Parallel Session: Developments in Operator Algebras

Friday 2:05 pm - 4:25 pm

UMC 247- 2:05 - 2:25: CP All the Way Up

John Quigg, Arizona State University
Valentin Deaconu, University of Nevada, Reno
Menevse Paulovicks, New Mexico State
Steven Kaliszewski, Arizona State University

We present a new method of showing that a k-graph C*-algebra is the Cuntz-Pimsner algebra of a correspondence over a (k-1)-graph algebra, using Menevse's functor from the correspondence category of correspondences, together with Valentin's iterative procedure for the Cuntz-Pimsner construction. One innovative aspect is that we go from the bottom up rather than from the top down. Work in progress. Joint work with Valentin Deaconu, Menevse Eryuzlu Paulovicks, and S. Kaliszewski.

UMC 247 - 2:35 - 2:55: The HK-Conjecture for Certain Groupoids Constructed by Putnam

Maggie Reardon, University of Colorado Boulder

Matui’s HK-conjecture proposes a relationship between the homology groups of a nice enough groupoid and the K-theory of the associated reduced C*-algebra. The conjecture is not true in general and there are a number of counterexamples. However, the conjecture holds for certain classes of groupoids including AF groupoids.

UMC 247 - 3:05 - 3:25: Commutation, Approximation, and Obstruction for Unitary Matrices

Lucas Hall, Michigan State University; University of Haifa
Adam Dor-On, University of Haifa
Ilya Kachkovskiy, Michigan State University

A question of Halmos asks whether a pair of approximately commuting operators is near to a pair of genuinely commuting ones. This question was famously solved for the self-adjoint matrices by Lin. Meanwhile, for unitary matrices a simple obstruction has been found which prevents resolution, and it is known that when the obstruction vanishes Halmos’s question has a positive resolution. In this talk we explore recent work concerning a quantitative refinement of the unitary approximate commutation problem, producing a function parametrized by the norm of the commutator which controls the distance between approximately commuting unitaries and their commuting counterparts.

UMC 247 - 3:35 - 3:55: C*-like Modules and Matrix p-Operator Norms

Anoushka Nerella, University of Colorado Boulder
Alonso Delfin, University of Colorado Boulder
Alessandra Calin, University of Colorado Boulder
Ian Cartwright, University of Colorado Boulder
Luke Coffman, University of Colorado Boulder
Charles Girard, University of Colorado Boulder
Jack Goldrick, University of Colorado Boulder
Wilson Wu, University of Colorado Boulder

The talk will be about a generalization of Hölder duality to algebra-valued pairings.

Roughly, Hölder duality states that if p and p' satisfy $(1/p)+(1/p')=1$ then the dual space of $X=L^p$ is isometrically isomorphic to $Y=L^(p')$. In finite dimension, this is easy to see as both $X=\ell_n^p$ and $Y=\ell_n^{p'}$ are algebraically isomorphic to $\Bbb{C}^n$ and it's just a matter of checking that the pairing $(x | y) = \sum_j x_jy_j$ does indeed define a linear functional that recovers the p'-norm of y.

In this talk we now take X to be the L^p-column direct sum of a fixed algebra A and Y to be the L^{p}-row direct sum of A. We now naturally get an A-valued dual pairing, so it makes sense to ask whether a version of Hölder duality still holds. I will present several examples of A for which a Hölder-like duality still holds, but also discuss other examples for which it doesn't.

The talk is based on an REU project that ran in CU-Boulder during Summer 2024.

UMC 247 - 4:05 - 4:25: The Generator Problem for C*-Algebras with Cartan Subalgebras

Vincent Ruzicka, University of Wyoming

It was shown by Popa that any II_1 factor with a Cartan subalgebra is singly generated. In this talk, we discuss the possibility of extending Popa's result to general C*-algebras with Cartan subalgebras.

Parallel Session: Developments in Operator Algebras

Saturday 10:40 am - 12:15 pm

UMC 247 - 10:40 - 11:00: Anti-C*-Algebras

Robert Pluta, Northeastern University Oakland

We introduce a class of Banach algebras that we call anti-C*-algebras. We show that the normed standard embedding of a C*-ternary ring is the direct sum of a C*-algebra and an anti-C*-algebra. We prove that C*-ternary rings and anti-C*-algebras are semisimple. We give two new characterizations of C*-ternary rings which are isomorphic to a TRO (ternary ring of operators), providing answers to a query raised by Zettl (Adv Math 48(2): 117–143, 1983), and we propose some problems for further study. (Joint work with Bernard Russo)

UMC 247 - 11:05 - 11:25: Ordinal Graphs and Their C*-Algebras

Benjamin Jones, Arizona State University

We introduce a class of left cancellative categories which generalizes the category of paths of a directed graph by allowing paths to have ordinal length. We use generators and relations to study the Cuntz-Krieger algebra defined by Spielberg. For each ordinal we find an associated C*-correspondence. These allow us to apply Eryüzlü and Tomforde's condition (S) and obtain a Cuntz-Krieger uniqueness theorem for ordinal graphs.

UMC 247 - 11:30 - 11:50: Rapid Decay and Fourier Coefficients in Reduced Groupoid C*-Algebras

Pradyut Karmakar, Miami University

Adam Fuller, Ohio University

Let $\Sigma \to G$ be a twist over a locally compact Hausdorff étale groupoid G. Given f in the reduced C⁎-algebra with open support $U \subset G$ we ask when f lies in the closure of the compactly supported sections on U. If G satisfies the rapid decay property with respect to a length function L, then we give a positive answer to our question in two instances: when L is conditionally negative-definite, and when L is the square-root of a locally negative type function on G.

