Miscellaneous Information

The invited lectures will be held in Room 148 of Pleasant Hall. The parallel sessions for contributed papers will be held in Room 148, Room E113 (in the wing of Pleasant Hall closest to Highland Road), Room 48A-B and Room 50 (in the basement below Room 148).

Rgistration will be held in the lobby of Pleasant Hall beginning Sunday 5:00–8:00 p.m. and continuing Monday 7:45 a.m.–6:00 p.m., Tuesday 7:45 a.m.–12:30 p.m., Wednesday and Thursday 7:45 a.m.–6:00 p.m., and Friday 8:00 a.m.–12:00 noon.

To leave an important message, phone the registration desk at (225) 578-6264. There will be a bulletin board in the lobby of Pleasant Hall.

Word processing, photocopying, and blank transparancies are available at Kinko's behind Pleasant Hall on State Street.

Coffee, soft drinks, and rolls will be available in the south half of Room 148 Pleasant Hall beginning Monday morning.

A book display will be set up in the library of Pleasant Hall, which is a small room adjoining the lobby.

A shuttle bus service will run between the conference hotel and Pleasant Hall. A schedule of times of service will be available at the hotel and conference registration desks.

SOCIAL EVENTS

Sunday, February 25

The Pre-Conference Mixer will be held from 6:00 to 8:00 p.m. in Room 148 Pleasant Hall. The registration desk will be open from 5:00 to 8:00 p.m. in the lobby of Pleasant Hall.

Monday, February 26

The Conference Wine-and-Cheese Reception will be held from 6:00 to 8:30 p.m. in the Faculty Club on Highland Road diagonally opposite the Student Union.

Tuesday, February 27

There will be a bus trip to New Orleans to view some of the Mardi Gras parades. The cost will be $30 per person. The bus will leave Pleasant Hall at 1:30 p.m. and leave New Orleans to return to Pleasant Hall at 10:30 p.m. Please sign up for this trip at the registration desk. Space is limited and will be allocated on the first-come first-served basis.

Wednesday, February 28

The Conference Louisiana Banquet will be held from 7:00 to 10:00 p.m. in the Cotillion Ballrom of the LSU Student Union Building. Beer, wine, and soft drinks will be available at a cash bar. This will be a buffet.

Thursday, March 1

A Survivors' Dessert Party will be held from 8:00 to 9:30 p.m. in Room 148 of Pleasant Hall.

INVITED INSTRUCTIONAL LECTURES

All invited lectures will be held in Room 148 of Pleasant Hall.

Monday, February 26

Professor Herbert Wilf of the University of Pennsylvania will lecture at 9:00 a.m. on *Search Engines, Eigenvectors, and Chromatic Numbers*, and at 1:30 p.m. on *The Lean, Mean, Bijection Machine.*

Tuesday, February 27

Professor Paul Seymour of Princeton University will lecture at 9:00 a.m. on *The Structure of Berge Graphs.*

Wednesday, February 28

Professor Noga Alon of Tel Aviv University will lecture at 9:00 a.m. on *Polynomials in Discrete Mathematics I: Geometric and Number Theoretic Applications*, and at 1:30 p.m. on *Polynomials in Discrete Mathematics II: Graph Theoretic Applications.*

Thursday, March 1

Professor Alexander Schrijver of CWI and the University of Amsterdam will lecture at 9:00 a.m. on *Permanents and Edge-Colouring* and at 1:30 p.m. on *Graph Embedding and Eigenvalues.*

Friday, March 2

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Wine and Cheese Reception

Monday

Invited Instructional Lectures

Monday 9:00–10:00, Room 148

Search Engines, Eigenvectors, and Chromatic Numbers

Herbert Wilf, University of Pennsylvania

A search engine can return a list of hits ranked in descending order of importance. How can they determine the importance of the web sites involved? The Kendall-Wei ranking scheme uses the Perron eigenvector of the matrix whose elements measure the influence of each site on the others. We will discuss this scheme, and the Perron-Frobenius theorem that underlies it. Applications will be given to web search, ranking of tournaments, football pools, etc.

Monday 1:30–2:30, Room 148

The Lean, Mean, Bijection Machine

Herbert Wilf, University of Pennsylvania

Beginning in the 1980's and continuing to the present, great strides have been made towards the goal of automating the discovery of bijective mappings that establish counting theorems in combinatorics. These include the Garsia-Milne Involution Principle, and later work by Remmel, Gordon, O'Hara, myself, and others. We'll survey these results, particularly as they apply to integer partitions, where they supply automated discovery and proof of theorems of the form "There are the same number of partitions of n such that … as there are such that … ".

Monday, 10:20–10:35

Room 148

The Crossing Number of $C_m \times C_n$

Jay Adamsson, Department of National Defence, Canada

Motivated by the problem of determining the crossing number of the Cartesian product $C_m \times C_n$ of two cycles, we introduce the notion of an (m, n)-arrangement, which is a set $\{S, T, C_1, C_2, \ldots, C_n\}$ of closed curves and a set $\{P_1, P_2, \ldots, P_m\}$ of paths in the plane, such that S and T are disjoint and in the same face of $C_1 \cup C_2 \cup \ldots \cup C_n$, each P_i joins a point on S to a point on T, and each P_i has a vertex $v_{i,j}$ on C_j so that in traversing P_i from S to T, the $v_{i,j}$ occur in the order $v_{i,1}, v_{i,2}, \ldots, v_{i,n}$. The main result is that every (m, n)-arrangement has at least $(m - 2)n$ crossings. This is used to show that "(m, n)-circular arrangements" (no S and T and the P_i are closed curves) which can be broken up into disjoint arrangements have $(m - 2)n$ crossings. This last fact implies that the crossing number of $C_7 \times C_n$ is $5n$, in agreement with the general conjecture that the crossing number of $C_m \times C_n$ is $(m - 2)n$, for $3 \leq m \leq n$.

Room E113

The Isometry Dimension of a Finite Group

Michael O. Albertson*, Smith College
Debra Boutin, Hamilton College

A set of points W in Euclidean space is said to *realize* the finite group G if the isometry group of W is precisely G. Using the Cayley graph and the Implicit Function Theorem we show that every finite group G can be realized by a finite subset of some R^n, with $n < |G|$. The minimum dimension of a Euclidean space in which G can be realized is called its *isometry dimension*. We report on work of ourselves and others specifying the isometry dimension of various groups.

Room 48A–B

On the Existence of Pairs of Mutually Orthogonal Symmetric Hamiltonian Double Latin Squares

A.J.W. Hilton*, University of Reading
M. Mays, West Virginia University
C.St.J.A. Nash-Williams, University of Reading
C.A. Rodger, Auburn University

A *double latin square* is a $2n \times 2n$ array on n symbols with each symbol occurring twice in each row and column. This has a natural interpretation as a 2-factorization of the complete bipartite graph $K(2n, 2n)$ in which one vertex set represents the rows and the other the columns. If this 2-factorization is in fact a decomposition into Hamilton cycles, we call the double latin square *Hamiltonian.* Two double latin squares are *orthogonal* if there are 4 pairs of corresponding cells containing each ordered pair of symbols. We discuss the problem of existence of pairs of MOSHLS($2n$), i.e. mutually orthogonal symmetric Hamiltonian double latin squares. There is a very useful interpretation in terms of graph theory which we shall discuss.

Room 50

A Characterization for a Tree to be a Unit Probe Interval Graph

Li Sheng*, Drexel University

A probe interval graph is an variation of interval graph that arose from the DNA physical mapping of molecular biology. Given a graph, and a partition of its vertex set into probe vertices and non-probe vertices. The graph is called a *probe interval graph* if an interval can be assigned to each vertex such that two vertices are adjacent if and only if their corresponding intervals have a nonempty intersection, and at least one of the interval is a probe vertex. *Unit probe interval graph* is a special case of probe interval graph where we require that all the intervals assigned to the vertices must have the same length. We give a characterization for a cycle free graph to be a unit probe interval graph using a list of forbidden subgraphs.

Monday, 10:40–10:55

Room 148

Apex Planar Graphs have bounded Detour Gap number

Michelangelo Grigni, Emory University
Papa A. Sissokho*, Emory University

Given an edge weighted graph, we want to find a spanning subgraph with low total weight, and which closely approximates shortest path distances in the original graph. Althöfer et al. presented a tradeoff between these two objectives in planar graphs. We extend their result to larger minor-closed graph families by analyzing the *detour gap number*. In particular we show that the apex of a planar graph has bounded gap number, and therefore such a tradeoff.

Room E113

Note: An Algebraic Proof of Alon's Combinatorial Nullstellensatz

Nisheeth Vishnoi, Georgia Institute of Technology

Alon proved the following using elementary ideas. Let k be a field and let $f \in k[x_1, x_2, \dots, x_n]$. Given nonempty subsets $S_1, \dots, S_n \subset k$, for $1 \leq i \leq n$, define $g_i(x_i) = \prod_{s \in S_i}(x_i - s)$. If f vanishes on $S_1 \times \cdots \times S_n$, then $f = \sum_{i=1}^{n} h_i g_i$, for some $h_i \in k[x_1, \dots, k_n]$, $1 \leq i \leq n$. In this note we give an algebraic proof of the same fact which uses some basic ideas from commutative algebra, hoping that it might lead to generalization of Alon's important result and yielding further applications.

Room 48A–B

On a Conjecture of Häggkvist on Filling Partial Latin Squares

Tristan Denley, University of Mississippi

Since Evans made his famous conjecture about partial latin squares there have been numerous attempts to generalise the condition of $n-1$ filled cells, be it to increase the number of filled cells, or limit the possible configurations. One such is the following conjecture of Häggkvist
Conjecture (1980) Any partial $nr \times nr$ latin square whose filled cells lie in $(n-1)$ disjoint $r \times r$ squares can be completed.
This talk will present some recent progress made on this conjecture.

Room 50

The Shields-Harary Number of a Tree

S.H. Holliday*, Auburn University
P.D. Johnson, Auburn University

The Shields-Harary graph parameter is a measure of the robustness or integrity of a graph. The parameters were first discussed by Frank Harary and the late Allen Shields in 1972 A.D. In this paper, we will give some results about the Shields-Harary numbers of trees.

Monday, 11:00–11:15

Room 148

Crossing Number Bounds for the Twisted Cube

Robert Cimikowski, Montana State University

The *twisted cube* has been proposed as a model for parallel computing architectures. The network is formed by exchanging a pair of independent edges of any 4-cycle of the hypercube. The resulting graph has diameter $n-1$, compared with n for the hypercube. We derive asymptotic upper and lower bounds for the crossing numbers of the twisted cube and generalized twisted cube.

Room E113

Polynomial Families Satisfying a Riemann Hypothesis

Omer Egecioglu*, University of California, Santa Barbara
C. Ryavec, University of California, Santa Barbara

Consider a linear transformation $T : \mathbb{R}[x] \rightarrow \mathbb{R}[x]$ defined on basis elements $1, x, x^2, \ldots$ by

$$T[x^k] = \frac{(x)_k}{k!}$$

where $(x)_k = x(x+1)(x+2)\cdots(x+k-1),\ k \geq 0$. We create several infinite families of polynomials of the form $T[p_n(x)]$, each member of which satisfies a Riemann hypothesis; i.e., their zeros lie on the line $[s = \frac{1}{2} + it : \ t \text{ real}]$. These include, for example, $p_n(x) = (x+r)^n + (1-x+r)^n$ for $n \geq 2$ and where r is any real number. Our proof uses a positivity argument together with certain elements of the theory of 3–term polynomial recursions. Numerical evidence suggests that the interleaving property of the zeros of orthogonal polynomials extends to the zeros of a wide class of image polynomials $T[q_n(x)]$ which satisfy 4–term and higher order recursions.

Room 48A–B

Minimal and Near-Minimal Critical Sets in Back-Circulant Latin Squares

J.A. Bate*, University of Manitoba
G.H.J. van Rees, University of Manitoba

A critical set in a latin square is a subset of its elements with the following properties.
1) No other latin square exists which also contains that subset.
2) No element may be deleted without destroying property 1.
It is conjectured that the cardinality of the smallest critical set in an NxN latin square $scs(N) = \lfloor N^2/4 \rfloor$, and that only back-circulant latin squares contain critical sets of this size. These conjectures have been proven for $N \leq 7$. In this paper, we further conjecture that in a back-circulant latin square of size $N > 4$, the critical set of size scs(N) is unique up to isomorphism, and that no critical set of size scs(N)+1 exists if N is even. Using a combination of analysis, automorphism groups, and backtrack searches, these conjectures are proven for all $N \leq 12$ except $N = 9$ and $N = 11$.

Room 50

Even Spanning Trees in Bipartite Graphs

Dean Hoffman*, Auburn University
Matt Walsh, Auburn University

A tree is defined to be even if the distance between any pair of leaves is even. We answer a question raised by Teresa W. Haynes by giving a polynomial algorithm to determine if a given bipartite graph has an even spanning tree. We also give Hall-type necessary and sufficient conditions for the existence of such a tree.

