Michigan Undergraduate Math Conference, October 30, 2004
Abstracts of Talks

9:30 AM, Dow 136

Careers in Industrial Mathematics

Dr. Charles R. MacCluer, Coordinator, proMSc program in Industrial Mathematics, Michigan State University

The new professional science Masters (PSM) degrees provide graduates with a large choice of rewarding careers in science project management. Modern science-driven industries require managers with advanced scientific training plus an understanding of the commercial implications of their work.

We will survey the proMSc industrial mathematics programs available nationwide and detail the industrial program at Michigan State. We will sample the many directions taken by our graduates.

9:30 AM, Dow 170

N Men, a Monkey and Some Coconuts

William Green, Albion College

A classic Diophantine equation is that of 3 men stranded on an island with a monkey and some number of coconuts. Through a series of equal divisions, each man subsequently takes one-third of the pile and leaves one coconut for the monkey. Simple analysis of this problem yields a family of solutions. What will happen if the same pattern of division is applied to 4, 5 or, more generally, N men? Solutions will be presented and derived for 3 and 4 men as well as a proof showing the answer for any number N.

(Advisor, Mark Bollman, Albion)

9:30 AM, Dow 179

Exploring the Lanczos Derivative

Nathanial Burch, Grand Valley State University

Developed in the 1950's, the Lanczos Generalized Derivative (LGD) is an integral-based, proper extension of the derivative. Lanczos' original construction of this derivative utilized a process of discretization and linear regression. Building upon this statistical origin of the LGD, we construct a new quantity called "instantaneous correlation," which is analogous to the usual discrete linear correlation coefficient. We show that the situation of a nonzero, normal derivative corresponds to perfect negative or perfect positive instantaneous correlation.

We also demonstrate how the LGD is a symmetric form of the so-called "Least-Squares Derivative" developed by Kopel and Schramm in 1990. This fact

yields an orthogonal polynomial interpretation of the LGD, a result that allows us to construct higher-order Lanczos' Generalized Derivatives. Such derivatives arise as convolutions involving Legendre Polynomials.

(Advisor, Dr. Paul Fishback, GVSU)

10:00 AM, Dow 136

The Graduate Program in Biostatistics

Dr. Jack Kalbfleisch, University of Michigan, Ann Arbor

The Department of Biostatistics in the School of Public Health at UM has graduate programs leading to the Master of Science, Master of Public Health and PhD degrees. Biostatistics concerns the study and development of statistical methods for the design and analysis of studies in biological and health sciences. We have a strong theoretical component in the Department and many links with researchers in public health, medicine, biology, genetics and bioinformatics.

If you enjoy the mathematical sciences and have an interest in applications of mathematics and statistics to the life sciences, you should think about biostatistics. Our Department is internationally known for research in survival analysis, bioinformatics, clinical trials, statistical genetics, image analysis, clinical trials and many other areas. Our Masters and PhD programs lead to a high demand market with many interesting challenging jobs.

In this talk, I will describe some background to the theoretical work done in analysis of survival and life history data, and also provide a preview of our Department and its activities.

10:00 AM, Dow 170

Order of the Group of Units in the Quaternions Modulo n

Andrew Wells, Hope College

This talk is on research conducted this summer at an REU program. The quaternions over the group of integers mod n form a ring. Explicitly, we are talking about the set of all $a+bi+cj+dk$ where a, b, c, and d are all elements of the integers mod n. This talk starts with some definitions of rings and units. It discusses the requirement for an element of this ring to be a unit, then discusses the number of units when n is 2. Finally, it finds the number of units of the ring when n is any prime number. Basic knowledge of group theory is needed.

(Advisor, Dr. Darin Stephenson, Hope College)

10:00 AM, Dow 179

Modeling Baseball as a Markov Chain

Thomas Kennedy, Grand Valley State University

A half inning of baseball can be modeled using a Markov chain. There

are 25 different out-base runner situations in baseball. We estimate a transition matrix that gives the probability of going from one state to another using actual play-by-play data. We discuss the relative importance of pitching and hitting to team performance.

(Advisor, Dr. John Gabrosek)

10:30 AM, Dow 136

A Survey of Graduate Programs in Mathematics Education

Dr. Katrina Piatek-Jimenez, Central Michigan University

During this talk, I will briefly discuss what research in Mathematics Education entails. I will provide information about a variety of graduate programs in Mathematics Education, including the program at Central Michigan University. To conclude this talk, I will address the current job market for this discipline.

