ABSTRACTS of Papers

presented at

MathFest 2010

MAA

Pittsburgh, Pennsylvania
August 5–7, 2010

Abstracts of Papers Presented at

MathFest 2010

Pittsburgh, Pennsylvania

August 5–August 7, 2010

MAA

Published and Distributed by

The Mathematical Association of America

Contents

Invited Addresses

Earl Raymond Hedrick Lecture Series

Robert L. Devaney Boston University

Complex Dynamics and Crazy Mathematics

In these lectures we will investigate some of the complicated dynamics and beautiful images that arise when complex functions are iterated. The chaotic regimes for these maps, the so-called Julia sets, are extremely rich from both a topological and geometric point of view. Yet to this day, the Julia sets for such simple maps as the quadratic function $z^2 + c$ and the exponential map λe^z are not completely understood. Each of these lectures will be independent and will focus on a particular class of complex maps. As a subtheme, each lecture will feature some of the "crazy" mathematics that is used to understand these sets.

Lecture 1: The Fractal Geometry of the Mandelbrot Set
Thursday, August 5, 10:30 – 11:20 am

In this lecture we will describe the structure of the Mandelbrot set, the parameter plane for the quadratic function $z^2 + c$. While the geometry of this set is very intricate, much of it can be understood as long as you know how to add and count the crazy way some number theorists do.

Lecture 2: Exponential Dynamics and Topology
Friday, August 6, 9:30 – 10:20 am

In this lecture we turn attention to the very different behavior of the complex exponential function λe^z. We will describe some of the incredible bifurcations this map undergoes when λ varies. And we'll see that many crazy topological objects like Cantor bouquets and indecomposable continua arise in these Julia sets.

Lecture 3: Sierpiński Galore
Saturday, August 7, 9:30 – 10:20 am

In this lecture we describe the dynamics of certain families of rational maps. Here we will focus on maps for which the Julia sets are Sierpiński curves. We will see that these types of Julia sets arise in a myriad of different ways and that they also exhibit some crazy geometric and topological properties.

MAA Invited Address

Saturday, August 7, 8:30 — 9:20 am

Frank Farris Santa Clara University

Creating Symmetry

A child can create symmetry by repeatedly stamping out a pattern with a cut potato, but a mathematician enamored of smoothness might prefer to find mathematical objects whose very nature is symmetry. A main example of a vibrating wallpaper drum leads to a more general story about symmetry that combines everyone's favorite objects: Fourier series, the Laplacian, and group actions.

MAA Invited Address

Thursday, August 5, 8:30 – 9:20 am

Rebecca Goldin George Mason University

An Attempt to Turn Geometry into (Decorated) Graphs

In the late 19th century, mathematicians were interested in problems such as this one: given four generically placed lines in three dimensions, how many other lines intersect all four? This question and many others can be formulated in terms of the intersections of subvarieties of the Grassmannian of k-planes in n-space, or more generally, flag varieties (whose points are sequences of inclusions of vector spaces). These intersection questions inside the flag variety and some generalizations, together with related algebraic and combinatorial questions, form the field of Schubert calculus. Of primary importance is that flag varieties can be realized as algebraic, symplectic manifolds with Hamiltonian actions by a compact torus. Among the magic properties are that the torus acts with isolated fixed points, and that codimension-one tori fix only points and two-spheres. The desire to compute associated algebraic invariants, such as the product structure of associated rings in special bases, has spawned many combinatorial and graph-theoretic objects. In this talk, we will discuss some graphs associated to certain manifolds with torus actions, and ask the question of how combinatorial games involving the graphs can be used to answer geometric questions about the original manifold and intersections of subvarieties therein.

MAA Invited Address

Thursday, August 5, 9:30 – 10:20 am

Martin Golubitsky Ohio State University

Mathematics Motivated by Biology

Interesting areas in biology (I'll stress neuroscience) often lead to new mathematics. For example, the characteristic rhythms of animal gaits lead to a classification of spatio-temporal symmetries of periodic solutions; the abstraction of experimentally determined connections between hypercolumns in the visual cortex (itself a Nobel Prize winning idea) leads to an embedding of the Euclidean group in the visual system (and a possible description of geometric visual hallucinations); and an attempt to understand the remarkable variety of bursting neurons leads to the understanding of the dynamics of bursting in multiple time-scale systems. In this talk I'll survey some of these connections.

MAA Invited Address

Saturday, August 7, 10:30 – 11:20 am

Zvezdelina Stankova Mills College

The Mathematics of Math Circles

The creation of math circles in the San Francisco Bay Area over a decade ago started a chain reaction, spreading to California and neighboring states, and resulting in over 75 circles in the U.S. and Canada. But what is a math circle? Are math circles designed for talented pre-college students or for those who don't yet know if they like mathematics? Must they concentrate on math contest preparation or on discovering interesting mathematical facts? Could and should circlers be introduced to advanced mathematical theories and research? The answer depends on which U.S. math circle you are thinking of. Born within a day apart in 1998, the Berkeley (BMC) and San Jose Math Circles (SJMC) combine all of the above aspects. They attract and train IMO medalists and Putnam winners; but more importantly, they introduce the students to beautiful mathematics in inspiring sessions by mathematical stars such as Vladimir Arnold, Elwyn Berlekamp, Robin Hartshorne, Olga Holtz, Ravi Vakil, and Kiran Kedlaya, to mention a few. Are you, as a mathematician, brave, skillful and confident to turn an advanced, even research, topic into a math circle session and deliver it with success? Are such "miracles" possible on a weekly basis? Does this have anything to do with your career as a research mathematician or as a math educator? In this talk, we shall address these questions and explore several possible paths of transforming advanced math topics and research into math circle sessions, by following examples selected from among the 750 sessions at the BMC and SJMC over the past decade. In the complementary session "The Mathematics of Math Circles and Beyond", nine famous alumni of the BMC and SJMC ranging from high school students to postdoctoral fellows will share their own inspiring examples of connections between research and math circles in a variety of advanced mathematical areas.

MAA Lecture for Students

Thursday, August 5, 1:00 – 1:50 pm

Sommer Gentry United States Naval Academy

Faster, Safer, Healthier with Operations Research

While mathematical advances of all sorts have impacted our world for the better, operations research is a branch of mathematics that is expressly focused on applying advanced analytical methods to help make better decisions. Operations researchers have eased traffic jams by closing selected streets, and gotten packages to you more quickly by planning U.P.S. routes with fewer left turns. Operations researchers have shown which personal decisions are the leading causes of death, and planned emergency responses for bioterror attacks and natural disasters. Operations research can increase the supply of kidneys available for patients who need a transplant. In a kidney paired donation, one patient and his incompatible donor is matched with another patient and donor in the same situation for an organ exchange. Patient-donor pairs can be represented as the vertices of a graph, with an edge between two vertices if a paired donation is possible. A maximum matching on that graph is an arrangement in which the largest number of people can receive a transplant. Operations research techniques even proved the impact of paired donation on the kidney shortage, motivating Congress to pass a law allowing the United Network for Organ Sharing to arrange these transplants.

Pi Mu Epsilon J. Sutherland Frame Lecture

Friday, August 6, 8:00 – 8:50 pm

Nathaniel Dean Texas State University

Incomprehensibility

After data collection the analysis of complex systems is usually accomplished by analyzing the data using various statistical approaches. However, to understand the structural interactions between entities (for example, people, objects or groups), systems of interactions can be modeled as graphs linking nodes (entities) with edges that represent various types of relations between the entities. Then the graph can be visualized, explored and analyzed using a variety of mathematical algorithms and computer tools. In this talk we discuss the limitations of this approach, why some graphs cannot be visualized, and hence why certain data are visually incomprehensible.

James R. Leitzel Lecture

Friday, August 6, 10:30 – 11:20 am

William McCallum University of Arizona

Exploring School Mathematics with Felix Klein

Felix Klein's Elementary Mathematics from an Advanced Standpoint, published in 1908, is a tour of the school mathematics of his time, guided by profound mathematical knowledge and deep appreciation of teachers. 100 years later it inspired the Klein Project, a joint effort of the International Mathematical Union and the International Commission on Mathematical Instruction, to develop resources that will help secondary mathematics teachers make connections between what they teach and the field of mathematics more broadly. What would a Klein tour of U.S. school mathematics today look like? How much of the countryside remains the same, and what new sights are there to see? In what condition are the original buildings? In this talk I will briefly revisit some of Klein's most striking illustrating of the fundamental unity of mathematics from high school to the frontiers of research, and then take a look at the current scenery of high school mathematics from Klein's perspective.

NAM David Blackwell Lecture

Friday, August 6, 1:00 – 1:50 pm

Asamoah Nkwanta Morgan State University

The Riordan Group Revisited: From Algebraic Structure to RNA

The purpose of this talk is to survey an infinite ordered matrix group called the Riordan group. The Riordan group arises in counting problems, combinatorial number theory, and the study of special functions. In this presentation we will focus on the algebraic structure of the group and explore some applications to molecular biology.

AWM-MAA Etta Z. Falconer Lecture

Friday, August 6, 8:30 – 9:20 am

Ami Radunskaya Pomona College

Mathematical Challenges in the Treatment of Cancer

What can mathematics tell us about the treatment of cancer? Cancer is a myriad of individual diseases, with the common feature that an individual's own cells have become malignant. It is believed that a healthy individual keeps potentially cancerous cells from developing into a threatening tumor through a complicated network of immune response and mechanisms built into the cell cycle that recognize aberrant cells and control their proliferation. Thus, the treatment of cancer poses great challenges, since an attack must be mounted against cells that are nearly identical to normal cells. Mathematical models that describe tumor growth in tissue, the immune response, and the administration of different therapies can suggest treatment strategies that optimize treatment efficacy and minimize negative side effects. However, the inherent complexity of the immune system and the spatial heterogeneity of human tissue gives rise to mathematical models that pose unique analytical and numerical challenges. These include modeling behavior over vastly different time scales, incorporating delays into the model, optimization in high-dimensional spaces, and fitting large sets of dependent parameters to data. In this talk I will present an overview of work that I have done in this area, with the help of many collaborators, over the last ten years, highlighting the various approaches we have taken to tackle these mathematical challenges.

Invited Paper Sessions

Visualizing Combinatorics Through Tilings

Thursday, August 5, 1:00 – 2:50 pm

Art Benjamin Harvey Mudd College (benjamin@math.hmc.edu)

Combinatorial Trigonometry

Using tilings, we provide a combinatorial proof that $\cos(n\theta) = T_n(\cos(\theta))$, where T_n is the nth Chebyshev polynomial defined by $T_0(x) = 1$, $T_1(x) = x$, and for $n \geq 2$, $T_n(x) = 2xT_{n-1}(x) - T_{n-2}(x)$.

Jennifer Quinn University of Washington Tacoma (jjquinn@u.washington.edu)

Linear Recurrences Involve Weighted Tilings

Binet's formula for the nth Fibonacci number, $F_n = \frac{1}{\sqrt{5}}\left(\frac{1+\sqrt{5}}{2}\right)^n - \frac{1}{\sqrt{5}}\left(\frac{1-\sqrt{5}}{2}\right)^n$, is a classic example of a closed form solution for a homogenous linear recurrence with constant coefficients. Proofs range from matrix diagonalization to generating functions to strong induction. Could there possibility be a better way? A more visual approach? A combinatorial method?

This talk introduces a combinatorial model using weighted tiles. Coupled with a sign reversing involution, Binet's formula becomes a direct consequence of counting exceptions. But better still, the weightings generalize to find solutions for any homogeneous linear recurrences with constant coefficients.

Bruce Sagan Michigan State University and NSF (sagan@math.msu.edu)
Carla Savage North Carolina State University (savage@cayley.csc.ncsu.edu)

Stalking the Wild Fibonomial

Let n, k be integers with $0 \leq k \leq n$. If one defines the binomial coefficients as

$$\binom{n}{k} = \frac{n!}{k!(n-k)!}$$

then it is not clear that this rational expression is always an integer. But if one shows that $\binom{n}{k}$ counts the number of k-element subsets of an n-element set, then integrality becomes clear.

The famous Fibonacci numbers are defined by $F_0 = 0$, $F_1 = 1$, and $F_n = F_{n-1} + F_{n-2}$ for $n \geq 2$. Consider an analogous "factorial" $F_n^! = F_1 F_2 \cdots F_n$ and the fibonomial coefficients

$$\binom{n}{k}_F = \frac{F_n^!}{F_k^! F_{n-k}^!}.$$

Using tilings, we give a simple combinatorial interpretation for $\binom{n}{k}_F$ closely related to the one for $\binom{n}{k}$, which also makes it clear that the fibonomials are always integers.

Brigitte Servatius Worcester Polytechnic Institute (bservat@wpi.edu)

Symmetry, Automorphisms, and Self-duality of Infinite Planar Graphs and Tilings

Imagine yourself in an enormous room so vast that the walls and ceiling are indiscernible. The floor is elaborately and beautifully tiled in polished stone, and moving about on the floor you see many many people, but on closer examination these people seem to be reflections of yourself. Can you, from the positions of the people, infer the location of mirrored walls? What if the mirrors are not ordinary, but have magical properties, such as transforming light to dark or blue to green? Can we tell if the room is finite or infinite? Let us discover this room's properties and examine its mysteries.

Combinatorial Games and Schubert Calculus

Session 1: Thursday, August 5, 1:00 – 4:50 pm

Julianna Tymoczko University of Iowa (tymoczko@umich.edu)
Megumi Harada McMaster University

Poset Pinball and Schubert Calculus

A poset is a directed acyclic graph: like a pinball machine, it's a collection of paths and chutes on a tilted board. In poset pinball, we place traps onto a poset, then drop balls from various points in the poset, letting the balls roll down until they're captured by traps. We show how a form of poset pinball can be used to compute equivariant cohomology with respect to circle actions, and to construct Schubert calculus for a collection of subvarieties of the flag variety. After an initial geometric analysis, this calculation is purely combinatorial (like GKM theory, which motivates our constructions). This is joint work with Megumi Harada.

Jennifer Morse Drexel University (morsej@math.drexel.edu)

A Tableaux Rasa Talk on Affine Schubert Calculus and Macdonald Polynomials

We introduce the combinatorial objects that give an explicit handle on the cohomology and K-theory of affine Grassmannians. We will discuss how these same objects come up in an unrelated study of symmetric functions called Macdonald polynomials.

Milena Pabiniak Cornell University (milena@math.cornell.edu)

Localization and Specialization in Equivariant Cohomology.

We consider a Hamiltonian torus action on a compact symplectic manifold M with isolated fixed points. We may then view the equivariant cohomology of M as a subring of a direct sum of polynomial rings. We are interested in determining the relations that cut out this subring. When M is a GKM space, there is a very simple answer in terms of the moment graph of M. In this talk, I will discuss the general algorithm for determining these relations in the case when we have a basis of canonical classes. The main ingredient of the algorithm is the localization theorem. The results will be illustrated by a variety of examples. The most important ones involve restricting a GKM torus action to a smaller torus (this process is called specialization).

Shrawan Kumar University of North Carolina (shrawan@email.unc.edu)

Eigencone, Saturation and Horn Problems for Symplectic and Odd Orthogonal Groups

This is a joint work with P. Belkale. We consider the eigenvalue problem, intersection theory of homogenous spaces (in particular, the Horn problem) and the saturation problem for the symplectic and odd orthogonal groups. The classical embeddings of these groups in the special linear groups play an important role. We deduce properties for these classical groups from the known properties for the special linear groups. The tangent space techniques play a crucial role. Another crucial ingredient is the relationship between the intersection theory of the homogeneous spaces for $\mathrm{Sp}(2n)$ and $\mathrm{SO}(2n+1)$. We solve the modified Horn and saturation problems for these classical groups.

David Johannsen George Mason University (djonhann1@gmu.edu)

Divisibility, Tori, and the Moment Polytope.

In their 1997 paper, Lerman and Tolman prove that given a simple rational polytope Δ with positive integers associated to each open facet, there exists a symplectic toric orbifold, (M, ω, T, Φ), such that $\Phi(M) = \Delta$. Moreover, the authors show that M can be obtained by symplectic reduction of $\mathbb{C}^N$ by the action of a torus, K (complementary to T in $\mathbb{T}^N$). We explore some consequences of the various divisibility relations among the components of the vectors giving the vertices of Δ and the facet weights. In particular, we ask the question of whether there is a combinatorial formulation for the number of connected components of K based on Δ and its associated integers. We will show some examples of disconnected K that can occur.

aBa Mbirika Bowdoin College (abukuse@hotmail.com)

Ideals of Symmetric Functions and a Possible Application to Cohomology

Let R be the polynomial ring $\mathbb{Z}[x_1, \ldots, x_n]$. We present two different ideals in R. Both are parametrized by a Hessenberg function h. The first ideal, which we call I_h, is generated by modified partial symmetric functions. This ideal is a generalization of the

Tanisaki ideal which was used with great success in a quotient presentation of the cohomology ring of the Springer variety. Like the Tanisaki ideal, the generating set for I_h is robust and at times redundant. We give a minimal generating set for this ideal. The second ideal, which we call J_h, is generated by modified complete symmetric functions. This ideal is combinatorially more pretty and useful. A quotient of R by this ideal has a very transparent basis due to the property that the generators of J_h form a Gröbner basis.

We introduce a partial ordering on the Hessenberg functions, and in turn we discover nice nesting properties in both families of ideals. When $h > h'$, we have $I_h \subset I_{h'}$ and $J_h \subset J_{h'}$. We conclude that I_h equals J_h when h is maximal. Since I_h is the ideal generated by the elementary symmetric functions when h is maximal, the generating set of J_h is a Gröbner basis for the elementary symmetric functions. Moreover, the quotient R/J_h gives another description for the cohomology ring of the full flag variety. At the writing of this abstract, the ideals I_h and J_h are only conjectured to be equal. By presentation time of this talk, we intend to conclude that indeed they coincide.

As an extra bonus, we have supporting evidence that as h varies, the quotient R/J_h may be a presentation for the cohomology ring of a subclass of Hessenberg varieties called Peterson varieties. The Hessenberg function h is one parameter used in Hessenberg varieties which were introduced in 1992 by De Mari, Procesi and Shayman. These varieties are a two-parameter generalization of Springer varieties.

William Graham University of Georgia (wag@math.uga.edu)

Relative Lie Algebra Cohomology and the Belkale-Kumar Product

Several years ago Belkale and Kumar introduced a new product on the cohomology of a generalized flag variety, with applications to the Horn problem. We show that this product arises naturally as the product on the space of global sections of a certain vector bundle constructed using relative Lie algebra cohomology. In particular, we identify the Belkale-Kumar cup product for every parameter. As a consequence, we extend a fundamental disjointness result of Kostant to a family of Lie algebras. This is joint work with Sam Evens.

Susan Tolman University of Illinois (stolman@math.uiuc.edu)

Schubert-type Formulas for Hamiltonian Manifolds

We will discuss recent techniques for extending some of the ideas from Schubert calculus to the more general setting of Hamiltonian torus actions on compact symplectic manifolds with isolated fixed points. Given a generic component Ψ of the moment map, which is a Morse function, we define a canonical class α_p in the equivariant cohomology of the manifold M for each fixed point $p \in M$. When they exist, canonical classes form a natural basis of the equivariant cohomology of M; in particular, when M is a flag variety these classes are the equivariant Schubert classes. The restriction of a canonical class α_p to a fixed point q can be calculated by a rational function which depends only on the value of the moment map, and the restriction of other canonical classes to points of index exactly two higher. Therefore, the structure constants can be calculated by a similar rational function. This restriction formula is *manifestly positive* in many cases, including when M is a flag manifold. Finally, it is an *integral formula* whenever M is a –tower" of complex projective spaces; this case includes coadjoint orbits of type A_n and C_n.

Based on joint work with Rebecca Goldin and Silvia Sabatini

Session 2: Friday, August 6, 2:00 – 3:50 pm

Kevin Purbhoo University of Waterloo (kpurbhoo@math.uwaterloo.ca)

Geometry of Jeu de Taquin

Jeu de taquin was first introduced by Schützenberger in the 1970s, and is now considered a fundamental construction in the combinatorics of Young tableaux. However, from the point of view of other branches of mathematics which use Young tableaux, (e.g., Schubert calculus, representation theory), it is not so clear why jeu de taquin is a natural operation. Surprisingly, a natural answer to this arises in studying the following problem: Let $g(z)$ be a polynomial. What can we say about the set of d-tuples of polynomials whose Wronskian equals $g(z)$?

I will talk about some of the history of this problem, and its relationship to jeu de taquin in the context of Schubert calculus.

Erik Insko University of Iowa (erik-insko@uiowa.edu)

Schubert Calculus and the Cohomology Ring of the Peterson Variety

From one point of view, Schubert calculus for the full flag variety interprets the cohomology ring of the flag variety as a ring counting the intersections of Schubert varieties. The Peterson variety is a singular subvariety of the flag variety studied in connection with the quantum cohomology of the flag variety by Peterson, Kostant, and Rietsch, among others. More recently, the equivariant cohomology of the Peterson variety has been identified independently by both Brion and Carrell and Tymoczko and Harada. I examine the interaction between Schubert varieties and the Peterson variety. Using only elementary geometry and standard facts in the Schubert calculus of the flag variety, I show that the cohomology ring of the flag variety surjects onto the cohomology ring of the Peterson variety.

Frank Sottile Texas A&M (sottile@math.tamu.edu)

Galois Groups for Schubert Problems

Building on work of Jordan from 1870, in 1979 Harris showed that a geometric monodromy group associated to a problem in enumerative geometry is equal to the Galois group of an associated field extension. These subtle geometric invariants are difficult to determine. A consequence of Vakil's geometric Littlewood-Richardson rule is a combinatorial criterion that the Galois groups of a Schubert problem on a Grassmannian contains at least the alternating group, and Vakil showed that most problems on small Grassmannians satisfy his criterion.

Exploiting Harris's equivalence, Leykin and I used numerical homotopy continuation to compute Galois groups of problems involving mostly divisor Schubert classes, finding all to be the full symmetric group. (This included one problem with 17589 solutions.)

My talk will describe this background and sketch a current project with Leykin, undergraduate students, graduate students, and postdocs to systematically determine Galois groups of all Schubert problems of moderate size on all small classical flag manifolds, investigating at least several million problems. This will use supercomputers employing several overlapping methods, including combinatorial criteria, symbolic computation, and numerical homotopy continuation, and require the development of new algorithms and software.

Tara Holm Cornell University (tsh@math.cornell.edu)

Equivariant Topology for Hamiltonian Torus Actions on Symplectic Orbifolds

Based on joint work with Tomoo Matsumura, I will discuss Hamiltonian R-actions on orbifolds $[M/S]$, where R and S are tori. We have proved an injectivity theorem and generalized Tolman-Weitsman's proof of the GKM theorem in this setting. The main examples arise from symplectic reduction. These include the class of compact symplectic toric orbifolds. In this case, our computations have a nice combinatorial form. The talk will be based largely on examples.

Complex Dynamics: Opportunities for Undergraduate Research

Session 1: Thursday, August 5, 1:00 – 5:20 pm

Rich Stankewitz Ball State University (rstankewitz@bsu.edu)

Undergraduate Explorations in Complex Dynamics

In an effort to inspire student driven research, several Java applets were recently created, together with Jim Rolf, to aid students as they explore complex dynamics phenomena (e.g., chaos, fractals, attracting basins). In this talk we tour just a few of the uses of these applets. We shall be careful to note along the way that students will not only be given the opportunity to explore phenomena well known to the experts, but also learn to ask (and hopefully answer) their own questions which naturally arise when given the tools to explore their own ideas. Specifically, we discuss the applets designed for investigating real and complex Newton's method, polynomial and exponential iteration, and their corresponding parameter planes. We also note that long time researchers can also make use of these applets in their own research and teaching.

Elizabeth Russell United States Military Academy (elizabeth.russell@usma.edu)

The Complex Dynamics of Rational Maps

In this talk we will explore the Julia sets (i.e., the chaotic set) that result from iterating singularly perturbed polynomial maps. The Julia sets that result will be Cantor sets of concentric curves and Sierpiński-like curves. The question regarding the structure of such Julia sets grew out of an undergraduate research project that occurred at Boston University in the 2000's.

Lorelei Koss Dickinson College (koss@dickinson.edu)

Iterating Elliptic Functions

An elliptic function is a meromorphic function on the complex plane which is periodic with respect to a lattice. Elliptic functions satisfy some strong algebraic properties that influence the resulting dynamical behavior. The dynamics of elliptic functions can vary widely even within an equivalence class of lattice shapes, and moving from one shape to another can also impact the dynamics. In this talk, we present an overview of the dynamics of elliptic functions, and we discuss some work done as part of a student honors thesis.

Sebastian Marotta University of the Pacific (smarotta@pacific.edu)

Fibonacci Plays the Chaos Game

The classical Fibonacci sequence starts with a pair of ones and then the next element in the sequence is the sum of the previous two, i.e., 1, 1, 2, 3, 5, 8,… The ratio between two consecutive terms converges to the *golden number* $\phi = \frac{1+\sqrt{5}}{2} \approx 1.618\ldots$

Random generalizations of the classical Fibonacci sequence where the elements are complex numbers lead to the study of some very interesting complex dynamical systems. These new sequences converge to beautiful fractal attractors in the Riemann sphere. The topological properties of some of these fractal sets will be discussed.

Sarah Koch Harvard University (kochs@math.harvard.edu)

Matings of Polynomials

Given two suitable complex polynomial maps, one can construct a new *dynamical system* by *mating the polynomials*; that is, by gluing together the *filled Julia sets* of the polynomials in a dynamically meaningful way. In this talk, we focus on quadratic polynomials — we begin with a brief discussion of complex dynamical systems, complex polynomials, and parameter space for quadratic polynomials (the Mandelbrot set). We then discuss the notion of mating two quadratic polynomials, and finally we explore examples where the mating does exist, and examples where it does not. The operation of mating two polynomials was introduced by Douady and Hubbard in 1983.

William Bond University of Alabama Birmingham (bondwil@uab.edu)

From Julia Sets to Laminations

The Julia set of a complex polynomial is a closed and bounded subset of the complex plane, forward and backward invariant under the polynomial, and on which the dynamics of the polynomial can be described as chaotic. Laminations of the unit disk in the plane are models for Julia sets of polynomials. A lamination is a closed collection of chords of the unit disk that meet, if at all, only in an endpoint of each. We call the chords the leaves of the lamination. We explain the analytic process by which the Julia set of a polynomial of degree d is associated with a lamination invariant under the circle map $\sigma_d : t \to dt \pmod 1$ on the unit circle (parameterized by $[0, 1)$ in the obvious way). We can study by this process only connected Julia sets, and we focus on degree 2 and 3 polynomials and their corresponding laminations in this talk.

John Mayer University of Alabama Birmingham (mayer@math.uab.edu)

Pullback Laminations

Laminations of the unit disk in the plane are models for Julia sets of complex polynomials. A lamination is a closed collection of chords (called leaves of the lamination) of the unit disk that meet, if at all, only in an endpoint of each. The action of the map $\sigma_d : t \to dt \pmod 1$ on the unit circle (parameterized by $[0, 1)$) models the action of a degree d polynomial on its Julia set. Laminations invariant (forward and backward) under σ_d are our subject of study. Since σ_d can easily be extended linearly to the leaves of the lamination, we can talk about leaves mapping to leaves. But in case a leaf has length (measured by the shorter arc of the circle it subtends) an integral multiple of $1/d$, it maps to a point on the circle. Such leaves are called critical leaves. An important class of laminations are those generated by a pullback process, starting from a forward invariant lamination, and guided by $k < d$ critical leaves. In this talk, we illustrate these classes in the cases of $1 = k < d = 2$ and 1 or $2 = k < d = 3$.

Debra Mimbs University of Alabama Birmingham (dmimbs@uab.edu)

Critical Leaf Configurations for σ_3

A lamination $\mathcal{L}$ of the unit disk $\mathbb{D}$ is a closed collection of chords of $\mathbb{D}$ that intersect, it at all, in an endpoint of each on the boundary circle, $\mathbb{S}$. The chords in $\mathcal{L}$ are called *leaves*. We parameterize $\mathbb{S}$ by $[0, 1)$ in the natural way. Consider the map $\sigma_3 : \mathbb{S} \to \mathbb{S}$ defined by $\sigma_3(t) = 3t \mod 1$. The map σ_3 can be extended to leaves linearly and continuously on $\cup\mathcal{L}$. A leaf $\ell \in \mathcal{L}$ is said to be *critical* if the images of its endpoints are the same point. Under the map σ_3 there are four basic configurations for critical leaves with respect to the fixed points 0 and $\frac{1}{2}$. We will investigate the general structure of laminations invariant under σ_3 resulting from each type of basic configuration. Further, we will explore the leaves that are forced or permitted by each basic configuration.

Jeffrey Houghton University of Alabama Birmingham (houghton@uab.edu)

Useful Tools in the Study of Laminations

A *lamination* is a closed collection of chords, called *leaves* of the unit disc. For quadratic laminations (those that remain invariant under the angle doubling map), there are several tools frequently used to study their dynamics. One such tool is the Central Strip Lemma. It gives us bounds to how leaves of the lamination can map. When we try to study cubic laminations, we need to rebuild these tools to work in our new setting. In particular, we will extend the Central Strip Lemma and several of its corollaries to the cubic case.

Session 2: Friday, August 6, 3:00 – 5:50 pm

Clinton Curry Stony Brook University (clinton.curry@stonybrook.edu)

Parameter Spaces for Some Slices of Cubics

The celebrated Mandelbrot Set acts as a roadmap to the dynamical possibilities for quadratic polynomials with connected Julia set. Its combinatorial structure has been completely determined. The cubic connectedness locus is, however, much more mysterious.

We will study the cubic connectedness locus by examining one-dimensional subspaces, like the set of cubic polynomials which have a critical point mapping to a fixed point.

Ross Ptacek University of Alabama Birmingham (rptacek@uab.edu)

Dynamics of Cubic Siegel Laminations

In this talk we will discuss the dynamics of cubic laminations with an invariant Siegel gap. A Siegel gap S is an infinite gap with a critical leaf which quotients to a Fatou component with dynamics conjugate to rigid irrational rotation of $\mathbb{D}$ in the topological Julia set. These components are called topological Siegel disks as they correspond to Siegel disks in actual Julia Sets. We focus on *capture* laminations (following the language of Zakeri), those in which the criticality not in the Siegel gap eventually maps into the Siegel gap. This means that there is some critical gap G which double covers S under some iterate of σ_3. In this talk, we will construct a parameter space for many capture laminations by introducing collapsing quadrilaterals connecting sibling leaves of G and will describe the relationship between this combinatorial model of parameter space and the actual parameter space of cubic polynomials with an invariant Siegel disk.

Kendrick White University of Alabama Birmingham (ricolw@uab.edu)
John Mayer University of Alabama Birmingham (mayer@math.uab.edu)
Lex Oversteegen University of Alabama-Birmingham (overstee@math.uab.edu)

Degeneracy of Cubic Pull-Back Laminations

We seek to establish combinatorial conditions under which two critical leaves of σ_3 generate a non-degenerate cubic lamination. By combinatorial conditions, we include characteristics such as one or both leaves being non rotational, existence and nature of coupling between these leaves, etc. The degree-two case of one critical leaf can be settled by a recursive algorithm described by Blokh, et al., in which a critical leaf is classified as either basic non-rotational, basic rotational, or pre-periodic and non-rotational. The first two cases correspond to non-degenerate and degenerate laminations, respectively, while the last case is inconclusive. The inconclusive case requires a renormalization of σ_2, and the classification procedure is then applied to the new critical leaf resulting from renormalization. A definite answer regarding the degeneracy of the critical leaf's lamination is reached in finitely-many applications of the procedure.

In our study, we consider how possible coupling between two critical leaves under σ_3, in addition to their individual properties of rotational, pre-periodic, etc., can affect the degeneracy of the corresponding lamination.

Gareth Roberts College of the Holy Cross (groberts@radius.holycross.edu)
Trevor O'Brien Brown University (trevor@cs.brown.edu)

Elusive Zeros Under Newton's Method

Newton's method applied to a complex polynomial can fail quite miserably, even on a fairly large open set of initial guesses. We investigate Newton's method applied to the quartic family $p_\lambda(z) = (z+1)(z-1)(z-\lambda)(z-\bar{\lambda})$ where $\lambda \in \mathbb{C}$ is a complex parameter. The symmetric location of the roots allows for some easy reductions. Classifying those λ-values where Newton's method fails on an open set leads to a complicated yet marvelous picture in the λ-parameter plane full of Mandelbrot-like sets, tricorns and swallowtails. This is joint work with former undergraduate student Trevor O'Brien.

Annalisa Crannell Franklin and Marshall College (annalisa.crannell@fandm.edu)

Fibonacci Harps and a Shift of Finite Type

This is an adventure story: the tale of a mild-mannered math major who accompanied a Super Student during her independent study project on topological dynamics and measure theory. But along the way, he discovered a hidden treasure. He made an explicit connection between the Fibonacci Harp (or Fibonacci String) and two well-known dynamical systems (a subshift of finite type and the baker's map on the unit interval). Fractal harps have links to analytic number theory, which has links to complex fractal dimensions and the Riemann Hypothesis. The mild-mannered math major showed that the boundary of the Fibonacci Harp is an embedding of a commonly studied shift of finite type in the unit interval. The story ends happily ever after, with graduate school, publications, and marriage.

Daniel M Look St. Lawrence University (dlook@stlawu.edu)

Introduction to Complex Dynamics via Multiple Circle Inversions

It is difficult to introduce complex dynamics to undergraduates lacking a foundation in complex analysis. For example, the intuitive nature of the function $z \mapsto z^2$ is lost on students who do not understand complex multiplication. As an alternative, a function derived from geometry in the complex plane (in particular, circle inversions) lends itself well to intuition and can be used to explore chaos without a firm understanding of the complex plane. We will explore this map and discuss the ways in which this map can be used in interactions with undergraduates and high school students.

Mathematical Neuroscience

Friday, August 6, 1:00 – 2:50 pm

Winfried Just Ohio University (just@math.ohiou.edu)

Exploring a Simple Discrete Model of Neuronal Networks

The most basic empirical fact about neurons is that they fire so-called action potentials over certain time intervals and stay in a resting state at other times. Thus one can try to model neuronal network dynamics by letting time advance in discrete steps and considering only two states of a neuron at any given time: firing or resting. Somewhat surprisingly, it can be rigorously proved that this simple model will accurately reflect the dynamics of much more elaborate differential equation models of neuronal networks with certain types of architecture.

One of the nice features of the simple model outlined above is that its properties can be easily explored with the help of a desktop computer and fairly elementary mathematical tools. The important question here is how the network dynamics depends on the connectivity of the network, that is, which neuron receives input from which other neurons. When studying the dynamics, we are interested in such questions as what kind of firing patterns are recurrent and how long it may take to reach such recurrent firing patterns.

This talk will describe some of the results along those lines that have been proved analytically and either discovered or confirmed by computer simulations. There is also a number of open questions that may be amenable to study with the help of quite elementary methods.

This talk is based on joint work of the presenter with David Terman, Sungwoo Ahn, and Xueying Wang of Ohio State University.

