

*Mathfest 2001*  
*Madison, WI*



*MAA and Pi Mu Epsilon*  
*Student Paper Sessions*  
*August 2 - 3, 2001*

## PME Session #1

Hall of Ideas H

1:00 P.M. - 2:35 P.M.

1:00 - 1:15

## ANALYZING THE AREA OF FRACTAL TILINGS

**Miyuki Breen**

University of Akron - Ohio Nu

Tilings of the plane are generated using a  $2 \times 2$  integer matrix  $A$ . If  $m = |\det A|$ , a tile  $T$  is the attractor of the iterated function system  $\varphi_j(x) = A^{-1}x + A^{-1}d_j$ ,  $1 \leq j \leq m$ . The set of vectors  $D = \{d_j : 1 \leq j \leq m\}$  can be selected so that  $T$  has a fractal boundary. A wavelet basis can arise from such a tile  $T$  having area one.

1:20 - 1:35

## CAN YOU FOLLOW OUR "TRAIN" OF THOUGHT?

**Tonya Kim and Nancy Nichols**

Randolph-Macon College - Virginia Iota

We develop a queueing model (based on the Borel-Tanner distribution) for maximal queue length at a railroad crossing in our small college town. We show that the increase in traffic that a new Wal-Mart is expected to bring will dramatically increase the likelihood of saturated traffic conditions.

1:40 - 1:55

## QUATERNIONS

**Bob Shuttleworth**

Youngstown State University - Ohio Xi

William Hamilton invented quaternions as an algebra in which quotients of vectors are well defined. Today, computer graphicists use quaternions, represented by orthonormal matrices, to rotate objects and spline camera paths. Examples of real-time interactive quaternionic animation will be presented. This research was developed at IlliMath 2001, an NSF-VIGRE supported REU program at UIUC.

2:00 - 2:15

## KAIROMONE

**Lorna Salaman**

University of Puerto Rico via Illinois Alpha

The corn rootworm *Diabrotica* is a serious agricultural pest. As part of IlliMath 2001, a VIGRE supported REU program at UIUC, a mathematical model using real-time interactive animations was developed based on finite-element methods. *Diabrotica*'s behavior is influenced by the diffusion of chemical food attractants and drift.

2:20 - 2:35

## NARNIA

**Alison Ortony**

University of Illinois Urbana-Champaign - Illinois Alpha

"Narnia" is an adaptation of Ken Brakke's "Polycut" to CAVE and CUBE virtual environments. Three-manifolds branched over knot and link complements will be navigated in real-time interactive animation developed at IlliMath 2001, a VIGRE supported REU at UIUC. In this project knot theory leads to a generalization of classical Riemann surfaces.

## PME Session #2

## Hall of Ideas I

1:00 P.M. - 2:55 P.M.

1:00 - 1:15

## FACTORIZABLE GROUPS

**Tom Wakefield**

Youngstown State University - Ohio Xi

A factorizable group  $G$  has two proper nontrivial subgroups  $H$  and  $K$  such that  $G = HK$ . This presentation examines some factorizable groups and identifies their common properties. In particular,  $S_n$  and  $A_n$  are shown to be factorizable for certain  $n$ .

1:20 - 1:35

## DIVISIBILITY ALGORITHMS FOR EUCLIDEAN RINGS

**Laura Hitt**

Samford University - Alabama Gamma

I developed algorithms that enable one to determine the divisibility of any element  $M$  in a Euclidean ring by another element  $n$ , where  $M$  and  $n$  are relatively prime. After creating a computer program to implement the algorithms, I compared the execution time of these divisibility algorithms with that of traditional methods. Finally, I proposed an encryption algorithm that is based on these divisibility algorithms.

1:40 - 1:55

## EXPLORING GRAPH THEORY THROUGH CONJECTURES OF "GRAFFITI"

**Barbara Chervenka**

University of Houston - Downtown - Texas Nu

As an introduction to Graph Theory, I examined conjectures generated by an educational version of the computer program "Graffiti". Most were related to bounds on the sum of the independence and clique numbers of a graph. In this presentation, I will discuss several of these conjectures and the tools I acquired through my efforts.

2:00 - 2:15

## GRAPH THEORY: DECOMPOSITIONS

**Enyinda Onunwor**

Youngstown State University - Ohio Xi

A *graph decomposition* of a graph  $G$  is a list of subgraphs of  $G$  such that each edge in  $G$  occurs in exactly one subgraph in the list. An  $S_k$  design is one with exactly one vertex that is adjacent to  $k$  vertices on the graph  $G$ . This talk concentrates on decomposing graphs into  $k$ -stars.