UMC 247 - 11:55 - 12:15: Mackey Embedding for Reduced Group C*-Algebras

Angel Roman, Washington University in St Louis

Nigel Higson, Penn State University

Pierre Clare, College of William & Mary

Recently, Nigel Higson and Alexandre Afgoustidis made precise an analogy proposed by George Mackey between some unitary representations of a semisimple Lie group and unitary representations of its associated semidirect product group. In this talk, I will show a construction of an embedding of the reduced group C-algebra of the Cartan motion group into the reduced group C-algebra of the

reductive group. This can then be used to characterize the Mackey bijection. We shall discuss the case of the complex reductive group before proceeding to discuss the difficulty behind the construction for a real reductive group.

Parallel Session: Meet a Mathematician

Friday 2:05 pm - 4:25 pm

UMC 382 - 2:05 - 2:25: Exploring Multilingual Students' Identities in Collaborative Precalculus and Calculus Courses

Jocelyn Rios, University of Northern Colorado

To foster equitable learning experiences for all students, it is essential to examine how identities intersect with the mathematics classroom and are negotiated during classroom interactions. This requires understanding identity across multiple scales. For example, positional identities, co-constructed in moment-to-moment classroom interactions, can accumulate over time to shape students' broader identities towards mathematics. Additionally, social identities can influence this process. In this talk, I focus on describing the experiences of students with multilingual identities in precalculus and calculus courses. I explore different positional identities that emerged during group work and how general course experiences can change their relationship towards mathematics.

UMC 382 - 2:35 - 2:55: Cleats, Calculus, and Confidence: Reclaiming Math Through Biology, Football, and Teaching

Lien Amin, University of Colorado Boulder

As a kid, I never saw myself as a "math person." Math felt distant—something for geniuses scribbling equations on chalkboards in movies like Good Will Hunting and A Beautiful Mind. But years later, I found myself breaking down chemical kinetics, analyzing limits with derivatives, and motion-tracking the perfect end-zone catch from players like Travis Hunter. Still, it wasn't until I stood waist-deep in an estuary, collecting data, that it clicked—math wasn't just abstract symbols on a page. It was real, practical, and already part of my world.

This same realization is missing for college athletes, whose everyday training is rooted in physics, biology, and data analysis—yet their knowledge is rarely recognized as scientific expertise. Despite making up 60.8% of Division I football teams, Black students earn only 9% of STEM degrees. As a PhD student in STEM Education, I am committed to closing this gap. I will be presenting on a football-based science curriculum and NIL policy reform, exploring how these athletes' lived experiences can bridge STEM learning and long-term financial success. It's time to reimagine who we see as scientists—and who gets to shape the future of STEM.

UMC 382 - 3:05 - 3:25: Mas o Menos: Centering Students' Multilingual Identity in a Large College Algebra Class

Jess Ellis, Colorado State University

Jocelyn Rios, University of Northern Colorado

One way to attend to students' mathematical identities is to center other aspects of their identity to inform the structure of the mathematical space. In this talk, we first draw on Jocelyn Rios's (2024) dissertation work that identified a number of promising instructional practices based on her interviews/conversations with multilingual students (both domestic and international). We then share how we used these findings to inform the instructional practices Jess Hagman used to teach a large (n=80), College Algebra class with a subsection restricted for multilingual students (n=14). We end by drawing on surveys and interviews from a subset of students in this class to discuss what did and did not land for students in this class. We hope this presentation can serve to (1) share practices that can support multilingual students and also many other students, and (2) exemplify how centering students' social identities can be used to design mathematics spaces to support more students to develop positive math identities.

UMC 382 - 3:35 - 3:55: Mathematical Maturity and Mathematics Identity Development

Peter Karanevich, University of Colorado Boulder

Mathematical maturity has been used to define a variety of characteristics of a mathematician. Steen (1983) defines mathematical maturity as the “intellectual growth that marks the transition from routine, elementary modes of thought to subtle, complex patterns.” She also notes that this transition happens as students become able to abstract structure from complex scenarios and create new ideas from old ones. Learning has been argued to happen as identity is developed into a certain type of person in their community practice (Lave & Wenger, 1991). Not only does the community of practice dictate the idealized, ‘mature’ person, but it also drives the identity formation of novices who are working through becoming masters themselves. This talk will look at how graduate students and professors in a mathematics program discuss mathematical maturity and how their identities have developed through participating in the mathematics program, i.e. classes, office hours, peer interactions, etc.

UMC 382 - 4:05 - 4:25: Strengthening Relationships Between Postsecondary and Secondary Math Education with New Recommendations for Math Pathways

Rachel Sefton, Community College of Denver

Raymond Johnson, Colorado Department of Education

A decade ago, Colorado’s colleges and universities came together in a task force to improve access and opportunity for students in higher education math pathways. For the past two years, a new task force has worked to create recommendations for building math pathways in high schools that bridge the gap between high school and college. In this session, we’ll summarize the five recommendations and discuss ongoing efforts to strengthen the relationships between postsecondary and secondary math education in Colorado.

Parallel Session: Meet a Mathematician

Saturday 10:40 am - 12:15 pm

UMC 382 - 10:40-11:00: Meet a Mathematician

Selvi Kara, Bryn Mawr College

Padi Fuster, University of Colorado Boulder

In this talk, we will give a brief introduction to the Meet a Mathematician project and play one of our interviews.