Stefanos Folias University of Pittsburgh (stefanos@pitt.edu)

Spatially-localized Synchronous Oscillations in Neuronal Networks

We study the qualitative behavior of localized synchronous oscillations organized by synaptic inhibition in two spatially-extended, conductance-based neuronal network models driven by a localized constant input. Typically such equations generate complex spatiotemporal behavior, however, with strong inhibitory coupling, the response of the network is a single band of neurons firing nearly synchronous action potentials, almost periodically. We subsequently derive one- and two-dimensional discrete maps that track the evolution of the width of the band of action potentials and show that the discrete maps qualitatively describe the behavior and bifurcations of solutions in the full model.

Jozsi Jalics Youngstown State University (jalics@math.ysu.edu)
G. Bard Ermentrout University of Pittsburgh (bard@pitt.edu)
Jonathan Rubin University of Pittsburgh (jonrubin@pitt.edu)

Stimulus-driven Traveling Waves in a Neuronal Model

We examine the existence of traveling waves for continuum neuronal networks modeled by integro-differential equations. For a scalar field model with a general firing rate function and spatio-temporally varying stimulus, we show stimulus-locked fronts exist for a certain interval of stimulus speeds. We also add a slow adaptation equation and obtain a formula, involving an adjoint solution, for stimulus speeds that induce locked pulses and perform a singular perturbation analysis to approximate the adjoint.

Peter Thomas Case Western Reserve University (peter.j.thomas@case.edu)

Synchronization of Noisy Integrate and Fire Neurons

The integrate and fire (IF) neuron is an analytically tractable, greatly simplified model of a single nerve cell. When subjected to noisy current input, arising for instance from transmembrane ion channel fluctuations, the IF model is equivalent to an Ornstein-Uhlenbeck (OU) stochastic process with reset. Upon reaching a fixed threshold the trajectory discontinuously resets to a given starting value. Until it reaches threshold, the dynamics are linear with additive Gaussian noise. When driven by a periodic suprathreshold injected current, real neurons typically show phase locking, or a repeating pattern of action potentials (voltage spikes, or threshold crossings) at a particular sequence of phases relative to the stimulus. Numerically it is well known that IF model neurons show similar synchronization behavior, but there are few analytical results characterizing phase locking in the presence of noise. The periodically forced noisy IF neuron is equivalent to an OU process with periodically varying coefficients, for which the first passage time distribution to a fixed boundary is not known analytically (even in the constant coefficient case). I will discuss conditions sufficient to guarantee synchronization of a noisy IF neuron to a periodic input. Equivalently, I will consider the problem of proving the existence of an invariant measure on the circle representing the firing phases relative to the periodic stimulus.

Geometric Group Theory

Friday, August 6, 1:00 – 4:50 pm

Matt Clay Allegheny College (mclay@allegheny.edu)

Free Group Stretching Exercise

An important example of a group, although not one customarily considered in an undergraduate algebra course, is the free group. In many regards, a free group behaves like a discrete non-commutative vector space. As such, some ideas from linear algebra are applicable. In this talk, we will focus on an example showing how the notions of *eigenvalue* and *eigenvector* relate to free groups. Get ready to get limber!

Johanna Mangahas University of Michigan (mangahas@umich.edu)

Ping-Pong for Free Groups

This talk is for anyone curious to understand and appreciate Ping-Pong. The Ping-Pong Lemma gives a method for detecting a free group. Simple yet useful, it neatly illustrates the geometric group theory tenet that one can get to know a group by observing its action on a space.

Angela K. Kubena University of Michigan (akubena@umich.edu)

Groups and Trees: Action!

Groups arise naturally when considering symmetries of spaces, but when can we realize a particular group as symmetries of a space of our choosing? For example, if we consider the real line, the integers $\mathbb{Z}$ can be naturally seen as a group of translations of the line. What other groups can act on the line? What happens when we move from the line to a more complicated tree? In this talk, we will look at what group actions on trees can tell us about the groups doing the acting. Examples and pictures galore!

Kim Ruane Tufts University (kim.ruane@tufts.edu)

Examples of CAT(0) Groups

A group G is called a CAT(0) group if G acts by isometries in a “geometric” way on a CAT(0) space. Examples of such groups include $\mathbb{Z}^n$, finitely generated non-abelian free groups, and certain isometry groups of the hyperbolic plane $\mathbb{H}^2$. The CAT(0) spaces these groups act on are $\mathbb{E}^n$, locally finite metric trees, and $\mathbb{H}^2$ respectively. These three geometries have quite different properties and we can use these geometric differences to prove that the corresponding groups must have very different algebraic properties.

Eduardo Martinez-Pedroza McMaster University (emartinez@math.mcmaster.ca)

Dehn Functions of Groups

The Dehn function of a finitely presented group measures the complexity of the word problem. This function has a natural geometric interpretation in terms of areas. Computing Dehn functions has been a challenging problem, and research in this area has generated beautiful combinatorial and geometric ideas. In this talk, I will define the Dehn function, discuss its geometric interpretation, and illustrate the ideas with some examples.

Tara Brendle University of Glasgow (tbrendle@maths.gla.ac.uk)

Mapping Class Groups: Where Algebra Meets Topology

Mathematicians have known how to classify 2-dimensional spaces, or surfaces, for about a hundred years now. However, the geometry and topology of surfaces gives rise to some fascinating algebraic objects, whose complete structure remains a mystery to mathematicians today. One such object is the mapping class group of a surface. We will give an elementary introduction to this group, assuming no background in topology or abstract algebra, focusing on the rich interplay between the geometry of surfaces and the algebraic properties of this group.

Greg Bell University of North Carolina (gcbell@uncg.edu)

Introduction to Asymptotic Dimension

The asymptotic dimension of a metric space is the large-scale analog of topological dimension. Since it is a large-scale invariant, it is a natural invariant of a finitely generated group considered with the word metric. It is also relatively easy to compute in many cases. We will introduce this concept, discuss several examples and implications and end with some open problems surrounding asymptotic dimension.

John Meier Lafayette College (meierj@lafayette.edu)

What's at the End of an Infinite Group?

We will explore some notions of the topology at infinity for infinite groups, such as the number of ends and the idea of being simply connected at infinity. While general results will be indicated, the ideas presented will be example driven.

Mathematical Visualization

Saturday, August 7, 1:00 – 2:50 pm

Johnathan Rogness University of Minnesota (rogness@math.umd.edu)

Flying through 3-Manifolds

We are accustomed to moving in three dimensional space, which makes the notion of a 3-manifold easier to understand. Yet the wide variety of 3-manifolds makes it very difficult to visualize their geometry and topology on two dimensional paper. We will use software (developed by Jeff Weeks) to fly through various elliptic, hyperbolic, and flat 3-manifolds and demonstrate how to detect their properties.

Frank Farris Santa Clara University (ffarris@scu.edu)

Lissajous Spheres: Twisted Spheres in 4-Space

This class of examples of immersed spheres gives a good laboratory for testing the equation that relates the normal and tangential Euler numbers to the number of complex points on a 2-surface in 4-space. A new use of color helps us visualize the Gauss map and see the explicit homology that guarantees the relationship among these topological invariants.

Ockle Johnson Keene State College (ojohnson@keene.edu)

Visualizing the Normal Euler Class for Polyhedral Surfaces in 4-Space

To compute the normal Euler class of a polyhedral surface in 4-space, we subdivide the surface and then push it off itself in 4-space, keeping vertices and centers of face fixed and moving midpoints of edges. We then compute the self intersections at vertices and faces in terms of self-linking numbers. This is done visually, using software developed by Davide Cervone. Visualization played an essential role not only in developing key examples, but also in discovering and analyzing the critical behavior that occurs when the push-off is modified, leading to the result that the normal Euler class is independent of the push-off. In this talk we will illustrate the definition and properties of the normal Euler class using pictures of key examples.

Thomas Banchoff Brown University (thomas_banchoff@brown.edu)

How to See Normal and Tangential Euler Numbers for a 2-Surface in 4-Space

This talks gives an overview of the meaning of these characteristic numbers for a surface in 4-space and describes an equation that, surprisingly, relates them to the number of points on the surface where the tangent space is a complex line in 4-space (considered as complex 2-space). On one hand, the dimensions involved are low enough to be manageable; on the other, it is not obvious what it means to "see" these geometric phenomena. The talk will be illustrated by computer-generated images and animations.

The Mathematics of Math Circles

Saturday, August 7, 1:00 – 3:20 pm

Gabriel Carroll MIT (gabriel.d.carroll@gmail.com)

How to Allocate Indivisible Objects to People

Consider the following problem: There are n people and n objects. Each person is to be given one of the objects. Each person has preferences over the objects — a favorite object, a second favorite, and so forth. How should the objects be allocated? A good allocation rule should balance three considerations: efficiency, equity, and incentives. That is, people should get objects they like, should be treated fairly, and should not be motivated to lie about their preferences in order to get a better object. No rule, either deterministic or random, perfectly satisfies all three criteria. This talk will discuss some rules that have been advocated in the theoretical literature, including random serial dictatorship, top trading cycles, and probabilistic serial, and will also touch on some practical applications.

Inna Zakharevich MIT (zakh@math.mit.edu)

Hilbert's Third Problem for All Ages

Hilbert's third problem asks the following question. Given two polyhedra of the same volume, is it possible to dissect one into smaller polyhedra and rearrange it into the other one? For polygons the answer is "yes" (and was known even to the Greeks). In 1901 Dehn showed that, in general, for polyhedra the answer is "no"; for example, a regular tetrahedron and a cube of the same volume cannot be rearranged into one another. In order to prove this, Dehn constructed an invariant on polyhedra which keeps track of the angles and edge lengths of the polyhedron. This invariant provides much more information about polyhedra than seems at first, however. In this talk, we will construct a more modern framework for considering problems about "scissors congruence" of this sort, and discuss how some of the classical answers generalize to scissors congruence in non-Euclidean geometries.

Evan O'Dorney Berkeley Math Circle (Emo916math@gmail.com)

The Dynamics of Continued Fractions

It is well known that a general linear fractional transformation $f(z) = (az+b)/(cz+d)$ of the extended complex plane has two fixed points, one –attractive" and one –repulsive": any sequence of iterates $(z_0, f(z_0), f(f(z_0)), \ldots)$ converges to the attractive point unless it starts at the repulsive point. If the coefficients of $f(z)$ and the initial value z_0 are rational, this property can be used to construct rational approximations to the attractive fixed point. In the special case where $d = \lfloor\sqrt{k}\rfloor$ for a positive integer k, the iterates of ∞ under $f(x) = (dx+k)/(x+d)$ converge on the attractive fixed point $\sqrt{k}$ especially rapidly, prompting the question of how they compare to the convergents of the continued fraction expansion of $\sqrt{k}$ (the latter are in some sense the –best" rational approximations of $\sqrt{k}$). Earlier research gave conditions for the two sequences to coincide, leaving open the question of when they contain infinitely many common terms. In this talk, we will examine a new viewpoint that combines techniques from elementary number theory, group theory, and linear algebra and that completely solves this problem. Surprisingly, the overlap of the two sequences, if infinite, includes every fraction p/q satisfying the Pell equation $p^2 - kq^2 = \pm 1$, while otherwise the finite overlap does not contain even a single such solution. It is unknown if these results can be generalized to other linear fractional transformations.

Tiankai Liu MIT (tiankai@math.mit.edu)

Modern Perspectives on Classical Geometry

Poncelet's porism is a result in classical Euclidean geometry: If two circles C, C' lie in the plane such that there exist n-gons P with circumcircle C and incircle C', then any point on C can be chosen to be a vertex of such a P. This result can be proved by methods accessible to high school students familiar with math Olympiads. But underlying this clever elementary proof are ideas from algebraic geometry. Thus, a more modern approach exploits the group law on an elliptic curve that can be abstracted from the pair (C, C'). This math circle–style talk will use Poncelet's porism to illustrate the interesting connection between classical and modern methods in mathematics.

Ivan Matic University of California, Berkeley (matic@math.berkeley.edu)

Collaborative Strategies in Multi-Player Mathematical Games

Winning strategy for a particular game is a procedure that will ensure a victory no matter how the opponent is playing. In multi-player games, many players are on a team. They need to collaborate and share the specific information they have, often abiding by very strict constraints of the game. In addition, the information they share can be observed by the opponents, who can then take advantage in case they manage to understand the exchanged information. We will discuss some games with winning strategies, try to recognize the patterns for finding such strategies, and generalize the strategizing theory to probabilistic games.

Panel Discussion:
Math Circles and Research Mathematics: Gaps, Bridges, and Successes

Andrew Dudzik University of California at Berkeley
Evan O'Dorney Berkeley Math Circle
Gabriel Carroll Massachusetts Institute of Technology
Inna Zakharevich Massachusetts Institute of Technology
Ivan Matic University of California at Berkeley
Jennifer Thompson Cambridge University, UK
Maksim Maydanskiy MSRI/Stanford
Tiankai Liu Massachusetts Institute of Technology
Victoria Wood University of California at Berkeley

The nine young panelists are formidable problem-solvers whose research projects are staggering in their breadth and depth. Very importantly, they all share a passion for mathematics that originated in their early years and was aided and developed to a large extent through mathematical circles. The five talks in this session present a combination of original research and exposition and have been presented, or are suitable after modifications to be delivered, at math circles. In the ensuing panel discussion, these nine past/present math circlers will share their inspirational stories of how they got drawn and nurtured into the field of mathematics, will present their personal viewpoint on the importance of the math circle movement for the new generation of budding mathematicians in the U.S. and around the world., and will bridge the two worlds of Mathematical Circles and Research Mathematics.

Mathematical Modeling of the Immune Response, Cancer Growth and Treatments

Saturday, August 7, 1:00 – 4:20 pm

Lisette de Pillis Harvey Mudd College (depillis@hmc.edu)

Modeling the Immune Response to Cancer

Immunotherapy, a treatment approach that enhances the body's natural ability to fight cancers, is becoming increasingly prevalent in multi-stage treatment programs that also include chemotherapy, radiation and surgery. The critical importance of the immune system in combating cancer has been verified both clinically and through mathematical models. The immune system is not one entity, but is instead a diverse and complex system of interacting components. In this talk, we will discuss the components of the immune system that have been shown to play an important role in the progression and control of cancer, along with our approaches to modeling tumor-immune interactions and treatment approaches that harness the power of the immune system.

Doron Levy University of Maryland (dlevy@math.umd.edu)

Can Mathematics Cure Leukemia?

Leukemia is a cancer of the blood that is characterized by an abnormal production of white blood cells. Traditional approaches for treating leukemia combine chemotherapy, radiotherapy, and bone marrow (or stem cell) transplants. The treatment of Chronic Myelogenous Leukemia (CML) was revolutionized over the past decade with the introduction of new molecular-targeted drugs. Unfortunately, these drugs keep many patients in remission but do not cure the disease.

In this talk we will discuss the results of our recent research in which we proposed a new way of treating CML. Our main idea is to boost the anti-leukemia immune response by providing timed cancer vaccines in intervals and doses that are adjusted to the individual immune response of each patient. The work is based on integrating math and medicine. The mathematical analysis together with the new experimental data imply that there may be a feasible, low-risk, clinical approach to enhancing the effect of the drug therapy, possibly leading to a durable cure of the disease. Time permitting, some new ideas connecting drug resistance, cancer stem cells, and CML, will be discussed.

This is a joint work with Peter Kim, Peter Lee, and Cristian Tomasetti.

Renee Fister Murray State University (renee.fister@murraystate.edu)

Optimal Control Scenarios in Cancer Dynamics

Models depicting cancer dynamics are investigated with the inclusion of optimal control strategies to minimize the cancer cells, toxicity of the drugs, and the cost associated with the regimen. The ordinary differential equation models coupled with state constraints will be studied and some numerical results will be discussed.

Peter Hinow University of Wisconsin (hinow@uwm.edu)

A Spatial Model of Tumor-Host Interaction: Application of Chemotherapy

We consider chemotherapy in a spatial model of tumor growth. The model, which is of reaction-diffusion type, takes into account the complex interactions between the tumor and surrounding stromal cells by including densities of endothelial cells and the extra-cellular matrix. When no treatment is applied the model reproduces the typical dynamics of early tumor growth. The initially avascular tumor reaches a diffusion limited size of the order of millimeters and initiates angiogenesis through the release of vascular endothelial growth factor (VEGF) secreted by hypoxic cells in the core of the tumor. This stimulates endothelial cells to migrate towards the tumor and establishes a nutrient supply sufficient for sustained invasion. To this model we apply cytostatic treatment in the form of a VEGF-inhibitor, which reduces the proliferation and chemotaxis of endothelial cells. This treatment has the capability to reduce tumor mass, but more importantly, we were able to determine that inhibition of endothelial cell proliferation is the more important of the two cellular functions targeted by the drug. Further, we considered the application of a cytotoxic drug that targets proliferating tumor cells. The drug was treated as a diffusible substance entering the tissue from the blood vessels. Our results show that depending on the characteristics of the drug it can either reduce the tumor mass significantly or in fact accelerate the growth rate of the tumor. This result seems to be due to complicated interplay between the stromal and tumor cell types and highlights the importance of considering chemotherapy in a spatial context. This is joint work with Philip Gerlee, Sandy Anderson and other friends and fellows of the Vanderbilt Integrative Cancer Biology Center (VICBC).

Kasia Rejniak Moffitt Cancer Center (kasia.rejniak@moffit.org)

Linking Changes in Epithelial Morphogenesis to Cancer Mutations: An Integrative Model

Epithelial tissues form highly selective barriers between different body compartments. They are composed from tightly packed cells that maintain an apical-basal polarity synchronized among all cells. In contrast, the disruption of such a well-organized epithelial architecture leads to various forms of epithelial tumors. In this talk, I will address several stages of the development of epithelial acini (an experimental 3D model of epithelial structures) using a bio-mechanical IBCell model and quantitatively compare computational results to experimental data. I will focus on the dynamics of cell membrane receptors that drive interactions between neighboring cells and between cells and their immediate microenvironment.

Jana Gevertz The College of New Jersey (gevertz@tcnj.edu)

Mathematical Simulations of Tumor Response to Cancer Treatment

Over the past several decades, mathematical modeling techniques have been incorporated into the armamentarium of cancer research. A relatively novel use of mathematics in the realm of oncology is in the process of computer-aided drug discovery — using computer simulations of mathematical models to identify novel drug targets and predict the efficacy of newly developed compounds. In this talk, I will describe a validated hybrid cellular automaton model of tumor growth in a vascularized environment. I will then demonstrate how computer simulations of the mathematical model can be used to study the antitumor activity of several vascular (blood vessel)-targeting compounds and chemotherapeutic agents. Results will be compared to preclinical and clinical trial data, wherever possible. Simulations have revealed that there are inherent limitations in using vascular-targeting drugs as a front-of-the-line cancer treatment. The mathematical model has also been used to identify a novel treatment protocol that, under the assumptions of the model, has more success at limiting cancer growth than standard protocols. Taken together, the analysis herein represents a proof-of-concept that mathematical models can be utilized to determine the antitumor activity of an existing or novel therapeutic compound.

Kara Thuy Pham Mathematics Department, University of California, Irvine (karap@math.uci.edu)
Hermann Frieboes School of Health Information Sciences, University of California, Irvine (hfrieboe@math.uci.edu)
Vittorio Cristini School of Health Information Sciences, University of California, Irvine (Vittorio.Cristini@uth.tmc.edu)
John Lowengrub University of California, Irvine (lowengrb@math.uci.edu)

Predictions of Tumor Morphological Stability and Evaluation Against Experimental Observations

The hallmark of malignant tumors is their invasion of neighboring tissue and infiltration of distant organs (metastasis), which can lead to life threatening consequences. One of the defining characteristics of aggressive tumors is an unstable morphology, including the formation of invasive fingers and protrusions observed both in vitro and in vivo. Thus shape instabilities (growing protrusions) are associated with local invasiveness, which is often a precursor to tumor metastasis.

We study tumor morphological stability by employing three mathematical models to gain insight into tumor invasion and metastasis. Modeling a solid tumor as an incompressible fluid, we consider three possible constitutive relations to describe tumor growth, namely, Darcy's law, Stokes law, and the combined Darcy-Stokes law. Darcy's law is used to describe fluid flow in a porous medium. Stokes flow describes the flow of a viscous fluid. Using linear theory, we study the tumor morphological stability described by each model and evaluate the consistency between theoretical model predictions and experimental data from in vitro 3D multicellular tumor spheroids. The analysis reveals that viscous stress makes the Stokes model more consistent with the experimental results and less sensitive to protrusions, making the model robust. We further show that it is feasible to extract parameter values from a limited set of data and create a self-consistent modeling framework that can be extended to the multiscale study of cancer. Numerical methods are used to simulate the nonlinear effects of stress on solid tumor growth and invasiveness.

The Klein Project

Saturday, August 7, 1:00 – 4:50 pm

Hyman Bass University of Michigan (hybass@umich.edu)

Algebraic Structure as a Source of Coherence in the School Curriculum

Poincaré once said, “Science is built up with facts, as a house is with stones. But a collection of facts is no more a science than a heap of stones is a house.” The school math curriculum often remains too much like a heap of stones. I want to show how modest investments in mathematical theory serve to unite collections of topics otherwise disconnected in the school curriculum. Examples of such mathematical story lines include:

1. The Binomial Theorem, Difference Calculus, and sums of integer powers, polynomials taking integer values at integers
2. Modular arithmetic, divisibility rules, decimal expansions of fractions
3. Euclidean Division for integers and polynomials, polynomial interpolation and the Chinese Remainder Theorem, the structure of (discrete) additive and multiplicative groups in $\mathbb{R}$ and in Z/mZ.

Harriet Pollatsek Mount Holyoke College (hpollats@mtholyoke.edu)

Cyclotomic Polynomials

Rather than discussing the solution of $x^n - 1 = 0$ as an algebra problem, Klein introduces the *cyclotomic numbers* (nth roots of unity) in his discussion of dividing the circle into equal parts. The nth *cyclotomic polynomial* $\Phi_n(x)$ is the product of linear factors $x - \zeta_j$, one for each *primitive* complex nth root of unity ζ_j. It is a monic polynomial of degree $\varphi(n)$ with integer coefficients. The cyclotomic polynomials have been studied since the eighteenth century, notably by Gauss, who proved they are irreducible over the rational numbers and used them to prove his theorem on the necessary and sufficient conditions for straight-edge and compass constructibility of the regular n-gon. Further developments (by Kummer and many others) were in search of a proof of Fermat's Last Theorem. Following a different path, we'll bring cyclotomic polynomials into the modern era via error-correcting codes, in particular *cyclic codes* arising as ideals in the ring $F[x]/\langle x^n - 1\rangle$ for a finite field F. In this setting, the easy-to-compute *cyclotomic cosets* in F facilitate the construction of *BCH codes*, a family of useful codes discovered fifty years ago by Hocquenghem and by Bose and Ray-Chaudhuri.

James Madden Louisiana State University (madden@math.lsu.edu)

Eudoxus, Euclid and Holder on Measurement, Ratio and Proportion

Much of what is taught in school concerning ratio and proportion comes from two sources. The arithmetical root is the ancient procedure known as the –Rule of Three", used for solving problems such as finding the price of one quantity of some commodity if the price of another quantity of the same commodity is known. The geometric root is Book V of Euclid's Elements, where Euclid develops the concepts of ratio and proportion for geometric magnitudes following Eudoxus. This theory is often understood as a precursor of the modern concept of the real numbers. In 1901 O. Hölder published an interpretation of the theory of Euclid-Eudoxus, showing its foundational role in the theory of measurement and demonstrating, along the way, that the multiplicative structure of the reals is implicit in its structure as an archimedean ordered group. The measurement strand of the Common Core Math Standards develops measurement concepts in a manner that is in harmony with Hölder's theory, but many deep conceptual connections are not made explicit. Moreover, some features of the theory are routinely misunderstood by textbook authors, and even some mathematicians. The purpose of this talk is to provide a clear statement of the theory of measurement in Euclid, and its relationship to the quantity theme in the Common Core Standards.

Susanna Epp DePaul University (susanna.s.epp@gmail.com)

Issues in the Transition from Concrete to Formal Mathematics

In discussing the transition from the concrete mathematics of positive numbers to the formal mathematics of negative numbers, Felix Klein wrote: –The complete mastery of this transition requires a high order of ability in abstraction." This talk will discuss the role of mathematical abstraction, especially logical reasoning, as it is needed for understanding mathematical ideas at several points in the K-12 curriculum.

Sybilla Beckmann University of Georgia (sybilla@math.uga.edu)

Repeating Decimal Representations of Fractions and Group Theory

Given a fraction, its decimal representation either repeats or terminates (assuming the numerator and denominator are natural numbers). How long is the repetend (the string of digits that repeat)? How are the decimal representations of the fractions of denominator N related to each other? Answers to these questions can be determined through group theory.

Bill Barton University of Auckland (barton@math.auckland.ac.nz)

Revisiting Felix Klein's Elementary Mathematics From An Advanced Standpoint

A century ago, in 1908, Felix Klein's lectures on mathematics for secondary teachers were first published (in German). This comprehensive view of the field challenged both teachers and mathematicians to consider, from a perspective sensitive to both mathematical rigor and pedagogical practice, the relationship between mathematics as a school subject, and mathematics as a scientific discipline. The intervening 100 years have witnessed many changes in mathematics - the crises in Foundations, the advent of computing, emergence of new fields, and resolutions of some major mathematical challenges. These have provoked major changes and challenges for school mathematics. While Klein's writing remains a valuable source insight, it seems timely to revisit this terrain by linking the topics and approaches of senior secondary or undergraduate mathematics with the field of mathematics. This is an important challenge for both mathematicians and mathematics educators. This presentation will describe a joint project between IMU and ICMI to revisit this work in a contemporary context. I will describe the progress to date and the process for contributing to the project.

Al Cuoco Educational Development Center (alcuoco@edc.org)
Glenn Stevens Boston University (ghs@math.bu.edu)

The Mathematcs of Task Design

Thinking deeply about the craft of task design can lead one to interesting mathematics. This talk will look at how algebra, geometry, and number theory can be used to create "nice" problems, including (among others) integer sided triangles with specified angles, cubic polynomial functions with rational zeros and extrema, triangles in $\mathbb{R}^3$ with lattice point vertices and integral side-lengths. The mathematics used to generate such problems involves arithmetic in number fields (cyclotomic and imaginary quadratic) as well algorithms for finding rational points on curves.

Roger Howe Yale University (howe@math.yale.edu)

The Secret Life of the $ax + b$ Group

Linear functions $x \to ax + b$ are a staple of Algebra 1, and appear in many other contexts later in high school mathematics. These functions can be thought of in two rather distinct ways: numerically, or geometrically. When thought of geometrically, they represent transformations of the number line to itself, and it is appropriate to consider composition and fixed points. The geometric point of view is much less common in high school mathematics, and is rarely explicit, but it is relevant in a number of topics that are important in the curriculum. This talk will discuss places where the geometric viewpoint is fruitful, including the quadratic formula, geometric series, and recursion.

Contributed Paper Sessions

Getting Students Involved in Writing Proofs

Session 1: Thursday, August 5, 8:50 – 10:25 am

Anders O.F. Hendrickson Concordia College (ahendric@cord.edu)

Elements of Style for Proofs

In English composition courses, the "little book" of Strunk & White, *The Elements of Style* (1959), is the classic guide to developing a clear and accurate prose style. We discuss the use of a similar handbook of mathematical style in proof-writing courses.

Penelope Dunham Muhlenberg College (pdunham@muhlenberg.edu)

Involving Students in Proof Writing with Peer Review

To write proofs effectively, students must be able to read critically, analyze texts, construct valid arguments, and present those arguments—orally or in writing—in a clear manner. The challenge of helping students develop such skills may require new pedagogical tools for math instructors. I've met the challenge with a device borrowed from colleagues in English: peer review. Beginning with a 200-level "transition" course and continuing through abstract algebra, my students read, discuss, and critique each other's work in and out of class—similar to the way peers comment on others' essays in a composition course.

I'll describe how to manage a peer review system (e.g., setting up the process; guiding students as reviewers and reviewees; solving logistical issues) for two levels of math courses. In our first "bridge" course, the entire class focuses on one student's presentation at a time; they critique the argument's validity, analyze the proof style, and offer alternate proofs. Later, in abstract algebra, pairs of students read work from all classmates on one proof and rank the solution for accuracy, terminology use, style, clarity, conciseness, and effective writing; then, each reviewing team presents two "best" proofs to the class with comments about unique approaches and common errors found in the rest. I'll conclude with student comments about peer review and effects of the program on students' mathematical understanding and writing.

Betseygail Rand Texas Lutheran University (brand@tlu.edu)
Sharon Strickland Texas State University (ss67@txstate.edu)
Sara Sliter-Hays Texas Lutheran University (ssliter-hays@tlu.edu)

Learning Proof-Writing: Applying English Composition Pedagogical Strategies to Undergraduate Mathematics

While successful strategies for teaching proof-writing are few, there are extensive established methods for teaching English Composition. One school of thought, offered by John Bean, is that students learn to think critically by revising their own writing. This becomes evident as the argument structure of a student's writing becomes more coherent and sophisticated, while she participates in the revision process.

Because proof-writing involves both understanding the key ideas of the theorem as well as structural norms of formal proofs, we hypothesize that students could similarly improve both content and structure of their proofs using the drafting techniques from English Composition research. Our research question is –Does proof revision lead to improved proof-writing skills?" We have conducted a pilot study on Linear Algebra students during the Spring 2010 semester, where students self-revised their proofs and turned in up to three drafts of each formal proof.

To show that this leads to measurable improvements in students' ability to write proofs, we will code and compare final exam proof questions belonging to Spring 2010 students with those final exam proof questions of Fall 2009 Linear Algebra students, who were not assigned multiple drafts of the same proof throughout the semester, but instead were assigned more single-attempt proofs. We will also code, analyze, and report on the Spring 2010 students' weekly draft assignments to better understand the revision processes students engaged in over the semester. Tentative results suggest that the proof revision assignment increased students' engagement, compared with students in past semesters who were assigned more overall proofs, but without any structured method for revision.

Patrick Rault SUNY Geneseo (rault@geneseo.edu)

Learning From my Students: A Personal Experience with the Moore Method

When students independently unravel definitions and make discoveries, their wording of proofs can be more natural and clear. While induction is often learned as an opaque memorized template, a geometric discovery of induction can lead to transparency and improved writing. Student blackboard presentations give convincing proof sketches, while smartboard presentations allow for a class discussion of what makes a polished proof. These experiences took place in the final semester of a three-semester study of Introduction to Proofs courses. We will discuss the qualitative and quantitative differences between semesters: the first revolving around lectures, the second a novice's version of the Moore Method, and the third a mentored Moore Method instruction.

Padraig McLoughlin Kutztown University of Pennsylvania (mcloughl@kutztown.edu)

Aspects of a Neoteric Approach to Advance Students' Ability to Conjecture, Prove, or Disprove

The author of this paper suggests several neoteric, unconventional, idiosyncratic, or unique approaches to beginning Set Theory that he found seems to work well in an introductory Foundations of Mathematics course. This paper offers some ideas on how the author uses certain 'unconventional' definitions and 'standards' to get students to understand the essentials of basic set theory.

The author of this paper submits that a mathematics student needs to learn to conjecture, to hypothesize, *to make mistakes* , and to prove or disprove said ideas; so, the paper's thesis is learning requires doing and the point of any mathematics course is to get students to do proofs, produce examples, offer counterarguments, and create counterexamples.

We propose a quintessentially inquiry-based learning (IBL) pedagogical approach to mathematics education that centers on exploration, discovery, conjecture, hypothesis, thesis, and synthesis which yields positive results—students doing proofs, counterexamples, examples, and counter-arguments. Moreover, these methods seem to assist in getting students to be willing to make mistakes for, we argue, that we learn from making mistakes not from always being correct!

We use a modified Moore method (MMM) to teach students how to do, critique, or analyze proofs, counterexamples, examples, or counter-arguments. We have found that the neoteric definitions and frame-works described herein seem to encourage students to try, aid students' transition to advanced work, assists in forging long-term undergraduate research, and inspires students to do rather than witness mathematics.

Session 2: Friday, August 6, 9:10 – 11:45 am

Allen Gregg Harbaugh Seattle Central Community College (agh.teach@gmail.com)

Student Proofs: Points of Entry in Developmental & Precalculus Math Courses

Using Vygotsky's theory of the Zone of Proximal Development (ZPD), this session will examine a set of activities designed to introduce students to the process of building and self-evaluating a proof. An emphasis on developing effective communication skills is the primary focus of these assignments. The intended level of mathematics instruction for the projects presented ranges from introductory algebra to trigonometry and precalculus. However, the theoretical framework can be extended naturally to upper-level undergraduate and introductory graduate courses.

Jennifer Gorman Kutztown University (jgorman@kutztown.edu)

A Proof a Day keeps the Red Pen Away

In this talk we will give examples of techniques used to involve students in proof writing. We will explore techniques implemented in a Linear Algebra class. Various approaches to engage students to help write proofs in class as well as strategies to assist in building students' confidence for writing proofs in homework will be explored. Pros and cons learned from the implementation, grades, and students' evaluations will also be presented.

Yun Lu Kutztown University of PA (lu@kutztown.edu)

Introduce Students to Their First Proofs

The course "Foundations of Higher Mathematics" offered in Kutztown University of PA is a first course introducing students what are proofs and how to write proofs. The students are those mathematics and mathematics education majors who have taken at least two college-level mathematics courses with calculus but are unfamiliar with formal proof. In the last couple of years, I've tried different methods to get students motivated and feel comfortable with the proof writing. For example, interactive lecture, in-class work, group projects, presentations, etc. Some worked,while others didn't. In this talk, I will share some of my successful experience with the audience along with students' feedback.

Violeta Vasilevska The University of South Dakota (Violeta.Vasilevska@usd.edu)

Proof Writing Activities in Abstract Algebra

In this talk we describe different methods/activities that have been used in Abstract Algebra classes at The University of South Dakota that encourage proof writing: Inquiry Based Learning, active in-class participation, weekly study sessions, writing projects, presentations. We will discuss what did/did not work well with each of these methods/activities. In addition, students' feedback and useful suggestions will be shared.

Bonnie Gold Monmouth University (bgold@monmouth.edu)

Growing Proof-Writing Skills Throughout the Undergraduate (Majors') Curriculum

At Monmouth, we developed our program to get our students to learn to write proofs by starting at the top level we expect our students to reach (in our Real Analysis course) and working backwards through what they need to develop along the way to meet this goal. We start with an Introduction to Mathematical Reasoning for freshmen, continue with Linear Algebra for sophomores, Number Theory and Modern Algebra in the junior year, and Real Analysis for seniors. Proof-writing is not just one skill: it combines a range of skills. One side is conceptual: understanding the mathematical concepts and how they interact. Another is formal: correct use of the language and logic of mathematics. A third is strategic: making sense of mathematical statements or definitions, deciding what type of proof to try, making effective use of examples. Our first course focuses on the formal side: getting students to successfully develop "unpack the definition" proofs. I combine activities in class with meeting with students in my office in pairs several times through the semester. There I walk them through the process of proof development. Recently, over 90% of the students are able to do short direct proofs by the end - and they are making the transition to more substantial proofs as they make their way through our curriculum. I will discuss several of the methods I use throughout this transition to proof course, and a few of the approaches in the Number Theory/ Modern Algebra sequence.