2:20 - 2:35

THE OPTIMAL ORIENTED DIAMETER OF THE  $3 \times 5$  TORUS  
AND JOINS OF GRAPHS**Camillia Smith**

Michigan State University - Michigan Alpha

One can define the optimal oriented diameter of a connected, bridgeless graph to be the minimum diameter over all strong orientations for that graph. I study this quantity for the torus – resolving one case of a conjecture by König, Kümme and Lazard – and also for classes of joins of graphs.

2:40 - 2:55

## ON THE NUMBER THEORY OF QUATERNIONS AND OCTONIONS

**Mohammed Abouzaid**

University of Richmond - Virginia Alpha

I will present results about the number theory of the quaternionic and octonionic equivalents of the set of rational numbers in the real numbers, and the set of Gaussian integers in the complex numbers. This subject is particularly interesting because it requires an understanding of the algebraic and geometric structure of these 4-dimensional and 8-dimensional spaces which often sheds new light on the number theory of the real and complex numbers.

**PME Session #3****Hall of Ideas H****3:00 P.M. - 4:55 P.M.**

3:00 - 3:15

## INTERNATIONAL PARITY RELATIONS AND REAL INTEREST RATES

**Teresa Selee**

Youngstown State University - Ohio Xi

What implications do international parity relations have for real rates of interest in different countries, and are the theories supported by data? The method used to test the data will be detailed, and the results will be given, with attention to real world applications for investors.

3:20 - 3:35

## PROTECTING THE PUBLIC HEALTH: PREDICTING PM FINE IN FORSYTH COUNTY

**Kathy Woodside**

North Carolina State University - North Carolina Gamma

PM fine is a harmful air pollutant that consists of both liquid and solid particles that are less than 2.5 micrometers in diameter. In this presentation I will discuss the forecasting of PM fine. I will explain the process of developing the model and discuss different tests of its accuracy.

3:40 - 3:55

## COOK'S THEOREM

**Joel Lepak**

Youngstown State University - Ohio Xi

A problem in class NP is one whose solution can be verified in polynomial time (but not necessarily one which can be solved in polynomial time). Cook's Theorem states that any problem in class NP can be reduced to a problem of determining whether an assignment of truth-values exists which will satisfy a set of Boolean clauses. This is one of the most important results of theoretical computer science. A proof of Cook's Theorem will be given, and its implications and related concepts will be discussed.

4:00 - 4:15

## PERIODICITY AND LONG TERM EVOLUTION OF CELLULAR AUTOMATA

**Nicole Miller**

Salisbury University - Maryland Zeta

In this paper, cellular automata are discrete dynamical systems generated by group multiplication for the local update rules. We will discuss the periodicity, transient phase, and long term effects of finite cellular automata by varying the grid size, initial conditions, and underlying group of the automata.

4:20 - 4:35

## FROM MATHEMATICS TO KRYPTON: THE PURSUIT OF RANDOM NUMBERS

**Neda Khalili and Janeen Peretin**

Duquesne University - Pennsylvania Upsilon

Random number generation is an integral component of many fields, including the computational sciences which conduct simulation-based research. However, due to the limitations of the modern computer, generating truly random numbers is a formidable task. We will compare the properties of popular "random" number generating algorithms, assess the quality of the random numbers which they produce, and demonstrate their usefulness.

4:40 - 4:55

## BANDWIDTH OF A PRODUCT OF CLIQUES OF UNEVEN SIZE

**Eric Appelt**

Miami University - Ohio Delta

The problem of the bandwidth of a product of two cliques of equal size was solved in 1992 by U. Heinrich and M. Stiebitz. In 2001, Z. Miller and I have developed a preliminary solution to the problem of the bandwidth of a product of two cliques of unequal size utilizing methods found in the previous problem, as well as ideas from three-dimensional calculus. This solution will be presented, along with applications of this problem to multi-channel communications and Internet communications.

## PME Session #4

Hall of Ideas I

3:00 P.M. - 4:55 P.M.

3:00 - 3:15

## NON-EUCLIDEAN GEOMETRY FROM 1820 TO 1920

**Tracy Pirkle**

Miami University - Ohio Delta

This paper traces the history of non-Euclidean geometry by looking at attempts to prove Euclid's parallel postulate, the discoverers of non-Euclidean geometry, its reception in the mathematical community, and its emergence in the collegiate mathematics curriculum.

3:20 - 3:35

## EXPLORING MELODIC PATTERNS IN DIATONIC AND CHROMATIC MUSIC

**Amy Joanne Herron**

Miami University - Ohio Delta

Music consists of a variety of repeated patterns. Using the inclusion-exclusion principle, it is possible to count 1) how many patterns exist in diatonic music (a seven note system) and chromatic music (a twelve note system) and 2) how many of these patterns include all the differently named notes of the systems.