UMC 382 - 11:05-11:25: Humanizing Math Activities

Selvi Kara, Bryn Mawr College

Padi Fuster, University of Colorado Boulder

In this session, we will introduce an in-class reflection activity related to a Meet a Mathematician video. The focus of these activities is for students to deeply engage with the videos and reflect on their math journey and math identity. Participants will be given an opportunity to complete one of the activities.

UMC 382 - 11:30-11:50: Reflection Activity Creation

Selvi Kara, Bryn Mawr College

Padi Fuster, University of Colorado Boulder

This session is a hands-on session where participants will be given prompts to create a reflection activity for a Meet a Mathematician video of their choice.

UMC 382 - 11:55 - 12:15: Math Activity Creation

Selvi Kara, Bryn Mawr College

Padi Fuster, University of Colorado Boulder

This session is a hands-on session where participants will be given prompts to create math activity for a Meet a Mathematician video of their choice.

Parallel Session: Teaching and Learning Mathematics

Friday 2:05 pm - 4:25 pm

UMC 386 - Friday 2:05 - 2:25: Second Chances: Core Mastery Testing for a Large Calculus Course

Silva Chang, University of Colorado Boulder
Robert Benim, University of Colorado Boulder

Since fall 2018, the Applied Math Department of the University of Colorado Boulder has given calculus students the opportunity to retest after each midterm in order to improve their scores. The retesting program, called Core Mastery Testing, gives low-scoring students extra opportunities to show that they have mastered the course content and are ready to progress to the next level. Testing large numbers of students involves logistical challenges. We will share results from this retesting program, focusing on APPM 1350 Calculus 1 for Engineers with fall enrollment of 700-900 students.

UMC 386 - Friday 2:35 - 2:55: Alternative Grading in Calculus I

Rebecca Swanson, Colorado School of Mines
Lucas Quintero, Colorado School of Mines

An increasing number of faculty have been exploring and implementing alternative grading in mathematics. After our own executions of standards-based testing in Linear Algebra and other upper-level classes, we were interested in how the system would be both received and experienced by first-year students in a highly coordinated course. Additionally, Calculus I is a much larger course, as we ran 16 sections consisting of about 550 students last fall, so we wanted to explore the extent to which alternative grading can be successfully scaled. In this talk, we will give preliminary results about both student experience and performance, as well as some data about the coordinated faculty experience from a faculty focus group.

UMC 386 - Friday 3:05 - 3:25: Mastery in Mathematics: Lessons from Calculus III and Linear Algebra

Karen Braman,South Dakota School of Mines

This talk explores the implementation of mastery-based assessment in Calculus III and Linear Algebra courses. Beginning with the rationale for choosing this method, we will detail the initial trials in Calculus III starting in Fall 2017 and continuing to the present semester, including the challenges faced and adjustments made. The presentation will highlight the observed differences in student performance and engagement, as well as the overall effectiveness of the approach.

The discussion will then cover the use of mastery-based assessment in a Linear Algebra course in Fall 2024, focusing on what worked, what didn't, and future plans. Attendees will gain valuable insights and practical takeaways for applying similar methods in their own courses.

UMC 386 - Friday 3:35 - 3:55: Building a Hut: A project for Multivariable Calculus

Keith Brandt, Rockhurst University

I will present a project that asks multivariable calculus students to design and build an odd-shaped hut. The project showcases many fundamental concepts studied in a typical course, including the distance formula, equations of lines and planes, intersection of planes, Lagrange multipliers, integrals in both Cartesian and polar coordinates, parametric equations, and arc length. I will discuss the development of the project, student response, and further questions that can be asked about the hut.

UMC 386 - Friday 4:05 - 4:25: 3D Models and Computer Visualization in Multivariable Calculus: A Geometric Derivation of the Lagrange Equations for Constrained Optimization

Shelby Stanhope, U.S. Air Force Academy

Paul Seeburger, Monroe Community College

In multivariable calculus, the method of Lagrange multipliers is often viewed by students as a black box algebra exercise. It is not usually clear to students where the Lagrange equations come from and why the list of points it produces contains the extreme values of the function subject to a constraint. To address this, we have created a hands-on activity using 3D models and visualization in CalcPlot3D. In this activity, students derive the Lagrange equations geometrically through a scaffolded discovery process. In this talk, I will show the details of the activity and also share how it has impacted our assessment of the topic in this course.

CASE W313 - Friday 2:05 - 2:25: Spicing Up Matrices with Some Graph Theory

Patricia McKenna, Metropolitan State University of Denver

At all levels, a quick bit of graph theory can make an introduction to matrices more interesting to students. In particular, graphs provide fertile ground for discussions about the usefulness of matrix multiplication. Both the adjacency matrix and the vertex-edge incidence matrix provide nice opportunities to see how matrix multiplication can yield useful results pertaining to a graph.

In proofs-based classes, the powers of the adjacency matrix of a graph provide a great opportunity to do a proof by induction that has a distinctly different flavor than all of the standard inductive proofs of sum formulas and divisibility results. The study of the eigenvalues and eigenvectors of the adjacency matrix of a graph also holds some interesting and accessible results.

In this digital age, students at all levels deserve a taste of graph theory as part of their mathematical education - let's spice things up!

