additional piece of cryptography, prepare for attendance at a future conference, and allow them to learn what their classmates had researched in a collegial setting.

Jeffrey T. Neugebauer Eastern Kentucky University

Green's Functions of Fractional Boundary Value Problems

In this talk, we will discuss Green's functions for fractional boundary value problems with fractional boundary conditions. First, the process of constructing these Green's functions will be discussed. Then, properties of the Green's functions, including positivity and monotonicity, will be explored.

Teaching Introductory Level Mathematics

Friday, August 5, 1:00–4:55 PM, Union D

Seongchun Kwon Missouri State University - West Plains
Minhui Paik University of Toledo

Relationship between students' success and students' academic backgrounds in developmental mathematics

Missouri State University-West Plains recently launched the blended course 'Intermediate Algebra with Preparation'. The newly developed course replaced the self-paced emporium course Pre-Algebra/Beginning Algebra and Intermediate Algebra. We discuss the relationship between students' academic backgrounds and their course outcomes in the newly developed course and the past emporium courses.

Mary Wagner-Krankel St. Mary's University

Redesigning An Intermediate Algebra Course using Active Learning Techniques

As part of a grant, a math department at a University was asked to redesign their Intermediate Algebra course by integrating active learning techniques into the course. Intermediate Algebra was identified as one of many high-risk foundational and STEM gateway courses to be redesigned due to its high DFW rate. Changes in the content of the course, active learning techniques integrated into the course, and DFW rates for the piloted sections will be discussed. Results from traditional vs. active assignments, initiatives to improve attendance, and initiatives to increase participation in tutoring services will also be highlighted.

Gary A. Olson University of Colorado Denver

Active Learning TACTivities for College Algebra

This talk will focus on the redesign of college algebra recitation sessions at the University of Colorado Denver. In an effort to better support our recitation TAs and provide them activities which could be used to foster an active learning environment we introduced the use of a "TA Coach." The TA Coach is an experienced TA who works with the Course Coordinator to develop activities and model a recitation environment for new TAs, as well as visit recitation sessions and offer assistance to other TAs in implementing activities. In this session, I will share some of the TACTivities that were developed as a result of the TA Coach experiment this semester. These are activities which are designed to be tactile and foster discussion among students regarding the college algebra content. This work is sponsored by an NSF DUE grant #1539602.

Forest Fisher Guttman Community College, CUNY

Inquiry-Based Learning Through Blogs

With the buzz around MOOCs and online learning, more and more college students are taking math classes online. Meta-analyses show that community college students have not fared well in these courses, and instruction has often been reduced to rote, procedural knowledge. We present an alternative approach to learning math online inspired by Jim Groom's DS106 course at the University of Mary Washington. This hybrid Precalculus course, which ran at Guttman Community College in Spring 2015 and Spring 2016, uses blogs as a way to create online learning communities for an authentic, inquiry-based learning experience. We'll discuss the challenges and affordances of this online environment for inspiring inquiry.

J. Andrew George Penn State Erie

First-year Students and Online Math Courses: A Dangerous Mix

Upon request of Engineering, we now offer a two-semester sequence of pre-calculus courses for Engineering Technology students entirely online. Despite a high level of student satisfaction with these courses (as measured by mid-semester surveys and end-of-course evaluations), the level of student achievement (as measured by course grades) has been alarmingly low. I will present ways I have strengthened the structure, scaffolding, and social/teaching/cognitive presence in these online courses over the past four semesters—along with the sobering results in student performance. The disconnect between student satisfaction and performance has striking implications when considering online instruction for first-year students.

Bariaa Shatila Flagler College

Using MyMathLab for teaching undergraduate Mathematics courses

Previous studies have shown that MyMathLab is a valuable online learning tool for college students. As part of their college curriculum, students are required to take math courses. However, some students need additional help to succeed in their Mathematics courses. In my presentation, I will show how MyMathLab helps students do well in this subject.

Emily Gismervig University of Washington Bothell

Using Reflective Writing to Improve Students' Attitudes Toward Mathematics

Recent research has suggested that non-cognitive factors like growth mindset, stereotype threat and belonging heavily influence how well students perform in introductory mathematics classes. The impact is even larger for first-generation college students and underrepresented minorities. The research further suggests that these traits are not fixed—that it is possible to instill a growth mindset in students, combat stereotype threat and cultivate a sense of belonging—and that when interventions are made, students are more successful in their mathematics classes. In this talk, I will detail a specific intervention I used in a Precalculus I course at a small, diverse public university. Each week, students completed a written reflection on a topic like growth mindset, and then we discussed the topic in small groups during class. I will present the writing prompts I used, detail outside materials I referenced, and show samples of student work.

Grace E. Cook Bloomfield College

Embedded Tutors in First Year General Education Mathematics Classes

Over the last three years, members of the Bloomfield College Mathematics Department have reorganized their general education freshman level mathematics courses. Currently students are required to take two courses, Transition to Collegiate Mathematics and either College Algebra or Precalculus, dependent upon their major. College Algebra and Precalculus are further split into two class types, unenhanced and enhanced. Unenhanced sections meet three days a week in a traditional course format. Students place into the unenhanced course based on scores on a mathematics placement test. Students who score lower are placed into the five day a week enhanced version of the course. Three days a week they meet with an instructor, while two days a week they meet with a specialist. During the specialist sections students review homework, ask questions about class materials, and review for tests. Additionally, embedded tutors are present in the specialist sections to assist the specialists with instruction and to tutor fellow students. Embedded tutors are students who have successfully completed the course with a grade of a B+ or higher. In addition, embedded tutors must have an instructor recommend them for the position and be work-study eligible. Bloomfield's use of embedded mathematics tutors has met with various levels of success. In this session, I will discuss the logistics, best practices, roadblocks, and future plans for the embedded mathematics tutoring program.

Karen F. Smith University of Cincinnati Blue Ash

Using Blanks in Guided Lecture Notes: Do They Enhance Learning?

Guided lecture notes are distributed to students and provide a framework of what will be discussed in class. Spaces are included for students to write and work examples during the classroom discussion. Use of guided lecture notes paves the way for students to leave class with higher quality notes (Kiewra, et al, 1988) and can lead to improved student organization and engagement. Furthermore, studies have shown the use of guided lecture notes improves students' performance on quizzes and exams (Austin, et al, 2002) and improves academic performance (Hamilton, et al, 2000). The practice of using blanks in place of key words or concepts to be filled in by students during classroom discussions was the focus of a classroom research study conducted in two different college-level math courses. Does using blanks in place of key information improve student learning? Does using blanks improve students' *perceptions* of their learning? Comparisons were made between using guided lecture notes with such blanks and guided lecture notes without blanks. The results of this study indicate that although the prevailing student perception is that use of blanks as described in this manuscript improves their learning, no measureable improvement in learning was observed.

Darryl Yong Harvey Mudd College

Radically Inclusive Mathematics Classrooms

Mathematicians are a less diverse group of people than they should be and want to be. Outreach programs are vital to broadening participation in the mathematical sciences, but we also need pay more attention to the thing we higher education mathematicians all do: teach mathematics. Attending to basic human needs (safety, belonging, and affirmation) might be the keys to creating a radically inclusive classroom environment. That welcoming classroom environment might in turn lead to the diversity that we desperately need.

Caroline Maher-Boulis Lee University
Jeneva Moseley Lee University
Jason Robinson Lee University

Career and Technical Content in High School Mathematics (CATCH Math)

Reports from an independent education reform organization indicate that individuals without post-secondary education are eligible only for "low skills" jobs, which do not offer career advancement opportunities, and provide for a lifestyle lower than middle class. CATCH Math targets students early in their academic years and emphasizes the accessibility of mathematics and its relevance to everyday life at the high school level. The project aims at raising awareness among high school teachers of non-academic career options in mathematics. This is done through creating real-world problems and activities that encapsulate targeted mathematical content and developing workplace and technical skills. In this talk we will present some of the tailored activities and the skills that are naturally embedded in the material and that are related to the workforce. The project is funded by the Tennessee Higher Education Commission under the Improving Teacher Quality Grant Program.