3:40 - 3:55

## THE ERDŐS SUM OF RECIPROALS CONJECTURE

**John T. Griesmer**

Miami University - Ohio Delta

Some time ago Erdős conjectured that any subset  $A$  of the positive integers such that  $\sum_{n \in A} \frac{1}{n} = \infty$  must contain arbitrarily long arithmetic progressions. He offered \$3000 for a proof or counterexample, and it is still unknown whether such a sequence must contain 3-term arithmetic progressions. The conjecture would imply that the set of prime numbers contains arbitrarily long arithmetic progressions. This talk covers the background of the conjecture, some possible approaches to solving it, and raises some related issues.

4:00 - 4:15

## SCHEDULING TOURNAMENTS USING COMBINATORIAL DESIGNS

**Dave Gerberry**

Youngstown State University - Ohio Xi

At first glance, the process of scheduling a season or tournament does not seem to be a mathematical one. However, when facing a list of conditions a schedule must satisfy, one quickly realizes that a systematic approach is needed to attack the problem. I will discuss how combinatorial designs can be used to create tournaments that satisfy various criteria.

4:20 - 4:35

## TRACING A STIRLING APPROXIMATION: DERIVATIONS OF STIRLING'S FORMULA

**Steve Mehlo**

Youngstown State University - Ohio Xi

Stirling's formula gives an asymptotic approximation for the  $n!$  function. Although it has a variety of applications, deriving and proving this gem is a bit of a challenge. In this presentation, a brief proof will be presented in addition to some background information on the formula itself.

4:40 - 4:55

## DISJUNCTIVE RADO NUMBERS

**Brenda Johnson**

South Dakota State University - South Dakota Gamma

The study of Rado numbers is part of Ramsey Theory, which is an area of combinatorics. We will introduce a variation of the classical Rado numbers which we call disjunctive Rado numbers. The presentation is based on the results of ongoing undergraduate research.

**PME Session #5****Hall of Ideas H****1:00 P.M. - 2:35 P.M.**

1:00 - 1:15

## EXPLORING FINITE TIME BLOW-UP

**Jared Williams**

Hendrix College - Arkansas Beta

When a solution to a differential equation “reaches” infinity in finite time, the solution is said to “blow up” in finite time. This project includes techniques for determining whether the solution to a differential equation blows up in finite time without solving the differential equation analytically.

1:20 - 1:35

## MODELLING POSITIVE ASSORTATIVE MATING

**Elissa Pfannenstein**

College of St. Benedict - Minnesota Delta

We investigate long-term distributions of phenotypes under positive assortative mating. In positive assortative mating, individuals select mates based on the similarities of their observable characteristics (phenotypes). This model is more realistic than traditional random mating models. Our non-linear model uses probabilities to account for varying strength of mating preferences.

1:40 - 1:55

## RECONSIDERING THE ANDERSON AND MAY MACROPARASITIC MODEL

**Adam Singleton**

Jacksonville University - Florida Lambda

This study provides a complete analysis of the three dimensional model proposed by Anderson and May in August 1979. A treatment term is introduced in this model which provides insight into the system dynamics. A stability analysis is performed, and the qualitative and quantitative effects of the critical values of lambda are considered. We plot some numerical solutions of the system for various values of parameters.

2:00 - 2:15

## PATTERN FORMATION IN BIOLOGICAL SYSTEMS

**Yakov Kronrod**

Worcester Polytechnic Institute - Massachusetts Alpha

Many models exist to describe patterns found in biological systems. Alan Turing proposed that diffusion could act as the destabilizing influence leading to patterns in a reaction-diffusion model. Using linear stability analysis and numerical simulations, we investigate patterns based on parameters proposed by Meinhardt and Gierer.

2:20 - 2:35

## NEW METHODS FOR COLLISION DETECTION

**Jonathan Moussa**

Worcester Polytechnic Institute - Massachusetts Alpha

Efficient collision detection algorithms are required to analyze complex geometric scenes with as little computation as possible. Certain restrictions, such as temporal coherence or uniformity of objects in a scene, dictate which algorithms are most efficient for a given situation. Here we are presenting a new algorithm for collision detection and comparing it with ones that are presently used.

**PME Session #6****Hall of Ideas I****1:00 P.M. - 2:35 P.M.**

1:00 - 1:15

## ORIGAMI AND MATHEMATICS

**Erin M. Bergman**

St. Norbert College - Wisconsin Delta

Everybody is familiar with origami, the art of paper folding. Less familiar are the connections between origami and mathematics. We will explore some of these connections, both by presenting an introduction to the theory and by giving some demonstrations

1:20 - 1:35

## SAVE A LOT OR A LITTLE?

**Sarah Grove**

Youngstown State University - Ohio Xi

When you go out into the world and start to make pricier purchases, is it worth your while to pay in full or to make payments? Of course we all know that with interest you will end up paying more if you take out a loan. However, is that extra money worth the hassle of saving up until you can make a purchase in full? How does this decision affect your financial status for the rest of your life?.