Joyati Debnath Winona State University (jdebnath@winona.edu)

Writing Proofs in Undergraduate Mathematics Courses

Although there are many text books on the techniques of writing proofs, getting students to understand the proof techniques and having them write their own proofs is not an easy task. Students usually try to capture the essence of the proof if they find relevance. This presentation will demonstrate what methods are used in courses like Real Analysis, Abstract Algebra, Topology, and Advanced Linear Algebra.

Molli R. Jones Immaculata University (mjones2@immaculata.edu)

Improving Proof Writing by Increasing Confidence, Communication, and Understanding

Because of the size of our department, I have the rare opportunity to be an ongoing part of our students' proof-writing development by guiding them through at least three proof-based courses. Through this series of courses, the students are engaged in activities where they create mathematical definitions and discover mathematical properties. An essential part of the process is that the students must defend their ideas in a way that will convince their classmates that their definitions or properties are correct. As a result, the students realize the benefits of clear, logical proofs to meet their own needs and not just to fulfill a homework assignment. Throughout this series of courses, students participate in activities that incrementally develop their ability to read, write, and edit proofs written by both them and their classmates. In this talk, I will describe the progression of activities that I use to develop the students' proof-writing skills. Examples will be drawn from Discrete Mathematics, Modern Algebra, and Real Analysis.

Kathleen Shannon Salisbury University (kmshannon@salisbury.edu)

Successful Strategies for Getting Students Involved in Proof Writing at Multiple Levels.

In this paper I will share the techniques for getting students involved in writing proofs that I have used with some success in four courses which I have taught regularly: Discrete Mathematics, Introduction to Abstract Mathematics, Analysis I and Analysis II. Learning to write proofs is a primary goal of all four of these courses but the audiences vary greatly. I will discuss the audiences, the mix of board work, written homework, group work and individual work and what evidence of success and sometimes, failure, I have seen. I will share class policies, assignments, and samples of student responses to a portfolio assignment in Analysis. I have found that a key to success is getting students to support one another and to learn from and with each other. It is helpful to discuss honestly the use of language in mathematics and how it differs from common usage and where it follows natural language as well as the times where there is ambiguity in what is needed to "prove" a statement. Another key is to create an atmosphere where the professor and students acknowledge that sometimes more learning occurs when students present incorrect proofs than when they present correct proofs. Finally I will briefly talk about proof writing as part of the university's Writing Across the Curriculum program.

The History of Mathematics and Its Uses in the Classroom

Session 1: Thursday, August 5, 1:00 – 3:55 pm

Jim Tattersall Providence College (tat@providence.edu)

Bringing Mr. Jefferson into the Classroom

Three mathematical vignettes from the papers of Thomas Jefferson are presented. Each is applicable to high school or collegiate mathematics classes. The first item deals with compound interest, the other two with geometric constructions: the four-circle ellipse and the octagon. The interest problem originates from a problem that appeared in a newspaper edited by Benjamin Franklin Bache and assumed political overtones associated with Alexander Hamilton's management of public finances. The two geometric constructions were put to good architectural use with Jefferson's designs of the Rotunda at the University of Virginia and Poplar Forest, his private retreat near Lynchburg, Virginia.

Janet Beery University of Redlands (janet_beery@redlands.edu)

Formulating Figurate Numbers

The multiplication formulas for figurate numbers and binomial coefficients we use today appeared in Western Europe in verbal form in the late 1500s and in symbolic form in the early 1600s. In this talk, we first recount the earlier history of figurate numbers and especially of multiplicative methods for computing them. We then focus on the development of multiplication formulas for figurate numbers in the late sixteenth and seventeenth centuries by Cardano, Faulhaber, Briggs, Harriot, Fermat, and Pascal. Throughout the talk, we display a variety of representations of essentially the same formula that you may wish to use in your classes, especially as you discuss with your students what it means to "have a formula for" a mathematical relationship.

Anders O.F. Hendrickson Concordia College (ahendric@cord.edu)

Lessons from Reading Clavius

The solar aspects of the Gregorian calendar reform of 1582 are well-known and can be stated in a few sentences. Less familiar and far more complicated are the reforms to the lunar calendar used to determine the date of Easter, which were devised by the Jesuit mathematician Christopher Clavius. This talk will discuss Clavius's *Romani Calendarii a Gregorio XIII P.M. Restituti Explicatio* (1687), its exposition of the new lunar calendar, and some lessons it offers to today's classrooms.

Rachel Cywinski Alamo Community College District (rcywinski@alamo.edu)

Light Through a Window: Evidence of Muslim Mathematics in Spanish Colonial Missions of San Antonio?

After centuries of integration of Christians, Jews and Muslims in Spain, the Spanish Crown financed Franciscans to evangelize Nueva España and create enough Spanish citizens that the Spanish empire could never again fall under foreign rule. But in trying to escape the shadow of Muslim Spain, the colonizers undoubtedly carried the cultural norms of many cultures with them. Franciscans used practical applications of mathematics in their placement of windows to provide lighting in those days before artificial lights. With our technologically advanced state of integrating technology with math and science, these practical applications may seen mysterious. What were some practical uses of Muslim mathematics that may have influenced the design of the windows in the Spanish colonial missions?

Doy Ott Hollman Lipscomb University (doy.hollman@lipscomb.edu)

Math Set in Stone: Famous Stones in the History of Math

This session will focus on famous stones of the past that reveal the numeration system of the culture or are good applications of their mathematical and astronomical knowledge. Examples will include the pyramids of Egypt, clay tablets of Babylonia, the Rosetta Stone, the Behistun Stone /Cliff, Stonehenge, Machu Picchu of the Incas, and many others.

Robert Rogers SUNY Fredonia (robert.rogers@fredonia.edu)

Teaching Introductory Analysis in Its Historical Setting

The author uses the history of analysis to provide the motivation for the nonintuitive definitions and theorems presented in his undergraduate introductory analysis course. Rather than relegating the history to 'sidebars', the author weaves the evolution from intuitive calculus ideas to rigorous analysis into the body of the course. Samples of the author's class notes and exercises will be presented. The author will also demonstrate how he develops students' mathematical writing by providing ideas of proofs of main theorems via scrapwork in the class notes and subsequent exercises where students provide polished proofs. A pdf file of the complete set of notes will be sent to anyone interested in using it as a textbook or a supplement.

Charlie Smith Park University (charlie.smith@park.edu)

The Cubic Controversy

One of the most intriguing episodes in the history of mathematics is the complete solution of the general cubic equation during the time period 1515–1545 in northern Italy. The plot is so intricate and entertaining that it makes great material for a movie of the future. The cast of characters, Cardano, Tartaglia, del Ferro, Fiore, and Ferrari, would make the Borgia family proud. A modern derivation of the general solution of the cubic equation can be presented to students who have passed College Algebra. Viete's substitution, a stroke of cleverness, facilitates this particular demonstration. Time permitting, one can delve into difficulties with the cubic formulas and alternative methods of solution.

Dale L. McIntyre Grove City College (dlmcintyre@gcc.edu)

The Heavens and the Scriptures in the Eyes of Johannes Kepler

"The heavens declare the glory of God . . . " Ps. 19:1

Acclaimed as one of the most accomplished and influential scientists of his time, the subject of this paper was also a passionate defender of the Christian faith who believed he had been called by God to glorify Him in the study of His Creation. We see a man who was so immersed in both the Scriptures and his exploration of the heavens that his scholarly writings often burst forth with biblical quotations and songs of praise for God the Creator. Though always magnanimous and tolerant of others, he suffered persecution from both Lutherans and Catholics for differing with them in points of doctrine, and risked his professional reputation by publicly upholding a scientific theory not yet accepted by most Christians or scientists. Such a man was the German astronomer and mathematician Johannes Kepler.

This paper intends to demonstrate Kepler's absorption in the Scriptures, exploring his understanding and application of them as gleaned from the many biblical quotations, paraphrases, and allusions found in his scientific works and in his personal letters. His perspective on the Bible's authority, its interpretation, and its bearing upon knowledge of the cosmos, will be addressed. Also, a biographical sketch will be given, emphasizing Kepler's call to vocation, position on the creeds, and personal character, in the context of his life and works.

Session 2: Friday, August 6, 8:30 – 11:45 am

Deana Deichert University of Central Florida (ddeichert@knights.ucf.edu)

Ciphering to the Rule of Three and the Evolution of Teaching Proportion

Abraham Lincoln described the extent of his own education when he said, "I could read, write, and cipher to the Rule of Three; but that was all." In this session, participants will discover what honest Abe meant by the Rule of Three and how this rule has changed throughout the history of American education. We will also take a look back through ancient history and see how the Rule of Three evolved from The Golden Rule. Participants will examine the replacement processes for solving proportions: analogy, algebra, cross product, and dimensional analysis. Participants will engage in discussions about the pros and cons of using these alternative procedures in an era of education that emphasizes conceptual learning.

Jerry Lodder New Mexico State University (jlodder@nmsu.edu)

Deduction Through the Ages: Teaching Elementary Logic via Primary Historical Sources

Abstract: A beginning undergraduate course in discrete mathematics is often taught as a fast-paced news reel of facts and formulas with little regard for the vast historical developments preceding the textbook presentation of modern, polished mathematics. In this talk we examine the development of propositional logic, and in particular the truth of an "implication" from ancient Greek sources to the twentieth century. Beginning with Philo of Megara's (4th century B.C.E.) statement that a valid hypothetical proposition is –that which does not begin with a truth and end in a falsehood," we examine various other major premises from another ancient Greek philosopher Chrysippus (280–206 B.C.E.) and discuss possible logical equivalences among them. This is followed by George Boole's (1815–1864) introduction of arithmetic symbols to codify verbal statements. Exhibiting a complete break between arithmetic and logic, the concept script of Gottlob Frege (1848–1925) is introduced, with particular emphasis on the "condition stroke." Philo's statement above is contrasted with Frege's declaration that the condition stroke is a function of two truth values that is false when the ζ (first) argument is true and the ξ (second) argument is false. The streamlined notation of the modern writers Bertrand Russell (1872–1970) and Alfred Whitehead (1861–1947) is introduced, and their definition of "p implies q" as "it cannot be the case that p is true and q is false" is contrasted with Frege's condition stroke and Philo's statement. Finally the truth tables of Emil Post (1897–1954) are discussed and his table for p implies q concludes the talk. By contrast, many modern textbooks on discrete mathematics begin the chapter on propositional logic with this very table.

Jeff Johannes SUNY Geneseo (johannes@member.ams.org)

Euclid's Neglected Postulate

Euclid's fifth postulate is appropriately famous. Euclid's first three postulates basically say "I have a compass and straightedge, and I know how to use them." But what about the fourth postulate: "That all right angles are equal to one another."? This postulate is occasionally even mocked for going too far in stating the obvious. What did Euclid have in mind? And what role has this postulate played throughout history? We will explore several historical meanings and consider the importance of this postulate in the modern geometry classroom.

Charles Rocca Western Connecticut State University (roccac@wcsu.edu)

History and Mathematics in Cryptology

Cryptology has a long history full of intrigue, this together with the importance of secrecy in modern society makes it a captivating subject. While in its earliest incarnations cryptology did not explicitly use mathematics it still presents excellent opportunities to discuss mathematical ideas. And, later in history encryption, decryption, and particularly cryptanalysis all came to depend heavily on mathematics. In this talk I will explore my past experiences, my plans for the immediate future, and my aspirations for the long term with regard to the teaching of the mathematics in cryptology from a historical stand point.

Nicholas A Scoville Ursinus College (nicholas.scoville@dartmouth.edu)

Rethinking the Way We Teach Point-Set Topology

A typical course in point-set topology starts with definitions and builds up to theorems. While this approach serves to organize the material well, students are often puzzled by the barrage of seemingly unmotivated and strange definitions. A different approach to point-set topology motivates the material through the history of the subject. Where did the study of point-set topology come from? What questions were being considered that caused the founders of topology to make the definitions they did? We will answer these questions and see how we might use those answers to introduce students to point-set topology. This not only motivates the study of point-set topology but also makes topology's relationship with other areas of mathematics more concrete.

Adam Edgar Parker Wittenberg University (aparker@wittenberg.edu)

The Benefits of Primary Sources in an ODE class.

The use of primary sources in teaching has many benefits. It can provide motivation for a topic, give historical or cultural context to a discovery, or remind us of underutilized or forgotten techniques (among other things). In this talk we will discuss why an Ordinary Differential Equations course is a particularly good place to utilize primary sources. We will illustrate this with a short discussion of how using primary sources to teach Bernoulli's Differential Equation let to a rediscovering of a solution method that doesn't appear to be taught much anymore.

Jeff Buechner Rutgers Univ-Newark and Saul Kripke Ctr., CUNY (buechner@rci.rutgers.edu)

The Ordered Pair: How its History and Philosophy has Pedagogical Importance in Teaching Mathematics

The concept of an ordered pair and the problem of providing a formal explication of it has a rich history in late 19th century and early 20th century mathematics|Peano, Peirce, Frege, Schröder, Wiener, Russell, Whitehead, Hausdorff, Kuratowski, VonNeumann, Bernays, Gödel, Tarski, Quine are key figures. Teaching the history of the ordered pair in the mathematics classroom provides several opportunities for enhancing a mathematics education. First, the distinction between intensional and extensional concepts is nicely illustrated by the task of providing a formal explication of an ordered pair (as is the idea of philosophical explication of a concept). Second, the reduction of the intensional notions of a function and of relations via the ordered pair to extensional ones|in terms of sets or classes|reveals one of the ways in which modern mathematics differs from classical mathematics. Third, that there are several, incompatible formal explications of the ordered pair each of which satisfies the formal criterion of an ordered pair (Peano's criterion: $\langle x, y\rangle = \langle v, w\rangle$ iff $x = v$ and $y = w$) provides an object lesson in how definitions of mathematical objects are accepted in mathematical practice.

Antonella Cupillari Penn State Erie (axc5@psu.edu)

The Other Curves of Agnesi

Maria Gaetana Agnesi's name is commonly associated with the curve know as "the witch of Agnesi." However the versiera, as Agnesi called it, is only one of many curves she introduced in her Instituzioni Analitiche (1748). Some of the other curves are somewhat more interesting and complex than the versiera, and they are grouped in the lengthy section (pp. 351–415) "On the construction of Loci of degree higher than second degree." We will look at Agnesi's presentation of some of them, which is made without using calculus methods.

Shawnee L. McMurran California State University San Bernardino (smcmurra@csusb.edu)
Jim Tattersall Providence College (tat@providence.edu)

Using the History of Divergent Series to Motivate Discussions about Series Convergence

Divergent series have no sum … or do they? In 1749, Leonhard Euler concluded that the alternating series $1 - 2 + 3 - 4 + \ldots$ should sum to $\frac{1}{4}$. What did he mean by this? Students in calculus and elementary analysis are inevitably faced with the study of series and conditions for convergence. Unfortunately, the beauty of the analysis is easily lost in a myriad of convergence tests and computation. The suggestion that $\sum_0^\infty 2^n = -1$, or that $\sum_0^\infty (-1)^n = \frac{1}{2}$, provides one way liven up a class discussion about series summation and emphasize the importance of definitions in mathematics. In this talk we will outline some of the early work on divergent series that might be used to motivate undergraduate discussions on series convergence and the role of definitions in mathematics.

Pat Touhey Misericordia University (ptouhey@misericordia.edu)

Using The History of Mathematics in a Basic Statistics Course

The typical student in a Basic Statistics course is usually deficient in basic mathematical skills. Algebraic formulas are often seen as an unintelligible jumble of symbols. We attempt to remedy that situation via the use of simple geometrical algebra and thus make strange concepts like; standard deviation, variance, Chebyshev's Theorem and Markov's Inequality, understandable.

Math & Bio 2010 in 2010

Thursday, August 5, 1:00 – 5:15 pm

Talitha M. Washington University of Evansville (tw65@evansville.edu)

Connecting First-Year Students to Current Trends in Mathematical Biology

Many first-year students are not provided an opportunity to see mathematics as a dynamic field. In this talk, I will share my experience of connecting calculus with current literature in mathematical biology. I developed and led a topics course that explored applications of differential and integral calculus to model the spread of infectious diseases. The four students that enrolled in this course were majoring in science, engineering, and mathematics. After working through some mathematical background, we carefully read through a paper by Dr. Ronald Mickens, developed simulations using MATLAB, and then each student presented a journal article that utilized a SIR model. After reading through Dr. Mickens' paper, I coordinated Dr. Mickens' visit to campus so that the students could engage in a research discussion with him. This course successfully enabled the students to see mathematics as a dynamic, exciting field.

Florence Newberger California State University, Long Beach (fnewberg@csulb.edu)

Connecting the disciplines through writing assignments in a calculus course for biology majors

To contribute meaningfully to the biology curriculum, a mathematics course must enable students to transfer its content to be used in courses and research activities beyond the mathematics classroom. With this goal in mind, I developed writing modules for a course in calculus for biology majors, in which students write about the relevance, applications and meaning of particular mathematical models used in biology. In addition to helping students transfer mathematical ideas, the goals for these assignments include guiding students to write well and use the language of the mathematical and biological disciplines, following ideas from the Writing Across the Curriculum and Writing in the Disciplines movements. I present these writing modules, as examples of how writing assignments can be constructed to directly address these goals. These modules also provide several examples of mathematical models that demonstrate, in the context of calculus, the relevance of mathematics to biology.

Instructors of the calculus course for biology majors at CSULB administer these assignments using a free on-line software called Calibrated Peer Review (http://cpr.molsci.ucla.edu/), which facilitates a peer review and includes a clever grading scheme that requires little oversight by the instructor, and puts much of each student's grade on his or her own ability to review the writing of others (rather than on the peers' assessments). Though some instructors choose to discuss the content of the assignments in class, the students can complete these assignments independently, outside of class, allowing the modules to be used without interfering with an existing course outline.

Timothy Comar Benedictine University (tcomar@ben.edu)

On Becoming Indepent Problem Solvers in Biocalculus Courses

The biocalculus courses at Benedictine University are designed to provide quantitative techniques and approaches that will be useful to students majoring in the biological and health sciences in their future coursework and careers. There is a particular emphasis on students interested in pursuing research. The courses use a threefold approach integrating mathematics, biology, and the use of computational software to investigate biologically oriented problems. This presentation will focus on how students develop intellectual independence through developing problem solving skills using computational software over the yearlong course sequence. We give examples ranging from simple exercises at the beginning of the first course to longer expository research projects and computer modeling projects. We discuss how the sequence of these activities enables the students to become independent problem solvers. We conclude with a discussion of student feedback and student research involvement after completion of the course sequence.

Urmi Ghosh-dastidar NYCCT, CUNY (ughosh-dastidar@citytech.cuny.edu)

Math, our Community and Civic Engagement—a SENCER based Approach

Attending SENCER summer institute in the last summer was really a life changing experience for me that reflected in my classroom teaching. Motivated by SENCER ideals, most of the problems that I chose are based on community issues. Examples of the topics that I introduced in the classroom are as follows: lead poisoning, water quality comparison, association between diabetes and obesity, and nosocomial infection (NI) or hospital acquired infection. Antibacterial resistance is an emerging problem in many bacterial infections and in particular, in NI infections. With the increased levels of antibiotic usage among humans, livestock, and crops, antibiotic resistance bacteria increased dramatically in past few years. Students used statistical analysis to study real data obtained from different communities of Brooklyn.

In particular, students worked in groups on nosocomial infection and perform regression analysis. During this project period students learned what nosocomial infections are, why we need to be aware of these infections and what preventive measures can be taken to minimize these types of errors. Each group produced a complete written report along with a flyer on nosocomial infection. The best flyer decided by the class will be distributed to a local hospital. Two emergent scholars Farjana Ferdousy and Aionga Pereira also worked on this topic. As emergent scholars they studied three of the most common pathogens responsible for NI infections: Klebsiella, Pseudomonas, and Acinetobacter. Single patient isolates were collected from fifteen different hospitals in Brooklyn during a three-month period in 2006 [for further information please consult: JAC 2007; 60:78-82]. Susceptibility and resistance to five of the most important antibiotics are studied. The antibiotics that we studied here are as follows: amikacin, ceftazidime, piperacillin-tazobactam, ciprofloxacin, and imipenem. We assumed our null hypothesis as no association exist between different Brooklyn hospitals and susceptibility rates to these five antibiotics. A chi-squared test was performed on susceptibilities for all five different antibiotics. The test revealed that there exist associations among different hospitals and antibiotic resistance with some exceptions. Now the question that we need to answer is as follows: what are the underlying causes of these differences? Does race, ethnicities, socio-economic condition matter?

Acknowledgement: I thank Dr. John Quale from SUNY Downstate Medical Center for providing data on nosocomial infection and his valuable time for us. I thank Dr. Liana Tsenova from the Department of Biological Sciences (City Tech) for sharing her knowledge on nosocomial infection with us. I also like to thank Dr. Arnavaz Taraporevala for valuable discussion and sharing her insights with us. I also like to acknowledge SENCER for providing me all valuable information during the summer institute of 2009. Lastly, I like to thank Dr. Pamela Brown, Dean of School of Arts and Sciences for her continuous support, enthusiasm and providing research opportunities for the emergent scholars.

Theodore Theodosopoulos Saint Ann's School (ttheodosopoulos@saintannsny.org)
Patricia Theodosopoulos Saint Ann's School (ptheodosopoulos@saintannsny.org)

Mathematics of Life

We describe an advanced high school seminar which explores the use of mathematical models to understand biological processes. This seminar investigates a diverse set of biological systems, from genetics and neuroscience to biochemistry and population dynamics. These systems provide concrete context to explore unfamiliar mathematical concepts including dynamical systems, Markov chains, random walks and optimization. In the talk we'll showcase our approach with a presentation of the adaptive immune system and the use of stochastic optimization as a modeling paradigm.

Maeve Lewis McCarthy Murray State University (maeve.mccarthy@murraystate.edu)

Ten Equations that Changed How I Teach Biomathematics

This talk will describe a Biomathematics course developed by the Departments of Biological Sciences and Mathematics & Statistics at Murray State University. The course is offered with minimal prerequisites and is required for participants in our UBM program, BioMaPS. Students carry out both wet labs and computational labs, attend seminars, write papers and give presentations.

For the last three years, the students have worked on a semester long project involving a topic from John Jungck's *Ten Equations that Changed Biology: Mathematics in Problem-Solving Biology Curricula*, Bioscene, vol. 23, 1997. Students have chosen topics such as Michaelis-Menten dynamics, Hodgkin-Huxley equations, and tomography. The impact of this project and the ten equations involved on the Biomathematics course, our UBM program and the university will be discussed.

John Zobitz Augsburg College (zobitz@augsburg.edu)
Ankur Desai University of Wisconsin (desai@aos.wisc.edu)
David J. P. Moore King's College (dave.moore@kcl.ac.uk)

A Hitchhiker's Guide to Data Assimilation in the Ecological Sciences

The amount of quantitative data in the ecological sciences will exponentially increase with the implementation of recent funding initiatives such as the National Ecological Observatory Network (NEON, www.neoninc.org). This large-scale network will allow for the analysis of sophisticated ecological questions across multiple spatial and temporal scales.

Data assimilation, or the systematic combination of informing a mathematical model with data, is becoming a necessary technique to analyze large datasets (such as ones provided by NEON) in the ecological sciences. Data assimilation provides a unique opportunity to increase the quantitative training of biologists and to increase interdisciplinary collaborations across the mathematical and biological sciences. This technique combines aspects of mathematical modeling, statistics, and computational analysis, further strengthening connections between mathematics and biology. Data assimilation differs from standard model analyses by potentially incorporating (a) mathematical models, (b) Bayesian parameter estimation techniques, (c) simultaneous estimation of model state variables and parameters, and (d) sophisticated computational algorithms. Successful implementation of a data assimilation analysis will require familiarity of all of these mathematical techniques and knowledge of the limitations of the biological data. As a result, effective utilization of large-scale databases requires knowledge of a diverse suite of mathematical tools and techniques not traditionally found in the undergraduate mathematics curriculum.

This presentation will describe approaches to training ecologists and mathematicians in data assimilation techniques, highlight different applications of data assimilation, and describe best practices for future development and education of data assimilation techniques.

Glenn Ledder University of Nebraska-Lincoln (gledder@math.unl.edu)

Using Virtual Laboratory Experiments to Motivate Mathematical Models in Biology

Mathematical modeling is the tendon that connects the muscle of mathematics to the skeleton of science. As such, it is a subject distinct from both mathematics and science. Neither the "applications" students see in mathematics courses nor the calculations students do in science courses provide an adequate introduction to mathematical modeling. Instead, mathematical modeling must be taught in the context of a scientific investigation. It is not generally feasible to conduct real-world scientific investigations in a mathematical modeling course; however, it is possible to conduct virtual-world scientific investigations without leaving the comfort of one's computer chair. In this talk, we use the BUGBOX suite of virtual laboratories to (1) derive a nonlinear model for predator-prey interaction and (2) to derive and analyze a matrix model for growth of a structured population.

Anton Weisstein Truman State University (weisstae@truman.edu)
Gretchen A. Koch Goucher College (gretchen.koch@goucher.edu)

Something Like a New Sense: The Biological ESTEEM Collection: Part I

How can we effectively convey to students the power and utility of quantitative approaches in studying biological systems? In this presentation, we introduce the philosophy and scope of the Biological ESTEEM Project, an open collection of Excel-based curricular modules. After illustrating three pedagogical approaches to integrating math and biology in the classroom, we will demonstrate a sample lesson plan for a pharmacokinetics module.

Gretchen A. Koch Goucher College (gretchen.koch@goucher.edu)
Anton Weisstein Truman State University (weisstae@truman.edu)

Something Like a New Sense: The Biological ESTEEM Collection: Part II

How can we effectively convey to students the power and utility of quantitative approaches in studying biological systems? In this presentation, we introduce the philosophy and scope of the Biological ESTEEM Project, an open collection of Excel-based curricular modules. After illustrating three pedagogical approaches to integrating math and biology in the classroom, we will demonstrate a sample lesson plan for a pharmacokinetics module.

Rebecca Vandiver Bryn Mawr College (vandiver.rebecca@gmail.com)
Sarah Hews Swarthmore College (shews1@swarthmore.edu)

The Mathbio Wiki: a Module Resource and Educational Tool

Many colleges are interested in enhancing undergraduate education in mathematical biosciences. This includes introducing mathematical modules in biology classes, establishing modeling classes, and teaching students to explain mathematics to those unfamiliar with the material. To facilitate these goals, we have created a MathBio wiki. The MathBio wiki has three components: a database of modules to incorporate mathematical biology into math and biology classes, a database of mathematical biology research papers that are appropriate for undergraduates, and a database of mathematics terms common in biological research. In addition to the benefit of providing faculty and students with resources in mathematical biology, the wiki has been incorporated into math courses for students to practice communicating their knowledge of mathematics in a manner that is accessible to scientists in other fields. In this talk we will introduce the wiki, explain the three components, and discuss how it has been used over the past year at Bryn Mawr College and Swarthmore College.

Matthew Glomski Marist College (Matthew.Glomski@marist.edu)

Modeling Uncertainty: Challenges and Opportunity in Undergraduate Biomathematics Research

Theoretical epidemiology provides an excellent springboard from which to study modeling in the undergraduate mathematics curriculum. Yet in applications involving real-world data, ideal models from the blackboard rarely suffice in capturing the complex biological dynamics at work. In this talk we will address lessons learned from a small undergraduate research course in mathematical epidemiology offered at Marist College. Specifically, we will discuss the important role played by interdisciplinary collaboration with colleagues and students in the biological sciences, health communication and computer science.

Darlene Olsen Norwich University (dolsen1@norwich.edu)

Undergraduate Research Projects in DNA Microarray Data Analysis

DNA microarrays are used to identify changes in expression levels of genes between tissues from different samples. This technological advancement has provided statisticians with more data that has caused an increased interest in the field of statistical genetics. To stimulate students' interest in the field of statistical genetics a collaboration between biology and mathematics is needed. This talk will discuss the initiation of the collaboration between departments at Norwich University and summarize four undergraduate research projects that involved the statistical analysis of microarray data.

Open and Accessible Problems in Applied Mathematics

Friday, August 6, 8:30 – 11:45 am

Ben Fusaro Florida State University (fusaro@math.fsu.edu)
Leon H. Seitelman (lseitelman@aol.com)

A Modeling Contest for HS Students

The STEM fields—Science, Technology, Engineering and Mathematics—suffer from a serious shortage of domestic students. A great deal of money has been thrown at this problem, with relatively little success, especially the attempt to recruit students to STEM after they have arrived in college. High school contests in applied mathematics generate interest, introduce students to the practice of working in teams, and expose them to realistic, open-ended problems. A successful example of this is the Moody's Mega Math Challenge. The Challenge is a one-day modeling contest for teams of high school juniors or seniors. It awards $100,000 in scholarship prizes to teams of 3–5 students, and it has no entrance or participation fees. There have been problems on stock investing, the corn-to-ethanol proposal, economic stimulus, and the 2010 census. The contest results show that high school students are fully capable of analyzing complex problems, finding various solutions, and justifying their solutions. College faculty can contribute to this effort by holding workshops for high school teachers and students. The Challenge is run by SIAM, and is funded by the Moody's Corporation. An overview of the contest guidelines and the role of a team's teacher-coach will be given. Examples of the students' work will be provided and a short video of some winning teams will be shown.

Jeong-Mi Yoon University of Houston-Downtown (yoonj@uhd.edu)

A Mathematical Modeling of Glassy-winged Sharpshooter Population in the Texas Vineyards

Pierce's disease (PD) results from an infection of grapevines by the bacterial plant pathogen Xylella fastidiosa (Xf). Xylem fluid-feeding insects transfer the bacterium from plant to plant. Specifically, the glassy-winged sharpshooter (Homalodisca vitripennis) has been shown to be a dominant vector for PD. Xf has emerged as a major pathogen affecting grapes in the US and its continued spread is a major agricultural concern. A database of putative PD vectors was created for 50 vineyards during 2003–2008 which was collected by Drs. Isabelle Lauziére and Forrest Mitchell in Texas AgriLife Research. The data set includes thousands of insect abundance for vineyards across Texas. A delay logistic equation (or Hutchison's equation) with harvesting term in a single species dynamics is used for representing the population model of Texas glassy-winged sharpshooter in the central Texas Hill regions. Undergraduate students generated the histogram of the vector population and are trying to fit the parameter values by simulating of the model with software, Matlab. Later the model will be extended to the spatio-temporal model of the vector dispersion based on the Fisher equation (or diffusive logistic equation). Also we'll build a dynamic model of between insects and vine based on an infectious disease model. Each model will be revised by the experimental phenomena with the continuous group discussions.

Kodwo Annan Minot State University (kodwo.annan@minotstateu.edu)

Mathematical Modeling of Solute Transfer during Hemodialysis Session

In an attempt to improve the quality and efficacy of Hemodialysis (HD) treatment many clinical and experimental approaches have been used to investigate solute transfer inside and across hemodialyzer membranes. However, these clinical and experimental protocols are expensive, time consuming, and often culminate in variable results. In addition, these experiments do not take into account the exchange of buffering (Bicarbonate) inside the dialyzer and therefore fails to describe fully and predict bicarbonate dynamics across the membrane. Since flow distribution and bicarbonate effect on solute transfer is indispensable for assessing and optimizing HD's efficiency, we develop mathematical model to quantify solute transfer in HD with bicarbonate dialysate. The model couples blood, dialysate and transmembrane (TM) compartment flows with bicarbonate buffering and replenishment. Unsteady state Navier-Stokes equations are employed to simulate the different equations governing the solute concentrations at both sides of the membrane. Kedem-Katchalsky equations are used to compute the TM flow. Our results give valuable insights, account for, and predict the dynamic exchange of solutes, such as bicarbonate, hydrogen ions and carbon dioxide during a typical HD session. The study is attractive for probing, analyzing, and understanding some of the physical and biochemical complexities associated with HD treatment. It could be used as an investigative framework tools for optimizing and rationalizing the choice of operative conditions, such as flow velocities and pressure, solute concentrations, and ultrafiltration rates during the administration of HD therapy.

Ricardo Sanchez DRC Data Recognition Corporation (rsanchezh70@yahoo.com)

An Applied Mathematician Visits the Navier-Stokes Equations

The Navier-Stokes Equations are the subject of many papers that look for a solution in three dimensions. This paper is not an exception to that rule. Using some of the most recent information and some classical approaches, we present a solution in three and more dimensions. It is a weak solution so does not qualify for a prize but uses the approaches from Leray, St Raymond, Molenaar, Green, and others to obtain an applied view of the subject.

Antonio Mastroberardino Penn State Erie (axm62@psu.edu)

Homotopy Analysis Method: Analytical Solutions for the 21st Century

Over the last few decades, several analytical methods have been developed to solve nonlinear differential equations that arise in various areas of applied mathematics. In this talk, I will present the nuts and bolts of one of these methods—the homotopy analysis method (HAM)—introduced by Liao in 1992. HAM has been applied in numerous areas in science and engineering such as viscous fluid flow, heat transfer, water waves, and mathematical biology. A major task in the construction of a HAM solution involves solving a sequence of linear nonhomogeneous differential equations. This process is made tractable by the aid of mathematics software capable of symbolic computation, and thus, is suitable for undergraduates. I will discuss a recent undergraduate research project in which HAM was used to solve a problem in fluid mechanics and will conclude with ideas for future projects.

Robert Rovetti Loyola Marymount University (rrovetti@lmu.edu)

So You Think You Can Add? The Summed Behavior of Nonlinear Systems

In applied problems, multi-scale systems are characterized by a hierarchical organization in which the whole system is comprised of smaller (and usually simpler) constituent parts. If we know the rules governing the individual parts, can we "add them up" to predict how the whole system will behave? For many inherently nonlinear problems the answer can be surprising. Readily accessible tools for understanding such systems include cellular automata and iterated maps. I will describe their use in both research and the classroom using examples from physiology (cardiac cell dynamics) and political science (voting outcomes), and discuss some current open questions about drawing general conclusions from numerical and analytical results.

Junalyn Navarra-Madsen Texas Woman's University (jnavarramadsen@mail.twu.edu)

Tangling and Untangling DNA

Will a double-stranded DNA ever be knotted in the cell? How can molecular biologists confirm this phenomenon? In this paper, we describe via tangle analysis proteins tangling and untangling double-stranded DNA. We utilize an invariant called Fox coloring to aid in modeling DNA changes done by these proteins. This simplistic model will help biologists explain protein mechanisms in the cell.

Pamela Kay Warton The University of Findlay (warton@findlay.edu)

Graph Theory Takes on International Terrorism in the United States

In this project, we were investigating which city should be targeted with the most resources in order to have the most detrimental effect on the international terrorist network. International terrorist cells within the United States were located and a weighted graph was created. Using methods from Discrete Mathematics, the weighted graph was analyzed node by node to determine which node was the most important to the operation of the network. The answer turned out to be quite surprising and raises more questions for future projects.