Luke Smith Auburn University at Montgomery

Benefits of encouraging student exploration of word problems before formally presenting the relevant algorithms

The presentation would report findings from an experimental study that addressed two different teaching paradigms that were used in post-secondary remedial mathematics courses. In this study, one group of students was taught by first developing students' procedural skills (i.e. algebraic techniques and algorithms) before later showing them how to apply those skills to solve application problems (i.e. word problems). Students in the other group were taught by first introducing them to realistic or intriguing application problems and encouraging to find solutions through non-algebraic means (such as pictures, tables, and graphs); after students had time to explore the application problems, the procedural skills related to those problems were subsequently introduced and developed in the context of the proposed application problems. This study found that students in the former group demonstrated a strong positive correlation ($r = 0.77$) between their scores on their application problems and their scores on procedural problems; more specifically, their procedural abilities tended to limit their abilities to solve application problems. In contrast, students in the latter group demonstrated a much weaker positive correlation ($r = 0.23$) between their application scores and their procedural scores; these students were more likely to earn scores on their application problems that were much higher than their scores on procedural problems. This difference in correlations was statistically significant and may be due to the fact that the group of students who learned to use non-algebraic techniques possessed additional techniques at their disposal to solve application problems.

Doug Titchenal The Ohio State University

Tying Math to Art With the Fibonacci Sequence

We all know the Fibonacci sequence. We all easily recognize it when it's written out. But there's another way to see it—by putting the math of it into pieces of art. In this presentation I will share artwork I have created that shows the Fibonacci sequence from 3 through 144 using three triangular numbers in an easy-to-count geometric nautilus shape. Showing this concept in a visually appealing way—tying math to art—works to encourage quantitative reasoning skills by engaging students on both an analytical level and an artistic one.

Janet St.Clair Alabama State University

Making Sense of Finite Mathematics Using Cartoons

To connect concepts with the real world and history and to promote communication and excitement about mathematics, I integrated cartoons in a finite mathematics college course. The students and I created cartoons using an online comic strip creator, MakeBeliefsComix.com. I used my created cartoons to introduce objectives, review concepts, and assign problems before students saw the cartoon characters' solutions. Also, I connected the cartoons with follow-up assignments that I created. These, along with the cartoons, gave a flavor of the richness of mathematics and a glimpse of its humanistic side. I asked students to create cartoons that connected concepts to the real world or history and, following Cho, Osborne, and Sanders 2015, to write a paragraph about their cartoon and its mathematics. I developed a rubric to evaluate their cartoons. To get a sense of the benefits of cartoons, I developed questions related to students' experiences in creating their cartoons, their thoughts about the cartoons that I created and presented, and specific concepts studied. Also, I gave them a motivation survey (Cho 2012). Student cartoons embedded concepts and problems in interesting situations. During classroom discussions I observed that students were more willing to give hypotheses about problem solutions and ask questions, including non-mathematical ones such as why some have mathematics anxiety. Descriptive statistics showed that students who did cartoons were better able to explain a concept and give examples of its real-world connection than those who did not. My experiences with integrating cartoons in mathematics show that they are a valuable resource to use to promote reform ideas in mathematics.

Chris Oehrlein Oklahoma City Community College

Teaching and Assessing Pre-Engineering Students at a non-Residential Institution

Pre-engineering students at community colleges and non-residential extension campuses of four-year institutions are there to complete the first two-years of their bachelor's degree curriculum. This includes calculus, differential equations, physics and introductory engineering courses, as well as the other required general education. Before taking these core courses, many students need to strengthen their backgrounds in basic mathematics and science. Ideally, they would be able to complete this remediation in a year or less and the rest of their program in about two more years. However, since almost all of these students are working full-time (even those classified as full-time students), they take longer to complete their two-year pre-engineering requirements. They therefore often take sequenced courses with at least one-term gaps. These time and knowledge gaps can either be ignored, or they can lead an instructor to seriously re-consider how to teach and assess.

Miquel A. Piera Universitat Autònoma de Barcelona

System Thinking Multidisciplinary Causal Modeling Exercices for a Better Understanding of Interdependencies Effects on Multi-criteria Problems

A short presentation of 3 different trade off optimization problems in the area of Air Transport, Logistics and Safety will be introduced through Simulation techniques. The benefits of causal modeling will be highlighted by a proper understanding of emergent dynamics and the design of mitigation mechanisms. The importance of designing the right Key Performance Indicators will be illustrated through the analysis of realistic scenarios in which socio-technological dynamics affects drastically feasibility of optimization results. As a result, a new experimental modeling approach will be outlined to understand the inherent complexity of social/technological/industrial processes for a new

way of thinking relying on context scenarios and the experimentation of different policy alternatives through conceptual models transforming opinions of decision makers into valuable implications.

History of Mathematics

Saturday, August 6, 8:30–11:40 AM, Union E

Tim Clayton Lincoln Memorial University

Euclid's Elements and the Beginning of Modern Science

This talk investigates Galileo's use of Euclid's *Elements* in proving physical ideas. Galileo is often credited with introducing experimentation to the scientific process and overturning the deductive method of scientific investigation advanced by Aristotle. Although Galileo's *Two New Sciences* describes his experimental observations, he also proves physical results mathematically using Euclid's *Elements*. For example, his book is known for recounting the use of inclined planes to show the distance an object travels is proportional to square of the time elapsed. However, a mathematical proof is also given using ratios of line segments representing the time, position and velocity of the falling object. Without dismissing Galileo's contribution of the inductive process to the scientific method, this talk acknowledges his inclusion of deductive reasoning to reinforce his argument.

Colm Mulcahy Spelman College

Pioneering Women in Mathematics in Ireland

The first Irish-born woman to get a PhD in pure mathematics in Ireland appears to have been Siobhan Vernon (nee O'Shea) from Cork, in 1964. In the century before that at least 75 women in Ireland earned degrees in mathematics or mathematical physics, and/or became engaged in mathematical work of some sort. Some of these were were educated privately, and several were British women who'd been denied the opportunity to be awarded university degrees closer to home. Very few of these pioneering women had the chance to enter academia. Some of the early ones ended up as astronomers, many more as teachers. Even those who started relevant careers generally had them cut short if they married. We'll highlight the more notable ones, from Cork, Dublin, Belfast, Galway and elsewhere, based in part on information buried in The Annals of Irish Mathematics at www.mathsireland.ie

Andrew Leahy Knox College

The Central Role of Centers of Gravity in Early Modern Mathematics

More than 2200 years ago, in several well-known classical works, Archimedes initiated the study of areas, volumes of revolution, and surfaces of revolution–topics that to this day occupy a privileged place in the calculus syllabus. In 1906, Heiberg answered the longstanding question of how Archimedes had been able to arrive at such an amazing compendium of results when he discovered one of the most famous palimpsests of modern times: Archimedes' *Method*. This work showed that the central concepts in Archimedes' thinking were his Law of the Lever and centers of gravity. While early modern mathematicians may have been unaware of Archimedes' *Method*, they weren't unfamiliar with its techniques. In our talk we will describe how mathematicians in the 16th and 17th centuries used facts about centers of gravity to prove an array of deep and important results.

Douglas Daniel Presbyterian College

Did Alan Turing Come to My College? A Mystery.

It started with an email from someone that I did not know: "Do you know if Alan Turing ever spent time at Presbyterian College?" Not knowing Andrew Hodges biography of Alan Turing, I did not realize that inside that book might be a clue that both asks and answers this question. Looking into this question I found a lot of good information that leads me to believe that I can answer this question. I also hope to reveal the story of the Martin family and their ties to the Department of Mathematics at Presbyterian College and to the math world at large.

Antonella Cupillari Penn State Erie -The Behrend College

Agnesi's Geometric Interpretation of the Solutions of Quadratic Equations

Maria Gaetana Agnesi's *Instituzioni Analitiche ad Uso della Gioventu' Italiana* included most of the mathematical ideas known at that time (1748), from basic arithmetic and algebra to differential and integral calculus. One of the first topics in algebra is the solution of quadratic equations, and this process has a very long history that includes geometric representations of the method of completing the square. While working in more recent times, Agnesi still made extensive use of the connections between algebra and geometry and produced geometric representations for the solutions of quadratic equations when the coefficients are seen as lengths of segments.