1:40 - 1:55

## AUTHORSHIP OF THE FEDERALIST PAPERS

**Abby Mroczenski**

St. Norbert College - Wisconsin Delta

The Federalist Papers were written in 1787-1788 by Alexander Hamilton, John Jay and James Madison to persuade the citizens of the State of New York to ratify the Constitution. Of these papers we are confident of the authorship of all but twelve. Presented here will be the results of a statistical analysis exploring the authorship of these 12 papers, using stepwise regression and logistic regression on variables created by DocuScope.

2:00 - 2:15

## BINOMIAL BASKETBALL: SUCCESS STRING PROBABILITIES

**Brian Muscia**

Elmhurst College - Illinois Iota

An unpublished paper dealt with the problem of finding the probability of making a specified string of successes in ten free throw attempts. The original author's expressions were simplified and a general formula was found for some restricted cases of a string of  $i$  successes in  $k$  attempts.

2:20 - 2:35

## DISSECTIONS: PLANE AND FANCY

**Julie Jones**

Moravian College - Pennsylvania Omicron

This presentation demonstrates and explains many geometrical dissections from Greg N. Frederickson's *Dissections: Plane and Fancy*. A detailed proof of H. Dudeney's dissection and rearrangement of an equilateral triangle into a square will also be shown.

THURSDAY

AUGUST 2, 2001

**MAA Session #1**

**Hall of Ideas E - Monona Convention Center**

**1:00 P.M. - 2:55 P.M.**

**The first four speakers in this session are students of Professor Ronald Umble in a special research program at Millersville University.**

1:00 - 1:15

NUMERICAL AND GRAPHICAL ANALYSIS OF DISTANCE MINIMIZING PATHS ON A CIRCULAR CAN

**Robert Painter**

Millersville University

There exists a path of shortest length connecting two arbitrarily chosen points on a circular can. This path is a geodesic consisting of a line segment, part of a helix, or some combination thereof. The desired shortest path is computed numerically and subsequently displayed.

1:20 - 1:35

GEOMETRIC ANALYSIS OF DISTANCE MINIMIZING PATHS CROSSING ONE RIM OF A CIRCULAR CAN

**Joel Mohler**

Millersville University

There exists a unique path of shortest length on a circular can connecting a point on the lid and a point on the side. This path is a geodesic that crosses the rim once and can be found by unrolling the can and analyzing an equivalent problem in plane geometry.

1:40 - 1:55

GEOMETRIC ANALYSIS OF DISTANCE MINIMIZING PATHS CROSSING EACH RIM OF A CIRCULAR CAN ONCE

**Heather Heston**

Millersville University

There exists a path of shortest length on a circular can connecting a point on the lid and a point on the base. The path is a geodesic that crosses each rim once and can be found by unrolling the can and analyzing an equivalent problem in plane geometry.

THURSDAY

AUGUST 2, 2001

2:00 - 2:15

GEOMETRIC ANALYSIS OF DISTANCE MINIMIZING PATHS CROSSING THE SAME RIM OF A CIRCULAR CAN TWICE

**Ellen Panofsky**

Millersville University

There exists a path of shortest length on a circular can connecting two points on the side. When these points lie near a rim, the path is a geodesic that crosses the rim twice and can be found by unrolling the can and analyzing an equivalent problem in plane geometry.

2:20 - 2:35



DOTS AND BOXES: NOT JUST FOR KIDS ANYMORE

**Sarah Anne Axton**

West Virginia Wesleyan College

In **The Dots and Boxes Game: Sophisticated Child's Play**, Elwyn Berlekamp explores the intricacies of the children's game. We discuss his strategies concerning double-cross moves and the long chain rule, as well as his techniques for counting chains. We also address adapting these strategies to variations such as Dots and Triangles, Dots and Hexagons, and more than two players.

2:40 - 2:55

AS THE TAXI FLIES AND OTHER SUCH NONSENSE: AN INTRODUCTION TO  
TAXICAB GEOMETRY

**Brian Boucher**

Jacksonville University

An introduction is given to Minkowskian geometry with specific emphasis on Karl Menger's Taxicab Geometry. The effects of the Taxicab metric on certain distance-defined figures like conics are analyzed. The author also introduces a new modification, Plaza Geometry, and analyzes it similarly.

