## Keynote Lectures

### MATHEMATICAL CRANKS
Underwood (Woody) Dudley, DePauw University

When people think of mathematical cranks (it they ever do), it's probably along the lines of "Oh, those nuts who square the circle and trisect the angle." This is an erroneous view. Cranks are usually not nuts and they attack, and think they have solved, an amazing variety of problems. This talk will give a brief survey of this vast field.

### CALCULUS BOOKS
Underwood (Woody) Dudley, DePauw University

Calculus books are important. This talk will give a survey of what has been and should be in calculus books from 1696 to the present. Seven important conclusions will be drawn, numbered so they cannot be missed.

## Mathematics Student Papers

### DIFFERENCE SETS IN GROUPS OF ORDER 70
Benjamin Skalland, Grinnell College

A Difference Set is a set of elements from a group such that each non-identity element of the group can be expressed, in the same number of ways, as a difference between elements of the set. Not all groups contain non-trivial difference sets, and while much is known about the existence of difference sets in Abelian groups, finding difference sets in non-Abelian groups is difficult. In our work, we used ideas from integral group rings, group representation theory, and algebraic number theory to narrow down the search for difference sets within two non-Abelian groups: $D_7 \times \mathbb{Z}_5$ and $D_5 \times \mathbb{Z}_7$. Then, by using the computer to sift through the remaining possibilities for difference sets in these groups, we were able to conclude that neither group contains a non-trivial difference set.

### THE $P_0$-MATRIX COMPLETION PROBLEM
Amy Wangsness, Iowa State University

A partial matrix is a matrix where some entries are specified and some are unspecified. We consider the given entries to be unknown, and we ask whether or not we can fill in the remaining entries of the given partial matrix to a matrix of the desired type. We will mention some strategies that can be used to complete a partial matrix, and we will also look at the relation between whether a matrix can be completed or not and its underlying graph. A $P_0$-matrix is a matrix where all of the principal minors are non-negative. Research results for the matrix completion problem for $P_0$-matrices will be reported.

### DIVISIBILITY BY SEVEN
Brian Bossé, Drake University

Rules of divisibility by prime numbers have always been an interesting topic in mathematics, both for its own sake and because of the applications to coding theory. In this paper we discuss several strategies for obtaining rules for divisibility by seven.

## THE GAME OF LIFE
### Ole Nelson, Grinnell College

This paper explores the Game of Life, developed by John Conway and usually played on an infinite grid. Instead, we used various toroidal surfaces, and found patterns in glider movement, many Gardens of Eden, and numerous new cycles. Some of these cycles exhibit a fractal pattern much like Sierpinski gasket. As a result of these investigations, we conjecture that, for any dimension tori, there exists a cycle which would not cycle on the standard, infinite grid.

## INTERPOINT DISTANCES IN EQUISUM HEXAGONS WITH TWO DIFFERENT SIDE LENGTHS
### Emily Resseger, Grinnell College

Consider a hexagon with only two different side lengths. There are seven possible side length arrangements. Suppose we require the sum of the side and diagonal lengths adjacent to each vertex of the hexagon to be the same for all six vertices. Of the seven different hexagons, which are possible with the above equisum requirement? Of those that have arrangements, what is the number of different distances between the vertices? Are there hexagons in which all the distances are integers? We show the hexagon with alternating side lengths has only four interpoint distances and an infinite family of integer solutions. Of the six remaining types of hexagons, only one is known to satisfy the equisum requirement.

## THE JOY OF CRYPTOLOGY
### Valerie A. Noonan, Loras College

In this talk I will discuss the topic of cryptology with a focus on the cryptography type of cryptology. I will explain several methods of private and public key encryption. If time allows, I will also address the history of the topic, as well as previous, present, and future applications.

### Mathematics Contributed Papers

## BEGINNING A COURSE WITH WHOLENESS
### Anne Dow, Maharishi University of Management

Students who are given a real grasp of the whole of a course right at the start have an advantage as the course unfolds: in appreciation, motivation, and understanding. At Maharishi University of Management, we aim to begin our courses by teaching the whole course in three or four lessons. This can be challenging for the teacher. In this talk, I will describe how I use the history of mathematics to do this in a multivariable calculus course and in an elementary analysis course.