Ishraq Al-Awamleh New Mexico State University

Ibn Al-Ha'im's 1402 poem, Al Mknifi'l-jabrwa'l-muqabala, On Algebraic Operations

An English translation of Ibn Al-Ha'im's (1356–1412 AD) poem, Al Mknifi'l-jabrwa'l-muqabala, will be presented. To our knowledge, it has not been translated into English before. He made contributions in mathematics and Arabic literature. One of Ibn Al-Ha'im's best-known contributions in mathematics is this poem, On Algebraic Operations. The poem reflects the main concepts of algebra (al-jabrwa'l-muqabala in Arabic) in the 14^{th} century. It was composed in 1402 AD and copied in 1882 AD. It's a versified poem consisting of 59 lines as follows: thanking the creator and his Prophet (2 lines), paying a tribute to the author's mathematics teacher, Abu Al-Hasan Ali Al Jalawi (1 line), introducing algebra (3 lines), presenting algebraic terminology (13 lines), discussing addition and subtraction (5 lines), discussing multiplication and division (8 lines), introducing the six canonical equations (15 lines), and presenting a summary/conclusion (12 lines). We will translate the verses in the poem and give them a modern interpretation. The translation will be based on two main sources: first, the interpretationand analysis in Arabic of the same poem by Zakariah Al-Ansari (1888 AD), and second, the work of Mahdi Abdeljaouad on the English analysis andinterpretation of another poem from the 12^{th} century, Urjūzafi'l-jabrwa'l- muqābala (which means Poem about Algebra), by Ibn al-Yāsamīn. Ibn al-Yāsamīn.

Andy Martin Kentucky State University

Viete Meets the Challenge!

In 1593 the Dutch mathematician Adriaan van Roomen published a challenge to others: to solve his 45-th degree polynomial equation. History records that when informed of the problem, François Viète not only produced a solution, but did so on the spot! How did he do it? This talk will describe both the problem and its solution.

Meredith G. Anderson Adams State University

The Trend Away from Euclid: A Glimpse Through the Looking Glass

'The Elements' of Euclid was the first known axiomatic mathematical work and one of the oldest surviving mathematical texts. For centuries, scholars at all universities were required to study 'The Elements,' both to learn geometry and also to practice rigorous, deductive reasoning. Then in the late 1800's, after over 2000 years of use in schools, many contemporary mathematicians of the time started to speak out that the works of Euclid were no longer suitable for the teaching and learning of geometry, and they began to look for alternatives to Euclid as the primary geometry text in schools. As a result, a mass of new textbooks was developed, all claiming to improve upon supposed flaws in Euclid's works, either in argument or logical sequence of results. One major opponent of this trend was Charles Dodgson, better known as Lewis Carroll, a clergyman, writer, and logician. Dodgson was so emphatic on this point that he wrote a book, "Euclid and His Modern Rivals," detailing how each of these new textbooks was at best just a copycat of the original. Of course, as we all know, Dodgson lost this battle and as a result the teaching of geometry has been forever changed. It seems pertinent to revisit this controversy in order to gain a full understanding of several important facets of the story: first, how could one mathematical compendium have persisted as the dominant text for so long and second, what exactly was the chain of events that precipitated this change? Moreover, are the arguments that brought about this switch still relevant today? In this talk, I will examine both sides of this debate and the implications that this trend had on the collegiate study of geometry.

Ann C. L. von Mehren University of Houston

Learning Elementary Math Logic from Gorgias

Calculus Responses Today to the Logos in "On the Nonexistent" by Gorgias Upcoming in June 2016, my paper about elementary math logic in "On the Nonexistent," by the Greek Sophist philosopher Gorgias (Fifth Century B.C.E.), will be published by JME i HMS, the *International Journal for Mathematics in Education*, published by the Hellenic Mathematics Society at the University of the Aegean in Rhodes, Greece. Because it has been so rewarding to be in dialogue with the JME i HMS reviewer(s), I would like to share with my MAA colleagues what the reviewer(s) discussed with me. My PowerPoint shares the article as published in the Hellenic Mathematics Society international English-language journal, plus the response I received that accepted my paper but asked me to make my explanations more exact about the logic of Gorgias that I found useful to elementary math lessons today, by referring to infinitesimal calculus and arithmetic education, such as: although [. . .] which is another indeterminate expression of [. . .] , having a different meaning in the context of infinitesimal calculus. Of course, this presupposes the enlargement of the conceptual framework of elementary arithmetic, which is beyond the reach of young children and pre-classic Greek achievements Because it has been so rewarding to be in dialogue with the JME i HMS reviewer(s) through the journal's editorial headquarters in Greece, I would like to share with my MAA colleagues what they discussed with me, accepted from me, and will be in publication form by August 2016.

Shigeru Masuda Ex. Long Term Researcher of RIMS, Kyoto University

The equations and theories of heat motion by Fourier and Poisson

We discuss historical development of classical heat theory from the viewpoint of mathematical physics, in particular, the differences of the equations and theories between Fourier and Poisson. Pr*é*vost's work on heat communication, which precedes Fourier, and whose initial scholar work and after it. Navier depends on the theory of Fourier's molecular action. Poisson issues the paper on heat theory : Poisson 1823 and the last book 1835 in rivalry to Fourier in which he discusses the essential theories emphasizing mathematical points such as complete integral, the trigonometric series in his three digressions. Poisson 1835 is very resembling with Fourier's style of his book 1822, in the volume and the structures of it, however the deductive method is quite different. Fourier proposes :

$$\frac{dv}{dt} = \frac{K}{C.D}\left(\frac{d^2v}{dx^2} + \frac{d^2v}{dy^2} + \frac{d^2v}{dz^2}\right),$$

where, K : conductibity, C : specific heat, D : density. On the other hand, Poisson's general equation is as follows :

$$c\frac{du}{dt} = k\left(\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2} + \frac{d^2u}{dz^2}\right) + \frac{dk}{du}\left(\frac{du^2}{dx^2} + \frac{du^2}{dy^2} + \frac{du^2}{dz^2}\right),$$

where, k is the constant value comes from his hypothesis. However, according to Poisson, Fourier's style is a particular case. Since then, many researchers create some stirs to incompletion of the heat problems : Dirichlet studies the solution to the Fourier's open problem in 1830, Liouville follows after Poisson's theory and extends it in 1835, Poincar*é* proposes the harmonic function which satisfies with the Dirichlet condition of both heat equation and its boundary condition in 1895.

Randy K. Schwartz Schoolcraft College

A Volume Optimization by Sharaf al-Dīn al-Tusi

Antedating the more general discoveries on extrema that were carried out by Fermat, Newton, and others in Europe was the work of Sharaf al-Din al-Tusi, who was born in northeastern Iran about 1135 CE. Building on earlier Greek and Arabic discussions of solid geometry problems, al-Tusi wished to know the *diorism* involved in solving a cubic polynomial equation related to the volume of a rectangular solid. In pursuing this, he was able to pinpoint the relative maximum of the cubic by solving a quadratic equation derived from it. The presenter will discuss this historical episode as well as a simple one-hour classroom exercise on al-Tusi's breakthrough that he has used successfully in a calculus course for 15 years.

Chuck Lindsey Florida Gulf Coast University

Nepohualtzintzin: a Closer Look

Nepohualtzintzin is an abacus-like counting and calculating device, whose name is derived from a Nahuatl phrase. It has been asserted, and frequently accepted, that the *nepohualtzintzin* was in use by the Aztecs and related indigenous groups in parts of Mexico and Central America for many years, perhaps centuries, before the arrival of the Spanish in the early 16^{th} century. We will attempt to trace the origin of the claim of a pre-Columbian invention of this device, and examine the evidence for it.