THURSDAY

August 2, 2001

**MAA Session #2**

**Hall of Ideas F - Monona Convention Center**

**1:00 P.M. - 2:55 P.M.**

**The first four speakers in this session are students of Professor Susan Loepp in the REU Program at Williams College.**

1:00 - 1:15

COMMUTATIVE ALGEBRA I: INTRODUCTION TO COMMUTATIVE RING THEORY

**Charles Samuels**

Williams College

This talk will be an introduction to Commutative Ring Theory. Topics covered will be prime ideals, maximal ideals, local rings, height of an ideal, unique factorization domains, and other relevant topics needed to understand our research.

1:20 - 1:35

COMMUTATIVE ALGEBRA II: COMPLETIONS OF LOCAL RINGS

**Grace Wang**

University of California, Berkeley

Given a local ring, we can define a metric on that ring. When we complete this metric space, we get another ring called the completion. We will define this metric, explore the relationship between a local ring and its completion, and investigate how it relates to our research.

1:40 - 1:55

COMMUTATIVE ALGEBRA III: CONSTRUCTING INTERESTING RINGS

**Sonja Mapes**

University of Notre Dame

Given a complete local ring  $T$ , we can construct rings whose completions are equal to  $T$  using a method developed by Heitmann. This construction yields rings which have unusual relationships with their completions. We will give a general overview of this construction and its relevance to our research.

THURSDAY

August 2, 2001

2:00 - 2:15

COMMUTATIVE ALGEBRA IV: COMPLETIONS OF UNIQUE FACTORIZATION DOMAINS

**John Bryk**

Williams College

We will discuss our results which contribute to the ongoing attempt to characterize completions of excellent local unique factorization domains.

2:20 - 2:35

COMPUTING INTEGRAL CLOSURES OF RINGS

**Kenneth A. Ferry**

Harvard University

In this talk, we discuss algorithms for computing the normalization of reduced affine algebras and issues of implementation in the Macaulay 2 computer algebra system. The current implementation has features that are costly in time and memory, such as radical computations and a computation of a Jacobian. We explore ways to simplify these computations.

2:40 - 2:55

## THE NUMBER THEORY OF THE COMPOSITION ALGEBRAS

**Jarod Alper**

Brown University

We present investigations into the number theory of the composition algebras over the real numbers. We explore generalizations of properties of rational integers, such as gcd and unique factorization, to rings of integers in the higher-dimensional algebras. In particular, we present results on the intersection of the left and right divisors of a quaternion or octonion of norm  $pq$ , where  $p$  and  $q$  are prime.

THURSDAY

AUGUST 2, 2001

**MAA Session #3**

**Hall of Ideas E - Monona Convention Center**

**3:00 P.M. - 4:55 P.M.**

3:00 - 3:15

ENDING DIGIT SEQUENCES OF CUBES

**Daniel P. Biebighauser and John D. Bullock**

Concordia College

We have been investigating the final digit sequences of cubes. For example, we have been able to answer the following question: Is there an integer  $n$  such that  $n^3$  ends in 2000 consecutive ones (from the Fifth Annual NCS/MAA Team Contest)? It turns out that such an integer does exist and we have been able to answer a variety of other such questions.

3:20 - 3:35

PYTHAGOREAN TRIPLES: CONJECTURES AND COUNTEREXAMPLES

**AnaMarie Sherman**

Phoenix College

I am going to make conjectures about Pythagorean Triples and prove them to be true or false. I will determine if each Pythagorean Triple is primitive or non-primitive while also showing patterns in the sequences of numbers.

3:40 - 3:55

THE DISTRIBUTION OF EUCLIDEAN PRIMES

**Rasha Atisha and Hamsa Yaqo**

Wayne State University

Euclid's proof of the infinitude of primes suggests methods for generating infinite sequences of prime numbers. Although there is a substantial literature on this subject, many results seem not to be well-known, resulting in much duplication of effort among different researchers and quite a few outright errors. Using recursive quadratic sequences in modular arithmetic, we have found all "Euclidean primes" up to 50,000,000 and have investigated their density among all primes.

THURSDAY

AUGUST 2, 2001

4:00 - 4:15

GEOMETRIC APPLICATIONS OF A SYSTEM OF CONGRUENCES

**Eva Kashat and Daniela Silva**

Wayne State University

The system of congruences

$$\prod_{j \neq i} n_j \equiv 1 \pmod{n_i}$$

for positive integers  $n_1, \dots, n_k$ , has wide ranging applications not only within number theory, but also to groups of symmetries of geometric objects, allowing the construction of three dimensional manifolds with interesting topological properties. Using computer search techniques, we have found all solutions of length  $\leq 8$ .

4:20 - 4:35

RATIONAL POINTS ON ELLIPTIC CURVES

**Rachael Lee Floit**

Augustana College

Elliptic curves have many uses. We will give the definition of an elliptic curve and show how the rational points on such a curve form a group. We will show how to find an elliptic curve with rational points by using Pythagorean triples.