10:30 AM, Dow 170

The Geometry of $\mathcal{H}(\mathsf{R}^n)$

Kristina Lund, Grand Valley State University

The collection of all non-empty compact subsets of R^n forms a complete metric space, $\mathcal{H}(\mathsf{R}^n, h)$ where h is the Hausdorff metric. This space in an important one for several reasons. For example, this is the natural space in which to study fractals. Applications of this metric can be found in image matching, in visual recognition by robots and in computer-aided surgery. In this presentation I will provide essential background information on $\mathcal{H}(\mathsf{R}^n)$ and basic results from our efforts to understand the geometry of this space.

(Advisor, Dr. Steven Schlicker, GVSU)

10:30 AM, Dow 179

Analysis of the Conditioning Effect of Future Polynomial Regularization

Daniela Banu, Hope College

In certain situations input data which is slightly inaccurate can give rise to grossly inaccurate solutions. The Volterra integral equations represent a class of functions that have this problem. We analyze a regularization technique that fixes the tendency for solutions to "run away" when solving the Volterra integral equation. In particular we analyze the condition numbers of matrices arising in a discrete version of a problem before and after regularization.

(Faculty advisor, Dr. Aaron Cinzori, Hope College)

11:00 AM, Dow 136

The Grand Valley State University REU

Ed Aboufadel, Matt Boelkins, Paul Fishback, Steve Schlicker, Grand Valley State University

Grand Valley State University will be hosting a Research Experiences for Undergraduates (REU) next summer, pending funding from the National Science Foundation. Four faculty will work with 8 students on problems on wavelets, Hausdorff geometry, generalized Lanczos derivatives, and the geometry of polynomials. This talk will give the details of the program, and will describe some of our past work and problems for the summer of 2005.

11:00 AM, Dow 170

Bases of Spaces of Modular Forms with Weight 3/2.

Chelsea Walton, Michigan State University

The aim of this research is to construct a basis for the space of modular forms with weight 3/2. Building on the work of Serre and Stark, a modular form subspace is initially constructed with certain ternary quadratic forms. These ternary forms result in theta series that are modular forms with weight 3/2. At various levels N, the dimension of these subspaces are compared with the dimension of the whole modular form space. If necessary, different types of modular forms with weight 3/2 are added to the subspace. Once the whole space is constructed for numerous levels, a conjecture for the basis of the space is formed.

(Advisor, Drs. Neil Calkin and Kevin James, Clemson University 2004 Summer REU)

11:00 AM, Dow 179

Optimizing the World, One Human at a Time

Jonathan Oaks, Ferris State University

It's effective. It's practical. It's clever. It's out to make all of us more productive. It's operations research. There's almost no big business today that doesn't have an OR department. It's saved some companies millions of dollars. What is operations research, how did it start, and how has it affected you already? This talk will tell about the many problems that can be solved using operations research and why it's a field that's not just for mad scientists anymore!

(Advisor, Mr. Robert McCullough)

11:30 AM, Dow 171

Proving What Counts by Counting to Prove

Dr. Jennifer Quinn, Occidental College, Los Angeles, CA

Counting proves to be a very useful mathematical tool. Every proof in this talk reduces to a counting problem – typically enumerated in two different ways. Counting leads to beautiful, often elementary, and very concrete proofs. While not necessarily the simplest approach, it offers another method to gain understanding of mathematical truths. To a combinatorialist, this kind of proof is the only right one. I have selected some favorite identities using Fibonacci numbers, Binomial coefficients, Stirling numbers and more. Hopefully when you encounter identities in the future, the first question to pop into your mind will not be "Why is this true?" but "What does this count?".

12:30 PM, near Dow 102...

LUNCH!

1:30 PM, Dow 107

Graduate Program in Mathematics at Central Michigan University

Dr. Mohan Shrikhande, Central Michigan University

This is a presentation on the graduate programs in mathematics at Central Michigan University. CMU's Department of Mathematics offers two graduate degree programs: A M.A. degree program and a Ph.D. in Mathematics with a Teaching emphasis at the collegiate level. Details about these degree programs, faculty research interests, and information about financial aid will be provided.

1:30 PM, Dow 136

The Graduate Program in Mathematics at the University of Nebraska-Lincoln

Dr. Mohammad Rammaha, University of Nebraska-Lincoln

The Graduate Program in Mathematics at the University of Nebraska has been granting Ph.D.'s for over one hundred years and has become a highly respected program nationwide. We are a friendly department that prides itself on diversity, on mentoring, and particularly on the attention and care it pays to its graduate students.

