The Mathematical Association of America
Rocky Mountain Section Meeting

April 16 and 17, 2010

Colorado State University

Fort Collins, CO

Rocky Mountain Section Meeting
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April 16 & 17, 2010

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MATHEMATICAL ASSOCIATION OF AMERICA

Schedule

Friday, April 16

8:00-12:00 **Section NExT workshop** (Virginia Dale)

9:30-11:30 **Workshop: *Proposal writing for the NSF DUE*** (Lory 217)
Stephanie Fitchett, NSF and University of Northern Colorado

11:45-12:45 **Luncheon for Dept. Chairs and MAA Liaisons** (Lory 230)

11:00-4:30 **Registration** (Lory 227)

1:00-1:10 **Opening Remarks and Welcome** (North Ballroom)

1:10-1:55 **Burton W. Jones Teaching Award Lecture** (North Ballroom)
Richard Grassl, University of Northern Colorado

1:00-5:30 **Publisher Exhibits, and MAA Book Sales** (Cherokee Park)

2:10-4:35 **Parallel Sessions-Contributed Papers & Special Sessions**

3:50-4:35 ***Effective Learning with Software Tools*** (N.Ballroom)
Wade Ellis, West Valley Community College

4:35-5:00 **Coffee Break** (University Club)

5:00-6:00 **Education Address** (North Ballroom)
Calculus as a High School Course
David Bressoud, Macalaster College

6:30-7:00 **Cash Bar** (Fort Collins Hilton, Prospect Road)

7:00-10:00 **Banquet and Awards Ceremony** (Fort Collins Hilton)
Banquet Address: 2010 Pólya Lecture (Fort Collins Hilton)
Codes on graphs: Shannon's challenge and beyond
Judy Walker, University of Nebraska, Lincoln
2009/10 MAA Pólya Lecturer

Saturday, April 17

8:00-11:30 **Registration** (Lory 227)

8:00-8:50 **Rocky Mountain Section Business Meeting** (N.Ballroom)

9:00-9:50 **Saturday Keynote Address** (North Ballroom)
Proofs and Confirmations: The Story of the Alternating Sign Matrix Conjecture
David Bressoud, Macalaster College

9:30-1:00 **Publisher exhibits and MAA Book Sales** (Cherokee Park)

9:50-10:10 **Coffee Break** (University Club)

10:10-1:00 **Parallel Sessions - Contributed Papers & Special Sessions**

9:00-4:00 **Workshop: Inspiring Your PreCalculus and Calculus Classroom: A TI Nspire Workshop** (NESB B322, Registration required)

12:00-4:00 **Section NExT workshop** (Virginia Dale)

Fri. Time	Combinatorics Lory 228	Contributed Papers Lory 224/6	Education Research Lory 230
2:10 -2:30	*__Colin Garnett__ (UWyoming) *Spectrally Arbitrary Companion-like Matrices* p.26	**Darel Hardy** (CSU) *Some Average Calculus Problems* p.28	*__Kristin King__ (UNC) *Learning in Introductory Statistics* p.39
2:35 -2:55	*__Reshmi Nair__ (UWyoming) *Acyclic matrices with few distinct eigenvalues* p.46	**Julie Barnes** (USAFA) *Hosting Math Treasure Hunts* p.15	**Alexandre Probst** (CCU/CSM) *Assessing student improvement in statistics* p.51
3:00 -3:20	*__Rodney James__ (CSU) *Sandpiles on edge-weighted graphs* p.37	**Michelle Ghrist** (USAFA) *Experiences with High School Mathematics Competitions* p.26	*__David Glassmeyer__ (UNC) *Assessment within Online Graduate Courses* p.26
3:25 -3:45	*__Yang Zhang__ (CSU) *Continuum Limits of Markov Chains and Network Modeling* p.58	**Louis Talman** (Metro State) *Mathematics on the Web* p.55	**Curtis Card** (Black Hills State) *Pass Rates in Developmental Math Classes* p.18
3:50 -4:10	*__Mary Allison__ (UWyoming) *Markov Chain Problem for the Union of Two Cliques* p.14	**Erich McAlister** (Fort Lewis) *Further Geometry of Derivatives of Complex Functions* p.44	**Gary Olson** (UC Denver) *College Mentoring for Pre-Service Teachers* p.47
4:15 -4:35	*__Cara Wiblemo__ (UWyoming) *Automorphism Decompositions of Graphs* p.57	**Jonathan Poritz** (CSU - Pueblo) *On entropy-preserving stochastic averages* p.51	**Zim Olson** (Zim Mathematics) *Systems and/or Sub Systems* p.48

* indicates a graduate student, ♣ an undergraduate student. Please provide support for our next generation of mathematicians.

Fri. Time	History of Mathematics N. Ballroom	Undergraduate Research Lory 210	Pure and Applied Lory 211E
2:10 -2:30	**Ginger Anderson** (Pikes Peak CC) *Alice in Matrixland* p.14	♣**Eric Kuss** (Fort Lewis) *Fibona00i (mod c)* p.41	**Travis Kowalski** (SDSMT) *Taylor series solutions to ODEs* p.40
2:35 -2:55	**Bill Briggs** (UC Denver) *Evolution of Calculus Art* p.17	♣**Adam Ruff** (UC Denver) *Analyzing Advice Networks of Math and Science Teachers* p.53	**Benjamin Dyhr** (Metro State) *Self-Avoiding Random Walk on the Strip* p.21
3:00 -3:20	♣**Melody Dodd** (SDSMT) *Methods for Orbit Determination* p.21	♣**Sara Linville** (Fort Lewis) *Möbius Transformations of Geometric Constructions* p.43	**Ivan Raykov** (CSU - Pueblo) *Approximation of Effective Diagonalization Strategies* p.53
3:25 -3:45	**Invited Presentation** 3.50-4.35 N. Ballroom	*__Dan Jones__ (CSU – Atmos.Sci.) *Controlling the Chaotic Lorenz System* p.38	**Daniel Swenson** (Black Hills State) *The Steinberg Complex of an Arbitrary Finite Group* p.55
3:50 -4:10	**Wade Ellis** (West Valley CC) *Effective Learning with Software Tools* p.23	♣**Mark Pengitore** (SDSMT) *Automorphisms of real submanifolds in* $\mathbb{C}^2$ p.49	*__Kristin King__ (UNC) *Mathematical Modeling in an Ecology Laboratory* p.38
4:15 -4:35	(talk continues until 4.35)	♣**Millie Mays** (USAFA) *Game Show Statistics* p.44	**Tianyu Zhang** (Montana State) *Phase model of biofilm* p.58

Sat. Time	Combinatorics Geometry Lory 228	Combinatorics Graph Theory Lory 226	Contributed Papers Lory 224
10:10 -10:30	**Stanley Payne** (UC Denver) *Finite Self-Dual Generalized Quadrangles* p.49	**Michael Ferrara** (UC Denver) *Saturation Numbers for Families of Ramsey-minimal Graphs* p.25	
10:35 -10:55	*__Cayla McBee__ (CSU) *Nucleotide Substitution Models and Hadamard Conjugation* p.44	*__Samantha Graffeo__ (UC Denver) *Quasi-Sum Graphs* p.27	
11:00 -11:20	**Patrick Fleming** (SDSMT) *Finite Semifields and Non-singular Arrays* p.25	*__Timothy Morris__ (UC Denver) *Anti-Directed Hamilton Cycles* p.45	
11:25 -11:45	*__Eric Nelson__ (CSU) *BLT-sets and Twisted Cubics* p.46	*__Breeann Tonnsen__ (UC Denver) *P-interval K-trees* p.56	
11:50 -12:10	**William Cherowitzo** (UC Denver) *15 Schoolgirls Take a Walk in Space* p.18	*__Craig Tennenhouse__ (UC Denver) *Subdivided Cycles and Graph Saturation* p.55	**Rick Kreminski** (CSU - Pueblo) *Etudes for calculus and complex variables* p.40
12:15 -12:35	*__Timothy Vis__ (UC Denver) *Fifteen schoolgirls and Forty-two Ovoids* p.57	**Michael Barrus** (Black Hills State) *Degree Sequences, Vertex Substitutions* p.16	**Stefan Erickson** (Colorado College) *Zeta Functions of Graphs and Hypergraphs* p.23
12:40 -13:00	*__Kenneth M Monks__ (CSU) *Möbius Numbers of Finite Groups* p.45	*__Shilpa Dasgupta__ (UC Denver) *Interval Bigraphs with containment restriction* p.20	

Sat. Time	Education Research N. Ballroom	Graduate Research Lory 210	Undergraduate Research Lory 230
10:10 -10:30	**Scott Evans** (Math Tutor) *What if Mathematics is a Psychomotor Skill?* p.24	*__Ramin Zahedi__ (CSU) *A lex. max-min design for detecting sparse signals* p.57	♣**Andreea Erciulescu** (CSU) *Solving Kakuro Puzzles* p.23
10:35 -10:55	**Brian Lindaman** (Montana State) *Students' Conceptions of Repeating Decimals* p.42	*__Jeffrey Larson__ (UC Denver) *Applications and Algorithms for Derivative-Free Optimization* p.42	♣**Rebecca Rasweiler-Richter** (USAFA) *Mathematics in Molecular Biology* p.52
11:00 -11:20	*__Rebecca Dibbs__ (UNC) *The perceived utility of precision teaching calculus* p.20	*__Yang Zou__ (CSU) *Spatial-Temporal Chaos* p.59	♣**Eric Robinson** (USAFA) *Dividing Products of Differences* p.53
11:25 -11:45	*__Mary E. Pilgrim__ (CSU) *Intervention in Calculus I* p.50	*__Jennifer Maple__ (CSU) *Steady State Mode Interaction in Anisotropic Systems* p.43	♣**Jacob Belka** (USAFA) *Optimizing GPS using mathematical programing* p.17
11:50 -12:10	**Alexander Hulpke** (CSU) *Using Video solutions in Calculus* p.37	*__Chris Smith__ (UCCS) *Matrix types of Leavitt path algebras* p.54	♣**Michael O'Connor** (USAFA) *FalconSAT-5 Operational Testing* p.47
12:15 -12:35	**Joe Champion** (UNC) *Affecting the Self-Efficacy of Students* p.18	*__Joseph Newhall__ (UC) *Convex Cones and Vector Efficiency* p.46	♣**Daniel Van der Vieren** (Regis) *The Rubik's Cube: A Trans-Composite Cipher* p.56
12:40 -13:00			♣**Niles Armstrong** (BHSU) *Pontryagin's Minimum Principle* p.14

