Abstracts
Midwest Undergraduate Mathematics Symposium
April 1, 2006

Plenary Talks

***How can something 10^{-6} meters in length affect the space shuttle?* by Dr. Tim Breitzman, University of Dayton Research Institute**

Applications of composite materials are increasing in number every day. One difficult issue associated with composites has been the characterization of the effects of multiple length-scales. This talk will explore the effects of micron-sized carbon fibers on the overall strength of composite materials used to build equipment ranging from aerospace vehicles and satellites to crutches and bridges. The characterization of these effects makes use of an interdisciplinary set of scientific skills that hinges on the mathematical description of the physical system.

***Multi-scale analysis* by Dr. Tim Breitzman, University of Dayton Research Institute**

Composite materials can have very complex structures. This complexity can be impossible to model explicitly. Thus simplifications are often made to enable calculations to be carried out on computer systems. Unfortunately, these simplifications do not always paint an accurate picture of the complex systems they represent. The multi scale strain analysis method is one way to recover information about the complex system from the simplified model. This talk will explore the central ideas of the multi scale strain analysis method. Pictorial evidence is shown to support conclusions about the need to consider the contributions of the microstructure and the prestress.

Oral Presentations by Undergraduate Students

***Understanding the Bible Code* by Robert Delsing, Simpson College**

In 1994, three mathematicians named Witztum, Rips, and Rosenberg (WRR) published an article in the journal *Statistical Science* claiming that the names of influential rabbis and their birth or death dates were encoded within the Book of Genesis. Three years later, three mathematicians named Bar-Hillel, Bar-Natan, and McKay wrote a series of articles proving that the procedure used by WRR was fundamentally flawed and that these codes could be found in any significantly long text. The purpose of my project is to study the processes used by the mathematicians in order to understand how their results were obtained.

The use of Equidistant Letter Sequences (ELS) is essential to the mathematicians' processes. The names of the rabbis, as well as their birth or death dates, were found in Genesis as ELS's, which are formed by choosing a starting letter and repeatedly skipping over a certain number of letters in the text to obtain the positions of the next letters of the ELS. I have discovered several properties of ELS's and I am working on creating a formula that calculates the total number of ELS's possible in a text with a given number of letters. I am currently researching the use of arrays and distance functions on cylinders, used by the mathematicians to calculate the "distance" between two words, which is crucial to their research.

***High-Precision Calculation of Pi Using Distributed Computing* by Jonathan Cottrill, Des Moines Area Community College**

With the growing power of today's personal computers, the importance of numerical analysis has become increasingly apparent. It is now possible to obtain extremely high-precision approximations for pi by using a combination of inverse trigonometric functions, parametric equations, and power series, while distributing the workload across a scalable computer networking environment. This presentation will demonstrate a simple approach to the mathematics of computing the value of pi, with a focus on developing a set of arguments near the convergent center of an inverse trigonometric power series, thus facilitating rapid convergence to the desired value.

***Monopolist Strategies in a Durable Goods Market* by Shikha Basnet, Simpson College**

In his classical model for durable goods monopoly, Ronald Coase conjectured that a monopoly will never be able to charge a price above the equilibrium competitive price and the monopoly will end up forgoing dominant market power. This talk will begin with discussing the ideas of Coase. Under certain circumstances, the ideas in the Coase conjecture break down, which we can see in high-end fashion industry. We will finish the talk by looking at a model that may shed light on this situation.

***Water Water Everywhere!* by Patrick Carlson, Joan Ritho, and Tim Fairfield, Simpson College**

For the 2006 Math Modeling Competition, our group investigated the water distribution capabilities of a sprinkler system on a rectangular field. We tried to maximize efficiency given the strict parameters of the problem. Using a combination of several fields such as geometry, algebra, and physics we came up with a model that ensured the constraints of the problem were met. We will discuss the two ways in which we attacked and analyzed the problem.

***Sperm Competition* by Jonna Anderson, Simpson College**

This introductory presentation will focus on the concept of sperm competition as proposed in the paper "Allocation to Mate Guarding or Increased Sperm Production in a Mediterranean Wrasse", authored by Suzanne H. Alonzo and Robert R. Warner. Following the ideas of the paper we will consider the benefits of allotting energy to mate guarding rather than increased sperm production, and look at this technique in the Mediterranean Wrasse *Symphodus ocellatus*. We will also look at the possibility of future research in the area, and how the model can be adapted to other populations.