About 60 graduate students are funded through Graduate Teaching Assistantships, GAANN Traineeships, and NSF-funded MCTP Traineeships. Various fellowships, including the prestigious 3-year Othmer Fellowships, enhance the financial aid packages offered to top applicants.

In this talk, I will give more details about the program, the university, and financial support available.

1:30 PM, Dow 170

Optimal Pebbling Number of a Graph

Kelly VanOchten, Central Michigan University

Consider a distribution of pebbles on the vertices of a graph G. A (p, k) *pebbling step* involves removing p pebbles from a vertex, paying a "toll" of $p-k$ pebbles, and moving the remaining k pebbles to an adjacent vertex. The *optimal pebbling number* of G, denoted $opt(G)$, is the smallest number of pebbles needed such that every vertex in G is pebbleable by a sequence of $(2, 1)$ pebbling steps for a particular distribution of that number of pebbles. We present results on optimal pebbling numbers for diameter 3 graphs and some possible generalizations to graphs of diameter d.

(Faculty advisor: Sivaram Narayan)

1:30 PM, Dow 179

Piecewise-linear Spirals

Andrew Craker (U. Notre Dame) & Erin M. Wicker (Alma College)

Originating from a "problem of the week" at Calvin College, we explore a process that begins with a polygon and generates additional points that spiral inwards to a point of convergence. We focus on the question of measuring the length of their path when the initial polygon is a triangle using geometric series and linear algebra. In particular, given P_0, P_1, P_2 and $t \in (0, 1)$ with $P_{k+3} = tP_k + (1-t)P_{k+1}$ for $k \geq 0$, we investigate the length of the resulting piecewise-linear spiral through these points.

(Advisor, Dr. Aaron Cinzori, Hope College)

2:00 PM, Dow 107

Research Experiences for Undergraduates at CMU

Dr. Lisa DeMeyer, Central Michigan University

Central Michigan University will host its fourth annual NSF funded REU program during the summer of 2005. We will describe our program, the problems that students will work on, and give highlights from the last several summer experiences.

2:00 PM, Dow 136

The Graduate Program in the Department of Mathematical Sciences at Michigan Technological University

Dr. Jianping Dong, Michigan Technological University

This talk will give a general view of the graduate program in the Department of Mathematical Sciences at Michigan Tech. The department has 28 tenure track faculty and 35 graduate students. The research activity of our faculty is focused on three areas: Applied Mathematics; Discrete Mathematics; and Statistics. Both MS and Ph.D degrees are offered in the above three areas. In addition, a MS degree is offered in the area of Pure Mathematics. Our faculty publish about 50 - 70 refereed papers per year and one third of our faculty receive external support from federal agencies such as NSF, NIH, NSA, and DOD. Our MS graduates have an excellent placement record. They have obtained teaching positions at junior and community colleges, insurance companies, drug companies, and federal agencies. Our Ph.D students have obtained tenure track positions at universities and at federal agencies.

2:00 PM, Dow 170

The (p, k) Pebbling Number of Diameter 3 Graphs

Jessica Muntz, Central Michigan University

Consider a distribution of pebbles on the vertices of a graph G. A (p, k) pebbling step involves removing p pebbles from a vertex, removing $p-k$ pebbles from G and moving the remaining k pebbles to an adjacent vertex. The (p, k) pebbling number of G is the smallest number of pebbles needed so that for every distribution of a certain number of pebbles, every vertex in G is pebbleable by a sequence of (p, k) pebbling steps. The (p, k) pebbling number of G is denoted $f(G)$. Results on $(2, 1)$ and (p, k) pebbling for diameter three graphs will be presented.

(Advisor, Dr. Sivaram K. Narayan)

2:00 PM, Dow 179

Optimization and Regional Cost Analysis for Wind/Diesel Hybrid Systems in Remote Alaska

Jennifer Bakisae, John Carroll University

The cost to deliver diesel fuel to remote native Alaskan villages for power generation is high due to severe weather and challenging terrain. Using wind turbines for power generation in these remote areas might be the solution! This presentation will discuss data collection and mathematical and computer modeling used to decide the feasibility and cost effectiveness of using wind/diesel hybrid systems for power generation. This analysis, done this past summer,

is part of a larger initiative by Department of Energy and the Alaskan state government to improve the quality of life for remote Alaskan villagers.

(Advisor, Dr. Leo Schneider, John Carroll Univ.)