Ze Cheng Sichuan University (kpzc7wl@hotmail.com)
Guang-Chong Zhu Lawrence Technological University (gzhu@ltu.edu)

Zipf's Distribution in "Gadsby"

An interesting fact about English is that it follows a statistical law discovered by George K. Zipf: the frequency of occurrence of a word is inversely proportional to its rank order in the frequency table. Other languages also exhibit similar behaviors except that Zipf's distribution would be modified by a parameter. In 1939, Ernest Wright published an unusual novel "Gadsby: Champion of Youth", which is a lipogram—it purposefully avoided the use of any word containing the letter "e", but is still grammatically correct, for a total of 50,110 words! In this work, we investigate how Zipf's law is affected in "Gadsby" due to the absence of the most frequently used letter and hence many frequently used words. We present our findings for both word frequency and letter frequency distributions.

Sarah Elizabeth Eichhorn UC Irvine (sfrey@math.uci.edu)
Jack Xin UC Irvine (jxin@math.uci.edu)
Hongkai Zhao UC Irvine (zhao@math.uci.edu)
Max Welling UC Irvine (mwelling@uci.edu)
Ernie Esser UC Irvine (esser@math.uci.edu)

Four Lower Division Student Research Topics: Preliminary Materials from UCI's Interdisciplinary Computational Applied Mathematics Program (iCamp)

iCamp is a new program at UC Irvine to provide research experiences in computational applied mathematics for first and second year undergraduate students. These early research opportunities are designed to attract students to the mathematics and computer science fields and provide a context for the regular major coursework. (Funded by NSF PRISM grant # 0948247.) In this talk, we will present four areas of proposed student research: Blind Source Separation, Collaborative Filtering, Image Processing and Game Simulation and Analysis. For each of these areas, we will give samples of open problems suitable for lower division undergraduate research. We will also share information about how to access training materials we are developing to prepare students for successful research in these fields.

Active Learning Intervention Strategies Accompanying Introductory Mathematics Courses

Saturday, August 7, 1:00 – 4:55 pm

Diana White University of Colorado Denver (diana.white@ucdenver.edu)

An Innovative Approach to Trigonometry Recitation Involving Pre-Service Secondary Math Teachers

We discuss a new internship for pre-service secondary math teachers that has substantively impacted our College Trigonometry classes. In this internship, which is now a required part of our pre-service secondary math teacher preparation program, undergraduate math majors who are pre-service teachers are grouped together and act as recitation instructors for College Trigonometry. In addition, there is an accompanying weekly seminar in which course pedagogy, course content, and history of trigonometry are discussed. Benefits of this program include: significant gains in student achievement, revitalizing the instructor's teaching of the class, exposing the pre-service teachers to trigonometry content (which most had forgotten significant portions of), and exposing the pre-service teachers to many algebra misconceptions. This model has been successful enough that it is being expanded to include other lower level classes and is being used as a model for graduate teaching assistants who are teaching for the first time.

William Bond University of Alabama- Birmingham (bondwil@uab.edu)
John Mayer University of Alabama- Birmingham (mayer@math.uab.edu)

Do Inquiry-Based Active Learning Strategies Add Value to Computer-Assisted Instruction?

Student success as measured by grades, and greater efficiency in terms of cost effectiveness, have been a driving force in "course reform" over the past 15 years, particularly at large state universities (NCAT, 2008). One prevalent direction of course redesign has been the development of, and widespread use of, sophisticated computer-assisted instruction. This approach has often been applied to large-enrollment service courses in mathematics. We do not dispute that computer-assisted instruction does promote active learning. Rather, we investigate what, if any, is the value-added of incorporating inquiry-based group work sessions in entry-level mathematics courses in which the primary pedagogy is computer-assisted instruction. Our research at a major state university investigates in randomized quasi-experimental studies the relative effects of combining computer-assisted instruction with inquiry-based group work sessions and with more traditional summary lectures of material to be covered in the computer-assisted part in two entry-level courses: Finite Mathematics and Basic Algebra. Results suggest that a group work session with individually written reports and regular feedback significantly improves students' ability in conceptual understanding, in showing evidence of problem-solving, and in the quality of explanation of reasoning leading to the solution. This added value is accomplished without any significant difference in students' course grades between treatments.

Philip B. Yasskin Texas A&M University (yasskin@math.tamu.edu)
Douglas B. Meade University of South Carolina (meade@math.sc.edu)

Electronic Study Guide for Precalculus and Calculus

Not enough time to grade hand-written solutions or give all students one-on-one attention? Frustrated by online homework systems with multiple choice questions or that check only the final answer and never locate the student's errors? Not satisfied with the finite and static content of a paper study guide such as Schaum's Outline? Looking to avoid the high cost (and uneven quality) of a private tutor? Electronic study guides, pioneered by the Maplets for Calculus (M4C), address each of these concerns.

The M4C (See http://m4c.math.tamu.edu) is a collection of over 125 Maple applets designed to ask a question and provide step-by-step guidance through the solution, requiring correct answers to intermediate steps. Hints are available and when errors are detected, instructive feedback is provided. There is an endless supply of problems with significant variation. The maplets use symbolic, graphic (2D or 3D, some animated), numeric and verbal devices to investigate problems. Problems are algorithmically generated or entered by the student or instructor. The M4C can be used for self-study, in a computer lab, or as lecture demonstrations. All of this enables students to use M4C as "a tutor without the tutor."

The M4C received the 2008 ICTCM Award for "excellence and innovation in using technology to enhance the teaching and learning of mathematics" at the 20th International Conference on Technology in Collegiate Mathematics and are supported in part by NSF DUE CCLI Grants 0737209 (Meade) and 0737248 (Yasskin).

Cristina Villalobos University of Texas-Pan American (mcvilla@utpa.edu)

Enhanced Student Services in Calculus 1 Classes

Calculus 1 forms the foundation for more advanced mathematics courses required by the STEM major and thus plays an important role in the undergraduate curriculum. At the University of Texas-Pan American, there is a need to provide classroom resources to students to help them succeed in Calculus 1. Therefore, several interventions were implemented beginning spring 2009, which included a Student Assistant—an undergraduate STEM major—who attended class and took down lecture notes in the Cornell note-taking style, graded assignments, posted assignments and conducted tutoring sessions. Results from spring 2009 to the present will be discussed.

jose huberto Giraldo Texas A&M University Corpus Christi (jose.giraldo@tamucc.edu)
Mufid Abudiab Texas A&M University Corpus Christi (mufid.abudiab@tamucc.edu)

Formative Assessments to Improve Performance in Pre-calculus and Calculus

One of the goals of an NSF/STEP grant implemented at Texas A&M University Corpus Christi is the success of science students enrolled in the mathematics component of the program. Several types of assessments have been implemented in the pre-calculus and calculus courses to evaluate the effectiveness of the instruction and the achievement of the student learning outcomes set for these courses. In this presentation we will share the types of assessment implemented, the modifications to them based on the results, and the impact in curricular changes generated by these results. Data of these assessments for two different populations will be presented. One population corresponds to a cohort of students taking three courses simultaneously, and the other population is of students who were not enrolled in classes as a cohort. In addition to the results of the assessments we will also present data related to grade comparison of the performance of the students in cohort in the science classes compared to the students in those classes and who are not in the cohort. These results are taken in consideration to make modifications in the next cycle of the project.

Angie Hodge North Dakota State University (Angela.Hodge@ndsu.edu)
Christina Weber North Dakota State University (Christina.d.Weber@ndsu.edu)

Helping Students Succeed by Engaging them in the Mathematics Classroom

What teaching and learning strategies help students succeed in the mathematics classroom and go on to pursue careers in STEM disciplines where mathematics often acts as a gatekeeper? Our research explores this question and seeks to gain insight into how these strategies help to recruit and improve student retention in these disciplines. This aligns with a push on the national level to recruit more majors into the STEM fields. For instance, the National Science Foundation (NSF) has taken initiative through grants such as Proactive Recruitment in Introductory Science and Mathematics classrooms (PRISM). To help determine what can make mathematics classes more meaningful, active, and engaging, we administered surveys and conducted interviews with students in mathematics classes at two levels: freshman (Calculus I) and upper-classmen (Differential Equations). In this presentation, we share our analysis of the findings in a manner that can be practically incorporated into mathematics classes at all levels.

Leslie M. Horton Delta State University (lhorton@deltastate.edu)

I Lost My Voice and Learned to Teach

On the second class day of the semester, my voice gave out and did not return for months. My students in a "real" math class (trigonometry) benefited from techniques borrowed from my math education classes. This paper will recount the evolution of teaching techniques, compare results from my class and a more traditional class taught the same semester, and consider the social implications of small groups.

Karen Sue Briggs North Georgia College & State University (kbriggs@northgeorgia.edu)
Thomas Cooper North Georgia College & State University (tecooper@northgeorgia.edu)

Moore Method in PreCalculus: An Interim Report

With the support of an EAF grant, we are conducting a two-semester quasi-experimental study on the effects of the Moore method versus traditional teaching methods in freshman-level PreCalculus. The first implementation of the experiment occurred during the Spring 2010 semester, with two sections using traditional lecture based teaching methods, and one section using the Moore method. This project will continue during the Fall 2010 semester with one traditional and two Moore method sections. Our initial statistical analysis of the data from the Spring semester has already produced intriguing results. In this talk, we will describe the study itself and outline the findings thus far.

David Wilson SUNY, Buffalo State (wilsondc@buffalostate.edu)
Robin Sue Sanders SUNY, Buffalo State (sanders@math.buffalostate.edu)

Promoting Success in Calculus Through Problem Solving and Undergraduate Teaching Assistants

This report describes the initial outcomes of the Buffalo State College mathematics department's efforts at revising our calculus course sequences to include a student-centered, problem solving session (PSS) as well as the integration of undergraduate TAs into these courses. This work has been supported by both an NSF STEP grant and a Title III grant. The revisions also involved developing a lengthy list of non-standard problems that are appropriate for use in the PSS and designing faculty/TA development workshops to increase faculty/TA comfort with student-centered learning. The PSS is designed to have the TA and instructor jointly facilitate student learning and encourage mathematical communication both orally and in writing; hence our PSS represents one model for implementing PLTL pedagogy into the mathematics curriculum at a mid-sized, less-selective state university. In addition to their classroom work during the PSS, our TAs are expected to schedule hours in our drop-in tutoring center to provide SI for calculus students. Preliminary data suggest the PSS positively impacts success and retention (DFW rate) and provides opportunities for students and the undergraduate TAs to interact in meaningful ways and consequently promotes peer-tutoring both inside the classroom during the PSS as well as outside the classroom in drop-in SI sessions.

Zdenka Guadarrama Rockhurst University (guadarrama@rockhurst.edu)
Mindy Walker Rockhurst University (Mindy.Walker @rockhurst.edu)

Service learning in a Precalculus class: An environmental awareness campaign

Service learning is an active learning strategy that allows students to become engaged in a class, creating a sense of ownership and purpose. We will describe how we infused our Precalculus curriculum with environmental issues and, as a class, developed an environmental awareness campaign. We will discuss shortcomings, further applications, and extensions of this service learning concept.

Emil Daniel Schwab The University of Texas at El Paso (eschwab@utep.edu)
Gabriela Schwab El Paso Community College (gschwab@epcc.edu)
Helmut Knaust The University of Texas at El Paso (hknaust@utep.edu)

Supplemental Instruction Model for Precalculus

We report on our cooperative project to integrate mandatory Supplemental Instruction (SI) sessions into El Paso Community College (EPCC) Precalculus courses. This strategy is aimed at helping freshmen students adjust to the unfamiliar learning environment they experience at the college level and at increasing student knowledge of the course material, thus improving student success and reducing the student drop-out rate for these courses. Graduate students from the University of Texas at El Paso serve as SI leaders for this Supplemental Instruction component at EPCC. A large portion of these graduate students started their academic career at a community college and are therefore able to act as role models for their EPCC peers.We will give an overview of the project including assessment data.

Julie Marie Skinner University of Texas - Arlington (julie.skinner@mavs.uta.edu)
James Anthony Mendoza Epperson University of Texas - Arlington (epperson@uta.edu)

Tasks in an Emerging Scholars Program in Pre-Calculus and Calculus via an Active Learning Lens

The quality of the tasks that students encounter in their mathematics courses influences their performance in their current mathematics course and possibly in subsequent mathematics courses. There is, however, a fine line between scaffolding tasks into pieces that eliminate thinking and presenting tasks in a way that truly engages the students (Hsu, 2007). At The University of Texas at Arlington, a program is being created to support and challenge students in Pre-Calculus II, Calculus I and Calculus II. These goals will be met through the creation and presentation of carefully designed tasks for the students to work on both individually and in an active group setting. Using The Mathematical Task Enrichment Guide (Epperson, 2005), traditional mathematical problems are explored and opened up to meet the students' needs. This talk will examine how these tasks are created and the expected benefits in student understanding of important concepts and skills.

Innovative Ideas for an Introductory Statistics Course

Session 1: Friday, August 6, 1:00 – 4:55 pm

Michael Miner American Public University System (jcmhs77@aol.com)

Y'all Ready For This? The First Night of Stats Class!

Getting off to a good start is essential in the course, BSA308, Business Statistics and Research at Averett University's School of Graduate and Professional Studies, Tidewater Campus. BSA308 is a core course in the Bachelor of Business Administration degree program offered to adult learners. This presentation details a first night of class data collection learning activity that has proven to be highly successful in accomplishing not only several key learning objectives of the first night of class but also is instrumental in: curbing students "statistics anxiety"; providing the instructor background information on the student's presentation ability and enthusiasm level; enabling students to understand that statistics is frequently practiced in daily undertakings; building learning team cohesion; and setting the stage for the remainder of the class.

Jeff Hamrick Rhodes College (hamrickj@rhodes.edu)

Using the Wolfram Demonstrations Project to Illustrate Elementary Statistical Concepts

The Wolfram Demonstrations Project includes numerous Mathematica notebooks, called Demonstrations, generated by using the Manipulate function in Mathematica (version six or higher). These demonstrations are freely available for classroom use. In this talk, we will discuss the syntax of the Manipulate command and show you how you can publish with your students at the Wolfram Demonstrations Project. We will highlight a few of the currently available demonstrations that are useful in an introductory statistics course. At the end of the talk, you should be convinced that a Mathematica demonstration is more flexible than using the textbook CD-ROM and is easier to produce than your own Java applet.

Magdalena Luca Massachusetts College of Pharmacy and Health Sciences (magdalena.luca@mcphs.edu)

Analyzing Real Biomedical Data Using Scientific Writing and TI Calculators

This presentation will address innovative teaching methods used in a specialized introductory Statistics course for students enrolled in pharmacy and health sciences programs. In our degree programs, statistical literacy is absolutely essential for students' understanding of how to responsibly treat patients, in the development and approval of any drug, and in everyday life. I will elaborate on the use of real biomedical data, use of statistical applications on TI calculators, use of misleading statistics in the mass-media, and use of scientific writing in my statistics course. Using TI calculators for complex statistics carried out on biomedical data allows for more lecture time being spent on independent problem solving, analyzing and interpreting real world data, and validating statistics in medical journal articles. Scientific writing is used by students during all lectures, tests, and assignments. These activities are successfully utilized to promote a deeper, conceptual understanding of statistics, improve complex cognitive skills and engage students in the learning process.

Karen Sue Briggs North Georgia College & State University (kbriggs@northgeorgia.edu)

Popular Media and Introductory Statistics

If Mark Twain correctly equated "damn lies" and statistics, the reason is the lack of society's statistical literacy. In an effort to improve our students' statistical literacy, we have implemented a Statistical Literacy Project in our Elementary Statistics course in which each student is asked to find a current popular media article of personal interest which cites statistics-based research. After obtaining a copy of the cited article, each student then provides a written analysis that contrasts the conclusions reported in both the research and media articles. Students are assessed upon how they use the concepts they have learned in class to evaluate the validity of the statistical argument reported in the media article. In this session, examples of students' projects will be demonstrated and discussed together with points of learning from the instructor's perspective. Many students in the pilot study embraced the projects and produced reports demonstrating increased maturity for statistical thinking.

Sue McMillen Buffalo State College (mcmillse@buffalostate.edu)

An Outbreak of Outliers

Participate in an activity designed to build conceptual understanding of outliers and address misconceptions about "how far away" an outlier must be. Use real data from major league baseball and long distance phone plans to predict, calculate, and identify some counterintuitive outliers. Explore their graphical connections to boxplots and back-to-back stem and leaf graphs. Discuss some real-life examples of outliers that were removed from data sets and the subsequent consequences of their removal.

Nathan Shank Moravian College (shank@math.moravian.edu)

Interdisciplinary Statistics Projects: Competitive Cross Curriculum Projects in Statistics

We will talk about objectives, outcomes, and new developments for a cross curriculum multivariate data project in an introductory statistics course. This particular project consists of three distinct pieces; 1) a proposal, 2) a research paper, and 3) a formal presentation. Students create a preliminary proposal for their project. Recently, we have worked with a two semester introductory psychology statistics class who critiques the proposal and offer valuable incite into the projects. During the talk, we will discuss details of the exchange and highlight some of the positive effects this interdisciplinary, cross curriculum exchange has on the students and their work. Students use the proposal, feedback from the instructor, and feedback from the psychology statistics class to develop a research paper. The formal research paper encompasses all the statistical analysis steps; from collection to analysis. At the end of the semester, students present statistical arguments based on their research to a “Board Of Directors” in a competition to receive funding (hypothetical of course!) to continue their research. Each member of the Board of Directors evaluates the projects based on a specific role. The Board of Directors then collectively picks a winning project. We wish to share our outline for the current projects, talk about developing similar projects at other institutions, and hear ideas for improving the project.

Robb Sinn North Georgia College & State University (robb@northgeorgia.edu)
Dianna Spence North Georgia College & State University (djspence@northgeorgia.edu)
Karen Sue Briggs North Georgia College & State University (kbriggs@northgeorgia.edu)

Authentic Discovery Experiences and Student-Centered Statistical Research Projects

Researchers and instructors share curriculum materials, teaching strategies, and student outcomes from the ”Authentic Discovery” initiative for elementary statistics. Curriculum materials for Authentic Discovery were developed during a recent NSF-supported study and are available online. These materials were piloted in elementary statistics courses at a four-year college, a two-year college and in a high school Advanced Placement Statistics class. Authentic Discovery projects allow students to investigate a research question of their choosing and to experience several key phases of statistical research: Students identify research variables; define the research question; design and implement sampling strategies and data collection, often using survey-based methods; carry out appropriate statistical analyses on the data collected; write a formal report describing the methodology and the findings; and deliver an in-class presentation of their results. Projects focus on the scientific method, emphasizing the role of statistics in analyzing data. Inferential and descriptive statistics course topics are reinforced through project implementation, student reports, and presentations. Five instructors who participated in the study share how this instructional approach changed and improved their courses; included in the discussion are several of their students’ research ideas and work samples. A brief summary will also be given of the research conducted to gauge the impact of the discovery projects on students’ content knowledge and attitudes. URL’s for all web-based instructional materials will be provided.

Brian Hollenbeck Emporia State University (bhollenb@emporia.edu)

What’s In Your Wallet? Analyzing Dollar Bills to Reinforce Statistical Concepts

What can we say about a typical dollar bill in circulation? How rare are certain types of serial numbers? Do theoretical probabilities match reality? We will discuss a project that allows students to use probability and statistics to make inferences about circulating U.S. dollar bills. The project required students to collect a random selection of bills. It also gave them the opportunity to reinforce their understanding of hypothesis testing, confidence intervals, and counting techniques. Specifically, students were asked to analyze the mean year on a bill, Federal Reserve Bank distribution, and the rarity of bills with certain serial number forms. An analysis of the assumptions for each statistical technique was necessary for students to draw valid conclusions.

Vicki-Lynn Holmes Hope College (holmesv@hope.edu)
Brooke Quisenberry Hope College (brooke.quisenberry@hope.edu)

Putting the Inferential back in Introductory Statistics: A Randomization Approach

The goal of this presentation is to introduce an alternative research-based approach to teaching introductory statistics that will enthuse students and promote a more conceptual understanding of probability while enhancing their problem solving and reasoning skills.

Traditional algebra-based introductory statistics courses are divided into three parts of relatively equal size: (a) Descriptive Statistics, (b) Probability and Sampling Distributions, and (c) Inferential Statistics. Basic problems found in this method are (a) Descriptive statistics were predominately redundant. Most of the material has been increasingly taught in K-12, thus making this a review; (2) Two-thirds of students were disenchanted with statistics following the computational aspect of probability; they became bogged down in the algebra of calculating, not interpreting t- and f- statistics; and (3) the big picture—inferential statistics—was lost. For the vast majority, the “meat” of the program—inferential statistics—became the periphery event.

One solution to this is in the reformed or inquiry based introductory statistics curriculum. This randomization-based approach implemented completely restructures the course by (a) limiting the actual teaching of descriptive statistics to review and reinforcement,; (b) finding 'true' probability (p-value) through permutations instead of explicit coverage of probability and sampling distributions; and (c) teaching inferential statistics throughout the entire course. The inferential, courtroom approach to interpreting and evaluating real-world data displays is based on Rossman's randomization method and blends interactive, technology (data modeling) with inferential pedagogical activities from day one.

Annela Kelly Roger Williams University (akelly@rwu.edu)

Probability with the Survivor Function and Expected Value Games

First, our talk will introduce probability as seen in the actuarial science. We will use the life-table model. The table lists the age X of a male and approximate number of males living to age X. The presentation will explain how to identify the survivor function S(X) as the probability for a single individual to survive at least X time units. This function is useful for introducing the concepts of union, intersection and conditional probability.

For the second part of the talk, we will discuss the expected value calculations using coins. We will introduce several games with coins that help us understand the expected value of discrete random variable. The students can easily play these with classmates and get more confident in calculating the expected value.

Session 2: Saturday, August 7, 8:30 – 11:45 am

Paul Taylor Shippensburg University (pttaylor@ship.edu)

Examples of Data Collection Using Clickers

Clickers are a fast convenient way to both engage students and collect real data for use in examples. A few examples are presented covering a variety of introductory statistics topics, from confidence intervals and sampling distributions to χ^2.

Kevin Scott Robinson Millersville University of Pennsylvania (kev2bec@yahoo.com)

Happyville and Statistical Thinking

A simple activity/handout called happyville, a community of 100 households, has been used successfully in general education and business introductory statistics courses. Illustrations will be give of how happyville is utilized throughout the semester to aid student understanding of statistical thinking including sampling techniques, sampling variation, sampling distributions, central limit theorem, confidence level, confidence intervals and type I & II errors. The happyville activity has the beneficial properties of being used throughout the semester, visual demonstration and student engagement. The activity lends itself to both hands on simulation as well as computer based simulation. The activity maintains the attention and engagement of students, enables the students to discover important statistical ideas and overcome misconceptions often encountered in introductory statistics courses. The happyville activity is flexible and its utilization has evolved over time to address more and more of the foundational statistical ideas encountered in a first statistics course.

Patrick Gorman Kutztown University (gorman@kutztown.edu)

A Hole in One: Using Miniature Golf in an Introductory Statistics Course

In this talk, we will give examples of how data collected from a class miniature golf trip can be used to motivate examples throughout an introductory statistics course. The data collected was used for a variety of topics seen in a one semester statistics course. This talk will show how the students' data was integrated in different projects for the course, and how it was used as a motivating tool for concepts during the semester.

Dean Nelson University of Pittsburgh at Greensburg (den@pitt.edu)

Exploring Linear Regression with Bouncing Balls

We present an activity that includes data collection and analysis to demonstrate the use of linear regression using a physical phenomenon with which all students are familiar. Students in groups perform several simple experiments dropping different kinds of balls from a set of pre-determined heights and recording their bounce heights. Each group produces a regression analysis to predict the bounce height of each type of ball. These data collections and analyses result in class data and model estimates that differ between and within ball type. This exercise provides a context within which to discuss experimental design (What choice of pre-determined heights should be used? Does it make a difference?), errors in measurement (What procedure do we use to measure bounce height? Does it control for bias or variability or both?), model assumptions (Is the relationship linear? Should we include an intercept? What do we mean by goodness-of-fit?), problems of extrapolation (What does our model describe? What are the limits of that description?), and model interpretation (Does our slope estimate describe a characteristic of the ball? Again we ask, what does our model describe? How does that description differ between different types of balls?), as well as all the concepts integral to linear regression analysis.

Chris Oehrlein Oklahoma City Community College (coehrlein@occc.edu)

A Matched Pairs Study Involving Proportions

Most studies on paired data that students encounter in an introductory statistics class involve analyzing means of differences between the paired subjects. Using data from a study done in West Germany in the 1970's, students are led through a significance test on a proportion calculated from paired subjects.

Lanee Young Fort Hays State University (lyoung@fhsu.edu)

Exploring Probabilities Through Simulations with Pigs

Many time probabilities are explored using manipulatives in which the sample space and theoretical probability are known. Using cards and dice illustrates the rules of probabilities quite well but does not provide students the opportunities to make these concepts their own. Through this activity students predict, design an experiment, use the definitions of theoretical and experimental probability, model the law of large numbers and discuss addition and multiplication rules of probability through the use of hands on manipulatives (toy pigs) and technology (Excel.)

Sarah L. Mabrouk Framingham State College (smabrouk@framingham.edu)

Martin vs. Westvaco: Honors Statistics Mock Trial

Since first teaching an Honors section of introductory statistics in Fall 2003, I have used the Martin vs. Westvaco data set found in the Watkins, Scheaffer, and Cobb text, "Statistics in Action", for the capstone assignment, a mock trial. The students, working in two groups, act as lawyer-statisticians to represent their clients, Mr. Robert Martin and the Westvaco Corporation. My statistics course, having dual enrollment—students enrolled in an Honors section meeting with students enrolled in a regular course section—provides the jury as well, the students enrolled in the regular course section. In this presentation, I will discuss how this data set is used, the analysis performed by the Honors students, including summary statistics, graphs and tables, the creation of additional variables for analysis, and sampling, the lawyer-statisticians' presentations of their age discrimination case to the jury, the responsibility of the jury, the determination of a decision for the case, and student reaction to this assignment.

Kenneth A. Ross MAA (rossmath@pacinfo.com)

Benford's Law, a Growth Industry

Benford's Law is based on the observation that in many sets of data, the first digit is 1 about 30% of the time, the first digit is 9 about 5% of the time, and the frequencies of the other possible first digits lie between 5% and 30%. In general, this is a statistical phenomenon that isn't easy to understand, but it also occurs in a deterministic setting which is easily understood. This will lead into an aspect of the phenomenon involving data that grow exponentially, such as populations of cities or counties, which can be explained to anyone who understands logarithms. By resorting to pictures, one can even avoid logarithms.

Geometry Topics That Engage Students

Session 1: Friday, August 7, 1:00 – 4:55 pm

Sarah J Greenwald Appalachian State University (greenwaldsj@appstate.edu)

Activities to Enliven a Course on Euclidean and non-Euclidean Geometries

Creative activities and projects can enliven a classroom and help students develop an ownership of the course material. In this talk we will discuss the creation and implementation of the following activities in a course on Euclidean and non-Euclidean geometries.

1. Axiom Systems and Wile E. Coyote http://mathsci.appstate.edu/∼sjg/class/3610/wile.html
2. Historical Timeline Project http://mathsci.appstate.edu/∼sjg/class/3610/timeline.html
3. Euclidean and Spherical Polyhedra http://mathsci.appstate.edu/∼sjg/class/3610/platonicsolids.html
4. Parallels and Connections Among Geometries http://mathsci.appstate.edu/∼sjg/class/3610/parallels.html

We will discuss the student reaction to the course before and after the implementation of these projects and classroom activities, and the benefits and challenges of including them in the course.

Kay Ellen Smith Saint Olaf College (smithk@stolaf.edu)

Finite Geometries and Games

Finite geometries provide a good setting in which to introduce axiomatic systems and illustrate the meaning of independence of axioms and model of a system. In this talk we describe two activities in which games are used to explore models of finite geometries. In the first activity students find models of a plane configuration (a type of finite geometry) that contain nine points with three points per line. After discovering three non-isomorphic models, students play tic-tac-toe on the models to help them better understand the differences in structure of the three models. In the second activity students first play the game of SET (http://www.setgame.com/) and then investigate questions about the finite geometry underlying the game such as "How many points are there?" and "How many lines pass through a given pair of points?"

Kristen Schemmerhorn Dominican University (kschemmerhorn@dom.edu)

Excursions on the Sphere

Exploring spherical geometry can help students get a better understanding of the properties of Euclidean geometry and hyperbolic geometry by comparing the different geometries. Using the Lenart sphere, students have an opportunity to discover properties of spherical geometry. Along with discovering properties of lines and triangles and comparing them to Euclidean and hyperbolic geometry, spherical geometry can also be used to see why the betweeness axioms are important for the exterior angle theorem. Some guided discovery activities on the Lenart sphere will be presented along with a discussion of what students should learn as a result of the activities.

Davida Fischman CSU San Bernardino (fischman@csusb.edu)

Engaging Students in Learning about Scaling

Scaling involves fundamental geometry concepts, and is one of the most difficult topics for students to appreciate and understand. As a result, they often ”check out” and passively await the next topic. We will describe a progression of activities that kept one class of liberal studies students engaged and actively involved in developing an understanding of scaling and its applications.

Ivona Grzegorczyk California State University Channel Islands (ivona.grze@csuci.edu)

Geometric Art and Algebraic Surfaces

We will show geometric activities based on the use of software for stimulating interest in 2D and 3D geometry. We include interesting mathematical images and surfaces from arts, science and architecture and meaningful artistic creations designed by students.

Xiaoxue Hattie Li Emory & Henry College (xli@ehc.edu)

Projective Geometry -Visualizing proofs and interpretations in Euclidean Space

The study of projective geometry, besides its own beauty and elegance, provides a way of gaining perspectives on other modern geometries. Euclidean geometry is a special case of projective geometry in the sense that the group of Euclidean motions is a subgroup of the group of projective transformations. This presentation will introduce two undergraduate research projects conducted in and after a modern geometry course. The first project explored the proof of Desargues' theorem in both two and three dimensional projective spaces through making 3D models of different constructs of the theorem. This has greatly engaged students in learning geometry since they could visualize the proofs and it stimulates their creativity. Our second project discussed the relationship between projective geometry and Euclidean geometry by interpreting this theorem, which takes place in projective space, to Euclidean setting. We provided two corollaries for Desargues' theorem when it is valid in Euclidean space.

Jack Mealy Austin College (jmealy@austincollege.edu)

Non-Euclidean Geometry Across the '7 Grade / Major' Spectrum

In this talk we first outline various subcategories of Geometry, in particular emphasizing the broader (and perhaps less standard) definition and scope of the subject. Then attention is given to the levels of difficulty in the study of these various subcategories. Finally we discuss efforts to bring specific proper subsets of these subcategories of Geometry into the curriculum of three phases of education: for Math majors, for the general education college student, and for students in High School / Middle School. Specifically:

1. Student projects from my upper level Geometry course will be discussed.
2. Specifics from my January Term course for general education students will be discussed.
3. Finally, we discuss the beginning of a new effort, the OTP (Outside The Plane) project, to introduce some of these ideas even more widely, i.e, to a segment of students at grade levels 7 through 12. Some specific examples will be included.

Len Smiley University of Alaska Anchorage (smiley@uaa.alaska.edu)

A Feuerbach Refresher

A digest of classical approaches to Feuerbach's Theorem on tangencies to a 9-point circle provides perspectives and toolkits often stimulating to prospective secondary educators.

Diana White University of Colorado Denver (diana.white@ucdenver.edu)

An Inquiry-Based Approach to Middle-Level Geometry for Preservice Secondary Teachers

We discuss course methodology and outcomes of a course for pre-service secondary teachers that involves an inquiry-based approach to middle-level (grades 4–9) geometry. This course was piloted in Summer 2009 and taught a second time in Summer 2010. Secondary teachers in some states are certified to teach grades 6–12, yet often we attend only minimally to the mathematics in grades 6–8. However, the mathematical knowledge needed to teach grades 6–8 is substantially different from that of the upper grades, and not traditionally taught in a mathematics major. This course arose out of a revision of our pre-service secondary math teacher preparation program to better align with the Conference Board of the Mathematical Sciences recommendations on the Mathematical Education of Teachers.

Cheryll Elizabeth Crowe Eastern Kentucky University (cheryll.crowe@eku.edu)

Developing Visualization Skills through an Exploration of Platonic Solids Using Technology and Traditional Methods

This paper describes a project implemented in a geometry class for elementary and middle school pre-service teachers. The purpose of the project was to develop visualization skills from 2D to 3D and make connections to surface area and volume through an exploration of Platonic Solids. Through the project, students also expanded their knowledge of Euler's formula and ascertained the history of Platonic Solids.

The project commenced with an overview of constructing nets for Platonic Solids using traditional methods (compass and straight edge) and technology (Geometer's Sketchpad and GeoGebra). Pre-service teachers constructed nets for each Platonic Solid by hand and with technology; then they calculated the surface area of each figure. Following this task, nets were folded to create three-dimensional renderings of the Platonic Solids, and students determined the volume of each figure. At the conclusion, pre-service teachers used their 3D Platonic Solids and an activity from the National Library of Virtual Manipulatives (NLVM) to explore Euler's formula and examine the history of Platonic Solids.

In this talk, the presenter will discuss the project, show samples of constructed Platonic Solids using traditional methods and technology, and demonstrate the NVLM activity exploring Euler's formula.

Lucy Dechene Fitchburg State College (ldechene@fsc.edu)

Informal Geometry for Aspiring TV/Film Directors and K-8 Educators

The Informal Geometry class we developed for K-8 pre-service teachers became extremely popular with Communications Media majors long before it became a requirement for education majors. The course is organized around 19 discovery labs and topics from Geometry: An Investigational Approach (O'Daffer and Clemens). The underlying theme of the course is symmetry, although topics from Fractals to Topology are investigated. A fair amount of time is spent on polyhedra. Topics and labs will be discussed in this presentation as well as the varied topics students have used for the 15-page research paper/visual semester project. We encourage as projects for TV/film majors the analysis of film scenes from favorite movies for the use of geometry to tell the story and engage the viewer, as well as for symmetry. We will also discuss the positive effects of mixed classes of Communications and Education majors.

Martha Waggoner Simpson College (murphy.waggoner@simpson.edu)

Reuse, Recycle, Re-Ceva

Since it was published over 300 years ago, Ceva's Theorem has been used, proven, generalized and extended many times. The simplicity of this theorem about triangles is an avenue for conjecture and proof for geometry students. In this talk, I will discuss how students used *Geometer's Sketchpad* to explore the theorem, give a glimpse into a versatile and intuitive method of proof, and outline the possibility of extending Ceva's Theorem to other figures such as higher order polygons or polygrams. This includes a brief discussion of the connection between Ceva's Theorem and the theorems of Menelaus and Hoehn. I will also provide a list of resources for future study.

Session 2: Saturday, August 7, 1:00 – 4:15 pm

Jane Cushman Buffalo State College (jcushman@math.buffalostate.edu)

Centers of Triangles (for GSP 5 and Geogebra)

The activities used have students construct the four centers of triangles and ultimately animate the Euler Segment. There will be a GSP 5 version and a Geogebra version of the handouts. An exit ticket is also used to determine if students understand locus of points that create the circumcenter, incenter and centroid.