Sat. Time	Pure and Applied Lory 211E	History of Mathematics Lory 224
10:10 -10:30	**Anton Dzhamay** (UNC) *Geometric Configurations Related to Matrix Factorizations* p.22	**George Heine** (BLM) *The Stereographic Projection is Conformal* p.37
10:35 -10:55	**R.M. Green** (UC Boulder) *Polytopal subcomplexes* p.27	**Janet Barnett** (CSU - Pueblo) *Abstract Awakenings in Algebra* p.15
11:00 -11:20	**Iuliana Oprea** (CSU) *A temporal route to spatiotemporal chaos* p.48	**Patrick Shipman** (CSU) *The Cantor Set and the Analytical Theory of Heat* p.54
11:25 -11:45	*__Ryan Croke__ (CSU) *Solutions for 2+1 Soliton Equations* p.19	
12:15 -12:35	♣**Christine Kistler** (USAFA) *Chaotic Behavior of Newton's Method* p.40	

* indicates a graduate student, ♣ an undergraduate student. Please provide support for our next generation of mathematicians.

Invited Talks

Richard Grassl
University of Northern Colorado
2009 Burton W. Jones Distinguished Teaching Award[1]

The ah Ha moment

Well designed problem solving episodes often elicit such moments from a broad range of audiences ranging from secondary students , to mathematics majors, and to inservice teachers; for example, the nice 10th grade problem: How many positive integers are there whose digits are in strictly increasing order (like 2478)? has an unexpected ah ha moment. Sometimes the presence of multiple disparate solutions ultimately yields the defining ah ha moment as often occurs with the following type of question: Verify that

$$\binom{m+n}{2} - \binom{m}{2} - \binom{n}{2} = mn.$$

Several such episodes will be highlighted as they have manifested themselves in my involvement over the years with problem solving courses for elementary and for secondary teachers (both preservice and inservice), with undergraduate research projects, and with the UNC Statewide Mathematics Contest. A brief presentation of the history, philosophy and results of the past 18 years of this contest will further illuminate how the trio Teaching - Research - Mentoring are intimately related.

* * *

Richard Grassl received his BA in mathematics from Santa Clara University and his graduate degrees from The University of Oregon and The University of New Mexico. After teaching at the U.of San Diego, UNM and as the

[1]Named in honor of Burton W. Jones, a lifelong advocate of excellence in teaching and supporter of the members and programs of the Mathematical Association of America. The Burton W. Jones Award for Distinguished College or University Teaching of Mathematics recognizes mathematics teachers who have been extraordinarily successful at the post-secondary level.

Truman Koehler Prof. of Mathematics at Muhlenberg College in Pennsylvania he was appointed Chair of Mathematics at The University of Northern Colorado. After 14 years as chair, and several semesters as assistant dean of the newly formed College of Natural and Health Sciences he has returned to full time teaching and research at UNC.

His 42 years in higher education has resulted in numerous publications in both mathematics (conbinatorics) and mathematics education, participation in a major NSF teacher enhancement grant, undergraduate research projects, and mentorship of talented secondary students through his involvement in statewide mathematics contests, first at UNM and now at UNC. Through the development of problem solving seminars he helped coach the UNM Putnam team to a ranking of #20. He started and has directed for the past 18 years the UNC Statewide Mathematics Contest for students in grades 7-12. Participation has grown from 150 initially to over 2200 recently.

Following the reception of teaching awards at UNM, Dr. Grassl earned college awards in three areas at UNC: Teaching , Research and Leadership.

David Bressoud

Macalaster College

President of the Mathematical Association of America

Calculus as a High School Course

Over the past quarter century, 2- and 4-year college enrollment in first semester calculus has remained constant while high school enrollment in calculus has grown tenfold, from 50,000 to 500,000, and continues to grow at 6% per year. We have reached the cross-over point where each year more students study first semester calculus in US high schools than in all 2- and 4-year colleges and universities in the United States. There is considerable overlap between these populations. Most high school students do not earn college credit for the calculus they study. This talk will present some of the data that we have about this phenomenon and its effects and will raise issues of how colleges and universities should respond.

Saturday Keynote

Proofs and Confirmations: The Story of the Alternating Sign Matrix Conjecture

What is the role of proof in mathematics? Most of the time, the search for proof is less about establishing truth than it is about exploring unknown territory. In finding a route from what is known to the result one believes is out there, the mathematician often encounters unexpected insights into seemingly unrelated problems. I will illustrate this point with an example of recent research into a generalization of the permutation matrix known as the "alternating sign matrix." This is a story that began with Charles Dodgson (aka Lewis Carroll), matured at the Institute for Defense Analysis, drew in researchers from combinatorics, analysis, and algebra, and ultimately was solved with insights from statistical mechanics. This talk is intended for a general audience and should be accessible to anyone interested in a window into the true nature of research in mathematics.

* * *

David Bressoud is DeWitt Wallace Professor of Mathematics at Macalester College and President of the Mathematical Association of America. He served in the Peace Corps, teaching math and science at the Clare Hall School in Antigua, West Indies before studying with Emil Grosswald at Temple University and then teaching at Penn State for 17 years. He chaired the Department of Mathematics and Computer Science at Macalester from 1995 until 2001. He has held visiting positions at the Institute for Advanced Study, the University of Wisconsin-Madison, the University of Minnesota, Universit Louis Pasteur (Strasbourg, France), and the State College Area High School.

David has received the MAA Distinguished Teaching Award (Allegheny Mountain Section), the MAA Beckenbach Book Award for Proofs and Confirmations, and has been a Pólya Lecturer for the MAA. He is a recipient of Macalester's Jefferson Award. He has published over fifty research articles in number theory, combinatorics, and special functions. His other books include Factorization and Primality Testing, Second Year Calculus from Celestial Mechanics to Special Relativity, A Radical Approach to Real Analysis

(now in 2nd edition), A Radical Approach to Lebesgue's Theory of Integration, and, with Stan Wagon, A Course in Computational Number Theory.

David has chaired the MAA special interest group, Teaching Advanced High School Mathematics as well as the AP Calculus Development Committee and has served as Director of the FIPSE-sponsored program Quantitative Methods for Public Policy.

Judy Walker

University of Nebraska, Lincoln

2009/10 MAA Pólya Lecturer

Codes on graphs: Shannon's challenge and beyond

Whenever information is transmitted across a channel, errors are bound to occur. It is the goal of coding theory to find efficient ways of adding redundancy to the information so that errors can be detected and even corrected. Coding theory began in 1948 with Shannon's groundbreaking result that efficient, reliable transmission of information is possible. This result was existential rather than constructive, however, and the challenge over the past half century has been to actually find the codes that Shannon proved must exist. In the past 10-15 years, it has been shown that certain graph-based codes come close to achieving Shannon capacity. Even with these recent advances, however, it is not clear whether Shannon's challenge has truly been answered. We will discuss the current situation as well as what the next big problems are for the field of coding theory.

* * *

Judy Walker is Professor and Graduate Chair at the University of Nebraska-Lincoln. Her main research interests are in algebraic coding theory, and her current work focuses primarily on codes on graphs. She has also studied connections between coding theory and both algebraic geometry and number theory. She is co-founder of the Nebraska Conference for Undergraduate Women in Mathematics and an editor for the Journal of Pure and Applied Algebra, Advances in Mathematics of Communications and the Rose-Hulman Undergraduate Math Journal.

Parallel Sessions

Combinatorics
Organized by Bryan Shader, University of Wyoming (Geometry) and Michael Ferrara, University of Colorado, Denver (Graph Theory)

Contributed Papers
Organized by Kyle Riley, South Dakota School of Mines & Technology

Graduate Student Research
Organized by Hortensia Soto Johnson, University of Northern Colorado, and Jeremy Muskat, Western State College

Mathematics Education Research
Organized by Robert Powers, University of Northern Colorado

Undergraduate Research
Organized by Jonathan Poritz, Colorado State University, Pueblo

Poincaré's Other Conjecture: The **History of Mathematics** and What It Can Teach Us
Organized by Janet Barnett (Colorado State University - Pueblo) and George Heine (Bureau of Land Management)

Pure and Applied Mathematics Research
Organized by Daniel Bates, Colorado State University

Undergraduate Poster Session
Organized by Carl Lienert, Fort Lewis College

Abstracts are listed jointly for all sections, sorted alphabetically by presenter name.

Mary Allison
University of Wyoming
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CO: Fri3:50

Fastest Mixing Markov Chain Problem for the Union of Two Cliques

A random walk on a graph G can be defined by prescribing weights to the edges in such a way that for each vertex the sum of the weights of the edges incident to the vertex is at most 1. The fastest mixing, Markov chain problem (FMMC) for G is to determine the weighting that yields the fastest mixing random walk. We solve the FMMC problem in the case that G is the union of two complete graphs.

Ginger Anderson HI: Fri2:10
Pikes Peak Community College
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Alice in Matrixland

Most of us have heard of Lewis Carroll's Alice's Adventures in Wonderland, but have we heard of Lewis Carroll's condensation method for evaluating determinants? This talk takes a brief look into the mathematical life and contributions of Lewis Carroll (Charles Dodgson), focusing mainly on his condensation method for evaluating determinants. We will explore examples of how and when his method works, and when and why it fails.