4:40 - 4:55

SELF-SIMILARITIES OF THE KOCH CURVE

**Kevin Murphy**

Augustana College

We show how to count the number of pieces of the Koch curve that are similar to the whole curve. We identify each such piece with an affine map that maps the whole curve to that piece.

THURSDAY

AUGUST 2, 2001

**MAA Session #4**

**Hall of Ideas F - Monona Convention Center**

**3:00 P.M. - 4:55 P.M.**

**The first four speakers in this session are students of Professor Frank Morgan in the REU Program at Williams College.**

3:00 - 3:15

DOUBLE BUBBLES ON FLAT TWO-DIMENSIONAL TORI I

**Nicholas Leger**

University of Texas at Austin

The 1990 SMALL Geometry Group proved the Double Bubble Theorem in the plane, which says that the standard double bubble provides the least-perimeter way to enclose and separate two areas. This configuration is qualitatively independent of the areas given. However, on a flat two-dimensional torus, new classes of perimeter-minimizing curves arise. I will discuss these new curves and more.

3:20 - 3:35

DOUBLE BUBBLES ON FLAT TWO-DIMENSIONAL TORI II

**Paul Holt**

Williams College

I'll report on progress on characterizing double bubbles in flat 2-tori and give comments on other spaces.

3:40 - 3:55

DOUBLE BUBBLES IN SPACES OF CONSTANT CURVATURE

**Joseph Corneli**

New College

I will report on the work of the SMALL Geometry Group concerning the form of double bubbles in spaces of constant curvature, such as the sphere  $S^3$ , hyperbolic space  $H^3$ , and flat tori.

THURSDAY

AUGUST 2, 2001

4:00 - 4:15

THE DOUBLE BUBBLE CONJECTURE FOR  $S^3$  and  $H^3$ .

**Eric Schoenfeld**

Williams College

Last year's SMALL Geometry Group characterized area-minimizing double bubbles for most cases of equal volumes in the 3-sphere  $S^3$  and hyperbolic space  $H^3$ . I'll discuss the case of unequal volumes.

4:20 - 4:35

DIGITALLY ANALYZING AND COMPRESSING THE ARTWORK OF EDWARD HOPPER

**Megan M. Sheets**

University of Nebraska - Lincoln

Using various mathematical techniques, I attempt to better approximate the digital intensity data for the artwork of 20<sup>th</sup> Century American artist Edward Hopper. These techniques are then compared using methods that quantitatively determine their efficiency and ability to preserve the essential characteristics of Edward Hopper's art.

4:40 - 4:55

#### LEARNING MORE WITH FRACTALS

**Chris Jones**

Youngstown State University

Can any information be inferred about dimension, perimeter, and/or area from a fractal's first few iterations? If so, where can this take us in the analysis of other fractal curves and figures?

In this presentation, fundamental concepts of fractal dimension will be discussed along with some of the results of my investigations.

FRIDAY

AUGUST 3, 2001

**MAA Session #5**

**Hall of Ideas E - Monona Convention Center**

**1:00 P.M. - 2:55 P.M.**

1:00 - 1:15

DUAL-EULERIAN GRAPHS

**Irma Servatius**

Worcester Polytechnic Institute

A graph embedded on an orientable surface is called Dual-Eulerian if there is an Eulerian trail which is at the same time an Eulerian trail of the geometric dual. We show that there is a Dual-Eulerian embedding of the octahedron on the two-holed torus.

1:20 - 1:35

ON THE EXISTENCE OF EXACT DISTANCE COLORED GRAPHS

**Collin Raymond**

Arizona State University

This paper examines whether there exist graphs that can be given a coloring  $\chi$ ,  $\chi$  having three properties:  $\chi$  uses  $r$  colors,  $\chi$  assigns each of  $r$  colors to exactly  $m$  points, and every two points  $x$  and  $y$  of the same color under  $\chi$  are distance  $d$  apart.

Proofs are given for the existence of graphs with  $m \in \{2, 3\}$  for all  $r$  and  $d \leq r$ , as well as with  $d = 2$  for all  $m$  and  $r \geq d$ . Some bounds on  $m$  (as a function of  $r$  and  $d$ ) are presented and future areas of research and conjectures are pointed out, both in regards to  $m > 3$  as well as non-uniform values of all three variables  $d$ ,  $r$ , and  $m$ .

1:40 - 1:55

GRAPHS AND MATRICES

**Aliyah N. Ali**

Rutgers University

We define  $A$ -matrices as those matrices with  $m$  rows and  $m - 1$  columns, exactly two non-zero entries in each column, and non-zero maximal minors. We associate the graphs of these matrices to trees and we can show that they are in one-to-one correspondence with trees. From these graphs, we found that the determinants of the matrices could be obtained by using simple illustrations called "bomb diagrams." We build on these graphs to find a simple description of the determinants of other matrices with two non-zero entries in each column.