Marc Renault Shippensburg University (msrenault@ship.edu)

GeoGebra and the Fermat-Torricelli Point

I will discuss my positive experience using the free software program GeoGebra in geometry class. In particular, I will demonstrate a successful group project based on GeoGebra experimentation and the construction of the Fermat-Torricelli point of a triangle. (The Fermat-Torricelli point is the point in a triangle for which the sum of the distances to the three vertices is minimal.)

Theodore Theodosopoulos Saint Ann's School (ttheodosopoulos@saintannsny.org)

Minkowski Geometry and Special Relativity

We describe an advanced high school seminar which introduces non-Euclidean geometries through an exploration of relativity from a geometric perspective. We begin with a graphical representation of the coordinate transformations between inertial frames. All along, we model space-time as a two-real-dimensional slice of C^2, with one (imaginary) spatial dimension and one (real) temporal dimension. We develop the two dimensional Poincare group of transformations that reconciles the principle of relativity with the inertial invariance of the speed of light in vacuum. This gives rise to the Lorentzian metric, together with its hyperbolic "circles." The resulting metric space is used as a laboratory for testing familiar geometric objects, like congruent triangles, right angles and areas in an unfamiliar setting. This environment also offers a concrete representation of more abstract concepts like curvature and homotopy.

Frank Morgan Williams College (Frank.Morgan@williams.edu)

Baserunner's Optimal Path

The fastest path around the baseball diamond, from a student talk to Rob Neyer's Monday Mendozas to the *Mathematical Intelligencer*.

Premalatha Junius Mansfield University (pjunius@mansfield.edu)

A Modern Geometry Class Works Overtime

What infuses a Modern Geometry class with curiosity and persistence so that students are deep in conversation even after class is over? The adidactical situation will be discussed.

Mark Schwartz Ohio Wesleyan University (mdschwar@owu.edu)

On Drawing Stuff

Do you think it's easy to draw a straight line? It's not! Try it (no rulers* allowed) and you'll see. What about other stuff like a perfectly shaped ellipse or parabola? They're even harder. Early practitioners in geometry devised ingenious methods to draw provably correct shapes. In this talk, we consider various examples and learn why they work.

* A ruler isn't allowed but it would be permissible to use a linkage. What's a linkage? That's part of the talk.

Sam Northshield SUNY Plattsburgh (samuel.northshield@plattsburgh.edu)

A Golden Graph

We give an example of a simply constructed infinite graph that exhibits many interesting connections with the golden ratio and Fibonacci numbers. Further, this graph can be embedded in the hyperbolic half-plane so as to form a tessellation by congruent squares and such that the vertices in the graph form a quasicrystal.

Lisa Mantini Oklahoma State University (mantini@math.okstate.edu)

Origami and Symmetric Colorings of the Platonic Solids

The rotational symmetry groups of the Platonic solids are isomorphic to groups of permutations, but these isomorphisms are not so easy to visualize, particularly for the identification of the icosahedral group with A_5. We illustrate rotation-invariant partitions of the collections of edges, faces, or vertices of a given solid through colored origami constructions and show how these colorings allow one to identify a given rotation with the corresponding permutation. Additional colorings give realizations of all of the irreducible representations of each rotation group.

Majid Masso George Mason University (mmasso@gmu.edu)

Using Biology to Teach Geometry: Protein Structure Tessellations in Matlab

The three dimensional (3D) atomic coordinates for thousands of solved protein structures, freely available at the Protein Data Bank (http://www.pdb.org), generate stunning visual depictions and provide a wealth of data with which to introduce and apply concepts from geometry. In particular, we begin with a coarse-grained protein structure representation, obtained by abstracting to a point each of the constituent amino acid building blocks. Delaunay tessellation of this point set in 3D yields a convex hull of non-overlapping, irregular tetrahedra with the points serving as tetrahedral vertices; hence, the methodology provides an objective way with which to identify quadruplets of nearest-neighbor amino acids in the folded protein structure. The tetrahedral simplices of a tessellation can be categorized into five types based on whether the four amino acids represented at the vertices are consecutive or distant from one another in the primary (linear) amino acid sequence of the protein. Formulas for calculating the tetrahedrality and volume of a tetrahedron are introduced and used to identify differences in the frequency distributions of these values across the five classes of simplices, based on the collection of tetrahedra obtained from the tessellations of over 100 diverse protein structures. Matlab codes, interspersed with detailed comments, are provided for performing and graphically visualizing Delaunay tessellations, classifying the tetrahedra into five subsets by type, and calculating tetrahedrality and volume.

Leon Hannah Tabak Cornell College (l.tabak@ieee.org)

Nearest Neighbors: Mathematics and Geography

Which addresses are closest to which post offices? The construction of a Voronoi diagram solves this (and similar) problems. Fortune's Algorithm efficiently draws a Voronoi diagram by sweeping a horizontal line from the top of a map to the bottom, pausing the sweep where enough information becomes available to allow the addition of vertices and line segments. A presentation of Fortune's Algorithm has helped students enrolled in a study of Geographic Information Systems to understand how a function of the software that they use works and to appreciate more fully the role of mathematics in answering geographic questions that arise in fields as diverse as biology, geology, business, and politics. Interactive, animated computer graphics show each step in the construction and inform the discussion of the character of this problem and the principles applied in its solution.

Open and Accessible Problems in Number Theory and Algebra

Friday, August 6, 1:00 – 5:35 pm

Thomas Koshy Framingham State College (tkoshy@framingham.edu)

Catalan's Factorial Problem

In this talk, we explore the numbers $X_{m,n} = \frac{(2m)!(2n)!}{m!n!(m+n)!}$, originally studied by the Belgian mathematician E. C. Catalan in 1874. We re-confirm that they are integers. Using their close relationship with Catalan numbers C_n, we establish some divisibility properties of C_n, including the fact that $f_k | C_{2M_k+1}$, where f_k denotes the kth Fermat number and M_k the kth Mersenne number. In addition, we develop an explicit summation formula using Pascal's triangle and then extract several byproducts from it.

Joshua Holden Rose-Hulman Institute of Technology (holden@rose-hulman.edu)

Mapping the Discrete Logarithm

The Discrete Logarithm Problem is a well-known problem in computational number theory that has many applications to the field of cryptography. In order to efficiently solve the problem one needs a thorough understanding of the inverse transformation x goes to g^x modulo n. This map is easy to compute and has many properties that are accessible to undergraduates, and yet there is no known efficient algorithm for inverting it. Analysis of the security of many cryptographic algorithms depends on the assumption that it is statistically impossible to distinguish the use of this map from the use of a randomly chosen map with similar characteristics. Over the past several years, my undergraduate students and I have been studying the of the functional graph of this map and comparing it to functional graphs from randomly chosen maps. The tools used involve not only number theory but also combinatorics, analysis, and statistics, in order to predict the structure of a randomly chosen graph and compare it to our experimental data.

Michael "Cap" Khoury University of Michigan (mjkhoury@umich.edu)

Interesting Problems in Apollonian Circle Packings

Begin with three mutually tangent disks, all tangent to and contained in a fourth circle, leaving four "holes". Inscribe a disk in each holes, creating twelve smaller holes, and so on, constructing an infinite configuration of disks. This construction leads quickly not only to beautiful pictures but also to beautiful mathematics. For if the initial four circles have integral curvature, then so do all the others! So each of these pictures gives a configuration of "numbers". In this talk we will focus on questions about the number-theoretic properties of such sequences. Which numbers appear in such a sequence? How many times does a particular curvature appear? How common are prime numbers in these pictures? Fibonacci numbers? Square numbers?

This is offered as a student-friendly presentation, assuming no prior familiarity with Apollonian circle packings, but it should be worthwhile for all. We will briskly survey basic properties as well as some classical and recent work; more importantly, we will sample the rich spectrum of pen problems awaiting further exploration.

Michael Krebs California State University, Los Angeles (mkrebs@calstatela.edu)

Number Derivatives: A Treasure Trove of Undergraduate Research Projects

A number derivative is a function that satisfies the Product Rule. Using only tools from elementary number theory, one can quickly classify all number derivatives from the set of integers modulo n to itself. (Example: The function $x^2 - x$ is a number derivative on the set of integers modulo 4.) Because these maps began life as analogues of the ordinary derivative from Calculus, one can easily generate new questions about them—at a level appropriate for undergraduate research—simply by attempting to extend the analogy. Given a number derivative, you might for example ask: How do you "integrate"? Can you find solutions for various "differential equations"? In this talk, we discuss some of the answers that have been found by undergraduates as well as a high school student; a large list of highly tractable problems that remain open; and ways to have students come up with these questions themselves. Based on joint work with C. Emmons and A. Shaheen.

Benjamin Kraft Hazleton Area High School (benjaminjkraft@gmail.com)
Keenan Monks Hazleton Area High School (keenaneek@gmail.com)

On Conjugacies of the $3x + 1$ Map Induced by Continuous Endomorphisms of the Shift Dynamical System

Lagarias showed that the shift dynamical system S on the set $\mathbb{Z}_2$ of 2-adic integers is conjugate to the famous $3x + 1$ map T by a conjugacy Φ. Thus for each continuous endomorphism f_∞ of S there is a corresponding endomorphism $H_f = \Phi \circ f_\infty \circ \Phi^{-1}$ of T and a map Ψ_f from the coimage of H_f to itself defined by $\Psi_f([x]) = [T(x)]$. We completely classify all continuous endomorphisms f_∞ of S for which Ψ_f is conjugate to T. We then define an infinite family of such maps, Ψ_{M_k}, that are –neutral" modulo 2^{k-1} in the sense that each element of the domain is a complete residue system modulo 2^{k-1}. By investigating the relationships between T-cycles and the Ψ_{M_k}-cycles that contain them, we obtain an alternate method for studying the dynamics of T. This method is used to prove several new results pertaining to T-cycles, which are then applied to yield several possible approaches to the $3x + 1$ conjecture. Consequent opportunities for future research are discussed.

Brian Hopkins Saint Peter's College (bhopkins@spc.edu)

Open Questions About Compositions

Compositions are sometimes considered "poor relations" to partitions, but there are many open questions about them. The integer partitions of 3, for instance, are $\{3\}$, $\{2, 1\}$, and $\{1, 1, 1\}$, the different sets of positive integers whose sum is 3, where order does not matter. For compositions, order *does* matter, so the compositions of 3 are the partitions above and also $\{1, 2\}$. While many questions for compositions are easier than the analogous questions for partitions, there remain many interesting and accessible open questions about compositions. Some of the open questions discussed in this talk will include generalizations of palindromes, generalizations of "Carlitz compositions," and various restricted compositions motivated by studying symmetric polynomials.

Sam Northshield SUNY Plattsburgh (samuel.northshield@plattsburgh.edu)

Some Accessible Problems Mostly Involving Sequences

1) Stern's diatomic sequence $(0, 1, 1, 2, 1, 3, 2, 3, 1, 4, 3, 5, 2, 5, 3, 4, 1, 5, ?)$ has the property that every relatively prime pair appears exactly once (e.g., every positive rational number is the ratio of two consecutive terms). Are there other sequences with this property? Are there sequences such that every relatively prime triple appears exactly once?

2) The Riemann hypothesis arguably has its most elementary description in terms of a homeomorphism from the Sierpinski gasket to an Apollonian circle packing. Any investigations in this area are of potential interest.

3) $X \mapsto (X + A \cdot X^{-1})/2$ is the Newton method for approximating the square root of A. With matrices, this behaves normally only if A and the initial guess X_0 commute; very little is known if they do not.

Ursula Whitcher Harvey Mudd College (ursula@math.hmc.edu)

Polytopes, Polynomials, and String Theory

Much current research in algebraic geometry is inspired by questions from theoretical physics, particularly string theory. By studying the properties of polytopes (including the permutohedron, the associahedron, and reflexive polytopes) and associated rings, we investigate questions in Gromov-Witten theory and the geometry of Calabi-Yau manifolds. This talk describes summer research conducted with Professor Dagan Karp and a group of undergraduate students at Harvey Mudd College.

Michael Nathanson St. Mary's College of California (man6@stmarys-ca.edu)

Conjugating Matrices to get Uniform Diagonals

Given a complex $n \times n$ matrix M, it is always possible to find a unitary U so that the diagonal entries of the matrix $U * MU$ are all equal. This nice result is fairly elementary and yet not widely known.

The above lemma is useful in the study quantum entanglement, in which context an analogous question also arises: Given a set of traceless $n \times n$ matrices $M_1, M_2, \ldots, M_k$; under what conditions does there exist a unitary U so that the diagonal entries of $U * M_i U$ are all zero for each $i = 1, 2, \ldots, k$? This question can be understood by a good linear algebra student, and yet its general solution is not known. I will mention some special cases and thoughts on approaching this work with students.

Brian Drake Grand Valley State University (drakebr@gvsu.edu)

Absolute Length in Triangle Groups

A *triangle group* is a group generated by reflections over the sides of a triangle. The triangle groups may be classified as finite, affine, or hyperbolic, depending on if the triangle is spherical, Euclidean, or hyperbolic. If we let the group act on an appropriate surface, we get a triangulation of the sphere, Euclidean plane, or hyperbolic plane. The usual length function gives the number of reflections needed to map an arbitrary triangle to the original triangle, reflecting only over the sides of the original triangle. We consider instead the *absolute length*, which is the number of reflections needed using any of the reflections in the group. The usual length is unbounded for affine groups, but we will show that the absolute length never exceeds 4 for these groups. In addition, we will find elements of unbounded absolute length for the hyperbolic group generated by an ideal triangle, and discuss the conjecture that the same is true for any hyperbolic triangle group.

Andrew Shallue Illinois Wesleyan University (ashallue@iwu.edu)

Tabulating Irreducible Polynomials over Finite Fields

Polynomials over finite fields make great objects of study for undergraduate research. Much is familiar, yet just enough is different to be surprising and exciting. In this talk we'll cover the best known methods for tabulating irreducible polynomials, and present open problems that can be tackled through theory and experimentation.

Thomas Hagedorn The College of New Jersey (hagedorn@tcnj.edu)
Jeffrey Hatley University of Massachusetts at Amherst (hatley@math.umass.edu)

The Probability of Relatively Prime Polynomials in $(Z/p^k Z)[x]$

Let $P_R(m,n)$ denote the probability that two randomly chosen monic polynomials $f, g \in R[x]$ of degrees m and n, respectively, are relatively prime. Benjamin and Bennett (2007) showed that $P_R(m,n) = 1 - 1/p$, when $R = Z/pZ$, the ring of integers modulo a prime p. Building upon this work, we can prove an explicit formula for $P_R(m,2)$, when $R = Z/p^k Z$. The talk will discuss the proof of this work and similar open problems.

Mu-Ling Chang University of Wisconsin-Platteville (changm@uwplatt.edu)

Is the Square Root of 2 Rational?

Everyone knows that $\sqrt{2}$ is not rational, but do you know how to prove it? If you do, then how many proofs have you seen? In fact, there are more than ten different ways to prove the irrationality of $\sqrt{2}$. In this talk, I will provide several methods in Algebra or Number Theory to show that $\sqrt{2}$ is not rational.

Effective Practices for Teaching Mathematical Communication Skills

Saturday, August 7, 8:30 – 11:45 am

Tessa Weinstein Coastal Carolina University (tweinste@coastal.edu)

Strategies for Improving Writing by Cultivating Metacognition

All too often, undergraduate students, who are perfectly capable of computational acrobatics, find themselves challenged when it comes to translating their problem solving skill into written form. Writing a mathematical paper requires metacognition: a student must think about the cognitive processes involved in solving a problem to be able to write coherently about it. A student may be able to find a solution, but not be able to explain why it is correct or how he/she obtained the solution. When this is the case, it points to a cognitive gap. This is one of the reasons making students write precisely about how a solution is obtained is so important in undergraduate mathematics: it quickly uncovers conceptual misunderstandings and gaps in knowledge. This talk discusses strategies for improving student metacognition, thereby improving mathematical writing skills.

Brian Kelly Bryant University (bkelly@bryant.edu)

Initial Experiences with Case Studies

At Bryant University, the actuarial mathematics track has the largest enrollment in the applied mathematics program. This talk focuses on writing assignments inspired by financial mathematics. Throughout the semester, the students are required to interpret their mathematical work in a manner accessible to someone not enrolled in the course.

For example, Calculus 2 includes a discussion of self sustaining streams of payments, such as annual scholarship awards. These perpetuity funds are studied as an application of summing geometric series. This invites in-class discussion of how to explain the results informally which leads into a short writing assignment. After obtaining the formal results, the students must discuss why their formula is compatible with a "common sense" perspective. This talk will address educational design for such assignments and provide examples from throughout the calculus sequence.

Joyati Debnath Winona State University (jdebnath@winona.edu)

Mathematical Communication Skills in Undergraduate Curriculum

Based on 2004 MAA CUPM Curriculum Guide it is evident that all undergraduate students in mathematics should be able to communicate mathematics both orally and in writing. Clearly it needs enormous amount of time for planning how this can be achieved. In this presentation, the speaker will demonstrate how students were involved in speaking and writing in class every day, developing presentation skills and finally writing research projects for classes ranging from Pre-Calculus and Calculus, up to upper-division courses such as Abstract Algebra and Real Analysis.

Kim Roth Juniata College (roth@juniata.edu)

Communicating Statistically

Statistical consulting at Juniata is a course requiring only Introduction to Probability and Statistics. For the final project the students analyze and report on real data that come from clients, mainly other departments across campus. I will discuss the successes and challenges of getting the students to communicate statistically at the level of their clients both in writing and speaking.

Benjamin Galluzzo Shippensburg University (bjgalluzzo@ship.edu)

Bridges from Math to English

Many applied math writing assignments encourage students to write (or develop a presentation) for a general audience. However, when feedback is provided, it's almost exclusively supplied by mathematicians. Identification of this apparent inconsistency prompted me to invite colleagues from my college's English department to assist in judging a regional math modeling contest. In this talk I will discuss how interdisciplinary collaboration and an extracurricular activity can have an immediate impact on student communication skills and curriculum design.

Lew Ludwig Denison University (ludwigl@denison.edu)

Preparing Students to Communicate Technical Information

The number of oral presentations by undergraduate mathematicians at local, regional, and national meetings continues to increase. Moreover, effective oral communication is a skill highly sought by employers. In this presentation, we will describe the curricular steps taken at Denison University to prepare our students to present technical information to a general audience, be it in the academic setting or the work place. We will outline our course structure, provide rubrics, and present portions of instructional videos used to prepare students in effective oral communication. Electronic versions of these materials will be freely available to the audience.

Charles Rocca Western Connecticut State University (roccac@wcsu.edu)
David Burns Western Connecticut State University (burnsd@wcsu.edu)

First-Year Introduction to Communications

In the second semester of our First Year Mathematics Seminar, which is required off all math majors, we focus on our students abilities to communicate verbally. With each new instructor we have tried different approaches to teaching these skills. Some classes have focused on group work and problem solving while others have looked for individual work and tried to introduce the students the breadth of what mathematics can be. In this talk we will look at the different approaches that we have tried and assess the pros and cons of each.

Jennifer Franko Vasquez The University of Scranton (frankoj2@scranton.edu)
Steven T. Dougherty The University of Scranton (doughertys1@scranton.edu)

Using Wikis and Journals to Increase Communication in Mathematics Courses

Beginning last fall, students created a mathematics journal for two upper division courses. For many, this was the first proof class which helped reinforce the idea that writing proofs is a multi-step process. The short "articles" went through two referees and then the students had time for revisions prior to submission to the editors (the professors). We used a wiki to help facilitate this activity. The wiki allowed the students to share their files with one another and provided an additional avenue of communication about the assignments. While compiling the journals, the students learned how to write proofs that were understandable and more importantly that mathematics requires review and reflection. This talk will discuss our experiences in this endeavor.

Martha Allen Georgia College & State University (martha.allen@gcsu.edu)
Blair T. Dietrich Georgia Military College (bdietrich@gmc.cc.ga.us)

Conversational Mathematics: Fostering Mathematical Communication Skills and Thinking in Introductory Courses

At our institutions, one of the student learning outcomes is that students will communicate mathematical ideas with clarity and coherence through both writing and speaking. In our introductory mathematics courses, we have implemented a variety of team-based and individual learning activities in an effort to foster the development of students' mathematical thinking and to promote both written and oral mathematical communication skills. In addition, these activities also encourage the students to become active learners and to take a greater responsibility in their learning of mathematics. In this presentation, we will discuss some of these activities, which may include identifying team members using specific mathematics concepts, calculus games, journal assignments, and team presentations.

Emily Elizabeth Puckette University of the South (eep@sewanee.edu)

Packing it All into Real Analysis

The undergraduate real analysis course at Sewanee is one of several junior/senior level courses that aim to give students ample guidance and experience in written and oral communication of mathematics in line with the CUPM guidelines. The course combines teamwork with writing and oral presentations to create a lively and intense classroom where student engagement is required. The course builds upon the foundations of proof-writing and oral presentation in the sophomore level Discrete Mathematics course and bridges to the "senior talk" where each major researches and delivers a 45-minute presentation as part of his or her senior capstone program.

First Year Seminar / First Year Experience Mathematics Courses

Session 1: Saturday, August 7, 8:30 – 11:45 am

Karen Clark The College of New Jersey (kclark@tcnj.edu)

First Year Seminar Voting Theory Course at TCNJ

I offered a First Year Seminar course on Voting Theory, Apportionment, and Fair Division in the Fall 2008 semester and will offer the course again in the Fall 2010 semester. The class is designated as "writing intensive" by the college, and thus must include a significant amount of student writing, including revisions of written work. The course also satisfies a liberal arts Quantitative Reasoning requirement, so it must include a nontrivial amount of mathematical content. I will discuss the challenges of balancing these requirements for an extremely diverse group of students - my class included students who were taking calculus, and included students who had difficulty with simple arithmetic.

Matthew Menzel Marietta College (mmm002@marietta.edu)

Freshmen, Problem Solving, and the Unknown Audience

The Marietta College First Year Experience Program was recently modified, which allowed for the creation of a first-year course in Problem Solving. When I began designing the course, I imagined that most students would be potential math majors and minors, and I envisioned that the course would allow me to introduce mathematically-inclined students to a variety of mathematical fields. When I began seeing math placement scores and prospective majors for the students enrolled in the course, however, I discovered that my audience would be significantly different than I had anticipated. This talk will address the flexibility required for creating an introductory mathematics course with no pre-requisites (either coursework or placement scores) and some of the challenges and successes that accompanied my experience.

Lew Ludwig Denison University (ludwigl@denison.edu)

The Art of Mathematical Thinking

As a liberal arts institution, Denison University has a rich history in the First Year Seminar experience. In this presentation, we will describe a mathematics course for non-majors where students learn the art of thinking like a mathematician. This is achieved by exploring an assortment of classic mathematical topics such as infinity, irrationality of the square root of two, Euler's formula, etc., but with a heavy focus on the thinking process, not just the end result. In this way, students learn thinking strategies that they can use throughout their lives in a variety of applications. We will also discuss effective writing projects and the use of a poster session as the final exam.

Sarah Elizabeth Eichhorn UC Irvine (sfrey@math.uci.edu)

A Course on the Mathematics of Numb3rs

Episodes from the hit TV show *Numb3rs* give glimpses into some beautiful pieces of mathematics and can be used as a springboard for undergraduate exploration and discussion of a wide range of mathematical topics. I designed and taught a First Year Seminar around episodes from *Numb3rs* and the book *The Numbers Behind Numb3rs*, by Devlin and Lorden. The goal of this course was to expose students to a range of high level mathematics topics, provide insight into the type of work done by research mathematicians and stimulate student enthusiasm for the subject. In addition to the mathematics content, the course aimed to "introduce students to the research university and encourage them to become active participants in intellectual interactions with their peers and professors."

In this talk I will present a summary of the course design, a sample of course activities, an assessment of the student mathematical learning in the course and an assessment of change in student attitudes about college and mathematics during the course.

Joyce Cutler Framingham State College (jcutler@framingham.edu)
Claire Ostrander Framingham State College (costrander@framingham.edu)

A Model of a First-Year Seminar Integrated with a College Algebra Course

The paper describes a model of a first-year seminar integrated with a College Algebra Course. The seminar is designed to support first-year students in their intellectual, social, and ethical development as members of the college community. The seminar hour and four-hour academic course enhance students' social transition to college and their academic growth. Our course model links several objectives of the seminar with the learning outcomes of College Algebra. For example, one project required students to perform historical research on flu pandemics, gather and analyze data from the CDC website, and investigate the college's response to the possible H1N1 flu epidemic. Other projects included the mathematical concepts of combinatorics, probability, linear functions, piecewise-defined functions in addition to data analysis and investigation of trends. In Fall 2010, we will co-teach one of three STEM-related content and seminar courses. The pilot program includes a service learning component. We will be conducting a semester-long service project linking algebra to an identified need in our local community.

David Marshall Monmouth University (dmarshal@monmouth.edu)

Reluctantly Creating a Mathematics First Year Seminar

Beginning with the academic year 2010–2011 all incoming freshman at Monmouth University will be required to take a three credit First Year Seminar. The intent is to integrate academic content with material aimed at addressing the issues first-year students face in transitioning to college life. Faculty members were encouraged to create courses with creative and exciting content that might not normally appear in the college curriculum. I reluctantly took on the task of creating a mathematical First Year Seminar titled "Numbers, Clocks, and Secret Codes", to be taught for the first time next fall. In this talk I will discuss several of the issues that arose in the creation of the seminar, such as choosing an appropriate topic, integrating college transition issues, and developing realistic expectations for the inaugural offering.

Steven B Zides Wofford College (zidessb@wofford.edu)

"Equation" as a Metaphor for Life in a Two Cultures Class

Faced with the prospect of constructing a First Year Experience (FYE) that is both true to one's discipline and liberally artistic in scope, it is easy to become overwhelmed by the exponentially growing number of curricular choices. Almost immediately, one is faced with questions such as "Do I need a textbook?", "Should I have humanistic readings, perhaps some short stories, a play, or even a novel?", "Will there be papers?" , "How do I create collaborative learning activities?" , and the ubiquitous "How on Earth do I generate active discussions on technical topics?" Although, such questions vex all FYE instructors, the challenges facing faculty members in the mathematical sciences seem particularly daunting.

In this talk, I will discuss my experiences in the construction of humanistic physics classes, for non-scientists. Much like the mathematical FYE, the goal of these courses is to cross the "two cultures" divide by engaging students in both scientific thought and humanistic issues. Specifically, I will outline how the concept of "Equation" will be handled in an Art/Physics hybrid course planned for spring 2011. Emphasis will be placed on practical concerns such as the readings, artwork, discussion topics and collaborative activities that will be used within the course.

Session 2: Saturday, August 7, 1:00 – 4:55 pm

Darren Glass Gettysburg College (dglass@gettysburg.edu)

A First Year Seminar on Cryptography

In this talk, I will discuss a first year seminar I teach entitled 'Cryptography: The Science of Secrecy'. The topic of cryptography lends itself nicely to a first year seminar, as it has both mathematical as well as historical aspects, and it also allows us to discuss a variety of political, sociological, and moral issues. This course has attracted a wide variety of students, and has been quite a bit of fun to teach. I will discuss some of the activities in this course that have been particularly successful (and some that haven't), as well as how the course meets the college's 'Science Technology and Society' curricular requirement and several co-curricular goals.

Tamara Lakins, Allegheny College Allegheny College (tlakins@allegheny.edu)

An Interdisciplinary First Seminar on Symmetry

Allegheny College requires each of its students to complete a sequence of three First-year/Sophomore seminars that emphasize writing and speaking. The instructor of the First Seminar also serves as academic advisor for each student in the class until he or she declares a major. The topic for each First Seminar is chosen by the particular faculty member who teaches it. My First Seminar, ”Symmetry through the Eyes of Mathematics”, investigates the interdisciplinary nature of symmetry: what it means in mathematics, how it occurs in other disciplines, and how to apply the mathematical ideas to symmetry in art and architecture. While all students in the class will have expressed interest in the topic, generally the class consists of students intending to major in a variety of disciplines.

Emily Helen Sprague Edinboro University of PA (esprague@edinboro.edu)

An Interdisciplinary First Year Experience in Mathematics and Music Theory

We seek to integrate interesting mathematics with topics from a first course in diatonic harmony. Chord progressions, voice leading, modulation, transposition and even guitar chord diagrams have natural connections to analytic geometry, number theory, probability and even matrix manipulations. These notes are from a course under development and planned for deployment in Fall 2011.

Jeff Johannes SUNY Geneseo (johannes@member.ams.org)

Four Different Experiences

Since 2002, I have run four distinct one-credit first-semester seminars. Along with universally welcoming incoming students to their new experience, they each had their own highlights. I will compare and contrast these classes about reality, local mathematics, calendars, and the mathematics major.

Timothy John McDevitt Elizabethtown College (McDevittT@etown.edu)

FYS: Cryptologic Mathematics

Cryptology is an excellent subject for a First Year Seminar for several reasons. First, few students have any prior experience with cryptology, so the entire class usually begins with the same knowledge base and the mathematical content can be tailored to the level of the students. For math majors, mathematical concepts in a cryptology course help prepare them for later courses in discrete math, number theory, and linear and abstract algebra. The interdisciplinary nature and widespread utility of the subject is appealing even to students who do not like math, and the history of cryptology offers wonderful material for semester research projects. Finally, cryptology has a great popular appeal that mathematics lacks in general. I will discuss the First Year Seminar that I have been teaching for the last four years to honors students at a small college and I will share the materials that I use to teach the course.

Sarah J. Greenwald Appalachian State University (greenwaldsj@appstate.edu)

Teaching a First Year Seminar on STEM Breakthroughs and Controversies

Appalachian State University recently instituted a first year seminar (FYS) requirement for all freshmen students. The FYS course must be interdisciplinary, introduce students to research, and make connections within the university. We have been teaching a course that examines the process of discovery as well as the implications of recent breakthroughs and developments in science and mathematics. In this context we focus on what is science and mathematics, strategies for success in these fields, ethical and philosophical considerations, humanistic perspectives, public perceptions, applications to daily tasks, and the relationship of science and mathematics to American competitiveness and the global economy.

In this talk we will report on the course setup, how it is integrated into the university mission, what types of students were attracted to the course, the reactions of the students, and the benefits and challenges of teaching the course. In addition, we will also discuss broader impacts, including the impact on STEM retention and a university effort to increase the number of STEM sections of the course.

For more information on the course, see http://mathsci.appstate.edu/∼sjg/class/fs/f09.html

James Sellers Penn State University (sellersj@math.psu.edu)

Balancing Numerous Goals in a Mathematics FYS — My Penn State Experience

In the late 1990s, Penn State mandated that all incoming baccalaureate students complete a first-year seminar experience. Since then, the Mathematics Department has been offering a first-year seminar for mathematics majors and students considering mathematics as a major. In this talk, I will describe the various goals I strive to accomplish in this course, from introducing the students to the university as a whole to introducing them to the Mathematics Department and to mathematics as a discipline. I will also describe, in detail, the in-class activities that are completed in the course.

Recreational Mathematics: New Problems and New Solutions

Saturday, August 7, 1:00 – 3:15 pm

Gyorfi Zoltan eRAD (zgyorfi@erad.com)

A Math Manipulative Puzzle to Help Understand What Formalism and What Intuition Are All About

Picture a tray divided into a few vertical parts all having a lower and an upper subdivision. Also, imagine that we have a number of indistinguishable pegs and a number of indistinguishable cubes (an infinite number of two different looking objects) that can be thrown into the subdivisions of the tray. There are four simple rules defined: (1) a cube can be put into, or can be removed from the lower subdivision of any part. (2) Two pegs (at the same time) can be removed, or can be put into the lower and the upper subdivision of the same part, etc. (there are two more rules). Also, there are operations by which we can combine and modify the configurations. By using the rules, the peg and cube configurations can be "simplified". By using the operations, the configurations can be made complicated. The meaning of the configurations, and that of the rules and the operations is not known at the beginning of a class meeting. The purpose of such a meeting is to teach the rules and and the operations and to make the students reveal the meaning sneaking in the background. I do not want reveal that meaning in advance. During my lecture I would like to show how to teach the rules, how to make the students use them, and how to present the enigmatic question about the meaning in question. Finding out the meaning will be left to the audience.

Heidi Burgiel Bridgewater State College (hburgiel@bridgew.edu)
Mahmoud El-Hashash Bridgewater State College (melhashash@bridgew.edu)

Tantrix and the Permutahedron

Tantrix is played by matching hexagonal tiles; it might be described as a game of two dimensional dominoes. While failing to mathematically analyze this game the authors found that the combinatorial properties of Tantrix tiles shed light on the structure of the permutahedron — a polytope whose vertices correspond to the permutations of a collection of n elements. In this talk, Heidi Burgiel will discuss some simple combinatorial properties of marked polygons and their relationships to the structure of the permutahedron.

Ryan Mullen Sacred Heart University (mullenr@sacredheart.edu)

A Non Random Dice Rolling Game

Starting with a lattice of squares choose one square and place a six-sided die in it with the one facing up. Choose another square and write a 6 in it. The goal of the game is to move the die to the square with the 6 in it and have the 6 facing up when you get there. The only allowable moves are to "roll" the die along any of its edges to an adjacent square. It turns out there is a fairly simple algorithm for winning the game, however we will discuss generalizations of this game such as playing the game with 4, 8, 10, 12, or 20 sided dice on the appropriate tilings of the plane. Or using non-platonic solids such as the deltahedrons or Johsnon solids with a majority of triangle faces. Yet another idea is to play the game on tilings of the hyperbolic plane.

Jay Lawrence Schiffman Rowan University (schiffman@rowan.edu)

Exploring Prime Decades Less Than Ten Billion

A quadruple of integers of the form p, $p+2$, $p+6$, $p+8$ such that all the entries are prime is called a prime quadruple. With the exception of 5, 7, 11, 13, all prime quadruples are of the form $30n+11$, $30n+13$, $30n+17$, $30n+19$. These are also known as prime decades. In this paper, we illustrate a number of prime decades and observe that all prime decades are at a distance that is a multiple of 30 from one another. I will also generate the initial one hundred forbidden cases in which the distance is a multiple of 30, but this distance cannot be the separation of two prime decades. For example, we show that there are no pairs of prime decades that are at distances 60 and 270 from one another using simple mod seven arithmetic. In addition, we secure the first prime decades that are up to 9000 apart distancewise. Finally we show all the prime decades at distances 30 and 90 from one another below ten billion and focus on the prime decades that comprise a set of eight consecutive primes. While prime decades are rare initially, a plethora exist between one hundred million and ten billion. Please join us to witness technology, number theory, and recreational mathematics emerging to form a tidy package.