Phil Blau Shawnee State University

Emmy Noether's Ideal Theory

In 1921 Emmy Noether published her monumental "Idealtheorie in Ringbereichen" in which she generalized decomposition theorems for the integers and those for ideals in algebraic number fields to ideals in arbitrary rings that satisfy the ascending chain condition. This paper was a major impetus towards the axiomatic and structural approach found in mathematics in general and algebra in particular ever since. In this talk we give a brief overview of the 4 different decomposition theorems contained in this seminal paper.

Number Theory

Saturday, August 6, 8:30–11:40 AM, Union D

Aaron J. Blodgett The University of Findlay

Finding Unique Coverings For Rings Of Integers

Covering systems were first introduced by Erdos in the 1930s, and distinct covering systems of the Gaussian integers and other simple integer rings have also been discovered. This talk details a general method of finding distinct covering systems for specific types of integer rings, as well as possibilities for other types of integer rings.

Ronnie S. Williams University of Central Oklahoma

Level compatibility in the passage from modular symbols to cup products

There is a correspondence that relates the geometry of the modular curve $X_1(N)$ and the arithmetic of the cyclotomic field $\mathbb{Q}(\zeta_N)$. The structure of these spaces depends on the choice of an integer N, which we will simply refer to as the level. One may now ask whether we can move between levels while still preserving this correspondence. The answer to this question is yes; however the method to do so is not quite as simple as applying one of the natural degeneracy maps. I will briefly discuss the structure of these spaces, and then I will describe a map which provides the desired level compatibility.

Yasanthi Kottegoda University of New Haven

Exploring the characteristics of modulo one sequences.

Modulo one sequences is a special category of sequences of pairwise relatively prime positive integers where an old idea of working with modulo arithmetic simultaneously in order to speed up computer arithmetic is used in the construction of these sequences. Let $m_1, m_2, \ldots, m_t$ be positive integers that are pairwise relatively prime. Set $M = m_1 m_2 \cdots m_t$ and $M_i = M/m_i$. Then the sequence is defined as a mod one sequence if $M_i \equiv 1 \pmod{m_i}$ for each i. I also discuss the necessary and sufficient conditions for the existence of the sequence and prove that there are such sequences of arbitrary length. Additionally, results on classification of the mod one sequences based on its length with the examples obtained from observations using MATHEMATICA will be discussed.

Michael Brilleslyper U. S. Air Force Academy

Prime Graphs and Generalized Euler Phi functions

A labeling of a simple graph is an assignment of the integers 1, 2, ...n to the vertices in such a way as to satisfy some desired condition. A prime graph is one where there is a labeling such that any vertices connected by an edge have labels that are relatively prime to each other. In this talk we investigate a very special case of prime graphs and also introduce a generalization of the well-known Euler-phi function from number theory. We give a few properties of these generalized functions and state several open problems. This talk is suitable for undergraduates.

Frederick Chichester New Jersey Microsystems

Generating Near-Isosceles Primitive Pythagorean Triples Using Pell-Type Sequences

If the integers of the Pythagorean triple (a, b, c) are arranged in ascending order, then a represents the length of the shorter leg, b the length of the longer leg, and the c the length of the hypotenuse of the corresponding Pythagorean triangle. If such a triangle approximates an isosceles triangle, its corresponding triple is said to be near-isosceles. In the case in which the sides a and b are to be made nearly equal, $b - a = d$. and the percent error of approximation is expressed as $100(b - a)/a = 100d/a$. In order to generate near-isosceles primitive Pythagorean triples (PPTs) it is necessary to find values of the Euclid integers, m and n, such that the error of approximation is sufficiently small for a given value of d. This problem has been solved in earlier work for the case in which $d = 1$ by using the Pell sequence: 0,1,2,5,12,29... . However, this solution rapidly leads to the generation of PPTs with large integers, especially those larger than (696, 697, 985) for which $m = 29$ and $n = 12$. In the present paper an approach is shown for generating near-isosceles PPTs in which d is greater than 1, the integers within the triple are smaller than those in (696, 697, 985) , and the error of approximation is less than or equal to 5% by using interwoven pairs of Pell-type sequences to find appropriate values of m and n.

Jeremiah Bartz University of North Dakota

Areas of Generalized Fibonacci Polygons

In this talk, we present a compact formula for computing the area of polygons whose vertices are comprised of either consecutive Fibonacci or consecutive Lucas numbers. In addition, we discuss related formulas for the area of triangles whose vertices involve certain types of sequences of Fibonacci, Lucas numbers, or their generalizations.

Charlie Smith Park University

Beautiful Integer Patterns: Version 2.0

Using only integers and the basic operations of addition, subtraction, multiplication and exponentiation, strikingly beautiful patterns can be created. This talk will explore several of these intricate designs. The aesthetic aspects of these structural gems will be highlighted. Proofs will be available upon request.

Timothy B. Flowers Indiana University of Pennsylvania
Shannon R. Lockard Bridgewater State University

Counting hyper *m*-ary partitions

An integer partition of n is a way of expressing n as a sum of positive integers called parts. Hyper m-ary partitions are integer partitions whose parts are powers of m and where each part appears at most m times. We examine patterns in the structures of various partitions and give identities that compare the number of hyper m-ary partitions for different values of m.

James Carpenter Iona College

Exploring Triangular Numbers

Triangular numbers present interesting topics which can be explored by college sophomores in courses such as Number Theory, Discrete Mathematics and Introduction to Proof. Some triangular numbers are also perfect squares. This presentation will explore some interesting problems about and relationships among these perfect square triangular numbers. In particular, if $n(n+1)/2 = ab$ is a perfect square, then both a and b are perfect squares, where $a = n/2$ and $b = (n+1)$ if n is even and $a = (n+1)/2$ and $b = n$ if n is odd. Can these perfect squares be generated? How many are there?

Jay L. Schiffman Rowan University

Patterns, Primes and Number Tricks Associated with the Jacobsthal Sequence

The Jacobsthal Sequence is a Fibonacci-like sequence which is ripe for exploring patterns. We define Jacobsthal (1) = 1 and Jacobsthal (2) = 1. For n ¿ 2, Jabobsthal (n) = Jacobsthal (n - 1) + 2 * Jacobsthal (n - 2). The first ten terms in the sequence are 1, 1, 3, 5, 11, 21, 43, 85, 171 and 341 respectively. In this paper, we will examine divisibility patterns as well as prime outputs and some neat number tricks associated with the sequence. While this sequence has varied applications including one involving the Collatz problem, our goal is to explore its structure. Results from a MATHEMATICA search in excess of the initial three hundred terms will be discussed.

Toufik Mansour University of Haifa
Hieu Nguyen Rowan University

A Digital Binomial Theorem for Sheffer Sequences

We extend the digital binomial theorem to Sheffer polynomial sequences by demonstrating that their corresponding Sierpinski matrices satisfy a multiplication property that is equivalent to the convolution identity for Sheffer sequences.

Larry Lehman University of Mary Washington

Seeding Polynomials for Congruences Modulo Prime Powers

When p^2 divides $f(q)$ and p divides $f'(q)$, it is generally difficult to describe all solutions of the polynomial congruence $f(x) \equiv 0 \pmod{p^k}$ for $k > 1$ by traditional methods. In that case, we show that there is an $e \geq 2$ and a polynomial $g(x)$ so that for all $k \geq 0$, every root $r \equiv q \pmod{p}$ of $f(x)$ modulo p^{k+e} can be expressed explicitly in terms of the roots of $g(x)$ modulo p^k. We will illustrate the effect of these "seeding" polynomials graphically, and will demonstrate thatthis method is particularly effective for counting those solutions modulo arbitrary powers of p.

