Annual Meeting
of the
Pacific Northwest Section
of the

MATHEMATICAL ASSOCIATION OF AMERICA

Willamette University
Salem, Oregon

April 12–13, 2013

Annual Meeting
of the
Pacific Northwest Section
of the
Mathematical Association of America

Sponsored & Hosted by

Willamette University
Mathematics Department
College of Liberal Arts
Salem, Oregon
April 12–13, 2013

Friday, April 12

7:45	**Packet pickup for Project NExT** *Ford 102*		
8:00–2:30	**Project NExT Meeting** *Ford 102*		
3:00	**Minicourse:** **Closer to Fair: Social Justice in Mathematics, Mathematics for Social Justice [1]** *Ford 201*		**Minicourse:** **Cryptology [2]** *Ford 204*
5:30	**Student Reception & Packet Pickup** *Ford 2nd Floor Hearth*	**Project NExT Dinner (No Host) & Discussion**	
7:00		**Packet Pick-up**[1] *Ford 2nd Floor Hearth*	*5:45 The Ram* *Restaurant and Brewery* *515 12th Street* *503.363.1904*
8:00	**Friday Evening Lecture: Liz McMahon** *Error Detection and Correction in the Card Game SET^{TM}* **[3]** *Montag Center*		
9:15–10:15	**Reception** *Montag Center*		

[1] Packet pickup will also be available in Ford 2nd Floor Hearth from 2:00-3:30

Saturday, April 13

7:45		**Executive Committee Meeting** *Ford 222* *Ford Hall*
8:00	**Packet Pickup & Registration** *Ford 2nd Floor Hearth*	
9:15		**Introduction and Welcome:** Stephen E. Thorsett, Willamette University President **Invited Talk: Frank Farris** *Undercover Symmetry* **[4]** *Cone Chapel, Waller Hall*
10:45		**Contributed Talks** *Ford Hall 102, 201, 204, 222, 301, 302, 304*
12:45	**Lunch (provided)** *Cat Cavern, University Center 2nd Floor*	
1:15 1:50		**Business Meeting** *Cat Cavern, Dining Rooms 1 & 2*
2:00 3:00	**Invited Talk: David Kung** *Symphonic Equations: A Mathematical Exploration of Music* **[5]** *Cone Chapel* *Waller Hall*	
3:15	**Contributed Talks** *Ford Hall 102, 201, 204, 301, 302, 304*	
5:45	**Social Hour** *University Center 2nd Floor*	
7:00	**Banquet Dinner - Section Awards** *Cat Cavern, University Center 2nd Floor*	
8:30	**Invited Lecture: Liz McMahon** *Mathematics in the Game of SET™* **[6]** *Cone Chapel* *Waller Hall*	

Program of Contributed Papers

The program of contributed papers appears on the following pages. In some cases, titles or other information are abbreviated for reasons of space; please see the full abstract for more information.

A dagger (†) indicates which contributor(s) will present when multiple contributors are listed and fewer are presenting the work. An asterisk (*) indicates the contributor is an undergraduate student. Double asterisks (**) indicate the contributor is a graduate student.

Session Organizers

- *Math Circles & Math Teachers' Circles: Mathematical Problem Solving for Students and Teachers*: David Scott, University of Puget Sound
- *Games* : Mary Riegel and Jenny McNulty, University of Montana
- *Accommodations for Students with Low-Incidence Disabilities in College Mathematics* : Paul Krouss, Washington State University, Vancouver
- *Junior Faculty Research*: Hannah Callender, University of Portland
- *Undergraduate Research*: Dominic Klyve, Central Washington University
- *General Contributed Papers*: Chuck Dunn, Linfield College

Please contact the session organizer with any questions about a session.

Moderators: Please start each talk on time, but **not** early. Meeting participants often move between sessions and will want to be there when the talks are scheduled to begin.

Contributed Talks – Saturday Morning

	Interactive Session: Accommodations	Games	Junior Faculty Research
	Ford 222	*Ford 201*	*Ford 204*
10:45–11:00	**Interactive Session** **Paul Krouss, WSU Vancouver:** *Organizer* **Speakers:**	*Designer Board Games for the Interested Mathematician* [46] **Josh Laison, WU**	*A Somewhat Constructive Approach to the Mountain Pass Lemma and Its Variants* [12] **James Bisgard, CWU**
11:05–11:20	*Accommodating Blind Students in College Mathematics; An Amateur's Guide* [45] **Paul Krouss, WSU Vancouver**	*Turning off the Lights* [30] **Gary Gordon, Lafayette College**	*Generating the Brauer Group of the Function Field of a p-adic Curve* [53] **Kelly McKinnie, UMT**
11:25–11:40	*A Math Accommodation Success Story* [49] **Zach Lattin, Washington State School for the Blind**	*Introduction to Competitive Graph Coloring* [24] **Chuck Dunn, Linfield**	*Using Spatiotemporal Brain Connectivity Matrices to Estimate Cortical Activity from EEG* [32] **David Hammond, UO**
11:45–12:00		*Competitive Graph Coloring on Complete Multipartite Graphs* [60] **Nino Barrett, University of Rochester*** **Chuck Dunn, Linfield** **Jennifer Nordstrom, Linfield** **John Portin, Linfield** †* **Alexander Sistko, Bradley University***	*Methods for High-Dimensional Multivariate Repeated Measures Data under General Conditions* [36] **John Hossler, SPU**
12:05–12:20		*Modeling the Game "7 Wonders"* [29] **Ben Gardiner, WU**	*Undergraduate Speed Research, and the Sum-of-Divisors* [41] **Dominic Klyve, CWU**
12:25–12:40		*FIRE and ICE™* [63] **Mary Riegel, UMT**	*Emergent Reducibility of Cubic Polynomials* [61] **Jason Preszler, UPS**

Contributed Talks – Saturday Morning

	Student Papers 1	Student Papers 2
	Ford 301	*Ford 302*
10:45–11:00	*To Reach a Sum on Dice* [18] **Karen Cole, WOU** *	*Student Success in Prerequisite-Linked Mathematics Courses* [11] **Peter Banwarth , OSU****
11:05–11:20	*A Representation of $SO(4,2)$* [39] **Tevian Dray, OSU** **Josh Kincaid, OSU**†*	*The Cost of Drunkenness for the Game of Cops and Robbers* [69] **Molly Stubblefield, WOU***
11:25–11:40	*Exploring Infinite Sequences of Hitches* [47] **Hanna Landrus, PU***	*Relations between Klein Knots and Torus Knots I* [8] **Enrique Alvarado, Gonzaga***
11:45–12:00	*Analysis of the Hammer Throw* [48] **Jennifer Larson, WOU***	*Relations between Klein Knots and Torus Knots II* [62] **Brandon Reeves, Gonzaga***
12:05–12:20	*Mathematical Illiteracy Causes Financial Collapse: Incorrect Implementation of the Black-Scholes Model* [50] **Kaci Linton, PU***	*A Model: Pollution Decay and Purification of Lake Onondaga* [16] **Lindsay Callahan, WOU***
12:25–12:40	*Searching for Optimal Book Embeddings for Families of Graphs* [52] **Lauren Joplin, PU*** **Maria Mai, PU***	*Euclidean Tessellations and Regular Polygons in the Taxicab Plane* [58] **Thomas Pitts, OSU***

Contributed Talks – Saturday Morning

	Student Papers 3	General Papers 1
	Ford 102	*Ford 304*
10:45–11:00	*Dining Etiquette and Combinatorics* [43] **Isaiyah Kovachy, WOU** *	*Oral Reviews in Calculus: Improving Student Understanding* [34] **Allison Henrich, SU**
11:05–11:20	*Zero-Divisor Graphs of* 2×2 *Matrix Algebras* [13] **Meghan Blanchet, Gonzaga***	*'Hanging Ten': Measuring Big Wave Intensities* [51] **Nancy Livingston Potter, CPTC**
11:25–11:40	*A Note on* λ*-Permutations* [73] **Madelyn Twain, WOU***	*Orthogonal Cayley-Sudoku Tables* [77] **Mike Ward, WOU**
11:45–12:00	*Examining Tangle Compositions and Their Implications to Tricolorability* [17] **Christopher Cericola, SU***	*A Course in Spherical Geometry for Undergraduates* [78] **Marshall Whittlesey, CSUSM**
12:05–12:20	*Approximating Square Roots from the Integers to the Modulars* [10] **Jennifer AnDyke, WOU***	*Who is Prepared for Calculus 1?* [79] **Nicholas Willis, GFU**
12:25–12:40	*Euclidean Constructions and the Geometry of Origami* [80] **Jonathan Woodruff, WOU***	*Both Teams Played Hard: Methods for Ranking Basketball Teams* [31] **Chris Hallstrom, UP**

