PPRUMC 2009 Talks

Dr. Don Estep
University Interdisciplinary Research Scholar
Director, Center for Interdisciplinary Mathematics and Statistics
Director, Program for Interdisciplinary Mathematics, Ecology, and Statistics
Department of Mathematics
Department of Statistics
Colorado State University, Ft. Collins

Title: *Continuum Modeling of Stochastic Wireless Sensor Networks*

Abstract: Wireless sensor networks are extremely useful tools for gathering information from a complex environment. The networks are made up of many (tens to thousands) of data gathering devices spread over a region. The devices are connected locally to each other to make a wireless network over which the collected information is transmitted. There are applications in many fields, e.g. ranging from measuring the absorption of pollution by trees in a forest to detecting the spread of an aerosol in a crowded airport to measuring the passing of submarines in the ocean. Unfortunately, both building networks and directly simulating their behavior are enormously expensive undertakings. Improving our ability to understand how a large wireless network behaves and to design a network that gathers and transmits the desired information accurately and reliably is a high research priority for the nation. This raises many mathematical challenges. I will describe an approach to create a mathematical model of a wireless sensor network that uses probability, differential equations, and computer solutions to greatly improve the speed with which network behavior can be described.

Tim Lewkow
University of Colorado, Colorado Springs
Faculty Advisor: Dr. Sarbarish Chakravarty
Title: *Line-Solitons Solutions of the Kadomtsev-Petviashvili Equation*

Abstract: This research project involves the study of a weakly two-dimensional version of the Kortweg-deVries equation, known as the Kadomtsev-Petviashvili (KP) equation. The KP equation models nonlinear wave interactions in shallow water. Recent works have also considered the KP model to describe the mechanisms causing extremely high elevation waves on the ocean surface. There exist many different classes of solutions for the KP equation, however the focus of this research work is on the so called line-soliton solutions. This paper describes some specific details of one particular line-soliton solution known as O-type 2-soliton. Along with the structure of this solution, and some details involving the amplitude at the interaction point, a combinatorial problem is also introduced.

Carla Elder, Maurisa Jensen, Kelley O'Toole
University of Wyoming
Faculty Advisor: Siguna Muller
Title: *Residues and Pseudoprimes*

Abstract: Starting with a discussion of Fermat's Little Theorem and Carmichael numbers, *Residues and Pseudoprimes* will discusses possible structures for Fermat pseudoprimes and those

pseudoprime's relations to quadratic and higher residues. The presenters will begin by touching on the research done by Daniel Shanks on numbers of the form (6M+1)(12m+1). Then they will introduce the modified form n=(2m+1)(2km+1) and talk about how the form is related to the bases for which n is a Fermat pseudoprime.

Tyler Takeshita
University of Northern Colorado
Faculty Advisor: Dr. Anton Dzhamay
Title: *Circuit Approach to Modeling Neurons*

Abstract: Motivated by Professor Bo Deng's work, a systematic circuit approach to modeling neurons with an ion pump is presented. Like Dr. Deng, the voltage-gated current channels of a neuron are modeled as conductors, the diffusion-induced current channels are modeled as negative resistors, and the one-way ion pumps are modeled as one-way inductors. This model differs from the well-known Hodgkin-Huxley model because it splits the active and the passive branches of each ion species where as the HH approach combines the electromagnetic, diffusive, and pump channels of each ion into one conductance channel. Our model maintains several of the known properties of HH models along with being rich in many new dynamical structures including chaotic behavior.

Aaron Sheppard
Western State College
Advisor: Dr. Jeremy Muskat
Title: *Failure to Bridge the Gap*

Abstract: The standard solution to the famous bridges of Konigsberg problem is an elementary graph theory result involving vertex degrees. In this talk we discuss an alternative approach using powers of the adjacency matrix. While this approach failed gloriously it still provided an opportunity to explore graph theory with linear algebra techniques.

Yongli Chen, Scott Harder, Tim Lewkow
University of Colorado, Colorado Springs
Faculty Advisor: Dr. Radu Cascaval
Title: *Cell Phone vs. Landline Power Consumption*

Abstract: Over the past twenty years, the worldwide cell phone industry has grown at an exponential rate. In the United States alone, the number of cell phone users has grown from 340,000 in 1985 to over 260 million in 2008. The growing number of cell phone users significantly contributes to the overall energy requirement in the United States and abroad. Additionally, because of the low cost of developing wireless infrastructure compared to that of wide spread land line development, many developing countries are turning to wireless networks to meet their communications needs. The purpose of this project was to estimate the impact of wireless communications growth on energy consumption and the environment, compared to that of landline development, in order to determine an optimum method of implementing residential phone service in emerging markets.