Ezra Brown Virginia Tech

Monthly Problem 3173, Sam Beatty, and 1/p + 1/q = 1

One of the most frequently cited problems ever posed in the Monthly is Problem 3173 from March of 1926, in which the reader is asked to prove that if p and q are irrational numbers greater than 1 such that $1/p + 1/q = 1$, then the sequences $\{[np] : n = 1, 2, 3, ...\}$ and $\{[nq] : n = 1, 2, 3, ...\}$ contain between them each positive integer without repetition. These sequences are connected with many diverse mathematical topics, including number theory, combinatorial games, electron diffraction, quasicrystals, Penrose tilings, and digital signal processing. We'll talk about some of the people involved with the history of this problem, including the English physicist Lord Rayleigh, the Dutch game theorist W. A. Wythoff, and the Canadian mathematician Samuel Beatty, who posed the problem and for whom these so-called Beatty sequences are named. Oh, and we'll also give a proof of this remarkable result.

Outreach and Other Topics

Saturday, August 6, 1:00–4:55 PM, Union D

R. Kevin Maxwell Penn State Fayette, The Eberly Campus
Nicole Hill Penn State Fayette, The Eberly Campus

Teachers Go Back To School!: Post-secondary and Elementary Schools Working Together

Description: The *C3 Project: Content, Connections, and Collaboration* was a 3-year intensive summer math academy for K-8 teachers (with follow-up days and instructional coaching) developed and presented by math educators at Penn State Fayette that focused on increasing mathematical content knowledge and developing rigorous tasks. Participants attended 80 hours of training each summer in the program and were then assigned mathematics instructional coaches that visited their classrooms throughout the school year. Presenters will share activities, results, and recommendations for implementation. Learning Outcomes: Attendees will learn how elementary and post-secondary schools can collaborate to deepen mathematical connections.

Maria G. Fung Worcester State University
Brendan Keenan Bagnall Elementary School

Mathematics Instruction Improvement Project at a STEAM K-6 School

In this talk we discuss a collaboration between a mathematician at a comprehensive regional university and a STEAM public K-6 school. We focus on initial observations, ideas to improve articulation among grades ,and the introduction of writing and quantitative literacy into the curriculum. Future plans to align instruction with STEAM projects and evaluations of the current plan are also considered.

Amy L. Hlavacek Saginaw Valley State University
Jan Hlavacek Saginaw Valley State University
Christopher Nakamura Saginaw Valley State University

STEM Opportunities Camp: Increasing Access to STEM Fields for At-risk Middle School Students

The 2015 Saginaw Valley State University Summer STEM Opportunities Camp was a four-week long day camp which targeted at-risk, predominantly under-represented minority, rising 7th, 8th, and 9th graders from Saginaw and Bay Counties. Approximately sixty middle school students were brought together with high school and college student mentors and also with SVSU faculty in a cooperative and supportive learning environment. Our main goal is long-term increased proficiency and interest in mathematics, leading to increased interest and access to higher education and STEM fields. This includes building mathematical competency & confidence, promoting shifts in attitudes towards education and technical fields, building awareness of career opportunities, and building self-esteem & sense of civic belonging. A typical day at camp includes Basic Math and Discovery Math. During Basic Math, fundamental concepts are reinforced, with an emphasis on number sense, mental math, and understanding concepts. During Discovery Math, we try to pique students' interests with higher level concepts, which can include fractals, sequences and series, the Monty Hall problem, etc. This past summer, we continued to offer a series of physics explorations, which included bottle rockets, statics, and amusement park physics. There was also dedicated problem solving time where rising seventh and eighth graders worked on practice standardized test problems as well as more open-ended problems.

Amanda L. Hattaway Wentworth Institute of Technology
Emma Smith Zbarsky Wentworth Institute of Technology
Joan Giblin Wentworth Institute of Technology

Summer Math Program for Incoming Engineering and Computer Science Students: Curriculum and Results

Wentworth Institute of Technology, a 4 year college, runs a summer math program for incoming freshmen and transfer students majoring in STEM. The goal of this National Science Foundation program is to graduate more STEM students at Wentworth from underrepresented groups and/or who face significant financial or academic challenges. We will talk about how students are selected for the program, the curriculum and results from the last four summer cohorts.

Britney Hopkins University of Central Oklahoma
Kristi Karber University of Central Oklahoma

Creating and Running an Urban ACT Prep. Program

The Urban ACT Prep. Program is an effort to bridge the academic achievement gaps that are a result of economic disparity. The program offers one-on-one tutoring that focuses on the mathematics portion of the ACT. In addition, university student researchers engage in a transformative learning experience by working with low-income high school students. We will discuss the details of our program, the benefits it provided to our students, as well as the challenges we faced and how we might overcome them in the future.

Jessie Hamm Winthrop University

Getting Starting in Outreach

Mathematical outreach is a valuable tool used to increase awareness of mathematics, promote diversity within STEM fields, and build confidence in critical thinking and problem solving among the participants. It is also an opportunity for graduate and undergraduate students to learn and teach interesting mathematics to young students within the community. Though many people are interested in outreach it can seem intimidating to start a program of your own. This talk will give practical advice on getting started in outreach. We will discuss types of programs, sources of funding, advertising, and implementation of such events.

Erion J. Clark University High School of Indiana

Learning from Freedom Summer

Learning from Freedom Summer In the summer of 1964, an organized group of college age Americans executed a plan to travel to the southern U.S. and register residents to vote. They also sought to educate the young people, to ensure that their generation would be able to exercise all of their rights as part of an enlightened society. Robert Moses, one of the architects of Freedom Summer, went on to support the struggle to fully educate children from underserved communities a generation later with The Algebra Project, an important organization that still educates students today. This talk will examine learning materials and lesson plans from Freedom Summer. It will examine Mr. Moses' strategy for making math literacy accessible and relevant to today's children. The objective is to encourage participants to reflect on their teaching and engage a new generation of students with the math skills needed to develop their full potential as 21st century Americans.

Daniel Showalter Eastern Mennonite University

Mathematics in Rural America: Access and Outcomes

Despite the universal nature of mathematics, rural areas of the U.S. differ from other locales in terms of recruitment and retention of qualified mathematics teachers; access to technology; and community contexts. These differences are likely to impact how students relate with mathematics and how they perform on standardized assessments. In this talk, I will present a series of original maps and tables that will give a sense of the big picture of rural mathematics education in the K-12 system across the country. Data to create the maps and tables come from federal datasets including the *American Community Survey*, the *Common Core of Data*, the *National Assessment of Educational Progress (NAEP)*, the *Civil Rights Data Collection*, and the *Educational Longitudinal Study of 2002:12*. The talk may be of interest to anyone interested in rural education or in broader trends occurring in mathematics education.

Carol Williams Texas Tech University

Building and Mentoring a Community

We will describe our successes and challenges building and mentoring communities of undergraduate mathematics majors. We will explore examples arising from our department's NSF-sponsored PRISM program and its offshoots.

G. Brock Williams Texas Tech University

Preparing Students for Successful Mentoring Relationships

In our efforts to increase retention of students from under-represented groups, it has become clear that many students struggle to form meaningful relationships with faculty. Merely assigning students an official mentor and instructing them to meet their mentor regularly has often proven completely inadequate to produce significant mentoring relationships. We will discuss our training program to help students develop the skills necessary for successful mentoring.

Violeta Vasilevska Utah Valley University

Math-Forensics Conference for High School Students

The *Math-Forensics Conference: Whodunit, Howdunit, Whendunit* (http://www.uvu.edu/conferences/mfc/) is a one day conference aimed at high school students of the surrounding area. Some of the objectives of the conference are: to show high school students, their teachers, as well as the undergraduate students involved in it, the importance of Forensic science, the application of math in Forensic science, to give students the opportunity to 'solve' fictional crimes using math, to provide opportunities to learn about various forensics careers and talk to forensic scientists to learn how they use math in their everyday jobs. In this talk we discuss the goals, the structure, and the impact of the program on all of the involved participants.

Frank Morgan Williams College

Future of Notices AMS

As new Editor of the *Notices of the American Mathematical Society*, I would like to discuss some of the new features, such as invited lecture samplers, the Graduate Student section, the Back Page, and the online commentary. I want to hear your suggestions.

