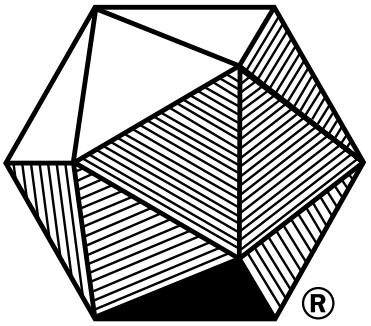
Annual Meeting

of the

Pacific Northwest Section

of the

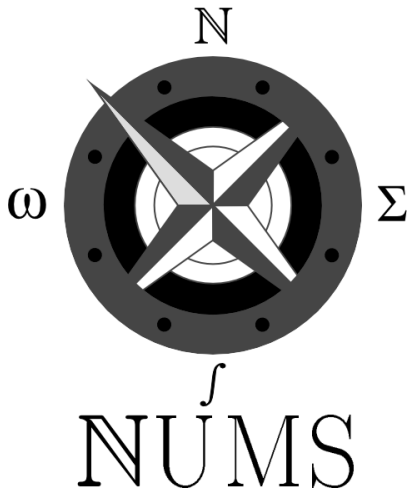


MAA

MATHEMATICAL ASSOCIATION OF AMERICA

together with the

7th Annual Northwest Undergraduate Mathematics Symposium



University of Washington Tacoma

Tacoma, Washington

April 10–11, 2015

Annual Meeting
of the
Pacific Northwest Section
of the
Mathematical Association of America
and the
Northwest Undergraduate Mathematics Symposium

Sponsored & Hosted by

University of Washington Tacoma
Tacoma, Washington

April 10–11, 2015

Friday, April 10

8:00	**Project NExT Meeting** *Dougan 201*	
2:00 2:45	**Registration** *William Philip Hall Entry*	
3:00 5:30	**Minicourse: Shannon Overbay & Thomas McKenzie** *Leadership Workshop* **[1]** *JOY 211*	**Minicourse: Gwen Fisher** *Using Mathematics to Design Beadwork* **[2]** *JOY 210*
5:30	**Student Marshmallow Challenge** *Sponsored by UWT Math Club* *JOY 117*	
7:30	**Registration** *William Philip Hall Entry*	
8:00 8:50	**Public Invited Lecture: Francis Su** *My Favorite Math Fun Facts* **[3]** *James A. Milgard Family Assembly Room, WPH*	
8:50	**Reception** *Columbia Bank Lobby, WPH*	

Saturday, April 11

7:30		**Executive Committee Meeting** *Holiday Inn Express Meeting Room*	
8:00			
9:00	**Registration** *Lobby WPH*	**Introduction and Welcome: Dr. Bill Kunz** Vice-Chancellor of Academic Affairs University of Washington Tacoma	
9:15		**Invited Lecture: Tevian Dray** *The Geometry of Relativity* **[4]**	
10:15	**Book Sale** *First Floor JOY*	*James A. Milgard Family Assembly Room, WPH*	
10:45		**Concurrent Talks** *JOY 105, 106, 109, 110, 113, 114, 206*	
12:45			
12:45		**Lunch (provided)** *WPH*	
1:30			**Business Meeting** *WPH*
2:00			
2:00	**Invited Lecture: Francis Su** *Combinatorial Fixed Point Theorems* **[5]** *James A. Milgard Family Assembly Room, WPH*		
3:00			
3:00	**Booksale**	**MAA 100th Birthday Celebration!** *JOY Atrium*	
3:30	**Poster Session** **3:15–4:00** *First Floor JOY*		
3:30		**Concurrent Talks** *JOY 105, 106, 109, 110, 113, 114, 206*	
5:30			
5:30	**Social Hour** *The Swiss*		
7:00			
7:00	**Banquet Dinner - Section Awards** *Jane Thompson Russell Commons, WPH*		
8:30			
8:30	**Invited Lecture: Gwen Fisher** *Mathematical Bead Weaving* **[6]** *James A. Milgard Family Assembly Room, WPH*		
9:20			

Program of Special Sessions and 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.

Sessions and Organizers

- *Active Learning Symposium*: Craig McBride, University of Washington Tacoma
- *Mathematical Modeling*: Julie Eaton, University of Washington Tacoma
- *Open Source X*: Daniel Heath, Pacific Lutheran University
- *Social Justice*: Ksenija Simic-Mueller, Pacific Lutheran University
- *Improving Undergraduate Programs*: Michael Boardman, Pacific University
- *NUMS Student Papers and Posters*: Nathan Gibson, Oregon State University
  - NUMS I: Optimization and COMAP
  - NUMS II: Calculus, ODE, and Linear Algebra
  - NUMS III: Probability and Number Theory
  - NUMS IV: Geometry
  - NUMS V: Combinatorics and Games
  - NUMS Posters
- *General Contributed Papers*: Ryan Card & Ruth Vanderpool, University of Washington Tacoma
  - Contributed I: Current trends in research
  - Contributed II: Topology
  - Contributed III: Pedagogy
  - Contributed IV: Fun and Games

Please contact the session organizers 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.

Saturday Morning Concurrent Sessions

	Active Learning Moderator: Craig McBride *JOY 106*	**Open Source X** Moderator: Daniel Heath *JOY 109*	**Modeling I** Moderator: Julie Eaton *JOY 206*
10:45–11:10	*Using Game Theory to Foster Inquiry and Writing* [54] **Jennifer Nordstrom, Linfield College**	*Authoring Open Source Mathematics Textbooks* [9] **Robert Beezer, University of Puget Sound**	*One versus two doses: what is the best use of vaccine in an influenza pandemic?* [45] **Laura Matrajt, Fred Hutchinson Cancer Research Center**
11:15–11:40	*Prospective Elementary School Teachers' Reconceptualization of Factors* [62] **Matt Roscoe, University of Montana**	*Open Educational Resources in Math—including a report of success using an open textbook for introductory statistics* [67] **David Straayer, Tacoma Community College**	*Numerical Analysis and Mathematical Biology* [81] **Brandy Wiegers, Central Washington University**
11:45–12:10	*How to use Active Learning Activities in a Flipped Mathematics Classroom* [46] **Craig McBride, University of Washington**	*SageMathCloud – collaboratively use Sage, IPython, LaTeX, and terminals in your browse* [66] **William Stein, University of Washington**	*Measuring Waves* [55] **Katie Oliveras, Seattle University**
12:15–12:40	*Leading Off-Campus Courses for Math Students* [25] **Chuck Dunn, Linfield College**	*A Comprehensive Introduction to Using WeBWorK* [20] **Dibyajyoti Deb, Oregon Institute of Technology**† **Joe Reid, Oregon Institute of Technology**† **Cristina Negoita, Oregon Institute of Technology**† **David Rosoff, College of Idaho**† **Robin Cruz, College of Idaho**† **Jim Fischer, Oregon Institute of Technology**†	*Asymptotic Behavior of Traveling Wave Solutions to Reaction-Diffusion Equations* [50] **Malley Nason, Linfield College***

Saturday Morning Concurrent Sessions		
	Contributed I: Research Moderator: Ingrid Horakova *JOY 105*	**Contributed II: Topology** Moderator: Courtney Thatcher *JOY 110*
10:45–11:10	*Isomorphy classes of finite order automorphisms of SL(2,k)* [10] **Robert Benim, Pacific University**[†] **Mark Hunnell, North Carolina State University**[**] **Amanda Sutherland, North Carolina State University**[**]	*Klein Links and Related Torus Links* [11] **Steven Beres, Gonzaga University**[*†] **Kaia Hlavacek, Gonzaga University**[*]
11:15–11:40	*Some Current Trends in Cryptography* [41] **Peter Horak, University of Washington Tacoma**	*Orbifolds via Groupoids* [72] **Courtney Thatcher, University of Puget Sound**
11:45–12:10	*Multiplicative Functions and Generalized Binomial Coefficients* [64] **Michael Spivey, University of Puget Sound**[†] **Tom Edgar, Pacific Lutheran University**	*Cohomology of Finite General Linear Groups* [65] **David Sprehn, University of Washington Seattle**[**]
12:15–12:40	*Families of Generalized Catalan Numbers* [26] **Tom Edgar, Pacific Lutheran University**[†] **Michael Spivey, University of Puget Sound**	*Martin-Lof randomness for Bernoulli measures* [8] **Logan Axon, Gonzaga University**

Saturday Morning Concurrent Sessions		
	NUMS I: Opt & COMAP Moderator: Ruth Vanderpool *JOY 113*	**NUMS II: Calc, ODE, Linear** Moderator: Olga Shatunova *JOY 114*
10:45–10:55	*Integer Solutions to Box Optimization Problems* [32] **Lorna Fullmer*, George Fox University**	*The Calculus of Rainbows* [36] **Agnes Guerry*, Shoreline Community College**
11:00–11:10	*Portfolio Optimization: A Modeling Perspective* [14] **Camarie Campfield*, Western Oregon University**	*Characterization of the Elliptical Pendulum* [59] **Anthony Podvin*†, David Laman, Aric Washines*, Heritage University; Sarah Moats**, Pacific Northwest University of Health Sciences**
11:15–11:25	*The Chipset Problem* [21] **Doug DePrekel, Central Washington University***	*The Intermediate Value Theorem-Obvious or Not?* [40] **Edward Hernandez-Corchado*, George Fox University**
11:30–11:40	*SIR Model for 2015 COMAP* [71] **Daniel Takamori*†, Clarice Mottet*†, James Rekow*†, Oregon State University**	*Differential Equations & CAS's: An Encounter with Uniquness* [29] **Samantha Fall*, Gonzaga University**
11:45–11:55	*A Whole-Ebola-Trouble* [52] **Zach Nilsson*†, Jeremy Bard*†, Katie Hamann*, Eastern Oregon University**	*Solving Ordinary Differential Equations* [60] **Victor Rielly*, Pacific University**
12:00–12:10	*Using Aircraft Trajectory and Ocean Surface Vectors to Assist in Locating Lost Vessels* [22] **Lauren DeVore*†, Alexander Ogle*†, James Knox*†Linfield College**	*Matrices* [77] **Kari Treese*†, UW Tacoma; Josh Spires*, UW Seattle**
12:15–12:25	*Looking to MARS to Locate Missing Aircraft* [16] **Grant Cates*†, Zakaria El Amrani Elidrissi*, Thomas Shearer*, Linfield College**	*The 400 Billion Dollar Algorithm* [63] **Luis Solis-Bruno*, University of Washington Tacoma**
12:30–12:40	*LOST: Finding an Oceanic Flight for Dummies* [61] **Graham Romero*†, Delaney Aydel*†, Alleta Maier*†, Linfield College**	*Singular Value Decomposition and its applications* [35] **Giovanna Graciani*, University of Washington Tacoma**