Monday, 11:20–11:35

Room 148

On the Lovász Number of Very Sparse Circulant Graphs

Reneta Barneva, Eastern Mediterranean University, TRNC.
Valentin Brimkov, Eastern Mediterranean University, TRNC.
Bruno Codenotti, IMC-CNR, Pisa, Italy
Valentino Crespi*, ISTS, Dartmouth College
Mauro Leoncini, Università di Foggia, Italy

The Lovász theta function of a graph attracts a lot of interest due to its relations to communication issues, as well as to some central combinatorial optimization problems. A remarkable property of this function is that it is computable in polynomial time, despite being "sandwiched" between two hard to compute integers, i.e., clique and chromatic number. Very little is known about the explicit value of the theta function for special classes of graphs. In this paper we undertake the investigation of the value of the Lovász function for some special classes of sparse circulant graphs. More precisely, we provide the explicit formula for the Lovász function of the union of two cycles in two special cases, and an efficient linear time algorithm, for the general case. Indeed our algorithm takes time proportional to j, where j is the displacement between the two cycles.

Room E113

Site Percolation Critical Probability Bounds for Two Archimedean Lattices

John C. Wierman, Johns Hopkins University

In a site percolation model, each vertex of an infinite connected locally-finite graph G is randomly declared to be open with probability p, $0 < p < 1$, and closed otherwise, independently of other vertices. Percolation theory is concerned with the subgraph of G induced by the set of open vertices. Of particular interest is the critical probability $p_c(G)$, above which the subgraph of open vertices contains an infinite component.

Determination of critical probabilities for periodic graphs has been a long-standing problem. Exact solutions are known for only regular trees and a small number of two-dimensional graphs. There has been continuing effort devoted to estimating critical probabilities (by the physics community), and to determining rigorous mathematical bounds for critical probabilities.

Site percolation on Archimedean lattices have been studied recently in the physics literature. A regular tiling of the plane is a tiling involving only regular polygons. An Archimedean lattice is the graph of a regular tiling of the plan which is vertex-transitive. There are exactly eleven Archimedean lattices.

We prove upper and lower bounds for the site percolation critical probabilities of two Archimedean lattices, named the (4,8,8) and (4,6,12) lattices according to the numbers of sides of successive faces around a vertex. In these cases, the upper and lower bounds are closer than for any other graph that is not exactly solved. The bounds are derived via the bond-to-site transformation, containment principle, and substitution method.

Room 48A–B

Generalized Transversals of Latin Squares

Ian Wanless, Christ Church, Oxford, United Kingdom

A Latin square of order n is an $n \times n$ matrix in which n symbols occur and each symbol occurs once in each row and once in each column. A transversal of such a square is a set of n entries which includes one representative of each row, column and symbol. We consider a generalisation of this concept, called a k-plex. A k-plex is a set of kn entries which includes k entries from each row, column and symbol. We consider questions such as which squares possess k-plexes? Going the other way, if given a partial Latin square with kn entries (k in each row,column,symbol), under what conditions can we complete the Latin square?

Room 50

A Limiting Theorem on 2-Coloured Trivalent Trees

A. Meir, York University, Canada
J.W. Moon*, University of Alberta
M.A. Steel, University of Canterbury, New Zealand

Let T_n denote one of the $(2n-5)!!$ trivalent trees with n leaves labelled $1, 2, \ldots, n$ and $n-2$ unlabelled interior nodes of degree three. Such trees are widely used to represent evolutionary relationships in biology; the labels of the leaves correspond to different species. Any binary property of the species can be represented by a 2-colouring of the associated tree T_n. The parsimony) length of T_n with respect to a given 2-colouring is the minimum number w of edges that join nodes with different colours over all the extensions of the given 2-colouring to a 2-colouring of all the nodes of T_n. This quantity w is the basis of the maximum parsimony approach for reconstructing phylogenetic trees from discrete data. A natural question in biostatistics asks for the distribution of the parsimony length w of a randomly chosen leaf-labelled trivalent tree T_n relative to a random 2-colouring in which each leaf is assigned a colour independently with constant probabilities. We show that this distribution is asymptotically normal and determine the leading terms of its mean and variance.

Monday, 11:40–11:55

Room 148

More Results on the Erdős-Gyárfás Conjecture in Claw-Free Graphs

Dale Daniel, Lamar University
Stephen E. Shauger*, Texas A&M University

We show that any claw-free planar graph with minimum degree at least three has a 2^k-cycle. Using an idea of Dean, we also show how to guarantee other cycle lengths in planar and toric graphs.

Room E113

Combinatorial Reconstruction

Luke Pebody, University of Memphis

Given an action of a group G upon a set X, a positive integer k and a finite subset S of X, the *k-deck* of S is the mapping that assigns to every $T \subseteq X$ with $|T| = k$ the number of distinct images of T under G which are subsets of S. The *reconstruction problem* for a group action $G : X$ asks for the minimal k, if such exists, such that all subsets S of X is determined, up to translation by G, by its k-deck.

Building on earlier results of Alon, Caro, Krasikov and Roddity and of Radcliffe and Scott, the author gave a complete solution to the reconstruction problem for Abelian groups. We will provide details of the proof and related results.

Room 48A–B

A Simple 6-Design on 14 Points and 5-Designs without Automorphisms from A_4

Reinhard Laue*, University of Bayreuth, Germany
Anton Betten, University of Bayreuth, Germany
Evi Haberberger, University of Bayreuth, Germany

A new simple 6-(14,7,4) design is presented with full automorphism group A_4. Combining the derived design with a residual design of one of the two known other simple 6-(14,7,4) designs with automorphism group C_{13} yield nearly 40 million isomorphism types of 5-(14,7,18) designs with trivial automorphism group.

Room 50

0-Centred and 0-Ubiquitously Graceful Trees

Frank Van Bussel, University of Toronto

We look at some empirical and theoretical results concerning graceful labellings of trees with respect to the assignment of specified labels to specified vertices. The main focus is on where in a tree the label 0 can be assigned gracefully. The following are defined:

1. *k-centred* labellings. The labelling f of the tree T is k centred if for T's centre vertex v we have $f(v) = k$. If T has odd diameter then either endpoint of the centre edge is acceptable.
2. *k-ubiquitously graceful* trees. The tree T is k ubiquitously graceful if for every vertex $v \in V(T)$ there is a graceful labelling of T such that $f(v) = k$. If T is k ubiquitously graceful for all k in the range $\{0, \ldots, |E(T)|\}$ then T is simply *ubiquitously* graceful.

We consider two very intriguing empirical findings concerning non-0-centred graceful and non-0-ubiquitously graceful trees. The first of these findings suggests that the only trees which do not possess 0-centred graceful labellings are a very small and easily characterized subset of diameter 4 trees; the second suggests that *all* trees which are not 0-ubiquitously graceful are generated by these diameter 4 trees in an exceedingly simple way. We are able to confirm these findings rigourously for all trees of diameter ≤ 4.

Monday, 12:00–12:15

Room 148

A Note on g-Outer Graphs

Onyeje Bose, Rochester Institute of Technology
Serge Lawrencenko*, Rochester Institute of Technology

We generalize the concept of an outer-planar graph G for surfaces S_g of arbitrary genus g. We suggest three definitions for a g-outer graph. All three definitions require the existence of a face which contains all the vertices of G in its boundary. We attack the problem of generalizing Harary's characterization of a 0-outer graph for g-outer graphs for a given g. Namely, we prove that there exists a characterization in terms of necessary subgraphs. Furthermore, we show that the family of necessary subgraphs is finite. However, we also show that to list all the members of that family, is analogous in difficulty to the task of characterizing the graphs of genus g in terms of forbidden subgraphs.

Room E113

On the Intersection Numbers of Association Schemes Based on Isotropic Subspaces

Michael Q. Rieck, Drake University

Let n be a positive integer and q an odd prime power. The vector space $V = \mathrm{GF}(q)^n$ equipped with an orthogonal, unitary or symplectic geometry (*i.e.* a special nondegenerate form) is said to have *Witt index d* if this is the dimension of a maximal isotopic subspace. A subspace is *isotropic* if the form vanishes identically on it. It is well known that such subspaces form the vertices of a distance-transitive graph (called a *dual polar graph*), whose intersection numbers and eigenvalues have been computed by D. Stanton and others.

Less studied seems to be the association scheme based on the isotropic m-subspaces, where $1 < m < d$ (m fixed), together with the orbitals associated with the isometry group of V acting on the set of isotropic m-subspaces. This action is generously transitive. The sizes of the orbits of the subgroup stabilizing two of these subspaces is here enumerated in a more or less direct manner, without the need for representation theory. This is accomplished by relying on a certain amount of modular lattice theory. The intersection numbers of the association scheme are then readily computed.

Room 48A–B

Colored Distance in Grid Graphs

James B. Phillips*, University of Alabama
Peter J. Slater, University of Alabama

For a graph facility location problem, each vertex is considered to be the location of a department. One seeks to optimally locate the departments in order to minimize some function of the distances between departments. For example, consider a factory that has rectangular planar area where L is the length and W is the width. Suppose that there are t-departments and department i requires a total area of n_i and the sum of the n_i's is equal to $L * W$, the total area. Members of the same department are not required to talk to each other but must talk with everyone else in each of the other departments. Here, we seek to minimize the total distance between members of different departments. We assume that each member is a 1×1 grid. Thus each department i has a total of n_i 1×1 grids, but these grids are not required to be adjacent. This is a particular instance of the colored distance problem, in which a general graph is colored with t-colors and the colored distance is the sum of the distances between vertices of different colors. Meiers and Slater studied the two color grid graph problem, and we discuss an extension of these results to the general case for t-colors where $t \geq 2$, with an emphasis on the equitable and nearly-equitable cases, where all colors occupy an equal or nearly equal number of vertices in the grid.

Room 50

The Maximum Total Relative Displacement of Permutations of a Path

Nam-Po Chiang, Tatung University, Taiwan, R.O.C.

Let $G = (V, E)$ be a connected graph and let ϕ be a permutation of V. Define the total relative displacement of permutation ϕ of G to be

$$\delta_\phi(G) = \sum_{x,y \in V} |d_G(x, y) - d_G(\phi(x), \phi(y))|$$

.

In this paper, we study the maximum value of $\delta_\phi(G)$ among all permutations of a path.

Monday, 2:40–2:55

Room 148

A Sharp Bound for the Number of Sets that Pairwise Intersect at k Positive Values

Hunter Snevily, University of Idaho

In this talk we prove that if $\mathcal{L}$ is a let of k positive integers and $\{A_1, \ldots, A_m\}$ is a family of subset of an n-element set satisfying $|A_i \cap A_j| \in \mathcal{L}$ for all $1 \leq i < j \leq m$, then $m \leq \sum_{i=0}^{k} \binom{n-1}{i}$. The case $k = 1$ was proven more than 45 years ago by Majumdar.

Room E113

Rectilinear Crossing Minimization

Nathaniel Dean, Rice University

In a *rectilinear drawing* of a simple graph G each vertex is mapped to a distinct point in the plane and each edge is represented by a straight-line segment with appropriate ends. The goal of rectilinear crossing minimization is to find a rectilinear drawing of G with as few edge crossings as possible. This minimum value $rcnG$ is called the *rectilinear crossing number* of G. Some new results on rectilinear crossing minimization are presented including (1) a mathematical programming formulation of the problem and (2) a comparative sizing of the problem for various graph families

Room 48A–B

The Frequency of Summands of a Particular Size in Palindromic Compositions

Phyllis Chinn*, Humboldt State University
Ralph Grimaldi, Rose-Hulman Institution of Technology
Silvia Heubach, California State University

A composition of a whole number n consists of an ordered sequence of numbers whose sum is n. A palindromic composition is one for which the sequence is the same from left to right as from right to left. This paper shows various ways of generating all palindromic compositions, counts the number of times each number appears as a summand among all the palindromic compositions of n, and describes several patterns among the numbers generated in the process of enumeration.

Room 50

Minimal Standard Enclosings of Triple Systems

Spencer P. Hurd*, The Citadel, Charleston, SC, USA
Dinesh G. Sarvate, The University of Charleston, Charleston, SC, USA

We solve the problem of existence of minimal standard enclosings of $X = \mathrm{BIBD}(v, k, u)$ into $Y = \mathrm{BIBD}(v+1, 3, u+w)$ for a minimal positive w. The number of points v in the design X may be any number, and the index u is 6 or less.