CASE W313 - Friday 2:35 - 2:55: Computational Technology in Mathematics and Statistics: Tools, Challenges, and Evolving Assessment Practices

Brianna Hitt, United States Air Force Academy
Shelby Stanhope, United States Air Force Academy
Maila Hallare, United States Air Force Academy

The use of computational tools such as MATLAB, R, and CalcPlot3D is increasingly integrated into undergraduate mathematics and statistics courses, yet student engagement varies widely depending on the course and its learning goals. In this talk, we will discuss (1) how technology is used in differential equations, calculus, and statistics, (2) how students respond to these tools, and (3) how assessments align with technological integration. In Differential Equations, students embrace MATLAB for solving complex problems, sometimes preferring computation over by-hand methods that build understanding. In Calculus III, visualization tools like CalcPlot3D support conceptual learning, while by-hand computation is de-emphasized. In Calculus I-II, R is introduced for basic computation, though students struggle to see its relevance. In introductory statistics, R is essential for modern practice, but students often resist coding in a math course. To address these challenges, we have adapted our teaching and assessment strategies. We will highlight challenges and share strategies for effectively integrating computational tools in mathematics education.

CASE W313 - Friday 3:05 - 3:25: Transforming Math Teaching: Lessons Learned from a Year with AI

Brianna Hitt, United States Air Force Academy

Join us for an enlightening exploration into the integration of Large Language Models (LLMs) in statistics education, reflecting on experiences from a year of implementation in two distinct courses. This session will introduce the basic concepts and practical applications of AI tools in the classroom, emphasizing the transformative potential they hold for enhancing teaching and learning. We will share insights into the impacts of AI on student engagement and performance, informed by concrete examples and feedback from the classroom. Discover the effectiveness of AI-driven strategies such as personalized learning environments and automated assessment techniques, with a focus on their accessibility and ease of integration for students and educators new to technology. The presentation will also highlight best practices for educators interested in gradually incorporating AI to enrich their teaching practices and improve learning outcomes.

CASE W313 - Friday 3:35 - 3:55: Real Data Activities in Applied Calculus and Precalculus

Bruce Lundberg, Colorado State University-Pueblo

This talk will discuss the use of actual data, demos, measurement and modeling in two service courses I regularly teach: bacterial growth and algae-rotifer data, addressing engagement and relevance challenges in Applied Calculus for biology students; and, for Pre-Calculus for engineering, where boredom with unmastered topics from prior math courses is an issue, I use bicycle wheel and damped spring-mass demo's. For the latter course, I am making new triangle solving practice activities with real historical diagrams and measurements, along with site and instrument pictures, from some "big science “– “shape of the earth” geodesy sites of the 18th and 19th century. The latter uses results of my new history of numerical analysis scholarship, including my site visits in Swedish and Finnish Lapland.

CASE W313 - Friday 4:05 - 4:25: Unusual and Hopefully Intriguing Items for Lower Division Mathematics Courses

Shahar Boneh

We will present several unusual and hopefully intriguing items for lower division mathematics courses, such as College Algebra, Calculus I, and Logic.

Parallel Session: Teaching and Learning Mathematics

Saturday 10:40 am - 12:15 pm

UMC 386 - Saturday 10:40: The One-Handed Tribe Provides Insights into the Structure of a Number System, Place Value and Operations for Preservice Elementary

Mark Koester, Metropolitan State University of Denver
Lilly Kofoed, Padilla Elementary School
Hannah Gaspard, Metropolitan State University of Denver

The teaching and learning of the Base 10 number and operation system to young children is a complex process. For the presenters, teaching a math class for preservice elementary teachers, our pedagogical challenge was to problematize the powerful ideas of our Base 10 number system and bring them to the surface so our preservice teachers could identify and use them. For this to be effective, we needed to position our students as new learners. Therefore, we use a set of innovative lessons and standard progression (i.e., One-Handed Tribe) where they can productively struggle with the ideas of an unfamiliar number system (i.e., Base 5). This leads to the preservice teachers making connections from their own challenges learning to count and perform arithmetic operations in Base 5 to the ones their students will have in Base 10.

UMC 386 - Saturday 11:05 - 11:25: Teaching Complex Thinking through Modeling: What is fair? What is best? What might happen?

Elizabeth Burroughs, Montana State University

Mathematical modeling requires students to understand the ideas and perspectives of others. It is in seeking to understand others' points of view that human beings engage in empathy. One role of education is to teach students critical thinking skills, and teaching modeling provides the opportunity to teach empathetic critical thinking skills. Modeling provides a way for issues to be understood beyond right or wrong, and beyond even "agree to disagree." Modeling provides a way for students—human beings—to use their mathematical skills to examine different solutions to authentic problems based on different perspectives. The modeler emerges from the modeling process knowing that different perspectives of a problem highlight different points of view that different people hold. A complex problem doesn't have a right or wrong answer; instead it has a problem statement and a proposed solution that captures something important about what another human being values.

UMC 386 - Saturday 11:30 - 11:50: The Role of a Course Assistant: Enhancing Learning and Teaching in Coordinated Courses

Jennifer Gensler, University of Colorado Boulder
Emily Montelius, University of Colorado Boulder
Courtney Hauf, University of Colorado Boulder

Coordinated courses, often taught across multiple sections with many instructors, benefit greatly from structured support roles that bridge faculty, students, and instructional resources. This talk will introduce the role of the Course Assistant (CA), outlining its responsibilities and impact. Course Assistants serve as key facilitators in large or multi-section courses, aiding with course organization, content creation, student engagement, and instructional consistency.