***Love and Loss in Wheelchair Service – A Modeling Contest Paper* by Max Schlatter, Shikha Basnet, and Maya Hristakeva, Simpson College**

The recent 2006 Mathematical Contest in Modeling (MCM) proposed developing a mathematical model for an airport wheelchair service. In this talk, we will present our model which consists of a scheduling algorithm that determines the movement of wheelchairs and escorts throughout each day and a cost/benefit analysis which uses the derivative of a negative exponential probability function to calculate the present cost and benefit estimates.

Poster Presentations by Undergraduate Students

Why Humans? **by Chase Richardson, Simpson College**

What did humans do through the course of evolution that allowed them to advance to the point of being considered one of the more dominant species on the planet? We will look at a mathematical model created by Robert Boyd and Peter Richerson that attempts to address this question. The results of this model provide evidence that the strategy of imitation is an evolutionary stable strategy and the combination of individual and social learning is the possible key.

The Chaotic World of Dynamical Systems **by Melinda Gatton, Simpson College**

Throughout the semester, I will be researching chaotic dynamical systems. This includes analyzing the mathematical equation $x_{n+1} = cx_n(1 - x_n)$. My analysis is focused of the results obtained though the process known as iteration, which is using the output of a previous operation as an input in the next operation calculated. After several iterations, the results could fall into one of three categories: the outputs of the equation could converge to one particular value, oscillate between two or more values, or the outputs are chaotic. The results obtained under one particular x_0 value are compared to the results obtained under a second x_0 value. In some cases the results obtained under the two x_0 values are the same, but in other cases the results are completely different. This difference in results is essentially what deems an equation to be classified as chaotic. My objective is to analyze the particular c-values that create chaos in systems.

Zeta functions of finite graphs **by Prakash Kayastha, Simpson College**

In 1966, Ihara defined the zeta function of a finite graph, and in 1989, Hashimoto discovered an equivalent definition. This presentation will focus on the definition given by Hashimoto. This presentation will show the relation between the number of edges and loops in a graph and the zeta function of the graph. Furthermore, we will give an example of two different graphs that have the same zeta function but different number of vertices.

Connected Sets **by Macy Allen, Simpson College**

Fundamental concepts of Point Set Topology include topology, neighborhood, limit point, and the closure of a set. These concepts allow us to consider separated sets, which is fundamental to understanding connected sets. The wording for the definition of connected sets is somewhat difficult to work with so the definition of a relative topology is introduced so a characterization of connected sets can be proven. This characterization shows that a set, A, is connected if and only if no nonempty proper subset of A is both open and closed relative to A. Using this information, we can examine connected sets in the discrete, indiscrete, and general topologies.

T_i* *Properties of Topological Spaces **by Mandi White, Simpson College**

Point-set topology allows us to study numerous structures of sets. This presentation focuses on separation properties concerning T_i spaces. T_0, T_1, T_2, T_3, and T_4 spaces are defined and illustrated by various examples. Examples are given to show If T_i, then T_{i-1}, for $i = 1,2$, and to show that the converse of these statements are not true. Special attention is given to the topology $\Im = \{\varnothing\} \cup \{\Re - F : F \text{ is a finite subset of } \Re\}$. Also examples for indiscrete and discrete T_i spaces and normal and regular spaces are presented.

Steady State Temperatures **by Brad Knox, Simpson College**

During this semester we have been working with conformal mappings. Our specific problem is to find the isotherms in an insulated, semi-infinite plate in the upper half of the complex $z = x + iy$ plane. In the semi-infinite plate along the x-axis the temperature is 0 except for $-1 < x < 1$, where the temperature is 1. To find the isotherms, we will use a transformation $w = f(z)$ to transform the original region from the $z = x + iy$ plane to the $w = u + iv$ plane. It will be easy to find a harmonic function, $T(u, v)$ to describe the isotherms in the uv-plane. Then we will compose T with the inverse function $f^{-1}(w)$ to get $T(x, y)$ which describes the isotherms in the xy-plane.

Folding and Cutting Paper **by Angela Servais, Simpson College**

Everyone has attempted to fold origami paper into a crane. However, did you know that you could create a silhouette of that crane by using a compass, a straight edge, a few folds in the paper and one cut with a scissors? This presentation will introduce the methods behind how to fold a piece of paper in a certain way that you can make one cut to get any polygon or silhouette of an animal. The presentation will also include on-the-spot demonstrations of how to create a polygon with one cut. The speaker will cover the origination of cut-and-fold method, flat origami folding, non-flat origami folding and mathematical proofs that you need to understand to form any closed polygon with one cut.

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