Niles Armstrong UR: Sat12:40
Black Hills State University
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A Note on Pontryagin's Minimum Principle and its Application

In this article, we shall introduce and discuss an important principle in optimal control theory, which is essentially a necessary condition, known as the Pontryagin's Minimum Principle (PMP). We shall state and discuss the PMP from a geometric point of view and note its relationship to Hamiltonian mechanics. Furthermore, we shall discuss through PMP, the relationship between calculus of variations and optimal control theory. We motivate this interrelationship by discussing the famous Dido's optimization problem and solve it by two methods: (i) Applying calculus of variations and then (ii) Reformulating and solving by application of the PMP. Then, in the sense of Sussmann, we describe the connection between calculus of variations and PMP by noting that PMP is somewhat of a generalization of

the Euler-Lagrange conditions in Calculus of Variations. Finally, we apply the PMP to a generalized non-linear Fullerfbs problem and derive an optimal control strategy, which is shown to be a bang-bang control even though LaSalle's Bang-Bang Control Theorem does not apply.

Julie Barnes CP: Fri2:35
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Hosting Math Treasure Hunts

Students love searching for treasure and solving puzzles. In this presentation, we look at a variety of math treasure hunts that have worked successfully both for a university math club and as a student activity at MAA-SE section meetings. We'll look at the logistics of running these events, a variety of activities students have done to collect clues, and types of clues that lead students to a final destination.

Janet Barnett HI: Sat10:35
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Abstract awakenings in algebra: Teaching and learning group theory through the works of Lagrange, Cauchy, and Cayley

The seeds of group theory can be recognized in several early nineteenth century mathematical developments. The common features of these apparently disparate developments were first explicitly recognized by Arthur Cayley (1812 –1895). In his 1854 paper "On the theory of groups, as depending on the symbolic equation $\theta^n = 1$, Cayley noted:

> The idea of a group as applied to permutations or substitutions is due to Galois, and the introduction of it may be considered as marking an epoch in the progress of the theory of algebraic equations.

Cayley himself extended the idea of 'a group' well beyond its application to permutations. In addition to defining a group as any (finite) system of symbols subject to certain algebraic laws, Cayley stated several important group theorems and proceeded to classify all groups up to order seven. Although focused on the general properties of arbitrary groups, he also did not neglect to motivate this abstraction through references to specific nineteenth century appearances of the group concept. As a result, Cayley's paper provides a powerful lens on the process and power of mathematical abstraction.

In this talk, we will examine this earliest paper on group theory through excerpts from a student module that uses this same powerful lens (together with several pre-Cayley original sources to provide historical and mathematical context for his paper) as a means to develop elementary group theory. In addition to an overview of the module and the historical developments on which it is based, we will consider how the module can be used in an introductory abstract algebra course. An overview of the rationale which guides the NSF-funded project *Learning Discrete Mathematics and Computer Science via Primary Historical Sources* that supported the development of this and 15+ other such student modules will also be provided.

Michael Barrus GT: Sat12:15
Black Hills State University
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Degree Sequences, Vertex Substitutions, and Matrogenic Graphs

To *substitute* a graph G for a vertex v in a graph H is to delete v and make each of its neighbors in H adjacent to every vertex of G. The substitution closure of a graph class $\mathcal{C}$ is the smallest graph class containing $\mathcal{C}$ that is closed under vertex substitutions. Motivated by a problem on degree sequences, we study the substitution closures of the classes of split graphs and matrogenic graphs, and we characterize these in terms of finite lists of forbidden induced subgraphs.

Jacob Belka UR: Sat11:25
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Optimizing GPS using mathematical programing

In the last two decades both civilian and military functions have grown to greatly depend on GPS. At a minimum, GPS consists of 24 satellites, four in each of the six equally spaced orbital planes. A GPS receiver on the ground must have at least four satellites in line-of-sight to obtain a reading, and the relative positions of those satellites determine the accuracy of the reading. The question comes: if we can add a spare satellite , which orbital plane do we pick and where in that plane should we place it for optimal performance? What if we can add two or more? Our approach uses mathematical programming and numerical methods, a technique that does not appear to have been previously applied to GPS. We are comparing our new results with those found by Air Force Space Command and contractors.

Bill Briggs HI: Fri2:35

University of Colorado at Denver

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The Evolution of Calculus Art

Before the advent of graphing technology, students and teachers of calculus undoubtedly struggled with sticks in the sand, chalk and slate, and pencil and paper to render curves, surfaces, and solids. (They were probably much better at handling these tools than we are today.) Our ability to visualize calculus has improved at a remarkable rate for the past 30–40 years, In this talk, I will give examples of early calculus textbook art (beginning with L'Hôpital) and show its evolution to the state of the art, at least as it stands today.

Curtis Card ED: Fri3:25

Black Hills State University

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Increasing the Pass Rates in Developmental Math Classes while Raising the Bar

Black Hills State University, like so many other universities, has been struggling with the problem of students failing Basic Algebra or Intermediate Algebra. Many of these students subsequently fail to graduate. In the fall of 2009 the mathematics department made structural changes in the way these courses were offered. A BLOCK format was implemented which required students to pass the material taught in a BLOCK prior to moving on to the next BLOCK. In addition to structural changes several instructional changes were implemented. This presentation discusses these implementations and the effect they had on the pass rate of students taking Basic Algebra and Intermediate Algebra.

Joe Champion ED: Sat12:15

University of Northern Colorado

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Affecting the Self-Efficacy of Students in Advanced Undergraduate Mathematics

In the minutes just before an exam, to what extent do students enrolled in undergraduate mathematics classes believe they can solve the problems? In this talk, I will summarize the results of a study that included structural equation modeling of self-efficacy, calibration, and exam performance for 195 students in courses ranging from Calculus I to Abstract Algebra II. In addition, I will discuss some qualitative themes that emerged from task-based interviews of 10 secondary mathematics majors. The focus will be on implications for instructors of undergraduate mathematics classes, especially the ways in which exams can affect students' self-efficacy to complete advanced mathematics.

William Cherowitzo CO: Sat11:50

University of Colorado Denver

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15 Schoolgirls Take a Walk in Space

We start with a geometric covering problem, namely, find the minimum number of pairs of skew lines in $PG(3,2)$ which will cover the 420 point-line anti-flags of that space. Numerically, 70 pairs of skew lines are needed

and this number can be achieved if there is a packing of $PG(3,2)$. A packing is a partition of the lines of the space into disjoint spreads and a spread is partition of the points of the space into disjoint lines. It turns out that packings of $PG(3,2)$ have been known for a long time since they are solutions to the Reverend Kirkman's famous problem posed in 1850 : "Fifteen young ladies in a school walk out three abreast for seven days in succession: it is required to arrange them daily, so that no two shall walk twice abreast." We shall pull these threads together and also look at generalizations of Kirkman's 15 schoolgirl problem and the geometric covering problem we started with.

Ryan Croke PA: Sat11:25
Colorado State University
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Generating an Infinite Number of Solutions for 2+1 Soliton Equations

Finding solutions for Partial Differential Equations is a difficult and laborious task, especially if the equations are nonlinear. In this case we cannot use standard techniques such as Fourier Transforms to find solutions to IBV PDE. If a PDE contains soliton solutions it can be solved using the Inverse Scattering Transform (IST), a monumental achievement of 20th century mathematics. However, using the IST can also be a difficult exercise, so we seek another method. In the last ten years there has been an explosion of solution techniques that extend a separation of variables technique called the multi-linear variable separation approach that will be familiar to anyone who has solved the heat equation.

In this talk I will explain this technique and show many examples of solutions for a wide range of nonlinear PDE. I will include as many examples of solitons, such as compactons, dromions, foldons, ring solitons, breathers, kinks, anti-kinks, etc. to display the richness and beauty of soliton equations. Usually, each PDE requires some sort of modification of the technique, and I will explain what I have done to apply this technique to my research.

Shilpa Dasgupta GT: Sat12:40
UC Denver
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Interval Bigraphs with containment restriction

J. Richard Lundgren
University of Colorado Denver

Breeann Tonnsen
University of Colorado Denver

An interval graph is proper if and only if it has a representation in which no interval contains another. Beyerl and Jamison introduced the study of p-improper interval graphs where no interval contains more than p other intervals in 2008. This paper extends the idea by introducing p-improper interval bigraphs, where no interval contains more than p other intervals of the same partite set. Several authors have studied proper interval bigraphs, including one characterization that has three forbidden subgraphs. We find bounds on the p-impropriety of a bigraph and structures of a special case of p-improper interval bigraphs.

Keywords: interval graph, interval bigraph, proper interval bigraph, p-improper

Rebecca Dibbs ED: Sat11:00
University of Northern Colorado
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The perceived utility of precision teaching calculus

The national failure rate in Introductory Calculus at the college level is estimated at 30–50%, and 228,000 students fail the AP Calculus exam each year. Furthermore, students who have taken calculus before are not selected as research participants, since they are "scarred by failing calculus" (Hsu, Murphy and Treisman, 2008 p. 7). This phenomenological study interviewed eight participants to discover what the experiences of students in calculus that have had prior exposure to the course topics; four students succeeded in their prior calculus course. The students, 6 of 8 were passing at the time

of the study, felt that the most important factors in a successful mathematics course are positive classroom culture and frequent assessment. Participants used several strategies to rationalize the need for repeating the course; all participants, regardless of their current grade felt they would pass calculus this time. Overall, participants reported increases in selfefficacy, motivation, and mathematical self concept as a result of retaking calculus.