## ON TRANSFORMATIONS OF FUNCTIONS

Bernadette Baker, Drake University
Clare Hemenway, University of Wisconsin Marathon
Maria Trigueros, ITAM, Mexico

The pre-calculus course in this study concentrated on the teaching of some basic functions, typically linear, quadratic, exponential, logarithmic, rational functions and their properties. From the study of these functions the student is introduced to more general functions by means of transformations: translations, rotations, and stretches of the basic functions. This function concept is considered a basic pre-requisite for the understanding of the other concepts included in most undergraduate mathematics courses.

The present study has several purposes:
(1)   acquiring a better understanding of students conception of transformations;
(2)   analysis of the success of a pre-calculus course based in the teaching of transformations of benchmark functions;
(3)   analysis of whether the use of graphing calculators aid in the process of visualization and whether writing as a tool helps students make the required abstractions and transfer their understanding to other graph properties such as domain and range.

The theoretical framework used as a basis of this study is APOS (Action, Process, Object, Schema) theory. As found by other researchers, this study shows that students have less difficulties when the basic functions are linear or quadratic and that vertical transformations seem to be easier for students that horizontal ones. Additional results and discussion of pedagogical suggestions will be included.

## JAVA APPLETS FOR CALCULUS AND LINEAR ALGEBRA

David Streid, Maharishi University of Management

I will present some Java applets developed at and following an NSF sponsored workshop on Mathematical Activities Using Java. The applets are visualizations of concepts in calculus and linear algebra, such as the fundamental theorem of calculus, numerical integration, and linear transformations of the plane.

## POLYOMINOES AND THEIR ORDERS

Charles Jepsen, Grinnell College

Many interesting questions arise in a study of polyominoes, i.e., plane figures composed of unit squares placed together along their edges. When does a polyomino tile a rectangle? What is the smallest number of copies that tile a rectangle? (This is the order of the polyomino.) Will an odd number of copies tile a rectangle? We answer these questions for an infinite collection of polyominoes and describe how such an investigation fits well into our newly-instituted Senior Seminar.

## MATHEMATICAL IDEAS IN THE WORK OF M. C. ESCHER

Cathy Gorini, Maharishi University of Management

Escher used a great variety of mathematical concepts in his work, including symmetry, color symmetry, perspective, non-Euclidean geometry, and topology. This talk will look at the mathematics Escher used along with examples of his works.

## HIDDEN GROUP STRUCTURE
Ruth I. Berger, Luther College

You might have seen a problem like: "Show that $\{5, 15, 25, 35\}$ is a group under multiplication modulo 40" in Gallian's Abstract Algebra book. This is quite puzzling to students since there is no obvious identity! Even after $e = 25$ has been identified, the question of determining inverses requires some thought. The above set is in fact $5*U(8)$, but that does not immediately explain its group structure. This talk will provide the details on why $k *U(n)$ is a group under multiplication modulo $k*n$, for certain k. This will allow you to produce many more such challenging examples for your students.

## DECADES OF ITERATED STRINGS
Marc Chamberland, Grinnell College

The study of iterations of finite strings has been discovered and rediscovered since the 1920s. This talk gives a survey of this simple yet fascinating subject and makes connections to the Sierpinski gasket, Fibonnaci and Tribonnaci numbers and one-dimensional dynamics.

## CORRESPONDING STRAIGHT LINES IN AERIAL PHOTOGRAPHS.
Irvin Roy Hentzel, Iowa State University

We have two photographs of a (not necessarily planar) surface taken by cameras from slightly different positions. Points on the photographs correspond if they are the image of the same point on the surface. The points of a curve in one photograph will correspond to a curve of points in the other photograph. A straight line in one photograph will not normally correspond with a straight line in the other.
We will show that each photograph has a pencil of (straight) lines, which are corresponding. That is, we show that there will always be two corresponding points, (p in photograph P, and q in photograph Q) for which every straight line through p in photograph P will correspond to a straight line through q in photograph Q. The points p and q may lie somewhere off of their respective photographs.