Saturday Afternoon Concurrent Sessions		
	Undergraduate Programs Moderator: Michael Boardman	**Social Justice** Moderator: Ksenija Simic-Muller
	JOY 105	*JOY 106*
3:30–3:55	*Designing the Major: The CUPM Curriculum Guide* [12] **Michael Boardman, Pacific University**	*Reparations as a Theme for a joint Mathematics-Political Economy Course* [47] **Paul McCreary, The Evergreen State College**† **Anthony Zaragoza, The Evergreen State College**
4:00–4:25	*Proposed Math Major at UWT* [79] **Ruth Vanderpool, University of Washington Tacoma**† **UWT Math Faculty, University of Washington Tacoma**	*The revolt against Algebra II (including StatWay experience)* [68] **David Straayer, Tacoma Community College**
4:30–4:55	*Technique versus Truth: promoting gradual mastery of mathematical theory.* [18] **Joshua Cole, Pacific University**	**Contributed III: Pedagogy** *Teaching Probability with Categorical Data* [76] **Terri Torres, Oregon Tech**
5:00-5:25	*Doing Less, Better* [19] **Lynda Danielson, The College of Idaho**∗† **Robin Cruz, The College of Idaho**∗†	*Putting differentials back into calculus* [24] **Tevian Dray, Oregon State University**

Saturday Afternoon Concurrent Sessions		
	Contributed IV: Fun and Games Moderator: Ryan Card	**Modeling II** Moderator: Julie Eaton
	JOY 109	*JOY 206*
3:30–3:55	*The Prisoners Paradox* [53] **Gail Nord, Gonzaga University**	*Laminar Model for the Development of the Visual System* [56] **Andrew Oster, Eastern Washington University†** **Paul Bressloff, University of Utah**
4:00–4:25	*The Lion and the Man* [15] **Ryan Card, University of Washington Tacoma**	*Modeling Two Common Business Decision Errors* [70] **Jeffrey Stuart, Pacific Lutheran University**
4:30–4:55	*Straightedge & Compass Constructions in Spherical Geometry* [39] **Daniel J Heath, Pacific Lutheran University†**	*Deconstructed Conductance: Axial and Radial Contributions to Water Flow* [44] **Frank Lynch, Eastern Washington University†** **Gretchen North, Occidental College**
5:00-5:25	*i-Block Transitive Tilings by Convex Pentagons* [48] **Jennifer McLoud-Mann, University of Washington Bothell†** **Casey Mann, University of Washington Bothell**	

Saturday Afternoon Concurrent Sessions			
	NUMS III: Prob. & Number Theory Moderators: Alan Barlett	**NUMS IV: Geometry** Yajun An	**NUMS V: Combinatorics & Games** Nathan Gibson
	JOY 110	*JOY 113*	*JOY 114*
3:30–3:40	*Trapezoidal Numbers* [38] **Christopher Hartman, Western Oregon University***	*The Stereographic Cylindrical Spherical Projection* [37] **Tara Hanst*, Southern Oregon University**	*Graph Theory and Sprouts* [82] **Derek Zeis, Western Oregon University***
3:45–3:55	*Markov Chains* [73] **Lane Thomason*, Southern Oregon University**	*Circumscribed polygons and circles* [51] **Duong Nguyen*, University of Washington Tacoma**	*Finite Linear Games: Exploring Math Behind Puzzles* [34] **Kirsten Grace*†, Lisa Smith*, University of Washington Tacoma**
4:00–4:10	*Pell's Equation and Continued Fractions* [58] **Kyle Peterson, Western Oregon University***	*Mean Curvature Flow of Tori of Revolution* [33] **Colin Gavin*, Lewis & Clark College**	*Race to the Origin* [27] **Logan Emonds*, Western Oregon University**
4:15–4:25	*The Guessing Game* [43] **Andrew Leise*†, Tzu Hsu*†, University of Washington Tacoma**	*Constant Vector Curvature in Three Dimensions* [74] **Albany Thompson*, Central Washington University**	*Competitive Tiling* [7] **Levi Altringer*, Linfield College**
4:30–4:40	*Deck Manipulation Through Perfect Shuffles* [80] **Nicole Welch*, Western Oregon University**	*Geometric Analysis of Topology of 1-Manifolds of Constant Curvature* [28] **Jonathan David Evenboer*, Oregon State University**	*Insolvable Configurations of Peg Solitaire* [49] **Christina Moorhead*, Western Oregon University**
4:45–4:55	*Permuted Petal Projections* [17] **Christopher Cericola*†, Colin Murphy*†, Seattle University**	*Shooting Pool* [30] **Alvaro Francisco Manuel*, Western Oregon University**	*A Combinatorial Model for Rational Base Representations of Natural Numbers* [78] **James Van Alstine*†, Hailey Olafson*, Pacific Lutheran University**
5:00–5:10	*Models for the Propagation of Uncertainty* [13] **Thomas Burns*, Southern Oregon University**	*A Practical Introduction to Stick Knot Theory* [57] **Cody Paulson*†, Matt Chatham*†, Dominic Clay*, Joel Jacobs*, Amy Yielding, Eastern Oregon University**	*List Coloring* [69] **Elizabeth Struxness*, Western Oregon University**
5:15–5:25	*Mathematical Modeling of Social Media* [75] **Alan Thuy*†, Narayani Choudhury, Lake Washington Institute of Technology**	*Untangling the Theory Behind Stick Knots and Their Pseudo Projections* [42] **Joel Jacobs*†, Dominic Clay*†, Cody Paulson*, Matt Chatham*, Amy Yielding, Eastern Oregon University**	*1-relaxed modular edge-sum labeling game number* [23] **Hang Do*†, Timothy Singer,*Linfield College; Brent Moran*, University of Colorado Denver**
5:30–5:40			*Playing with Abelian Sandpiles* [31] **Andy Fry, Western Oregon University***

Social Events

Friday Project NExT Dinner
(For Project NExT Participants Only, No Host)
5:45

Student Marshmallow Challenge and Pizza Party
For undergraduate students, sponsored by the UWT Math Club
5:30 Joy 117

Friday Evening Invited Public Lecture
My Favorite Math Fun Facts
Francis Su [3]
8:00 James A. Milgard Assembly Room, WPH

Friday Evening Reception
8:50 Columbia Bank Lobby, WPH

Saturday Morning: Coffee, Bagles, & Fruit
8:00–10:30 Columbia Bank Lobby, WPH

Saturday Lunch
12:45–2:00 Columbia Bank Lobby, WPH

Saturday Afternoon: MAA 100th Birthday Celebration
Be sure to wander the student posters after signing the Birthday card while eating your cupcake.
3:00-3:30 JOY Atrium

Satuday Evening Social Hour
5:30 The Swiss

Saturday Evening Awards Ceremony and Banquet Dinner
7:00 Jane Thompson Russell Commons, WPH

Introduction of new Section Project NExT Fellows
Presentation of 25- and 50-year MAA membership certificates
Announcement of NUMS Student Presenter awards
PNW MAA Distinguished Teaching Award

Saturday Evening Invited Lecture
Mathematical Bead Weaving
Gwen Fisher [6]
8:30 James A. Milgard Assembly Room, WPH

Minicourse Descriptions

Friday, April 10

1 *Leadership Workshop*

Shannon Overbay & Thomas McKenzie, Gonzaga University

Graduate programs prepare future faculty members for teaching and research. However, most fall short in preparing candidates for leadership. Academic institutions typically expect faculty members to serve in leadership roles during their careers. The question is, how does one make this transition?

If you are currently serving or considering serving as division head or department chair, or plan to do so in the near future, this workshop is for you. We will discuss strategies for dealing with difficult students and faculty members, negotiating with administration, delegating tasks, and consensus building. The session moderators are the past and current chairs of the Mathematics Department at Gonzaga University.

2 *Using Mathematics to Design Beadwork*

Gwen Fisher, beAd Infinitum

A bead is anything with a hole, and the center of a hole is an oriented line segment in space. One way to bead a polygon is to sew a loop of beads with the same number of sides as a polygon. Since polygonal tilings are objects composed of polygons, we can arrange beads on any surface that is covered with a polygonal tiling, and then weave them together in that arrangement. Learn to use a tiling to create beaded representations of mathematical objects, including tilings of the plane and polyehdra, and then weave them with beads and thread. Materials will be provided.

Abstracts of Invited Lectures

(in chronological order)

3 *My Favorite Math Fun Facts*
Francis Su, Harvey Mudd College

For several years, I have been collecting "Math Fun Facts", which are juicy math tidbits that I have been using to start off math classes as a warm-up activity. Math Fun Facts are can be from any area of mathematics, can be presented in less than 5 minutes, and are meant to arouse my students' curiosity and show that mathematics is full of interesting ideas, patterns, new modes of thinking, and come from diverse sources. In this talk, I will present my favorite Math Fun Facts. They're definitely fun, but will they be YOUR favorites? You decide.

4 *The Geometry of Relativity*
Tevian Dray, Oregon State University

The geometry of special relativity can be neatly described using hyperbolic trigonometry. The geometry of general relativity can be similarly described using differentials and differential forms. This talk presents an excursion through both special and general relativity, emphasizing geometric structure and using (mostly) elementary concepts from trigonometry, linear algebra, and vector calculus. You may never view those topics the same way again...

5 *Combinatorial Fixed Point Theorems*
Francis Su, Harvey Mudd College

The Brouwer fixed point theorem and the Borsuk-Ulam theorem are beautiful and well-known theorems of topology that admit combinatorial analogues: Sperner's lemma and Tucker's lemma. In this talk, I will trace recent connections and generalizations of these combinatorial theorems, including applications to the social sciences. Some of this work includes research with undergraduates.

6 *Mathematical Bead Weaving*
Gwen Fisher, beAd Infinitum

Weaving beads with a needle and thread provides an excellent method for creating aesthetically pleasing mathematical models. Many sorts of mathematical objects can be represented with woven bead work, including those from geometry, tiling theory, algebra (symmetry), and topology. In this talk, I will present numerous examples of beaded objects, as well as the mathematics that inspired their designs.