Beyond supporting course logistics, the CA role provides significant professional development for graduate students. It enhances their teaching experience, communication skills, and pedagogical understanding, offering a valuable stepping stone for future academic and professional careers. Additionally, faculty and students in coordinated courses benefit from increased instructional cohesion, more responsive student support, and improved course outcomes.

This presentation will explore the multifaceted benefits of Course Assistants, share best practices for their integration, and discuss how institutions can leverage this role to enhance both graduate student development and course effectiveness.

UMC 386 - Saturday 11:55 - 12:15: Constructing Divided Spheres: A Collaborative Geometry Workshop

John Carter, Metropolitan State University of Denver
Henc Bouweester, Metropolitan State University of Denver
Don Gilmore, Metropolitan State University of Denver

In this hands-on workshop, we invite participants to explore the fascinating world of divided spheres. A dry run for the upcoming Bridges Conference at the Eindhoven University of Technology, this session will focus on the creative process of constructing large, impressive divided spheres using recycled materials. Working together as a group, attendees will craft a family of divided spheres out of coroplast—utilizing political signs and binder clips to form these intriguing geometric structures. With multiple facilitators guiding the process and offering diverse examples, you'll gain the skills to build these impressive models yourself. Expect to leave with more questions than answers, as we delve into the possibilities of geometry, material reuse, and creative collaboration. This workshop is an opportunity to learn by doing, and to share in the joy of creating something both beautiful and thought-provoking.

Parallel Session: Research in Undergraduate Mathematics Education

Saturday 10:40 am - 12:15 pm

UMC 425 - Saturday 10:40 - 11:00: Undergraduate Students' Metacognition During Proof Construction

Sarah Sparks, University of Northern Colorado

This phenomenological case study explores the metacognitive knowledge of undergraduate students that they accessed while constructing mathematical proofs, and the related actions they take in their proof process with that knowledge. Two pairs of undergraduate mathematics majors completed two proof-construction task-based video-recorded interviews and engaged in follow-up qualitative interviews asking them to watch clips of their work and reflect on their thinking. This preliminary report discusses the qualitative data analysis process that has explored the control actions taken related to metacognitive knowledge of one pair of students during the first proof task.

UMC 425 - Saturday 11:05 - 11:25: What Do Students See as 'Abstract' About Abstract Algebra?

Alice Mehalek, Colorado State University

Abstract Algebra is often cited as being a difficult course for undergraduate students because it is more abstract than computationally-based courses such as Calculus (e.g. Veith et al., 2022; Weber & Larsen, 2008). But what does it mean for something to be 'abstract'? Data from both a groups-first and a rings-first approach to Abstract Algebra at the same university show that students' personal definitions of abstract go beyond conceptions of abstraction discussed in the literature (Mehalek, 2025). In this study I conduct a grounded theory analysis of student survey data from two semesters of an Introduction to Abstract Algebra course to explore how students view what it means to be abstract and not abstract. Students' definitions of abstraction are influenced by their experiences in and outside of math, and their personal definitions impact the way they view abstract algebra concepts and the importance they ascribe to them.

UMC 425 - Saturday 11:30 - 11:50: Assessing Undergraduate Students' Statistical Literacy Using Media-Based Tasks

Samuel Waters, University of Northern Colorado

In today's digital world, it is important to prepare students to meaningfully engage with data and statistics they encounter in everyday life. This mixed-methods study used a course-wide assessment and individual task-based interviews to explore the statistical literacy of undergraduate students in an introductory statistics course. This talk will focus on the qualitative interviews where students responded to statistical information in media contexts. Themes include different approaches to navigating missing information, strong engagement with sampling, and challenges with formal comparison and study design. Findings suggest the need to incorporate discussions of media items in introductory statistics courses to develop students' propensity for applying statistical knowledge outside classroom settings.

UMC 425 - Saturday 11:55 - 12:15: Autoformalization with AI: Bridging Informal Math Statements and Formal Lean 4 Proofs

Mustafa Sameen, Colorado College

In this talk, I present a novel approach to translating natural language mathematics into rigorously verified Lean 4 code using artificial intelligence. By combining retrieval-augmented generation (RAG) and an iterative feedback loop that leverages Lean 4's error messages, this method refines its output until a valid formalization is achieved. The system demonstrates how low-resource language models can be effectively harnessed to automate formal proofs without relying on massive computational resources. Through examples and an interactive workflow, attendees will see how AI can streamline the formalization process and potentially broaden access to rigorous mathematical proofs, making advanced reasoning more approachable for students and researchers alike.

Parallel Session: General Math Session

Friday 2:05 pm - 4:25 pm

UMC 415/417 - Friday 2:05 - 2:25: The Missing Factor: Ethics as Part of a Mathematics Degree

Kyle Riley, South Dakota School of Mines

A careful review of the CUPM curriculum guidelines reveals an odd omission: there is no requirement for ethics in the mathematics major. Many other disciplines have clear ethical requirements for their majors, with some even offering entire courses devoted to the topic. Given the significant role mathematics plays in our society, we should not ignore the benefits and dangers it presents to our knowledge-driven economy. Our professional community should work to create more awareness regarding ethics, and we will discuss a few ways to incorporate this topic into the curriculum for mathematics majors.

