# Pure and Applied Talks by Women Math Warriors

**presented by EDGE (Enhancing Diversity in Graduate Education)**

**Tuesday January 13, 2015, 1:00 p.m.-5:00 p.m.**

**2015 Joint Mathematics Meetings, Room 216A, Convention Center**

## Schedule

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Abstracts

Solving the KO Labyrinth
Alissa Crans*, Loyola Marymount University

The KO Labyrinth is a colorful spherical puzzle with 26 chambers, some of which can be connected via holes through which a small ball can pass when the chambers are aligned correctly. The puzzle can be realigned by performing physical rotations of the sphere in the same way one manipulates a Rubik’s Cube, which alters the configuration of the puzzle. The goal is to navigate the ball from the entrance chamber to the exit chamber.

We will find the shortest path through the puzzle using Dijkstra’s algorithm and explore questions related to connectivity of puzzle using the adjacency matrix, distance matrix, and first passage time analysis. We will show that the shortest path through the maze visits only ten chambers, whereas a random walk through the maze visits, on average, about 340 chambers before reaching the end. We will pose an analogue of the gambler’s ruin problem and separately consider whether we are able to solve the puzzle if certain chambers are off-limits. Finally, we will conclude with questions for future investigation. This is joint work with Robert Rovetti and Jessica Vega.

Geometric Transitions of the Group of Diagonal Matrices
Arielle M Leitner*, University of California, Santa Barbara

A geometric transition is a continuous path of geometries which abruptly changes type in the limit. We explore geometric transitions of the Cartan subgroup in $SL_n(\mathbb{R})$. For $n = 3$, it turns out the Cartan subgroup has precisely 5 limits, and for $n = 4$, there are 15 limits. For $n \geq 7$, it turns out that there is a continuum of non conjugate limits!

Some recent results on magic-type labelings of directed graphs
Alison M Marr*, Southwestern University

This talk will focus on three types of magic labelings for directed graphs. We will discuss recent results related to magic labelings, vertex-magic edge labelings, and in-magic labelings of directed graphs. Each of these definitions is slightly different, but the main idea is that the sum of labels going into and/or out of a vertex will be constant across all vertices. Examples will be given and future questions will be posed. Much of this work is in collaboration with undergraduate students and thus this talk is accessible to undergraduates. Collaborators on this work include Brian Cohen, Matthew Nickell, Sarah Ochel, Bianca Perez, Kendall Richards, and David Vaden.
Algorithm to Enhance Stereoscopic Imagery
Michelle Craddock Guinn*, Belmont University

The objective of my research is to design an algorithm to present enhanced stereoscopic imagery that is adapted to the viewing distance of the observer, with seamless transitions among stereo and hyperstereo levels. I will design an algorithm that use the image smoothing techniques to provide this enhancement. The research will improve images that Soldiers can use to perform several tasks and can potentially provided better situational awareness.

Modeling the dynamics of insulin-mediated ovarian steroid production
Erica J. Graham*, North Carolina State University, James F. Selgrade, North Carolina State University

The ovulatory cycle is a tightly regulated system of feedback that depends largely on cross-talk between brain- and ovary-derived hormones. Polycystic ovary syndrome (PCOS), a common cause of infertility, results from dysregulation of these hormones and is often characterized by increased ovarian androgen production (hyperandrogenism). Hyperandrogenemic PCOS is also associated with elevated insulin levels resulting from cellular insulin resistance (an important mediator of type 2 diabetes). Although the precise mechanisms of ovulatory dysfunction in PCOS remain to be elucidated, we can explore its pathogenesis through mathematical modeling of known endocrine processes. Here, we develop a system of nonlinear ordinary differential equations to describe follicle development and intracellular mechanisms of insulin-mediated ovarian steroid production. We estimate a typical set of parameters by optimizing the model with data obtained from the literature and present numerical results. We then explore abnormal parameter regimes and discuss implications for the role of insulin in ovulatory dysfunction.

Supplemental Immunization Activities: a Mathematical Model for Measles Control in Kenya
Laurel A Ohm*, University of Minnesota, Twin Cities

Though sustained progress has been made, measles continues to pose a serious health concern during early childhood in many developing countries. Sub-Saharan Africa alone accounted for nearly 40 percent of measles mortality in 2010 (about 50,000 deaths). Elimination of the disease within the next fifteen to twenty years represents a major goal for the World Health Organization. In this paper, we present an SEIR model for measles transmission in Kenya based on historical and projected demographic data as well as recorded immunization activities. We explore the effects of routine infant vaccination and periodic mass-vaccination campaigns for the under-five population on the persistence of the disease thirty to fifty years into the future. We show that, in the case of Kenya, given a certain level of routine measles vaccination, we can determine the corresponding SIA periodicity and coverage necessary for measles control, allowing for exploration of the tradeoffs in feasibility and cost-effectiveness between sustained routine coverage and periodic SIAs.

Mathematical Modeling of Cardiovascular Dynamics during Head-up Tilt
Nakeya D Williams*, The United States Military Academy

Pulsatile and non-pulsatile models that predict dynamic changes in arterial blood pressure during head-up tilt (HUT) are presented in this work. This study shows how mathematical modeling can be used to predict changes in cardiac contractility and vascular resistance, quantities that cannot be measured invasively, but which are useful to assess the state of the cardiovascular system. The models are rendered patient specific via the use of parameter estimation techniques. This process involves sensitivity analysis, prediction of a subset of identifiable parameters, and nonlinear optimization. Results show that it is possible to identify a subset of model parameters that can be estimated allowing the models to predict changes in arterial blood pressure observed at the level of the carotid bifurcation. It is also shown that a simpler non-pulsatile model can be used in conjunction with other physiological models; yet still portray the same dynamics as the pulsatile model. We also show that an optimal control approach is useful for controlling quantities that effect the cardiovascular system during HUT in comparison to numerical optimization with piece-wise linear splines.
Parameter-free methods distinguish Wnt pathway models and guide design of experiments
Adam L MacLean, University of Oxford, Zvi Rosen, University of California, Berkeley, Helen M Byrne, University of Oxford, Heather A. Harrington*, University of Oxford

The canonical Wnt signaling pathway is crucially involved in development, adult stem cell tissue maintenance and a host of diseases including cancer. We propose a new mechanistic model that targets spatial localization and compare this model and existing models from the literature to data. Using Bayesian methods we infer parameters for each of the models to mammalian Wnt signaling data and find that all models can fit this time course. We are able to overcome this challenge by appealing to algebraic methods (concepts from chemical reaction network/injectivity theory and matroid theory) to analyze the models without recourse to specific parameter values. These approaches provide insight into Wnt signaling: The new model (unlike any other investigated) permits a bistable switch in the system via control of shuttling and degradation parameters, corresponding to stem-like vs committed cell states in the differentiation hierarchy. Our analysis also identifies groups of variables that must be measured to fully characterize and discriminate between competing models, and thus serves as a guide for performing minimal experiments for model comparison.