Abstracts of Contributed Talks

(in alphabetical order, by presenter)

7 *Competitive Tiling*
Levi Altringer, Linfield College[*†]
(*Session:* NUMS V—Combinatorics and Games)

Competitive Tiling consists of two players, a tile set, a region, and a non-negative integer d. Alice and Bob, our two players, alternate placing tiles on the untiled squares of the region. They play until no more tiles can be placed. Alice wins if at most d squares are untiled at the end of the game, and Bob wins if more than d squares are untiled. For certain regions and tile sets, we are interested in the smallest value of d such that Alice can win. We call this the game tiling number. In this talk we will focus on finding the game tiling number for the game played with dominoes on $2 \times n$ rectangles, modified $2 \times n$ rectangles, and rectangular annular regions.

8 *Martin-Lof randomness for Bernoulli measures*
Logan Axon, Gonzaga University[†]
(*Session:* General Contributed Talks II—Topology)

Continuous maps on Cantor space induce maps between measures on the space. Mauldin has answered the question of when two Bernoulli measures are related by such a map by giving a purely number-theoretic condition on the parameters of the measures. The proof of this result is constructive and hence compatible with algorithmic randomness. We show how Mauldin's result extends to tt-functionals and Martin-Löf randomness.

9 *Authoring Open Source Mathematics Textbooks*
Robert Beezer, University of Puget Sound
(*Session:* Open Source X)

Despite there being many excellent tools for authoring, producing and distributing open source textbooks, it is still a technical challenge to self-publish a mathematics textbook. This is especially true now that there are so many options for output formats: print, PDF, web, and EPUB to name some of the most obvious choices. Our experiences authoring open source textbooks have led us to meet these challenges with the design of a new authoring language, MathBook XML. In this talk we will describe several textbook projects using this language and give an overview of its capabilities.

10 *Isomorphy classes of finite order automorphisms of SL(2,k)*
Robert Benim, Pacific University[†]
Mark Hunnell, North Carolina State University[**]
Amanda Sutherland, North Carolina State University[**]
(*Session:* General Contributed Talks I—Current Trends in Research)

In this talk, we consider the order m k-automorphisms of Sl(2,k). We first characterize the form that order m k-automorphisms of Sl(2,k) will take and then we find simple conditions on matrices A and B involving eigenvalues and the field that the entries of A and B lie in that are equivalent to isomorphy of the order m k-automorphism Inn_A and Inn_B. We examine the number of isomorphy classes, and consider a few examples.

11 *Klein Links and Related Torus Links*
Steven Beres, Gonzaga University[*†]
Kaia Hlavacek, Gonzaga University[*]
(*Session:* General Contributed Talks II—Topology)

Klein links form a classification of links which may be embedded across the surface of a Klein bottle. That is, a Klein link is a set of interlocking mathematical knots which may be drawn across the surface of a Klein bottle without intersection. This particular classification of links has not yet been well studied by the mathematical community. Initially, our interest in these links stemmed from the relation between Klein knots and torus knots. It is a fairly well-known fact that all Klein knots are torus knots. The initial goal of our research had been to explore the nature of this relationship through the use of elementary methods. These investigations led us to extend our inquiries to Klein links. After studying these links for some time, we came to discover that Klein links do not bear the same relation to torus links that Klein knots bear to torus knots. In other words, not all Klein links are torus links. In this presentation, we will briefly discuss the major results of our research on these links. The techniques that we used in our study of these links (such as Reidemeister moves and linking number) were purposefully elementary, so this presentation does not require any background in topology or knot theory. Topics will range from basic construction of the links on the Klein bottle to specific sub-classifications of Klein links which are not torus links.

12 *Designing the Major: The CUPM Curriculum Guide*
Michael Boardman, Pacific University[†]
(*Session:* Improving Undergraduate Programs in Mathematics)

The MAA Committee on the Undergraduate Program in Mathematics and the MAA have released the 2015 CUPM Curriculum Guide to Majors in the Mathematical Sciences. The speaker, a member of the CUPM, will present a high level overview of the guide and its development.

13 *Models for the Propagation of Uncertainty*
Thomas Burns, Southern Oregon University[*†]
(*Session:* NUMS III—Probability and Number Theory)

Simple estimates of the level of uncertainty in a measurement (usually as relative or absolute error) are easy to calculate and understand, but when doing any sort of computation or inference using these measurements, things become quite a bit more complicated. This project explores several models for dealing with the propagation of uncertainty and will discuss probabilistic justifications for these standards and the difficulties of finding associated confidence intervals.

14 *Portfolio Optimization: A Modeling Perspective*
Camarie Campfield, Western Oregon University[*†]
(*Session:* NUMS I—Optimization and COMAP)

Investing is critical in the business world and is an avenue to make profit for many. Making the decisions of what to invest in involves intricate mathematics in order to reduce risk. We investigate portfolio optimization, which is a branch of economic and financial modeling that typically has the goal of maximizing an investments expected return. We explore a linear programming approach to a decision model for a first time investor. We then compare our results to the expectation and compute different outcomes based on adjusting our models used for calculating rates of return and failure rates in order to best capture reality.

15 *The Lion and the Man*
Ryan Card, University of Washington Tacoma†
(*Session:* General Contributed Talks IV—Fun and Games)

A lion and a man in a closed circular arena have equal maximum speeds. The lion wishes to catch the man while the man tries to evade capture. Who has the winning strategy? We will discuss the incorrect “solution” which stood for more than 20 years, its error, and the surprising answer to that turns the original “solution” on its head. We will also discuss some other related pursuit and evasion games.

16 *Looking to MARS to Locate Missing Aircraft*
Grant Cates, Linfield College∗†
Zakaria El Amrani Elidrissi, Linfield College∗
Thomas Shearer, Linfield College∗
(*Session:* NUMS I—Optimization and COMAP)

Locating aircraft that have crashed in open water is a monumental task. The recent disappearance of Malaysian Airlines Flight 370 underscores the importance of having a robust, yet flexible response system in place. In this paper, we outline a recommendation to the Obama Administration for the implementation of MARS, Missing Aircraft Recovery System, to locate missing aircraft feared to have crashed in open water. We use information collected by the FAA (Federal Aviation Administration) about the missing the plane to determine the remaining engine runtime and the algorithm behind Google Maps Places Search to locate all potential emergency landing sites within range of the aircraft. We then outline a method to determine the likelihood of the pilot choosing each site, and then prioritize search zones using the same methods used to create topographic maps. This information is then passed along to the USAF (United States Air Force), which will dispatch a fleet of MQ-1B Predator drones to conduct the search. In the event that new information on the missing aircraft becomes available, MARS has contingency plans built in for updating search zones and determining the most probable point of impact once debris is discovered utilizing existing models for predicting drift paths. With response times only limited to that of computer processing speeds, MARS can revolutionize the ways in which search and rescue operations are performed and save an untold number of lives.

17 *Permuted Petal Projections*
Christopher Cericola, Seattle University∗†
Colin Murphy, Seattle University∗†
(*Session:* NUMS III—Probability and Number Theory)

In our talk, we will present the idea of a multicrossing projection of a knot and the specific projection called the petal projection. A petal projection is a projection of the knot containing a single crossing. Imagine that we have such a diagram where we do not know which strand is on top of which. What are the possible knots that such a projection might represent? When we choose a particular ordering of strands, we find that the knots created are an interesting family called torus knots. We examine how petal diagrams can be simplified to result in a standard diagram of a knot in the torus family. While much of the work that we will discuss in this talk was done by Colin Adams and student collaborators in the SMALL REU, we will also describe our current research related to their work.

18 *Technique versus Truth: promoting gradual mastery of mathematical theory.*
Joshua Cole, Pacific University[†]
(*Session:* Improving Undergraduate Programs in Mathematics)

At all levels (elementary, high school, and university), doing mathematics is at once about discovering truth and getting the right answer. It is interesting that getting the right answer is often possible without understanding why the method works. Using examples from all levels of mathematics, I argue that it is actually not always bad to give our students algorithms without explaining why they are true. At times it takes two or three passes through a topic before a student is ready for the underlying theory. Sometimes the prudent course is to give just a hint for the intuition the first time around, and I will give examples from the Calculus sequence. Reflection on this pedagogy should also include seeing the importance of finally achieving mastery of the theory. (How many Calculus students remain mired in bad algebra habits because they can't distinguish in complicated contexts which moves are legal, not grasping the underlying ontology that determines what is allowed?) Finally, a pedagogy of gradual introduction of theory leads to a solution of a thorny problem: inspiring in students a desire for mathematical theory without leading to too many complaints on evaluations.

19 *Doing Less, Better*
Lynda Danielson, The College of Idaho[*†]
Robin Cruz, The College of Idaho[*†]
(*Session:* Improving Undergraduate Programs in Mathematics)

Faced with growing demand from very different student populations, The College of Idaho developed a three-year plan to redesign its entry level mathematics courses. Our objective two years ago was to streamline the sequence of courses for our bimodal audience of students with and without calculus in high school. The redesigned courses Applied Calculus and Single Variable Calculus utilize ideas from the flipped classroom approach, such as daily reading questions due before class and in-class group activities. We will discuss strategies we tried and what seems to work for us.

20 *A Comprehensive Introduction to Using WeBWorK*
Dibyajyoti Deb, Oregon Institute of Technology[†]
Joe Reid, Oregon Institute of Technology[†]
Cristina Negoita, Oregon Institute of Technology[†]
David Rosoff, College of Idaho[†]
Robin Cruz, College of Idaho[†]
Jim Fischer, Oregon Institute of Technology[†]
(*Session:* Open Source X)

WeBWorK is a well-tested, free homework system for delivering individualized problems over the web. It was originally developed in 1995 by Professors Arnold Pizer and Michael Gage at the Department of Mathematics at the University of Rochester. A team of developers from a number of institutions now supports the system, which is currently used for a wide range of courses in mathematics and related disciplines. Through a series of six interactive presentations we will show how to use this homework system. We will begin with basic procedures such as creating and editing problem sets, modifying problems, and using scoring tools. The presentations will progress to more advanced topics including making connections to other course materials, creating problems with some of the newer MathObjects and examples of integrating WeBWorK problems with software such as R. We will conclude with a brief discussion of

where to find resources, professional development opportunities and how faculty can contribute to WeBWorK. This is a hands-on presentation, and attendees are highly encouraged to bring their laptops/tablets/etc.

21 *The Chipset Problem*
Doug DePrekel, Central Washington University[*†]
(*Session:* NUMS I—Optimization and COMAP)

This talk explores subsets of the integers, called chipsets, that are subject to an iteratively defined constraint. We will establish a test to determine whether a subset of the integers is a chipset and use this to determine whether various sets are chipsets.