Melody Dodd HI: Fri3:00
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A Comparison of Gauß's and Laplace's Methods for Orbit Determination and the Hunt for Least Squares

Both Gauß and Laplace developed methods for determining the orbit of a celestial body based only on a small amount of observational data. Historical evidence suggests that Gauß's method emerged as the superior of the two processes, but Gauß didn't immediately publish his methods, and many mysteries remain over Gauß's computations. Further controversy ensued when Gauß claimed that he used least squares in his orbit computations, several years before Legendre published the method. We are left to ask, why was Gauß's method better than Laplace's? Did Gauß discover least squares years before Legendre? These are the questions we examine in this presentation.

Benjamin Dyhr PA: Fri2:35
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Predicting Random Variables Associated with the Self-Avoiding Random Walk on the Strip.

The self-avoiding random walk (SAW) is a deceptively easily described model of deep interest to chemists and physicists. The macroscopic structure of long SAWs is of fundamental importance for models of linear polymers in chemical physics, which can be composed of thousands of monomers. On the other hand, as a mathematical object, basic questions about SAW elude

known probabilistic methods. Recent advances in mathematical physics, namely the conjectured identification between Schramm-Loewner evolution (SLE) and the scaling limit of SAW, allow for predictions of certain random variables associated with the Self-Avoiding Walk across an infinite strip. In this talk, theoretical machinery associated with SLE are used to predict the distribution of these random variables, and numerical simulations are used to support the validity of these conjectures. This is joint work with Michael Gilbert, Tom Kennedy, Greg Lawler, Shane Passon.

Anton Dzhamay PA: Sat10:10
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Geometric Configurations Related to Matrix Factorizations

We are interested in understanding the Lagrangian description of discrete integrable systems. One of the main approaches to the study of the integrability mechanism of such systems is via their Lax Pair representation. In this setting, the basic dynamical "flows" of the system are generated by the so-called re-factorization transformations of its Lax matrix. To be able to write down the Lagrangian function of the system directly from its Lax matrix, one has to explain how to factor the Lax matrix into basic blocks and also how to find a coordinate system on the space of Lax matrices that is adapted to the Lagrangian description of the re-factorization transformations of these blocks. In this talk we describe some recent results in this direction. Namely, we consider the case of rational Lax matrices with the Blaschke-Potapov factors playing the role of elementary blocks. Using residue techniques we show that the exchange rules for the components of such blocks can be visualized by atomic trivalent graphs, and that such atomic triples can be glued together following certain strict rules. In particular, the configuration corresponding to the quadratic case (two elementary factors) is a cube (which is very unexpected), and both the correct choice of the Lagrangian coordinates and the expression for the Lagrangian itself can be readily obtained from the labeling of the edges and vertices of this cube. This result not only suggest the correct formulation of the general case, but also provides a link between two main approaches to the integrability of discrete systems — the Lax Pair approach and the Multidimensional Consistency Approach.

Wade Ellis CP: Fri3:50
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Effective Learning with Software Tools: A Teacher's Perspective

The use of technology in teaching and learning mathematics should focus on mathematics. Examples of the use of technology tools to improve the mathematical knowledge and skills of students will be presented with emphasis on how to promote student engagement through effective teacher generated inquiry questions.

Andreea Erciulescu UR: Sat10:10
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Solving Kakuro Puzzles as Linear Minimization Problems

Kakuro puzzles are NP-complete ("Non-deterministic Polynomial Time"), a complexity class that is often found in the computational complexity theory. Although brute-force guessing is a possible way to solve them, a better weapon is the understanding of the various combinatorial forms that entries can take for various pairings of clues and entry lengths. We consider this puzzle a linear problem with variable entries and are trying to solve it over $\mathbb{Z}$. Smith Normal Form and lattice reduction are the two important mathematical concepts that helped us to complete an algorithm to solve Kakuro without guessing.

Stefan Erickson CP: Sat12:15
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Zeta Functions of Graphs and Hypergraphs

Zeta functions are one of the most important tools in number theory. Broadly speaking, zeta functions are built out of the "primes" of a mathematical object. In fact, zeta functions are the subject of the Riemann Hypothesis and

the Birch Swinnerton-Dyer Conjecture, two of the seven million-dollar Millennium problems.

An interesting development in recent years is to define zeta functions for graphs, which have been studied extensively by Ihara, Bass, Hashimoto, Stark, Terras, and many others. One can hope that graph zeta functions behave similarly to other zeta functions. Work of Koetter, Li, Vontobel, Walker have also made a link between zeta functions of graphs and coding theory.

In this talk, we briefly describe what a prime in a graph is, how to construct a graph zeta function, and the connection with coding theory. We also present a generalization of primes in hypergraphs with applications to low-density parity-check codes. This is ongoing work with Judy Walker (University of Nebraska, Lincoln) and Marina Gresham (undergraduate at Colorado College).

Scott Evans
Mathematics Tutor
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ED: Sat10:10

What if Mathematics is a Psychomotor Skill?

Mathematics, like sports, music or dance, has a beauty that involves more than the cleverness of an idea, but also in the skill of its execution. In music, even a simple piece played flawlessly is exciting. Perhaps, mathematical beauty is also mainly in the execution: the economy of a proof, the orderliness of a difficult integration, or the power of a physical analogy. Yet these dimensions which we admire and attribute to mathematical acumen, are not intellectual or cognitive feats as much as they are the product of continual practice–often dogged practice. Mathematics shares more in common with sports, music and dance, than we care to admit: mathematics is a psychomotor skill.

What is the evidence this is true? What is the difference between a cognitive skill and a psychomotor skill? Are there underlying mathematical models we can use? Should we change our teaching or learning? Do we risk turning students away from math by implying math is just about knowing instead of doing? Are current trends in decreasing homework loads and internet assignments helping or hurting. What can we learn from this model?

Michael Ferrara GT: Sat10:10
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Saturation Numbers for Families of Ramsey-minimal Graphs

Let $\mathcal{F}$ be a family of graphs. A graph G is *$\mathcal{F}$-saturated* if G contains no member of $\mathcal{F}$ as a subgraph, but for any pair of nonadjacent vertices u and v in G, $G + uv$ contains some member of $\mathcal{F}$. We say that G is *Ramsey-minimal* with respect to H_1 and H_2 if every red-blue coloring of the edges of G contains either a red copy of H_1 or a blue copy of H_2, but no proper subgraph of G has this property.

Here we study the problem of determining the minimum number of edges in an $\mathcal{R}_{min}(H_1, H_2)$-saturated graph of fixed order, where $\mathcal{R}_{min}(H_1, H_2)$ denotes the family of graphs that are Ramsey-minimal with respect to H_1 and H_2. In particular, we affirm the first nontrivial case of a 1987 conjecture of Hanson and Toft for complete H_1 and H_2.

Patrick Fleming CO: Sat11:00
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Finite Semifields and Nonsingular n-dimensional Arrays

Donald Knuth First proposed generalizing the concept of nonsingular matrices to include arrays of dimensions larger than 2 in 1965. He provided 3-dimensional examples as a means to construct finite semifields. Since the primary interest in this topic was related to semifields, constructions in larger dimensions have been almost completely ignored. In this presentation, we will discuss the connections between finite fields, semifields and nonsingular arrays. I will touch on how we can create n-dimensional arrays which are nonsingular for any $n > 2$.

Colin Garnett CO: Fri2:10
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Spectrally Arbitrary Companion-like Matrices

In this talk we discuss the construction of several classes of spectrally arbitrary matrices, where the entries are polynomials and there are precisely $2n - 1$ polynomial entries. These classes are shown to exhibit companion-like properties, that is to say they are like a companion matrix . The study of such matrices is related to the $2n$ conjecture and will hopefully either provide a counterexample in the Spectrally Arbitrary Pattern (SAP) case, or give the tools for a proof of the conjecture for SAPs.

Michelle Ghrist CP: Fri3:00

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My Experiences with High School Mathematics Competitions

As a secondary student, I delighted in taking math contests. Therefore, many years later, I jumped at the chance to take part in the development process of some of the contests of the American Mathematics Competitions, which oversees contests ranging from the AMC8 to the American Math Olympiad. In this talk, I discuss some of the history of these contests, the development process for the exams, and my experiences while serving on both the MAA-E2-80-99s Committee on the AMC10 and AMC12 contests and the AMC Advisory Panel. I will also discuss opportunities for others to become involved in this outstanding STEM Outreach activity and present some of the more interesting problems from recent contests.

David Glassmeyer ED: Fri3:00

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Message Posted: Perspectives of Formative Assessment within Online Graduate Courses

Tom Jensen

University of Northern Colorado

As more universities integrate online courses into teacher development programs, educators are faced with the challenge of providing quality teaching and learning within this new environment with little research to guide them. In this mixed methods approach, though mainly phenomenological, focused on how teachers in two online masters-level courses viewed three different formative assessment tasks. Observations, surveys, and interviews conducted with participants in online classes helped illustrate what factors influenced the perception and feelings of these tasks. Participant responses indicated virtual community, personal preferences, and academic purpose were the three main elements that caused these responses. Recommendations for future online courses are then established based on these findings in order to support learning within online synchronous and asynchronous settings.

Samantha Graffeo GT: Sat10:35
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Quasi-Sum Graphs

Introduced by Harary in 1990, a graph $G = (V, E)$ is a sum graph if $V(G) = S \subset \mathbb{N}$ and $E(G) = \{(uv) : u + v \in S\}$. It was proved that for any graph G with m edges, $G \cup mK_1$ is a sum graph. The smallest non-negative integer σ such that $G \cup \sigma K_1$ is a sum graph is called the sum number of G, denoted $\sigma(G)$. We consider a related problem for quasi-groups, specifically we show that for any graph G there exists a quasi-group Q and a function f such that $f : V(G) \to Q$ and $(uv) \in E(G)$ if and only if $f(u) + f(v) \in Q$. We then determine the minimum order of such a Q for several classes of graphs.