Contributed Talks – Saturday Afternoon

	Games/Math Circles	**Student Papers 4**	**Student Papers 5**
	Ford 201	*Ford 204*	*Ford 301*
3:15–3:30	*What Do Games Tell Us About Graphs?* [59] **Demitri Plessas, UMT**	*Dropping the Lowest Score: A Mathematical Analysis of a Common Grading Practice* [14] **Rosie Brown, WOU***	*Stable and Instability: Affine Drama of Transformations* [70] **Erika Stutts*and Michael Vandeberg*, GFU**
3:35–3:50	*The Link Smoothing Game* [37] **Inga Johnson, WU**	*Dodgson's Condensation Method for Calculating Determinants* [22] **Micah Donor*and Mitch Main*, GFU**	*Custom Locks: Counting the Combinations* [71] **Christopher Tasner, WOU***
3:55–4:10	*Navajo Nation Math Circles Project* [67] **Tatiana Shubin, SJSU**	*Zero-Sum Games* [26] **Jose Figueroa, WOU***	*Exotic Vector Spaces* [66] **Sarah Gilmore*and Josiah Shoemaker*, GFU**
4:15-4:30	*Notes from the Missoula Math Circle* [54] **Kelly McKinnie, UMT**	*The Prime Values of a Quadratic Polynomial* [9] **Matt Anderson, WU***	*Perfect Shuffling* [27] **Emily Flora, WOU***
4:35-4:50	*What is a Math Wrangle?* [67] **Tatiana Shubin, SJSU**	*The Spider and the Fly* [76] **Zihao Wang*and Hailey Meekins*, GFU**	*Computer AI for the Game of Go* [25] **Kyle Evitts*†et al., Linfield**
4:55-5:10	*What Makes a Math Teachers' Circle* [64] **David Scott, UPS**	*Winning at Rock, Paper, Scissors* [42] **Tyler Koglin*and Jake Larson*, GFU**	*Newcastle Disease in Wild Parrots: Building a Mathematical Model* [33] **Cassy Hanson, WOU***

Contributed Talks – Saturday Afternoon

	General Papers 2 *Ford 302*	Student Papers 6 *Ford 304*	Student Papers 7 *Ford 102*
3:15–3:30	*Linear Algebra and Digital Signal Processing* [7] **Mohamed Allali, Chapman University**	*Mathematical Resilience in Biological Systems* [38] **Eric Keller, UAS***	*Application of Pólya Enumeration Theorem to Non-Isomorphic Graphs* [35] **Sky Hester, WWU** *
3:35–3:50	*A Hybrid Statistical and Point-Neuron Simulation Environment for Neuronal Simulation* [15] **Nicholas Cain, Allen Institute**	*How Art Can Become Mathematical Proof?* [75] **Debra Virden, WOU***	*Iterative Congressional Redistricting* [40] **Evan Kleiner, Whitman***
3:55–4:10	*Teaching Calculus for Transfer, Assessing Conceptual Understanding* [19] **Noelle Conforti Preszler, UW** **Jason Preszler, University of Puget Sound**	*Generalized Ramsey Numbers for Near-Diagonal Pan Graphs and Relatively Prime Tadpole Graphs* [56] **Timothy Perisho, SPU***	*Ta-Yen Encryption* [44] **Anna Kralovec, WOU***
4:15-4:30	*What's New in WeBWorK* [20] **Robin Cruz, C of I**	*Cyclic Permutations of Claps and Patterns* [74] **Cydney Tyler, WOU***	*The Combinatorial Structure of PS-Ear Decomposable Graphs* [57] **Nima Imani, UW** * **Lee Johnson, SU** * **McKenzie Keeling-Garcia, SU** * **Steven Klee, SU** **Casey Pinckney, SU** †*
4:35-4:50	*Cubies* [23] **Tevian Dray, OSU**	*Cases of Dirichlets Theorem* [21] **Raven Dean, CWU***	*The Role of Linear Independence* [65] **Ariel Setniker, WOU***
4:55-5:10		*Pan-Magic Cayley Sudoku Tables: An Undergraduate Research Experience* [55] **Rosanna Mersereau, WOU***	*Pascal Matrices* [28] **Eva Forrester, PU***

Social Events

Thursday Project NExT Gathering
7:00 Venti's Café and Taphouse, 2840 Commercial St SE, 503.391.5100
No Host

Friday Project NExT Dinner
5:45 The Ram Restaurant and Brewery, 515 12th Street, 503.363.1904
No Host

Friday Student Reception
5:30–7:30 Ford 2*nd Floor Hearth*

Friday Invited Lecture
Error Detection and Correction in the Card Game SET™
Liz McMahon [3]
8:00 Montag Center

Friday Reception
9:15 Montag Center

Saturday Morning: Coffee, Pastries, & Fruit
8:00–11:00 Ford 2*nd Floor Hearth*

Saturday Lunch
12:45 Cat Cavern, University Center 2*nd Floor*

Saturday Afternoon: Coffee
2:00–5:00 Ford 2*nd Floor Hearth*

Saturday Evening Social Hour
5:45 University Center 2*nd Floor*

Awards Ceremony and Banquet Dinner
7:00 University Center 2*nd Floor*

MC: Josh Laison

Introduction of new Section Project NExT Fellows

Presentation of 25- and 50-year MAA membership certificates

PNW MAA Distinguished Teaching Award

Saturday Evening Invited Lecture
Mathematics in the Game of SET™
Liz McMahon [6]
8:30 Cone Chapel

Campus Information

WiFi is available to conference participants in the following locations:

- In Ford Hall, the Willamette Guest network (no password necessary)
- In the Mark O. Hatfield Library and J.W. Long Law Library, the Public network (no password necessary)

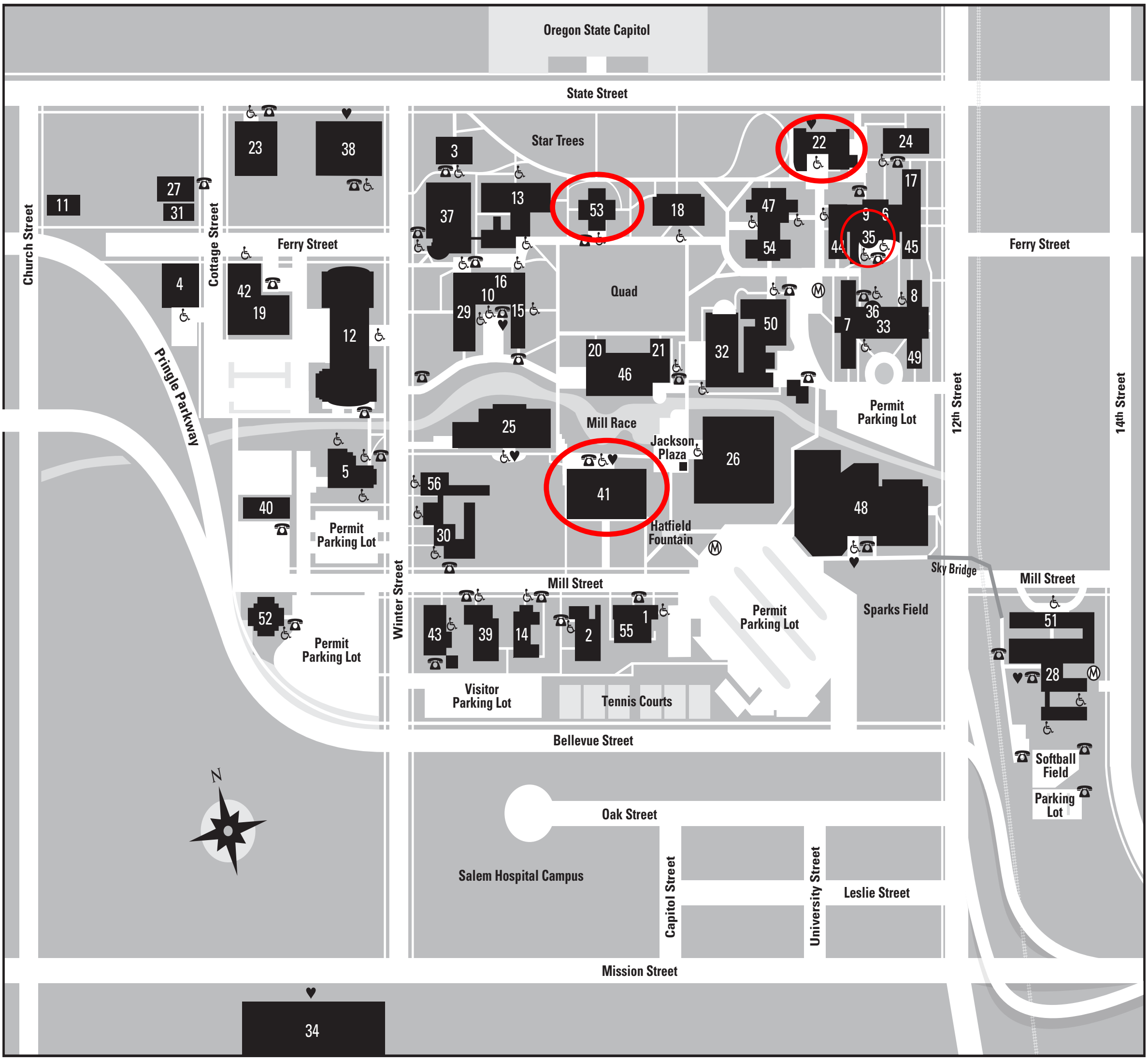
Parking:

- Friday during the day you can park in the (paid) Visitor Parking Lot at the corner of Bellevue and Winter streets.
- Friday afternoon and Saturday you can park in any lot marked “Permit Parking Lot” on the campus map at no charge. The closest is the lot adjacent to Sparks Field off Bellevue Street.