22 *Using Aircraft Trajectory and Ocean Surface Vectors to Assist in Locating Lost Vessels*
Lauren DeVore, Linfield College[*†]
Alexander Ogle, Linfield College[*†]
James Knox, Linfield College[*†]
(*Session:* NUMS I—Optimization and COMAP)

We present a model developed for the COMAP Mathematical Competition in Modeling to assist in searching for aircraft assumed to have crashed in open water. We began by determining all potential and most probable crash locations based on the plane's trajectory and when and where its ACARS 'handshake' signal was last completed. Using a simulation programmed in MATLAB, we were able to generate a generic ocean current map in the form of a vector field which simulates the forces acting on the downed plane. A matrix of possible plane crash sites was then generated based on the plane's prior trajectory and the time between ACARS signals. The simulation calculated the plane's location after some time interval between runs, finally showing a collection of locations of the downed plane, given a spread of initial crash locations. We then developed protocols for recommended search planes to optimize the speed for rescuers to find the plane. Overall, our model has the potential to incorporate real world data and generate more accurate drift simulations, making it a useful tool for future search scenarios.

23 *1-relaxed modular edge-sum labeling game number*
Hang Do, Linfield College[*†]
Brent Moran, University of Colorado Denver[*]
Timothy Singer, Linfield College[*]
(*Session:* NUMS V—Combinatorics and Games)

Motivated in part by anti-magic labeling and similar schemes, we introduce a new graph labeling and derive from it a game on graphs called the *1-relaxed modular edge-sum labeling game*. The players, Alice and Bob, alternate turns with Alice going first. Each turn, the player chooses an unlabeled edge e, and assigns to e a label $w(e) \in [n]$. At any point in the game, let L' be the set of labeled edges. For any turn t, let v be a vertex for which $N'(v) \cap L' \neq \emptyset$. We define the label for v at this point in the game to be $\ell_t(v)$ according to the following:

$$\ell_t(v) = \sum_{e \in N'(v) \cap L'} w(e) \pmod{n}.$$

The defect of v is the number of vertices which are adjacent to v and labeled identically to v. We call a labeling *legal* if each labeled vertex has defect at most 1, and we require that the

players maintain a legal labeling at each stage of the game. Alice wins if play continues until $L' = E(G)$; otherwise, Bob wins. The least n such that Alice has a winning strategy for on G using $[n]$ is called the *1-relaxed modular edge-sum labeling game number of* G. We provide an upper bound for this number on trees, as well as providing the exact value of the number for various classes of graphs.

24 *Putting differentials back into calculus*
Tevian Dray, Oregon State University†
(*Session:* General Contributed Talks III—Pedagogy)

The use of differentials in introductory calculus courses provides a unifying theme which leads to a coherent view of calculus. We show in particular how differentials can be used to determine the derivatives of trigonometric and exponential functions, without the need for limits, numerical estimates, solutions of differential equations, or integration.

25 *Leading Off-Campus Courses for Math Students*
Chuck Dunn, Linfield College†
(*Session:* Active Learning Symposium)

I will discuss two courses I have developed and led with undergraduate mathematics students. The first follows in the footsteps of Leonhard Euler and considers a small part of his impact in a few fields of mathematics. The course starts in St. Petersburg, Russia, then moves to Berlin, Germany, and ends in Basel, Switzerland. In the second course, I traveled with students to China and Japan. In China, we studied ancient Chinese mathematics and traveled to Beijing and Xi'an. In Kyoto, Japan, we discussed the influence of Chinese mathematics on Japanese mathematics, and studied sangaku, which were geometry problems on wooden tablets that were left as offerings or challenges to visitors to shrines and temples during the Edo period. We also visited shrines with existing sangaku.

26 *Families of Generalized Catalan Numbers*
Tom Edgar, Pacific Lutheran University†
Michael Spivey, University of Puget Sound
(*Session:* General Contributed Talks I—Current Trends in Research)

Binomial coefficients, when defined as quotients of partial products of the natural numbers, can be generalized to any nonzero integer sequence, but the resulting ratios cannot be expected to be integers. As will be demonstrated in another talk, if a sequence is both multiplicative and divisible, the associated generalized binomial coefficients will be integers. Once one has integral generalized binomial coefficients, it is natural to ask about analogs of Catalan numbers. The classical Catalan numbers can be defined in terms of central binomial coefficients. In this talk, we use that definition to define generalized Catalan numbers and describe a proof showing that these will also be integers when the original sequence is both multiplicative and divisible. Along the way we will mention a handful of relevant examples of sequences having integer generalized Catalan numbers.

27 *Race to the Origin*
Logan Emonds, Western Oregon University∗†
(*Session:* NUMS V—Combinatorics and Games)

Race to the Origin is a two player game where players take turns moving from a coordinate in the first quadrant toward the origin according to a specific set of rules. The first player to the origin wins. This is a variant of the game NIM. We will discuss the rules of play and give winning strategies. Learn how to beat your friends every time you play!

28 *Geometric Analysis of Topology of 1-Manifolds of Constant Curvature*
Jonathan David Evenboer, Oregon State University[*†]
(*Session:* NUMS IV—Geometry)

We explore and compare, via geometric methods, the topology of the hyperbolic-unit interval and the spherical-unit interval with respect to the Euclidean-unit interval. We do so using analysis of the density of rational and irrational numbers in the real plane by employing methods of refraction resulting from the geometric lens formed by the intersection of the circle, the aster, and the square rotated by $\pi/4$. Isometry of the square to its rotational rotational analogue allows for a mapping of hyperbolic and spherical subspaces to a Euclidean metric. A sheet of foundational notation will be available at least a week before the talk at **http://jonathandavidevenboer.weebly.com/blog/foundational-notation-for-nums-15-talk**

29 *Differential Equations & CAS's: An Encounter with Uniquness*
Samantha Fall, Gonzaga University[*†]
(*Session:* NUMS II—Calculus, ODE, and Linear Algebra)

In this talk we discuss the danger of ignoring uniqueness criteria when solving an initial value problem either by a traditional pencil and paper approach or with computer algebra systems (CAS's). In particular, we consider both an exact ordinary first-order differential equation and one that may be solved using a basic solution technique such as separation of variables. In doing so, both analytic and numerical results are considered to emphasize the necessity of first analyzing the equation before attempting to solve it. We show that if we do not proceed with care our solutions to even these simple equations may be erroneous.

30 *Shooting Pool*
Alvaro Francisco Manuel, Western Oregon University[*†]
(*Session:* NUMS IV—Geometry)

Many people are familiar with the game of Billiards, commonly known as pool. We will consider a simple version of this game consisting of just the cue ball, cue stick, and table. The ball is shot at a 45 degree angle from the lower left hand corner. In this talk, we will find a general formula for a generic size table that gives us the number of bounces it takes before the ball lands in a corner pocket. Also, we will find a formula for predicting which pocket it will go into.

31 *Playing with Abelian Sandpiles*
Andy Fry, Western Oregon University[*†]
(*Session:* NUMS V—Combinatorics and Games)

Imagine yourself on a beach, playing in the sand. You begin to make a sandpile by adding handfuls of sand. Now you consider dropping another grain of sand onto the pile but you don't know what will happen. It may cause nothing to happen or it may cause the entire pile to collapse in a massive avalanche. This is the idea behind the Abelian sandpile model. We measure the sizes of these avalanches and build what is called the avalanche polynomial. This topic is based on graph theory and enumerative combinatorics.

32 *Integer Solutions to Box Optimization Problems*
Lorna Fullmer, George Fox University[*†]
(*Session:* NUMS I—Optimization and COMAP)

Box optimization problems (how to find the maximum volume of a box from its dimensions) have been discussed in calculus classes for years. This talk will discuss the insights given by an article, written by Vincent E. Coll, Jeremy Davis, Martin Hall, Colton Magnant, James Stankewicz,

and Hua Wang, from The College Mathematics Journal on integer solutions to these problems. It will then discuss of an application of these integer solutions to the maximization of the volume of a cylinder.

33 *Mean Curvature Flow of Tori of Revolution*
Colin Gavin, Lewis & Clark College[*†]
(*Session:* NUMS IV—Geometry)

Mean curvature flow is the L^2 gradient flow of the volume functional on embedded surfaces. As a nonlinear system of parabolic equations, its behavior is quite complicated, but generally solutions become more spherical over time as their volume decreases. The evolution of tori under this flow is of interest because their non-trivial topology prevents them from becoming round. This leads to the formation of a variety of singularities. In this talk, I will focus on tori of revolution, which reduces the problem to a version of planar curve shortening flow. From this viewpoint, the possible singularities can be classified and, in some cases, their asymptotic behavior can be determined.

34 *Finite Linear Games: Exploring Math Behind Puzzles*
Kirsten Grace, University of Washington Tacoma[*†]
Lisa Smith, University of Washington Tacoma[*]
(*Session:* NUMS V—Combinatorics and Games)

This talk explores using matrix algebra techniques to solve modulo restricted finite linear games. All finite linear games possess a definite number of game states; the state changes are predictable, tied to specific actions, and obey the commutative law. Solving these puzzles with a structured approach will ensure a solution is found, so long as one exists, and is more reliable than haphazard guesswork. The importance of proper identification and translation of a puzzle's mechanics into the matrix algebra space is also briefly discussed.

35 *Singular Value Decomposition and its applications*
Giovanna Graciani, University of Washington Tacoma[*†]
(*Session:* NUMS II—Calculus, ODE, and Linear Algebra)

Singular value decomposition (SVD) allows a transformation from matrix A into product $U\Sigma V^T$ by first computing eigenvectors and eigenvalues. By computing $U\Sigma V^T$ we are able to refactor a digital image into singular values, which allows for the image to be represented by a smaller set of values. SVD allows for the preservation of important features of an image while still providing image compression. Image compression is used to reduce the size of graphics files for improved storage efficiency. Keywords: singular value decomposition, image compression

36 *The Calculus of Rainbows*
Agnes Guerry, Edmonds Community College[*†]
(*Session:* NUMS II—Calculus, ODE, and Linear Algebra)

Rainbows are created when raindrops scatter sunlight. They have fascinated mankind since ancient times and have inspired attempts at scientific explanation since the time of Aristotle. In this project we use the ideas of Descartes and Newton to explain the shape, location, and colors of rainbows.