Heather Thomas
Mesa State College
Faculty Advisors: Dr. Chris Hallstrom and Dr. Stephanie Salomone (University of Portland)
Title: *Voice-Printing Great Horned Owls Using Wavelet Analysis*

Abstract: This past summer I was chosen to participate in an 8-week Research Experience for Undergraduates (REU) through the Willamette Valley Consortium for Mathematics Research (WiVaM). There were four schools that hosted undergraduates as well as current high-school teachers, and each school worked on a different project. I was chosen to work on a project through the University of Portland (UP) analyzing owl calls using Fourier and Wavelet techniques. We found that the wavelet transform is an attractive tool for gleaning unique information from a signal and more effective than traditional Fourier techniques. This information can then be used to analyze the properties of an owl call and develop a profile for a particular bird. Our primary goal was to affirm the results of a biology student at UP indicating that voice-printing was an effective method of identification.

Molly Moran
Colorado College
Faculty Advisor: Dr. Roberto Pelayo (University of Hawaii, Hilo)
Title: *Braid Theory and the Alexander Polynomial*

Abstract: In 1923, J.W. Alexander gave knot theorists a new way of approaching the study of knots by proving that any oriented knot or link can be presented as the closure of a braid. Thus, braid theory and knot theory have become intertwined fields of study, allowing mathematicians to draw upon properties of both fields to answer their research questions. Often, these questions boil down to the ability to distinguish knots through the use of invariants. Alexander made another important contribution to the field in 1928 with his introduction of the first polynomial knot invariant, aptly named the Alexander polynomial. During the presentation, we will introduce basic concepts of braid theory, followed by a discussion of this groundbreaking invariant and some of its properties, a method of computation using braid theory, and the ability of this invariant to distinguish between nontrivial knots and the trivial Alexander polynomial.

Andrew Hauser, Karl Heimbuck, Heather Robinson
University of Wyoming
Title: *Applications of Lucas Sequences in Primality Testing*

Abstract: Given integers P and Q, a Lucas sequence is defined as the list of all U_n and V_n such that $U_{n=1} = PU_n – QU_{n-1}$ and $V_{n=1} = \mathrm{P}V_n - QV_{n-1}$. By testing specific conditions of U_n and V_n in combination with the Fermat test, the primality of n can be tested. The goal of this research was to determine which combinations of the conditions on U, V and the Fermat test work best to yield the least amount of pseudoprimes when used as a primality test.

Heather Thompson
University of Northern Colorado
Faculty Advisor: Dr. Anton Dzhamay
Title: *Normal Form of the Skein Algebra*

Abstract: Given that a framed link in a 3-manifold is a subset homeomorphic to a finite disjoint union of circles cross [-1,1], we are interested in looking at these framed links lying inside 2-dimensional surfaces cross the interval [-1,1]. These 3-manifold "cylinders over a surface" have some interesting properties when we compute their skein module. Building on Bullock and Przytycki's paper, Multiplicative Structure of Kauffman Bracket Skein Module Quanitizations, we examine multiplication of simple closed curves lying on the punctured torus and converting words from the skein algebra into normal form. Finally we program Mathematica to reduce words into normal form for us.

James Garcia
CSU Pueblo
Faculty Advisor: Dr. Bruce N. Lundberg
Title: *Space the Final Frontier: Explorations of Halo Orbits in the Three-Body Problem*

Abstract: Halo orbits have an important role in some recent and planned space missions. My talk will consider the computation of halo orbits in the restricted three body problem, using a linearization about each libration point to analytically determine useful orbits and to select approximate target conditions for entering a halo orbit. Examples of halo orbits about Earth-Moon libration points L_2 and L_4 will be given. The stability of these orbits in the nonlinear dynamics will be examined using numerical integration. I will conclude with some applications and future goals of this work.

JewellAnne Hartman
University of Colorado, Colorado Springs
Title: *Series Investigations and Fractals and their Applications*

Abstract: Series investigations and fractals. The results of a project for which I have conducted research for a mathematics class. An exploration of the properties of a Cantor Set, Sierpinski Carpet, and Koch Snowflake analyzed through a series and sequential perspective. The applications of the Cantor set and the Koch snowflake, particularly in the field of topography and Triadic Koch Fractal Antenna respectively, will also be discussed.

Andrew Bean
Colorado College
Advisor: Amelia Taylor
Title: *Measuring Uncertainty in Phylogeny Inference*

Abstract: In the science of inferring phylogenies, many methods are available for producing phylogenetic trees from genetic data, yet the reliability of the results is quite difficult to estimate. The need for statistical measures of uncertainty (and of accuracy) in the trees has become a central problem in mathematical phylogenetics. In this talk, I introduce a version of the most common method for measuring uncertainty: the bootstrap. From a single genetic data set, the bootstrap resamples randomly and with replacement to produce pseudosamples that provide a sense of the accuracy and repeatability of a phylogenetic tree. In this research, a new method of bootstrapping is created to accommodate short-tandem-repeat data for human populations, a variation on bootstrapping methods which are designed to deal with DNA sequences. Issues of interpretation and implementation of the bootstrap in phylogenetics will also be discussed.