Willamette Campus Safety:

- Police/Fire/Medical Emergency: 911
- Campus Safety: 503-370-6911

WILLAMETTE UNIVERSITY CAMPUS MAP



1 Admission Office (CLA)
2 Alpha Chi Omega Sorority
3 Art Building
4 Atkinson Annex
5 Atkinson Graduate School of Management (Seeley G. Mudd Building)
6 Baxter Hall
7 Belknap Hall
8 Beta Theta Pi Fraternity
9 Bishop Wellness Center
10 Campus Safety
11 Centers for Academic Excellence
12 College of Law (Truman Wesley Collins Legal Center)
13 Collins Science Center
14 Delta Gamma Sorority
15 Doney Hall
16 Doney North Offices
17 East House
18 Eaton Hall
19 Executive Building
20 Fine Arts West
21 Fine Arts East
22 Ford Hall
23 Hallie Ford Museum of Art
24 Gatke Hall
25 Goudy Commons
26 Mark O. Hatfield Library
27 Haseldorf Apartments
28 Kaneko Commons
29 Lausanne Hall
30 Lee House
31 Mahoney Building
32 Mary Stuart Rogers Music Center (Hudson Hall)
33 Matthews Hall
34 McCulloch Stadium and Athletics Complex
35 Montag Center
36 Office of International Education and the Writing Center
37 Olin Science Center
38 Oregon Civic Justice Center
39 Pi Beta Phi Sorority
40 Physical Plant
41 Putnam University Center
42 School of Education and Willamette Academy
43 Shepard House
44 Sigma Chi Fraternity
45 Sigma Alpha Epsilon Fraternity
46 Smith Auditorium
47 Smullin Hall
48 Lestle J. Sparks Center
49 Terra House
50 Theatre Playhouse
51 Tokyo International University of America
52 University Apartments
53 Waller Hall
54 Walton Hall
55 Willamette International Studies House (WISH)
56 York House

♿ Handicapped Access
☎ Emergency Telephone
♥ Automated External Defibrillator
Ⓜ Short-term Parking Meters

9/18/09

Acknowledgments

Without a lot of people's hard work, this meeting would never have happened. Thanks go out to (in no particular order):

- Project NExT Coordinator Jenny McNulty and Project NExT Local Arrangements Chair Colin Starr for organizing the Section NExT meeting.
- Program Co-Chair for Contributed Talks Chuck Dunn for organizing the contributed sessions, and editing this program.
- Dominic Klyve for organizing the undergraduate student talks.
- David Scott, Mary Riegel, Jenny McNulty, Paul Krouss, and Hannah Callender for organizing contributed paper sessions.
- Kathryn Nyman and Chris Linn for coordinating all the food for the conference.
- Mark Janeba for organizing the book sale.
- Yumi Li for designing the conference website and coordinating with the hotels.
- Colin Starr and Brian Hoyt for handling registration and implementing the registration webform.
- Mitch Jones and Jeff Schreiner-McGraw for handling all the technology for the conference.
- Trina Morgan and Nicole Rodgers for printing and editing name badges and other conference documents.
- Hans Nordstrom, Chris Hallstrom, Erin McNicholas, and Nancy Neudauer for sage advice, moral support, and general helpfulness.
- Math club officers Georgia Mayfield, Marla Williams, and Katie Tucker for organizing math club help with the student social event and manning the registration table and book sale.
- Dean Marlene Moore and Willamette alum Jim Albaugh for providing funding for the conference.
- Liesa Kister for scheduling all the rooms.
- Jeff Bolt for setting up all the rooms.
- All the conference speakers and participants for making the conference awesome.

Thanks everyone!

Josh Laison

Local Arrangements Chair

Minicourse Descriptions

Friday, April 13

1 *Closer to Fair: Social Justice in Mathematics, Mathematics for Social Justice*

David Kung, St. Mary's College of Maryland

The world is an unfair, unjust place. What can math teachers do about it? This talk will focus on two specific ways mathematicians have worked to address issues of social justice both in our classrooms and in our world. The first half of the workshop will focus on the inequalities that pervade mathematics and science classrooms and what people have done to help level the playing field, especially in college math classrooms. In the second half, we will look at how math teachers are using innovative curricula to raise awareness of social justice issues while simultaneously teaching math content. These courses ask students to use the tools of mathematics to study, understand, and even address issues ranging from economic inequity to environmental impacts. Sample classroom activities will illustrate the types of content that might replace the algebra-intensive curriculum for many humanities students.

2 *Cryptology*

Stuart Boersma, Central Washington University
Cheryl Beaver, Western Oregon University

The codebreaking competition, KRYPTOS, is the week following the PNW-MAA meeting. Come and hear about KRYPTOS, learn about some ciphers, and test your skills at cryptanalysis! Helpful online cryptanalysis tools will be shared with participants together with some tried and true pencil and paper techniques. Students are particularly encouraged to attend!

Abstracts of Invited Talks

(in chronological order)

3 *Error Detection and Correction in the Card Game SET™*

Liz McMahon, Lafayette College

We begin with a variation of the game of SET™, which makes use of a parity check. This allows us to detect (but not correct) one error made in the play of the game. More analysis of this situation leads us to define a Hamming distance on the deck of cards; we can use this distance to classify different categories of non-sets, three cards that do not form a set. The metric also gives us a perfect single error-correcting code.

4 *Undercover Symmetry*

Frank A. Farris, Santa Clara University

Spend some time with the images shown, which, according to the usual classification, have exactly the same symmetry type. Something seems different about the right-hand image: Why do the yellow/pink bowties seem to have mirror symmetry, which are not symmetries of the pattern as a whole? Why are they set at such strange angles relative to the orientation of the grid of red dots? These strange features led me to discover new types of symmetry in wallpaper patterns, with unexpected connections to such things as eigenvalues of a Laplacian and the length spectra of orbifolds.

5 *Symphonic Equations: A Mathematical Exploration of Music*

David Kung, St. Mary's College of Maryland

Mathematics and music seem to come from different spheres (arts and sciences), yet they share an amazing array of commonalities. We will explore these connections by examining the musical experience from a mathematical perspective. The mathematical study of a single vibrating string unlocks a world of musical overtones and harmonics - and even explains why a clarinet plays so much lower than its similar-sized cousin the flute. Calculus, and the related field of differential equations, shows us how our ears hear differences between two instruments - what musicians call timbre - even when they play the same note at the same loudness. Finally, abstract algebra gives modern language to the structures beneath the surface of Bach's magnificent canons and fugues. Throughout the talk, mathematical concepts will come to life with musical examples played by Willamette students and the speaker, an amateur violinist.

6 *Mathematics in the Game of SET™*

Liz McMahon, Lafayette College

The card game SET™is played with a special deck of 81 cards. There is quite a lot of mathematics that can be explored using the game. Well look at questions in combinatorics, probability, linear algebra, and especially geometry. The deck is an excellent model for the finite affine geometry $AG(4,3)$ and provides an entry to surprisingly beautiful structure theorems for that geometry. If youd like some practice before the talk, go to www.setgame.com for the rules and a Daily Puzzle.

Abstracts of Contributed Talks

(in alphabetical order, by presenter)

7 *Linear Algebra and Digital Signal Processing*

Mohamed Allali, Chapman University

Many realistic and interesting applications have already been incorporated into a standard linear algebra course. However, digital signal processing tools have not been used extensively in linear algebra. In this talk, I will show through many practical and easy to implement examples how digital signal processing can be incorporated into linear algebra. This approach makes the course more visual and interesting for instructors and students.