37 *The Stereographic Cylindrical Spherical Projection*
Tara Hanst, Southern Oregon University[*†]
(*Session:* NUMS IV—Geometry)

The representation of a sphere, or spherical object such as the Earth, on a Euclidean plane has been of interest to mathematicians, cartographers, and navigators for centuries and, as a result, many different spherical projection methods have been developed. This presentation will explore the Stereographic Cylindrical Projection which involves antipodal points and a Euclidean plane tangent to the sphere along a great circle. A proof of the coordinate conversions from spherical to Euclidean space using this projection technique will be presented. Spherical properties, such as distance, angular measures, and area will be compared to the corresponding properties on the projection plane in order to measure distortions caused by the projection's conversions.

38 *Trapezoidal Numbers*
Christopher Hartman, Western Oregon University[*†]
(*Session:* NUMS III—Probability and Number Theory)

Trapezoidal numbers are those which can be written as a sum of consecutive positive integers where the smallest number must be at least two. We will look at the mathematics behind trapezoidal numbers and how to find all such representations. We will give a clever construction which shows how each representation corresponds to an odd divisor of the number.

39 *Straightedge & Compass Constructions in Spherical Geometry*
Daniel J Heath, Pacific Lutheran University[†]
(*Session:* General Contributed Talks IV—Fun and Games)

We examine straightedge and compass constructions in spherical geometry. We show via examples that the starting conditions affect the outcome. Although current tools do not allow for a complete solution, we take a tour through group theory and real analysis to show that, in general, the set of constructible points is dense on the sphere. However, we conclude with more questions than answers.

40 *The Intermediate Value Theorem-Obvious or Not?*
Edward Hernandez-Corchado, George Fox University[*†]
(*Session:* NUMS II—Calculus, ODE, and Linear Algebra)

Many Calculus I instructors often do not prove the The Intermediate Value Theorem because it seems intuitive and obvious to both the instructor and the students. Moreover, the proof can be complicated. The talk addresses why the IVT is not as obvious through examples and the benefits of having the proof; even if it is not formal.

41 *Some Current Trends in Cryptography*
Peter Horak, University of Washington Tacoma[†]
(*Session:* General Contributed Talks I—Current Trends in Research)

In this short contribution we will briefly mention: (i) So called side-channel attacks on RSA public cryptosystem, one of the most frequently used ciphers; (ii) Impact that scalable quantum computers will have, once they become available, on all deployed public key cryptosystems and electronic signature schemes. A year ago I became one of the international team of experts working on a NATO grant entitled Secure Implementation of Post Quantum Cryptography. At the end I describe main goals of this project that are related to (i) and (ii).

42 *Untangling the Theory Behind Stick Knots and Their Pseudo Projections*
Joel Jacobs, Eastern Oregon University[*†]
Dominic Clay, Eastern Oregon University[*†]
Cody Paulson, Eastern Oregon University[*]
Matt Chatham, Eastern Oregon University[*]
Amy Yielding, Eastern Oregon University
(*Session:* NUMS IV—Geometry)

In this talk we describe our research into stick knots and projections of stick knots undertaken by our undergraduate research group at Eastern Oregon University during Summer 2014-Winter 2015. Our goal was to find a method, or several methods, for identifying which 2-D projections of stick knots were fully realizable in 3-space and which were pseudo-projections. We present our research methods, our successful results, problems and issues we encountered along the way, and possible future avenues of inquiry into this field.

43 *The Guessing Game*
Andrew Leise, University of Washington Tacoma[*†]
Tzu Hsu, University of Washington Tacoma[*†]
(*Session:* NUMS III—Probability and Number Theory)

Ryan writes two distinct real numbers on two separate piece of papers and puts them into two envelopes. Ruth chooses one of the envelopes randomly and she must guess whether the other real number in the closed envelope is less than, or greater than, the one she picked. Most people would think that the probability is about $\frac{1}{2}$. However, in this presentation, we will prove by using probability theory and real analysis, we can develop a much more accurate method of guessing.

44 *Deconstructed Conductance: Axial and Radial Contributions to Water Flow*
Frank Lynch, Eastern Washington University[†]
Gretchen North, Occidental College
(*Session:* Mathematical Modeling II)

A measured value of total hydraulic conductance in the tank bromeliad *Guzmania lingulata* is decomposed into separate conductances in the axial and radial directions. This decomposition uses the numerical solution of a second order initial value problem where an unknown parameter is selected to satisfy a third boundary condition. The unknown parameter, representing radial conductance, is used to characterize the ability *G. lingulata* to conduct water through its axial and radial pathways.

45 *One versus two doses: what is the best use of vaccine in an influenza pandemic?*
Laura Matrajt, Fred Hutchinson Cancer Research Center[†]
(*Session:* Mathematical Modeling I)

Avian influenza A (H7N9), emerged in China in April 2013, sparking fears of a new, highly pathogenic, influenza pandemic. In addition, avian influenza A (H5N1) continues to circulate and remains a threat. Currently, influenza H7N9 vaccines are being tested to be stockpiled along with H5N1 vaccines. These vaccines require two doses, 21 days apart, for maximal protection. We developed a mathematical model to evaluate two possible strategies for allocating limited vaccine supplies: a one-dose strategy, where a larger number of people are vaccinated with a single dose, or a two-dose strategy, where half as many people are vaccinated with two

doses. We prove that there is a threshold in the level of protection obtained after the first dose, below which vaccinating with two doses results in a lower illness attack rate than with the one-dose strategy; but above the threshold, the one-dose strategy would be better. For reactive vaccination, we show that the optimal use of vaccine depends on several parameters, with the most important one being the level of protection obtained after the first dose. We describe how these vaccine dosing strategies can be integrated into effective pandemic control plans.

46 *How to use Active Learning Activities in a Flipped Mathematics Classroom*
Craig McBride, University of Washington†
(*Session:* Active Learning Symposium)

This discussion contains a description of my experiences flipping undergraduate mathematics and statistics courses for the first time with some advice for any fellow novice flippers. I discuss ways to start small and build up to a completely flipped class over the span of a few terms with advice on what technology to use including software and hardware. Attention will be given to active learning activities such as group work and polls, and how these things enhance the flipped classroom experience.

47 *Reparations as a Theme for a joint Mathematics-Political Economy Course*
Paul McCreary, The Evergreen State College†
Anthony Zaragoza, The Evergreen State College
(*Session:* Social Justice)

We will describe experiences in teaching a course titled Calculating the Value of Reparations and the History of Mathematics. The issues of reparations is in the recent news, e.g. fourteen Caribbean nations suing for slavery reparations and Greece requesting additional WWII reparations. Reparations were addressed by national governments concerning the internment of Japanese-Americans and in the agreement between Israel and Germany. They are still being considered in the cases of African slaves and their descendants, and of Native Americans vis-a-vis the actions of the US and Canadian governments and corporations. Computing and debating the validity and value of reparations is timely and relevant. Finding connections with these issues and the history of Egyptian, Mayan, and Basque mathematical ideas provides a natural context for investigations in the liberal arts.

48 *i-Block Transitive Tilings by Convex Pentagons*
Jennifer McLoud-Mann, University of Washington Bothell†
Casey Mann, University of Washington Bothell
(*Session:* General Contributed Talks IV—Fun and Games)

The problem of classifying the convex pentagons that admit tilings of the plane is a long-standing unsolved problem. There are 14 known distinct kinds of pentagons that admit tilings of the plane. Five of these known types admit tile-transitive tilings. The remaining 9 known types admit either 2-block transitive tilings or 3-block transitive tilings; these are tilings comprised of clusters of 2 or 3 pentagons such that these clusters form a tile-transitive tiling. In this talk, we present some combinatorial results concerning pentagons that admit i-block transitive tilings. These results form the basis for an automated approach to finding all pentagons that admit i-block transitive tilings. We will present the methods of this algorithm and the results of the computer searches so far.

49 *Insolvable Configurations of Peg Solitaire*
Christina Moorhead, Western Oregon University[*†]
(*Session:* NUMS V—Combinatorics and Games)

Peg solitaire is a board game that has been played and studied for many years. Examination of the game offers an opportunity to explore a practical application of group theory. Through the use of the Klein Four Group, the insolvability of different board configurations will be examined. We will also explore variations of the game using alternate rules in order to fully understand the game of peg solitaire.

50 *Asymptotic Behavior of Travelling Wave Solutions to Reaction-Diffusion Equations*
Malley Nason, Linfield College[*†]
(*Session:* Mathematical Modeling I)

We will discuss travelling wave solutions to reaction-diffusion equations of the form: $u_t = u_x x + u^p(1-u^q)$ which can be used as a mathematical model for various biological phenomena, as well as to model problems in combustion theory. We identify conditions on the wave speed so that travelling wave solutions exist for the case $p \geq 1$ and $q \geq 1$. Moreover, we estimate the rate of decay of the travelling wave solutions. When $p > 1$ and $q \geq 1$, this estimate requires center manifold theory because the typical linear methods fail to work. Through the mathematical analysis of reaction diffusion equations, we can gain a better understanding of non-linear dynamical systems and their responses to varying parameters.

51 *Circumscribed polygons and circles*
Duong Nguyen, UW Tacoma[*†]
(*Session:* NUMS IV—Geometry)

Starting with a one unit circle, circumscribed by a regular triangle, circumscribed by a circle outside, circumscribed by a square, circumscribed by a circle, circumscribed by a regular pentagon and so on by circles and regular polygon. Will the radius of the circle diverge or converge when we continue to add more polygon and circles? This presentation will use Taylor series and comparison test to answer whether the radius will approach infinity or converge at some point.

52 *A Whole-Ebola-Trouble*
Zach Nilsson, Eastern Oregon University[*†]
Jeremy Bard, Eastern Oregon University[*†]
Katie Hamann, Eastern Oregon University[*]
(*Session:* NUMS I—Optimization and COMAP)

In this talk we develop a mathematical model that not only fits the current Ebola outbreak, but also extrapolates the situation by considering the spread of the disease, the quantities of drug necessary, rate of drug synthesis, systems and locations of drug delivery, and any other critical factors (burial rates, isolation, symptom progression) that affect the outbreak, with the ultimate goal of eradicating the disease. We employ four different models; all based upon the same algorithm and use a fourth-order Runge-Kutta method that explores the effects of isolation, medication, safe burials, and vaccination. Then optimize a combination of these variables to achieve eradication quickly and with a minimal number of deaths, in a realistic fashion. We quantitatively compare the impact factor of each variable, which considers the number of days passed and total deaths at the point of eradication. We conclude that vaccination is 19 times

more effective than medication, whereas safe burial is 21 times more effective than medication, and 1.1 times more effective than vaccination. Due to the impracticality of enforcing such strict methods of burial, we deem the vaccine rate to be the most feasible option, while still maintaining a high impact factor.