FRIDAY

AUGUST 3, 2001

2:00 - 2:15

ON PERMUTATIONS ARISING FROM CARD SHUFFLING

**Jeffrey Warchal**

Shippensburg University

We find invariant properties of certain types of card shuffles that allow for the creation and performance of some new mathematically-based card tricks.

2:20 - 2:35



RANDOM WALKS ON CO-OCCURRENCE MATRICES IN ECOLOGICAL NULL MODELS

**Timothy K. Teräväinen**

New College

Ecologists studying species distribution use random sampling from null models (without hypotheses) to determine whether their data merit investigation or are due simply to chance. The null model datasets are often too large to generate in practice. We examine the use of Markov Chain Monte Carlo methods to randomly sample.

2:40 - 2:55

MATHEMATICAL CORRELATIONS STUDIES IN NATURALLY OCCURRING  
FLUCTUATIONS: APPLICATIONS TO DNA SEQUENCES ALONG WITH FINANCIAL  
DATA

**Sabyasachi Guharay**

Princeton University

Statistical studies of mathematical correlation properties of  $\sim 7,500$  gene sequences are presented. Mutual information function, Hölder exponent, and power spectrum analyses are determined for the aforementioned data. Conclusions, along with relevant implications, are discussed. Time permitting, other applications of these mathematical methodologies are discussed (particularly to problems in mathematical finance).

FRIDAY

AUGUST 3, 2001

**MAA Session #6**

**Hall of Ideas F - Monona Convention Center**

**1:00 P. M. - 2:55 P.M.**

**The first four speakers in this session are students of Professor Colin Adams in the REU Program at Williams College.**

1:00 - 1:15

KNOT COMPLEMENTS: THE HYPERBOLIC ALTER-EGO OF OUR TWISTED FRIENDS

**Eric Katerman**  
Williams College

Everyone knows that tying knots is fun and beneficial, e.g., knots keep shoes on feet and boats near docks. However, most people don't know that if we remove a thin knot from space, the shortest paths in the resulting manifold aren't straight. This talk will introduce the magic ingredient in hyperbolic 3-manifold theory and its links to knot theory.

1:20 - 1:35

CUSPS IN KNOT COMPLEMENTS AND HYPERBOLIC 3-MANIFOLDS

**Adam Comstock**  
Williams College

If we drill a knot out of space, we can get a hyperbolic 3-manifold. We can then look at a tubular neighborhood around the missing knot, called a cusp, which generates a beautiful pattern of horoballs in hyperbolic space. These horoball diagrams are fascinating because they can be used to give us good bounds on the lengths of curves around our cusp and on its volume. Pictures will be included!

1:40 - 1:55

IMMERSED SURFACES IN HYPERBOLIC 3-MANIFOLDS

**William D. Gillam**  
Wesleyan University

Although surfaces which cross themselves may not seem interesting on their own, when placed (immersed) in a 3-manifold or knot complement, these generalized surfaces often intersect interesting parts of the manifold called cusps. Using hyperbolic geometry, the areas of these intersections can be used to find bounds on curve lengths, surface areas, and even volumes.

FRIDAY

AUGUST 3, 2001

2:00 - 2:15

CLEAN GEODESIC JOURNEYS THROUGH HYPERBOLIC MANIFOLDS

**James Fowler**  
Harvard University

Travelling in "hyperbolic manifolds" is fun, but dangerous. You might walk into a dirty cusp and hurt yourself! We'll learn about safe hyperbolic hiking by finding "clean geodesics" avoiding the dirty cusps. Along the way, we'll discover amazing connections to number theory.

2:20 - 2:35

## CRITICAL NUMBERS OF POLYNOMIALS AS A FUNCTION OF ROOT LOCATION

**Matthew J. Wells**

Grand Valley State University

We examine certain polynomial functions and how a given critical number is a function of the location of surrounding roots. We'll also explore how critical numbers changed when roots are "dragged" in a consistent manner. Some interesting results on where critical numbers cannot lie will also be discussed.

2:40 - 2:55

## RANDOM NUMBERS AND THE TI-83 CALCULATOR

**F. Ronald Ogborne III**

SUNY College at Fredonia

The TI-83 uses a combination of Linear Congruential Generators in its pseudo-random number generator. We will propose, test, and discuss a modified generator implementing a theorem stating that, for any positive irrational number  $x$ , the decimal parts of the sequence  $\{x, 2x, 3x, \dots\}$  are uniformly distributed on the interval  $(0, 1)$ .