UMC 415/417 - Friday 2:35 - 2:55: A Concrete(-ish) Application of Dirichlet's Theorem

Dan Swenson, Black Hills State University

Suppose we wish to randomly select one element from a k-element set, so that each element has probability 1/k of being selected. And, our method of selection will be: repeated flips of a single, possibly-biased coin. OK, no problem! Except, let's also say we want to guarantee that the process will be finished after a fixed finite number of flips, say N. So, none of this "if no one wins then re-flip" stuff! It is up to us to specify (in advance) both N and the bias of the coin. We'll see how we can choose these values and select our element--with the help of Dirichlet's Theorem, which says that every non-constant arithmetic sequence of positive integers contains a prime (provided that its first term and common difference are relatively prime). Note: At last year's Rocky Mountain Section Meeting, one of the speakers was heard to wonder aloud whether there exists a concrete application for Dirichlet's Theorem. We leave it to the audience to determine whether this scenario qualifies!

UMC 415/417 - Friday 3:05 - 3:25: Where Do Polynomials Turn the Sharpest?

Erik Packard, Colorado Mesa University

First an explanation of why the definition of curvature makes sense will be given only requiring Calculus I and II concepts. Then different classes of polynomials will be studied to investigate where their maximum curvature could occur.

UMC 415/417 - Friday 3:35 - 3:55: Blake Polynomials: an Exploration from Precalculus

Eric Miles, Colorado Mesa University

We will explore a class of polynomials that came up when a student named "Blake" asked a question in my precalculus class. This fun (and not very serious) research is accessible to any precalculus student (and also to mathematics majors and faculty).

UMC 415/417 - Friday 4:05 - 4:25: Cleaning up Hard to Reach Proofs with Soap, Water, and Vector Calculus

Neil Steinburg, South Dakota School of Mines

Of all surfaces enclosing a given volume, what has the least surface area? You might know the answer, but can you prove it? What if you need to connect the surface to a specific wire frame, but still enclose a volume? What then? Well, it turns out that bubbles are smarter than you and already know all the answers to this and more. But, with a little basic calculus, you might be able to get the answers, too. In this talk we'll play with some bubbles, play with some calculus, and hopefully solve some good problems along the way.

UMC 425 - Friday 2:05 - 2:25: NBA Betting Odds: Replicating Sportsbook Predictive Models

Cort Ballinger, United States Air Force Academy

Justin Graham, United States Air Force Academy

NBA Betting is a dynamic and often unpredictable landscape where fans and enthusiasts wager on various aspects of the game, from player performances to team outcomes. This project seeks to replicate the predictive methods that sports books employ by using data from the 2023-2025 seasons. Betting comes with inherent financial risks, as losing a bet means losing real money. National sports books set odds, which are used to determine potential payouts based on the amount wagered. To generate these odds, sports books use unknown complex statistical models designed to forecast game outcomes and player performances. This project aims to develop a model that mirrors the odds-making process, providing insights into expected outcomes and enabling more informed betting decisions. By leveraging data on individual player stats, team performance, and game conditions, this project will offer users a tool to evaluate potential bets and understand the statistical likelihood of different scenarios.

UMC 425 - Friday 2:35 - 2:55: Mathematical Exploration of Muscle Contraction

Isaac Heim, United States Air Force Academy

The Hill model describes the relationship between the tension a muscle is able to generate and the velocity at which it is able to contract. The Huxley model provides a basic explanation for the interactions of cross bridges within muscle sarcomeres. In this presentation, we will briefly overview muscle physiology, look at the impact of different crossbridge binding rate functions used in the Huxley model on the force-velocity relationship, and investigate the behavior of the Huxley model during negative contraction velocities and under the assumption that filament crossbridges act as linear springs.

UMC 425 - Friday 3:05 - 3:25: Tuberculosis Testing: A Comparative Analysis of Group Testing Strategies in Cameroon and Kansas

Ryan Tremain, United States Air Force Academy

Group testing for infectious diseases includes a variety of algorithms designed to efficiently identify positive specimens, making it particularly valuable in outbreaks or limited-resource settings. During the COVID-19 pandemic, group testing played a critical role in expanding testing capacity despite supply chain shortages. This research builds on those principles by examining the use of group testing for Tuberculosis (TB), drawing on insights from a report detailing its application in Cameroon during the COVID pandemic. Specifically, it compares individual testing with low-sensitivity assays to group testing with high-sensitivity assays. By analyzing cost-effectiveness and accuracy in both the Cameroon study and a theoretical application to the 2024 TB outbreak in Kansas, this research offers insights into optimizing testing strategies for future outbreaks.

UMC 425 - Friday 3:35 - 3:55: From Generators to Seven Patterns: An Algebraic Journey Through Frieze Group Symmetries

Napayshni Young, Fort Lewis College
Ren Martino, Fort Lewis College
Patricia Chavira, Fort Lewis College
Sam Chee, Fort Lewis College

We analyze the linear symmetries of frieze groups, which are two-dimensional patterns that repeat in one direction. Starting with generating sets of one element, we systematically build up to sets of five elements, identifying all possible symmetry combinations. By examining these combinations, we establish the existence of precisely seven observable patterns. We then classify these groups using traditional algebraic structures, such as direct and semi-direct products, and further explore their subgroup structures. This approach provides a deeper understanding of the underlying mathematical properties that govern frieze groups and their classification.

UMC 425 - Friday 4:05 - 4:25: Symmetry in Tradition: Identifying Frieze Patterns in Indigenous Art

Patricia Chavira, Fort Lewis College
Sam Chee, Fort Lewis College
Ren Martino, Fort Lewis College
Napayshni Young, Fort Lewis College

Frieze groups can provide a mathematical framework for analyzing indigenous artifacts, revealing the collections of symmetries embedded in artistic traditions. Our research examines artifacts housed at the Center of Southwest Studies, identifying and classifying frieze patterns in local artifacts, such as pottery and textiles. By determining which of the seven frieze groups appear, we explore the mathematical precision and cultural significance of these designs. Our presentation will feature artifact images, pattern classifications, and discussions on how mathematical structures naturally emerge in artistic expression. This interdisciplinary research aims to bridge abstract mathematics and cultural heritage, offering new insights into the universality of symmetry in art.