53 *The Prisoner's Paradox*
Gail Nord, Gonzaga University†
(*Session:* General Contributed Talks IV—Fun and Games)

Abstract: On the television show, Let's Make A Deal, the announcer, Monty Hall, asks a contestant to pick one of three curtains/screens. A new car is hidden behind one the curtains. Monty Hall opens one of the two remaining curtains, showing it does not have the car. He asks the contestant if he/she wishes to change his/her initial selection to the other curtain. We will see if the contestant increases his/her odds by doing so. This game (Shell Game), the Prisoner's Paradox, and other paradoxes of conditional probability will be explored. Gail Nord, Gonzaga University Title: The Prisoner's Paradox

54 *Using Game Theory to Foster Inquiry and Writing*
Jennifer Nordstrom, Linfield College†
(*Session:* Active Learning Symposium)

Linfield College requires an Inquiry Seminar of all first-year students. The purpose of this course is to introduce students to academic discourse through writing. As the course title suggests, it motivates writing as a means of posing interesting questions and providing reasoned arguments to answer these questions. Faculty members from all disciplines teach Inquiry Seminars, focusing on themes they find particularly interesting. Although undergraduate mathematics, as a discipline, may seem miles away from undergraduate writing, especially in first-year courses, this talk will focus on the success of a first-year writing course with the theme of mathematical game theory. Mathematics provides a robust framework for students to explore questions of rationality, value, cooperation, and societal versus individual good. Such questions can engage students with wide-ranging interests and backgrounds in mathematics. We will discuss how educational approaches familiar to mathematicians coincide with those of writing faculty, and how these pedagogical methods can be used to encourage students to develop habits of inquiry that can apply to all disciplines.

55 *Measuring Waves*
Katie Oliveras, Seattle University†
(*Session:* Mathematical Modeling I)

As evident from the recent events in Japan, Chile, and Sumatra, tsunamis are destructive waves that can devastate coastal communities. The best defense is an early warning system that gives people time to reach higher ground. But how exactly does one predict a tsunami? This talk will focus on some of the challenging mathematical aspects of the water-wave problem and how we can use ideas from ordinary and partial differential equations to measure water waves and possibly help predict tsunamis thus saving lives.

56 *Laminar Model for the Development of the Visual System*
Andrew Oster, Eastern Washington University†
Paul Bressloff, University of Utah

(*Session:* Mathematical Modeling II)

In this talk, we will introduce the architecture of the visual system in higher order primates and cats. Through activity-dependent plasticity mechanisms, the left and right eye streams segregate in the cortex in a stripe-like manner, resulting in a pattern called an ocular dominance map. We introduce a mathematical model to study how such a neural wiring pattern emerges and extend it to consider the joint development of the ocular dominance map with another feature of the visual system, the cytochrome oxidase (CO) blobs, which appear in the center of the ocular dominance stripes. Since cortex is in fact comprised of layers, we introduce a simple laminar model and perform a stability analysis of the wiring pattern. This intricate biological structure (ocular dominance stripes with 'blobs' periodically distributed in their centers) can be understood as occurring due to two Turing instabilities combined with the first-order dynamics of the system. We show recent numerical simulations showing how monocular deprivation during development can dramatically alter the ocular dominance pattern, while leaving the CO blob distribution nearly unaltered.

57 *A Practical Introduction to Stick Knot Theory*
Cody Paulson, Eastern Oregon University[*†]
Matt Chatham, Eastern Oregon University[*†]
Dominic Clay, Eastern Oregon University[*]
Joel Jacobs, Eastern Oregon University[*]
Amy Yielding, Eastern Oregon University
(*Session:* NUMS IV—Geometry)

Knots have been used throughout human history, from tethering boats to tying your shoes. Knot theory formalizes the nature and properties of knots. This talk will introduce participants to the history, fundamentals, and applications of a subset of knot theory, stick knots, using interactive exercises. Participants are encouraged to attend a subsequent talk discussing the results of a student inquiry into two-dimensional stick knot representations completed by the Eastern Oregon University 2014-2015 Undergraduate Mathematics Research Group.

58 *Pell's Equation and Continued Fractions*
Kyle Peterson, Western Oregon University[*†]
(*Session:* NUMS III—Probability and Number Theory)

Pell's equation is the famous equation $dx^2 + 1 = y^2$. We will use the continued fraction representation of the irrational numbers $\sqrt{d}$ to find solutions to this famous equation when d is square-free.

59 *Characterization of the Elliptical Pendulum*
Anthony Podvin, Heritage University[*†]
David Laman, Heritage University
Aric Washines, Heritage University[*]
Sarah Moats, Pacific Northwest University of Health Sciences[**]
(*Session:* NUMS II—Calculus, ODE, and Linear Algebra)

The relationship between the oscillation period and the length of a simple pendulum is well known. Other more complex pendulums such as physical, double, and inverted pendulums have been thoroughly examined as well. We present here, for the first time to the best of our knowledge, a systematic modeling and experimental analysis of the elliptical pendulum. An

elliptical pendulum is a mass that is constrained to oscillate along the arc of an ellipse. Our dynamical modeling indicates that the period is dependent on both the initial displacement of the pendulum and the eccentricity of the ellipse. We have measured the period as a function of initial displacement and eccentricity in order to test our dynamical model. The period was measured using a rotary motion sensor and was compared to the period predicted from a Lagrangian dynamics analysis of the motion with the displacement angle from the vertical as the generalized coordinate. The Lagrangian analysis generated an equation of the motion which was used to predict the period of oscillation for a given ellipse eccentricity and initial displacement angle. Good agreement of the model with the data was obtained for ellipse eccentricities in the range of 0.1-0.3. For higher eccentricities, however, the model deviated appreciably from the data. There are particular indications in the data that suggest these deviations originate with the apparatus and not with the model. Future directions include building a new apparatus that addresses the faults of the original apparatus and continued refinement of the model to better account for small deviations of the actual path of the pendulum from that of a perfect ellipse.

60 *Solving Ordinary Differential Equations*
Victor Rielly, Pacific University[*†]
(*Session:* NUMS II—Calculus, ODE, and Linear Algebra)

We present a few rudimentary and general methods of solving first order linear and nonlinear differential equations which satisfy a specific form. We present general tests which can be run on the differential equations in question. If the equations satisfy the tests, the solutions to the differential equations can be written out directly. The analysis can be extended to a large class of differential equations, and can already tackle the general first order linear differential equation, the Bernoulli equation, separable differential equations, and a few differential equations we may be the first to solve.

61 *LOST: Finding an Oceanic Flight for Dummies*
Graham Romero, Linfield College[*†]
Delaney Aydel, Linfield College[*†]
Alleta Maier, Linfield College[*†]
(*Session:* NUMS I—Optimization and COMAP)

Our approach for finding a missing oceanic flight begins with modeling the most probable locale of said flight. To do so, we use our model to plot a projected region in which the plane likely first made contact with the water. Then our model breaks this region into smaller objects that flow with ocean current (based on known surface current data) for any given number of days. This enables us to create data relating which spots of the ocean are most likely to contain survivors, floating debris or wreckage on the ocean floor. Next we form a comprehensive search method using known sensors, vessels and effective search patterns, assuring that all of our practices conform to international laws and treaties. In analyzing different technologies, we find that a mix of infrared, multi-beam SoNAR, LiDAR and line of site are the most effective means of detecting any debris or survivors. For search pattern techniques we use a hybrid of localized and generalized approaches; having focused search parties in locations of high probability given in our simulation as well as search parties that carry out maneuvers to scan a wider area of probability.

62 *Prospective Elementary School Teachers' Reconceptualization of Factors*
Matt Roscoe, University of Montana†
(*Session:* Active Learning Symposium)

Research on pre-service elementary school teachers' (PSTs') understanding of the multiplicative structure of number shows that PSTs struggle to use prime factorization to identify a number's factors. This study investigates the benefits of a sequence of three instructional tasks aimed at strengthening PSTs' understanding of factor by exploring the relation between a number's prime factorization and its factors. Analysis of written pre- and post-assessments of 69 pre- and in-service elementary and special education teachers shows that the use of these tasks strengthened PSTs' abilities to use prime factorization to identify factors and non-factors of both prime and composite numbers.

63 *The 400 Billion Dollar Algorithm*
Luis Solis-Bruno, University of Washington Tacoma∗†
(*Session:* NUMS II—Calculus, ODE, and Linear Algebra)

PageRank is an algorithm used by Google to present the user with the most important, helpful, or relevant pages first when they enter keywords or phrases into the search engine. We will introduce the algorithm, highlight key subjects of Linear and Matrix Algebra the algorithm implements, and run through an example. Subjects that will be covered include Eigenvectors and Eigenvalues. This project originated from a linear algebra course at the University of Washington Tacoma campus and was conducted primarily independent from class.

64 *Multiplicative Functions and Generalized Binomial Coefficients*
Michael Spivey, University of Puget Sound†
Tom Edgar, Pacific Lutheran University
(*Session:* General Contributed Talks I—Current Trends in Research)

The binomial coefficient $\binom{n+m}{n}$ can be thought of as $\dfrac{f(1)\cdots f(n+m)}{(f(1)\cdots f(n))\,(f(1)\cdots f(m))}$, where $f(j)=j$. We can generalize the binomial coefficient by considering functions f other than the identity function. In particular, what kinds of functions f give rise to generalized binomial coefficients $\binom{n+m}{n}_f$ that are integers for all values of n and m? In this talk we describe research into generalized binomial coefficients for multiplicative functions f. Our main results are (1) a formula for $\binom{n+m}{n}_f$ when f is multiplicative in terms of the values of f at prime powers and carries when n and m are added in prime bases; and (2) a proof that if f is both multiplicative and divisible then $\binom{n+m}{n}_f$ is an integer for all nonnegative integer values of n and m.

65 *Cohomology of Finite General Linear Groups*
David Sprehn, University of Washington Seattle∗∗†
(*Session:* General Contributed Talks II—Topology)

I will give a survey of what's known (very little!) about the mod-p cohomology of the general linear groups over finite fields of order p^r. I'll briefly describe a recent construction of a new class in (lowest possible) degree $r(2p-3)$, valid more generally for finite groups of Lie type.

