

REU Seminar Series

Thursday, 1:00pm, Nesbitt Room

June 28

Martin J. Strauss, Faculty

Title: *We examine the card game Spot it! with applications to art, error-correcting codes, and finite fields*

Abstract: We'll also answer the following puzzle, related to group-testing in drug discovery. We are given 13 coins, and told that one is counterfeit and lighter than the others, or one is heavy, or all are true. We can use a pan balance and other coins known to be true. How do we find the counterfeit coin, if there is one, in three weighings?

Jaeyoon Kim and Charles Devlin

(Mentor: Ian Tobasco)

Title: *Optimal Isometric Approximation of Curves*

Abstract: In 1954, John Nash proved that any smooth embedding of a Riemannian manifold which shrinks distances may be approximated arbitrarily closely by C^1 isometric embeddings. While such isometric embeddings are necessarily rough, featuring large or infinite curvatures in general, quantifying the precise amount of roughness required remains an open problem. Inspired by connections with elasticity theory, we consider the problem of minimizing the "bending energy" or total square curvature of an arbitrary arc-length parameterized curve approximating a given short one. We produce an explicit helical construction and prove that it is nearly optimal in the large curvature limit.

Jonathon Jacobs

(Mentor: Hailun Zheng)

Title: *Minimal Triangulations of Sphere Products*

Abstract: Calculating the face numbers of triangulations of topological spaces is a difficult problem. Trying to find a triangulation with the fewest vertices and deciding whether or not it is unique is even harder. In this talk, we present facts, previous results, and one or two triangulations of the product of spheres that are close to minimal.

Alison Elgass

(Mentor: Marisa Eisenberg)

Title: *A decision-theory based approach to modeling HPV vaccination & disease patterns*

Abstract: HPV is the most common sexually transmitted infection in the U.S. A vaccine was introduced in 2006 and is recommended for girls and boys starting at ages 11-12. Unfortunately, this vaccine has seen lower uptake rates than many other childhood vaccines, begging the question: why and how do parents decide to vaccinate or not vaccinate their children against this disease? In this talk, I'll explain how we can use decision theory to mathematically model this choice. I will go through the derivation and calculation of the Nash equilibria of the system, and talk about how changing parameters can affect its dynamics, mimicking the complicated interactions and preferences we see in real life. If time permits, I will talk about how I next plan to incorporate this decision model into an ODE-based disease transmission model.

Ariella Goldberg

(Mentor: Sofia Piltz)

Title: *Modeling Processing of Pain and Spinal Cord Stimulation*

Abstract: The body processes painful stimulus mainly in the dorsal horn of the spinal cord, which contains complex neural circuitry. Nerve fibers receive inputs from painful stimulation in peripheral tissues, like the skin and other organs, and respond with signals to different neuron populations located in the dorsal horn. For instance, a painful pinch to the skin activates certain fibers, which relay this information to populations of neurons in the dorsal horn, and results a painful sensation. For our research, we are interested in the behavior of these populations of neurons: namely, inhibitory neurons, excitatory neurons, and wide dynamic range (WDR) neurons. WDR neurons send pain signals from the dorsal horn to the brain. Excitatory neurons increase the activity of WDR neurons, while inhibitory neurons inhibit the activity of WDR neurons. We use ordinary differential equations to model the activity (in terms of average firing rates) of excitatory and inhibitory neuron populations and their impact on the firing rate of WDR neurons. In our model simulations, we incorporate experimental results in the values of model parameters representing the characteristics of different nerve fibers and the behavior of the neuron populations. In particular, we are interested in spinal cord stimulation (SCS), which increases A β fiber activity. The resulting behavior of the WDR neurons has been shown to induce pain relief. Our goal is to reproduce these experimental results, and investigate what factors cause SCS to be effective or ineffective in relieving pain.