PAST PROJECTS

Summer 2007

1. Groundwater Flow Director: Ken Luther Paper: Self-Influencing Interpolation in Groundwater Flow
   In this project we will investigate analytic (closed form) solutions to three dimensional steady state groundwater flow problems. While numerical solutions to groundwater flow problems are more commonly used in practice, especially in the three-dimensional realm where analytic solutions are cumbersome or even nonexistent, the construction of some analytic solutions is essential so that numerical models can be validated. The specific problem at hand will involve flow to a well in a stratified aquifer, and/or interaction between a horizontal well and a surface water body. *Prerequisites*: multivariable and vector calculus, linear algebra, and differential equations Exposure to partial differential equations is a plus, and experience with MATLAB is a double plus.
2. Functions on the Mosaic of n Director: Rick Gillman Paper: Mosaics: A Prime-al Art Any integer n can be uniquely factored into a product of prime powers. Each of the resulting exponents greater than 1 can, in turn, be factored into a product of prime powers. Iterating this process until there are no composite exponents results in an array of numbers called the mosaic of n. In this project we will define new arithmetic functions on the mosaic of n, and investigate their arithmetic and algebraic properties. *Prerequisites*: linear algebra or another proof-oriented course A course in elementary number theory would be helpful.
3. Understanding Mathematics Tutoring Dialogue (Computer Science project) Director: Michael Glass Paper: Computerized Tutoring As part of building dialogue-based computer tutors for mathematics, this project works on developing the techniques for computer understanding of student utterances. During the course of a tutoring conversation students can perform discourse actions such as checking whether some idea is true, asking a question, expressing confusion, and so on. Examining transcripts of tutoring sessions, this project will work on software methods for guessing the intentions behind a student's utterance. This summer's experiments may involve both numerical and symbolic methods, such as statistical models, latent semantic analysis, and finite-state machines. *Prerequisites*: one mathematics class above calculus Students should have strong programming abilities including experience in a high level language, for example Python or Lisp.

Summer 2006

1. Distributions of Interest for Quantifying Reasonable Doubt and their Applications Director: Dr. James Caristi Paper: Distributions of Interest for Quantifying Reasonable Doubt and Their Applications The concept of reasonable doubt is a standard of our legal system; however, it is a standard that is not well defined. Differences in the way reasonable doubt is applied in different courts and states, as well as ambiguities in its different definitions, suggest that the standard puts pressure on due process and equal protection concerns. This paper explores probability distributions that will aid in the understanding of the American legal system as it is today, what reasonable

doubt means under this system, and how reasonable doubt should be defined.

2. Systems of Matrix Equations Director: Dr. Patrick Sullivan Paper: On the Properties A(m,n) for Subspaces of C(kk) This project will study properties of complex matrices. The students will explore what subsets of matrices have certain properties related to rank one matrices. We will be studying when arrays of matrices can be solved simultaneously as rank one matrices up to a certain equivalence.
3. Graph Labelings Director: Dr. Zsuzsanna Szaniszlo Paper: L(3,2,1)-Labeling of Simple Graphs An L(3,2,1)-labeling is a simplified model for the channel assignment problem. It is a natural generalization of the widely studied L(2,1)-labeling. An L(3,2,1)-labeling of a graph G is a function f from the vertex set of the graph to the set of positive integers such that for any two vertices x,y, if d(x,y)=1 then | f(x)-f(y) | #3; if d(x,y)=2, then | f(x)-f(y) | #2; and if d(x,y)=3, then | f(x)-f(y) | #1. The L(3,2,1)-labeling number k(G) of G is the smallest positive integer k such that G has an L(3,2,1)-labeling number for paths, cycles, caterpillars, n-ary trees, complete graphs and complete bipartite graphs. We also present an upper bound for k(G) in terms of the maximum degree of G.

Summer 2005

1. Mathematical Models in Traffic Assignment and Congestion Pricing Director: Dr. Lihui Bai Paper: *A Genetic Algorithm for the Minimum Tollbooth Problem* This project uses rigorous mathematical models to study traffic assignment in urban transportation networks. Traffic assignment distributes vehicles in a transportation network so that certain criterion are satisfied. The study of traffic assignment models can be used in traffic congestion management, where traffic planners want to minimize the total travel delay for a given transportation network.
2. Crystallographic Groups Director: Dr. Kimberly Pearson Paper: *Virtually Cyclic Subgroups of Three-Dimensional Cyrstallographic Groups* An enumeration of the virtually cyclic subgroups of the three-dimensional crystallographic groups (â€œspace groupsâ€#) is given. Additionally, we offer explanations of the underlying group theory and develop several exclusion theorems which simplify our calculations.
3. Power Distributions in Weighted Voting Systems Director: Dr. Rick Gillman Paper: *Using Sets of Winning Coalitions to Generate Feasible Banzhaf Power Distributions* Given a weighted voting system, the Banzhaf Power Index can be used to determine the power distribution of the individual voters. We are interested in the converse of this problem: given a collection of voters, can a weighted voting system be constructed which has a prescribed power distribution? This problem has been solved for a system with four voters, but still open in more general settings.