R.M. Green PA: Sat10:35
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Polytopal subcomplexes and homology representations

A (convex) polytope is the convex hull of a finite set of points in Euclidean space, and a regular polytope is a polytope whose symmetry group acts transitively on its flags. Examples of regular polytopes are simplices, hypercubes, and hyperoctahedra (the duals of hypercubes).

There are also interesting classes of non-regular polytopes with large symmetry groups, and in these cases, the polytope may have several types of faces of the same dimension. A simple example is the solid obtained by truncating the corners of a cube to form a polytope with both triangular and square faces. When there are several types of faces, it may be possible to obtain subcomplexes of the polytope by removing orbits of faces of various types. This talk will explain why this is interesting from the viewpoints of combinatorics, topology and representation theory of finite groups.

Darel Hardy
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CP: Fri2:10

Some Average Calculus Problems

This talk is about helping students use independent solutions to validate their own mathematical thinking. What is the average distance between two numbers chosen in the unit interval? A quick thought experiment indicates that 1/2 is too large and 1/4 is too small, so 1/3 is a reasonable guess. Use random numbers to get another estimate. Use calculus to get an exact answer. A calculus answer that is compatible with other estimates provides a high level of confidence that that answer is actually correct. Several "average" problems are included in this talk, accompanied with pictures, simulations, and calculus solutions.

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USA Mathematical Olympiads 1972-1986	NML-33	$16.00
Using History to Teach Mathematics	NTE-51	$18.00
Using Writing to Teach Mathematics	NTE-16	$21.50
Visual Group Theory-New!	VGT	$51.75
Vita Mathematica	NTE-40	$18.00
Voltaire's Riddle-New!	DOL-39	$43.25
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What is Calculus About?	NML-02	$22.50
When Less is More: Visualizing Basic Inequalities-New!	DOL-36	$43.25
Which Way Did the Bicycle Go?	DOL-18	$22.50
Who Gave You the Epsilon-New!	WGE	$47.50
The William Lowell Putnam Mathematical Competition 1938-1964	PB1	$40.50
The William Lowell Putnam Mathematical Competition 1965-1984	PB2	$25.25
The William Lowell Putnam Mathematical Competition 1985-2000	PB3	$40.50
The Words of Mathematics	WORDS	$36.00
Writing in the Teaching and Learning of Mathematics	NTE-48	$21.50
Writing Projects for Mathematics Courses	WPM	$31.50

Prices listed here are discounted and **only** valid at the meeting. They are available to all meeting participants. To purchase books at the listed prices (10% below membership prices!) please come to the MAA booksales booth in the Cherokee Park Ballroom.

George Heine HI: Sat10:10
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The Stereographic Projection is Conformal — An Entertaining Proof

We begin with some remarks about the meaning and historical significance of the proposition, and then present two short proofs:

- An XVII century geometric and visual proof;
- An entertaining visual proof from David Hilbert's 1932 classic "Anschauliche Geometrie" (Geometry and the Imagination)

Alexander Hulpke ED: Sat11:50
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Using Video solutions in Calculus

Web Videos of problem solutions can help in a calculus course not only outside class but also as a tool to keep technical issues outside class. I will show how we have been producing and using such videos in an engineering calculus course.

Rodney James CO: Fri3:00
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Sandpiles on edge-weighted graphs

We present a generalization to the abelian sandpile model on an edge-weighted graph over a subring R of the reals. Toppling is extended to allow multiple concurrent toppling sites. A toppling move that incorporates a subset of the possible sites is called a subset-toppling, and a toppling move that incorporates a multiset of the possible sites is a multiset-toppling. We show

that a configuration that is subset-toppling stable is also multiset-toppling stable, and that all such configurations form a group isomorphic to the edge-weighted Jacobian of the graph. If the subring R is the integers, these results reduce to existing results for multigraphs.

Dan Jones UR: Fri3:25

Department of Atmospheric Science,
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Stability Analysis of the Chaotic Lorenz System with a State-Feedback Controller

The Lorenz model is considered a benchmark system in chaotic dynamics in that it displays extraordinary sensitivity to initial conditions and the strange attractor phenomenon. Even though the system tends to amplify perturbations, it is indeed possible to convert a strange attractor to a non-chaotic one using various control schemes. In this work it is shown that the chaotic behavior of the Lorenz system can be suppressed through the use of a feedback loop driven by a quotient controller. The stability of the controlled Lorenz system is evaluated near its equilibrium points using Routh-Hurwitz testing, and the global stability of the controlled system is established using a geometric approach. It is shown that the controlled Lorenz system has only one globally stable equilibrium point for the set of parameter values under consideration.

Kristin King PA: Fri3:50

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Introducing Mathematical Modeling in an Undergraduate Ecology Laboratory

Joe Champion
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We report on an interdisciplinary collaborative to develop an introduction to mathematical modeling in a undergraduate Ecology laboratory. The lab, which includes a model for the introduction of Feline Leukemia Virus in an island feral cat population, introduces coupled differential equations and considers some questions appropriate to the development and analysis of an ecological model. The ecology students also interacted with a Mathematica-based visualization of the model, and preliminary feedback was positive. We will describe the design of the lab and discuss some benefits arising from our collaboration.

Kristin King
University of Northern Colorado
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ED: Fri2:10

Active Learning in an Introductory Statistics Course

The field of statistics education is new and has been growing over the past 30 years. In 1992, Cobb called for a change in statistical education, and in 2005, the ASA and NCTM joint committee developed the Guidelines for Assessment and Instruction in Statistics Education (GAISE), providing six recommendations for teaching statistics: 1. Emphasize statistical literacy and develop statistical thinking; 2. Use real data; 3. Stress conceptual understanding rather than mere knowledge of procedures; 4. Foster active learning in the classroom; 5. Use technology for developing conceptual understanding and analyzing data; 6. Use assessments to improve and evaluate student learning; In this presentation, I will discuss my experience with action research in an introductory statistics class as I evaluate incorporation of recommendation four, foster active learning. In my classroom, I conducted three lesson experiments and used pre- and post-test to measure student learning. I will also discuss personal and professional implications from this action research.

Christine Kistler UR: Sat12:15
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Chaotic Behavior of Newton's Method

Newton's method is a well known algorithm for approximating the roots of functions. The choice of a starting point for the algorithm directly affects its success. When applying the method to complex functions, the success of the algorithm is very unpredictable. We will investigate the chaotic behavior of how the choice of starting point affects the success of Newton's method for complex functions. Fascinating images can be observed.

Travis Kowalski PA: Fri2:10
South Dakota School of Mines and Technology
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Elementary proof of the convergence of Taylor series solutions to ODEs

Undergraduate students are typically exposed to various techniques for solving ordinary differential equations, including power series methods. A common result stated in connection with this technique is that the unique solution to an analytic differential equation at a regular point is itself analytic, but few undergraduate textbooks provide even a hint of a proof. In this talk we give an elementary proof this result using a variation of the power series method accessible to undergraduate students, and in fact use it to provide a lower bound for the radius of convergence of such a solution.

Rick Kreminski CP: Sat11:50
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3 easy pieces: etudes for calculus and complex variables

This talk will show students of calculus (including faculty) a few things that hopefully seem novel, interesting, and maybe even surprising .

1. We provide a non-traditional pedagogical way to visualize the chain rule and rule for differentiation of inverse functions. (Suitable for calc I and complex variables.)

2. We present results about the error term in Taylor series for some familiar functions. More specifically, if f is sufficiently nice on $[a, b]$, and if the Taylor series error term is expressed in the usual Lagrange form as $f^{(n+1)}(c)/(n+1)!(x-a)^{(n+1)}$, then we show where c lies in (a, b) — it's not randomly distributed in (a, b), and for many typical functions its location in (a, b) is essentially independent of f. (Suitable for calc II.)

3. We show how calculus could have allowed Vieta (Viete) to use his beautiful product formula for π — the one with nested square roots of two — and accelerate the convergence dramatically. By hand, he could have computed π, back in the late 1500s, to dozens of digits. (We used this to compute π to hundreds of thousands of digits.) (Suitable for calc I and II or even precalc.)

Eric Kuss UR: Fri2:10

Fort Lewis College Student

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Fibona00i (mod c)

I will be exploring the consequences of reducing the Fibonacci sequence modulo m, based on the approach of D.D. Wall. Doing this will give a periodic sequence with a length of h. There are many different theorems resulting from this idea, including how the prime factorization of m relates to h. Hopefully, I will find some strong correlation between prime factorization of m and dividing the Fibonacci numbers in such a way that we get the Lucas Numbers. However, I will push on to also explore Group Theory involving the Fibonacci Numbers.

Jeffrey Larson GR: Sat10:35

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Applications and Algorithms for Derivative-Free Optimization

Functions with expensive or unavailable derivatives are the foundation of problems across fields as diverse as astrophysics, chemistry, and nanotechnology. The high cost or unavailability of derivatives can arise from a variety of problems including sophisticated and time-intensive simulations, black-box functions, and unsupported legacy code. Even when derivatives can be calculated, numerical and stochastic noise can result in dubious derivatives which only hinder progress towards an optimum. Nevertheless, locating the optimal solution to these problems is desirable. In this talk we present examples where derivative-free optimization is required, highlighting recent collaborative research with the Systems Biology group at the National Renewable Energies Lab to increase production of hydrogen by photosynthetic bacteria. We outline traditional methods for solving these problems, as well as their failings. Lastly, we propose our own method for finding optimal solutions to general derivative-free optimization problems using weighted least squares regression models within a trust region framework.