CASE E351 - Friday 2:05 - 2:25: Exploring the Spectrum of Hamming Graphs Under a Group Action

Alissa Romero, Colorado State University
Christopher Peterson, Colorado State University

Hamming graphs, H(n,p), are a type of graph in which the vertex set is made up of n-tuples where the entries come from a set with p elements. Two n-tuples (vertices) are connected by an edge whenever they are identical in all by one position. If a group acts on the vertex set of a Hamming graph, then it partitions the set of vertices into orbits. These orbits can then be used as the vertices of a new graph, which we call the 'Hamming graph under a group action'. Like Hamming graphs, the vertices of Hamming graphs under a group action are connected whenever there is an n-tuple in one orbit which is identical to an n-tuple in another orbit in all but one position. We consider the spectrum of the Laplacian matrix of both Hamming graphs and Hamming graphs under a group action, illustrating relationships between the spectra of the original Hamming graph and the Hamming graph under a group action for several specific examples. We end by highlighting future questions about acting by more complex group actions on Hamming graphs and studying the spectra of the resulting graphs in relation to the original Hamming graph.

CASE E351 - Friday 2:35 - 2:55: A Novel Optimization Framework to Estimate Parameters of a Sleep Neuronal Model Using Sleep Hypnograms

Shreshtha Chaturvedi, The University of Texas at Arlington
Souvik Roy, The University of Texas at Arlington
Pedro Maia, The University of Texas at Arlington

Understanding the emergence of cyclical patterns in biological neuronal networks is crucial for gaining insights into sleep mechanisms and sleep-related disorders. This work explores a dynamical system of coupled nonlinear ordinary differential equations (ODE) that models the interactions among three distinct neuronal populations. Although direct measurements of their firing rates are typically unavailable, tracking the dominant population over time produces stage transition patterns resembling those observed in sleep hypnograms. We develop an automated parameter estimation method for this model using a smoothed winner-takes-all strategy based on neuronal firing rates. The approach formulates a constrained minimization problem, which is converted into an unconstrained one via the Lagrangian. The optimality system is derived from state equations, adjoint equations, and optimality conditions. To infer the unknown ODE parameters numerically, we implemented a projected nonlinear conjugate gradient scheme. We validated our framework by achieving successful reconstructions for 111 out of 139 hypnograms curated from the Sleep-EDF database at PhysioNet. Ultimately, the inferred parameters capture key characteristics of the neuronal populations governing sleep dynamics, including interaction strengths, timescale constants, and the variability in NREM-promoting neurons. These parameters, which cannot be directly obtained from hypnograms, may offer significant insights into the mechanisms of sleep generation, the nature of sleep disorders, and the effects of pharmacological agents on sleep dynamics.

CASE E351 - Friday 3:05 - 3:25: Conjunctive Decompositions and Gluing Bundles

Howy Jordan, University of Colorado Boulder

It is well-known that the topology of a space can be recovered from an open cover. When the space is decomposed into disjoint subsets, more data is needed to recover the topology. The theory of Artin gluing describes sufficient conditions that allow one to recover the topology from finite decompositions. In this talk we describe conditions for infinite decompositions, which we call conjunctive decompositions.

The theory of Artin gluing also allows for gluing together sheaves on spaces, hence etale bundles. We demonstrate how to extend this to gluing arbitrary bundles, in particular fiber bundles, whenever the decomposition is conjunctive.

CASE E351 - Friday 3:35 - 3:55: A Pedagogical Approach in Understanding Witten's Computation of Some Topological Invariants Using Supersymmetry

Parthasarathi Nag, Black Hills State University

During the 1980's, the concept of a grand symmetry between bosons [force carrying particles example: photons] and fermions [mass particles example: electrons] was hypothesized to accomplish amongst many things a unification between two major theories of the 20th century Physics: General Theory of Relativity [GTR] and Quantum Mechanics [QM]. This grand symmetry between bosons and fermions is called SuperSymmetry [SUSY].

Edward Witten published a series of articles discussing various mathematical aspects of SUSY breaking and relating it to several topological invariants of the manifold M on which the $\sigma-{\rm model}$ is defined. In this presentation we will attempt to discuss pedagogically two well-known topological invariants, the Euler Characteristic $\chi(M)$ and Hirzbruch's Signature Characteristic $Sign(M)$ by using well-known properties of SUSY quantum mechanics as formulated by Witten.

CASE E351 - Friday 4:05 - 4:25: Triangle Measurement Reconciliation

John Albers

Three laws that apply to every triangle are the law of sines, the law of cosines, and the sum of the angles. There are six measurements of a triangle, three sides and three angles. There are nineteen ways of calculating the remaining three parts of a triangle using three measurements, all of which require some adjustments to meet the laws. A triangle measurement reconciliation algorithm has been developed which simultaneously adjusts all six measurements to meet the laws. It is similar to linear regression in that it is a constrained optimization problem. In simple linear regression the objective is to minimize the sum of the squared errors subject to the constraint of a linear model. In triangle measurement reconciliation the objective is to minimize the weighted sum of the squared adjustments subject to the constraints of the law of sines and the sum of the angles.