## THE TRANSPORT OF HEAVY POLLUTANTS FROM GROUND LEVEL AERIAL SOURCES
Shyam L. Kalla, University of Central

Studies concerning environmental protection have lead investigators to tackle problems dealing with the transport of heavy pollutants in the atmosphere. A number of factors are involved in the process: weather conditions, type of pollutant source and properties of the pollutants. Here, first we introduce a generalized form of the Hankel transform and study some of its basic properties including the transform of a modified differential operator. Then we consider the problem of transfer of heavy pollutant (dust) from a ground level aerial source within the framework of diffusion theory. An analytical solution of the problem is obtained by an appeal to the generalized Hankel transform. The pollutant concentration inside the strip $(0 < x < L)$ is expressed in terms of flow of pollutant in the atmosphere. Some examples are given and the results are tabulated. The concentration outside the strip $(x > L)$ is obtained using an integral representation of the solution of an analogous problem with an arbitrary initial pollutant distribution. We also investigate a time dependent PDE governing the transport of heavy pollutants in the atmosphere. Finally, we consider a generalized form of a PDE dealing with the diffusion of heavy pollutants in the atmosphere. Our generalization takes into account the nonlinear case of the vertical component of the turbulent exchange coefficient.

## WHAT DO LIPSCHITZ FUNCTIONS HAVE TO DO WITH THE CANTOR-BENDIXSON THEOREM?
### Dave L. Renfro, Central College

Lipschitz functions are a useful class of functions lying between the classes of continuous functions and functions having a bounded derivative. The Cantor-Bendixson theorem for $\mathbb{R}^n$ says that any closed set is the union of a perfect set with a countable set. Although these notions are not usually associated with each other, I will show how an analysis of the Cantor-Bendixson theorem leads to Lipschitz functions.

## CERTAIN ENUMERATION PROBLEMS INVOLVING ISOTROPIC SUBSPACES
### Michael Rieck, Drake University

The maximal isotropic subspaces of a finite vector space, equipped with a suitable bilinear (or sesquilinear) form, form a distance-transitive graph called a dual polar graph. These have been extensively studied and the intersection numbers and eigenvalues of the corresponding association graph have been computed by D. Stanton. When one considers the isotropic subspaces of some arbitrary fixed dimension in place of the maximal ones, a more complicated association scheme results. Computing the intersection numbers in this case appears to be rather difficult, but certain results of an enumerative nature point the way toward a possible approach toward this goal.

## Statistics Contributed Papers

## PUTTING THE SQUEEZE ON RANDOM NUMBERS
### Russ Lenth, University of Iowa

Many new statistical methods rely on simulation techniques, and for those we need pseudo-random number generators. There are several existing techniques for testing whether an algorithm produces output that behaves like a sequence of random numbers, but many of them are awkward to use and only test specific aspects of randomness. Meanwhile, virtually everyone who uses a personal computer has software for compressing and decompressing data. One would think that random numbers should be less compressible than nonrandom numbers— thus, data-compression software could be used as the basis of a statistical test of randomness. The talk will give a brief overview of tests of randomness and of how data-compression algorithms work, and describe some of the technical issues and pitfalls of "squeeze tests" of random numbers. Simulation results will be shown.