8 *Relations between Klein Knots and Torus Knots I*

Enrique Alvarado, Gonzaga University †*
Brandon Reeves, Gonzaga University*
Kaia Hlavacek, Gonzaga University*

Knot theorists have devoted a considerable amount of attention to torus knots, which are knots embedded on the surface of an annulus. Some classes of torus knots act as a fundamental building blocks. In contrast, knot theorists seem to devote little attention to knots embedded on the surface of a Klein bottle. In this talk, we will introduce the notion of these two types of knots by discussing their similarities and differences. No background is needed.

9 *The Prime Values of a Quadratic Polynomial*

Matt Anderson, Willamette University*

The prime numbers are not well understood. There are many open problems regarding prime numbers. For example, it is not known if x^2+1 has an infinite number of prime values for integer x. I have analyzed a trinomial, and described a way to find all the cases that x^2+x+41 has a factor less than 1000.

10 *Approximating Square Roots from the Integers to the Modulars*

Jennifer AnDyke, Western Oregon University *

In this Presentation, we will explore various methods for approximating square roots. We consider a few methods that deal with approximating the square root of an integer. Next, we continue our exploration into the integers modulo a prime number. These methods are used in certain cryptology applications.

11 *Student Success in Prerequisite-Linked Mathematics Courses*

Peter Banwarth, Oregon State University**

Most university students enroll in lower-level mathematics courses that follow a prerequisite sequence. A common concern among mathematics educators is that students who earn a C in the first term of a prerequisite sequence face a disproportionate risk of failing the second term of the sequence compared to students who earn a B or higher. In this poster I will present some results of a statistical analysis of the effect of student grades in the first term of a mathematics prerequisite sequence on success in the second term of the sequence. I will demonstrate that while C students are at a higher risk of failing the second term than B students, this higher risk can be explained by an analysis of combinatorial outcomes, and does not indicate that the risk of failing among C students is disproportionately high. Additional comments and interpretations of the analysis will be welcomed, with a specific intention to generate strategies for increasing student success in prerequisite-linked mathematics courses.

12 *A Somewhat Constructive Approach to the Mountain Pass Lemma and Its Variants*
James Bisgard, Central Washington University

The Mountain Pass Lemma and its variants are important tools in nonlinear analysis, especially in proving the existence of solutions to a large variety of differential equations, and their proofs tend to be very abstract. In this talk with lots of pictures, we will outline a (somewhat) constructive proof and explain the geometry and intuition behind them. Hopefully, the proof and intuition will make the Mountain Pass Lemma and its variants accessible to a more general audience.

13 *Zero-Divisor Graphs of* 2×2 *Matrix Algebras*
Meghan Blanchet, Gonzaga University *

A zero-divsor graph is a graph constructed from a ring, where the vertex set is the elements of the ring, and there is an edge from a to b whenever $ab = 0$. This poster describes the classification of zero-divisor graphs for 2×2 matrix algebras over $\mathbb{Z}/p\mathbb{Z}$ where p is any prime number.

14 *Dropping the Lowest Score: A Mathematical Analysis of a Common Grading Practice*
Rosie Brown, Western Oregon University*

A common grading practice among educators has been to drop low test, quiz, or homework scores to help students in their classes. Although there exist simple cases in which it is easy to determine which scores should be kept and which scores should be dropped, there are many more complex cases that require an algorithm to solve. I will be discussing different ideas for how to easily determine the best set of scores to keep, why some methods do not work, and will go into detail about an efficient algorithm.

15 *A Hybrid Statistical and Point-Neuron Simulation Environment for Neuronal Simulation.*
Nicholas Cain, Allen Institute for Brain Science†
Ramakrishnan Iyer, Allen Institute for Brain Science
Vilas Mennon, Allen Institute for Brain Science
Michael Buice, Allen Institute for Brain Science
Tim Fliss, Allen Institute for Brain Science
Christof Koch, Allen Institute for Brain Science
Stefan Mihalas, Allen Institute for Brain Science

How can the immense dimensionality of a whole-brain neuronal simulation be reduced to a problem of tractable size? The central nervous system expresses phenomena that can be mathematically modeled at multiple spatial scales. Choosing the proper scale to generate scientific understanding requires a tradeoff between tractability and realism. For example, well-parameterized and detailed neuronal simulations are currently limited to modeling systems that are several orders of magnitude smaller than the entire mammalian nervous system. We propose a mathematical modeling framework that incorporates and leverages this diversity of spatial scales. We combine fast semi-analytic numerical methods to solve equations describing homogeneous neuronal populations with more conventional neuronal simulation environments. The populations are characterized by an equation for the voltage probability density of leaky integrate-and-fire neurons with shot-noise synapses (master equation), and interactions are modeled with current-based synaptic transmission. This approach allows simultaneous investigation of coarse-grain and fine-grain phenomena with relatively small amounts of computational resources. The ultimate goal of this method is to help bridge the gap between high-dimensional neuronal simulations and functional understanding of the mammalian nervous system.

16 *A Model: Pollution Decay and Purification of Lake Onondaga*
Lindsay Callahan, Western Oregon University*

This study builds mathematical models based on compartmental analysis to analyze the behavior of mercury contaminants in Lake Onondaga, Syracuse, New York, an uncontrolled hazardous waste site that falls under the federal government's Superfund cleanup program. Beginning with a basic decay model and concluding with an equilibrium shift model that are used to analyze the behavior of mercury; the contaminant, during different environmental situations in Lake Onondaga. The analysis of the information from our models is compared to models and data obtained in previous studies. The models in our study are used to predict the amount of time necessary to reduce the levels of mercury to a given percentage or to obtain equilibrium under certain conditions.

17 *Examining Tangle Compositions and Their Implications to Tricolorability*
Christopher Cericola, Seattle University *

Tangles have a very interesting properties concerning tricolorability. Kauffman devised a black-box approach for tangles embedded in braids that can be extrapolated to general tangles through examining how colors are forced through tangle compositions. This gives a simple way to determine the invariant of tricolorability of a knot formed from the closure of tangle composition.

18 *To Reach a Sum on Dice*
Karen Cole, Western Oregon University *

There are usually many different ways to count the same thing. For this presentation, we will count the number of ways we can reach a sum if we throw so many dice. Using combinatorics we will develop a formula to give us the number of possible ways to reach the sum and then take that over the total possibilities. Then we will examine a recursion method where we look at finding a sum less than k on one less die and finding the difference on the remaining die. Lastly, we will consider generating functions that resemble the first method. We will also consider the case of extending these methods to dice of non-conventional shapes such as those with eight sides.

19 *Teaching Calculus for Transfer, Assessing Conceptual Understanding*
Noelle Conforti Preszler, University of Washington †
Jason Preszler, University of Puget Sound†

Results from a qualitative case study of mathematics professors' calculus teaching at one small liberal arts college will be used to frame a discussion with the audience about assessing conceptual calculus understanding. The study considered mathematics professors' perspectives about the required nature of calculus in various disciplines, and attempted to identify how calculus instructors teach with the aim of preparing students to apply calculus knowledge in their future coursework Results suggest that the professors acknowledge the role of mechanical skills in calculus learning, but ultimately strive for conceptual understanding by students. However, professors struggle to find acceptable ways to assess students' conceptual understanding. Audience members will be asked to share attempts to assess conceptual understanding in calculus with the goal of furthering collective knowledge of calculus teaching practices.

20 *What's New in WeBWorK*
Robin Cruz, The College of Idaho

Several new developments in versions 2.6 and 2.7 will affect the next upgrade of your WeBWorK installation. These include the move from the NationalProblemLibrary (NPL) to the OpenProblemLibrary (OPL), the essayQuestions and Achievements features, and the integration of R into statistics problems. Model courses for standard math courses are in development; in this talk, the model course for *Introductory Statistics* is demonstrated.

21 *Cases of Dirichlet's Theorem*
Raven Dean, Central Washington University

Mathematicians have been fascinated by primes for at least twenty-five hundred years. In 300 BC Euclid proved that there are infinitely many primes. Since that time mathematicians have continued to study and make breakthroughs in the study of primes. Today primes are absolutely essential to the study and use of cryptology. In this talk we will be discussing primes in certain arithmetic progressions. We will go over Dirichlet's theorem, which states that if a and d are positive integers with no non-trivial common factors, then there are infinitely many primes in the sequence $a, a+d, a+2d, a+3d$. We will then mention some easy cases of Dirichlet's theorem. Since the proof of general Dirichlet's theorem is very difficult we will prove Wendt's case. By comparison, the proof of Wendt's case (there are infinitely many primes in the sequence, $1, 1+d, 1+2d, ..., d \in \mathbb{Z}$) is simple as it only requires a little abstract algebra and some properties of cyclotomic polynomials.