66 *SageMathCloud – collaboratively use Sage, IPython, LaTeX, and terminals in your browse*
William Stein, University of Washington†
(*Session:* Open Source X)

I am a professor in the mathematics department at UW, and the founder of SageMath, Inc. In 2005, I founded SageMath, which is the main large open source pure mathematics research software (and is often used in undergraduate teaching), with many hundreds of contributors. Sage is an open source free download, which is pretty big and can be difficult to install. Since 2006, we've always had some sort of web-based interface. In 2013, I launched SageMathCloud (SMC), which is a new web interface to Sage, with much general functionality that has little to do with Sage, and is of interest to people outside mathematics research. For example, all development of SMC is done from within SMC, so SMC is also an online development environment. There's also support for editing LaTeX documents, using IPython notebooks, tracking tasks, etc. In this talk I'll give an overview of SMC, then talk about some incidental connections with reproducibility, including how SMC aggressively snapshots all user files periodically, and records nearly every keystroke (with a history slider) when editing worksheets. This talk will be similar to **https://youtu.be/_ff2HdME8MI**

67 *Open Educational Resources in Math—including a report of success using an open textbook for introductory statistics*
David Straayer, Tacoma Community College†
(*Session:* Open Source X)

Tacoma Community College recently adopted Kathryn Kozak's "Statistics Using Technology" for its introduction to statics course. In addition to saving the students significant expense (under $20 vs over $190), we're finding it empowers a return to an ancient now nearly lost note-taking strategy: taking notes in the margin of the book. Of course that only works for the students who buy a paper copy, others download a free e-book on their laptop, tablet, or even on their smart phones. Yes, the open-source texts often don't have the seductive inducements provided by the textbook publishers, but open source alternatives like WAMAP online assessment and instructor-shared slide sets can bridge the gap quite nicely.

68 *The revolt against Algebra II (including StatWay experience)*
David Straayer, Tacoma Community College†
(*Session:* Social Justice)

Many institutions, including the University of Washington, Seattle, require that a student has successfully completed an Intermediate Algebra course in order to be considered for admission. An yet the world is full of people who say things like "I never could pass that algebra course" or "I only got by because of the mercy of a kind teacher". Some succeeded in spite of their algebra-aversion, some were denied the opportunity of post-secondary education because of it. Statistics is becoming the most popular and appropriate college-level mathematics course for many students. Yet we are finding that many students are quite capable of succeeding in it without more than a basic algebra basis. Carnegie Foundation for the Advancement of Teaching has been promoting an approach called StatWay that combines elementary algebra with college-level statistics. Tacoma Community College has been an early participant in this program, and has demonstrated success with it.

69 *List Coloring*
Elizabeth Struxness, Western Oregon University[*†]
(*Session:* NUMS V—Combinatorics and Games)

Though some may be familiar with the topic of coloring from graph theory, few may be familiar with list coloring. List coloring is a generalization of coloring, where each vertex is assigned a list of available colors. In this talk, we will discuss the similarities and differences between coloring and list coloring.

70 *Modeling Two Common Business Decision Errors*
Jeffrey Stuart, Pacific Lutheran University[†]
(*Session:* Mathematical Modeling II)

Two major mistakes that a business can make are pursuing a new line of business that is not actually worthwhile, and not pursuing a new line of business that is actually worthwhile. The likelihood that a firm decides to make one of these two mistakes is modeled as a function of a firm's organizational structure, employee decision accuracy, and several other business-related variables.

71 *SIR Model for 2015 COMAP*
Daniel Takamori, Oregon State University[*†]
Clarice Mottet, Oregon State University[*†]
James Rekow, Oregon State University[*†]
(*Session:* NUMS I—Optimization and COMAP)

We construct and analyze three models for the spread of ebola within a single city. One model was a standard Susceptible, Infected, Recovered (SIR) model with natural births and deaths (deaths not due to ebola) and deaths due to ebola. We then extended this model two other models that incorporated production and distribution of medicine. In order to compare the effectiveness of various courses of action described in each model we formulated a cost function to measure the total damage caused by the ebola outbreak. The cost function summed the costs due to loss of human life as well as the cost of producing and transporting medicine used to combat ebola.

72 *Orbifolds via Groupoids*
Courtney Thatcher, University of Puget Sound[†]
(*Session:* General Contributed Talks II—Topology)

Orbifolds are generalizations of manifolds that allow certain singularities. They were originally defined using charts and atlases, similar to manifolds, but working with these atlases is hard, particularly when dealing with maps between orbifolds. Orbifolds can alternatively be defined using groupoids, and this approach gives a way to define maps between orbifolds that works well with homotopy theory. In this talk we will define orbifolds and orbispaces, and give examples using the groupoid definition. Additionally how the orbigroupoid category can be used as a basis for developing results about orbispaces will be touched on.

73 *Markov Chains*
Lane Thomason, Southern Oregon University[*†]
(*Session:* NUMS III—Probability and Number Theory)

I shall briefly introduce what Markov Chains are and some theory behind how the transition matrix can be used. I will then apply the theory to an example that models the movement of

pieces on a Monopoly board. Some examples of the theory I will demonstrate are finding and interpreting powers of the transition matrix, and calculating expected turns until landing in an absorbing state (in the Monopoly example this is Jail) based on the fundamental matrix.

74 *Constant Vector Curvature in Three Dimensions*
Albany Thompson, Central Washington University[*†]
(*Session:* NUMS IV—Geometry)

Differential geometry is the use of the techniques and tools of calculus to study the geometric properties of manifolds. One of the most commonly studied properties of manifolds their curvature. We can measure the curvature of a manifold at a point by using a metric called an algebraic curvature tensor and a geometric object known as a model space. A model space is formed when a manifold, inner product, and algebraic curvature tensor are grouped together. There are several curvature conditions that a model space can satisfy. This research is concerned with the necessary and sufficient conditions for a model space in three dimensions with positive definite inner product to have the specific curvature condition of constant vector curvature. This presentation summarizes the background for this research along with its findings.

75 *Mathematical Modeling of Social Media : Descriptive Statistics and Poisson Regression Analysis of Facebook Data*
Alan Thuy, Lake Washington Institute of Technology[*†]
Narayani Choudhury, Lake Washington Institute of Technology
(*Session:* NUMS III—Probability and Number Theory)

Social media platforms offer excellent opportunities for real life Mathematical modeling, Data science and Math education. We carried out detailed descriptive statistics and a Poisson regression analysis of Facebook data. We used cluster sampling to infer about the population. The five number summary and frequency distributions of friends ages and their number of Facebook posts were computed. We used the observed data to estimate the expectation or average value of the number of Facebook posts per week. We used Poisson distribution models to analyze the discrete probability distributions of the number of posts on Facebook. Alan Thuy is a freshmen student, currently studying Calculus I at Lake Washington Institute of Technology (LWIT). Alan is also a Math tutor at the MathLab at LWIT. Dr. Narayani Choudhury is a Math instructor at Lake Washington Institute of Technology. Email: Narayani.choudhury@lwtech.edu

76 *Teaching Probability with Categorical Data*
Terri Torres, Oregon Tech[†]
(*Session:* General Contributed Talks III—Pedagogy)

Help students explore the rules of probability with one interesting data set. Is there a statistically significant dependence between variables? What is joint and marginal probability? Is there an easy way to comprehend conditional probability? All of these questions and more can be answered with a simple categorical data table.

77 *Matrices*
Kari Treese, UW Tacoma[*†]
Josh Spires, UW Seattle[*]
(*Session:* NUMS II—Calculus, ODE, and Linear Algebra)

Non-negative matrix factorization (NMF) is a technique in matrix algebra used to factor a matrix into 2 sub-matrices. NMF proves to be very useful in data clustering and analyzing raw data.

We will discuss research on the work of Berry et al. regarding factorization and analysis of the Enron email corpus. Additionally, we will consider how researchers can use NMF to analyze data and discuss NMF as a useful tool for researchers outside of mathematics.

78 *A Combinatorial Model for Rational Base Representations of Natural Numbers*
James Van Alstine, Pacific Lutheran University[*†]
Hailey Olafson, Pacific Lutheran University[*]
(*Session:* NUMS V—Combinatorics and Games)

Everyone is familiar with the standard base-10 representation of numbers; others may also be familiar with the binary representation of natural numbers useful for computing. In this talk, we discuss our summer research, which involves representing natural numbers using a rational number as the base instead. In an attempt to generalize results of previous PLU summer researchers, we built an entire combinatorial theory around these representations. In this talk, we define rational base representations and introduce a family of trees that describe the important features of this method of representing numbers. With the combinatorial model in place we describe certain aspects of these rational base representations and answer some relevant combinatorial questions.

79 *Proposed Math Major at UWT*
Ruth Vanderpool, University of Washington Tacoma[†]
UWT Math Faculty, University of Washington Tacoma
(*Session:* Improving Undergraduate Programs in Mathematics)

The math faculty at University of Washington Tacoma have proposed a Bachelors of Science in Mathematics that is in the final review process. As the primary author of the proposal, I will present the structure of the new major, highlighting influences from the Committee on Undergraduate Programs Report, and discuss the review process. The speaker hopes that many colleges near Tacoma who share their student body with UWT will attend to collect information and provide feedback for the program.

80 *Deck Manipulation Through Perfect Shuffles*
Nicole Welch, Western Oregon University[*†]
(*Session:* NUMS III—Probability and Number Theory)

Perfect shuffles on a deck of cards perfectly interleave the cards. Out-shuffles leave the top and bottom card in the same positions, while in-shuffles do not. When in and out shuffles are combined, a card can be moved from any place in the deck to any other position the shuffler desires. This presentation will explore the algorithm that makes this possible.

81 *Numerical Analysis and Mathematical Biology*
Brandy Wiegers, Central Washington University[†]
(*Session:* Mathematical Modeling I)

The root growth process is characterized by the plant cells absorbing water which, in turn, generates pressure on the cellular wall. This pressure forces the cell to grow by inflating it like a water balloon, stretching the cellular wall to the point that the expansion is irreversible. The primary question that plant physiologists have about this process is, where is the water coming from to enable the growth? The theories of the source of water to facilitate plant growth can be tested by evaluating the plant root growth model using numerical methods and comparing the estimates to experimental observations. Results of this model are providing valuable insight into the plant root growth theories and provide an engaging sample of different numerical analysis techniques.

82 *Graph Theory and Sprouts*
Derek Zeis, Western Oregon University[*†]
(*Session:* NUMS V—Combinatorics and Games)

Games are a great way to learn a new subject. Sprouts is a game that uses graph theory in many ways. In order to explore how moves are made, and how to restrict the bound for the number of moves requires graph theory. Along with graph theory, combinatorial game theory plays a role in determining a winning strategy for the game of Sprouts.