Brian Lindaman

Montana State University

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ED: Sat10:35

Infinitely Hard: A Discussion of Calculus Students' Conceptions of Repeating Decimals

Prior research has utilized repeating decimals as a means to gauge student understanding of real numbers, limits, and infinity. (Dubinsky, 2005; Tall, 1981, 1994). This talk will present findings from a current research study on undergraduate and advanced high school students' understandings of this surprisingly difficult topic. Specifically, this study was focused on answering the following questions: Is difficulty with understanding .999 . . . attributed to notation? Does the difficulty "carry over" into two-digit repetends? Does math ability make a difference? Does instruction impact understanding? After a brief overview of related research, results from the study will be presented, along with samples of the instruments used. Special attention will be given to the Action-Process-Object-Schema (APOS) and Stage Distinction and Activity-Effect learning models which provide a theoretical context for

the findings and conclusions. The talk will conclude with future directions for this type of research.

Sara Linville UR: Fri3:00
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Möbius Transformations of Geometric Constructions

Ancient Greeks were fascinated with what could be constructed only using a compass and a straightedge without markings. They were able to construct many things like bisecting an angle, but others like doubling the cube baffled them. The ability to show that these and other problems were or were not possible did not come until 2000 years later with the discovery of algebra in the nineteenth century. We are now able to use extension fields of the rationals to fully understand these geometric constructions. The question I will explore is the following: if there are two constructions that build the same extension field, is there a relationship between the Möbius transformations that map one construction to the other and the constructions' base field? I will do this by looking at various examples of such constructions and their corresponding Möbius transformations in an attempt to understand the general case.

Jennifer Maple GR: Sat11:25
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Steady State Mode Interaction in Anisotropic Systems

We present a theoretical and numerical analysis of a system of four globally coupled complex Ginzburg-Landau equations modeling steady oblique-normal Hopf mode interaction observed in experiments in electroconvection of nematic liquid crystals.‘

Millie Mays UR: Fri4:15
U.S. Air Force Academy
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Game Show Statistics

We will examine the statistics of "Let;s Make a Deal" and "Deal or No Deal" to discuss possible winning strategies. We will also examine the most important differences, statistically speaking, between these somewhat similar game shows.

Erich McAlister CP: Fri3:50
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Further Geometry of Derivatives of Complex Functions

One of the most fundamental results in the theory of functions of a single complex variable is that if a function $f : \mathbb{C} \to \mathbb{C}$ is differentiable at a point, then its real and imaginary parts must satisfy the Cauchy-Riemann equations. The standard proof is done by simply differentiating along two different directions in the complex plane. In this talk we will explore what happens when we go further and consider all possible directions. It turns out that the set of all possible such directional derivatives is a set with very nice geometric properties even when it does happen to contain more than one point, i.e., the function in question is not differentiable.

Multiple representations of complex numbers, arithmetic, functions, and differentiation should make this an interesting talk for teachers and students of linear algebra and multivariable calculus, as well as complex analysis.

Cayla McBee CO: Sat10:35
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Nucleotide Substitution Models and Hadamard Conjugation

Combinatorial phylogenetics is an area of mathematical biology that uses genetic data available from presently extant organisms to determine their

evolutionary relatedness. Determining these historical relationships is important to various areas of research including evolutionary biology, conservation genetics and epidemiology. I will provide an overview of a group-based nucleotide substitution model and its use with Hadamard conjugation. I will also discuss the possibility of extending Hadamard conjugation to evolutionary models which are not considered to be group-based.

Kenneth M Monks CO: Sat12:40
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Möbius Numbers of Finite Groups

The Möbius number is a very useful combinatorial invariant of a finite lattice. In addition to appearing in enumerative combinatorics, number theory, and topology, Philip Hall introduced their use in group theory. Given any finite group we can ask for the Möbius number of its lattice of subgroups. In this talk we will discuss an ongoing project to compute the Möbius numbers of various classes of finite groups.

Timothy Morris GT: Sat11:00
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Anti-Directed Hamilton Cycles

Given a directed graph D, an anti-directed hamilton cycle is a hamilton cycle such that each vertex has either indegree 2 and outdegree 0 or indegree 0 and outdegree 2. We find Dirac type conditions to guarantee a directed graph has an anti-directed hamilton cycle.

Reshmi Nair CO: Fri2:35
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Acyclic matrices with a small number of distinct eigenvalues

We continue the study of the spectral properties of $\mathrm{Sym}(\mathcal{T})$, the set of all n by n symmetric matrices corresponding to a tree $\mathcal{T}$ on n vertices where $a_{ij} \neq 0$ for $i \neq j$ if and only if i–j is an edge in $\mathcal{T}$. For a given list of integers $m_1, m_2, \ldots, m_k$, we study the problem of characterizing the trees $\mathcal{T}$ for which there is an $A \in \mathrm{Sym}(\mathcal{T})$ whose eigenvalues have multiplicities $m_1, m_2, \ldots, m_k$. An approach based on Smith Normal Form, Hamming distance, and Parter and Fiedler vertices is used to characterize the acyclic matrices that have at most 5 distinct eigenvalues.

Eric Nelson CO: Sat11:25
CSU Graduate Student
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BLT-sets and Twisted Cubics

I will give a construction of the Fisher-Thas-Walker BLT-set family via twisted cubics. The construction will use the Klein correspondence, some number theory, and a condition on triples of points for a set to be a BLT-set.

Joseph Newhall GR: Sat12:15
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Convex Cones and Vector Efficiency

Vector efficiency is an important topic in optimization. In this talk we show how to define a partial order on a vector space using a convex cone and we discuss some of the notions of efficiency and optimality which arise in this context. We will state and discuss the famous theorem of Arrow, Barankin and Blackwell regarding the density of the regular efficient points as well as some modern generalizations of this result. Only basic knowledge of Linear Algebra and Topology will be assumed.

Michael O'Connor UR: Sat11:50
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FalconSAT-5 Operational Testing, Analysis, and Anomaly Resolution

FalconSAT-5 is a small experimental spacecraft with three primary payloads, two of which are SERB rated. As part of the testing of the spacecraft, cadets sent FalconSAT-5 to Edwards Air Force Base for an Operational Test Campaign. The three primary payloads are WISPERS, iMESA, and SPCS. SPCS, the most complicated of the payloads, has an Hall-effect Ion Source and Neutral Source thruster. To properly test the thruster, a vacuum chamber is required. Edwards Air Force Base supplied the use of a 30 foot diameter vacuum chamber which allowed the testing of the SPCS thruster. WISPERS and iMESA also require the use of a vacuum chamber when operating in high voltage modes. The presentation will briefly delve into these payloads, their capabilities, the test methods. We will also provide an overview of the satellite setup , design, and build philosophy. During the test campaign at Edwards AFB, FalconSAT-5 performed anomalously, with multiple processor reboots. The presentation will outline the deviations from expected performance, steps taken to resolve the anomaly, as well as the data analysis and study that took part concurrently in order to locate the problem. We will outline the many broad categories of potential problems, and show the steps taken to eliminate each possibility. Among those discussed will be possible design flaws, temperature and heating dangers, software errors, part failures, and experimental setup shortcomings. We will discuss ongoing efforts to specify performance factors, develop system transfer functions, and further test the satellite in order to create repeatable anomaly scenarios.

Gary Olson

University of Colorado Denver

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ED: Fri3:50

A College Mentoring Experience for Pre-Service Mathematics Teachers

Diana White

University of Colorado,
Denver

We discuss an innovative college internship in which pre-service secondary math teachers work together as recitation instructors for College Trigonometry. This experience was developed and piloted in Spring 2010 as part of the NSF Rocky Mountain Noyce Scholars Program at the University of Colorado Denver. This college-level internship has had substantive impacts on the pre-service teachers as well as the trigonometry students, and will impact the future training of math graduate teaching assistants. We will provide details of the development, implementation, advantages, impacts, and lessons learned from the pilot of this program.

Zim Olson ED: Fri4:15

Zim Mathematics - Author / Owner

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Systems and/or Sub Systems as Mathematical Paradigm - With the Creative Method

The existential properties of Systems and/or their Sub-Systems are vigorously explored producing previously unexplored Mathematical territory such as a System-Sub System Algebra, showing combinations of their expressions and their categories of Transformation(s); expressions of Operation(s) also as systems highlight a variety of existential results; Principles of System-Sub System expression, including "Critical Information" in Systems, documentation of the existence of Unconditional Logic in known paradigms; and a Reference Mobile concept, Creative Calendar Sequences, Zim Math Farms, and Chaos Clocks are explored, etc. The Creative Method used in this work is outlined. Symbolic limits in these existential paradigms are documented

Iuliana Oprea PA: Sat11:00

Colorado State University

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A temporal period doubling route to spatiotemporal chaos

We analyze spatiotemporal complex dynamics in a system of four globally coupled Ginzburg Landau equations describing the dynamics of instabilities in the electroconvection of nematic liquid crystals, in the weakly nonlinear

regime. If spatial variations are ignored, these equations reduce to the normal form for a Hopf bifurcation with $O(2) \times O(2)$ symmetry. Complex spatiotemporal dynamics, including spatiotemporal intermittency, as well as a temporal period doubling route to spatiotemporal chaos, corresponding to a period doubling cascade towards a chaotic attractor in the normal form, are also identified and discussed, for values of the parameters including experimentally measured values of the nematic *I*52.

Stanley Payne CO: Sat10:10
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Finite Self-Dual Generalized Quadrangles

We collect some known facts about self-dual generalized quadrangles and consider especially the number of absolute points of a duality. The only known finite self-dual GQ are the $T_2(\mathcal{O})$ constructed by J. Tits where $\mathcal{O}$ is a translation oval in a finite desarguesian projective plane of even order. We review a construction of these GQ in enough detail to study he sets of absolute points of certain dualities. We can then interpret recent work by B. Temmermans in terms of equations over certain finite fields to show that these equations must have a prescribed number of solutions.