22 *Dodgson's Condensation Method for Calculating Determinants*
Micah Donor and Mitch Main, George Fox University *

In 1866, Charles Ludwidge Dodgson (a.k.a. Lewis Carroll) published a paper regarding determinants. In it, he determined a method based on a well known theorem of determinants (Jacobi's Theorem). The method provides a very efficient process to calculate determinants of large matrices, using determinants of consecutive 2 x 2 minors. Because the method requires divisions by the interior, there can be problems when zeroes reside in the interior of the matrix; but, by using row operations, they can be avoided. Despite this weakness, the method circumvents half the calculations required for normal calculations of determinants.

23 *Cubies*
Tevian Dray, Oregon State University †
John Huerta, Instituto Superior Técnico (Lisboa)
Corinne A. Manogue, Oregon State University
Robert A. Wilson, Queen Mary University of London

The Freudenthal-Tits magic square of Lie algebras parameterizes certain Lie algebras in terms of two division algebras; the octonionic cases describe 4 of the 5 exceptional Lie algebras. As part of an ongoing effort to understand this construction at the group level, we describe the third, quaternionic, row of this magic square in terms of "cubies", the components of antisymmetric rank-3 representations of (generalized) symmetric groups. This leads to a new interpretation of the minimal representation of the exceptional group E_7, with possible relevance to particle physics.

24 *Introduction to Competitive Graph Coloring*

Chuck Dunn, Linfield College

We consider the following two-person game played on a finite graph G with a set of r colors. Alice and Bob alternate coloring the vertices (or edges) of G. At each step of the game, the players must use legal colors, where the definition of legal depends on which variation of the game being played. We will examine a number of these variations on a number of classes of graphs. We will present known results and provide a number of open problems.

25 *Computer AI for the Game of Go*

Kyle Evitts, Linfield College †∗
Emily Amundson, Trinity University∗
Jason Galbraith, Sunset High School
Sam Stewart, Lewis and Clark∗
Ryan Takahashi, Harvey Mudd College∗
Vincent Zhuang, Westview High School
Nick Sylvester, Lewis and Clark∗
Jet'aime Mullins, Lewis and Clark∗

The game of Go is one of the few board games at which computers cannot reliably best human professional players. In this presentation we talk about our work last summer in an REU at Lewis and Clark college to improve Orego our computer go playing AI.

26 *Zero-Sum Games*

Jose Figueroa, Western Oregon University ∗

Two people zero-sum games are some of the most popular games in game theory. Each player has a finite set of pure strategies. Some-zero sum games have a pure strategy equilibrium .The output from playing the pure strategies that result on equilibrium guarantees a payoff to each player. When a zero-sum game doesn't have equilibrium by just using pure strategies, the concept of mixed strategies is used. So in order to argue that an equilibrium pair of mixed strategies exists, then the Minimax Theorem can be used. The Minimax Theorem says that there exists an equilibrium pair of mixed strategies for any two people zero-sum game, hence each player's highest security level equals at equilibrium.

27 *Perfect Shuffling*

Emily Flora, Western Oregon University ∗

Using a system of equations to model the output of perfect shuffles provides fascinating relationships between the original card position, rational numbers, orbits, and the corresponding binary representations. These relationships can be used to determine when particular cards return to their starting positions and link deck sizes directly to orbit lengths.

28 *Pascal Matrices*

Eva Forrester, Pacific University†∗
Gilbert Strang and Alan Edleman, MIT

This is a paper written by Gilbert Strang and Alan Edelman professors from MIT in 2004. They begin by putting the famous Pascal triangle into a matrix. By truncating they find that it can go into a lower triangular L, an upper triangular or symmetrical matrix S:

$$L = \begin{bmatrix} 1 & & & \\ 1 & 1 & & \\ 1 & 2 & 1 & \\ 1 & 3 & 3 & 1 \end{bmatrix} \quad U = \begin{bmatrix} 1 & 1 & 1 & 1 \\ & 1 & 2 & 3 \\ & & 1 & 3 \\ & & & 1 \end{bmatrix} \quad S = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 2 & 3 & 4 \\ 1 & 3 & 6 & 10 \\ 1 & 4 & 10 & 20 \end{bmatrix}$$

These binomial numbers are derived in three ways:

1. Recursion
2. A formula for $\binom{i}{j}$
3. The coefficients of $(1+x)^i$

The amazing result comes in the discovery that $S = L \times U$ for a 4×4 matrix. This factorization and its comprising matrices reveal some interesting and unexpected properties. I will illustrate the different ways to prove the result. I will be presenting their work in poster form, as I find their work quite fascinating and with potential for further investigations.

29 *Modeling the Game "7 Wonders"*
Ben Gardiner, Willamette University*

In the ever-growing field of artificial intelligence and machine learning, we utilize simplified models for complex sets of decisions as forums to measure the efficiency and overall 'intelligence' of the program. One such set of modeling systems is board games, for which there are clearly a series of complex decisions that interact with each other to form a strategy, and these decisions can be modeled using a tree of possible game states. In this talk, we will discuss the rules and strategy of the game "7 Wonders," and how probability based weights are assigned to nodes of the tree to model the decisions involved in a simplified version of the game.

30 *Turning off the Lights*
Gary Gordon, Lafayette College

The game "Lights Out!" is played with 25 buttons arranged in a 5 by 5 grid, where each button is either on or off. Pressing a button changes the parity of that button and all its neighbors. Given an initial on-off configuration, which buttons should you push to turn off all the lights? Does every configuration admit a solution? We'll use linear algebra to answer both of these questions and explore (briefly!) some generalizations.

31 *Both Teams Played Hard: Methods for Ranking Basketball Teams*
Chris Hallstrom, University of Portland

In this talk, I will discuss and compare a variety of methods used for ranking basketball teams. I will also discuss some applications of these methods to the problem of seeding a post-season tournament.

32 *Using Spatiotemporal Brain Connectivity Matrices to Estimate Cortical Activity from EEG*
David K. Hammond, NeuroInformatics Center, University of Oregon

Electroencephalography (EEG) data consist of voltages on the scalp surface generated by cortical current activity inside the brain. Estimating these cortical currents is a highly underdetermined inverse problem, and generally requires imposing some regularization by assuming prior knowledge about the cortical activity. Recent developments in diffusion weighted MRI imaging allow the non-invasive measurement of the white matter fibers forming these connections, enabling construction of a weighted graph representing brain connectivity. In this talk I will discuss recent work on extending this type of spatial brain connectivity graph into a spatiotemporal connectivity graph that enables joint spatiotemporal estimation of cortical sources from time-series EEG measurements. This procedure involves introducing spatiotemporal edges added in a manner modeling signal delays due to finite axonal propagation velocity. Regularization is given by penalizing sums of squares of differences across the spatiotemporal edges. I will discuss solving the resulting variational problem by conjugate gradients, and compare against a related purely spatial approach which does not exploit temporal regularity.

33 *Newcastle Disease in Wild Parrots: Building a Mathematical Model*
Cassy Hanson, Western Oregon University *

We begin with a commonly known *SIR* disease model, and demonstrate the process of adapting it to a specific wild life population. Our model considers the somewhat likely “what if” scenario of a particularly virulent disease, specifically Newcastle Disease, finding its way into a species of wild parrots in the jungles of Peru. We find that population density along with two stages of the disease that respond differently in young versus mature birds, make this model especially challenging, but we expect that it will lend itself nicely to future modeling situations.

34 *Oral Reviews in Calculus: Improving Student Understanding*
Allison Henrich, Seattle University

Oral reviews are hour-long, ungraded opportunities for students, working with faculty or advanced students, to negotiate meaning, make conceptual connections, discuss why procedures work, and draw representations that make concepts clearer. Incorporating oral reviews into calculus classes has proven to significantly improve student performance. In this talk, we’ll look in more detail at what oral reviews are, see how they have been implemented, and give evidence of their benefit to students.

35 *Application of Pólya Enumeration Theorem to Non-Isomorphic Graphs*
Sky Hester, Western Washington University *

An essential question in characterizing the space of all possible graphs is to know how much variety there is among graphs of a given order. In other words, how many essentially different graphs of order p are there? Or, more specifically, how many non-isomorphic graphs exist of order p and size q? In order to answer these questions, we will explore the dynamic interplay between group actions and generating functions, allowing us to enumerate varieties of structures while accounting for their inherent symmetry. Along with the presentation of the exact number of graphs having p vertices and q edges for $p \leq 15$, this exposition demonstrates visually the method by which these numbers are determined.