Monday, 3:00–3:15

Room 148

Smallest Limited Edge-to-Edge Snakes in Euclidean Tessellations

Heiko Harborth, Techn. Univ. Braunschweig, Germany

A snake is a sequence of n cells of a Euclidean tessellation such that both end cells have exactly one and all other $n-2$ cells have exactly two edge-to-edge neighboring cells. A snake is called limited if it is not a proper subsnake of another snake The minimum numbers $n = 20$, 19, and 13 of cells of limited snakes are determined for triangles, aquares, and hexagons, respectively. (Common with T. Bisztriczky)

Room E113

Minimum Number of Edges with At Most s Crossings in Rectilinear Drawings of the Complete Graph

Christian Thürmann, Technische Universität Braunschweig, Germany

The minimum number $r_s(n)$ of edges with at most s crossings in rectilinear drawings of the complete graph K_n will be discussed. Each rectilinear drawing has at least five edges without crossings for $n \geq 5$. We ask for the minimum number of vertices such that $r_s(n) = 5$.

Room 48A–B

Rises, Levels, Falls and “+” Signs in Compositions and Palindromes

Silvia Heubach*, California State University
Phyllis Chinn, Humboldt State University
Ralph Grimaldi, Rose-Hulman Institution of Technology

A composition of a whole number n consists of an ordered sequence of positive integers whose sum is n. A palindromic composition is one for which the sequence reads the same forwards and backwards. We derive results for the number of “+” signs, levels (a summand followed by itself), rises (a summand followed by a larger one), and falls (a summand followed by a smaller one) for both compositions and palindromes of n. This paper extends some of the results by Alladi and Hoggatt who considered compositions and palindromes whose only summands are 1 and 2. Several patterns for the quantities of interest will be established, as well as a connection to the Jacobsthal sequence.

Room 50

On Point Enclosings of Triple Systems

Spencer P. Hurd, The Citadel, Charleston
Dinesh G. Sarvate*, University of Charleston

We define a new minimum point enclosing and solved completely the problem using graph theory and group divisible designs for index 1,2,3,and 5 and obtained Partial results for index 4 and 6.

Monday, 3:20–3:35

Room 148

On Geometric Graphs

Horst Martini, University of Technology Chemnitz, Germany

A geometric graph $G(V, E)$ (without isolated vertices) any two edges of which intersect is said to be an intersector. (E.g., special intersectors are interesting in connection with Conway's Thrackle Conjecture.) On the other hand, $G(V, E)$ is called a successor if for each vertex v from V the subgraph of edges incident with v is a convex star whose edges form a succession in the angle ordering of their affine hulls. We present a collection of topological and combinatorial properties of such geometric graphs (and slight modifications). Further on, we will show that both these notions have surprisingly many applications, e.g. with respect to metrical problems from planar geometry. In particular, we will discuss how intersectors and successors are used for proving theorems on

- the weak circular intersection property of planar point sets,
- isoperimetric inequalities for sets of constant width,
- the time-optimal exhaustive construction of Reuleaux polygons in the spirit of computational geometry.

Room E113

On the ℓ-Distance Face Coloring of 6-Regular Plane Graphs

Wai Chee Shiu*, Hong Kong Baptist University
Peter Che Bor Lam, Hong Kong Baptist University

The ℓ-distance face chromatic number of a connected plane graph is the minimum number of colors in such a coloring of its faces that whenever two different faces are at distance ℓ or less, they receive different colors. In this paper, we estimate ℓ-distance face chromatic numbers for connected 6-regular plane graphs.

Room 48A–B

Adjacency Matrix and Eigenvalues of the Hypercube

Ke Qiu, Acadia University, Canada

We study the adjacency matrix and eigenvalues of the hypercube. In particular, we characterize the eigenvalues of the adjacency matrices of hypercubes of different dimensions, including the actual values and their multiplicity.

Room 50

Tiling with Notched Cubes

Robert Hochberg*, East Carolina University
Michael Reid, University of Massachusetts

Any polyomino which tiles a rectangle also tiles a larger copy of itself. That's been proven. It is unknown whether the converse is true—that any polyomino which tiles a larger copy of itself must also tile a rectangle. There is no great reason to believe that the converse is true, but no counterexamples have been found. We settle the question in all dimensions greater than 2 by considering a "notched cube," which turns out to have some excellent tiling properties, not the least of which is the property of having exactly one way of tiling an octant (orthant).

Monday, 4:00–4:15

Room 148

Book Embeddings of Graphs and Minor-Closed Classes

Robin Blankenship*, Louisiana State University
Bogdan Oporowski, Louisiana State University

A *book* consists of a finite collection of half-planes, called *pages*, whose boundaries have been identified to form a line, called the *spine*. A *book embedding* of a graph places the vertices on the spine and assigns edges to pages so that each edge lies on a single page and no two edges cross. The minimum number of pages needed to embed a graph in a book is the *book thickness* of the graph.

We use methods and results of Heath and a structure theorem of Robertson and Seymour to prove that for every minor-closed class of graphs, other than the class of all graphs, there is an integer K such that all members of the class have book thickness at most K.

Room E113

Random Models for the Propagation of Information in the World Wide Web

Thomas Boehme, Ilmenau Technical University, Germany
Frank Goering, Ilmenau Technical University, Germany
Herwig Unger*, University of Rostock, Germany

In this talk we consider the propagation of information in a computer network with a completely decentralized information management.

One of the models we consider consists in a finite set X which is initially partitioned into a finite number of subsets $X_1, \ldots, X_k$, called colors. The coloring $(X_1, \ldots, X_k)$ is subject to an evolutionary process as follows. In each step of this process for any element $x \in X$ a subset A_x of X is chosen at random. The color of x in the next step is determined by its actual coloring and the induced coloring of A_x. It is proved that the evolutionary process tends to a stable state whenever some natural condition are satified.

Room 48A–B

On Solvable Groups and Cayley Graphs

Edward Dobson, Mississippi State University

A graph Γ is *vertex-transitive* if $Aut(\Gamma)$, the automorphism group of Γ, acts transitive on the vertex set of Γ. Perhaps the most important class of vertex-transitive graphs are *Cayley graphs*. These graphs are most succintly described as those vertex-transitive graphs whose automorphism group contains a transitive subgroup whose order is the order of the graph. In 1983, Marušič asked for which values of n is every vertex-transitive graph of order n a Cayley graph of n? Much work has been done on this problem, and this work generally falls into two categories: those vertex-transitive graphs such that the minimal transitive subgroup of the automorphism group is solvable, and those whose minimal transitive subgroup is nonsolvable. We are interested in those vertex-transitive graphs such that the minimal transitive subgroup of the automorphism group is solvable. It is known that such a vertex-transitive graph is necessarily a Cayley graph if the number n of vertices is p, p^2, p^3, (p a prime), 12, $n = pqr$, $r < q < p$ are distinct primes and r does not divide $q - 1$ or q does not divide $p - 1$, or if the greatest common divisor of n and $\varphi(n)$ (Euler's phi function) is 1. It is also known that there exists vertex-transitive graphs whose minimal transitive subgroup of their automorphism group is solvable that are not Cayley graphs if p^2 divides n (with the above mentioned exception of $n = 12$), if there exists a primes p and q dividing n such that q^2 divides $p - 1$, or if there exists primes $r < q < p$ dividing n such that r divides $q - 1$ and q divides $p - 1$. Let n be a square-free positive integer such that the greatest common divisor of n and $\varphi(n))$ is q a prime, and if $p|n$ is prime, then $q^2 \not| (p - 1)$. We prove that a vertex-transitive graph Γ of order n is isomorphic to a Cayley graph of order n if and only if $Aut(\Gamma)$ contains a transitive solvable subgroup.

Room 50

Counting Classes of Labeled 2-Connected Graphs

Sridar Kuttan Pootheri, Lawrence Berkeley National Laboratory

Tutte's theorem decomposes 2-connected graphs into bonds and cycles with at least three edges, and 3-connected graphs. Based on this theorem unique structural characterizations of several classes of 2-connected graphs were provided in author's Ph.D. thesis.

In this paper three of the decomposition theorems are translated into exponential generating functions and exact counting equations are derived for labeled versions of minimally 2-connected graphs, 2-connected minimally 2-edge-connected graphs, and 2-connected 3-edge-connected graphs. Standard methods are then applied to count labeled 3-edge-connected graphs and minimally 2-edge-connected graphs (not necessarily 2-connected). Tables of results computed from the derived counting equations are included for all five classes of graphs.

Monday, 4:20–4:35

Room 148

Fast Generation of Graphs Embedded on the Torus

Matthew Skala*, University of Victoria, Canada
Wendy Myrvold, University of Victoria, Canada

A graph is planar if it can be drawn without any edges crossing on the plane. Similarly, a graph is toroidal if it can be drawn without any edges crossing on the torus, a surface shaped like a doughnut and created by adding one handle to the plane. A graph may be drawn on a surface in several distinct ways, called embeddings. We describe and implement an algorithm to generate, without duplication, all embeddings on the torus of graphs that are not planar, up to a chosen number of vertices and edges. The resulting lists of embeddings, as well as being of interest in themselves, are useful in investigating torus obstructions, the simplest graphs that are not toroidal.

Room E113

Reliability of Networks with Delay Constraints

Louis Petingi*, College of Staten Island
Jose Rodriguez, Long Island University

Let $G = (V, E)$ be graph with a distinguished set $K \subseteq V$. We define the K-diameter of G as the maximum distance between any pair of nodes of K. If the edges fail randomly and independently with known probabilities (nodes are always operational), we define the *Diameter-bounded K-terminal Reliability* of G, $R_K(G, D)$, as the probability that surviving edges span a subgraph whose K-diameter does not exceed D.

If, in a network (modeled by a graph $G = (V, E)$), the links fail randomly and independently, and the transmissions between every two nodes in a distinguished subset K are required to experience a maximum delay DT (where T is the delay experienced at single node), then the probability that after random failures of the communication links, the surviving network meets the maximum delay requirement is precisely $R_K(G, D)$.

The diameter-bounded K-terminal reliability measure subsumes the classical K-terminal Reliability measure $R(G)$. Indeed, $R(G) = R(G, n - 1)$ where n is the number of nodes of G. In this talk we present some results and open problems related to the Diameter-bounded K-terminal Reliability.

Room 48A–B

Long Cycles Through Many Specified Edges

Tristan Denley,University of Mississippi
Haidong Wu*, University of Mississippi

Egawa, Glas, and Locke generalized two well-known theorems of Dirac by proving the following result. Suppose that G is a k-connected graph (where $k \geq 2$) of order at least 2δ and with minimum degree δ. Then given any set S of vertices of size k, there is a cycle of length at least 2δ containing all vertices of S. In this paper, we study long cycles containing many independent specified edges or paths. Häggkvist and Thomassen proved that for any set S of independent edges of size k in a $(k+1)$-connected graph, where $k \geq 1$, there is a cycle containing all edges of S. Enomoto and Hirohata, respectively, proved that any edge in a 3-connected graph is contained in a long cycle. Suppose that G is a $(k+2)$-connected graph of order at least $2\delta - k$ and with minimum degree δ. We show that given any set of k independent edges (where $k \geq 0$), there is a cycle of length at least $2\delta - k$ containing all edges of S. We also prove some extensions which generalize Enomoto's theorem. This is a preliminary report.

Room 50

Doyen-Wilson Theorem for K_3 with Two Pendant Edges

Kimberly S. Kirkpatrick, Transylvania University

We investigate partitioning the edges of a complete graph on n vertices with a hole of size v (K_n/K_v) into isomorphic copies of K_3 with a pendant edge at two vertices. We will present the necessary and sufficient conditions as well as some of the techniques used in the proof.

Monday, 4:40–4:55

Room 148

Toward the Rectilinear Crossing Number of K_n: New Drawings, Upper Bounds, and Asymptotics

Alex Brodsky, University of British Columbia
Stephane Durocher*, University of British Columbia
Ellen Gethner, University of British Columbia

Scheinerman and Wilf (1994) assert that "an important open problem in the study of graph embeddings is to determine the rectilinear crossing number of the complete graph K_n." A *rectilinear drawing of* K_n is an arrangement of n vertices in the plane, every pair of which is connected by an edge that is a line segment. We assume that no three vertices are collinear, and that no three edges intersect in a point unless that point is an endpoint of all three. The *rectilinear crossing number of* K_n, denoted $\overline{cr}(K_n)$, is the fewest number of edge crossings attainable over all rectilinear drawings of K_n. Given an arbitrary graph G, determining a drawing of G in the plane that produces the fewest number of edge crossings is NP-Complete. The complexity is not known for an arbitrary graph when the edges are assumed to be line segments. We study the specific instance of determining $\overline{cr}(K_n)$ and we offer drawings with "few" edge crossings. The difficulty of determining the exact value of $\overline{cr}(K_n)$, even for small values of n, manifests itself in the sparsity of literature. Jensen (1971) and Hayward (1987) contribute general constructions that yield upper bounds and asymptotics, none of which lead to exact values of $\overline{cr}(K_n)$ for all n. Starting with a recursive construction of Singer (1971), we observe that the edges originating from different sides of particular subgraphs have different responsibilities (number of edge crossings). Exploiting this fact, we exhibit a recursive asymmetric construction for a family of rectilinear drawings of K_n that is asymptotically better than any other available construction; specifically, we show $\lim_{n\to\infty} \frac{\overline{cr}(K_n)}{\binom{n}{4}} \leq \frac{6467}{16848} \approx 0.3838$. Moreover, we provide some novel constructions that yield good asymptotics.