Roger Bilisoly Central Connecticut State University (bilisolyr@ccsu.edu)

Randomness and Patterns in the Digits of Squares

We first note that $320432^2 = 1026753849$, and $990662^2 = 9814072356$. These two squares have exactly the same digits: i.e., they are anagrams of each other. How often does this occur? Is it unusual? Second, $81401637345465395512991484^2 = 6626226562522666562566262626625256655262265652 2256$, which was found by Hisanori Mishima. This square contains only three distinct digits without any obvious pattern. Again, is this unusual? Although the digits of squares are not strictly uniformly distributed, it turns out that this is not far from the truth. By assuming uniformity, estimates can be made about how common a digital pattern might be, which informs a programmer on which searches are likely to find results. Finally, algorithms for computer searches can even suggest mathematical arguments that can form a basis for a theorem. For example, this talk ends with a proof that the proportion of n-digit squares that have anagrams that are also squares tends to 1 as n goes to infinity.

Greg N. Frederickson Purdue University (gnf@cs.purdue.edu)

Symmetry vs. Economy in Dissections of Squares and Cubes

Michael Boardman gave lovely, symmetrical dissections of squares for the sequence of identities $3^2+4^2=5^2$, $10^2+11^2+12^2=13^2+14^2$, etc. I will describe dissections with fewer pieces, and which are hingeable. I will derive an analogous sequence of cube identities, for which I will first give symmetric dissections of cubes and then give arguably minimal dissections. I will demonstrate the dissections with animations that highlight their symmetry.

Matthew Coppenbarger Rochester Institute of Technology (mecsma@rit.edu)

Oodles and Oodles of Googols; Iterations of the Words to Numbers Function

The *Words to Numbers* function, as originally given by Gardner, is defined. Iterating a nonnegative integer through this function eventually leads to a cycle or a fixed point. We are given a positive integer k and are asked to determine the smallest nonnegative integer n such that exactly k iterations are required for n to reach a cycle or a fixed point. Our travels take us from some simple answers, to a brief etymology of large numbers, to the current representation of the names of large numbers, and finally to some combinatorial calculations to arrive at our main answer.

General Contributed Paper Sessions

Session 1: Thursday, August 5, 9:00 – 10:25 am

Ilhan M. Izmirli George Mason University (iizmirl2@gmu.edu)

Categorizing Musical Pieces by Their Correlation Coefficients

In this paper my goal is to seek a method to measure the correlation between the notes that make up a musical piece. Mathematically speaking, there seems to be no rule as to the distribution of the notes that make up a melody. However, since melodies seem to have become detached and seemingly incoherent and disjointed in twentieth century music, one would expect to find a "weak correlation" between the notes that appear in more modern works. On the other hand, in more classical pieces, where "rules of harmony" are loyally followed, one would expect to find a very "strong correlation". How should we define a mathematical measure that would agree with this intuitive approach? I propose a system that would convert notes to certain relevant ordered pairs of numbers and use the correlation coefficient.

Kyle Riley SD School of Mines & Technology (kriley@taz.sdsmt.edu)

A Mathematical Tour of Robotics

Our department has recently instituted a Masters program in Robotics and Intelligent Autonomous Systems. I could easily see some of the basic connections between mathematics and the study of robotics, but I was surprised to learn the rich interaction that exists between the two disciplines. This talk will be a brief survey of just a few of the mathematical topics that one can find in the study of robotics.

Barbara Margolius Cleveland State University (b.margolius@csuohio.edu)

Flash Applets for WeBWorK Online Homework System

The availability and use of virtual manipulatives for mathematics instruction is spreading. We believe that we have only just begun to see what is possible for enriching education with emerging technologies. But even as these resources become more pervasive, their effectiveness in instruction is not well-understood. By embedding applets in the online homework system WeBWorK and developing resources so that others can do so as well it will be easier to do this assessment. In this talk we will demonstrate some Flash enhanced WeBWorK problems developed under NSF CCLI grant 0941388 and talk about where resources will be available so that you can use problems like these in your own courses.

Geoffrey Dietz Gannon University (dietz005@gannon.edu)
Joanne Revelt Gannon University (revelt001@gannon.edu)

Some Highs and Lows Using WeBWorK Throughout the Calculus Curriculum

We will discuss some anecdotal results from using the University of Rochester's WeBWorK system in selected sections of Calculus at Gannon University. WeBWorK was used for online homework as well as gateway testing of derivative and integration rules. The (informal) results presented will include impacts on exam scores as well as student feedback.

Kevin Charles Moore Arizona State University - RIMSE (kevin.c.math@gmail.com)

The Role of Quantitative and Covariational Reasoning in Trigonometry Curriculum

Recent research studies report that students and teachers have weak understandings of central ideas of trigonometry, including angle measure and trigonometric functions. In light of these research findings, multiple studies have suggested rethinking trigonometry instruction. Thompson and Bressoud suggest that trigonometry instruction should begin by developing students' understanding of angle measure and the process by which an angle is measured. They also advocate that students learn to use the radius of a circle as a unit for measuring an angle. This presentation will describe a sequence of instructional activities designed to support the construction of meanings and connections that have resulted in students understanding the sine and cosine functions.

Both the creation and implementation of the instructional activities were set within an investigation focused on the understandings students develop as they interact with research designed curricular materials. In addition to various research findings in trigonometry, research on covariational and quantitative reasoning informed the design and implementation of the materials. The activities were intended to engage students in making meaning of applied problems such that they identified quantities, the relationships between quantities, and how the values of the quantities changed together. These applied contexts were conjectured to provide a context in which students could reflect upon and construct mathematical understandings consistent with the instructional goals. The presentation of the sequence of instructional activities will highlight the role of quantitative and covariational reasoning in learning trigonometry by discussing the meanings and understanding that students developed when these instructional materials were used.

Jason Molitierno Sacred Heart University (molitiernoj@sacredheart.edu)

Applied Maple Projects in Linear Algebra

In this talk, I describe three out-of-class projects that make use of the program Maple. The first project deals with applications of linear algebra to nutrition, electrical networks, and populations distribution. Students use Maple to perform the necessary calculations. The second project focuses on linear transformations. In this project, students use Maple to visualize transformations of the plane. Students also apply linear transformations to calculus and differential equations. The third project applies linear algebra to systems of differential equations. Students use Maple to compute the necessary eigenvalues and eigenvectors, and then continue to use Maple to graph the phase portraits and highlight specific solution curves. These projects can be adapted to other mathematical programs such as Mathematica.

Session 2: Thursday, August 5, 1:00 – 5:40 pm

Anne G Albert The University of Findlay (albert@findlay.edu)

Assessment — Required; Worthwhile? — Yes!

Do you nominate yourself for the assessment committee? Can you not wait for the next assessment you are required to do? Although I am not eager to do assessment, I have found some value in the grant assessment, course assessments, program assessment, accreditation assessments, and general education assessments that I have done recently. Are we being successful? I will present some of the information that we have gathered and give suggestions on organizing the data and assuring that all faculty members participate. What have I learned? I will give examples of the changes in my classes that have come from the assessments. It is always exciting to improve our programs, teaching and students' learning!

Jeff Hildebrand Georgia Gwinnett College (jhildebr@ggc.edu)

Designing an Assessment Program for a Mathematics Major.

Many accrediting agencies are now expecting schools to develop assessment programs to determine if student needs are being met and to provide insight into possible areas for improvement. In some ways, the hardest part of the process is just getting started. Georgia Gwinnett College recently implemented an assessment program as part of their new math major. This talk will present an outline of the assessment framework as well as mentioning some of the pitfalls that can arise.

Jeffery D. Sykes Ouachita Baptist University (sykesj@obu.edu)

The Mathematics Seminar and Program Assessment at a Small Liberal Arts College

At many colleges and universities, the mathematics program now includes a senior-level capstone course. These courses vary widely, but many place a significant emphasis on having students develop the skills necessary to succeed in future study of and work in mathematics; among these are problem-solving, learning outside of the classroom setting, and communication of mathematics. Rather than use a single course to address these goals, the faculty at Ouachita Baptist University has implemented a four-semester Mathematics Seminar sequence. The author will discuss the structure of this course sequence, as well as some of the ways we will be using the Mathematics Seminar for program assessment.

Ronald M Brzenk Hartwick College (brzenkr@hartwick.edu)

A Capstone Course for Mathematics Majors

My department changed the graduation requirement that mathematics majors must complete a senior project (thesis) to the requirement that they complete a Senior Capstone course. This paper will explain why the change occurred and also identify components of the course. The "good" and the "bad" of the course will be discussed as well as how student performance, the writing assignments, and the oral presentations of the course are assessed.

Zdenka Guadarrama Rockhurst University (guadarrama@rockhurst.edu)
Mindy Walker Rockhurst University (Mindy.Walker@rockhurst.edu)

A Summer Interdisciplinary Model of Service Learning for First Year Seminar

At Rockhurst University, we developed a Summer Interdisciplinary (Mathematics, Biology, Chemistry and Philosophy) Institute with an environmental theme as a bridge program for at-risk high school students. The mathematics section of our program focused on the modeling of environmental data and culminated in the creation of posters that were displayed at the students' high school as part of an environmental awareness campaign. We will describe the general idea of our program, the links established between the disciplines, and why we believe this program is a good model for first year seminars with themes.

Timothy A. Redl University of Houston-Downtown (redlt@uhd.edu)

Senior Projects in Computational Mathematics with MATLAB at the University of Houston-Downtown

The recent development of a MATLAB-based Introduction to Computational Mathematics course at the University of Houston-Downtown has spawned a number of interesting independent student research projects in computational mathematics by seniors at the university. In this talk, I will briefly describe the work from three such senior projects for which I have been fortunate to serve as faculty research advisor. These projects involve a computational analysis of Newton's Method for finding roots of polynomials, a simulation of gene network evolution, and a study of solution methods for a popular problem from graph theory and combinatorial optimization known as the Traveling Salesman Problem.

Molli R. Jones Immaculata University (mjones2@immaculata.edu)

Developing Mathematical Thinking and Communication Skills through Guided Discovery Learning in Modern Algebra

Before teaching abstract algebra, I could not imagine twelve of my students spending 75 minutes intensely arguing over properties of groups while using correct mathematical language, but that is what happened twice a week for an entire semester. Inspired by material from the MAA book, "Innovations in Teaching Abstract Algebra," and building on my current teaching style, I created a course that developed the basic concepts of group theory through a guided discovery-learning process. The students started the semester by building operation tables for a variety of examples. From these tables, they extracted the properties of groups. Each week new definitions would either be introduced or "discovered" by the students, and then the students would make observations and prove properties using these definitions. Since there was no authority figure, such as the professor or a textbook, telling them if they were right or wrong, they had to rely on their own logical arguments to determine the validity of their definitions and properties. In this talk, I will discuss how the course was developed, what materials were used to teach the course, and how the experience has affected the communication skills of our students.

Sarah L. Mabrouk Framingham State College (smabrouk@framingham.edu)

The Developmental Discussion in the Mathematics Classroom: Let's Do It Together

Watching others do proofs and solve problems does not allow the student to experience the thought, analysis, and puzzling that are involved in breaking down and analyzing if/given/suppose statements and determining how this information can be used or connected to then/therefore statements. When one is learning to solve problems or to do proofs, this analysis and puzzling process needs to be experienced, and working on problems and proofs together, as a group during class, using a developmental discussion allows the instructor to act as a facilitator and to provide guidance while the students explore how they can use concepts, information, ideas, and theorems to solve problems and to do proofs. Gaining this experience and exposure to the problem-solving and proof mindsets together allows students to ask questions and to discuss ideas associated with how concepts and theorems are related and can be connected as well as help them to feel more secure when they perform such analysis on their own. In this presentation, I will discuss how I use developmental discussions in Calculus III, Differential Equations, and Numerical Methods courses in problem solving as well as in the analysis and proof of theorems.

Jeffrey Clark Elon University (clarkj@elon.edu)

Undergraduate Research and LaTeX

This talk will discuss the issues involved in encouraging students to use LaTeX in their research. It will include sectioning, inclusion of figures and tables, references, conversion from papers to presentations, and conversion from papers to posters.

Diana White University of Colorado Denver (diana.white@ucdenver.edu)

Using "Jigsaw" Presentations to Develops Student Communication Skills

We discuss an approach to presentations, adapted from a model used for in-service teacher professional development workshops, known as "jigsaws". Specifically, students prepare brief (approx. 15 min) presentations prior to class, present them to small groups of 3–6 classmates in class, and then rotate groups and/or presenters to listen to or give additional presentations. This approach has several advantages over large class presentations. First, it gives novice presenters a low-threat environment in which to practice their oral presentation, as they are only presenting to a few classmates instead of an entire class. Second, students often give their presentation multiple times to different groups during class. This provides for additional practice and refinement of their presentation. Finally, the students listening tend to be much more attentive in such a small group environment. While the context will be a history of math class, this approach can be readily adapted to other undergraduate math classes.

Monika Vo Saint Leo University (monika.vo@saintleo.edu)

WAC — Writing Across the Curriculum in Mathematics Classes

In this presentation, we will discuss how different forms of writing assignments can be implemented in different levels of mathematics courses. We will share the ways in which these activities supposed to assist students in meeting some of the general education requirements, including improved communication skills, critical thinking skills and problem solving skills. In addition, we will share grading rubrics for some of these assignments.

Samuel Hansen University of Nevada, Las Vegas/ACMEScience (samuel@acmescience.com)

Auditory Mathematics: Podcasting as Mathematics Outreach

There is no doubt that one of the major problems that mathematics faces is the perception that the public has of both the discipline and its practitioners. Historically the main avenues of changing these perceptions have been through the publication of popular mathematics literature and public speaking/lecture engagements. More recently we have been able to harness the power of modern technology and spread mathematics through occasional television appearances and an active mathematical blogging community. In this talk we will discuss the advent of a new path of outreach: podcasting. As the host of two mathematical podcasts I will discuss all the steps between solidifying your podcast idea to the finished product. With a low cost of entry and ever-growing popularity podcasting is becoming a truly powerful member of the media landscape and while there are mathematics podcasts on the bleeding edge right now, we have a real chance to expand the visibility and increase the excitement of mathematics through podcasting if we increase our numbers.

Patricia Kiihne Illinois College (pkiihne@ic.edu)

Differentiated Instruction and Gender: the Illinois College Science and Math Learning Collaborative

The Illinois College Science and Math Learning Collaborative is a group of college faculty and middle school math and science teachers which has been conducting action research on ways to improve girls' participation in Science, Technology, Engineering and Mathematics fields. In this talk, I will discuss theories of gender-based differences and how those theories impacted differentiated instruction units developed by members of the collaborative. We found some of these theories helpful but also discovered that others weren't as applicable in mathematics and science classrooms. I will also discuss how differentiated instruction helped improve student learning and how that might translate to a college mathematics class.

Senan Hayes Western Connecticut State University (hayess@wcsu.edu)

How To Get More Underrepresented Minority Students in Mathematics Related Fields

In this talk the results of a persistence study of graduates of the A Better Chance (ABC) program in mathematics related fields will be discussed. A Better Chance is a nationally recognized program for aiding minority students in their advancement in education. The mission of ABC "is to increase substantially the number of well-educated young people of color who are capable of assuming positions of responsibility and leadership in American society." The study was designed to answer the following questions: What are the attitudes, perceptions and beliefs of ABC graduates with regard to mathematics? What dimensions of the ABC program affected the field of study and career choice of ABC graduates? and What factors influence the persistence of ABC graduates in a mathematics related field? To address these questions, each participant was invited to complete a Fennema-Sherman attitudes scale survey and also invited to participate in an interview following the completion of the survey. The research methods used to gather data for this study were quantitative and qualitative to give a holistic view. Details of the study's design and interview protocol will be shared and the results from the surveys and interviews will be given at the presentation.

Elizabeth (Betsy) Yanik Emporia State University (eyanik@emporia.edu)
Joe Yanik Emporia State University (hyanik@emporia.edu)

Outreach Programs for Hispanic Students

This presentation will summarize the main features of Si Se Puede, an outreach program for Hispanic middle school students. Also a summer program, the Kauffman Scholar Institute will be described. The successes and challenges of these initiatives will be discussed.

John Frohliger St. Norbert College (john.frohliger@snc.edu)

St. Norbert College's Natural Science PRIDE Program

St. Norbert College has an NSF-funded scholarship program designed to recruit and retain students majoring in mathematics and computer science. This presentation will describe the program and discuss its challenges and benefits for students and faculty alike.

Philip B. Yasskin Texas A&M University (yasskin@math.tamu.edu)

Texas A&M Summer Educational Enrichment (SEE-Math) for Middle School Students: The Use of Technology

For the last nine years, the Texas A&M Math Department has conducted a Summer Educational Enrichment Program (SEE-Math) for gifted middle school students entering the 6th, 7th or 8th grade. Last year, the instruction was provided by 18 faculty with the help of 5 grad students, 2 undergrad students, and 9 high school students. There were 81 applicants, from which we have accepted 50 students based on their ability and interest in math and science as reported by their teachers.

The curriculum consists of a collection of activities which do not appear in the usual grade school curriculum. Many of the activities are organized so that the students recognize patterns, make conjectures and either prove or disprove them. These include Platonic solids, Euler numbers, toothpick puzzles, Pythagorean theorem, map coloring, logic puzzles, Mobius strips and graph theory. Other activities teach applicable computation, such as computer animations, geometric constructions, pigeon hole principle, Venn diagrams, cryptography, probability, and search ranking algorithms.

More information is available at http://www.math.tamu.edu/outreach/SEE-Math/

The focus of this talk will be on the activities which make use of computer technology: computer animations, cryptography and search ranking algorithms.

Aloysius B. Kasturiarachi Kent State University at Stark (akasturi@kent.edu)

Top Ten Mathematical Topics that Undergraduates in Mathematics should Master

The presentation will introduce ten mathematical topics, spanning the undergraduate mathematics curriculum that we believe, every undergraduate mathematics student should master before embarking on a journey in graduate studies in mathematics. The topics and concepts were chosen in a manner that best reflect the characteristics required to be successful in graduate school, while maintaining a balanced knowledge during the crucial early years. A few of the concepts will be explored in detail.

Kristel Ehrhardt UMBC (kehrha1@umbc.edu)

Effects of Staggered Lunch Periods on Geometry Students at an Inner-City High School

Our school day at Digital Harbor High School in Baltimore City, MD, is made up of four periods, or ”blocks”. Third block is composed of four staggered lunch periods and class instruction. What effects, if any, do the staggered lunch periods have on Geometry students and what are the thoughts of the teachers and students? Are there any advantages or disadvantages to their particular lunch time? Is there any data to support their opinions? Through the use of an anonymous survey, students and their respective teachers were able to share their opinions regarding the time of their lunch period. The conclusions were varied. Some students enjoyed the split classroom instruction, while many felt it was a distraction. Others enjoyed having class instruction with no interruptions. Teacher opinions were not split. They felt that having class split in two was a major distraction and classroom management issue.

Kazuko Ito West Keio Academy of New York (kwest@keio.edu)

Where is a Mathematically Competent Teacher Candidate?

“Spring of 2009 should be a great time to hire a mathematics teacher. Mathematically competent people might think of embarking on teaching due to less availability of financial sector jobs.” That's what a mathematics department chair at a college preparatory private high school near New York City, the epicenter of the current financial crisis, had thought at the end of 2008. Resumés of applicants she got looked great. Most of the results of a mathematics employment exam she gave to them were disastrous. The talk will present the exam problems, and how most applicants failed to apply mathematics they had supposedly mastered.

Session 3: Friday, August 6, 8:30 – 11:55 am

Stephen Davis Davidson College (stdavis@davidson.edu)
Stephen Kokoska Bloomsburg University (skokoska@bloomu.edu)

AP Calculus: Facts, Figures, and FAQs, (I)

The Advanced Placement Calculus Program has grown dramatically over the last decade. More students than ever are taking AP Courses and the exams, and success in AP Calculus still serves as a measure of high academic achievement for students, teachers, and schools. The purpose of this presentation is to emphasize the depth and rigor of the AP Calculus curriculum, and the collaboration with college faculty in question development and the grading process. An outline of the course, example questions, scoring standards, and the methodology for determining grades will be used to demonstrate the skills necessary to succeed in AP Calculus. The intent is to increase understanding and knowledge of the AP Calculus program and strengthen connections with high school and college faculty.

Stephen Kokoska Bloomsburg University (skokoska@bloomu.edu)
Stephen Davis Davidson College (stdavis@davidson.edu)

AP Calculus: Facts, Figures, and FAQs (II)

The Advanced Placement Calculus Program has grown dramatically over the last decade. More students than ever are taking AP Courses and the exams, and success in AP Calculus still serves as a measure of high academic achievement for students, teachers, and schools. The purpose of this presentation is to emphasize the depth and rigor of the AP Calculus curriculum, and the collaboration with college faculty in question development and the grading process. An outline of the course, example questions, scoring standards, and the methodology for determining grades will be used to demonstrate the skills necessary to succeed in AP Calculus. The intent is to increase understanding and knowledge of the AP Calculus program and strengthen connections with high school and college faculty.

Thomas McMillan University of Arkansas at Little Rock (tcmcmillan@gmail.com)
Jim Fulmer University of Arkansas at Little Rock (jrfulmer@ualr.edu)

What to do on Day One in Calculus One

This talk will describe our opening day in Calculus I. We will describe how we motivate the study of calculus by discussing a problem of interest to most students. Our discussion leads to consideration of rates of change. In this talk we will also discuss how we get students to formulate in their own mind the answer to the question "What is Calculus?" We will also illustrate how we deal with technically accurate proofs and how "proofs without words" can make otherwise unintuitive concepts seem natural. The main goal of our talk is to describe our attempts to energize student interest in Calculus I on the opening day of class.

Linda McGuire Muhlenberg College (lmcguire@gw.muhlenberg.edu)

Calculus Consultants

This talk will outline an approach to help first and second level calculus students acquire, develop and deepen problem-solving and mathematical communication skills.

In this group work activity, students act as "Calculus Consultants" for their classmates. Typically a group of three to four students is assigned to introduce a new concept, work through more difficult examples, or lead a class exploration with the rest of the group. Sometimes groups are asked to facilitate technology-based labs or demonstrations. There are clear guidelines and expectations with regard to the oral and written aspects of these assignments.

This approach has proven to be very successful in generating student excitement, encouraging student focus, developing communication skills, teaching students how to anticipate questions, and improving individual as well as collective output.

During the presentation the underlying structure of the activity would be introduced and defined. Sample problems and presentations from introductory calculus classes would be discussed as well as several examples of student work. Assessment tools used to measure efficacy and student reactions upon course completion would also be addressed.

Guang-Chong Zhu Lawrence Technological University (gzhu@ltu.edu)
Chris Cartwright Lawrence Technological University (ccartwrig@ltu.edu)

Engaging Projects for Problem-Based Learning in Calculus

Problem-based learning (PBL) is a strategy pioneered by McMaster University to enhance students' learning through collaborative teamwork on challenging, open-ended problems. In this talk, we will present several engaging projects designed to foster PBL in Calculus, such as exploring interesting properties about a mysterious curve—the tractrix, applying knowledge in related rates and optimization in real world problems, designing roller-coasters, and investigating hypocycloids and epicycloids, etc. To do these projects, students who work in groups are often required to find outside resources and do their own research to find related material in addition to what they have learned in class. We will discuss how these projects were implemented and how they benefited students' learning.

Bob Robertson Drury University (rroberts@drury.edu)

Early Vector Calculus: A Path Through Third-Semester Calculus

The theorems of vector calculus—Stokes' Theorem, Green's Theorem, and the Divergence Theorem—unify multivariable calculus in much the same way that the fundamental theorem ties together single-variable calculus. We have found, however, that calculus teachers often struggle to reach these important theorems. In this talk, we present a way to order textbook sections so that vector calculus becomes the focus of third-semester calculus rather than an interesting topic that is rarely covered.

David Dwyer University of Evansville (dd4@evansville.edu)
Mark Gruenwald University of Evansville (mg3@evansville.edu)

Resequencing Calculus: An Early Multivariate Approach

Neither traditional 3-semester calculus sequences nor diluted survey of calculus courses are a good fit for a growing number of students in the life sciences and certain other STEM disciplines. Some institutions have responded by creating custom 2-semester calculus sequences targeting the specific needs of majors in a single discipline, most often a life science. But these discipline-specific calculus sequences can be impractical for smaller institutions to implement and can pose problems for students who change majors. The presenters will describe an alternative approach in which the standard 3 semester calculus sequence is reformulated—primarily by changing the ordering of topics—so that the first two semesters constitute a strong 2-course sequence for students in the life sciences, economics, and chemistry. The most significant change is the introduction of multivariate calculus into the second semester and the postponement of a full treatment of infinite series until the third. These changes, though inspired by the needs of students majoring in the life sciences, economics, and chemistry, may hold surprising benefits for math, engineering, and physics majors who take the entire 3-course sequence. This project is supported by NSF DUE CCLI grant #0836676, and details can be found at http://www.resequencingcalculus.com.

Eric Weber Arizona State University (webered2009@gmail.com)

Helping Students Make Sense of Multivariable Functions: A Case Study

This investigation sought to explain the conceptions and ways of thinking second-semester calculus students developed during the course of a teaching experiment intended to foster thinking about multivariable functions in calculus. First, this presentation explains how thinking about function as covariation of two or more quantities supports students' process conception of function, and allows for a coherent extension of a function of one variable to functions of more than one variable. Next, the presentation describes how each student in the study thought about graphing functions of one variable, and how those ways of thinking persisted while thinking about functions of more than one variable. These ways of thinking will be illustrated by two case studies, one of which highlights a covariation perspective of function, and one which displays thinking about graphs of functions as shapes, and connected dots. The study revealed that thinking about graphs of functions as shapes and connected dots led to difficulty in conceiving of functions of more than one variable in a coherent manner. The presentation concludes by suggesting that understanding function as covariation of quantities in algebra and precalculus could support thinking about functions of more than one variable, and proposes ways in which teachers might support this way of thinking.

Paul Seeburger Monroe Community College (pseeburger@monroecc.edu)

Playing with Multivariable Calculus Concepts Wearing 3D Glasses

A tour of an NSF-funded project that seeks to develop geometric intuition in students of multivariable calculus. This online exploration environment allows students (and instructors) to create and freely rotate graphs of functions of two variables, contour plots, vectors, space curves generated by vector-valued functions, regions of integration, vector fields, parametric surfaces, etc. 3D glasses can be used for a real 3D perspective! A series of assessment/exploration activities has also been created to help students ”play” with the 3D concepts themselves, and to assess improvements in geometric understanding gained from these activities. Topics of these explorations include Dot Products, Cross Products, Velocity and Acceleration Vectors, Lagrange Multiplier Optimization, Contour Plots, and Gradient Vectors. The grant project is titled, Dynamic Visualization Tools for Multivariable Calculus (NSF-DUE-CCLI #0736968). See http://web.monroecc.edu/calcNSF/.

Susan Wildstrom Walt Whitman High School (susan@wildstrom.com)

Homework Helpers---Using MAPLE in a Multivariable Calculus Course

Adapting MAPLE worksheets to fit the topics and processes of a multivariable course, the presenter provides students with boilerplate code that they can adapt to check their homework assignments. Using the many facilities of MAPLE, such worksheets permit students to graph functions easily, view regions formed by multiple functions, calculate derivatives and integrals, even multiple integrals, symbolically as well as numerically, and even see all of the steps in a procedure. Not a substitute for students' own computational fluency, these worksheets can enable students to learn by reading examples closely, can help students find errors in their own work, and can encourage students to use complete procedural steps as they study the mathematics.

Teena Carroll St. Norbert College (teena.carroll@snc.edu)

Using Gateway Exams in Calculus I

Gateway exams are designed to test computational skills with an all-or-nothing computational test which students are allowed to take multiple times. This presentation will include the rationale behind the tests, a nuts and bolts description of my implementation decisions, student feedback, and some information on student performance.

Kenneth Luther Valparaiso University (kenneth.luther@valpo.edu)

Is Your Integral Zero?

Just as students in a first semester calculus course should recognize when some integrals, such as $\int_0^{2\pi} \sin(x)\,dx$ should yield zero, students in a multivariable calculus course should be able to recognize when some double, triple, line and surface integrals will yield zero. Practicing this enforces visualization of both the function being integrated and the region over which the integration takes place, and these questions can be asked before students are buried under brute force computation and alternate coordinate systems. Further, such questions can involve functions more complicated than those in integrals intended for computation by hand. I will give a suite of examples of such problems, that I hope will encourage you to design more of your own.

Session 4: Friday, August 6, 8:30 – 11:55 am

Deborah J. Gougeon University of Scranton (gougeond1@scranton.edu)

An Examination of Student Attitudes in a Business Statistics Course

Over a period of five years, this study surveyed a total of 386 undergraduate students on the first day of a required Introductory Business Statistics course. Students were asked to respond to eleven questions that measured their attitudes and expectations regarding this course. For example, students were asked whether they felt the course would be relevant or not to their overall business education, how much time they anticipated spending on homework assignments as well as on general study for the course, and what they anticipated their final grade would be, in addition to other specific questions. Overall, the findings of this survey reveal, among other things, a generally negative attitude towards the course, an inclination to dedicate minimal study time, and an anomalous expectation of achieving a high final grade.

Carol Vobach University of Houston Downtown (vobachc@uhd.edu)

Community Engagement in an Applied Statistics Course

Community engagement (service learning) is beginning to become a desirable part of college experiences. Students involve themselves in a “good citizen ship” activity, perhaps have a sense of giving back to the community and also add an extra item to vitas in a very competitive job market. Typically, the service project accompanies and solidifies content in a particular course. No one who does this for the first has any idea of the time and energy commitment. This presentation will be a description of a financial tutoring project with groups from a beginning statistics course, populated mostly by students from the college of business. The logistics of implementing the project, responsibilities of students, their activities, their opinions and subsequent evaluation are discussed. Pros and cons for the faculty member will also be described.

Gowribalan Vamadeva University of Cincinnati (gowribalan.vamadeva@uc.edu)

Effective Ideas to Engage Repeating Developmental Mathematics Students

Have you struggled to accept teaching a first course in developmental mathematics in the spring semester? This session will give you innovative procedures to be enthusiastic with the curriculum and class that includes students who are motivated to learn and succeed regardless of their previous failures.

Developmental Mathematics faculty are often caught trying to balance their act to satisfy the needs of each student. A first semester developmental class offered in the second semester involves such a dilemma. This presentation involves activities that would help navigate through such tough positions and make it a learning experience for all students with varied skill levels. Faculty will also benefit from acquiring various strategies that will focus on having a motivated group of students being in class.

Kira Hamman Penn State Mont Alto (kira@psu.edu)

Current Events Friday

“Why do we need to know this?” is possibly the second most-asked question in introductory mathematics courses, right after, “will this be on the test?” Answering the former with the latter (“You need to know it because it will be on the test”) is unsatisfactory to most of us and, in any case, simply begs the question of why it is important enough to be on the test. Current Events Friday is both an attempt to deal with this question in a Finite Mathematics course and a subversive way to infuse quantitative literacy and civic engagement into an otherwise traditional curriculum. Think of it as infiltration, if you want. Think of it as a low-risk way to try out such an approach, if you prefer. Either way, it gets meaningful applications of lower-level mathematics into the classroom without a trip to the curriculum committee. What’s not to love?

Susan Lea Beane University of Houston-Downtown (beanes@uhd.edu)

Increase Success Using Stories That Teach Mathematics

The concepts taught in mathematics are not difficult; the difficulty lies in the remembering and recalling of these concepts. Cognitive research has provided the necessary means for understanding how information is mentally stored and retrieved. This research forms the foundation for why the use of stories can help students retain and recall important mathematical concepts and formulas which increase student success. These short math stories are a fun way to help students remember key mathematical concepts and formulas.

Dan Hrozencik Chicago State University (dhro@att.net)

Gateways Ensuring Mathematics Mastery

Gateway Exams are short examinations that test a student's ability to perform simple mathematical tasks without the use of calculators. Gateway Exams help a department ensure that students have mastered basic skills across multiple sections, and give feedback to students who are struggling. We will discuss Chicago State University's implementation of Gateway Exams, particularly in Developmental Math and College Algebra. This work is supported by a grant from the United States Department of Education.

Michael Miner American Public University System (jcmhs77@aol.com)

Introducing Online Resources to College Algebra Students in Online Classes

The challenges facing delivery of a College Algebra class to nontraditional undergraduate students in nontraditional higher education programs are especially pronounced when the environment for learning is online. Outside of entering the program with varying degrees of mathematical competencies, students are more than likely to encounter different styles and techniques of learning mathematical concepts than previously encountered in prior mathematical educational endeavors. However, along with this alternative structure, scores of web-based algebraic resources exist and are readily available to support learning and understanding of course related instructional materials. Additionally, many of these resources are rich and powerful in scope. Web-based algebraic resources range from the elementary and basic techniques to extremely complex theoretical algebraic structures. However, the key for the online instructor/facilitator is to not only balance the appropriate number and complexity of resources but also to insure that students effectively use them for understanding the algebraic concepts presented to them. This research considers how online algebraic resources are introduced in the online learning environment and which method is the most effective strategy to support teaching and learning of College Algebra.

Darcel Ford Strayer University (dford64@comcast.net)

Quantitative Reasoning

For students to compete successfully in a global environment, it is imperative that the level of technological competency be elevated and for the development of a technologically capable workforce. Within these constructs, Strayer University is geared towards sustaining active learning in Algebra classrooms in order to complete baccalaureate requirements. The more troubling aspect of the adult learner's foray into higher education is the lack of quantitative reasoning skills. The introductory Algebra curriculum at Strayer University is designed to smooth the transition into other courses that require a post secondary level of quantitative reasoning. The course is a coherently coordinated quantitative reasoning course that interrelates cross discipline quantitative concepts to prepare learners for the rigors of the quantitative courses. This presentation will discuss the attributes of the curriculum and how these attributes assist adult learners. The following topics are addressed in this presentation:

1) Fundamentals of Reasoning and Logic
2) Functions and graphs,
3) Probability and "odds,"
4) Recent developments and discoveries in mathematics

Kayla Bradley Dwelle Ouachita Baptist University (dwellek@obu.edu)

Questioning the Questions of Liberal Arts Math Students

Students, by their very nature, come into a Liberal Arts Math class with questions but all too frequently, they are the wrong questions: "Why must I take this class?", "When will I ever use math?", "How can I do the least amount of work possible to pass?". In this session, we will discuss strategies to redirect these questions by engaging in activities that ignite better, more productive questions like "What is mathematics?" and "How am I and how are others already using mathematics?".

Christian Constanda University of Tulsa (christian-constanda@utulsa.edu)

Rigor, Error, and Humor in the Mathematics Classroom

The importance of mathematics to everyday life and the progress of human society cannot be overstated. But its use as a tool demands strict adherence to its rules, whose violation may, depending on circumstances, have consequences ranging from hilarious to very grave. Is the earth flat? Can anyone afford a Porsche? Does the universe exist? A sample collection will be presented of the absurdities that can be "proved" if absolute mathematical rigor is not emphasized enough in the classroom, from middle school to graduate level.

Natalya Vinogradova Plymouth State University (nvinogradova@plymouth.edu)

Show me the Formula

During this presentation, formulas for sums of consecutive integers, triangular numbers, oblong numbers, squares and cubes will be developed via geometric visualizations. These visualizations, developed by the presenter, not only serve to justify algebraic formulas, but are also intended to emphasize the intrinsic connections between them.