36 *Methods for High-Dimensional Multivariate Repeated Measures Data under General Conditions*
Solomon W. Harrar, The University of Montana
John Z. Hossler, Seattle Pacific University †

With technological, research, and theoretical advancements, the amount of data being generated for analysis is growing rapidly. In many cases, the number of subjects may be small, but the number of measurements taken on each subject may be very large. To address these types of phenomena, we present inferential procedures in two-factor repeated measures multivariate analysis of variance (RM-MANOVA) models where the covariance structure is unknown and the number of measurements per subject tends to infinity. Both in the univariate case, in which the number of dimensions or response variables is one, and the multivariate case, in which there are several response variables, different sums of squares and cross product matrices are proposed to compensate for the unknown structure of the covariance matrix and unbalanced group sizes. Based on the new matrices, we present some multivariate test statistics, giving their asymptotic distributions under fairly general conditions.

37 *The Link Smoothing Game*
Inga Johnson, Willamette University

A knot can be viewed as a closed loop of string in space. Knots are studied mathematically by looking at a regular projection of the knot onto a plane that is then decorated to include crossing information. In this talk we discuss a topological combinatorial games that uses the regular projections of knots and links as their initial game board. The Link Smoothing game is played by two players that take turns smoothing crossings, one player with the goal of disconnecting the projection and the other player moves to keep it connected. We will study scenarios where winning strategies for these two games are known and discuss open questions.

38 *Mathematical Resilience in Biological Systems*
Eric Keller [*†], Dr. Megan Buzby, University of Alaska Southeast, Mentor

Resource managers have long been interested in the stability of ecological systems. Stability is assumed to be an important ecosystem property or “statistic” because organisms can only adapt to changes slowly, but what is stability and how do you measure it? Stability, very simply, describes a system’s ability to remain constant in character over time. While there are numerous ways to refer to stability, there are really only three properties that it is influenced by: constancy, persistence, and resilience. Resilience can be thought of as a measure of a system’s ability to return to some previously defined state (usually an equilibria) after some shift from that state occurs. We construct several definitions of resilience, then explore implementations of each using methods such as Monte Carlo. The intention of these definitions is to inform management strategies for (potentially) complex ecosystems, given by a system of differential equations.

39 *A Representation of $SO(4,2)$*
Joshua Kincaid, Oregon State University [†]**
Tevian Dray, Oregon State University

An explicit representation of SO(4,2) is constructed using 4×4 matrices with elements in $\mathbb{H}' \otimes \mathbb{C}$. We also express the known isomorphism between the conformal group and $SO(4,2)$ in terms of this representation. This construction generalizes to matrices with elements in $\mathbb{K}' \otimes \mathbb{K}$ for $\mathbb{K}'$ any split algebra over the reals and $\mathbb{K}$ any normed division algebra over the reals. In particular, one has a representation for each of the groups appearing in the 2×2 Freudenthal-Tits magic square.

40 *Iterative Congressional Redistricting*
Evan Kleiner, Whitman College †*
Albert Schueller, Whitman College

Every ten years, the federal government conducts a census. After the census, each state is assigned a number of seats in the House of Representatives according to its population. Currently, this process is quite politicized. We present a redistricting algorithm (and applet) that emphasizes equal populations and compact districts. This iterative algorithm divides population evenly and creates compact districts. It also allows for human input after each iteration based on a scoring algorithm that emphasizes minimum perimeter districts. It meets the equal population and compactness criteria quite well, but fails to preserve county lines, city limits, and census tracts (and other important traits). The paper and applet are currently under review at the MAA's Loci on-line journal and can be viewed at http://carrot.whitman.edu/MathDL! The applet is written in the open source Processing-JS language, a simple library that allows Processing applications to be embedded in web pages.

41 *Undergraduate Speed Research, and the Sum-of-Divisors*
Dominic Klyve, Central Washington University

This talk has two purposes. First, we will discuss an unusual undergraduate research experience in which faculty and students have one week to try to do original mathematics. Second, we will discuss the results of one such research project, in which we worked with the classical sum-of-divisors function.

42 *Winning at Rock, Paper, Scissors*
Tyler J. Koglin, Jake C. Larson, George Fox University*

This presentation suggests two strategies to help beat a human opponent at Rock, Paper, Scissors. The strategies are based on knowledge that no player has a truly random selection process. In the presentation there is also a similar game that is introduced where the strategies are put to the test.

43 *Dining Etiquette and Combinatorics*
Isaiyah Kovachy, Western Oregon University *

In this article we look at a scenario where dinner guests are seated one by one randomly around a circular table and choose a napkin to their left or right depending on their preference. Given that there is only a one-to-one ratio of napkins to guests, it is obvious that some will most likely end up without a napkin. We consider combinatorial techniques to analyze this problem from several viewpoints and use these methods to find the percentage of people without a napkin. In the case of large groups, this solution will depend only on the preference of the guests.

44 *Ta-Yen Encryption*
Anna Kralovec, Western Oregon University *

The Ta-Yen cipher is a new cryptosystem based on the Chinese Remainder Theorem. In this talk we explore this system by learning how to encrypt and decrypt. The system affords benefits over other cryptosystems for keeping data secure in the cloud.

45 *Accommodating Blind Students in College Mathematics: An Amateur's Guide*
Paul Krouss, Washington State University Vancouver

Over the past academic year, I have had a blind student in my second semester calculus and linear algebra courses. With only a few weeks' notice and not much experience with blind students at this level of mathematics, we found it necessary to act quickly and creatively to accommodate this motivated student. In this talk, I will discuss the accommodations we made, what worked well, and what could be improved upon. Attendees' experiences and insights are most welcome during this presentation. Because blind math students are not a monolithic group, this is not meant to serve as a recipe that works for every individual. Rather, I will also describe my approach at taking apart my class functions and the collaborative method of constructing student solutions.

46 *Designer Board Games for the Interested Mathematician*
Josh Laison, Willamette University

In recent years "designer" board games (so called because the designer's name is printed on the box) have seen an explosion of popularity, in part because of their availability in stores like Target, and in electronic form on iOs devices. Many of these games have a mathematical component in their design, mechanisms, or strategy. In this talk we'll give several examples of designer board games, their connections to mathematical research, and their potential for incorporation in the classroom.

47 *Exploring Infinite Sequences of Hitches*
Hanna Landrus, Pacific University *

A hitch is a tangle about a pole. When climbing a hitch could save a climber's life; when sailing a hitch could prevent a boat from floating away. In this talk we will present a model for determining when a hitch will hold, in particular we will relate the determinate of a matrix to the friction required for the hitch to hold. We will then use this model to further explore hitches. This exploration includes sequences of hitches, as well as hitches with a restricted number of crossings. We will explore two sequences of hitch and how the minimum friction to hold changes as the pattern in these hitches is repeated infinitely. We will show that the determinate resulting from one of our hitch sequences has a closed form that relates to Pascal's Triangle.

48 *Analysis of the Hammer Throw*
Jennifer Larson, Western Oregon University *

In this paper, we develop the vector function representing the position equation for a model depicting the projectile of an object. The model developed considers the effect of air resistance. Furthermore, we analyze the optimal angle for the projectile to achieve maximum height and distance. Specifically, we consider the hammer throw and compare the theoretical range with the experimental range.

49 *A Math Accommodation Success Story*
Zach Lattin, Washington State School for the Blind

I am a working professional who is totally blind from birth. I graduated from the University of Washington with a degree in pure mathematics. In this session, I will discuss some of the accommodation's that the UW and I worked out, from extended time on visual differential geometry exams to converting symbol-heavy combinatorics textbooks from LaTeXto braille. Time Permitting, I will give a demo of the use of Maple and math eBooks in conjunction with screen-reading software.

50 *Mathematical Illiteracy Causes Financial Collapse: Incorrect Implementation of the Black-Scholes Model*
Kaci Linton, Pacific University*

The Black-Scholes formula is a mathematical model used to find the value of a European call option in a manner that nearly eliminates risk. Upon publishing the formula, the buying and selling of options increased significantly. The Black-Scholes formula assumes ideal market conditions and derives a partial differential equation, commonly referred to as the Black-Scholes construction; the solution to the PDE is the Black-Scholes model. We investigate what is needed in order for the model to produce accurate results and find that the parameters must follow a normal distribution. It is thought that invalid assumptions of ideal conditions in the market directly contributed to the financial market collapse in 2008. We attempt to determine which parameters do not follow normal distributions and analyze the weaknesses of the Black-Scholes model. In the market situation of 2008, the stock price followed a fat-tailed distribution. Often compared to the normal distribution, fat-tails exhibit a large kurtosis which means observations far from the mean are more likely to occur as compared to normally distributed occurrences. This lead to an incorrect implementation of the Black-Scholes model and ultimately contributed to the financial market collapse in 2008.