Robert Rovetti Loyola Marymount University

An Experimental Undergraduate Course in Complex Systems

What do chemical enzyme kinetics, collapsing sandpiles, foraging ant trails, flocks of birds, and the Prisoner's Dilemma all have in common? From the small to the tall, large collections of interacting objects with relatively simple dynamics exhibit an uncanny ability to self-organize into coherent behavior at the group level, without the benefit of a leader or a master plan. Here we will outline an exciting semester-long journey undertaken by a team of mathematics, biology, physics, and economics undergraduates to understand the strange world of complex systems. Our course, funded by the W.M. Keck Foundation as part of an interdisciplinary development grant, encouraged students to approach the topic rigorously through a combination of analytical approaches (e.g., difference and differential equations), computer simulation (agent-based modelling), and hands-on laboratory and field experiments.

Richard Edwards Michigan State University

Student reported connections between math and science courses for non-STEM majors

Every year, thousands of undergraduates enroll in mathematics and science courses, despite the fact that they are pursuing non-STEM majors. How do these students benefit from such courses? Is there any connection between these educational experiences? This talk presents the results of research on the kinds of connections students themselves made between their first-year mathematics and general education science courses. The researcher studied the experiences of undergraduates who all passed the same quantitative reasoning course, and later enrolled in a variety of general education science courses, including both the physical and biological sciences. Students reported a variety of connections centered on specific mathematical/statistical components. Implications of this study extend to both science and mathematics educators.

Orion Martin Rose-Hulman Institute of Technology

Simulating Imperfect Quantum Algorithms

Quantum computers are rapidly approaching the point of performing useful calculations. Research on quantum gates in silicon and extending qubit lifetimes show great promise for the field. Despite this, very few individuals have a detailed understanding of how to write algorithms for these computers. My research covers the development of Qlang, a programming language for quantum computation, and the simulation of Shor's prime-factorization algorithm using it. Ostensibly, this serves to demonstrate both the utility of a simulated quantum computer in learning quantum algorithms and the feasibility of quantum algorithms, even accounting for imperfections in code.

Abdulmajeed Abdurrahman Shippensburg University
Nicholas Brunswick Shippensburg University
Ibrahim Abdurrahman Shippensburg University

Ffactorization in Closed String Field Theory

The interacting comma 3-vertex operator for the bosonic closed string in the full string basis is derived using the coherent states techniques. The result indicates that the closed string vertex operator can be built as a product of left- and right-moving vertex operators. Thus proving that factorization of closed string vertices is not special to tachyons but is a general rule at least for N=1,2,3.

Probability, Statistics and Calculus

Saturday, August 6, 1:00–5:00 PM, Union E

Abdullahi M. Salman Michigan Technological University
Shurong Fang Fairfield University

Quantification of Uncertainty in Probabilistic Seismic Risk Assessment of Electric Power Systems

Electric power systems are susceptible to damage due to natural hazards such as earthquakes. For example, the 1994 Northridge earthquake caused damage to electric power systems causing over 2.5 million customers to lose power. Similarly, the 1995 Great Hanshin earthquake, 2008 Wenchuan earthquake, as well as the 2010 Chile earthquake caused various levels of damage to electric power systems. Considerable effort needs to be made to develop methodologies for assessing the reliability of electric power systems under earthquakes. This presentation presents a framework for quantification of uncertainty in probabilistic risk assessment of electric power systems subjected to seismic hazard. The framework includes hazard and structural component vulnerability models, system reliability analysis, and multi-hazard risk assessment. A notional electric power network assumed to be located in Charleston and Seattle is used to demonstrate the proposed framework. The framework can be used for pre-disaster preparation, mitigation, and post-disaster response planning.

Jillian Stupiansky University of North Alabama
David Schmidt Westminster College
Brian Steffen South Louisiana Community College

Statistical Analysis of Sedimentological and Paleontological Data

A fossil-bearing stratum within the Blackwater Draw Formation has revealed new information about the ancient channel of Running Water Draw (RWD) in Texas. Textural changes in sediments and fossil mollusc abundances occur laterally along the fossil-bearing stratum. Statistical analyses were performed on the sediments and fossils from three sampled intervals along the stratum, and the results suggest that different microenvironments exist within the channel. To further support this conclusion, statistical comparisons were made between the stratum of RWD and different regions of the Double Mountain Fork Brazos River channel. Our study used integrated sedimentology, invertebrate paleontology, and statistics to demonstrate a more complex depositional history of RWD channel than was previously known. The focus of this talk will be on the statistical analysis.

Andrew Matchett University of Wisconsin - La Crosse

Beyond real data in teaching statistical inference

The idea that teachers of statistics should use real data is an old one. This paper will cite pedagogy recommendations from the statistics community since 1992, which were interspersed with cries from the psychology community that all was not well with hypothesis testing. The conflict came to a head in 2015 with an editorial in the journal Basic and Applied Social Psychology. The editorial stated that hypothesis testing was invalid. There followed immediately a promise from the ASA to address this. The ASA was true to its word and in March, 2016, published 6 principles delineating the use of P-values. We suggest a concrete, enjoyable strategy for incorporating 3 of the principles into the curriculum of an elementary statistics course.

Dennis L. Clason University of Cincinnati Blue Ash College

Physical models of population parameters

Students in introductory statistics classes often struggle with the ideas related to population parameters and their properties. Physical models fabricated from uniform density materials can make the ideas of mean, standard deviation, median and quartiles and interquartile range concrete by relating them to measurable physical properties of the models. Aside from the models, the only additional materials needed are ruler and an accurate kitchen scale. Samples of the models using the Normal, χ^2 and Beta distributions and demonstrations using them are presented.

David DiMarco Neumann University
Ryan Savitz Neumann University
Blane Hollingsworth Middle Georgia State College

On Resistant Versions of the Standard Score

On Resistant Versions of the Standard Score David DiMarco, Neumann University Blane Hollingsworth, Middle Georgia State College Ryan Savitz, Neumann University Abstract If a large outlier is introduced to a data sample it will result in the z-scores of the other data values decreasing in magnitude and tending to be negative. Should the outlier be large enough, the mean will be greater than the second largest value and the z-scores of all of the data values, except the outlier, will be negative. If the outlier is much less than the other data values the z-scores of the other values will tend to become positive. Both circumstances are undesirable. In this presentation we consider variations of the z-score which are resistant to outliers. Said variations substitute corresponding resistant measures for both the mean and standard deviation in the usual z-score formula. The breakdown points of the new measures will be considered. Ease of computation will also be considered. Some of the new measures are flexible, consequently a user can choose the measure whose properties best fit the application at hand.

M. Z. Raqab Kuwait University

Comparing Pitman's Measure of Closeness with Other Optimality Criteria

In the sense of probability theory, Pitman's measure of closeness is used frequently in the last three decades to measure the distances between different variates and other related functions. Here in this work, we study the importance and motivations for using this measure in some prediction problems and then compare it with other measures used in statistical inference such as the mean square prediction error.

Barbara Margolius Cleveland State University

Roots of Unity and Asymptotic Analysis of Periodic Queues

We explore the queue length distribution for stable queues for which transition rates vary periodically. For the class of queues that can be modeled as level independent Quasi-Birth-Death processes, as t tends to infinity, the probability of k in the queue, $\pi_k(t)$, tends to a periodic function. As k tends to infinity, $\pi_k(t) \sim r^k f(t)$ where $f(t)$ is periodic and r does not depend on time. The figure illustrates this asymptotic behavior. Exact and asymptotic estimates for probability of k in the queue are shown. This result is general for QBDs with time-varying periodic transition rates. We also look at a specific example. We derive an explicit formula for the generating function of a random walk with non-constant transition rates when steps to the right are distributed k-erlang. The generating function can be expressed in terms of roots of unity.

Andrew Gard University of the Virgin Islands

New Perspectives on Curves of Pursuit

Pursuit curves describe the behavior of objects or creatures as they attempt to intercept moving targets about which they have only limited information. Although the differential equations governing such motion are not generally solvable in closed form, they are amenable to both numerical and qualitative analysis. We will engage in both, as well as covering some history and obtaining some interesting new results.