Mark Pengitore UR: Fri3:50
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Automorphisms of real submanifolds in $\mathbb{C}^2$

The determination of all local biholomorphisms between two real hypersuafces in $\mathbb{C}^2$ is one of the main problem areas in CR geometry. For hypersurfaces with a particular type of degeneracy condition called "infinite type," it is possible to use Taylor series techniques to determine such mappings. In this talk, we use this technique to compute the local automorphism group of the hypersurface $\{\mathrm{Im}(w) = \mathrm{Re}(w)^2|z|^2\}$ in $\mathbb{C}^2$.

Mary E. Pilgrim ED: Sat11:25
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The Effects of a Concepts for Calculus Intervention in Calculus I

Kenneth F. Klopfenstein
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At the Spring 2009 section meeting Reinholz and Klopfenstein described the experimental course MATH 180 *Concepts for Calculus* the CSU Math Department planned to offer Fall, 2009, for students at risk of failing MATH 160 Calculus for Physical Scientists I.

MATH 180 was taught Fall, 2009. Students who performed poorly on the first MATH 160 midterm exam given during the fourth week of classes were invited to change from MATH 160 to MATH 180 for the remaining 12 weeks of the semester. Twenty-seven students accepted the invitation.

Concepts for Calculus is a blended course with a classroom component and an on-line component. The classroom component is designed to develop students' ability and inclination to think mathematically by using problems to prompt students to reexamine the function concept from various perspectives. In the online component students use the course Preparation for Calculus from ALEKS Corporation to develop their pre-calculus skills. After completing MATH 180, students then had the option to continue on to MATH 160 in the spring 2010 semester. The academic progress of these students is being tracked and compared to the academic progress of students that did not accept the invitation for MATH 180 but are repeating MATH 160.

This presentation reports on the effects of this intervention on students' beliefs about mathematics — as measured by the Modified Indiana Mathematics Belief Scales (MIMBS), their inclination to continue studying mathematics, and their success in Calculus I.

Jonathan Poritz CP: Fri4:15
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On entropy-preserving stochastic averages

When an $n \times n$ doubly-stochastic matrix A acts on an n-long probability distribution P, the resulting distribution AP is referred to as their *stochastic average*. The goal of this talk is to determine the structure of the set $\mathbf{\Gamma}_n$ of pairs (A, P) whose stochastic averages have unchanged entropy: $H(AP) = H(P)$. $\mathbf{\Gamma}_n$ is a subset of $\mathbf{B}_n \times \mathbf{\Sigma}_n$, where $\mathbf{B}_n$ is the polytope of doubly stochastic matrices and $\mathbf{\Sigma}_n$ is the simplex of probability distributions.

In his seminal paper of 1948 which largely created the field of Information Theory, Shannon noted that a pair $(A, P) \in \mathbf{B}_n \times \mathbf{\Sigma}_n$ belongs to $\mathbf{\Gamma}_n$ if and only there is a permutation matrix π such that $AP = \pi P$. Two other equivalent characterizations of $\mathbf{\Gamma}_n$ will be proven: $(A, P) \in \mathbf{\Gamma}_n$ if and only if

- $A^T AP = P$; or
- the *column-index partition* of A refines the *coincidence partition* of P — these two partitions of $\{1, \ldots, n\}$ are determined in a simple way from A and P which shall be described in the talk.

These new perspectives on $\mathbf{\Gamma}_n$ make it possible to understand completely its rather intricate combinatorics, geometry and topology. Some of this structure shall be explained, with the examples $\mathbf{\Gamma}_2$ and $\mathbf{\Gamma}_3$ worked out quite completely.

Alexandre Probst ED: Fri2:35

Colorado Christian University / Colorado School of Mines

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Assessing student improvement in an introductory statistics class to measure the effectiveness of instructional change

Cobb stated that "statistics classes everywhere were despised by students" and further research demonstrated very poor performance in standardized tests for students completing introductory statistics classes. A classroom intervention involving the use of Tablet PCs to improve statistics instruction has been tested in undergraduate classes at Colorado Christian University for the last 2 years. The challenge is how to measure whether improvements have been realized. An NSF funded project named ARTIST

(Assessment Resource Tools for Improving Statistical Thinking) at the University of Minnesota produced the CAOS (Comprehensive Assessment of Outcomes in a first Statistics Course) test. The test has been used at numerous institutions and provides standardized results for users. The question, however, is whether a multiple choice objective test can accurately measure what students have learned in an introductory statistics class and subsequently whether it can provide a good measure of pedagogical improvement. In addition, introductory statistics classes are often fairly small and the grade distribution on objective tests tends to be non-normal complicating the pre/post comparisons as well as comparisons with other classes. This presentation will examine 3 years of data (comparing the results of a multiple choice test developed by the current author to the results using the CAOS test) for introductory statistics classes that were subjected to a variety of pedagogical changes. The grade distributions will be analyzed for normality and compared with a baseline to determine the effects of pedagogical change. A variety of statistical techniques including rank transformation, analysis of covariance and some non-parametric tests will be used to evaluate pre/post improvement in a class and compare results with a baseline class. A discussion on the effectiveness of objective tests to determine pedagogical improvement will conclude the presentation.

Rebecca Rasweiler-Richter UR: Sat10:35
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Mathematics in Molecular Biology

In this talk we will look at different mathematical applications in molecular genetics. We will focus on mathematical models used in this field of biology and delve into some specific examples such as in the rapidly growing field of epigenetics.

Ivan Raykov PA: Fri3:00
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Quasi-Consistent Approximation of Effective Diagonalization Strategies for the Solution of a Class of Optimal Design Problems

This paper continues the work of [HP]. We determine successive approximation algorithm which consists of two sequences of progressively finer stages of discretization, diagonalization method, with a prescribed number of iterations of the optimization algorithm carried in each stage. The solutions of these problems are discretization strategies which minimize the time needed to reduce the initial cost-error by prescribed amount.

Eric Robinson UR: Sat11:00

U.S. Air Force Academy

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Dividing Products of Differences

Imagine selecting four integers at random, say 3, 8, 11, and 17. Now, find all non-negative differences between these integers. For this selection we have $17-11 = 6, 17-8 = 9, 17-3 = 14, 11-8 = 3, 11-3 = 8$, and $8-3 = 5$. The product of these nonnegative differences is $6\cdot 9\cdot 14\cdot 8\cdot 5 = 30\,240$. What if the numbers chosen were 2, 3, 5, and 7? Then the product of nonnegative differences is 240. Clearly 12 divides both 30240 and 240. Is this true in general for all sets of four integers chosen? What if we chose more than four integers, maybe 20? Are we guaranteed to find an integer greater than 1 that will divide the product of all nonnegative differences of these 20 integers? If so, what is the largest such integer that we know will divide this product? All of these questions will be explored in this presentation.

Adam Ruff UR: Fri2:35

University of Colorado Denver

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Analyzing Advice Networks of Math and Science Teachers

We discuss our use of social network analysis to study the advice networks of math and science teachers who participated in the Rocky Mountain Middle School Math and Science Partnership. Social network analysis is a powerful

technique which can be used to gain information about many types of personal and professional interaction. Analyzing school network data requires mathematical concepts from graph theory and statistics. We will provide an overview of the basic concepts needed, assuming no prior knowledge of the area, as well as describe our findings. We will conclude by comparing our study with results from similar studies and discuss similar research currently in progress.

Patrick Shipman HI: Sat11:00
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The Cantor Set and the Analytical Theory of Heat

Cantor's theory of sets and cardinality was motivated in part by the practical problem of heat flow and Fourier's advances in his book The Analytical Theory of Heat. We will review the history of how Fourier's work led to new thoughts on infinity in both math and science and then demonstrate a chemical experiment involving diffusion, nucleation, and growth that gives rise to a Cantor-like set.

Chris Smith GR: Sat11:50
University of Colorado, Colorado Springs
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The matrix type of purely infinite simple Leavitt path algebras

The Leavitt path algebras are a recent generalization of William Leavitt's algebras of type $L(1,n)$. We completely describe the so-called matrix type of any purely infinite simple unital Leavitt path algebra $L(E)$ – that is, the pairs of positive integers (c,d) for which there is an isomorphism of matrix rings $\mathrm{M}_c(L(E)) \cong \mathrm{M}_d(L(E))$ – in terms of the order of $[1_{L(E)}]$ in the Grothendieck group $K_0(L(E))$.

Daniel Swenson PA: Fri3:25
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The Steinberg Complex of an Arbitrary Finite Group

The Steinberg Complex is a generalization, to the case of an arbitrary finite group G, of the Steinberg Representation of a finite group of Lie type. It was defined about 20 years ago in terms of the conjugation action of G on its poset of p-subgroups (analogous to the building in the classical case).

Today, the Steinberg Complex remains a somewhat mysterious object. I will briefly describe the history and definition of the Steinberg Complex, and indicate some directions for further research.

Louis Talman CP: Fri3:25
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Mathematics on the Web

Websites that deal with mathematics and the teaching of mathematics have proliferated in the last decade. One can learn a great deal of mathematics at all levels on the Web. In this talk, I will point to a number of such sites. I will discuss, in some detail, a pair of such websites that I've had the good fortune to help create and maintain. We'll visit the sites, and I'll talk about how some of their resources are created.

Craig Tennenhouse GT: Sat11:50
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Subdivided Cycles and Graph Saturation

Let H and G be simple graphs. H is *G-free* if it does not contain a subgraph isomorphic to G, and *G-saturated* if it is edge maximally G-free. G-saturated graphs have been studied by Turán, Erdös, Moon, Tuza, and many others for their role in extremal graph theory. An edge xy of G can be *subdivided* by replacing it with a new vertex z and new edges xz, zy. We examine graphs saturated with respect to subdivisions of cycles, giving exact results for small cycles and an asymptotic result in general.