51 *'Hanging Ten': Measuring Big Wave Intensities*
Nancy Livingston Potter, Clover Park College

Today, the entire world is feeling the effects of the 2011 Honshu earthquake/tsunami event. The Cascadia subduction zone, which spans over 800 miles, extending from Vancouver Island to northern California, is soon expecting its 500-year quake with magnitude 8+ to be followed by a tsunami. Much attention is being given to planning for this expected disaster and its after-effects: landslides, fires, hazardous material spills, building damages, etc. The devastating effects of tsunami events include millions of deaths and billions of dollars in damages. Over the years numerous attempts have been made to quantify tsunami severity but none have been completely satisfactory. We define a quantitative measure of tsunami severity and show it to be an improvement by comparing the 'Top 10 Lists' of devastating tsunami as calculated by each measure. Finally, based on our own research in statistical modeling, we will offer an implementation strategy for multidisciplinary student projects aimed at the planet earth.

52 *Searching for Optimal Book Embeddings for Families of Graphs*
Presenters: Maria Mai and Lauren Joplin, Gonzaga University *

A standard n-book is a line in 3-space (called the spine), together with n half-planes (the pages), joined together at the spine. A graph is embedded in a book by ordering the vertices along the spine and placing the edges within the pages of the book so that no two edges cross each other or the spine. The book-thickness of a graph G is the smallest number of pages needed to embed G in a book. This presentation will explore optimal book embeddings for certain families of graphs and show how evolutionary algorithms can be used to find near-optimal embeddings for other families of graphs.

53 *Generating the Brauer Group of the Function Field of a p-adic Curve*
Kelly McKinnie, The University of Montana

I will discuss what it means to generate the Brauer group by classes of cyclic algebras. From there we will discuss the specific case of the Brauer group of $Q_{p(t)}$ and function fields of other p-adic curves.

54 *Notes from the Missoula Math Circle*
Kellie McKinney, University of Montana

The "Missoula: Math Beyond the Classroom" program is a relatively recent startup. It is an after school enrichment program aimed at interested 8-12th graders. We have had great success with a once yearly math enrichment program and are in the process of figuring out the best way to extend this success to our Math Beyond the Classroom program. I will discuss some parts of our program, including a foray into virtual meetings.

55 *Pan-Magic Cayley Sudoku Tables: An Undergraduate Research Experience*
Rosanna G. Mersereau, Western Oregon University †*
Michael B. Ward, Western Oregon University, Mentor

A Cayley Sudoku Table (C-S Table) is the Cayley table of a finite group arranged (unconventionally) so that the body of the Cayley table is divided into blocks containing each group element exactly once, as in a sudoku puzzle. The second author and his students introduced C-S Tables in *Mathematics Magazine* **83** (2010) pp. 130-139. In this talk we introduce Pan-Magic C-S Tables in which each block of the C-S Table is a pan-magic square. That is, the (group) sum of the entries in each row, each column, each of the two major diagonals and each of the broken diagonals of each block equals the same fixed group element. Examples, theorems, and open questions suitable for undergraduate research are included.

56 *Generalized Ramsey Numbers for Near-Diagonal Pan Graphs and Relatively Prime Tadpole Graphs*
Timothy Perisho, Seattle Pacific University*

In this paper we use two original methods to find and prove new Ramsey number formulas for certain tadpole graphs based upon known Ramsey number formulas for arbitrary cycle graphs. A tadpole graph $Q_{n,t}$ is formed by connecting one end of a path graph on t points (called the "tail") to a cycle of size n (called the "head"). A pan graph Q_m is defined as a tadpole graph with $t = 1$. First we use an intuitive counting method to prove exact Ramsey number formulas for all "near-diagonal" pan graphs, i.e. those pairs of pan graphs where the maximum cycle size of the pair is no more than $\frac{5}{2}$ times the minimum cycle size. Then, we demonstrate a number-theoretic method to find exact Ramsey numbers for arbitrarily far-from-diagonal tadpole pairs, with arbitrarily long tails. However, the second method requires that the tadpoles meet number-theoretic constraints (rather than size constraints). For example, in the diagonal cases, $n-1$ must be relatively prime to $n+t$, where either $n-1$ has an odd order $(\bmod\, n+t)$ or the additive inverse of $n-1$ has an even index relative to $n-1$ $(\bmod\, n+t)$. We demonstrate that these "scattered" on- and off-diagonal results provide upper bounds on the Ramsey numbers for other tadpole pairs that fail to meet the number-theoretic constraints. Finally, we develop an algorithm for finding pairs that meet the constraints and give a table of small cases. We also include miscellaneous results for some other graphs containing a single cycle.

57 *The Combinatorial Structure of PS-Ear Decomposable Graphs*
Nima Imani, University of Washington *
Lee Johnson, Seattle University *
McKenzie Keeling-Garcia, Seattle University *
Steven Klee, Seattle University
Casey Pinckney, Seattle University †*

A graph is PS-ear decomposable if it can be decomposed as a union of a short cycle and short paths. In this talk, we will present a canonical way in which to represent a PS-ear decomposable graph that will make its combinatorial structure easier to understand. This representation gives rise to a natural connection between PS-ear decomposable graphs and families of monomials that encode this combinatorial data. Our work is a first step toward a more general approach of solving a longstanding conjecture about the combinatorial structure of matroids that was made in the late 1970's by combinatorialist Richard Stanley.

58 *Euclidean Tessellations and Regular Polygons in the Taxicab Plane*
Thomas Pitts, Oregon State University *

Tessellations are planes made from repetitions of geometric shapes without gaps or overlaps. Tesselations exist in elliptic, hyperbolic and Euclidean geometries, but tessellations in Euclidean geometry are perhaps the most widely known and explored. Of particular interest are *regular tessellations*, tessellations which, in Euclidean geometry, are made of equilateral and equiangular polygons. We have an intuitive notion of what it means to be equilateral under the usual Euclidean metric, but how does a change of metric affect equilateral and regular Euclidean polygons? Here we explore Euclidean tessellations viewed under a different metric, namely the taxicab metric. First, we examine how the three regular Euclidean tessellations change when viewed under the taxicab metric. After observing that regularity is not preserved by our change of metric, we redefine regular polygons to be equilateral polygons under the taxicab metric. With this definition in hand, we explore new options for regular tessellations, and in particular show that we are not limited to tessellations of triangles, squares, and hexagons as we are under the Euclidean metric.

59 *What Do Games Tell Us About Graphs?*
Demitri Plassas, University of Montana

By their very nature, games engage students. Games are also great for teachers; they foster collaboration and investigation. The focus of this talk will be about how games can be used to teach concepts in Graph Theory. By playing games on graphs, students can be introduced to major concepts such as graph vertex coloring, and Ramsey Theory. The analysis of games also helps determine graph parameters and graph algorithms with a variety of applications. We will survey these results and investigate how we can add game playing to our graph theory curriculum.

60 *Competitive Graph Coloring on Complete Multipartite Graphs*
Nino Barrett, University of Rochester*
Chuck Dunn, Linfield College
Jennifer Nordstrom, Linfield College
John Portin, Linfield College $^{\dagger *}$
Alexander Sistko, Bradley University*

Competitive graph coloring is investigated by studying a two-player game on a finite graph G with a set of r colors. The players alternate coloring the vertices of G. In the k relaxed coloring game, a color c is legal for a vertex whenever that vertex has already at most $k-1$ neighbors previously colored c. At each step of the game the players must use a legal color. We will show results about the 0, 1, and 2-relaxed game chromatic number of complete multipartite graphs.

61 *Emergent Reducibility of Cubic Polynomials*
Jason Preszler, University of Puget Sound

In this talk we will discuss the problem of when an irreducible polynomial composed with itself *n* times can become reducible, referred to as emergent reducibility. After a brief summary of recent results on the quadratic case, we will focus on what can be extended to the case of cubic polynomials.

62 *Relations between Klein Knots and Torus Knots II*
Brandon Reeves, Gonzaga University †*
Enrique Alvarado, Gonzaga University*
Kaia Hlavacek, Gonzaga University*

Building on the previous talk, we will present our results about Klein knots and consider the claim that Klein knots are uninteresting. Within this talk, we discuss the necessary and sufficient conditions for obtaining a knot on a Klein bottle as opposed to several linked components of knots. Further, we find the surprising result that a specific class of Torus knots rests at the heart of every Klein knot or link. A basic understanding of modular arithmetic is beneficial, but not required, for this talk.

63 *FIRE and ICE™*
Mary J. Riegel, University of Montana

The game of FIRE and ICE™: "A mystic struggle for a great line of power" is a two player game designed by Jens-Peter Schliemann. By manipulating the rules of play, Schliemann has created an interesting variation on Tic-Tac-Toe that is easy to learn but difficult to master. The board of the game involves joining Fano Planes into an interesting configuration that has many layers of symmetry one can and must explore in an analysis of the game. In this talk we will explore not only this game, but also some of the variations that it has inspired. In particular we will consider strategies for certain situations, boards inspired by the game, and a dynamic version of Tic-Tac-Toe that changes the outcome for this classic game.