Abstracts of Poster Presentations

(in alphabetical order)

83 *Sphere Number of Simple Hexagonal Lattice*
Izaak Berg, University of Washington - Bothell[*†]

Lattices are collections of points in 3-space generated by integral linear combinations of vectors in 3-space. Lattices naturally occur as the centers of solid polyhedra that tesselate 3-space. The simple hexagonal lattice is the collection of centers of hexagonal prisms that tesselate 3-space, or can be viewed as combinations of the vectors $(1,0,0)$, $(1/2,(\sqrt{3})/2,0)$, and $(0,0,1)$. One defines a lattice sphere of radius r centered at the origin to be the collection of lattice points that are within a distance r of the origin. Lattice knots are closed non-intersecting polygons whose vertices lie on the lattice. Our project focuses on finding the smallest radius of a lattice sphere containing a non-trivial lattice knot - this number is the sphere number of the lattice.

84 *Artificial Intelligence of Modern Board Games: Battle Line*
Daniel Bladow, Gonzaga University[*†]

Many turn based board games played by computers use game state trees to determine what moves to make. Traversing through game state trees can be extremely time consuming, especially if the game involves random factors such as a deck of cards. Battle Line is a game where two players are competing over nine different three card poker hands using a 60 card deck with six suits and number values one through ten. Each hand is called a flag and the type of hand (such as straight flush or a three of a kind) is called a formation. Together, the deck and flags create an intractably large number of game states. We created an artificial intelligence where the computer uses a probabilistic approach to approximate future game states. We estimate future game states by determining the top formations we could make by playing a card from our hand on each flag. Then we calculate the odds of completing each formation, of each formation beating whatever the opponent can make, and finally of any of the top formations resulting in a win on that flag. By using probabilities the computer avoids traversing through numerous game states, and the computer's strategy is based on mathematical principles. There are two advantages to this approach to artificial intelligence. First of all, it is less time consuming and can be played on weaker computers, possibly cell phones. Secondly, the computer's thinking avoids ad-hoc strategic knowledge. It is given a mathematical concept and the rules of the game and then makes its own decisions about quality moves. Therefore, the computer is both more time efficient and capable of devising unique strategies based on mathematical principles.

85 *Chutes And Ladders*
Allison Coleman, George Fox University[*†]
Mary Fugle, George Fox University[*]

Our talk explores the effect of the spinner size on the length of a game of Chutes and Ladders. Starting by considering the size of the game board, and then integrating the effects of the chutes and the ladders, one can predict the length of the game through mathematical process. This general idea can then be applied to other similar games.

86 *From rice fields to wheat fields: modeling the effects of herbivore and predator vitality on crop yields*
Allison Fisher, Gonzaga University[*†]

The idea of agricultural intensification is what defines modern agriculture in that it uses technological advances in order to increase productivity. The goal of this project was to examine through mathematical modeling how agricultural intensification through driving herbivore-predator interactions can be beneficial or harmful to plant growth. In this study we used a tri-trophic Lotka-Volterra based model to investigate the overall plant-herbivore-predator interactions. From this model we were able to establish patterns that affect crop supply as well as investigate other plant-herbivore-predator interactions. The equations are very general and therefore can be applied to variety of situations.

87 *Differential Models of Parachuting Dynamics*
Ryan Magee, Gonzaga[*†]

The United States Air Force has a need for parachute operations which will work outside the scope of the current parachute systems. These operations can be constructed to mimic certain egress conditions, the end goal is always to obtain complete, unhindered openings of the parachute and a safe landing for the parachutist. Currently, USAF SERE Specialists operating as parachutists at Fairchild Air Force Base are using parachute systems designed for high altitude, high speed egress and openings. These parachutes are designed using parameters that cannot be recreated in a reasonable, safe or fiscally responsible sense. Therefore, these parachutists may face very real hazards inherent in the design of a parachute system being used outside of design parameters. The objective of our research is to develop differential models for these parachute systems and their functions using known design characteristics, and determine new or confirm actual parameters in the real-world deployment of these parachute systems. Our main focus is on low-altitude, low-speed parachute deployment under a range of atmospheric conditions. The objective is to confirm that parachutists involved in these parachuting events are being subjected to minimal risk while employing the current parachute systems and standard operating procedures. The rate of descent, location of landing, and the speed of reaching the ground will be studied through a differential equation model. Our results have very real implications in U.S. Air Force parachuting operations safety, standard operating procedures and financial responsibilities to include air support operations.

88 *Modeling Mathematical Formulas with Computational Art*
Sarah Prata, Gonzaga[*†]

The purpose of this project is to represent mathematical summations and recurrence relations, visualizing the sum by generating a work of art. This project was inspired by recurrent complex patterns in both art and nature. Simple manipulations of famous recurrence relations, such as the Fibonacci sequence, are programed in Java, creating a broad variety of artistic designs. The result of this project is a beautiful demonstration of the intimate relationship between math and art.

89 *Knights, Knaves, Normals, Neutrals, and Nonsense: An Examination of Paradoxes on Tripledonia*

Andrew Spivey, George Fox University[*†]
Jacob Lohr, George Fox University[*†]

We are taking Jason Rosenhouse's article "Knights, Knaves, Normals, and Neutrals" (The College Mathematics Journal Vol. 45, No. 4 (September 2014) (pp. 297-306)) and applying his concepts to various paradoxes.

Campus Information

Building Codes:	DOU	Dougan
	WPH	William Philip Hall
	JOY	Joy

Wireless Login Info Open any web browser and type in the web address: www.tacoma.uw.edu At that time a login window should appear. Please use the user name and password below.

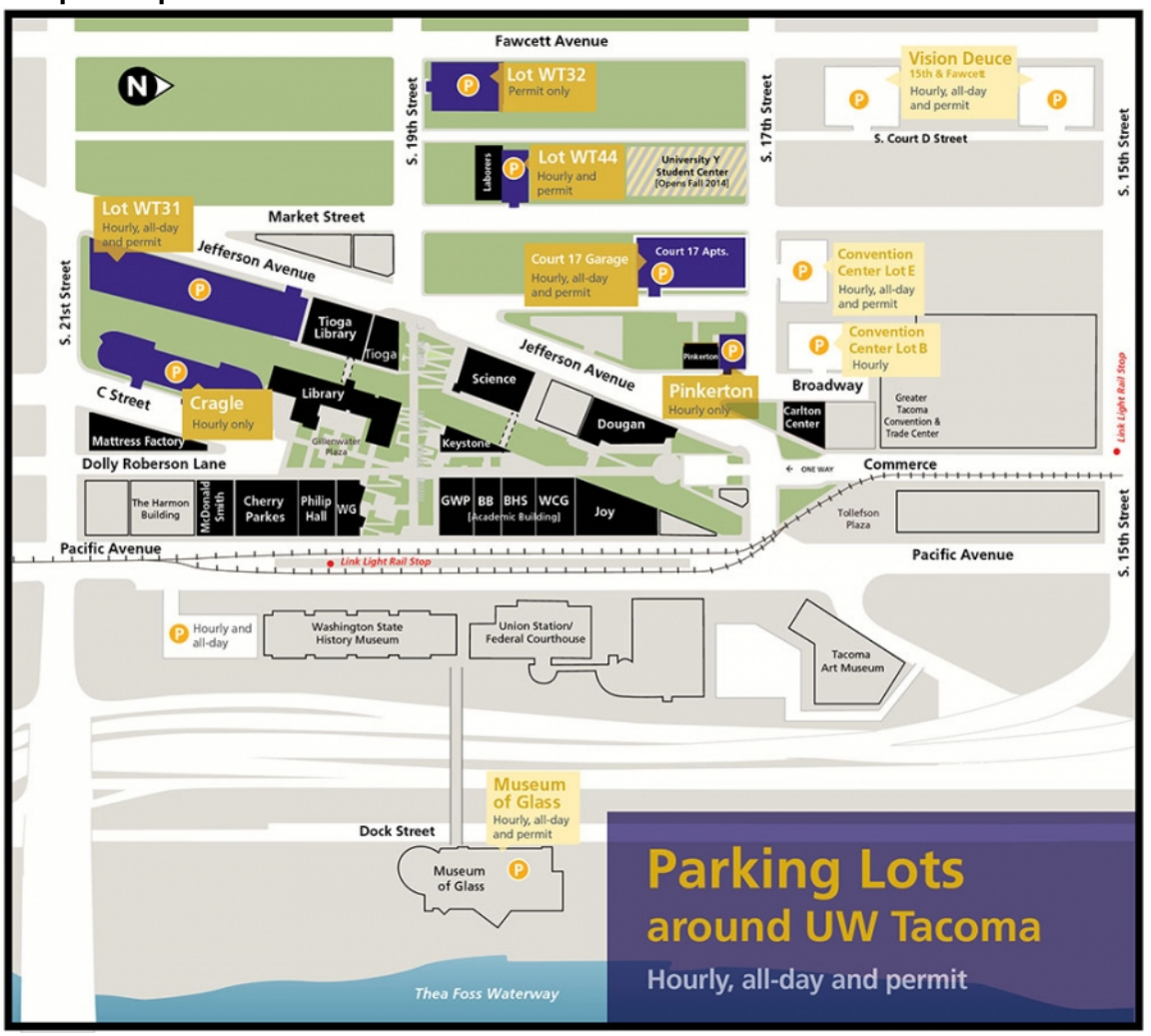
UW NetID: event0213
Password: dDAo_jKEy_mNEy

Emergency Information:

- Police/Fire/Medical Emergency: 911
- UWT Campus Safety and Security: Emergency (253) 692-4888; Non-Emergency (253)692-4416

Campus Map and Parking Information

Campus Map



Parking:

- Parking permits are required to park on campus:Daily Passes are sold in the parking lots listed below. The costs vary by lot.
  - **Lot W31** sells all-day parking passes for $7 and evening passes (after 5 pm) for $1.
  - **Lot 44** on 19th and Market on Friday and Saturdays, sells all-day passes for $4 and evening passes (after 5 pm) for $2.
  - **Court 17** sells all-day passes for $6 and evening passes (after 5 pm) for $6.
- If you don't mind walking a few blocks up and down the hills, you can park for free between Fawcett Street and Tacoma Avenue, from South 21st to South 17th street and south of 21st street. Be warned, Saturday April 11th is the Daffodil parade and parking will be tight downtown.
- Metered On-Street Parking is limited to 90 minutes around campus and 2-hours outside of campus. It's not really a viable option.

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- All the conference speakers and participants for making the conference an awesome one!

Thanks for sharing your mathematics with us at UW Tacoma this weekend.
Jenny Quinn