David Shoenthal Longwood University (shoenthaldw@longwood.edu)

Success in Face-to-Face versus Online Finite Mathematics Class

We will discuss data gathered from two concurrent Finite Mathematics classes—one taught face-to-face and the other entirely online. The two courses were both taught by the same professor using the same assignments and tests. We will discuss whether there was a statistically significant difference in the success rates of students in the two courses.

Sue R. Beck Morehead State University (s.beck@moreheadstate.edu)

Reforming Developmental Mathematics at the College and High School Level

At Morehead State University (in eastern Kentucky) we have been using technology for assessment and evaluation in our developmental classes for 15 years — to increase student involvement, understanding and comprehension. In more recent years we have been able to redesign our courses through the use of software. This has allowed us to provide a more diverse style of classes to meet the diverse needs of our students. The implementation of various class styles - lecture, individualized instruction, and internet classes will be discussed. Regularly we have given the students surveys to help us understand their needs. Data from a recent curriculum audit and from the student surveys will be shared.

In the past two years, our state has raised the bar in an effort to upgrade the standards of education. All students in high school must take the ACT during their Junior year. The school system is then required to "remediate" students who are underprepared, during their senior year. The university is also held accountable for helping with the early intervention of the underprepared students. So our newest adventure, through a grant, is working with seniors in the regional high schools. The results of this program have been phenomenal. The data from the third year of the collaboration will be shared in the presentation.

Allen Gregg Harbaugh Seattle Central Community College (agh.teach@gmail.com)

Preparatory Assignments: Changing Students' Attributions, Motivations & Epistemic Beliefs

Preparatory or preliminary assignments are ubiquitous in most college classes. One would not entertain a discussion of Hamlet without having first read the play. Yet, many students (and instructors) see math class as the sole introduction to new material, and they cannot imagine how preparation for the lesson might be one of their responsibilities. This session will discuss the benefits of using preliminary reading assignments as a means to prepare students to learn about new material in mathematics lectures. The discussion will present theoretical motivation for these assessment tools, and there will be a brief introduction to the educational research on this topic. Finally, we will present our findings on practical issues in implementing such assignments at the course and department level.

Session 5: Friday, August 6, 1:00 – 5:55 pm

Anita Mareno Penn State Harrisburg (anitamareno@aol.com)

Maximum Principles and Higher-order Partial Differential Equations

A variety of semilinear partial differential equations of order greater than two are considered. We use classical maximum principles to deduce that certain functionals defined on the solutions to these equations achieve their maximum values on the boundary of their domains. A priori bounds are deduced on certain quantities of interest.

Srilal Krishnan Iona College (skrishnan@iona.edu)

The Unresolved Kadison-Singer Problem and its Implications.

The Kadison-Singer Problem is one of the major unresolved problems in functional analysis. The problem is a query: "Does every pure state on the diagonal subalgebra of the C^*-algebra of all bounded linear operators on l_2 i.e. $B(l_2)$ extend uniquely to a pure state on all of $B(l_2)$?" The problem is also equivalent to conjectures in other fields of study. This talk will focus on the implications of a successful resolution to the problem.

Huseyin Cakalli Maltepe University (hcakalli@gmail.com)

On Quasi-Cauchy Sequences

A sequence (x_n) of points in a metric space (X, d) is called quasi-Cauchy if $\lim \delta x_n = 0$ where δ denotes the forward or the backward distance operator, i.e. $\delta(x_n) = d(x_{n+1}, x_n)$ or $\delta(x_n) = d(x_n, x_{n+1})$. A subset E of X is called ward compact if any sequence of terms in E has a quasi-Cauchy subsequence. Some results on totally boundedness are obtained.

Gianluca Caterina Endicott College (gcaterin@endicott.edu)

An order-preserving property of additive invariants for Takesue-type reversible cellular automata

Additive invariants for cellular automata have been widely studied over the last two decades, especially in connection with the fundamental role they play in physical modeling. In this paper we show that, for a fairly large class of reversible, one-dimensional cellular automata, the set of additive invariants exhibits an algebraic structure. More precisely, if f and g are one-dimensional, reversible cellular automata of the kind considered by Takesue, we show that the component-wise maximum $\vee$ on these automata is such that $\psi(f) \subseteq \psi(f \vee g)$, where $\psi(f)$ denotes the set of additive invariants of f and $\subseteq$ denotes the inclusion relation between real subspaces.

Adam Coffman Indiana University - Purdue University Fort Wayne (CoffmanA@ipfw.edu)

Glaeser's Inequality on an Interval

"Glaeser's Inequality" is a theorem of elementary calculus which states that if a function f is non-negative on $\mathbb{R}$ and has continuous second derivative bounded by M, then the first derivative satisfies $\left|f'(x)\right| \leq \sqrt{2Mf(x)}$ at every point x. It is easy to find counterexamples if we change the domain $\mathbb{R}$ to an arbitrary interval, but I will present an analogous pointwise inequality for functions on an interval, which specializes to Glaeser's inequality as a limiting case. (Joint work with Y. Pan, IPFW and Jiangxi Normal University)

Brian Simanek California Institute of Technology (bsimanek@caltech.edu)

Verblunsky Coefficients for Paraorthogonal Polynomials on the Unit Circle

In this talk, I will introduce paraorthogonal polynomials on the unit circle from two perspectives and use recent developments to provide extremely simple proofs of some important theorems concerning their zeros. Time permitting I will conclude with some new results in the same genre.

Alan Horwitz Penn State University (alh4@psu.edu)

Taylor Polynomials Positive on the Real Line

We discuss some special cases, and approaches for proving the general case, of the following. Conjecture: Let n be a given even whole number, and let f be a positive function defined on the real line, R. Assume also that the nth derivative of f exists on R. Then there exists $c \in R$ such that the Taylor polynomial of order n to f at c is positive on R. The case $n = 2$ is known and in fact was a problem submitted by the author to the *American Mathematical Monthly* several years ago. Special cases are also known, but we do not have a proof of this conjecture for general n.

Sayel Ali Minnesota State University Moorhead (alis@mnstate.edu)
Marion Deutsche Cohen Arcadia University, PA (cohenm@arcadia.edu)

The Phi-Ratio Test

The phi-ratio test is a generalization of a special case of the mth ratio tests that appeared in the *American Mathematical Monthly*, volume 115, Number 6, June-July 2008. The mth ratio tests are a new family of convergence tests for series. These tests are stronger than the ordinary ratio test. They succeed in testing many series for which the ordinary ratio test fails. For series with decreasing nth terms, the mth and phi-ratio tests have simple statements.

John Patrick Coleman Franciscan University of Steubenville (jcoleman@franciscan.edu)

How Rare is Independence?

We investigate the probability that two randomly chosen events in a discrete, uniform probability space with n elements are independent. We show how this probability depends on the prime decomposition of n and provide an asymptotic bound which is sufficient to prove that this probability tends to zero as n tends to infinity.

Christopher G Moseley Calvin College (cgm3@calvin.edu)

Geometry of Control Systems with Drift

Satellite three-axis control, inertial navigation systems, and NMR quantum computers are examples of *control-affine systems:* control systems which are subject to an uncontrolled "drift" vector field. This is a much broader category of interest than control-linear systems, a class whose geometry is well understood. Recent investigations have shown that geometric invariants for control-affine systems of constant type appear in dimensions as low as three; by contrast, control-linear systems have no such invariants in dimensions lower than five. In this talk I will explain recent results and some questions for future research. This is joint work with J. Clelland of Boulder and G. Wilkens of Hawaii.

Papiya Bhattacharjee Penn State Erie, The Behrend College (pxb39@psu.edu)

Introductory Frame Theory

A frame is a complete lattice which satisfies a strong distributive law. Frame theory has been studied since 1930's and has evolved as a generalization of topology. Other than topology, frame theory has applications to commutative ring theory and lattice-ordered group theory. In particular, a great deal of examples of frames can be found in the study of real-valued continuous functions.

In this talk Dr. Bhattacharjee will introduce basic frame theory and will give examples of frames in the areas of mathematics mentioned above.

Brad Emmons Utica College (bemmons@utica.edu)

Sum of Terms of Periodic Continued Fractions

The simple continued fraction of the square root of the nth non-square has been studied extensively, and their connections to the solutions to quadratic forms is well-known. In this talk we investigate the sum of the terms in the periodic continued fraction expansion for square roots and their implications to problems in Number Theory, including the subtraction only version of the Euclidean Algorithm.

Steven J. Tedford Misericordia University (stedford@misericordia.edu)

Combinatorial Interpretations of Convolutions of Catalan Numbers.

The Catalan numbers are known for having a simple definition, $c_n = \frac{1}{n+1}\binom{2n}{n}$ and a large variety of combinatorial interpretations (over 175 currently known). Additionally, combinatorial interpretations for the first convolution of the Catalan numbers are also well known. However, combinatorial interpretations for higher convolutions of the Catalan numbers are not as well known. We will introduce a new interpretation for these higher convolutions and exhibit a wide variety of equivalent interpretations.

Eric M. Werley Lehigh University (erw309@lehigh.edu)

Proving Fibonacci Identities Using Generating Functions

Generating functions are very useful as a technique for discovering and proving identities that may be very difficult to study using other means. In this talk, generating functions will be used to prove some interesting identities that deal with the Fibonacci and Lucas numbers. We will also discuss how to generalize these identities using generating functions.

Paul D. Olson Penn State Erie (pdo2@psu.edu)

Sequences of Rationals from Games

When analyzing Blue–Red Hackenbush , certain rational numbers are generated . My student researchers have explored sequences of these numbers by considering specific games and investigating Dedekind cuts for certain irrational numbers . I will summarize the results from the students' work .

Ryan Stuffelbeam Transylvania University (rstuffelbeam@transy.edu)

The Collatz Conjecture and the 2-adic Integers

Given an initial positive integer, the $3n+1$ algorithm produces an infinite sequence of positive integers according to the following rubric: if a_n is even, a_{n+1} is $a_n/2$, if a_n is odd, a_{n+1} is $(3a_n+1)/2$. The Collatz Conjecture asks whether the $3n+1$ algorithm always reaches the terminal repetition of twos and ones. Arising from the 2-adic absolute value on the rationals, the 2-adic integers are useful number-theoretic objects. The goal of this presentation is to describe a natural link between the $3n+1$ algorithm and the 2-adic integers and provide an alternative approach to the Collatz Conjecture.

Norman W. Johnson Wheaton College (Mass.) (njohnson@wheaonma.edu)

Basic Systems of Integral Octonions

A *basic system* of integral octonions has the following properties: (1) the coefficients of the rank equation of each element are rational integers, (2) the elements form a subring of **O** with the units forming a finite Moufang loop, and (3) when **O** is taken as a vector space over **R**, the elements are the points of an eight-dimensional lattice spanned by the units. There are just four such systems: the *Gravesian octaves*, with 16 units; the *Hurwitzian octaves*, with 48 units; the *Dicksonian octaves*, with 240 units; and the *hybrid octaves*, with 24 units.

Benselamonyuy Ntatin Austin Peay State University (ntatinb@apsu.edu)

On Orbits of Semi-simple Lie Groups acting on Flag Manifolds

Let $Z = G/Q$ be a flag manifold of a complex semi simple Lie group G, and G_0 a real form of G. Both G_0 and K, the complexification of the maximal subgroup of G_0, act on Z with finitely many orbits, and as such, at least one open orbit. All the other lower dimensional orbits lie in the boundary of this open orbit, and the smallest orbit is unique and closed. The open orbits have been studied extensively. It is our aim in this talk to focus on the unique closed orbit and use the Matsuki duality to characterize the cycle space associated to this closed orbit.

Shrawan Kumar University of North Carolina (shrawan@email.unc.edu)

Title: Eigencone, saturation and Horn problems for symplectic and odd orthogonal groups

Abstract: This is a joint work with P. Belkale. We consider the eigenvalue problem, intersection theory of homogenous spaces (in particular, the Horn problem) and the saturation problem for the symplectic and odd orthogonal groups. The classical embeddings of these groups in the special linear groups play an important role. We deduce properties for these classical groups from the known properties for the special linear groups. The tangent space techniques play a crucial role. Another crucial ingredient is the relationship between the intersection theory of the homogeneous spaces for Sp(2n) and SO(2n+1). We solve the modified Horn and saturation problems for these classical groups.

Chris Frenzen Naval Postgraduate School (cfrenzen@nps.edu)

Complex Numbers in Plane Geometry

There are many ways into geometry. This talk explores geometry in the plane through the notion of isometry, first intuitively, then by using complex numbers. One can move from an informal approach to a computational approach relatively smoothly because of the unique nature of the complex numbers. Visualization is easy, and computing with transformations readily engages students. Reflections become the building blocks for all isometries in the plane, and these use the complex conjugate. Rotations use the complex exponential function. Several examples will be given, and a proof or two. We will finish with a brief discussion of the extension of these ideas to three dimensions and higher, and the limitations of the complex numbers there.

Session 6: Saturday, August 7, 8:30 – 11:55 am

J Bradford Burkman Louisiana School for Math, Science, and the Arts (bburkman@lsmsa.edu)

Choosing Exercises for Well-Rounded Problem Sets

When writing a set of exercises, the teacher or curriculum designer decides which skills the student should practice and can make a list of “good” exercises. How does one then choose a “best” set of exercises from the list?

For instance, the exercise $\frac{11}{21} - \frac{2}{35}$, practices not only fraction-addition skills but also the multiplication-table elements $5 \cdot 7$, $3 \cdot 7$, $2 \cdot 3$, $5 \cdot 11$, $7 \cdot 7$, and $3 \cdot 5$. Is there a smallest set of exercises that practices all elements of the 9×9 multiplication table? Yes. Among those sets, is there one that practices addition with carrying and subtraction with borrowing several times each? Yes. Given that there are many such sets, are there more specifications the curriculum designer would like to put on it, would it exist, and how would one find it?

The presentation does not seek to contribute to the discussion of which skills students should practice; rather, given a list of criteria for which skills a problem set should cover, how would one find the set of exercises that best fits the given criteria? The talk will present a model for cooperation between curriculum designer, mathematician, and programmer (which could all be the same person wearing different hats), give examples, and suggest topics for further discussion. A rudimentary familiarity with for() loops, if() statements, and multidimensional arrays (even on a graphing calculator) is the only programming background necessary to follow the discussion.

Lynne Yengulalp University of Dayton (yengullc@notes.udayton.edu)

Implementation of Web-Based Skill Tests for Pre-calculus, Calculus I and Calculus II

I will describe a team project that I was involved with at the University of Kansas. The team established a framework for administering web-based skill tests to more than 2000 pre-calculus and calculus students at the University of Kansas using the online testing software MapleTA. I will talk about how student, instructor, technology and process factors all influenced the design of the testing system. I will also explain our method of analyzing the large amount of data gathered from the system to make conclusions about the learning of the students, the merit of the exam itself and behavior patterns of test takers.

Alison Ahlgren University of Illinois (aahlgren@illinois.edu)
Marc Harper UCLA (marcharper@gmail.com)

Readiness Assessment, Course Placement, and Effective Course Redesign through Introductory Calculus

Theory of knowledge and learning spaces is used to assess readiness and determine course placement for mathematics students at or below introductory calculus at the University of Illinois. Readiness assessment is determined by the artificially intelligent system ALEKS, which effectively reduces overplacement and is more effective than the previously used ACT-based mechanism.

Significant enrollment distribution changes occurred as a result of the mechanism implementation. ALEKS assessments provide more specific skill information than the ACT. Correlations of ALEKS subscores with student maturity and performance meets expectations in many cases, and revels interesting characteristics of the student population in other (systematic weakness in exponentials and logarithms). ALEKS revels skill bimodality in the population not captured by the previous placement mechanism.

The data shows that preparation, as measured by ALEKS, correlates positively with course performance, and more strongly than the ACT in general. The trending indicates that while a student may pass a course with a lower percentage of prerequisite concepts known, students receiving grades of A or B generally show greater preparedness. Longitudinal comparison of students taking Precalculus shows that ALEKS assessments are an effective measure of knowledge increase. Calculus students with weaker skills can be brought to the skill level of their peers, as measured by ALEKS, by taking a preparatory course. Interestingly, the data provided by ALEKS provides a measure of course effectiveness when students performance is aggregated and tracked longitudinally.

The data is also used to measure course effectiveness and visualize the aggregate skills of student populations.

Mike Hall Arkansas State University (mhall@astate.edu)

Redesigning Algebra in the Classroom: Using Assessment to Drive Instruction

This presentation will provide participants with information regarding the implementation, assessment, and continued assessment of a computer-assisted learning environment in freshman level algebra courses; which include student success rates prior to and after implementation, strategies to best implement the dramatic change in instructional practice, and assessment strategies that illustrate overall project success. Any teacher, administrator or technology coordinator will benefit from attendance.

Andy Martin Kentucky State University (andrew.martin@kysu.edu)

Pixie Sines: Viewing Y = sin(50x) through the ”Wrong” Windows on the TI-84+

If the TI-84+ is set in CONNECTED and RADIAN modes, and $Y1 = \sin(50x)$ is graphed in the window $\text{Xmin} = -6$, $\text{Xmax} = 6$, $\text{Ymin} = -1$, $\text{Xmax} = 1$, then $1\frac{1}{2}$ periods of a beautiful sine curve of period about 8 appears. This is a shock, considering that Y1 has a period of $2 * \text{Pi}/50$, and so about $95\frac{1}{2}$ periods should be visible in the given window! Switching to DEGREE mode increases the perpexion, as now you have another beautiful sine curve of period about 7 appearing ! An explanation for these and related results will be given. In addition connections will be made with the topics in [1] and [2].

[1] Staib, John and Demos, Miltiades, “On the Limit Points of the Sequence $\{\sin n\}$.” *Mathematics Magazine*, 40 (1967), 210–213.

[2] Strang, Gilbert, Calculus. Wellesley-Cambridge Press, 1991. Section 1.6 “A Thousand Points of Light.”

Yun Lu Kutztown University of PA (lu@kutztown.edu)

Use of Online Homework System in Teaching Mathematics

I teach mathematics for business course regularly in Kutztown University of PA. This course focuses on the application of mathematical concepts and methods to problems that arise for students who major in Business or Computer Science. Recently, I start to use online homework system in this course, and analyze the effectiveness of this system for assessment. In this talk, I will share some of my experience with the audience along with students’ feedback.

Gina Monks Pennsylvania State University (monks@psu.edu)

The Math Dimension: A Centralized Mathematics Tutoring Center

Two years ago, the Hazleton branch campus of the Pennsylvania State University saw the need to have a centralized Math Tutoring Center to help their students. We will describe how the center was created, from its initial design to its current state. We will look at how and why it has changed significantly in only two years’ time, the impact of the tutoring center on the students’ learning, and the ways in which it has become integrated with other education initiatives of the Mathematics department. Future plans for the center will also be discussed.

Rama Rao University of North Florida (rrao@unf.edu)

A Calculus-oriented Inquiry Based Learning approach to teach a PreCalculus course

This presentation describes a Calculus-oriented Inquiry Based Learning approach to teach a PreCalculus course. The study of the standard classes of functions—polynomial, rational, exponential, logarithmic, trigonometric and absolute value—is based on a uniform line of inquiry—a set of questions asked about each of these types of functions. The questions are:

What numbers can this function accept and what numbers can it produce? Where is the function value equal to zero? Positive? Negative? Where is the function increasing in value? Decreasing in value? What is the minimum value for the function? What is the maximum value? What is the geometric shape of the function? What is the direction of the function from one point to another? At a point?

The study of each function type begins by answering as many of these "standard" questions as possible and then moves on to any special properties it may have. This uniform inquiry based method gives the student a good handle on the structure of each topic and sets proper expectations as we move from topic to topic. It is made clear to the student at each stage, which of these questions can be answered at this level and which require knowledge of Calculus and what other questions (like how fast is the function changing its value or how curved is the graph of the function) can be answered with a knowledge of Calculus. This also gives them a hint of what to expect in Calculus.

Marshall Gordon Park School of Baltimore (mgordon@parkschool.net)

Mathematical Habits of Mind: Teaching Students How to Think Mathematically

Many students think of mathematics as that discipline where you either get it or you don't. This has naturally evolved from a number of reasons, including the textbook/classroom emphasis on algorithms that provide efficiency but omit explanation, and that in the absence of having a practiced technique, students feel at a loss as how to proceed. Teaching mathematics from a focus on the process of inquiry where habits of a mathematical mind are the content helps enable students to draw upon heuristics to bring some light to their confusion. This would include teaching such actions as: tinkering; taking things apart; visualizing; and a number more, showing students how these actions provide a very valuable means to productive mathematical thinking - that is, sharing with students what those of a mathematical mind do when they face confusion. In this way, students can gain confidence in their own thinking, and not be left adrift in the absence of an algorithm and not otherwise having any ideas as how to proceed. Examples will be provided.

David Arney United States Military Academy (david.arney@usma.edu)
Kristin Arney United States Military Academy (kristin.arney@usma.edu)

First-Year Mathematics at USMA: Modeling in a Real and Complex World

The United States Military Academy (USMA) by its very nature has an intensive first-year academic experience. Its core (required) introductory mathematics course is designed around the development of all students as confident and competent interdisciplinary modelers and problem solvers. The course contains a liberal arts focus emphasizing critical thinking, creativity, active learning, writing, analysis, and inquiry. The course topics are intended to show the breadth of undergraduate mathematics — discrete and continuous, stochastic and deterministic, linear and nonlinear, dynamic and static — and the breadth of student-relevant applications in the physical, social, life, decision, and informational sciences. The book and course title (modeling in a real and complex world) tells only part of the story. The course includes both an applied and theoretical perspective that confronts important concepts such as optimization, equilibrium, stability, solution, long-term behavior, prediction, computational complexity, and dimension. For example, projects involving population prediction have involved data collection and stability analysis. To help student understanding and level the diverse student backgrounds, the course uses technological tools both for student learning and advanced problem solving. The USMA presenters will explain how the course is curricularly designed (objectives, topics, standards) and pedagogically taught (activities, instructional styles, student engagement, assessments). The main goals of the course are the development of student awareness, vision, engagement, curiosity, and learning skills. Data are presented to show how the course meets its goals and how students' attitudes about STEM are impacted by such a course.

Saleem Watson California State University, Long Beach (saleem@csulb.edu)

Models and Not Models — College Algebra and the Real World

Using real-world models to enliven and give meaning to the college algebra course is a well-established goal. However, in the enthusiasm to provide students with "real-world" models, textbooks sometimes provide misleading ways of modeling real-world data, and in some cases, provide "models" which are actually not models at all. We have found that in the classroom such "models" have the opposite of the intended effect|they turn the modeling process into a meaningless exercise that adds no interest or significance to the subject. So what, exactly, is a model? There is a statistical answer to this question (involving F-tests, variable inflation factors, and other topics taught in advanced statistics courses) but there is also an intuitive answer that can be useful for college algebra instruction. When constructing a model we need to ask ourselves several questions. First: Is there an intuitive relationship between the variables? Second: If there is a relationship, what type of model is appropriate? Third: Does the model provide useful information about the thing being modeled? The answer to this last question is critical|a model must serve some useful purpose to be worthy of the name. We give several examples of real-world models, as well as "models" that are not actually models. These counterexamples help clarify the concept of a model.

Ivona Grzegorczyk California State University Channel Islands (ivona.grze@csuci.edu)

Poetry, Games and Art Activities in Algebra Classroom

Many students do not achieve algebra proficiency till they enter college. We will present supplementary activities that include art, poetry and games that address needs for various learning styles and can be used as early as middle school. The activities were assessed in high school and college classrooms, and in workshops for teachers. Data show improvement of student' understanding of the content matter, and increased positive attitude towards mathematics across the board.

Beverly K. Michael University of Pittsburgh (bkm@pitt.edu)

Two Kinds of College Algebra for Two Kinds of Students

Non-math, non-science majors deserve a College Algebra course that fits their needs. Using a modeling approach to teach College Algebra allows these students to succeed. This talk describes the curriculum differences between two forms of College Algebra, one intended for those headed to calculus and one for students for which this will be a terminal course. Results on common final exam questions will compare significant differences between a modeling section and a traditional College Algebra section.

Mary B Walkins Lee University (mwalkins@leeuniversity.edu)
Caroline Maher Boulis Lee University (cboulis@leeuniversity.edu)

Using Critical Thinking Skills in College Algebra

As a means of increasing critical thinking by our students, Lee University adopted five Critical Thinking Skills (CTS) for special emphasis. Lee conducts an annual Summer Institute, which is funded by a Title III Strengthening Institutions Grant, to encourage faculty members to enhance one or more of their courses with critical thinking skills instruction. As part of that program, we piloted the teaching of two of those skills in our College Algebra classes both in the fall of 2009 and in the spring of 2010. We will present the skills used, how they were taught, and how we assessed the effectiveness of our instruction.

Session 7: Saturday, August 7, 8:30 – 11:55 am

Ralucca M Gera Naval Postgraduate School (rgera@nps.edu)
Eunjeong Yi Texas A&M University at Galveston (yie@tamug.edu)
Daniela Ferrero Texas State University, San Marcos (df20@txstate.edu)
Andrew Chen Minnesota State University Moorhead (chenan@mnstate.edu)

Functigraphs: A Generalization of Permutation Graphs

Let G_1 and G_2 be copies of a graph G, and let $f : V(G_1) \to V(G_2)$ be a function. Then a *functigraph* $C(G, f) = (V, E)$ is a generalization of a permutation graph, where $V = V(G_1) \cup V(G_2)$ and $E = E(G_1) \cup E(G_2) \cup \{uv : u \in V(G_1), v \in V(G_2), v = f(u)\}$. We present general results on functigraphs, with emphasis on colorings and planarity.

Hollie L. Buchanan West Liberty University (hbuchanan@westliberty.edu)

A $(2n - 2)$-regular Graph on $2n + 1$ Vertices Admits a Hamiltonian Decomposition

A Hamilton circuit of a graph is a 2-regular spanning subgraph. It has long been known that every complete graph on an odd number of vertices admits a Hamiltonian decomposition (so the edge-set can be partitioned into Hamilton circuits). In 1984, Hilton offered a novel proof of this fact by using amalgamations. By extending this method, we prove that the graph obtained by removing a 2-factor from a complete graph on an odd number of vertices also admits a Hamiltonian decomposition.

Robin Blankenship Morehead State University (r.blankenshi@moreheadstate.edu)
Richard Douglas Chatham Morehead State University (d.chatham@moreheadstate.edu)
Joseph V. Harless Morehead State University (j.harless@moreheadstate.edu)
Brian Salyer Morehead State University (bksaly01@moreheadstate.edu)
R. Duane Skaggs Morehead State University (d.skaggs@moreheadstate.edu)
B. Nicholas Wahle Louisiana State University (bwahle1@math.lsu.edu)

Covering Powers of Cycles by Equivalence Graphs

Given a finite simple graph G, the equivalence number $eq(G)$ of G is the minimum number of disjoint unions of cliques needed to cover all the edges of G. We establish some general bounds of the equivalence number of arbitrary finite simple graphs, then determine improved bounds on the equivalence number of powers of cycles.

Michael D. Barrus Black Hills State University (michael.barrus@bhsu.edu)

On Antimagic Labelings of Graphs

An *antimagic labeling* of a graph with m edges is an injective assignment of the labels $\{1, \ldots, m\}$ to the edges with the requirement that the sums of edge labels at every vertex are distinct. The Antimagic Labeling Conjecture states that every connected graph on at least three vertices has an antimagic labeling. We describe the *canonical decomposition* of a graph, introduced by R. I. Tyshkevich, and show that the Antimagic Labeling Conjecture is true for all graphs except, possibly, for a class of indecomposable graphs under the canonical decomposition.

Louis Shapiro Howard University (lshapiro@howard.edu)

The Uplift Principle and the Riordan Group

We look at various classes of ordered trees with uniform out degree requirements. A partial list includes ordered trees, 0.1.2 Motzkin trees, incomplete binary trees, complete binary trees, even trees, and hex trees. For each of these the generating function identity $V = LT$ applies where T is the generating function for the the number of trees in the class, V is the generating function for the number of such trees with a marked vertex, and L is the generating function for the number of such trees with a marked leaf. Usually V and and T are quite easy to find while L is the useful building block. The uplift principle consists of solving a problem at the root and then lifting it up by multiplying by L. If we classify by the heights of the leaves we have an element of the Riordan group. The height of the vertex gives a second such element. As one application we can quickly show that among all vertices among all ordered trees with n edges there are more children than grandchildren.

Melanie Laffin Michigan Technological University (melanie.laffin@gmail.com)

Group Divisible Designs with Block Size Six and First and Second Associates

A group divisible design GDD$(n, m, k; \lambda_1, \lambda_2)$ is a collection of k element subsets of a set of $v = nm$ points called blocks. These points are partitioned into m groups of size n, and the blocks have the property that each pair of points from the same group appears in exactly λ_1 blocks and each pair from different groups appears in exactly λ_2 blocks. We present necessary and sufficient conditions about the existence of group divisible designs with 2 groups and block size 6.

Rosemary Sullivan West Chester University (rsullivan@wcupa.edu)

A Modification of Sylvester's Four Point Problem

In 1865, Sylvester posed the problem of finding the probability that four points randomly chosen with a uniform distribution over a compact convex region K in the plane form the vertices of a convex quadrilateral. This led to substantial research on the ratio $\rho_K = \frac{\mathrm{E}(\mathrm{area}(\Delta))}{\mathrm{area}(K)}$, where Δ denotes a triangle formed by three independent and uniformly distributed points in K. In this talk we consider the problem of studying the behavior of the ratio $\rho_P^* = \frac{\mathrm{E}(\mathrm{area}(\Delta))}{\mathrm{E}(L^2)}$, where L is the distance between two independent points with distribution P and Δ is a triangle with three independent vertices with distribution P. We call this the Modified Sylvester Four Point Problem.

Jack Mealy Austin College (jmealy@austincollege.edu)

Constructing Hyperbolic-like Systems Via Snell Geometry

Further results in the category of Snell Geometries. (See abstracts: “Paracycles in Snell Geometries”, MathFest 2008; “Area estimates for paracycles in Snell Geometries”, MathFest 2009.) Recall, a Snell Geometry is a system consisting entirely of regions of locally constant curvature, wherein Snell's Law (of optics) is in play across the boundaries between these regions of constant curvature. After a brief overview of the general methodology of Snell Geometry (including in particular how the scheme compares with other categories in Geometry), for this talk we will focus on the subcategory wherein the regions are 2-dimensional and all have curvature zero, yet exhibit different “indexes of refraction”; the boundaries are smooth curves. We undertake the construction of models wherein the parameter space is the entire plane (as opposed to a half-plane (typically) used for paracycle constructions). Of note, these models feature a rotational symmetry. Then, for example, a relationship between area and angular defect is investigated and exhibited in these systems; other dynamics also investigated. A further goal would be to construct in this fashion an approximate model of the hyperbolic plane that covers the parameter plane, and which maintains this rotational symmetry. Since any such Snell system is evidently non-homogeneous, at best only approximate models of a hyperbolic plane could be so constructed; some elaboration of the measure of success of this scheme will be reported.

Work occurring during the summer of 2010 on length minimizing networks in Snell systems may also be included in the presentation. Further, the extension of these ideas to regions of constant positive curvature, but with distinct indices of refraction in different regions, may be included.

G. Gerard Wojnar Frostburg State University (gwojnar@frostburg.edu)

Exploring Relationships Within Families of Triangles Via Reperesentation Spaces

Relationships among members of families of triangles (sometimes parametrized by a $t \in \mathbb{R}$ or $\mathbb{Z}$) are illuminated by representing any triangle by the triplet of its sidelengths $(a, b, c) \in [0, \infty)^3$, and representing the similarity class by the representative of unit perimeter. Examples: Given any triangle (a, b, c), consider the one-parameter family $(a^t, b^t, c^t)_{t \in \mathbb{R}}$. Consider triplets of iterated pedal triangles. More generally, for any derived triangle (e.g., orthic triangle), consider the family obtained via iteration. Quite generally, triangle theorems involving a bisection ($t = 1/2$) or trisection ($t = 1/3$) can often generate a family via allowing $t \in \mathbb{R}$, promoting broad conjectures.

Kevin Ferland Bloomsburg University (kferland@bloomu.edu)

Generalizing the Pythagorean Theorem and Its Proof

Simple proofs of the Pythagorean Theorem using pictures are well-known. We study in depth a particularly elegant one and explore how such an argument can be generalized. This leads to the discovery a similarly elegant proof of a special case of a well-known result in trigonometry.

Leon Brin Southern CT State University (newhallco@yahoo.com)

Rep-tiling the Trapezoid

Any shape that can be dissected into a finite number of similar copies of the whole is a so-called rep-tile. Certain conditions on the side lengths of a trapezoid lead to trapezoidal rep-tiles. We will present a geometric argument for this claim. From these geometric conditions, each dissection will lead to a system of nonlinear equations in the lengths of three of the sides (a, b, and c) of the trapezoid. The solution of such a system, which is often $c = \sqrt{ab}$, proves that the dissection under consideration is possible.

Robin Blankenship Morehead State University (r.blankenshi@moreheadstate.edu)
Craig Hamilton Morehead State University (cshami02@gmail.com)
Tabatha Sturgill Morehead State University (trstur01@moreheadstate.edu)

Undergraduate Research Projects on Hextile Knot Mosaics

Knot mosaics using square tiles, studied by Lomonaco and Kauffman, inspired the creation of hextile knot mosaics: tessellations of regular hexagons with one, two, or three strands connecting midpoints of edges in various over and under crossing patterns such that the union of the strands forms a knot or link. The number of unique hextiles, up to rotation, is 27. A mosaic of radius one consists of a fixed center tile and the six tiles that surround it. The number of hextile mosaics that can be constructed within radius one and two of a fixed center tile and an algorithm for finding the number of hextile mosaics for an arbitrary radius will be discussed. The next step is to simplify hextile knot mosaics through planar isotopy and Reidemeister moves, and examples of these moves will be demonstrated.

Atabong Timothy Agendia Madonna University Okija, Elele Campus, Nigeria (agendia@yahoo.com)

Interrelating tumors and fractals

Fractals as we know are self similar and scale invariant structures. Links have been established between the Cantor set, solid tumor and Fractals in both their distribution and shape. We have established more interrelationships between fractals and other types of tumor and cancer in this work. This notion of tumor as fractals has greatly influence the overall performance of undergraduate students in mathematical Biology in particular and mathematical modeling in general at Madonna University. This paper discusses these relationships between fractals and tumor. The goal is to seek new solution to old problems across various disciplines such as the understanding of tumor angiogenesis.

Session 8: Saturday, August 7, 1:00 – 5:55 pm

Sheldon Lee Viterbo University (shlee@viterbo.edu)

Random Walks and Continuum Coupling

A random walk can be thought of as a discrete version of the diffusion equation. In this talk, we discuss an idealized stochastic-deterministic coupling problem involving one-dimensional Brownian motion adjacent to a continuous region. We discuss the connection of random walks to the diffusion equation, and the coupling of these models, along with convergence and stability issues involved in such a coupling.