Breeann Tonnsen GT: Sat11:25
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P-interval K-trees

Interval p-graphs were introduced by Brown, Flink, and Lundgren in 2002 as a generalization of interval bigraphs. Little work has been done towards characterizing them. For interval bigraphs the only known forbidden subgraph characterization is for trees. As it appears to be quite difficult to find a forbidden subgraph characterization, we limit our work to an extension of trees called k-trees. We characterize p-interval k-trees ask spiny interior k-lobsters and use this result to give a forbidden subgraph characterization. We apply a similar technique to 2-tree probe interval graphs, studied by Prẑulj and Corneil in 2005, and characterize them in terms of a subset of spiny interior 2-lobsters.

Daniel Van der Vieren UR: Sat12:15
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The Rubik's Cube: A Trans-Composite Cipher

Have you ever tried to solve a Rubik's Cube and found yourself looking online or in a book to figure out the algorithm? Well, this presentation will not show you how to solve the Cube, but will provide a look at how the Cube can be used to encode and decode plaintext messages. Douglas W. Mitchell, an economist, proposed a system of transposition to encode plaintext that would be safe against multiple anagramming attacks. With his technique, we will add a Vigenère component to create a "more secure" cryptographical system. The cryptosystem has not yet reached the stage of thorough cryptanalysis to test security. Further research must be conducted in order to determine the strength of the cryptosystem as well as potential weaknesses and plausible means of exploitation.

Timothy Vis CO: Sat12:15
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Fifteen schoolgirls and Forty-two Ovoids

Although there is no Steiner quintuple system on seventeen points, there is a unique four-fold balanced design on seventeen points having blocks of sizes five and six. The blocks of size five all arise by extending planes of AG(4,2), while the blocks of size six arise as seventy pairs of skew lines and forty-two ovoids in PG(3,2). We describe a straightforward construction of the forty-two ovoids required for this design, a construction that utilizes a solution to the Kirkman schoolgirl problem.

Cara Wiblemo CO: Fri4:15
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Automorphism Decompositions of Graphs

Given a graph G with adjacency matrix A, G has an automorphism decomposition if it is a sum of automorphisms in the following sense: there exists a set of permutation matrices $S = \{P_1, P_2, ..., P_k\}$ such that $A = P_1 + P_2 + \cdots + P_k$ and $(P_i)A = A(P_i)$ for all $P_i \in S$. This talk will discuss properties of such graphs as well as their connection to Cayley graphs.

Ramin Zahedi GR: Sat10:10
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A lexicographic max-min design for detecting sparse signals

In this paper, we use a lexicographic optimization approach to maximize the worst- case signal-to-noise ratio (SNR) for a sparse signal. We begin by finding a family of optimal solutions for 1-sparse signals. Then, we look for optimal solutions in this set for 2-sparse signals. We continue this procedure until we find a solution set for k-sparse signals. We show that for all

sparse signals, columns of the optimal measurement matrix form a uniform tight frame. For 2-sparse signals, the largest absolute value of cosines of angles between element pairs of this frame must be minimized. For k-sparse signals where $k > 2$, the difference between the largest cosine and the smallest cosine of such angles must be as small as possible. We show that under certain conditions, columns of the optimal measurement matrix form an equiangular uniform tight frame.

Tianyu Zhang PA: Fri4:15
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Phase model of biofilm

We derive a set of phase field models for biofilms using the one-fluid two-component formulation in which the combination of extracellular polymeric substances (EPS) and the bacteria are effectively modeled as one fluid component while the collective ensemble of nutrient and the solvent are modeled as the other. The biofilm is assumed an incompressible continuum. Numerical simulations are carried out in one and two space dimension using a velocity-corrected projection method for incompressible flows. Biofilm growth, expansion, streaming, rippling, and detachment are simulated in shear cells numerically. Viscoelastic properties of the biofilm is investigated as well.

Yang Zhang CO: Fri3:25
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Continuum Limits of Markov Chains and Network Modeling

We investigate the continuum limits of a class of Markov chains, which is motivated by the modeling of very large networks. We show that under some conditions, a sequence of Markov chains converges in some sense to the solution of a partial differential equation. Based on such convergence we approximate Markov chains modeling networks involving a large number of components by partial differential equations. While traditional numerical

simulation for very large networks is practically infeasible, partial differential equations can be solved with reasonable computational overhead using readily available mathematical tools is investigated as well.

Yang Zou GR: Sat11:00
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Is spatial-temporal intermittency a route to spatial-temporal chaos?

Spatio-temporal Chaos (STC), exhibiting disorder in both space and time, is found extensively in fluid experimental and simulations of PDEs, while spatio-temporal intermittency (STI), characterized by the coexistence of laminar states of regular dynamics and burst states of irregular dynamics, is also ubiquitous in experiments and simulations. In this talk I will introduce both STC and STI in simulations of Ginzburg-Landau equation. The route from temporal intermittency to temporal chaos will be briefly discussed. Intermittent behavior is found in simulations for some specific modes of envelopes of patterns in Ginzburg-Landau equation. Finally I will characterize this type of intermittency, which could imply a route to spatio-temporal Chaos from spatio-temporal intermittency.

POSTERS

Kathleen Haus :
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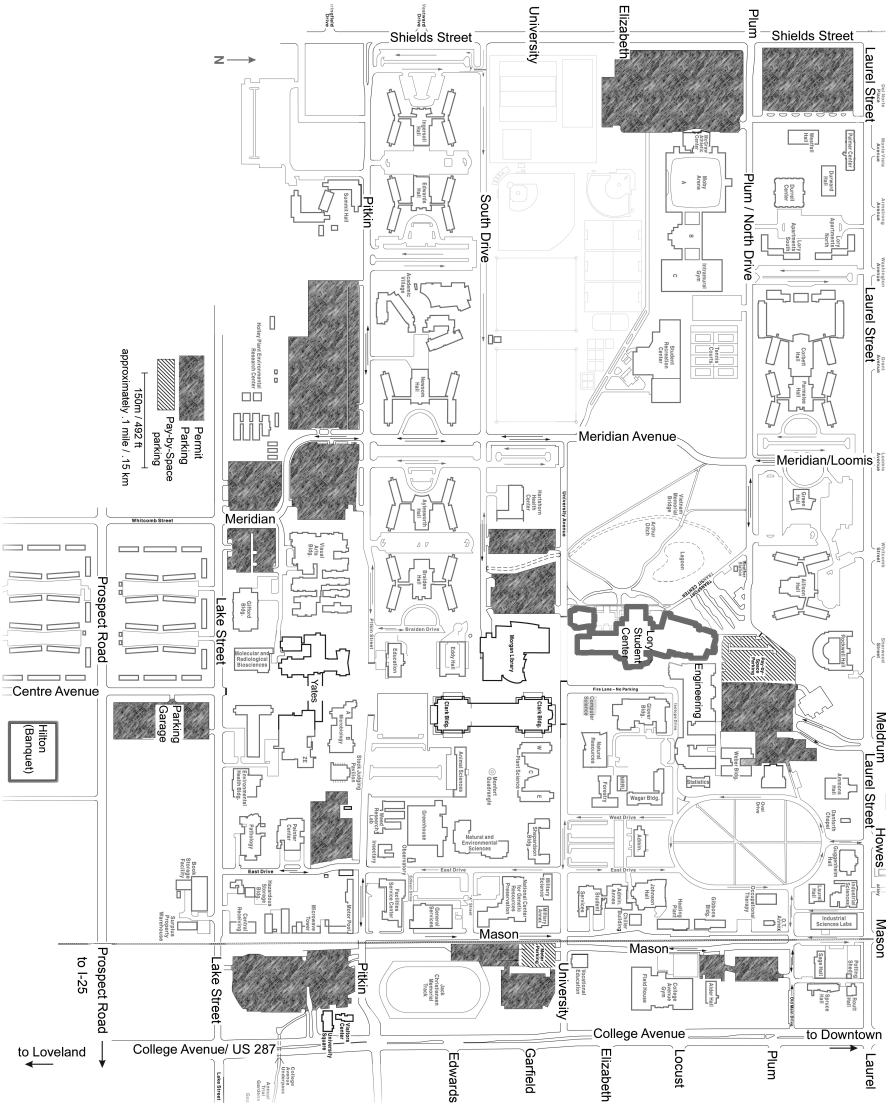
$Aut(S_6)$ and a bijection

While reading "A Description of the Outer Automorphism of S_6, and the Invariants of Six Points in Projective Space" (Howard, Millson, Snowden, Vakil), I became interested in a bijection between a set of six pentagons, and six sets of 20 triangles. I will explain the bijection and then consider some possibilities for generalizing this bijection to a polygon with n-sides. I will discuss some challenges that arise in generalizing this bijection and show where those challenges have led me.

Notes

Campus Map



The meeting takes place in the Lory Student center on campus. The confrence banquet will be in the Fort Collins Hilton, just south of campus. Parking on Friday before 4pm (and all time in the parking garage) requires a permit, there is a limited number of meters. Saturday parking in the open lots is free.

Internet Access is available via public terminals in Lory. We unfortunately cannot offer general internet access for private computers.

Food: The ground floor of the Lory Student Center holds a food court and coffee shop. They are closed on Saturday. A wide variety (in taste, style and price) of restaurants are available on Laurel Street and College (NE corner of Campus, 7 minutes walk) and (more upmarket) in Old Town (about half a mile north of Campus on College Avenue).

Rocky Mountain Section of the MAA

Section Chair Mike Brilleslyper, USAFA, Colorado Springs, CO 80840

Chair Elect Daluss Siewert, Black Hills State University, Spearfish, SD 57799

Vice Chair Sarah Pauley, Western Wyoming Community College, Rock Springs, WY 82902

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Program Chair Alexander Hulpke, Colorado State University, Fort Collins, CO 80523

We gratefully recognize our exhibitors and sponsors:

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The lanyards for the name tags were sponsored by Lisa Moller / Pearson Higher Education.

This booklet will be available in PDF format on the conference webpages.

Lory Student Center 2nd Level

http://www.math.colostate.edu/~hulpke/MAA/