FRIDAY

AUGUST 3, 2001

**MAA Session #7**

**Hall of Ideas E - Monona Convention Center**

**3:00 P.M. - 4:35 P.M.**

3:00 - 3:15

THE PROBABILITY OF RANDOMLY GENERATING A FINITE GROUP

**Kimberly L. Patti**  
St. Louis University

This talk considers the problem, given a finite group with  $n$  generators, what is the probability that  $n$  randomly chosen elements generate the group? This talk investigates this problem for some specific finite cyclic and non-cyclic groups. Examples for these specific groups are also provided.

3:20 - 3:35

DISTINCT ELEMENT VECTORS OVER FINITE GROUPS

**Cody Patterson**  
Texas A&M University

Given a group  $G$  of  $n$  elements, a *distinct element vector (DEV)* over  $G$  is an  $n$ -vector over  $G$  with  $n$  distinct components. We say  $G$  is 2-summable if there exist two *DEV*'s over  $G$  whose componentwise product is a *DEV*. I will give some partial characterizations of 2-summable groups.

3:40 - 3:55

IDEMPOTENT COCYCLES ON CYCLIC GROUPS

**John Meth**  
Indiana University

Let  $G$  be a finite group. An idempotent cocycle on  $G$  is a function  $e : G \times G \rightarrow \{0, 1\}$  satisfying  $e(g_2, g_3)e(g_1, g_2g_3) = e(g_1, g_2)e(g_1g_2, g_3)$  for all  $g_1, g_2, g_3 \in G$ . These cocycles arose in the work of Haile, Larson, and Sweedler. We classify these cocycles for  $G$  cyclic of moderate size.

FRIDAY

AUGUST 3, 2001

4:00 - 4:15

RESPONSE TIME VS. ACCURACY IN HUMAN LEARNING OF BOOLEAN CONCEPTS

**Amy R. Young**  
Southwest Texas State University

120 participants were given a computerized concept test based on Boolean expressions, presented as geometric objects. This experiment tested the hypothesis that the less time on average that a participant took deciding whether an object represented the concept or not, the more likely they would answer incorrectly.

4:20 - 4:35

USING COMPLEX NUMBERS IN GEOMETRIC PROOFS

**Beth Rybak**  
South Dakota State University

This presentation will show how complex numbers are used to make geometric proofs simpler by

replacing cleverly used theorems with algebraic computations.

FRIDAY

AUGUST 3, 2001

**MAA Session #8**

**Hall of Ideas F - Monona Convention Center**

**3:00 P.M. - 4:35 P.M.**

**The speakers in this session are students of Professor Cesar Silva in the REU Program at Williams College.**

3:00 - 3:15

DOUBLE ERGODICITY, GENERALIZATIONS, AND RANK-ONE INFINITE  
MEASURE-PRESERVING TRANSFORMATIONS I

**Deepam Patel**

Brandeis University

We discuss characterizations of doubly ergodic and power doubly ergodic rank-one infinite measure-preserving transformations. We also discuss generalizations in the presence and absence of properties such as multiple recurrence and power-weakly-mixing.

3:20 - 3:35

DOUBLE ERGODICITY, GENERALIZATIONS, AND RANK-ONE INFINITE  
MEASURE-PRESERVING TRANSFORMATIONS II

**Robert Waelder**

University of California, Berkeley

We discuss explicit examples of rank-one transformations exhibiting double ergodicity and generalizations thereof. In particular, we discuss some dynamical features of staircase and step staircase transformations.

3:40 - 3:55

MULTIPLE RECURRENCE AND OTHER DYNAMICAL PROPERTIES OF INFINITE  
MEASURE-PRESERVING TRANSFORMATIONS I

**Fred Hines**

Williams College

A transformation is defined as multiply recurrent if it is  $d$ -recurrent for any positive integer  $d$ . We discuss  $d$ -recurrence and multiple recurrence in the presence and absence of other properties of infinite measure-preserving transformations.

FRIDAY

AUGUST 3, 2001

4:00 - 4:15

MULTIPLE RECURRENCE AND OTHER DYNAMICAL PROPERTIES OF INFINITE  
MEASURE-PRESERVING TRANSFORMATIONS II

**Kathleen A. Gruher**

University of Chicago

Details of the relationship between multiple recurrence and other dynamical properties of infinite measure-preserving transformations are not fully known. Examples of various infinite measure-preserving transformations satisfying multiple recurrence and other dynamical properties will be discussed.

4:20 - 4:35

RANK-ONE MIXING AND UNIFORM ERGODICITY

**Darren Creutz**  
Williams College

We study mixing for rank-one finite measure-preserving transformations and show that a rank-one transformation satisfying a condition called restricted growth is mixing when its spacer sequence is uniformly ergodic. Uniform ergodicity of the spacer sequence is a generalization of ergodic sequences and Cesaro averaging to what we call dynamical Cesaro averaging.