## USING RANDOMIZATION TESTS TO STUDY INFANT HANDLING BEHAVIOR BY FEMALE BABOONS.
### Tom Moore, Grinnell College

We will examine a set of observations of a troop of 23 adult female yellow baboons at a primate preserve in Kenya. Of the 23, 11 are mothers with a single infant and our data set consists of counts of attempts by females to handle infants that are not their own. Independent of these interactions, females were ranked in a dominance hierarchy and given ranks of either low, medium, or high. The question of interest is whether these dominance hierarchy rankings carry over to infant handling. The research hypothesis is that females will tend to handle infants of females ranked the same or lower than themselves. Three-by-three contingency tables arise from cross classifying handling attempts by handler's rank and mother's rank. Descriptive analysis of the 3-by-3 table suggests support for the research hypothesis, but because counts violate assumptions of the usual chi-square tests, we use randomization tests to assess statistical significance.
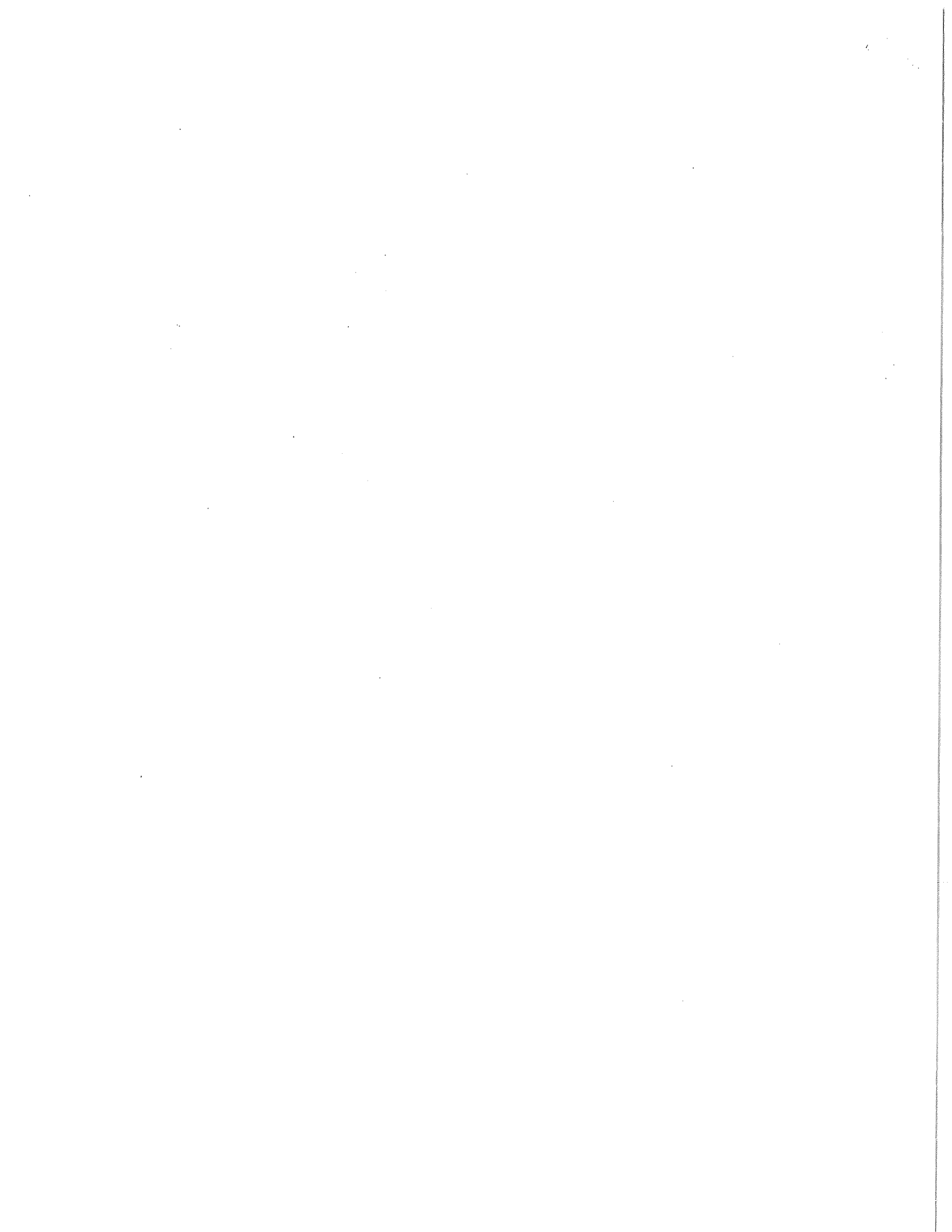
# MOUSING THROUGH THE SIMPLEX METHOD
## Al Hibbard, Central College

This talk will illustrate a button-driven application to reduce the tedium of pivoting in solving a linear programming problem. Although this is written using Mathematica, our business majors who take this course do not need to know anything about the program. After typing a matrix into a form, all subsequent tasks involve only clicking buttons. This tool is employed after students have illustrated that they have mastered and understand the technique of pivoting. Due to the symbolic nature of Mathematica, this can be readily used to perform sensitivity analysis as well.