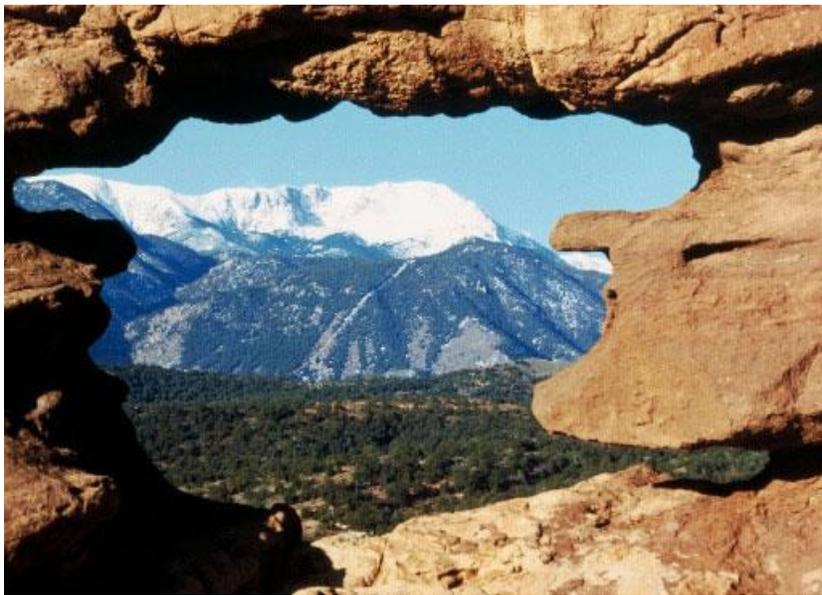


# ABSTRACTS BOOKLET

Twentieth Annual  
Pikes Peak Regional  
Undergraduate Mathematics Conference



University of Colorado Colorado Springs  
Saturday, March 18, 2023

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# **Keynote Address**

**Dr. Hortensia Soto**  
**Colorado State University**

## *The E in REU*

Research experiences for undergraduate mathematics majors takes shape in various ways. In this presentation, I will paint a picture of the different landscapes for REUs and the affordances that they each provide. While we can all agree on the importance of the research, I will stress the value of the varied experiences

## **Speaker Biography**

Hortensia Soto is a Professor at Colorado State University. She has published in various areas of mathematics education including assessment, mathematical preparation of elementary teachers, outreach efforts for high school girls, and especially in the area of teaching and learning of undergraduate mathematics. Her current research efforts are dedicated to investigating the teaching and learning complex analysis, where she adopts an embodied cognition perspective and is part of the Embodied Mathematics Imagination and Cognition community. Since her days as an undergraduate student, Hortensia has mentored young women and promoted mathematics via summer outreach programs. She has also been involved with facilitating professional development for K-16 teachers in Nebraska, Colorado, and California. As a result of this work she received the MAA Deborah and Franklin Tepper Haimo Award for Distinguished College or University Teaching of Mathematics.

Hortensia is a working member of the Mathematical Association of America. She has served as the Associate Treasurer, the Associate Secretary, and an editor of the *MAA Instructional Practices Guide*, and currently serves as MAA President.

In her spare time, she enjoys hiking, practicing yoga, meditating, reading, and most of all spending time with her son Miguel.

# Student Presentations

*Except where otherwise noted, the affiliations of the faculty sponsors are the same as those of the speakers.*

## **Bjorn Cattell-Ravdal**

Metropolitan State University of Denver

Faculty Sponsor: Dr. Daniel Visscher

### *Playing Billiards on the Sphere and other Surfaces of Revolution*

Have you ever wondered what it would be like to play pool on a table that isn't flat? The game of mathematical billiards is a type of dynamical system in which we determine the long-term behavior of "billiard balls" bouncing around a table. The mathematical billiard game is classically played on a flat surface, however the billiard game can also be played on non-flat surfaces. Billiard behavior on flat surfaces is well understood while non-flat billiards have been much less studied. During this presentation I will introduce the concept of mathematical billiards as well as present results from research completed over the summer of 2022 into billiard dynamics on non-flat surfaces. I will discuss the dynamical properties which can be exhibited by a flat billiard table and will then extend the discussion to include dynamics on non-flat surfaces, primarily surfaces of revolution. I will conclude by presenting the results of original research into the dynamic properties of multiple types of billiard tables on surfaces of revolution.

## **Orin Crouse**

University of Colorado at Denver

Faculty Sponsors:

Drs. Erin Austin and Adam Spiegler

### *Survey Economic Impacts of Political Risk Insurance*

This talk explores the concept of Political Risk Insurance (PRI) for Canadian oil and gas companies. The goal is to determine whether these companies should seek out PRI by obtaining results that hope to show the benefits or consequences. The conditions considered are the country's influence on the business cycle, rare world changing events, and federal elections. Simulations that have included changes in probabilities and random distributions to cover possible outcomes were repeated a thousand times. The results show that the rare usage of PRI is simply a lack of knowledge. Another finding is that from a policy point of view, companies see an ebb and flow with revenue. So, why spend money in attempt to sway the outcome of elections if it is shown to futile.