Room E113

Cliques and Independent Neighbor Sets in Random Graphs

Daniel Ramras*, Cornell University
Sam Greenberg, Oberlin College

The random graph $G(n,p)$ is the graph on n vertices formed by placing each edge with probability p. The clique number, $cl(G)$, of a graph G is the cardinality of the largest complete subgraph of G. D.W. Matula showed, in 1972, that there is a function $d(n,p)$ such that as $n \to \infty$, $P[cl(G(n,p)) = d(n,p)$ or $d(n,p)+1] \to 1$. This result was originally proven only for constant p, but has been improved to deal with any function $p(n)$ satisfying $c < p(n) < 1 - \frac{1}{n^\delta}$ for each $\delta > 0$ and for some $c > 0$. We improve this result further to deal with any function $p(n)$ satisfying $\frac{1}{n^\delta} < p(n) < 1 - \frac{1}{n^\delta}$ for each $\delta > 0$. Using this result, we then prove a similar two-point concentration on the size of the largest independent neighbor set of a vertex of $G(n,p)$. (An independent neighbor set of a vertex v is a set N of neighbors of v such that no two members of N are connected by an edge.) This concentration holds in the same range of $p(n)$ as mentioned above. Concentrations of several closely related graph invariants are also obtained. Independent neighbor sets were originally studied by Fred Galvin, and he showed that if $f(v)$ denotes the cardinality of the largest independent neighbor set of a vertex v in a graph G, then the average value of $f(v)$, taken over all vertices of G, is never more than $\frac{n}{2}$. Our results easily give the expectation of this average on $G(n,p)$.

Room 48A–B

A New Infinite Series of Edge- but not Vertex-Transitive Graphs

Felix Lazebnik, University of Delaware
Raymond Viglione*, University of Delaware

Regular edge transitive graphs that are not vertex transitive are not easy to construct. Examples of such graphs are relatively rare. We construct an infinite two-parameter family $G_n(q)$ of such graphs for any integer $n \geq 3$ when q is any prime power, and for $n = 2$ when q is an odd prime power. Graphs $G_n(q)$ are q-regular of order $2q^{n+1}$, and are connected when $n < q$. They are defined via systems of polynomial equations over the finite field $GF(q)$. Some results on the automorphism groups of these graphs are obtained.

Room 50

The Chromatic Number of the Plane: the Bounded Case

Clyde P. Kruskal, University of Maryland

The chromatic number of the plane is the fewest colors needed in order to paint each point of the plane so that no two points distance (exactly) 1 apart are the same color. It is known that seven colors suffice and at least four colors are necessary.

We investigate how large a bounded region can be, and still be 2-colorable or 3-colorable. We obtain tight bounds for coloring regions enclosed by circles, regular polygons, and rectangles.

It turns out that if a region is 2-colorable or 3-colorable, there is a simple coloring for the region. Mostly, we will look at “pretty” pictures.

Monday, 5:00–5:15

Room 148

On Imbeddings of Rejection and Exclusion of Graphs

Ghidewon Abay-Asmerom, Virginia Commonwealth University

In this paper we consider genus imbeddings of the rejection and exclusion of graphs H and G. For their vertex sets both rejection and exclusion have $V(H) \times V(G)$, the cartesian product of the vertex sets of H an G. The edge set for the rejection consists of edges $\{(u_1, v_1)(u_2, v_2)\}$ whenever $u_1u_2 \in E(\bar{H})$ and $v_1v_2 \in E(G)$. Exclusion has the edges $\{(u_1, v_1)(u_2, v_2)\}$ whenever $v_1 = v_2$ and $u_1u_2 \in E(H)$ or $u_1u_2 \in E(H)$ and $v_1v_2 \in E(\bar{G})$. We denote the rejection of H and G by H/G and that of the exclusion of H and G by $H\Theta G$. The rejection of graphs was first introduced by Harary and Wilcox.

When G is a regular graph, both rejection and exclusion can be regarded as covering spaces of voltage graphs H^* obtained by modifying H according to the configuration of G. This always starts with a suitable imbedding of H in some orientable surface followed by a modification of the edges of H to get H^*. Conditions are put on H and G so that the imbedding of the covering graph of H^* is minimal. Minimum genus results for H/G, and $H\Theta G$ of some special graphs will be presented.

Room E113

Expected Value for Trees and Rooted Graphs

Gary Gordon, Lafayette College

When G is a rooted graph where each edge may succeed with probability p, we consider the expected number of vertices in the operational component of G containing the root. This expected value $EV(G;p)$ is a polynomial in p. We present several distinct equivalent formulations of $EV(G;p)$, unifying prior treatments of this topic. Results on network resilience (introduced by Colbourn) are used to obtain complexity results for computing $EV(G;p)$. We derive closed form expressions for $EV(G;p)$ for some specific classes of graphs. For trees and rooted trees, we present extremal results that determine both the largest and smallest expected values, and precisely when these extreme bounds are achieved. We conclude by considering ‘uniformly optimal’ rooted graphs, optimal root placement and some counterexamples. (Several undergraduate students have worked on various aspects of this project, some through an NSF-REU program at Lafayette College.)

Room 48A–B

Identity Digraphs of Minimum Size

Frank Harary, New Mexico State University
Robert W. Robinson*, University of Georgia

The minimum size $\sigma(n)$ for an identity digraph of any given order n is determined in a way that provides for efficient calculation. Here the *order* is the number of vertices and the *size* is the number of edges. An *identity* digraph is one for which the identity is the only automorphism. It is shown that $\sigma(n) = n - \delta(n)$ where $\delta(n)$ is a positive nondecreasing function with growth rate $\Theta(n/\log n)$. The number $\nu(n)$ of nonisomorphic identity digraphs of minimum size and order n is also studied; it takes the value *1* infinitely often but is unbounded.

Room 50

Edge-Magic K_p

Linda Valdés, San José State University

Gerhard Ringel, one of the principal speakers at the Eighth Quadrennial International Conference on Graph Theory, Combinatorics, and Algorithms introduced several open questions. In particular, he spoke of the question of when K_p is edge-magic. He and Erdos had discovered that K_6 was edge-magic, but had not determined if this was true for any other $p > 6$. It will be shown that K_p is edge-magic only when $p = 1, 2, 3, 4$, and 6.

Monday, 5:20–5:35

Room 148

Square-Free Perfect Graphs

Michele Conforti, Università di Padova, Italy
Gérard Cornuéjols, Carnegie Mellon University
Kristina Vušković*, University of Leeds, United Kingdom

A graph is square-free if it does not contain a chordless cycle of length 4 as an induced subgraph. We prove that square-free perfect graphs are bipartite graphs or line graphs of bipartite graphs or have a 2-join or a star cutset. It follows that the Strong Perfect Graph Conjecture holds for square-free graphs.

Room E113

Self-Stabilizing Algorithms for Minimal Dominating and Maximal Independent Sets

S.M. Hedetniemi, Clemson University
S.T. Hedetniemi*, Clemson University
D.P. Jacobs, Clemson University
P.K. Srimani, Clemson University

Self-stabilization is a relatively new algorithmic paradigm for distributed computation. In a self-stabilizing algorithm each node has only a local view of the system. Yet, in a finite amount of time, the system converges to a global state satisfying some desired property. It appears that, in the literature, the only self-stabilizing method for constructing a maximal independent set or a minimal dominating set is one that is a byproduct of a coloring algorithm. In this paper we present more efficient self-stabilizing algorithms for finding a maximal independent set and a minimal dominating set in any graph.

Room 48A–B

One-Color Triangle Avoidance Games

Steven C. Cater*, Kettering University
Frank Harary, New Mexico State University
Robert W. Robinson, University of Georgia

The results of computational analysis of the game digraphs for triangle avoidance on $n \leq 12$ nodes are reported. Computational methods and related games are also discussed.

Room 50

The Fibonacci Numbers, Matching Polynomials, and Normality

Lou Shapiro*, Howard University
Frank Schmidt, Herndon, Virginia

It is easy to show, using Godsil and Harper's work on matching polynomials, that the rows of the Fibonacci matrix approach a normal distribution. It takes a bit more to find the mean and variance. We show that some similar families also approach a normal distribution and we also obtain results involving Lucas and Pell numbers using various kinds of Chebyshev polynomials along the way.

Monday, 5:40–5:55

Room 148

Query Optimization for Multilist Files Using Internal Graphs

Dionysios Kountanis, Western Michigan University
Sha Tang*, Western Michigan University

Given a multilist file structure and a query to the file, a critical question is how to minimize the number of records retrieved from the file. The file can be represented by a line graph. The graph is used to reorganize the file structure and to create an appropriate directory so the query can be processed to reduce the records retrieved from the file. The main idea in our approach is to reduce the overall overlap of lines on the line graph. Experimental results compare the new approach with other approaches to the query optimization problem. The results indicate that our process reduces the number of retrieved records.

Room E113

Self-Stabilizing Maximum Matchings

J.R.S. Blair, United States Military Academy
S.M. Hedetniemi, Clemson University
S.T. Hedetniemi, Clemson University
D.P. Jacobs*, Clemson University

Self-stabilization is a relatively new algorithmic paradigm for distributed computation. In a self-stabilizing algorithm each node has only a local view of the system. Yet, in a finite amount of time, the system converges to a global state satisfying some desired property. In the literature there exists a self-stabilizing algorithm for constructing maximal, but not necessarily maximum, matchings in any graph. In this paper we describe a self-stabilizing algorithm for finding a matching of maximum size in a tree.

Room 48A–B

Relations for Skein-Type Graph Polynomials

Joanna A. Ellis-Monaghan, University of Vermont

The Penrose, Tutte, and circuit partition (a translation of the Martin polynomial) polynomials can all be viewed, in at least certain cases, as skein-type polynomials, i.e. those that are computed via local reconfigurations at the vertices. Furthermore, these polynomials are interrelated in ways that reveal properties of important classes of graphs such as Eulerian, planar, cubic, and bipartite graphs. These interrelations also mean that new results for one of these polynomials immediately yield new insights and valuations for the others. Since significant advances have been made recently for the circuit partition polynomials, we have new results for the Penrose and Tutte polynomials as well.

Room 50

Optimal Sequenced Matroid Bases Solved by Genetic Algorithms

Michael L. Gargano*, Pace University
William Edelson, Long Island University

We consider an extension to the optimal matroid base problem whereby the matroid element costs are not fixed, but are time dependent. We propose a genetic algorithm (GA) approach to solve the optimal sequenced matroid base problem (OSMBP) by employing efficient codes which are suffixed by a standard permutation code. These novel encoding schemes insure feasibility after performing the classical operations of crossover and mutation and also ensure the feasibility of the initial randomly generated population (i.e., generation 0). A variety of real world practical matroid applications with time dependent costs will also be presented.