Mike J. Johnson Meredith College (johnsomi@meredith.edu)

Queueing Models with Unknown Service Parameters for Congested Systems

In a typical application of queueing theory, basic system characteristics such as server capacities are known, and one computes the resulting wait time or total system time as a function of offered load and server capacities. In this presentation I briefly summarize a queueing model for systems having the interesting property that server capacity decreases in response to increased offered load, so that not even an average capacity can be predicted. I show that some such systems can be effectively modeled as a single queueing system with unknown server capacity. For these cases, in practical applications a nonlinear regression yields an equivalent server capacity for the congested system as a function of offered load, as a fit to observed total system times. I will then explore conditions under which such a model is not adequate to describe the steady state of the system.

Yun Kang Arizona State University (yun.kang@asu.edu)
Dieter Armbruster Arizona State University (armbruster@asu.edu)

Dynamics of a Two-Patch Model for Plant-Insect Interactions

We formulate and study a simple two-patch discrete time plant-insect model coupled through a dispersal of insect. A fundamental feature of the model is the occurrence of three different time separated phases: Plant growth is followed by insect attacks which is followed by its dispersal. Our objective is to understand how different intensities of dispersal impact both local and global population dynamics of the two-patch model, especially, we pay attention to two situations: when the single-patch model (i.e., in the absence of dispersal) is permanent and when the single-patch model exhibits Allee-like effects. First, we explore the existence and stability of synchronous and asynchronous dynamics between two patches. If the single-patch system is permanent, our analysis shows that the permanence of the system can be spoiled by large dispersals and large attacking rates of insect, thus, create multiple attractors; If the single-patch model exhibits Allee-like effects, the analytical and numerical results indicates that the small intensity of dispersals can generate source-sink dynamics between two patches, while the intermediate intensity of dispersals promote the extinction of insect in both patches, which may suggests a possible biology control strategy to stop the invasion of a pest by controlling its migration between patches.

Julia Arciero University of Pittsburgh (jarciero@pitt.edu)
G. Bard Ermentrout University of Pittsburgh (bard@pitt.edu)
Yoram Vodovotz University of Pittsburgh (vodovotzy@upmc.edu)
Jonathan Eric Rubin University of Pittsburgh (rubin@math.pitt.edu)

Mathematical Model of Necrotizing Enterocolitis: Effects of Probiotic Treatment and Toll-like Receptor 4 Inhibition

Necrotizing enterocolitis (NEC) is a severe disease of the gastrointestinal tract in preterm infants characterized by increased intestinal permeability and an exaggerated inflammatory response. Treatment with probiotics is thought to improve the intestinal barrier function and reduce the severity of NEC. Inhibiting Toll-like receptor 4 expression is also hypothesized to improve the outcome for preterm infants with NEC. The potential of these strategies is analyzed with a mathematical model. Ordinary differential equations are used to describe bacterial and immune system interactions within the intestinal lumen, intestinal mucus layer, and blood. The model predicts conditions under which the health of the host is promoted and also identifies situations in which disease or inflammation may be increased despite treatment attempts.

J. Christopher Tweddle University of Evansville (ct55@evansville.edu)

Mathematical Modeling of Atmospheric Dispersion: An Undergraduate Research Project.

Atmospheric modeling can be used to predict the dispersion of pollutants from smoke-stack emissions into the surrounding environment. This summer, students and faculty from the departments of mathematics and chemistry at the University of Evansville began a project studying the accumulation of mercury in soil samples in southwest Indiana. Our goal is to model in the impact of nearby coal-fired power plants. This talk will include a brief introduction to atmospheric modeling, an overview of our findings, and some remarks on conducting interdisciplinary research with undergraduate students.

Kathryn Weld Manhattan College (kathryn.weld@manhattan.edu)

Rationality as a Threshold for Evolution Towards Cooperation.

Using elementary game theory, difference equations and the idea of the gradient, it is possible to describe an interesting two parameter model of competition for resources. The two parameters, the propensity to cooperate and the level rationally consistent behavior, interact to determine a threshold for the development of selfishness in the population over time. This threshold is a curve in the strategy space which depends on the level of rationally consistent behavior. On one side of the threshold, types will tend to evolve to become more cooperative, while on the other side, less rational types with the same propensity to cooperate would tend to mutate towards selfishness.

Genghmun Eng (geng001@socal.rr.com)

Using Distorted Gaussians To Model Device Lifetimes

Given the probability density function (PDF) for a purely lognormal distribution, $\rho_o(X - X_o; X_R)$, describing device times-to-failure (TTF), it is a Gaussian on $X = \ln(t/t_u)$ axes, with t_u as a chosen unit time, and X_o and X_R as the Gaussian centroid and width. It corresponds a specific function of time, $\rho_o\{t; X_o, X_R\}$. We derive the physical basis for an exponential extension of the lognormal, and show it gives rise to an Exponential-Lognormal (ExpLn) distribution. This extension contains a new parameter X_d, which can be associated with small manufacturing defects that degrade the device lifetime from its original value. As a function of $X = \ln(t/t_u)$, the ExpLn PDF is a distorted Gaussian, $\rho_N(X - X_o; X_R, X_d)$, with $\rho_N\{t; X_o, X_R, X_d\}$ then having the following early-life behavior: $\rho_N\{t = 0; X_o, X_R, X_d\}$ vanishes for $X_d < 1$; it is a constant for $X_d = 1$; but it develops an integrable singularity for $X_d > 1$, indicating that failures at first turn-on can have a sudden onset, while still being part of the same population group as those devices with a finite TTF.

Martha Waggoner Simpson College (murphy.waggoner@simpson.edu)

Ray-based Tomography: An Application for Linear Algebra

Ray-based tomography is a way to investigate the body (CT scans), the earth (seismic data) and other hidden structures. Rays are passed through an object and travel time recorded. Using discretization, a system of equations is then solved for the "slowness" factors of the regions of the structure. In this talk, I will explain how the systems of equations are developed and give examples of both forward and inverse problems for a linear algebra course, with emphasis on underdetermined systems.

John Noonan Mount Vernon Nazarene University (jnoonan@mvnu.edu)

Solutions to a Generalization of the Mixture Problem From Differential Equations.

The standard Introductory Differential Equations class includes discussions of mixture problems. Typically salt water is added to a vat or pure water while a portion of the mixture is removed. In this paper, we explore similar problems. When several vats are connected in series, the resulting solutions for the concentration of salt in the vats are polynomials some of which include portions of familiar integer sequences as coefficients. We describe a method for solving such problems and exhibit some of the more interesting solutions.

Amy Parrott University of Wisconsin-Oshkosh (parrotta@uwosh.edu)
J. David Logan University of Nebraska - Lincoln (dlogan@math.unl.edu)

The Effects of Climate Change on a Species with Temperature Dependent Sex Determination.

Temperature-dependent sex determination is an evolutionary strategy in which the temperature during development of the organism determines the sex of the animal. It is conceivable therefore, that if temperature changes favor only one sex, then dire consequences for those populations and their ecosystems could occur. We examine effects that climate change, in particular, temperature variation, may have upon painted turtles (Chrysemys picta), a freshwater species with TSD. Specifically, we look at the effects caused by an increase in average temperature and a change in daily temperature variance on the nest. We examine a computational model that connects these environmental changes to the sex of the nests and subsequently to the male/female population structure.

Daniel Joseph Galiffa Penn State Erie (djg34@psu.edu)

An Epidemiology Model Suggested by Yellow Fever

In this talk we discuss how a mathematical model suggested by various insect borne diseases, e.g., Yellow Fever, was constructed and implemented. The model itself is a nonlinear reaction-diffusion epidemiological model consisting of two integral-differential equations and an ordinary differential equation. We first elaborate on how the essence of the Yellow Fever virus contributed to the model's development and then briefly discuss how analyzing the nonlinear auxiliary problem leads to the existence and uniqueness of the analytical solution. From there, we show how a finite-difference method was constructed to approximate the analytical solution and conclude with some corresponding numerical experiments and a concise discussion of some open questions and subsequent extensions.

Christina Weaver Franklin & Marshall College (christina.weaver@fandm.edu)
Aniruddha Yadav Mount Sinai School of Medicine (aniruddha.yadav@mssm.edu)
Georgi Gamkrelidze NYU Langone Medical Center (ggamkrelidze@gmail.com)
Robert Baker NYU Langone Medical Center (Robert.Baker@nyumc.org)

Sensitivity and Robustness of a Neuron Model are Affected by Dendrite Shape

Nonlinear interactions between a neuron's electrical parameters and its shape (morphology) remain largely unexplored. Recently we introduced a computational sensitivity analysis method to quantify how these distinct kinds of parameters affect neuronal function. Here we have extended our method to analyze interactions between explicit pairs of parameters. We reconstructed the morphology and built multi-compartment models of three vestibular neurons, using automated parameter optimization to fit each model to physiological data. We used partial least squares regression to identify sensitivity trends globally across parameter space, and then analyzed the second order sensitivity matrices (Hessians) of model outputs. We identified parameter combinations to which neuronal outputs were highly sensitive, and highly robust. Our method can predict precise perturbations of intrinsic properties, including morphology, sufficient to induce functional changes that may underlie neuronal plasticity.

Brian Patrick Yurk Hope College (yurk@hope.edu)

The Evolution of Mountain Pine Beetle Development Time in Response to Climate Change

Since developmental timing in insects is temperature-dependent, it is likely that climate change will result in dramatic changes in insect populations. For insects, reproductive success depends on the timing of developmental events, such as emergence and oviposition. For example, in mountain pine beetles (MPB), an important outbreak insect that infests pine forests in western North

America, reproductive success depends both on the degree to which development is synchronized within populations and on the timing of sensitive life stages relative to seasonal weather extremes. Developmental synchrony is necessary for MPB, because they depend on mass attacks to overwhelm host tree defenses; these attacks can only occur if there are large numbers of beetles emerging within a short time period.

In this talk, I will discuss a mathematical model of insect population dynamics that incorporates temperature-dependent developmental timing while allowing its evolution in response to natural selection on emergence time and density. The model has been parameterized using development time data from laboratory experiments for MPB. Analysis of the model shows that persistence of a population depends largely on its ability to evolve to maintain the presence of developmental fixed points—times of the year at which emerging individuals will produce offspring that emerge at the same time the next year. The model predicts conditions under which local populations will adapt to warming temperatures and conditions under which they will go extinct.

Eduardo Montoya CSU-Bakersfield (emontoya2@csub.edu)
Wendy Meiring UCSB (meiring@pstat.ucsb.edu)

Relative Efficiency Gains of a Monotone Functional Non-linear Model.

Functional regression models that relate a set of functional predictors to a set of scalar responses are becoming more common due to the availability of functional data. We introduce a functional non-linear model with a scalar response where the parameter curve is monotone. Relative efficiency gains provided by monotonically constraining the parameter curve are presented using a simulation study. In addition, we discuss connections between a non-linear mixed model and our functional non-linear model.

Lisa Joan Holden Northern Kentucky University (holdenl@nku.edu)

Spirographic Orbits in Extended Mass Distributions: Results From a Collaborative Research Effort with Undergraduates

Planets are believed to form out of the disks of gas and dust that are known to surround newly formed stars. In turn, most stars in our galaxy are born in clusters of between thirty and two thousand members within cloud-like structures of molecular gas. The interaction between the members of these clusters can significantly affect planet formation. Specifically, the most massive stars within these clusters can produce enough ultraviolet light to evaporate the disks of gas and dust surrounding the other stars before planets can form.

A proper analysis of this physical mechanism requires an understanding of how stars orbit within their cluster environment. Unlike the two-body problem (for which orbits are known to be elliptical), the orbits of stars moving within a cluster can be complex. In order to simplify the problem, we consider the interaction of a single star with an extended mass distribution where the distribution is used to model the density of the entire system as a continuous function. Others have investigated the spirographic orbits that arise in this scenario. While most of the recent work has focused on one particular form for the spherically symmetric mass distribution, we consider more general forms. In addition, we use these results to calculate the average flux that impinges upon the orbiting star from the centrally located massive star (which is the dominant source of ultraviolet light in these environments) in order to determine whether its surrounding disk can form planets before being evaporated by the UV light.

Richard Marchand Slippery Rock University (richard.marchand@sru.edu)

A Comparison of Mechanical and Thermal Damping in a Thermoelastic Beam.

The vibrations of a thermoelastic beam are governed by a fourth order coupled system of partial differential equations. The system has been shown to be uniformly stabilizable with either mechanical damping applied to one boundary of the beam or through thermal effects alone. This presentation will provide a comparison of the decay rates for each of these methods with particular emphasis on their physical limitations. Both computational and theoretical results will be presented. Computational results are obtained by approximating the eigenvalues of the system using finite differences. A PDE multiplier technique is used to derive complementary theoretical decay rates.

Brian J. Lunday Grado Department of Industrial and Systems Engineering, Virginia Polytechnic Institute and State University (lunday@vt.edu)
Hanif D. Sherali Grado Department of Industrial and Systems Engineering, Virginia Polytechnic Institute and State University (hanifs@vt.edu)

A Dynamic Network Interdiction Problem

We present a novel dynamic network interdiction model that accounts for interactions between an interdictor deploying resources on arcs in a digraph and an evader traversing the network from a designated source to a known terminus, wherein the agents may modify strategies in selected subsequent periods according to respective decision and implementation cycles. For the resulting minimax model, we develop a reformulation that facilitates a direct solution procedure using the commercial software BARON, and examine certain related stability and convergence issues. We demonstrate cases for convergence to a stable equilibrium of strategies for problem structures having a unique solution to minimize the maximum evader flow, as well as convergence towards a bounded oscillation for structures yielding alternative interdictor strategies that minimize the maximum evader flow. We also provide insights into the computational performance of BARON for these two problem structures.

Darlene Olsen Norwich University (dolsen1@norwich.edu)

Analyzing Differentially Expressed Genes in Short Time Series Microarray Data

In DNA microarray experiments the expression levels of thousands of genes are measured simultaneously to study the effect of conditions or treatments on gene expression. Time course microarray experiments capture expression levels for a gene over time (the temporal profile of a gene) to examine the dynamic interaction of gene expression. Often in temporal microarray experiments, a limited number of time points are taken resulting in short time series data. This talk will give an overview of some techniques used to analyzing differentially expressed genes in short time series microarray data.

Joshua C Sasmor Seton Hill University (sasmor@setonhill.edu)

What Does the Julia Set for $f(z) = z^{5/2} - \frac{1}{2} + \frac{i}{10}$ Really Look Like?

The authors investigate the Julia Set for $f(z) = z^{5/2} - \frac{1}{2} + \frac{i}{10}$, generated using different algorithms. The common escape-time algorithm is shown to be insufficient; the interval of the branch cut is of vital importance to the convergence of points, and new code is written to examine both the behavior of the branch cut and the nature of the Julia set itself.

Graduate Student Session

Expository Talks for Undergraduates by Graduate Students

Saturday, August 7, 1:00 – 5:30 pm

Kristen Kobylus Abernathy NC State University (kekobylu@ncsu.edu)

A Tourist's Dilemma

A tourist wishes to visit the attractions listed on his itinerary in an efficient manner. He hopes to begin and end each day at his hotel without passing by any attraction more than once, but making sure to visit each attraction on his list. When is this possible?

This problems dates back to the 18th century and was the beginning of the area of mathematics now known as graph theory. During this talk, we will introduce some basic graph theory definitions and theorems to solve this tourist's dilemma. This talk assumes no knowledge of graph theory and is accessible to all undergraduates. If you have some knowledge of graph theory, this talk will still be entertaining as we consider some unique spins on classic graph theory problems.

Zachary Abernathy NC State University (zjaberna@ncsu.edu)

Why Should I Care About i?

Many students are introduced to the concept of imaginary numbers very early in their mathematical education, yet these numbers are generally absent from the calculus sequence. The purpose of this talk is to highlight some of the applications of imaginary numbers in undergraduate mathematics, focusing on some interesting and aesthetically-pleasing results involving trigonometric identities and real-valued definite integrals.

This talk is accessible to all undergraduates, with no previous knowledge of complex analysis required, so please stop by if you're curious about imaginary numbers!

Reema Al-Aifari Johannes Kepler University (al-aifari@indmath.uni-linz.ac.at)

Sparse Phase Reconstruction in Adaptive Optics

The effect of wavefront distortion due to turbulence in the Earth's atmosphere has made it necessary to develop tools for ground-based telescopes that compensate for this aberration. Therefore, the technology of Adaptive Optics (AO) has been investigated and used in astronomy. However, AO systems require to solve large linear ill-conditioned systems for phase reconstruction. In our work we deal with possible approaches to find regularized solutions of such systems.

We start with an introduction to Adaptive Optics and the underlying mathematical modeling. We proceed to introduce some regularization methods and apply the CGNE method to the problem of phase reconstruction. Then, we discuss whether some bases are likely to yield sparse representations of the desired solution and describe the algorithm of iterative soft-thresholding (ISTA) that promotes sparsity. Finally, we use an accelerated version (FISTA) of this method and conclude by giving some numerical results.

John Asplund Michigan Technological University (jsasplun@mtu.edu)

Mutually Orthogonal Latin Squares

A Latin square of order n is an array where each of the n numbers appears once in each row and column. After centuries of studies, Latin squares are still investigated to this day. Sudoku is an example of a Latin square. Even further, we can construct mutually orthogonal Latin squares (MOLS) from Latin squares. MOLS have been studied extensively for several centuries, even by Leonard Euler who notably studied the existence of two MOLS of order 6. Uses of MOLS can be seen within designs of experiments as well as the construction of semi-magic squares.

David Clark Michigan Technological University (dcclark@mtu.edu)

The Joy of Scheduling Chores

You and your many siblings have a massive list of chores to do. How do you divide them up fairly? *Can* you divide them fairly? Is there more than one way to keep Billy and Dani from getting within hair-pulling distance of each other? You can solve your family's problems with the help of *combinatorial designs*. Designs help you divide chores fairly, organize successful study groups, devise experiments to test cancer treatments, arrange talks for world peace – and even choose a headache medicine after you've heroically saved the day. In this talk, you'll learn how to create and use designs to bring peace and harmony to households everywhere.

Samuel Hansen University of Nevada, Las Vegas/ACMEScience (samuel@acmescience.com)

Graph Theory: Play as Mathematics and Research

Vertices and edges are such an intuitive way of looking at the connections formed between objects that when Euler tackled the problem of the Bridges of Konigsberg they are exactly what he used, and through that use was birthed the mathematical discipline of Graph Theory. It is this intuitive nature that makes Graph Theory such a playful subject; an example is only a quick sketch away and proofs are rarely farther than that, except for the intractable problems of course. Traveling down the highway of Graph Theory we will take exits to see notable landmark problems that a grade school child can enjoy, but still contain the depth and beauty that make lifelong mathematicians, some of whom we will meet, gasp. We will finish our trip with a look into the play in Graph Labeling that your tour guide has managed to disguise as research. With such highlights as the Four-Color Theorem and the Travelings Salesman Problem, personalities such as Paul Erdos and Frank Ramsey, and a once in a lifetime look at the actual research behind new results in Graph Theory this trip is not one to miss.

Tolga Karayayla University of Pennsylvania (tkarayay@math.upenn.edu)

Classifying Symmetries of Rational Elliptic Surfaces with Section

This is a complex algebraic geometry talk in which I will discuss how to give a classification of the group of symmetries of rational elliptic surfaces. A rational elliptic surface is the blow up of the projective plane at the 9 base points of a pencil of cubics. Equivalently it is an algebraic surface birational to $\mathbb{P}^2$ which has a map to $\mathbb{P}^1$ with generic fiber an elliptic curve. Singular fibers of this map play an important role in the structure of the group of symmetries of the surface and we can obtain very useful combinatorial information from them to determine this group. The group of symmetries of a rational elliptic surface is simply the semi-direct product of an at most rank 8 abellian group which is known in the literature as the Mordell-Weil group of the surface and a finite group of order at most 24 which is a special subgroup of the group of symmetries defined in terms of the section of the map from the surface to $\mathbb{P}^1$. The Mordell-Weil group is known for every rational elliptic surface and is determined by the configuration of singular fibers, in my work I am describing the second factor of the semi-direct product structure of the group of symmetries in terms of the singular fibers.

Amy Mihnea FAU (amalyamy@yahoo.com)

Interesting Proofs for Combinatorial Formulas

We present some combinatorial formulas and some interesting proofs for them. The derivation of these formulas was done independently, without help from outside sources.

Donald Sampson Brigham Young University (sampson.dcs@gmail.com)

Playing with Bubbles: Metacalibration and Optimization

Do you remember the last time you played with soap bubbles? Whether you play with them outside on a sunny day, take a bubble bath in the tub, or use them to wash dishes in the sink, soap bubbles always form spheres. You probably know that soap bubbles tend to minimize surface area. So if we know that spheres minimize surface area, how do we prove it? Historically mathematicians have used a method known as calculus of variations to solve this kind of problem. Unfortunately, this method is fairly complicated and typically beyond the reach of undergraduates. In this talk I will present a new method of proof that uses only the tools of undergraduate level calculus that can replace calculus of variations. This presentation will include work done by undergraduates and possible projects for future undergraduate research. This talk will be suitable for anyone with a basic understanding of first year calculus.

Daniel Richard Shifflet Bowling Green State University (drshiff@bgsu.edu)

Solving the Pirate Game

One sunny afternoon a group of 10 pirates discovers a treasure chest. Inside they find a bounty of 100 gold coins ripe for the taking. Unfortunately, one doesn't become a pirate by believing the "equal share, all is fair" mantra. He has to live by a different code. It is a code ruled by ruthlessness and selfishness, but one that is not without its own logic. Using this code, how will the pirates divide up the treasure? The answer may surprise you.

Charles D. Wessell North Carolina State University (cdwessel@ncsu.edu)

Cluster Analysis Using Nonnegative Matrix Factorization

The field of cluster analysis tries to find structure hidden in data sets. This problem is especially challenging when the data set is large and high-dimensional. In the past decade, cluster researchers working with nonnegative data have had access to a new tool available to them—nonnegative matrix factorization (NMF). This talk will give a high-level introduction to the NMF algorithm, show how a matrix factorization can be used to cluster a data set, share results from real-world data sets, and reveal some weaknesses of the algorithm and how they are inspiring new research.

Early Career and Graduate Student PosterFest

Thursday, August 5, 3:30 pm – 5:00 pm

Rachel Cywinski St. Philip's College

"Deaf can't do math!" Barriers to Deaf students in mathematics classrooms in the United States of America

Deaf students are significantly underrepresented in post-secondary education. Many deaf students struggle in school at all levels, and some believe that they simply can't do math. Access to education, and achievement, varies greatly by country. In the United States of America, deaf students lag behind hearing peers. For some deaf students, being in a classroom with hearing students is not necessarily the "least restrictive environment." Many deaf students struggle to graduate from high school, and few attend college. There are many barriers to deaf students in education. What are some factors that contribute to the difficulties of deaf students in school and in learning mathematics specifically?

Robert Niichel Indiana University

A Bivariate Central Limit Theorem Under ρ'-Mixing

The classical CLT requires independence of the random variables. In this paper, we use the well-known tools of modern probability to prove a CLT when the random variables (which are indexed by $\mathbb{Z}^d$ for d a fixed whole number) are dependent. After that, we shall prove a corollary about the moments of the normalized sums, showing that, under reasonable assumptions on the original random variables, they converge to the appropriate moments of an exponential random variable.

Tristan Tager Indiana University

Beta Spaces: A Generalization of Metric and Uniform Spaces Sufficient for Generalized Fractal Theorems

Beta Spaces are characterized by the simple concept of a topological space where the topology is generated by a generalization of open balls. We take a set R of radial values, and a function $\beta : X \times R \to \mathcal{P}(X)$, where $\beta(x, r)$ intuitively yields the open ball about x of radius r. We introduce a few simple axioms of beta spaces, and show how these axioms are sufficient to describe very structured machinery and to prove powerful theorems. In particular, beta spaces are sufficient to characterize fractal machinery which typically resides exclusively in a complete metric space. We give generalizations of theorems on the hyperspace of compact sets, iterated function systems, and fractal dimension, together with specific examples of generalized fractals that live in non-metrizable spaces.

Amy Montalbano Clemson University

Confessions of a Procedural Math Teacher: Problematizing Teacher Practices in Mathematics to Support Instructional Change

The purpose of this session is to present the differences between procedural and conceptual mathematics instruction as they pertain to classroom teachers problematizing their current instructional practices and the inherent difficulties of changing one's practice. One of our primary purposes it to relate the experiences of a Ph.D. student who has recently left the mathematics classroom and has begun to problematize her teaching practices and perceptions of practice through exposure to literature (Battista, 1999; Thompson, Philipp, Thompson, and Boyd, 1999; Smith, Smith, and Williams, 2005) and classroom experiences. Smith, Smith, and Williams (2005) offer a framework for changing beliefs and practices about mathematics instruction that requires interest in change, problematizing instruction and posing solutions, exploring alternatives, and reflective analysis. Practices such as those incorporated in this framework are essential to changing teacher practices and it is imperative that mathematics educators, district personnel, and classroom teachers are addressing strategies for changing mathematics instruction in university courses and through professional development.

Tuyen Truong Indiana University

Degree complexity of birational maps related to matrix inversions

For $q \geq 3$, let $\mathcal{M}_q$ denote the space of $q \times q$ matrices with coefficients in $\mathbb{C}$, and let $\mathbb{P}(\mathcal{M}_q)$ denote its projectivization. For a matrix $x = (x_{ij})_{1 \leq i,j \leq q}$, we consider two maps. One is the Hadamard inverse $J(x) = (x_{ij}^{-1})$ which takes the reciprocal of each entry of the matrix, and the other is the matrix inverse $I(x) = (x_{ij})^{-1}$. Define $K = I \circ J$. This map was introduced by some mathematical physicists to study some problems in statistical mechanics.

In joint work with Professor Eric Bedford, we showed that the degree complexity $\delta(K)$ of K is equal to the largest modulus of the roots of the polynomial $\lambda^2 - (q^2 - 4q + 2)\lambda + 1$. Recently, I proved that the same number is also the degree complexity of the restriction of the map K to the space of symmetric matrices. These results were conjectured by Angles d'Auriac, Maillard and Viallet.

Aladar Horvath Michigan State University

Function composition: An essential link to calculus students' understanding of the chain rule

The chain rule is a vital topic that many undergraduate students fail to grasp in the first semester of the Calculus sequence. This poster presents research on calculus students' understanding of the chain rule which indicates that students' difficulties in learning the chain rule may be related to a weak understanding of function composition. Students who flexibly composed and decomposed functions were the most successful on routine and non-routine calculus chain rule problems. This poster also describes the implications this research has for the teaching of the chain rule and offers suggestions to calculus instructors on ways to strengthen students' abilities to compose and decompose functions during a lesson on the chain rule rather than in extra lessons or a beginning of the semester review.

SooYeon Lee California State Polytechnic University of Pomona

History of Korean Mathematics

From the history of mathematics texts, we learn some history of Asian countries such as China and Japan but we don't really know much about Korea's history of mathematics. Usually people think history of Korean mathematics will be very similar to China or Japan's but they are different. A brief history of Korean mathematics between the 1400's to 1700's will be given with a timeline. Some mathematicians from two different classes will be introduced with their work. One problem from the book KuIlJip will be introduced with a solution. Lastly, some differences between Korean mathematics and Chinese and Japanese mathematics will be highlighted.

Kazeem Oare Okosun University of Western Cape of South Africa

Optimal control analysis of a malaria disease transmission model that includes treatment and vaccination with waning immunity

We derive and analyse a deterministic model for the transmission of malaria disease with two different forms of infection, mass action and standard incidence. Firstly, we calculate the basic reproduction number, R_0, and investigate the existence and stability of equilibria. The system is found to exhibit backward bifurcation for mass action form of infection and bifurcation of multiple endemic equilibria for standard incidence. The implication of this occurrence is that the classical epidemiological requirement for effective eradication of malaria, $R_0 < 1$, is no longer sufficient, even though necessary. Secondly, by using optimal control theory we derive the conditions under which it is optimal to eradicate the disease and examine the impact of a possible combined vaccination and treatment strategy on the disease transmission. When eradication is impossible, we derive the necessary conditions for optimal control of the disease using Pontryagin's Maximum Principle. The results obtained from the numerical simulations of the model show that a possible vaccination combined with effective treatment regime would appreciably reduce the spread of the disease.

Reema Al-Aifari Johannes Kepler University Linz

Parameter Estimation for Constitutive Models of Deformable Objects

In computer animation, characters are deformable objects that can be controlled by animators through rigs. Physical simulations are used as a supplementary tool. This work is done for Disney and Pixar Animation Studios and our goal is to fit parameters of a given constitutive model to a rigged character so that the resulting physical simulation matches the behavior of the rig. Specifically, we solved an inverse problem to fit material parameters to hand-animated target data. This work presents a solution to this problem using two different approaches: non-linear least squares fitting, implemented using the Gauss-Newton algorithm, and TV regularization, implemented using the Split Bregman algorithm. Target data in one, two, and three dimensions is matched efficiently and accurately. The algorithms were implemented with both homogeneous and heterogeneous parameters and tests were performed for sparse and noisy target data.

Amy Mihnea Florida Atlantic University

Patterns in Derangements

We present a method for finding the distribution of the differences between adjacent elements, in all derangements of order n. This distribution depends on the number of derangements of order less than n. We also construct a family of matrices and we relate it to these differences.

Carol Ann Aschenbrenner Wake Forest University

Randomness, Dynamics, and Equal Representation

In this poster, we consider various aspects of randomness with special attention to goals of equal representation among several classes. Particular emphasis will be on aspects related to choice functions, memory, runs and other related concepts. Potential applications are in clinical trials, data and network processing, decision theory and sampling.

Amit Sharma National Institute of Technology,Hamipur(H.P) India

Reflection of acousto diffusive wave from the surface of semiconductor

The paper concentrates on the study of propagation and reflection characteristics of waves from the rigidly fixed, semiconductor material half space. The concept of positivly charge carriers (holes) fields is also taken. The ratio of reflection coefficients to that of incident wave is obtained for P and N (electron wave)wave incident cases. The special cases of normal and grazing incidence are also derived and discussed. Finally, the numerical computations of reflection coefficient are carried out for silicon (Si) semiconductor material with the help of functional iteration numerical technique.

Kristi Karber University of Central Oklahoma

Remarks and Open Problems Regarding Certain Backward Shift Invariant Subspaces

This poster presentation is a portion of joint research with John R. Akeroyd. We investigated backward shift invariant subspaces of the form K_I, the orthogonal complement of $IH^2(\mathbb{D})$ in $H^2(\mathbb{D})$, where I is a certain inner function. Open problems involving K_I spaces, as well as some comments regarding known progress made on these problems will be presented.

Bao Nhan Ho a Trobe University

Simple game graphs

An *impartial combinatorial game* G is a two-player game involving a finite acyclic digraph, denoted by Γ_G, with precisely one source and one sink. The vertices of the digraph are the positions of the game, and the directed edges issuing from a position p are the possible moves from p. Two players, called P_1 and P_2, move alternatively in which P_1 starts at the source and after that each player starts from the position terminated by another player in the previous move. The player who cannot move loses. The graph Γ_G is said the *game graph* (of G). In a game graph Γ_G, the *height* of a position p is the length of the longest directed path from p to the sink. The *value* of a position p is either 0 or 1 and is defined by induction on the height as follows: (i) the sink has value 0; (ii) a position p of height $h > 0$ has value 1 if and only if there is a move from p to a position with value 0.

For impartial combinatorial games G, H, a *game homomorphism* is a digraph homomorphism $f : \Gamma_G \to \Gamma_H$ that sends sink to sink and respects the value functions. A game graph Γ_G is *simple* if every surjective game homomorphism $f : \Gamma_G \to \Gamma_H$ is an isomorphism. A natural question is that when will a game graph be simple. We will answer this question. A statistics of simple game graphs of height at most 4 will be then given.

Shigeru Masuda Graduate School of Tokyo Metropolitan University

The "two-constants" theory and tensors of the microscopically-descriptive Navier-Stokes equations

The "two-constants" theory introduced first by Laplace in 1805 is the currently accepted theory describing isotropic, linear elasticity. The original, microscopically-descriptive Navier-Stokes equations were derived in the course of the development of the "two-constants" theory. From the viewpoint of these equations, we trace their evolution and the notion of tensor following in historical order the various contributions of Navier, Cauchy, Poisson, Saint-Venant and Stokes, and note the concordance between each. Also in the formulation of equilibrium equations, we get the confronting theories of "two-constants" in the capillary between Laplace and Gauss. As an epilogue of our talk, we would like to trace the practice in terminology of naming of the Navier-Stokes equations.

Candice Jean-Louis Morgan State University

The Algebraic Structure of the Riordan Group

Interesting properties of the Riordan group are investigated in this poster. For instance, centralizers, stabilizers, isomorphisms between subgroups and semi-direct products are presented. Riordan matrices are defined by pairs of formal power series or generating functions. In addition, we establish a relationship between the pair of generating functions in order to define a Riordan matrix as a stochastic Riordan matrix. The relationship is then used to generate elements of the stochastic subgroup of the Riordan group. Finally, two new subgroups: the power-bell and the derivative are also introduced.

Scott Zimmerman John Carroll University

The Characterization of Banach Spaces via the Complemented Subspace Problem

This paper addresses the complemented subspace problem in Banach space theory. The problem asks if a Banach space in which every complemented subspace is closed is necessarily isomorphic to a Hilbert space. In other words, if a Banach space behaves like a Hilbert space, is it in fact a Hilbert space? This problem was originally solved by Lindenstrauss and Tzafriri in 1971, but we will examine this question in a slightly different manner. First, we will observe an example in a familiar Banach space relating closely to the initial formulation of this problem through the analysis of bases and complemented spaces. Then, with the help of Dvoretzky's theorem and previous work in Banach space theory, we will draw two conclusions that, when combined, provide a solution to the complemented subspace problem.

Jessica Beth Grossbard California State University Los Angeles

The Parameter Involved in the Lonely Runner Conjecture for Three Element Sets

We investigate the parameter involved in the Lonely Runner Conjecture by improving upon known bounds for three element sets and by determining instances where these bounds are sharp. Connections between the Lonely Runner and other problems are explored; specifically, we extend our results to consider the density of sequences of integers with missing differences and the fractional chromatic number of distance graphs.

Daniel Richard Shifflet Bowling Green State University

Using a Game Show to Teach Hypothesis Testing

It is common practice for an introductory college statistics course to culminate in a final project. As instructors we usually have two options: spend countless hours trying to find the perfect topic that emphasizes the mathematical concepts discussed during the semester long course or let the students pick their own. Unfortunately, the first option rarely results in a subject of interest to the students while the second tends to lack any mathematical substance (university tuition prices are increasing — surprise!). Using the popular game show "Deal or No Deal," this poster presents an option for such a project that appeals to the average student and utilizes numerous simple statistical concepts to arrive at an interesting mathematical conclusion. Hopefully, it will not only lead to better understanding of the material, but also a better appreciation of its importance.

Index of Speakers

CALENDAR

of

Upcoming MAA Meetings

2011

AMS-MAA Joint Mathematics Meeting

New Orleans, LA
January 6–9, 2011

MathFest

Lexington, KY
August 4–6, 2011

2012

AMS-MAA Joint Mathematics Meeting

Boston, MA
January 4–7, 2012

MathFest

Madison, WI
August 2–4, 2012