2:30 PM, Dow 107

Actuarial Careers at Auto-Owners

Brandi Holly & Ted Reinbold, Auto Owners Insurance

A brief discussion about what qualities are important for a successful actuary and a few examples of mathematical concepts used on the job. Questions about Auto-Owners or the actuarial profession are welcome.

2:30 PM, Dow 136

The University of Kentucky Graduate School Program

Matt Benander & Erin Militzer, University of Kentucky

The Department of Mathematics at University of Kentucky offers programs leading to the degrees of Master of Arts, Master of Science and Doctor of Philosophy. The department maintains a colloquium series as well as many weekly research seminars. The colloquium brings distinguished visitors to the campus. The graduate students also have a seminar weekly where graduate students and visitors can present research in a more relaxed environment. Financial support for graduate students is available in the form of Teaching Assistantships, Fellowships and Research Assistantships; these are awarded on a competitive basis.

2:30 PM, Dow 170

Tight Subdesigns of the Higman-Sims Design

Steven Klee, Valparaiso University

The Higman-Sims design is an incidence structure of 176 points and 176 blocks of cardinality 50 with every two blocks meeting in 14 points. The automorphism group of this design is the Higman-Sims simple group. We demonstrate that the point set and the block set of the Higman-Sims design can be partitioned into subsets $X_1, X_2, ., X_{11}$ and $B_1, B_2, ..B_{11}$, respectively, so that the substructures (X_i, B_i), $i = 1, 2, .., 11$, are isomorphic symmetric $(16, 6, 2)$-designs.

(Advisor, Yury Ionin, CMU)

2:30 PM, Dow 179

A Mathematical Model of a Tri-Trophic Interactions

Michael Cortez & Michael Nelsen, Hope College

While more difficult, the analysis of tri-trophic systems yields more insight than more commonly studied predator/prey models. Using non-linear differential equations, we modeled the interactions between a grass infected by a fungal endophyte, an herbivore, and a parasitoid. Analysis was conducted both experimentally and theoretically.

(Advisors, Dr. Janet Andersen and Dr. Tom Bultman, Hope College)

3:15 PM, Dow 107

Informal conversations about actuarial science with Brandi Holly and Ted Reinbold, Auto Owners Insurance.

3:15 PM, Dow 136

Be safe: use LaTeX.

Michael Farmer, Oakland University

LaTeX is the program used to create mathematics papers and texts. It is an exceptionally helpful and useful tool for any math major to know how to use. Unfortunately, few undergrad students have even heard of, let alone know how to use LaTeX. It is, however, very easy to use; this presentation should provide students with the knowledge necessary to install LaTeX, format a document, and use many of the important commands. After attending this short talk, students should be able to create a well formatted math paper using LaTeX.

(Advisor: Dr. Eddie Cheng)

3:15 PM, Dow 170

A Demonstration of the Countability of the Rationals

Aaron Satterlee, Central Michigan University

Many proofs exist to show that the rational numbers are countably infinite. This demonstration takes the Calkin-Wilf (C-W) method of showing this, namely by mapping the natural numbers to the positive rational numbers using a binary-tree-like representation, and expands upon it. A self-designed computer program visually demonstrates the C-W method in addition to demonstrating an inverse mapping from the positive rational numbers to the natural numbers. Topics discussed will include the mechanics of the computations, the limitations of such a method, and possible ways to expand the ability of the program (i.e. how to include 0 and the negative rational numbers). (No programming knowledge necessary.)

3:15 PM, Dow 179

Genes That Are, And Are Not

Tiffany Prest, Michigan State University

Pseudogenes, are inactive, yet seem to persist in bacteria. *Mycobacterium leprae* harbors pseudogenes in about 2/3 of its chromosome. This study compared information properties of functional and pseudo genes in *M. leprae* to related genes in *Mycobacterium* tuberculosis. Pair-wise comparisons of information property vectors of orthologous gene sets revealed patterns that distinguished functional genes from pseudogenes. χ^2 and cross correlation comparisons of 59 dimensional vectors of relative codon frequencies for each gene compared to the genomic mean, and of 20 dimensional vectors of relative amino acid coding frequencies for each gene with its genomic mean, distinguished the vector patterns of pseudogenes from functional genes.

Pseudogenes were also distinguished from functional genes by differences in ratios of synonymous to non-synonymous variation. Vectors of information properties can distinguish pseudogenes from functional genes in closely related bacteria and show promise to distinguish functional genes from pseudogenes within a single genome.

(Faculty advisor: Dr. Julius H. Jackson, Michigan State University)