**Dans Uriel Ferrer & Muhammad Maulana**

United States Air Force Academy

Faculty Sponsor: Dr. Maila Hallare

*Plotting Airfoils Using the Joukowski and Karman-Trefftz Maps*

An airfoil is a cross-section of an aircraft wing, a turbine, a wing of a bird, or a fin of a fish. As a two-dimensional figure, an airfoil is tear-shaped with a smooth leading edge on one side and a cusp on the trailing edge and in general, there is no closed-form expression to describe its shape. We provide a method of producing an airfoil as an image of a conformal mapping using the Joukowski Map and Karman-Trefftz Map. We demonstrate how to generate the points of the airfoil using a spreadsheet. The mathematical computations use pre-calculus skills only. This is a preliminary research report of first-year cadets of the US Air Force Academy, and the results from this research can be used to analyze the fluid dynamics around airfoils.

**Chase Giglio**

Western Colorado University

Faculty Sponsor: Dr. Forest Mannan

*Modeling the Coordinated Beating of Chlamydomonas*

Chlamydomonas, a single-celled algae, swims in a breaststroke motion with its two hair-like appendages called flagella. Yet, how does this organism maintain this coordinated swimming? Using rotors to simulate its movement through liquid, this talk will investigate how the flagellum interact from hydrodynamical and mechanical forces to better explain this in phase pattern. Topics include numerical methods, linear algebra, and physics. Come explore how math can explain our observable world!

**Kenneth Huynh**

University of Colorado at Denver

Faculty Sponsor: Dr. Adam Spiegler

*Measuring and handling the impact of missing data on a longitudinal cohort study using the Pulmonary Hypertension Association Registry*

Missing data is inevitable in large datasets. To address the missing data in The Pulmonary Hypertension Association Registry (PHAR) from the year 2015 to 2022 we performed data exploratory techniques to evaluate missingness by using various packages and tools in the statistical program, R. In addition, we have also attempted to predict missing values by building linear regression models to perform imputations. By using the available information and observation from other variables, missing values can be predicted to a limited extent. Of the 122740 observations, there were a total of 30205 observations missing (NA, no data collected). We were able to generate several plots which can all be visualized in the project report and the RShiny application and the imputation efforts were successful to some extent by predicting values for the variable death (predicted 77.58%) and six-minute walking distance (predicted 44.08%).

**Brennan Romanoff**

United States Air Force Academy

Faculty Sponsor: Dr. Ian Pierce

*Mathematical Analysis of Quantum Mechanics and General Relativity*

Mathematical discussion of General Relativity and Quantum Mechanics to assess compatibility of the postulates. I will introduce General Relativity and Quantum Mechanics as pillars of modern physics, and briefly and qualitatively address conflicts between the two. We will analyze some of the "weirdness" of quantum mechanics and relate how General Relativity is fundamentally different.

**Joseph Skene**

Metropolitan State University of Denver

Faculty Sponsor: Dr. John Ethier

*Consecutive Integer Partitions and Their Identities*

An Integer Partition is a way to express a positive integer as a sum of positive integers. As is often the case with topics in Number Theory, something easy to say becomes deceptively complicated. But Integer Partitions often provide insight into many well known sequences of numbers, from Fibonacci numbers to Catalan Numbers. The purpose of this research was to investigate the Integer Partitions with consecutive numbers, and identify a constructive identity from these Partitions to another Integer Partition.

**Nicole Venner**

Metropolitan State University of Denver

Faculty Sponsor: Dr. John Carter

*Geometry of Transcendental Curves*

While geometry with transcendental curves, like the quadratrix of Hippias and the spiral of Archimedes, played a significant role in our modern developments of geometry and algebra. Investigation has fallen off in the modern era despite advancements with algebraic tooling. This talk gives a description of the fields using modern techniques such as Galois theory while solving an open conjecture in a 1988 paper to provide an answer to if these curves can solve the problem of doubling the cube.

**Emerson Worrell**

Colorado College

Faculty Sponsor: Dr. Molly Moran

*On Characterizing Cuboctahedral Fully Augmented Links*

We give a combinatorial description for all cuboctahedral Fully Augmented Links (FALs) that respect the preferred horoball packing, analogous to Purcell's description of octahedral FALs. Additionally, we show how this family of FALs can be belt-sum decomposed (using Colin Adams belt-sum operation), and also find common geodesics in a subset of this family.

**NOTES:**

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