64 *What Makes a Math Teachers' Circle*
David Scott, University of Puget Sound

What is involved in running a Math Teachers' Circle? Three and a half years of things learned.

65 *The Role of Linear Independence*
Ariel Setniker, Western Oregon University *

Linear independence is one of the main defining characteristics in vector space theory as it guarantees a unique representation in terms of basis vectors. Further, we can expand the concept of linear independence with the study of frames, which generalize the idea of a basis while allowing for more desirable traits. In this talk we examine certain collections of functions, both finite-dimensional and infinite-dimensional, and the necessary conditions for linear independence within. In closing, we take a look at linear independence as applied to wavelet theory.

66 *Exotic Vector Spaces*
Sarah Gilmore and Josiah Shoemaker, George Fox University *

A lot of linear algebra textbooks often spend large amounts of time covering vector spaces. The paper we researched and expanded upon is actually written to linear algebra teacher's and professors about how to help student's gain a better understanding of vector spaces. Examining a general formula, we take specific examples and utilize them to explain vector addition and scalar multiplication and how diverse you can make these vector spaces and how easily you can transition this into more challenging, exotic vector spaces.

67 *Navajo Nation Math Circles Project*
Tatiana Shubin, San Jose State University

The goal of the Navajo Nation Math Circles Project is to develop and demonstrate the Math Circle concept in the Native American community, simultaneously creating math circles for students, and a math teachers circle network which will promote the culture of problem solving among all members of the community. Together these two components will bring more Native Americans into mathematics and other STEM fields. What makes this project unique and exciting is the fact that implementing a familiar math circle model on the Navajo Nation territory has specific challenges. We will talk about these difficulties and of our approach to overcoming them.

68 *What is a Math Wrangle?*
Tatiana Shubin, San Jose State University

A Math Wrangle is one way of encouraging problem solving. What is it?

69 *The Cost of Drunkenness for the Game of Cops and Robbers*
Molly Stubblefield, Western Oregon University *

The Game of Cops and Robbers was first presented in the 1980's. Since then, this graph theoretical game has been studied extensively. In this presentation we will consider a version in which the robber is drunk, meaning the robber chooses which neighboring vertex to move to with equal probability. We will consider what affect the drunkenness has on the capture time on various game boards.

70 *Stable and Instability: Affine Drama of Transformations*
Erika Stutts and Michael Vandeberg, George Fox University*

Affine Maps can be used to define graphical transformations that generate fractals, which have the interesting property of containing both linear and nonlinear terms. In this presentation, we will outline a method by which specific affine maps can be rewritten as higher dimension linear transformations. Using this method, we define a relation from affine map stability analysis to linear stability analysis, with a specific emphasis on eigenvalues. This linear approach can then be applied to a larger span of transformations, including the original fractal generating maps.

71 *Custom Locks: Counting the Combinations*
Christopher Tasner, Western Oregon University *

Counting the possible entries in a standard combination lock is trivial when we recognize that any lock with buttons 1 to n will have precisely $n!$ combinations. In this presentation, we explore different methods of counting combinations when the buttons on our lock can be pushed simultaneously. Using recurrence relations and generating functions to derive formulas, we see that it is possible to count the number of combinations of any such lock with buttons 1 to n.

72 *A Brief Tour of the Art Gallery Problem*
Anne Trefry, Whitworth University

The Art Gallery Problem is an interesting question that question that draws from Computational Geometry and Graph Theory, and has numerous variations. In its most basic form it is an interesting application of graph coloring. This talk will introduce participants to the basic problem, and then consider variations such as the right-angled gallery.

73 *A Note on λ-Permutations*
Madelyn Twain, Western Oregon University *

λ-permutations are a new and exciting discovery when it comes to the world of rearranging series. First mentioned by S.G. Krantz and J.D. McNeal in 2004, they have the ability to preserve convergence in convergent series, and rearrange conditionally divergent series to make them converge. This presentation is an expansion of D.J. Velleman's 2006 paper *A Note on λ-Permutations*, defining and exploring the properties of λ-permutations.

74 *Cyclic Permutations of Claps and Patterns*
Cydney Tyler, Western Oregon University *

In this study we look at the different repeated patterns that come from songs. We will remove any indication of different pitches and only look at sound vs. no sound, which can be represented in claps and pauses. The question that we are trying to answer is the following: if we have a combination of claps and pauses, then how many distinct songs can we make? As part of our solution, we allow the repeated pattern to cycle endlessly to create a distinct song. In order to avoid double counting, we will use cyclic permutations along with the Burnside's Lemma to find the number of patterns that are fixed and the number of distinct songs respectively.

75 *How Art Can Become Mathematical Proof?*
Debra Virden, Western Oregon University *

In this paper, we investigate certain mathematical relationships from a geometric perspective. We prove these relationships in one or more of the following ways, algebraic, geometric and dissection proofs. Specifically, dissection proofs are aesthetically pleasing since they use tessellations that are found in many art forms such as paintings, quilting, and architecture to name a few.

76 *The Spider and the Fly*
Zihao Wang, Hailey Meekins, George Fox University*

Description: Henry Ernest Dudeney's famous problem, The Spider and the Fly, seeks to find the geodesic from a spider to a fly in a rectangular room. We explore Keith E Mellinger and Raymond Viglione's article which places the spider 1 ft. away from the ceiling on a wall of equal length and width and the fly on the opposing wall 1 ft. away from the floor. Many would think the shortest path would be when the spider traverses straight across the ceiling and drops down to the fly; however Mellinger and Raymond discover that this is not always the case. We then consider a fly that is not motionless. Through an algebraic approach, we seek to find the dimensions of the room which change what path the spider should take to reach the fly in the shortest time.

77 *Orthogonal Cayley-Sudoku Tables*
Michael Ward, Western Oregon University

A Cayley-Sudoku table [CS table] is the Cayley table of a finite group arranged (unconventionally) so that the body of the Cayley table may be divided into blocks containing each group element exactly once, as in a sudoku puzzle. The speaker and his students introduced CS tables in MATHEMATICS MAGAZINE (2010). Since every Cayley table is a (bordered) Latin square, the existence of an orthogonal mate is of interest. Cayley tables having orthogonal mates are known as a consequence of the recently proven Hall-Paige Conjecture. We are interested in the (possibly) more restricted question: "Which CS tables have orthogonal mates that are still CS tables?" We present a preliminary existence theorem and apply it to some groups. Above all, we hope some Latin square expert in attendance will lend insight on this entire matter!

78 *A Course in Spherical Geometry for Undergraduates*
Marshall Whittlesey, California State University San Marcos

A century ago, spherical geometry (the study of geometric objects on the surface of a 3-dimensional ball) was a standard part of the mathematics curriculum in high schools and colleges. Its applications were needed by many people: anyone who wanted to navigate on the surface of the earth by using the stars needed to know something about the subject. However, in the decades since the 1940s, it has slowly disappeared from the curriculum for most students, and today most mathematicians only learn about it as a short topic in geometry survey courses. In this talk we survey some of the standard theorems of spherical geometry and compare them to those of plane geometry. These include: (1) the spherical law of cosines and how to use it easily to determine the distance between two cities (2) the spherical Pythagorean theorem, unknown to most mathematicians and how it compares with the plane Pythagorean theorem (3) the AAA congruence theorem for spherical triangles, a surprising contrast to plane geometry where AAA only guarantees similarity of triangles and (4) the area theorem for triangles which states how to calculate the area of a spherical triangle from its angles. We also will discuss some of the interesting applications of spherical geometry in astronomy, mainly how to determine the time of sunrise and sunset. We also briefly mention applications of spherical geometry to crystallography and the study of the regular polyhedra (e.g., how explicitly to construct them and how to determine the angles between faces.) We suggest spherical geometry as a good subject for future high school teachers to learn, but also think more mathematicians should be generally aware of its theorems and applications.

79 *Who is Prepared for Calculus 1?*
Nicholas J. Willis , George Fox University†
Sarah Gilmore, George Fox University∗

Have you ever wondered if students who have seen a little Calculus in high school are really any better prepared for Calculus 1 that students who have not had any Calculus? What really indicates success in college Calculus? These two questions will be explored using the last four years of freshman Calculus students at George Fox University as a sample.

80 *Euclidean Constructions and the Geometry of Origami*
Jonathan Woodruff, Western Oregon University ∗

Origami is an art that bears the potential to benefit mathematics. We explore an axiom system of origami geometry that is equivalent to the Euclidean geometry axiom set. In this process, we find that origami possesses a special axiom that is impossible to execute by Euclidean methods. This special axiom permits us to find the cubic root of the length of a segment, solve general cubic equations, and trisect angles. We also discover that parabolas play a key role in the geometry of origami.