Louis E. Effiong Abia State Polytechnic, Aba, Nigeria
Ugochukwu Agomuo Abia State Polytechnic, Aba, Nigeria
Godswill U. Achi Abia State Polytechnic, Aba, Nigeria

Computation of Solutions of Non-Linear Functions Using Julia Set

There exists so many iterative procedure or technique in finding a root or zero of a given function. However, in any iterative technique, the paramount interest is to find an initial seed which leads to roots. The technique for understanding iteration of functions at least in one-dimensional case was first studied by Julia and Fatou. In this paper , we try to establish the solution of non-linear functions by the application of Julia set theory to the one-dimensional method.

Bathi Kasturiarachi Kent State University at Stark

Excursions in Newton's Method

Using Newton's method as an intermediate step, we introduce several iterative methods that numerically approximate the solutions of $f(x) = 0$. The order of convergence and the computational efficiency of the proposed methods will be presented.

Amera Almusharrf Oakland University

On the Logistic Equation with Two Delays

We present four different versions of the logistic equation with two delays. Each version has a different interpretation as a model &gt population dynamics with different underlying assumptions. Mathematical analysis &lt numerical simulations show the behavior of each one of the four models.

Orlando B. Alonso Lehman College
Otilio B. Mederos Universidad Autónoma de Coahuila

Integration of problem solving, modeling, & technology in the study of the geometric mean & the planar p-means

A new visual simple proof for the order relationship among the geometric mean and the planar p-means for any distinct real positive numbers a, b and any real number p follows from a discussion of a pedagogical method designed as a framework to study conceptual interconnections and geometric interpretations of these means. The method designed integrates problem solving, model with mathematics, and technology to study the geometric mean and the planar p-means. It is an outgrowth of Maor's (1977) work that could serve as a framework for students to investigate geometric interpretations of these concepts and understand their interconnections through a Calculus classroom project. Problems proposed are solved using first a straightforward algebraic approach and then using an analytic-geometric constructivist approach. As mathematical models using parametric and non-parametric equations and their corresponding visual representations are obtained using virtual manipulative tools designed in a dynamical software environment, the power of the modeling method and the geometric constructions are revealed. Thus, producing pedagogically organized mathematics generalizations enhancing student conceptualization techniques. Subsequently, it is presented a new visual simple proof for the order relationship among these means when a and b are different. Generalizations of geometric problems associated to means of two real positive numbers to means of n real positive numbers that will be introduced will put under scrutiny the concept of mean.

MK Panahi El Centro College
Mikiko Okura El Centro College

Calculus of Generating Functions

Generating Functions are a helpful tool for studying many properties of sequences as well as proving combinatorial identities. It is also used for solving recurrence relations by translating the relation into closed forms involving a generating functions. One may take advantage of the relatively simple relationship between closed forms and power series concepts, taught in a typical calculus course in order to motivate students that usually struggle with series and sequences concepts.

Jonathan Martin Purdue University
Andy Martin Kentucky State University

Some Results Concerning Real Infinite Series

Consider an infinite series of positive terms which shrink to zero. Of course the series may or may not converge. If the series diverges, must it have a convergent infinite subseries? If yes, how many of its subseries converge and how many diverge? If the series contains infinitely many negative terms but is not alternating, what can be said?

Susan Wildstrom Walt Whitman High School

An IBL activity for multivariable differential calculus

When students study multivariable differentiation and its applications, they study partial derivatives, gradients, directional derivatives, total differentials, error management and approximation, tangent planes, normal lines, and unconstrained extrama. This activity allows students to explore and review all of those ideas in a setting that involves physically active small group collaboration.

Alexander L. Garron Sand Box Geometry LLC

Finding a Calculus Primitive source for our 2-space parabola curve

We have all heard the term 'Primitive' used in difficult integration implying we may not be able to get there from here. What is a Calculus Primitive? I will use the Apollonian Section Parabola defined as a three dimensional curve and demonstrate it is the Primitive of the two dimensional parabola curve we use today. I will construct our two dimensional parabola at the unit circle of the cone diameter, and having done so demonstrate the unit circle propensity to carry physical property of wave energy such as sound using *Mathematica*. The unit circle will then become my independent curve as initial wave form of one second and use the dependent curve unit parabola energy tangent slope to find wave plane displacement per unit time.

Graduate Student Session

Great Talks for a General Audience: Coached Presentations by Graduate Students

Saturday, August 6, 1:00–5:00 PM, Madison

Christine Caples University of Iowa

Tangle Classification

A knot can be thought of as a knotted piece of string with the ends glued together. A tangle is formed by intersecting a knot with a 3-dimensional ball. The portion of the knot in the interior of the ball along with the fixed intersection points on the surface of the ball form the tangle. Tangles can be used to model protein-DNA binding, so another way to think of a tangle is in terms of segments of DNA (the strings) bounded by the protein complex (the 3-dimensional ball). Like knots, the same tangle can be represented by multiple diagrams which are equivalent under deformations (no cutting or gluing allowed). A tangle invariant is a value that is the same for equivalent tangles. This talk will look into how tangle invariants can be used to classify tangles into families which allows one to study properties of tangles that may be useful for solving tangle equations.

Richard G. Ligo University of Iowa

The Energy of a Curve

Objects such as cables or DNA can be represented mathematically by space curves. In order to better study such curves, mathematicians have defined a variety of curve-specific statistics, called energies. Among closed curves, considerable effort has been devoted to describing the configurations that minimize said energies. In this talk, we will define the elastic and Möbius energies of a curve, explain their key properties, and present examples of their minimizers.

Katelyn Leisman Rensselaer Polytechnic Institute

Modeling how Light Travels through Rubies and Other Media

The Maxwell-Bloch Equations model how light travels through some media. As is, they have solutions which look like a single traveling pulse of light (called a soliton). When we add two terms to the equations to make them more relevant to physical systems, the solutions change. We will look at what happens to the light pulse as we change the size of these terms. When the terms are small, the light pulse from before seems to slow down and get smaller. When the terms are quite large, the original pulse stops and dies out. However, energy from that pulse forms what looks like a new pulse which actually accelerates!

Daniel Eckhardt Rensselaer Polytechnic Institute

Suppression of the Magnetorotational Instability

Magnetorotational Instability (MRI) is of great importance to astrophysics, as it is theorized to be the accretion driving phenomenon in accretion disks in astrophysical flows for example around black holes. Though MRI has long been known, it has yet to be observed at in laboratory experiments due to the difficulty in recreating the exact necessary conditions. MRI can be studied by considering magnetized Taylor-Couette flow in a hydrodynamically stable regime according to the Rayleigh criterion. However, it is shown here that MRI is in fact suppressed when the term representing the twisting of radial magnetic components into azimuthal ones is dropped, and that no other instabilities occur, even with Navier-slip and conducting boundary conditions, as opposed to no-slip and insulating boundaries.

Jordan Bounds Kent State University

On Commuting Maps Over the Ring of Strictly Upper Triangular Matrices

We say that a map $f : A \to A$ where A is a ring is called commuting if $[f(x), x] = 0$ for all $x \in A$. Let $N_n(F)$, $n \geq 4$, be the ring of strictly upper triangular matrices over a field F. We describe all linear commuting maps over $N_n(F)$ given that char$F = 0$.

Maria I. SanchezMuniz City College of New York

On the product of all finite prime fields

We have been studying the structure of the ring that is the product of all finite prime fields F_π, where π is the ith prime, $p_1 = 2$; $p_2 = 3$; ..., and details a relationship of principal ideals within the ring with subsets of the natural numbers. This project's motivation is to understand the ring by determining if it is finitely generated, a Von Neumman regular ring, and the relationship with the weak direct product. We examine first order definable sets in this ring and attempt to topologyze it using dictionary order. Also we present the elements with torsion and cyclotomic polynomials.