Tuesday

9:00–10:00

148 Paul Seymour, *The Structure of Berge Graphs*

10:00–10:20

Coffee break

10:20–10:35

148 Matt DeVos*, Paul Seymour, *Packing* T*-Joins*

E113 P.D. Johnson Jr.*, E.B. Wantland, *More Problems Involving Hall's Condition*

48A-B Dalibor Froncek, *Scheduling the Czech National Basketball League*

50 L. Goddyn*, P. Hliněný, W. Hochstättler, *Circular Chromatic Number of an Orientable Matroid*

10:40–10:55

148 E.J. Cockayne*, A.P. Burger, C.M. Mynhardt, *The* n*-Queens Problem on the Torus*

E113 Gary S. Bloom*, Samer Salame, *Constructing More Graceful Trees*

48A-B Robert C. Brigham, Gary Chartrand, Ronald D. Dutton, Ping Zhang*, *Full Domination in Graphs*

50 Manoel Lemos, *Matroids with Many Common Bases*

11:00–11:15

148 A.P. Burger, C.M. Mynhardt*, *The Queens Domination Problem on the Torus*

E113 Kengo Shirakata, Etsuro Moriya*, *Parallelization in Extended* μH *Systems and its Universality*

48A-B Varaporn Saenpholphat*, Ping Zhang, *Connected Resolvability of Graphs*

50 Talal Al-Hawary, Jenny McNulty*, *On Closure Matroids*

11:20–11:35

148 Peter Adams, Darryn Bryant, Heather Gavlas*, *Decompositions of the Complete Graph into Small* 2*-Regular Graphs*

E113 Dorothy Bollman*, Edusmildo Orozco, *A Faster Algorithm for the Solution of the* n*-Queens Problem*

48A-B Gary Chartrand, Raluca Muntean*, Varaporn Saenpholphat, Ping Zhang, *Graphs and Divisibility of Positive Integers*

50 Allan D. Mills, *Perfect Binary Matroids*

11:40–11:55

148 Andre Kezdy*, Hunter Snevily, *Distinct Sums Modulo* n *and Tree Embeddings*

E113 Patric R.J. Östergård, Alfred Wassermann*, *A New Lower Bound for the Football Pool Problem for* 6 *Matches*

48A-B Gary Chartrand, Alice Chichisan*, Ping Zhang, Curtiss E. Wall, *On Convexity in Graphs*

50 Nancy Ann Neudauer*, Brett Stevens, *Enumeration of the Bases of the Bicircular Matroid on a Complete Bipartite Graph*

12:00–12:15

148 Miklós Bartha*, Miklós Krész, *Open Graphs with Perfect Internal Matchings*

E113 L. Eugene Chipman*, Clyde P. Kruskal, *The Complexity of Some Common Strategy Games*

48A-B David Brown, J. Richard Lundgren*, Cary Miller, *On Probe-Clone Interval Graphs*

50 David Neel, *Modular Contractibility in Binary Matroids*

Invited Instructional Lecture

Tuesday 9:00–10:00, Room 148

The Structure of Berge Graphs

Paul Seymour, Princeton University

A *hole* in a graph means an induced cycle of length at least 4, and an *antihole* is an induced subgraph whose complement is a cycle of length at least 4. A graph is *Berge* if it has no odd holes or antiholes. Berge's *strong perfect graph conjecture* states that every Berge graph has chromatic number equal to the size of its largest clique, but that remains open. A great deal is known about the structure of a minimum counterexample to this conjecture, if one exists; but not so much is known about Berge graphs in general. This talk is a collection of conjectures, and some partial results, about the structure of Berge graphs. For instance, is there a reason why none of the natural classes of Berge graphs have both big holes and big antiholes?

Complicated Berge graphs show a tendency to admit *skew partitions* (a partition of the vertex set into four non-empty subsets A, B, C, D, so that there are no edges between A and B and every edge is present between C and D); and we have found some little Berge graphs so that every Berge graph containing one of our little ones must admit a skew partition. We sketch these results. This is joint work with Neil Robertson and Robin Thomas, and also partly with Jim Geelen and Carsten Thomassen.

Tuesday, 10:20–10:35

Room 148

Packing T-Joins

Matt DeVos*, Rice University
Paul Seymour, Princeton University

Let $G = (V, E)$ together with the set $T \subseteq V$ be a graft. We let $\tau(G)$ denote the size of the smallest T-cut and we let $\nu(G)$ denote the size of the largest collection of disjoint T-joins. Since every T-cut meets every T-join, $\nu(G) \leq \tau(G)$.

A number of important problems in graph theory concern finding lower bounds on ν in terms of τ. For instance, Menger's theorem on edge-disjoint paths is equivalent to the statement that $\nu(G) = \tau(G)$ when $|T| = 2$. Also, if G is k-regular and $T = V$, then $\nu(G) = \tau(G)$ if and only if G is k-edge-colorable.

We prove that $\nu(G) \geq \lfloor \frac{1}{6}\tau(G) \rfloor$ for every graft G. In the special case that G is Eulerian or $T = \{v \in V \mid \; deg(v) \text{ is odd}\}$, we prove that $\nu(G) \geq \lfloor \frac{1}{2}\tau(G) \rfloor$.

Room E113

More Problems Involving Hall's Condition

P.D. Johnson Jr.*, Auburn University
E.B. Wantland, Western College of the University of Montana

Suppose G is a simple graph, L is an assignment of finite sets ("lists") to the vertices of G, and κ is an assignment of non-negative integers to the vertices of G. A proper (L, κ)-coloring of G is a choice function ϕ on $V(G)$ such that $\phi(v) \subseteq L(v)$ for every $v \in V(G)$, $|\phi(v)| = \kappa(v)$ for each $v \in V(G)$, and $\phi(u)$ and $\phi(v)$ are disjoint, if u and v are adjacent in G.

Hall's condition is a fairly well known numerical relation involving G, L, and κ, a conjunction of inequalities necessary for the existence of a proper (L, κ)-coloring of G. There is some interest in the question of when Hall's condition is sufficient for such a coloring. Here we solve two problems:

(i) supposing V is a finite set, which $\kappa : V \to \{0, 1, 2, \ldots\}$ have the property that for every G with $V(G) = V$ and list assignment L to V such that G, L, and κ satisfy Hall's condition, there is a proper (L, κ)-coloring of G?

(ii) Which G and κ have the property that for every list assignment L to $V(G)$ satisfying Hall's condition with G and κ, there is a proper (L, κ)-coloring of G?

Room 48A–B

Scheduling the Czech National Basketball League

Dalibor Froncek, University of Vermont and Technical University Ostrava

The first part of the Czech National Basketball League is played as a two-leg round robin tournament with twelve teams. Due to the scheduling pattern used until 1999, some teams had to play six consecutive games in opponents' fields while some others played six consecutive games in their home fields. There was even one team that was scheduled to play seven out of eight consecutive games at opponents' fields.

In this talk we present several schedules that were constructed by the author for the Czech Basketball Federation. These schedules decreased the number of consecutive games in opponents' fields or in home fields to three or four, depending on the type of schedule. One of the suggested schedules was actually adopted by the Federation and used in 1999/2000 season, another one in 2000/2001.

Room 50

Circular Chromatic Number of an Orientable Matroid

L. Goddyn*, Simon Fraser University, Canada
P. Hliněný, Victoria University, New Zealand
W. Hochstättler, Universität Clausthal, Germany

An old formula of Minty expresses the (circular) chromatic number of a graph in terms of finding an orientation for which all circuits are 'balanced in ratio'. This vertex-free viewpoint allows one to extend the notion of 'chromatic number' to the very general setting of *orientable matroids* and *pseudosphere complexes*.

We give a gentle introduction to the topic and prove, with a probabilistic argument, that the circular chromatic nubmer of any loopless orientable matroid is bounded above by a function of its corank. This generalizes the fact that the chromatic number of any loopless connected graph (V, E) is bounded above by approximately the square root of its Beti number $|E| - |V| + 1$.

Tuesday, 10:40–10:55

Room 148

The n-Queens Problem on the Torus

E.J. Cockayne*, University of Victoria, Canada
A.P. Burger,University of South Africa
C.M. Mynhardt, University of South Africa

We consider the independence number of toroidal queens graphs, i.e., graphs obtained from the moves of queens on chessboards drawn on the torus, and give exact values for this parameter in infinitely many cases and bounds otherwise.

Room E113

Constructing More Graceful Trees

Gary S. Bloom*, CIty College (CUNY) and the Graduate Center of CUNY
Samer Salame, The Graduate Center of CUNY

Starting with small graceful trees, we construct families of larger and more complex trees by using the “canonical adjacency matrices” of the smaller trees. A set of matrix transformations and merging operations are the basis of these constructions.

Room 48A–B

Full Domination in Graphs

Robert C. Brigham, University of Central Florida
Gary Chartrand, Western Michigan University
Ronald D. Dutton, University of Central Florida
Ping Zhang*, Western Michigan University

For a graph G, let f be a function from $V(G)$ to the set of all subgraphs of G. A vertex v in G is said to dominate the subgraph $f(v)$, as well as every vertex and edge of $f(v)$. A set S of vertices of G is a full dominating set (with respect to f) if S dominates G, that is, if every vertex of G is dominated by some vertex of S, as is every edge of $f(v)$. The minimum cardinality of a full dominating set in G (with respect to f) is its full domination number. We discuss some results involving full domination numbers for three such functions f.

Room 50

Matroids with Many Common Bases

Manoel Lemos, Universidade Federal de Pernambuco, Brazil

In this talk we shall present a solution for Mills's conjecture: for two $(k+1)$-connected matroids whose symmetric difference between theirs bases collections has size at most k, there is a matroid which is obtained from one of these matroids by relaxing n_1 circuit-hyperplanes and from the other by relaxing n_2 circuit-hyperplanes, where n_1 and n_2 are non-negative integers such that $n_1+n_2 \leq k$. We shall also discuss some extensions of this result.

Tuesday, 11:00–11:15

Room 148

The Queens Domination Problem on the Torus

A.P. Burger University of South Africa
C.M. Mynhardt*, University of South Africa

We determine exact values for the domination and independent domination numbers of toroidal queens graphs in infinitely many cases, and bounds - some good and some not so good - in other cases.

Room E113

Parallelization in Extended μH Systems and its Universality

Kengo Shirakata, Waseda University, Japan
Etsuro Moriya*, Waseda University, Japan

Splicing system is a rewriting system which models the process of cut and recombination of DNA sequences under the influence brought by restriction enzymes and lygases. Among a variety of splicing systems, the extended μH system uses only natual operations (in the sense that they are based on biological reality or realizable by the present technology). Instead of imposing restrictions on the use of rewriting rules as other systems do, it utilizes the notion of "multiset" so that rewritable strings are restricted to those whose mutiplicity are just one, which gives it the universal power of generation at the sacrifice of loss of the most appealing characteristics of DNA-based computations, the capability of massive parallel generation.

In this paper, we extend the extended μH system so that it can rewrite strings in parallel. This is done by giving each string its own number. Furthermore we introduce a new splicing operation based on really existing enzyme which cuts DNA sequences at the positions at some distance from the recognition sites, which can reduce the complicatedness of the rewriting rules in our new system. Our new system has only finitely many initial strings (axioms) as well as finitely many rewriting rules (splicing rules), but it is still universal.

Room 48A–B

Connected Resolvability of Graphs

Varaporn Saenpholphat*, Western Michigan University
Ping Zhang, Western Michigan University

For an ordered set $W = \{w_1, w_2, \ldots, w_k\}$ of vertices and a vertex v in a connected graph G, the representation of v with respect to W is the k-vector $r(v|W) = (d(v, w_1),\ d(v, w_2),\ \ldots,\ d(v, w_k))$, where $d(x, y)$ represents the distance between the vertices x and y. The set W is a connected resolving set for G if distinct vertices of G have distinct representations and the subgraph $\langle W\rangle$ induced by W is a nontrivial connected subgraph of G. We present some results in this area.

Room 50

On Closure Matroids

Talal Al-Hawary, Mu'tah University, Jordan
Jenny McNulty*, The University of Montana

A closure matroid is defined as a matroid M such that $\overline{A} \cup \overline{B} = \overline{A \cup B}$ for all subsets A and B of $E(M)$. We relate closure matroids to modular matroids, show closure matroids play a role in analyzing strong maps, characterize this class of matroids in terms of flats and classify all closure matroids.

Tuesday, 11:20–11:35

Room 148

Decompositions of the Complete Graph into Small 2-Regular Graphs

Peter Adams University of Queensland, Australia
Darryn Bryant, University of Queensland, Australia
Heather Gavlas*, Grand Valley State University

An H-decomposition of the complete graph K_n is a set S of subgraphs of K_n, each of which is isomorphic to H, such that each edge of K_n appears in exactly one of the subgraphs in S. For all positive integers n and every 2-regular graph H with no more than ten vertices, we prove necessary and sufficient conditions for the existence of an H-decomposition of K_n.

Room E113

A Faster Algorithm for the Solution of the n-Queens Problem

Dorothy Bollman*, University of Puerto Rico
Edusmildo Orozco, University of Puerto Rico

The 8-queens problem is a classical combinatorial problem in which it is required to place eight queens on an 8×8 chessboard so that no two can attack, that is, so that no two of them are on the same row, column, or diagonal. A trivial generalization of this problem requires one to place n queens on an $n \times n$ chessboard so that no two can attack. Thus, each solution of the n-queens problem is a permutation matrix such that for any pair of positions (i, j) and (k, l) containing a one, we have $|i - k| \neq |j - k|$. Alternativel, each solution can be viewd as a permutation π on $N_n = \{1, 2, \ldots, n\}$ in which $|\pi(i + d) - \pi(i)| \neq d$ for all $i = 1, 2, \ldots, n - d$ and all $d = 1, 2, \ldots, n - 1$. In this work we develop a new backtracking algorithm for generating solutions of the n-queens problem. This algorithm differs from the usual backtracking algorithms in two aspects. First, our algorithm juxtaposes terms to both (not just one) sides of a sequence, as in ordinary backtracking. Second, it exploits the fact that the set of permutations satisfying the n-queens property is invariant under the group of rigid motions of the square generated by reflections about the horizontal and vertical axes.

A sequential implementation of our algorithm on a Sun Sparc V runs more than seven times faster that the standard algorithm. We achieve parallelism by using the manager-worker technique. Implementation of the parallel version in C-MPI on an SGI Origin 2000 yields almost linear speedup.