CASE W311 - Friday 2:35 - 2:55: An Analysis of Variants of BINGO!

Bennet Eld, South Dakota School of Mines

BINGO! is a popular game of chance in which players match labels on randomly drawn balls to those printed in different arrangements on cards, with the winner being the first to match five in a straight line (called a “bingo”). Alternate methods of play include changing the arrangements of the cards (such as the exclusion of a free space), the geometric structure of the bingo (such as “postage stamps” or “blackout”), or replacing the calling of numbers with the playing of snippets of songs (the more challenging “music bingo”). In this talk, we describe a mathematical model of bingo that allows us to describe these different scenarios, and use it to determine the likelihood of winning under various scenarios, such as single and multiplayer play under perfect and “noisy” conditions.

CASE W311 - Friday 3:05 - 3:25: Generalized Rosette Harmonic Mappings and Minimal Surfaces

Colin Garnett, Black Hills State University

In this talk I will discuss several variants of the game of cops and robbers played on discrete graphs. This is a wonderful topic to use in a classroom, as it requires very little set up, and even high performing high school students will start to ask the right questions within very little time. It is also a great way to get students to start thinking of their own variations on the game and how to approach the problems that arise in each variation.

CASE W311 - Friday 3:35 - 3:55: Modeling Transmission Lines: Numerical Solutions to the Telegrapher’s Equations

Keeler Spear, Colorado Early Colleges Douglas County North, Metropolitan State University of Denver

This session will explore the numerical solutions for voltage and current in a transmission line. These properties at all spatial points at all times within the specified domains are modeled by the telegrapher’s equations: a set of coupled first-order partial differential equations relating voltage, current, inductance, capacitance, resistance, and conductance. Using numerical methods for partial differential equations, approximate solutions to a specific case of the telegrapher’s equations will be developed. This session will investigate a numerical solution of the telegrapher's equations along with accuracy, efficiency, and stability analysis.

CASE W311 - Friday 4:05 - 4:25: The Walk Sequence of Polytrees

Cormac Moss, Regis University

A walk sequence for a connected graph is a sequence where the n-th term is the number of paths of length n in the graph for $n \geq 0$. We hoped to understand the graph isomorphism problem better by looking at walk sequences. We decided to study polytrees because any polytree with n vertices has n-1 edges, which allows us to recognize a graph as a polytree just by looking at its walk sequence. We looked at all the polytrees up to 7 nodes and classified them based on their walk sequences. We found that although it is hard to identify a polytree just by its walk sequence, certain graphs and structures can be identified using only the walk sequence.

Parallel Session: General Math Session

Saturday 10:40 am - 12:15 pm

UMC 415/417 - Saturday 10:40 - 11:00: Variants of Cops and Robbers

Conor Wellman, Colorado College

Jane McDougall, Colorado College

A harmonic mapping f is a complex valued univalent harmonic function defined on a region in the complex plane. Rosette harmonic mappings are generalizations of the polynomial harmonic mappings through modifying the canonical decomposition with hypergeometric 2F1 factors. We expand upon the Rosette Harmonic Mappings, which have analytic and coanalytic parts with exterior angles of $\pi/2$ at the nodes. By introducing a parameter q, we define Generalized Rosettes, which have analytic and coanalytic parts with exterior angles of $q\pi$. For appropriate parameters, these Generalized Rosettes 'lift' through Weierstrauss Enneper equations to the Generalized Rosette Minimal Surfaces. At small values of q, these surfaces approximate the classical minimal surface known as Enneper's Surface, creating a link between this classical surface and the triply periodic Rosette Minimal Surface. As q increases, the angles at the nodes of the surfaces become increasingly sharp, and the surfaces eventually become unbounded. Moreover, their projections are no longer univalent harmonic functions. By introducing a rotation angle β, with $0 \leq \beta \leq 2\pi$, we find that seemingly unrelated Generalized Rosette Surfaces are in fact part of an associated family, suggesting they are conjugate surfaces.

UMC 415/417 - Saturday 11:05 - 11:25: Series Expansions for Particular Solutions

Travis Kowalski, South Dakota School of Mines

The usual process for solving a nonhomogeneous system of linear differential equations is to find the general complementary homogeneous solution first and then construct a particular solution from it. When can we flip the script on this process and compute a particular solution first? In this talk, we look at two cases when this is frequently possible: when the nonhomogeneous forcing function is expressible as a power series, and when it is expressible as a Fourier series. We present series expansions for these peculiar particular solutions and describe their connection to more familiar techniques like variation of parameters and undetermined coefficients.

UMC 415/417 - Saturday 11:30 - 11:50: Colorado Math Circle: The First 20 Years

Silva Chang, University of Colorado Boulder

For the past 20 years, the Colorado Math Circle has hosted math talks and problem-solving sessions for middle and high school students from across the state. The math circle encourages students to work collaboratively to tackle challenging math problems. The primary goal is to create a community where students can connect with peers who share their love for mathematics. In this presentation, we will describe current and past activities of the math circle, as well as share feedback from alumni.

UMC 415/417 - Saturday 11:55 - 12:15: The Discovery of Neptune--by Mathematicians!

Donald Teets, South Dakota School of Mines

The discovery of Neptune in 1846 is a frequently told tale in the history of astronomy. But the mathematics that made the discovery possible is rarely described, probably because…well, it's hard! This talk will shed a bit of light on the subject, showing once again the incredible connection between the history of mathematics and the history of astronomy.