PosterFest 2016

PosterFest 2016

Friday, August 5, 3:30–5:00 PM, Exhibit Hall

Adeyemi D. Joke University of South Africa

Constructivist learning, problem solving skills in mathematics education

Constructivism is a recent educational philosophical development. This study was designed to ascertain the level of constructivism implemented in the Industrial technology program as observed by students. The study also sought to determine the level of constructivism students' desire, and the relationship between what they observed and what they preferred. The faculty view of the implementation was also collected. A comparison was made between the faculty view of the level of constructivism and the student view of the amount of constructivism being used. skills than for their peers. Satisfactory indices of a good fit between a hypothesized model and the observed data led to the development of a structural equation model. This model suggested that student learning in an constructivist environment could improve their self-directed learning readiness, problem-solving skills and teamwork skills.

Jakob Kotas University of Portland

Optimal stopping for response-guided dosing

One important decision in response-guided dosing is when to stop treatment. In practice, stopping often occurs for patients in remission, or due to a finding of futility or a desire to switch to a different drug. We have previously developed a stochastic dynamic programming framework for response-guided dosing which tailors dose to a patient's stochastic evolution of disease state. In this talk we present an extension of that model that allows for stopping before the scheduled end time. Our numerical simulations show optimality of stopping below a threshold state. We also outline structural properties of the stopping formulation, including monotonicity of the threshold state with respect to time.

Andrew Sward Augustana College
Forrest Stonedahl Augustana College
Susa Stonedahl St. Ambrose University

Gotta catch 'em all: Pursuit curves for accelerating prey

Pursuit curves have gained popularity in recent years, with applications from missile defense and drone interceptions to surviving a zombie apocalypse. In our research we examine 3 models of pursuit of a target undergoing a constant acceleration. The first is the Bouguer interception course, where the pursuer always travels directly toward the target at a constant speed. In the second model, the pursuer always travels (at constant speed) directly toward the estimated future position of the target, based on the target's current instantaneous velocity. In the third model, the pursuer takes acceleration into account and travels directly toward where the target will actually be. We derive the non-linear differential equations that describe the path of the pursuer in the first two models, analytically solve the third model, and use numerical/simulation techniques to further investigate and compare all three models. For a given target acceleration and pursuit speed, we determine the relative initial positions of the target and pursuer for which interception is feasible. Within this feasible region, we also examine the amount of elapsed time prior to interception as a function of the actors' initial positions. Finally, we vary the pursuit speed relative to target acceleration, and investigate the effect on the interception feasibility curves and the interception times.

Linda Slowik University of Detroit Mercy
Xiaohui Zhong University of Detroit Mercy
Dawn Archey University of Detroit Mercy
Domonique Anderson University of Detroit Mercy

Faculty views of tenure policies: An empirical investigation

The goals of the ADVANCE ITC grant at the University of Detroit Mercy (UDM) was to conduct institutional self-assessment to identify issues impeding the recruitment, retention, and promotion of women faculty in the STEM disciplines and to create an action plan to transform the institutional climate. Part of this effort was to examine faculty perceptions toward promotion and tenure policies to provide a foundation for institutional transformation. To understand these perceptions, a climate survey was administrated to all full-time UDM faculty. Information on the fairness, clarity, and the need for modification of promotion and tenure policies were collected from faculty and analyzed. Results reveal that policy perceptions are structured parsimoniously into two main factors (fairness/need for modification and clarity). As predicted, faculty views varied significantly as a function of gender and as a function of tenure status. In addition, relationships between policy perceptions and organizational and individual outcomes are explored from a social science perspective. Recommendations are suggested for creating action plans at the institutional level to improve the fairness and clarity of policies for all faculty.

Yanping Ma Loyola Marymount University

A stochastic model for microbial fermentation process under Gaussian white noise environment

In this work, we proposed a stochastic model for the microbial fermentation process under the framework of white noise analysis, where Gaussian white noises are used to model the environmental noises, and the specific growth rate is driven by Gaussian white noises. To keep the regularity of the terminal time, the adjustment factors are added in the volatility coefficients of the stochastic model. Then we prove some fundamental properties of the stochastic model: the regularity of the terminal time, the existence and uniqueness of a solution and the continuous dependence of the solution on the initial values.

Justin Dunmyre Frostburg State University

Alternative grading for intro level courses

What does it mean if a student gets a C in your course? How about a B? Using traditional based grading, my best answer was "they did some homework, and got some partial credit on exams." Unhappily, I had no evidence that my students were leaving the class having really mastered anything - even the basic skills they may need in another course. Alternate grading schemes place emphasis on this point - it is more desirable for a student to earn a C by mastering some things, rather than demonstrating partial knowledge on many things. In this poster, I will share two implementations of the mastery based grading scheme I developed for an introductory statistics course, though it generalizes nicely to other low-level mathematics courses (e.g. calculus). One version of this course requires writeups of short reports on "miniprojects." I developed a grading rubric inspired by specifications based grading approaches, the goal of which was to aid students in writing clear reports while also speeding up the grading process. The poster will include a discussion of this and other rubrics.

Manjuladevi Gottapu Albany State University

Testing Security Measures for Computer Systems

Testing and Refining Dynamic Statistical Penetration Testing Security Measures for Computer Systems ABSTRACT: Dynamic and accurate measures for the security of computer systems is still an open question for which much research continues to be carried out. In previous research, Owor et.al [1] developed theoretical Penetration Testing Statistical Indices for determining the security of a computer system. While much work has been done on the theoretical framework, these indices are yet to be practically tested and refined. In this research, a set of information assurance statistical measures derived from Penetration Testing for Committee for National Security and Standards' Courses (CNSS4011, CNSS4012 and CNSS4016) at Albany State University will be tested for computability and practical reliability. Among the content areas for which statistical measures will be tested are reconnaissance, vulnerabilities, threats, attacks and defenses. The analysis of the statistical measures will be done from an attacker's point of view. Refinements and practical adaptations will be made on the statistical measures based on the practical results obtained. Finally a report of findings will be published. Keywords: Algorithm, Design, Measurement, Testing, Stochastic, Cyber security

Morufu A. Adejuwon University of Lagos

Stability of Mann Type Iteration Using Zamfirescu Operators in Banach Spaces

In this paper, we prove some stability results for modified Mann iterative procedure in a Banach space by employing a class of Zamfirescu contractive-like definition. As corollaries, some stability results of Jungck (pair of maps) and Picard (single map) iterative procedures are also estab- lished. Our stability results generalize and extend several related results involving pair and single maps in the literature. Keywords and Phrases: Mann type iterative procedure, Zamfirescu con- tractive mapping, stability result, Banach space. 2000 Mathematics Subject Classification: 47H09; 47H10.

Maria I. SanchezMuniz City College of New York

On the product of all finite prime fields

We have been studying the structure of the ring that is the product of all finite prime fields F_π, where π is the ith prime, $p_1 = 2$; $p_2 = 3$; ..., and details a relationship of principal ideals within the ring with subsets of the natural numbers. This project's motivation is to understand the ring by determining if it is finitely generated, a Von Neumman regular ring, and the relationship with the weak direct product. We examine first order definable sets in this ring and attempt to topologyze it using dictionary order. Also we present the elements with torsion and cyclotomic polynomials.

Youssef Qranfal Wentworth Institute of Technology

Data Assimilation Using Filtering Methods Based on Kullback-Leibler Distance

In this paper we will present two filtering algorithms that minimize a cost function of weighted Kullback-Leibler (cross entropy) distance rather than the standard Euclidean distance. Because Kullback-Leibler distance is non-symmetric two filtering methods emerge, the EM (expectation maximization) filter and the SMART filter (simultaneous multiplicative algebraic reconstruction technique). These filters were originally developed to solve an ill-posed inverse problem that arises in reconstructing a time-varying medical image. The algorithms hold potential for data assimilation applications in geophysical fluid problems where we are also interested in time-varying variables of large-scale systems. These new methods have advantages over traditional methods, such as the Kalman filter, in that they do not involve matrix-matrix multiplication or matrix inversion and thus are computationally more efficient. We introduce the EM and SMART filter as a solution to the data assimilation problem and implement these methods on a few simple data assimilation applications. Results are compared with those from more standard approaches. We will highlight the advantages and disadvantages of the EM and SMART filters and demonstrate the potential benefits of the algorithms for geophysical data assimilation applications.

Index of Speakers