Room 48A–B

Graphs and Divisibility of Positive Integers

Gary Chartrand, Western Michigan University
Raluca Muntean*, Western Michigan University
Varaporn Saenpholphat, Western Michigan University
Ping Zhang, Western Michigan University

We study a class of graphs defined in terms of divisibility of positive integers and present some results.

Room 50

Perfect Binary Matroids

Allan D. Mills, Tennessee Tech. University

Since being introduced by Berge, perfect graphs have been extensively studied. In this paper a definition of perfect binary matroids is considered and it is shown that, analogous to the Perfect Graph Theorem of Lovasz and Fulkerson, the complement of a perfect matroid is also a perfect matroid. In addition, the classes of critically imperfect graphic matroids and critically imperfect graphs are compared.

Tuesday, 11:40–11:55

Room 148

Distinct Sums Modulo n and Tree Embeddings

Andre Kezdy*, University of Louisville
Hunter Snevily, University of Idaho

In this talk we first address the following conjecture due to Snevily:

> CONJECTURE: For any positive integers n and k satisfying $k < n$, and any sequence $a_1, a_2, \ldots, a_k$ of not necessarily distinct elements of Z_n, there exists a permutation $\pi \in S_k$ such that the elements $a_{\pi(i)} + i$ are all distinct modulo n.

We prove this conjecture when $2k \leq n+1$. We then apply this result to tree embeddings. Specifically we show that, if T is a tree with n edges and radius r, then T decomposes K_t for some $t \leq 32(2r+4)n^2+1$.

Room E113

A New Lower Bound for the Football Pool Problem for 6 Matches

Patric R.J. Östergård, Helsinki University of Technology, Finland
Alfred Wassermann*, University of Bayreuth, Germany

In the football pool problem one wants to minimize the cardinality of a ternary code, $C \subseteq F_3^n$, with covering radius one, and the size of a minimum code is denoted by σ_n. The smallest unsettled case is $63 \leq \sigma_6 \leq 73$. The lower bound is here improved to 65 in a coordinate by coordinate backtrack search using lattice basis reduction and complete equivalence checking of subcodes.

Room 48A–B

On Convexity in Graphs

Gary Chartrand, Western Michigan University
Alice Chichisan*, Western Michigan University
Ping Zhang, Western Michigan University
Curtiss E. Wall, Norfolk State University

For two vertices u and v of a connected graph G, the set $I[u,v]$ consists of all those vertices lying on a $u-v$ shortest path in G, while for a set S of vertices of G, the set $I[S]$ is the union of all sets $I[u,v]$ for $u,v \in S$. A set S is convex if $I[S]=S$. The convexity number of G is the maximum cardinality of a proper convex set of G. We present some results in this area.

Room 50

Enumeration of the Bases of the Bicircular Matroid on a Complete Bipartite Graph

Nancy Ann Neudauer*, Pacific Lutheran University
Brett Stevens, Simon Fraser University, Canada

Let G be a graph (loops and parallel edges allowed) with vertex set $V=\{1,2,\ldots,n\}$ and edge set E. The *bicircular matroid* of G is the matroid $B(G)$ defined on E whose circuits are the subgraphs which are subdivisions of one of the graphs: (i) two loops on the same vertex, (ii) two loops joined by an edge, (iii) three edges joining the same pair of vertices. A set of edges is independent in $B(G)$ provided that each connected component contains at most one cycle of G. If G is a connected graph that is not a tree, then the bases of $B(G)$ are the spanning subgraphs of G each of whose connected components is a unicyclic subgraph of G. We enumerate the bases of the bicircular matroid on $K_{m,n}$. We first find the number of single-component bases of the bicircular matroid on $K_{m,n}$, then use this to calculate the total number of bases. The techniques herein may enable the enumeration of the bases of bicircular matroids on larger classes of graphs; indeed one of the motivations for this work is to show the extendibility of the techniques recently used to enumerate the bases of the bicircular matroid on K_n in a paper of Neudauer and Meyers.

Tuesday, 12:00–12:15

Room 148

Open Graphs with Perfect Internal Matchings

Miklós Bartha*, Memorial University of Newfoundland, Canada
Miklós Krész, University of Szeged, Hungary

A perfect internal matching of a graph G is a matching that covers all vertices of G with degree at least two. Such vertices are called internal, while vertices of degree one are external in G. An open graph is one that has at least one external vertex. Open graphs serve as underlying objects for certain molecular switching devices called soliton automata.

Open graphs having a perfect internal matching are decomposed into elementary components, and these components are grouped into pairwise disjoint families according to the so called "two-way accessible" relationship among them. Each family is then arranged in a family tree reflecting the order in which family members are accessible by external alternating paths. Every component in the family has not only a unique father, but also a unique mother, being the canonical class of the father component from which the offspring is two-way accessible. The families themselves are also arranged in a partial order, which again reflects the order in which they can be covered by external alternating paths.

Room E113

The Complexity of Some Common Strategy Games

L. Eugene Chipman*, University of Maryland
Clyde P. Kruskal, University of Maryland

One way to measure complexity of a game is to count how many possible games can be played. This can be estimated with computers using statistical methods based around Knuth's backtracking algorithm. For some games this is a useful exercise, which provides interesting insights such as whether a specific player may be favored or how the difficulty of the game (measured as average branching factor) varies over the course of the game. We study othello, backgammon, bridgit, and hex.

Room 48A–B

On Probe-Clone Interval Graphs

David Brown, University of Colorado at Denver
J. Richard Lundgren*, University of Colorado at Denver
Cary Miller, University of Colorado at Denver

Interval graphs originated in Benzer's original work on DNA in 1959. More recently, in 1997 Zhang introduced probe interval graphs as a means of studying various problems associated with physical mapping of DNA. Interval graphs are a special case of probe interval graphs. Possible applications to these same problems have led us to introduce a new graph called a Probe-Clone Bipartite Interval Graph(PCBIG). A bipartite graph G with bipartition P and C is a PCBIG if each vertex v can be assigned an interval $I(v)$ such that for x in P and y in C, then xy is an edge iff $I(x)$ and $I(y)$ overlap. For bipartite noncyclic graphs, we show that the sets of interval graphs, probe interval graphs, and also interval bigraphs are all properly contained in the set of PCBIG's. We also give a characterization of PCBIG's in the noncyclic case and some general properties in the cyclic case.

Room 50

Modular Contractibility in Binary Matroids

David Neel, Truman State University

If all contractions of a matroid M are modular, we say that M is modularly contractible. This paper examines the problem of characterizing binary modularly contractible matroids.

Wednesday

9:00–10:00

148 Noga Alon, *Polynomials in Discrete Mathematics I: Geometric and Number Theoretic Applications*

10:00–10:20

Coffee break

10:20–10:35

148 Dirk Vertigan*, Matt DeVos, Luis Goddyn, Bojan Mohar, Xuding Zhu, *Near Duality of Circular Coloring and Circular Flow in Orientable Surfaces*

E113 David Cariolaro*, Anthony J.W. Hilton, *Regular Graphs of Even Order and High Degree are* 1*-Factorizable*

48A-B Peter Horák, David Pike, Michael Raines*, *Hamilton Cycles in Block-Intersection Graphs of Triple Systems*

50 Arundhati Raychaudhuri, *Distance-*2 *Labeling for Strongly Chordal Graphs and* $2-K_2$ *Free Graphs*

10:40–10:55

148 Bruce Reed, Benny Sudakov*, *Asymptotically the List Colouring Constants are* 1

E113 Robert Molina*, Ken Smith, P_n*-Randomly Decomposable Graphs*

48A-B M.N. Ferencak*, A.J.W. Hilton, *Outline and Amalgamated Triple Systems*

50 D. Pillone, R. Laskar*, *Extremal Results in Rankings*

11:00–11:15

148 Arnfried Kemnitz*, Massimiliano Marangio, *Colorings and List Colorings of Integer Distance Graphs*

E113 Ronald J. Gould, Emily A. Hynds*, *Forbidden Subgraphs and* 2*-Factors*

48A-B Jeff Bonn, *Ordering Steiner Triple Systems and the Codes of Their Points*

50 David R. Berman, Sandra C. McLaurin, Douglas D. Smith*, *Fair Team Tournaments*

11:20–11:35

148 Jeannette Janssen, *Partial List Colourings of Graphs with Bounded Degree*

E113 Sam Greenberg, *Multiple Matchings*

48A-B Tomoko Adachi*, Masakazu Jimbo, Sanpei Kageyama, *Combinatorial Structure of GDDs without Nontrivial* α*-Resolution Classes in Each Group*

50 Richard Anstee, Ron Ferguson*, J.R. Griggs, *Circular Permutations with Low Discrepancy Consecutive* k*-Sums*

11:40–11:55

148 Balázs Montágh, *Anti-Ramsey Theorems on Spanning Trees*

E113 Hong Wang, *Vertex-Disjoint Quadrilaterals in Graphs*

48A-B Yukiyasu Mutoh*, Toshio Morihara, Masakazu Jimbo, *A Grid Design Related to DNA Library Screening*

50 Clifton E. Ealy Jr.*, *On the Genus of Semi*λ*-Partialplanes*

12:00–12:15

148 Maria Axenovich*, Tao Jiang, *Anti-Ramsey Numbers for Small Bipartite Graphs*

E113 John J. Watkins*, Jesse Gilbert, *Packing Caterpillars into Complete Graphs*

48A-B Selda Küçükçifçi*, C.C. Lindner, *The Metamorphosis of* λ*-Fold Block Designs with Block Size Four into* λ*-Fold* $(K_4 \setminus e)$*-Systems,* $\lambda \geq 2$

50 Adrian Bondy, Jian Shen*, Stéphan Thomassé, Carsten Thomassen, *Density Conditions Implying Trangles in k-Partite Graphs*

12:15–1:30

Lunch

1:30–2:30

148 Noga Alon, *Polynomials in Discrete Mathematics I: Graph Theoretic Applications*

2:40–2:55

148 Ellen Gethner*, David G. Kirkpatrick, Nicholas Pippenger, *M.C. Escher Inspires a Coloring Problem of a Different Colour: Art, Mathematics, and Computer Science Collide*

E113 Martin Charles Golumbic*, Marina Lipshteyn, *On the Hierarchy of Tolerance, Probe, and Interval Graphs*

48A-B Gayla S. Domke*, Jean E. Dunbar, Lisa R. Markus, *The Inverse Domination Number of a Graph*

50 Charles A. Anderson, *Some Sequences Related to the Catalan Numbers*

3:00–3:15

148 Peter C. B. Lam* and W. C. Shiu, *A Class of Graphs with χ^* Close to $\chi - 1$*

E113 Anthony Bonato*, Peter Cameron, Dejan Delić, Stéphan Thomassé, *New Vertex Partitions Properties of Graphs and Digraphs*

48A-B Peter Dankelmann, *Size and Domination in Graphs*

50 Wen-jin Woan, *Diagonal Lattice Paths*

3:20–3:35

148 Chao Gui*, Ronald D. Dutton, *Distribution of In-Degree in Random Digraphs*

E113 D. Aulicino*, M. Lewinter, *Pan-Central Graphs*

48A-B John Gimbel*, Mihaela Nicolescu, Cherie Umstead, Nicole Vaiana, Brian D. Van Gorden, *Location with Dominating Sets*

50 Seyoum Getu, *A 'dot' Product and Lattice Paths*

3:35–4:00

Coffee break

4:00–4:15

148 Joan P. Hutchinson, *Three- and Four-Coloring Nearly Triangulated Surfaces*

E113 Arthur M. Hobbs*, Louis Petingi, *The Weighted-Edge Case of Strength and Fractional Arboricity in Graphs*

48A-B David C. Fisher, Suzanne M. Seager*, *The Total Domination Number of Graphs of Maximum Degree* 3

50 D. Elizabeth "Betsy" Sinclair*, Julia Eaton, *Competition Between Geometric Random Variables I: One-Dimensional Results*

4:20–4:35

148 Jan Kratochvíl, Zsolt Tuza, Margit Voigt*, *b-Colorings of Graphs*

E113 Dean Hoffman, Mark Liatti*, *Partitioning the Edges of $2K_{c,d}$ into Copies of $K_{a,b}$*

48A-B Teresa Haynes, Debra Knisley*, *Colored Domination in Graphs*

50 Yung-Ling Lai, *On the Profile of the Tensor Product of Paths with Complete Bipartite Graphs*

4:40–4:55

148 Andrea Hackmann, *Critically Edge Colourable Planar Graphs*

E113 Art Finbow*, Bert Hartnell, Richard Nowakowski, Michael D. Plummer, *On Well-Covered* 5*-Connected Triagulations*

48A-B Kenneth Proffitt*, Teresa W. Haynes, Peter J. Slater, *Paired-Domination in Grid Graphs*

50 Dorea Claassen, *The Bandwidth of a Random Graph*

5:00–5:15

148 Mathew Cropper*, Andras Gyarfas, Jeno Lehel, Mike Jacobson, *Comparing the Hall Ratio and the Chromatic Number*

E113 Saad I. El-Zanati, *On Generalizations of the Oberwolfach Problem*

48A-B Ruth Haas*, Thomas Wexler, *Signed Domination Number of a Graph and Its Complement*

50 Narsingh Deo, Pankaj Gupta*, *Sampling the Web Graph With Random Walks*

5:30–6:00

148 Frank Harary, *Graphs and Their Games*

7:00–10:00

Banquet

Invited Instructional Lectures

Wednesday 9:00–10:00, Room 148

Polynomials in Discrete Mathematics I: Geometric and Number Theoretic Applications

Noga Alon, Tel Aviv University

Elementary properties of polynomials can be very powerful in the study of various combinatorial problems. I will illustrate this fact by discussing several problems in Combinatorial Geometry and by describing a general technique that can be called "Combinatorial Nullstellensatz" together with some of its applications in Additive Number Theory. Some of its Graph Theoretic applications will be described in the second lecture.

Wednesday 1:30–2:30, Room 148

Polynomials in Discrete Mathematics II: Graph Theoretic Applications

Noga Alon, Tel Aviv University

I will illustrate how polynomials can be used to attack problems in Graph Theory. These include extremal problems, graph coloring problems, and the study of the Shannon capacity of graphs, which is motivated by questions in Information Theory.

Wednesday, 10:20–10:35

Room 148

Near Duality of Circular Coloring and Circular Flow in Orientable Surfaces

Dirk Vertigan*, Louisiana State University
Matt DeVos, Rice University
Luis Goddyn, Simon Fraser University, Canada
Bojan Mohar, University of Ljublijana, Slovenia
Xuding Zhu, National Sun Yat-Sen University, Taiwan

Suppose $G = (V, E)$ is a graph and $r \geq 2$ is a real number. A *proper r-coloring* of G is a mapping $f : V \to [0, r)$ such that for every edges xy of G, $1 \leq |f(x) - f(y)| \leq r - 1$. The *circular chromatic number* $\chi_c(G)$ of G is the least r for which G is r-colorable. For an oriented graph G, a *flow* is a mapping $f : E \to R$ such that for each vertex v, $\Sigma_{e \in E^+(v)} f(e) = \Sigma_{e \in E^-(v)} f(e)$. A *proper r-flow* is a flow f such that for each edge e, $1 \leq |f(e)| \leq r - 1$. The *circular flow number* $\Phi_c(G)$ of a undirected graph G is the least r for which an orientation of G admits a proper r-flow.
It is not difficult to derive from the definition that for any graph

$$\chi(G) - 1 < \chi_c(G) \leq \chi(G),$$

$$\Phi(G) - 1 < \Phi_c(G) \leq \Phi(G).$$

Moreover, circular coloring and flow are dual concepts in the sense that, for a planar graph G and its dual G^*,

$$\chi_c(G) = \Phi_c(G^*).$$

This extends to regular matroids.
Here, we consider the relationship between the circular chromatic number of a graph G on a surface Σ, and the circular flow number of its *surface* dual $G^{\Sigma *}$. The *edge-width* of G on the surface Σ is the length of the shortest non–null homotopic circuit. We prove the following theorem. Suppose Σ is an orientable surface. For any $\varepsilon > 0$, there exists a constant c such that if G is a graph embedded in Σ with edge-width at least c then

$$\Phi_c(G^{\Sigma *}) \leq \chi_c(G) \leq \Phi_c(G^{\Sigma *}) + \varepsilon.$$

A related result holds for *all* surfaces.

Room E113

Regular Graphs of Even Order and High Degree are 1-Factorizable

David Cariolaro*, University of Reading, United Kingdom
Anthony J.W. Hilton, University of Reading, United Kingdom

An old conjecture states that a regular graph with $2n$ vertices and degree at least n is 1-factorizable, i.e. its edge set can be partitioned into 1-factors (perfect matchings). Despite major efforts by a large number of mathematicians over the past two generations, the conjecture remains unsettled. In 1989 Chetwynd & Hilton proved the conjecture for all graphs G with $d(G) \geq 5n/3$, where $d(G)$ is the degree of the regular graph G. We have improved this to $d(G) \geq 3n/2$, and in this talk we give an outline of the proof.

Room 48A–B

Hamilton Cycles in Block-Intersection Graphs of Triple Systems

Peter Horák, Kuwait University
David Pike, Memorial University of Newfoundland
Michael Raines*, Western Michigan University

Given a BIBD $S = (V, B)$, its 1-block-intersection graph G_S has as vertices the elements of B; two vertices $B_1, B_2 \in B$ are adjacent in G_S if $|B_1 \cap B_2| = 1$. In this talk, we consider the hamiltonicity of G_S when S is a λ-fold triple system.

Room 50

Distance-2 Labeling for Strongly Chordal Graphs and $2 - K_2$ Free Graphs

Arundhati Raychaudhuri, College of Staten Island

We present some results on distance-2 labeling for Strongly Chordal graphs and $2 - K_2$ free graphs. In distance-2 labeling, each vertex of a graph G is assigned a positive integer $f(x)$, such that, if the distance between vertices x and y in G is 2, then $f(x)$ and $f(y)$ must be different, and if the distance is 1, then the absolute value of $f(x) - f(y)$ must be at least 2. There is no constraint on the labels if the distance between two vertices is greater than 2. The span of this labeling is denoted by $sp(f)$, which is maximum value of $f(x)$ over all vertices of G. The goal is to estimate $\lambda_2(G)$, which is the minimum value of $sp(f)$ over all distance-2 colorings. It is known that $\lambda_2(G)$ is at most $d^2 + 2d$ for an arbitrary graph G, where d is the maximum degree of a vertex in G. For a Strongly Chordal graph, using a strong elimination orderiung of $V(G)$, we improve this upper bound to $3d - 2$. Also, for $2 - K_2$ free graphs, we ! show that $\lambda_2(G)$ is at most d^2; it has been conjectured that this is true for all graphs.

Wednesday, 10:40–11:00

Room 148

Asymptotically the List Colouring Constants are 1

Bruce Reed, CNRS, France
Benny Sudakov*, Princeton University and Institute for Advanced Study

The semirandom method (Rödl Nibble) is the general approach to prove the existence of something by generating it through many iterations, applying probabilistic reasoning at each step.
One area of Combinatorics where semirandom method has had the greatest impact is graph coloring. In fact, many of the strongest result in graph coloring over the past decade are examples of this method. We will illustrate how semirandom method works by proving the following result:
Let $G = (V, E)$ *be a graph with the sets of lists* $S(v)$*, one for each vertex* v *of* G*, such that*

- *for every vertex* $|S(v)| = (1 + o(1))d$ *and*
- *for each color* $c \in S(v)$*, the number of neighbors of* v *that have* c *in their list is at most* d*.*

Then there exist a proper coloring of G *from these lists.*

Room E113

P_n-Randomely Decomposable Graphs

Robert Molina*, Alma College
Ken Smith, Central Michigan University

A decomposition of a nonempty graph G is a family of subgraphs of G such that their edge sets form a partition of the edge set of G. If all of the subgraphs in such a decomposition are isomorphic to some graph H, we say that G is H–decomposable. We say that G is randomly H–decomposable if every family of edge disjoint subgraphs of G, each subgraph isomorphic to H, can be extended to an H–decomposition of G. We will investigate P_n–randomly decomposable graphs, focusing mainly on the case when G is the union of two paths with common end vertices. A characterization of such graphs with 4 or fewer vertices of degree 4 is given.

Room 48A–B

Outline and Amalgamated Triple Systems

M.N. Ferencak*, University of Pittsburgh at Johnstown
A.J.W. Hilton, Reading University

A triple system of order n and index λ is thought of as a decomposition of the λ-fold complete graph on n vertices into edge disjoint copies of K_3. An amalgamated triple system is derived from a triple system by identifying a subset (or several subsets) of the vertex set while preserving all edge adjacencies at the new vertex (or vertices). Edges between amalgamated vertices become loops on the new vertex. The amalgamation of a directed triple system is defined analogously. We will discuss some recent results on embedding partial triple systems and partial directed triple systems using the technique of amalgamation.

Room 50

Extremal Results in Rankings

D. Pillone, Scientific Games
R. Laskar*, Clemson University

For a graph $G = (V, E)$, a function $f : V(G) \rightarrow \{1, 2, \ldots, k\}$ is a k-ranking for G if $f(u) = f(v)$ implies that every $u - v$ path contains a vertex w such that $f(w) > f(u)$. The rank number $\chi_r(G)$ and the arank number $\psi_r(G)$ are, respectively, the minimum and maximum value of k such that G has a minimal k-ranking.
Let n, k be positive integers with $n \geq k$. We define $\chi_r^+(n, k) = \max\{\mid E(G) \mid : \mid V(G) \mid = n$ and $\chi_r(G) = k$ for some graph $G\}$, $\psi_r^+(n, k) = \max\{\mid E(G) \mid : \mid V(G) \mid = n$ and $\psi_r(G) = k$ for some graph $G\}$, $\chi_r^-(n, k) = \min\{\mid E(G) \mid : \mid V(G) \mid = n$ and $\chi_r(G) = k$ for some graph $G\}$, $\psi_r^-(n, k) = \min\{\mid E(G) \mid : \mid V(G) \mid = n$ and $\psi_r(G) = k$ for some graph $G\}$. In this paper these parameters are investigated.

Wednesday, 11:00–11:15

Room 148

Colorings and List Colorings of Integer Distance Graphs

Arnfried Kemnitz*, Techn. Univ. Braunschweig, Germany
Massimiliano Marangio, Techn. Univ. Braunschweig, Germany

An integer distance graph is a graph $G(D)$ with the set of integers as vertex set and with an edge joining two vertices u and v if and only if $|u - v| \in D$ where the distance set D is a subset of the set of positive integers.
A (vertex) coloring of a graph G is an assignment of colors to the vertices of G such that adjacent vertices are colored differently. The minimum number of colors necessary to color the vertices of G is the chromatic number $\chi(G)$ of G.
If $L = \{L(v) : v \in V(G)\}$ is a set of lists of colors then an L-list (vertex) coloring of a graph G is a coloring of G such that each vertex obtains a color from its own list. A graph G is called k-choosable if such a coloring exists for each choice of lists $L(v)$ of cardinality at least k. The minimum k such that G is k-choosable is the choice number $\chi(G)$ of G.
We present some general upper bounds for the chromatic number and the choice number of integer distance graphs and some exact values for graphs with distance sets of small cardinality.

Room E113

Forbidden Subgraphs and 2-Factors

Ronald J. Gould, Emory University
Emily A. Hynds*, Samford University

Every 2-factor of a graph G consists of a spanning collection of vertex disjoint cycles. In particular, a hamiltonian cycle is an example of a 2-factor consisting of precisely one cycle. A characterization has been given of all pairs of forbidden subgraphs that imply a 2-connected graph of order $n \geq 10$ is hamiltonian. We generalize this idea by examining some pairs of forbidden subgraphs that imply a 2-connected graph of order $n > 3k + 15$ contains a 2-factor consisting of k disjoint cycles ($k \geq 1$).

Room 48A–B

Ordering Steiner Triple Systems and the Codes of Their Points

Jeff Bonn, Michigan Technological University

A Steiner Triple System has a code of the points as the row space over GF(2) of the point-by-block incidence matrix of the Steiner Triple System. It has been conjectured that non-isomorphic Steiner Triple Systems will always give rise to non-isomorphic codes of their points as has been seen for the 80 Steiner Triple Systems of order 15. Ordering Steiner Triple Systems give rise to why the conjecture should be true.

Room 50

Fair Team Tournaments

David R. Berman, University of North Carolina at Wilmington
Sandra C. McLaurin, University of North Carolina at Wilmington
Douglas D. Smith*, University of North Carolina at Wilmington

The question of fairness arises in team tournaments such as whist and spouse-avoiding mixed doubles round-robin tournaments because individuals play on different teams during the course of a tournament. The design of the tournament may, under some reasonable criteria for projecting wins, provide an advantage for some players over others. We have previously considered fairness by projecting the outcome of each match as either a win for one team or a tie. However, the actual outcome of each match will be a win for some team, with no ties permitted. In this paper we investigate fairness relative to an intuitively appealing scheme for projecting wins or losses, with no ties.

Wednesday, 11:20–11:35

Room 148

Partial List Colourings of Graphs with Bounded Degree

Jeannette Janssen, Dalhousie University, Canada

Let G be a graph, and $\mathcal{L}^t$ an assignment of lists of size t to the vertices of G. A partial list colouring of G is a proper colouring of a maximum number of vertices of G so that each coloured vertex received a colour from its list. The size of the partial list colouring is the number of vertices that are coloured. We consider the parameter $\lambda_t(G)$, which is the minimum, taken over all assignments of lists of size t, of the size of a partial colouring of G with the given lists. It was conjectured by Albertson, Grossman and Haas that for any s-choosable graph, $\lambda_t(G) \geq (t/s)n$, where n is the size of G. We show that this conjecture holds if G has maximum degree s.

Room E113

Multiple Matchings

Sam Greenberg, Oberlin College

For a given graph, we define a *perfect matching* as a set of edges such that every vertex is contained in exactly one edge. A *random perfect matching* is a perfect matching chosen at random from the entire set of possible perfect matchings on the graph.

We look at the expected value of the size of the intersection of two random perfect matchings to find the expected number of edges that appear both times, depending on the graph. We examine a variety of graphs, eventually focusing on the $2 \times n$ and $3 \times n$ lattices. The analysis uses interesting Fibonacci methods and generating functions.

Room 48A–B

Combinatorial Structure of GDDs without Nontrivial α-Resolution Classes in Each Group

Tomoko Adachi*, Keio University, Japan
Masakazu Jimbo, Keio University, Japan
Sanpei Kageyama, Hiroshima University, Japan

Let $v = mn\,(m, n \geq 2)$, r, k, λ_1 and λ_2 be positive integers. A *group divisible design* (GDD) with parameters $v = mn$, r, k, λ_1 and λ_2 is a pair $(V,\mathcal{B},\mathcal{G})$ where V is a v-set of points, $\mathcal{B}$ is a collection of k-subsets (*called blocks*) of V and $\mathcal{G} = \{G_1, \cdots, G_m\}$ is a division of V into m groups of n points each such that every point of V occurs in r blocks of $\mathcal{B}$, and that any two distinct points in the same group occur together in exactly λ_1 blocks of $\mathcal{B}$, while those in different groups occur together in exactly λ_2 blocks of $\mathcal{B}$. In particular, when λ_1 is equal to λ_2, a GDD is called a *balanced incomplete block design* (BIBD) with parameters v, r, k and $\lambda(= \lambda_1 = \lambda_2)$.

For positive integers v', r and λ, an (r, λ)-*design* with parameters v', r and λ is a pair $(V', \mathcal{B}')$ where V' is a v'-set of points and $\mathcal{B}'$ is a collection of subsets of V' such that every point of V' occurs in r blocks of $\mathcal{B}'$, and that any two distinct points of V' occur together in exactly λ blocks of $\mathcal{B}'$. In particular, when every block has the same size $(=k)$, an (r, λ)-design is a BIBD with parameters v, r, k and λ. For a subcollection $\mathcal{B}''\ (\subset \mathcal{B}')$, if every point of V' occurs in exactly α blocks $(1 \leq \alpha \leq r-1)$ of $\mathcal{B}''$, then $\mathcal{B}''$ is called a *nontrivial α-resolution class* of $(V', \mathcal{B}')$.

Jimbo and Kageyama (2000, to appear in ICA Bulletin) showed that GDDs with $r = \lambda_1 + 1$ are characterized in terms of Hadamard tournaments and strongly regular graphs from the viewpoint of the construction.

We show that combinatorial structure of GDDs without nontrivial α-resolution classes in each group are also specified by Hadamard tournaments and strongly regular graphs. The result in GDDs with $r = \lambda_1 + 1$ is included in our result as a special case.

Room 50

Circular Permutations with Low Discrepancy Consecutive k-Sums

Richard Anstee, University of British Columbia, Canada
Ron Ferguson*, University of British Columbia, Canada
J.R. Griggs, University of South Carolina

Let k, n be given and let π be a permutation of $1, 2, \ldots, n$. Consider the permutation as being placed on a circle so that indices are taken modulo n. There are n sums of k consecutive entries and their average is $k(n+1)/2$. We say the maximum difference of any consecutive k-sum from the expected value of $k(n+1)/2$ is the discrepancy of the permutation and then seek a permutation of minimum discrepancy. We obtain a number of results that show that the discrepancy can be made small (always $\leq 7/2$ where $\gcd(n, k) > 1$ and $\leq k + 6$ where $\gcd(n, k) = 1$), and obtain lower bounds that show that in certain cases it cannot be made smaller (sometimes $\Omega(k)$).

Wednesday, 11:40–1:55

Room 148

Anti-Ramsey Theorems on Spanning Trees

Balázs Montágh, University of Memphis

Erdős, Simonovits and Sós initiated the investigation of anti-Ramsey problems for graphs. Call a graph *totally multicolored* (TMC, for short) if any two edges have different colors. Given a family $\mathcal{L}$ of graphs, let $AR(n, \mathcal{L})$ be the maximum of t for which there exist t-colorings of the edges of K_n, where every color is used at least once, without a TMC subgraph that belongs to $\mathcal{L}$. It is easy to see that $AR(n, \mathcal{L}) \geq ex(n, \mathcal{L}^*) + 1$.

Let $\mathcal{T}_n$ be the family of the trees on n vertices, that is, the family of all spanning trees of K_n, and let $\mathcal{T}_n^d$ be the family of the trees on n vertices of diameter at most d. Bialostocki and Voxman proved that if $n \geq 3$ then $AR(n, \mathcal{T}_n) = \binom{n-2}{2} + 1 = ex(n, \mathcal{T}_n^*) + 1$. Bialostocki conjectured that $AR(n, \mathcal{T}_n) = AR(n, \mathcal{T}_n^4)$. In other words, if the number of colors is greater than $\binom{n-2}{2} + 1$ then there is a TMC spanning tree of diameter at most 4.

We shall show that even more is true: $AR(n, \mathcal{T}_n) = AR(n, \mathcal{T}_n^3)$. That is, if the number of colors is greater than $\binom{n-2}{2} + 1$ then there is a TMC spanning tree with an edge dominating the whole tree. We shall call such a tree a *double star*.

For the case of diameter 2, it is easy to see that if $n \geq 4$ then $AR(n, \mathcal{T}_n^2) > AR(n, \mathcal{T}_n)$ since $ex(n, \mathcal{T}_n^{2^*}) = \binom{n}{2} - n > ex(n, \mathcal{T}_n{}^*)$. It is more interesting that, as we shall see, for $n \geq 6$ we have $AR(n, \mathcal{T}_n^2) - ex(n, \mathcal{T}_n^{2^*}) > 1$. This means that for the spanning star the extremal anti-Ramsey coloring uses at least two colors more than once. In fact, $AR(n, \mathcal{T}_n^2) = \binom{n}{2} - \lceil \frac{2n}{3} \rceil$.

However, $AR(n, \mathcal{L}) = AR(n, \mathcal{T}_n)$ holds even for a family $\mathcal{L}$ much smaller than $\mathcal{T}_n^3$. Let $\mathcal{DS}_n^4$, $\mathcal{DS}_n^3$ be the families of the double stars with n vertices whose maximal degree is at least $n-4$, $n-3$, respectively. We shall show that $AR(n, \mathcal{T}_n) = AR(n, \mathcal{DS}_n^4) < AR(n, \mathcal{DS}_n^3)$.

Room E113

Vertex-Disjoint Quadrilaterals in Graphs

Hong Wang, The University of Idaho

Let k be a positive integer and G a graph of order n. In [Bert Randerath, Ingo Schiermeyer, H. Wang, On quadrilaterals in a graph, Discrete Mathematics, 203(1999), 229–237], we proved that if $n = 4k$ and $\delta(G) \geq 2k$ then G contains $k-1$ vertex-disjoint quadrilaterals. In this paper, we investigate vertex-disjoint quadrilaterals in G with $n \not\equiv 0 (mod\ 4)$, and we have found the best minimum degree condition $\delta(G) \geq \lceil \frac{1}{2} n \rceil$ such that G contains $\lfloor \frac{1}{4} n \rfloor$ vertex-disjoint quadrilaterals. As a result of our method, we have improved our previous result as follows: If $n = 4k$ and $\delta(G) \geq 2k-1$ then G contains $k-1$ vertex-disjoint quadrilaterals.

Room 48A–B

A Grid Design Related to DNA Library Screening

Yukiyasu Mutoh*, Keio University, Japan
Toshio Morihara, Keio University, Japan
Masakazu Jimbo, Keio University, Japan

Fu, Hwang, Jimbo, Mutoh and Shiue (2000) introduced the concept of a grid design, which is defined as follows: For a v-set V, let $\mathcal{G}$ be a collection of $r \times c$ arrays with elements in V. A pair $(V, \mathcal{G})$ is called a $r \times c$ *grid design* if every distinct two points i and j in V occurs exactly once in the same row or in the same column. This is design originated from the use of DNA library screening. They gave some general constructions and proved the existence of 2×3 grid designs and 3×3 grid designs. In this talk we give some constructions and show the existence of 3×3 grid designs which are included in Fu et.al (2000). Moreover, we show the existence of 2×4 grid designs.

Room 50

On the Genus of Semiλ-Partialplanes

Clifton E. Ealy Jr.*, Western Michigan University

Informally, a semi λ-partialplane is a connected incidence structure such that any two distinct points are on 0 or λ blocks, every point is on $t + \lambda$ blocks, and every block is on $s + \lambda$ points with $s + \lambda, t + \lambda \geq 3$. In this paper, we bound the genus of some classes of semi λ-partialplanes.

Wednesday, 12:00–12:15

Room 148

Anti-Ramsey Numbers for Small Bipartite Graphs

Maria Axenovich*, Iowa State University
Tao Jiang, Michigan Technological University

Given two graphs G and $H \subseteq G$, we consider edge-colorings of G in which every copy of H has at least two edges of the same color. Let $f(G, H)$ be the maximum number of colors used in such a coloring of $E(G)$. Erdős, Simonovits and Sós determined the asymptotic behavior of f when $G = K_n$ and H contains no edge e with $\chi(H - e) \leq 2$. We study the function $f(G, H)$ when $G = K_n$ or $K_{m,n}$, and H is $K_{2,t}$.

Room E113

Packing Caterpillars into Complete Graphs

John J. Watkins*, Colorado College
Jesse Gilbert, Lawrence University

The Tree Packing Conjecture asserts that any family of trees havings orders 2 through n can be packed into the complete graph on n vertices. This conjecture has been verified for a number of special cases, for example if each tree is either a path or a star. We will extend these results by showing that packings can also beconstructed for certain families of trees based upon caterpillars.

Room 48A–B

The Metamorphosis of λ-Fold Block Designs with Block Size Four into λ-Fold $(K_4 \setminus e)$-Systems, $\lambda \geq 2$

Selda Küçükçifçi*, Auburn University
C.C. Lindner, Auburn University

A λ-fold $K_4 \setminus e$ -design of order n is a pair (X, K), where K is a collection of edge disjoint copies of $K_4 \setminus e$ which partitions the edge set of λK_n with vertex set X. Let (X, B) be a λ-fold block design with block size 4. If we remove one edge from each block in B, we obtain a partial λ-fold $K_4 \setminus e$ -design. If the deleted edges can be arranged into copies of $K_4 \setminus e$ the result is a λ-fold $K_4 \setminus e$ -design, called a *metamorphosis* of the λ-fold block design (X, B). Quite recently, C. C. Lindner and A. Rosa determined the spectrum for λ-fold block designs with block size 4 having a metaporphosis into λ-fold $K_4 \setminus e$ -designs when $\lambda = 1$. We give a complete solution of the spectrum problem for λ-fold block designs with block size 4 having a metamorphosis into a λ-fold $K_4 \setminus e$ -design for all $\lambda \geq 2$.

Room 50

Density Conditions Implying Trangles in k-Partite Graphs

Adrian Bondy, Université Claude Bernard Lyon 1, France
Jian Shen*, Southwest Texas State University
Stéphan Thomassé, Université Claude Bernard Lyon 1, France
Carsten Thomassen, Institute of Mathematics, Denmark

We consider the problem of finding a large or dense trangle-free (or C_3-free) subgraph in a given graph G. In response to a question of P. Erdös, we prove that, if the minimum degree of G is at least $(19 - \sqrt{117})|V(G)|/10 + 1(\approx 0.818|V(G)| + 1)$, the largest triangle-free subgraphs are precisely the largest bipartite subgraphs in G. We investigate in particular the case where G is a complete k-partite graph. For $k = 3$, we prove that a finite 3-partite graph with edge density between each pair of partite sets greater than the golden ratio, $(\sqrt{5} - 1)/2(\approx 0.618)$, has a triangle. Also we show that this golden ratio bound is best possible.

Wednesday, 2:40–2:55

Room 148

M.C. Escher Inspires a Coloring Problem of a Different Colour: Art, Mathematics, and Computer Science Collide

Ellen Gethner*, University of British Columbia
David G. Kirkpatrick, University of British Columbia
Nicholas Pippenger, University of British Columbia

Dutch artist M.C. Escher is a familiar friend to Artists, Computer Scientists, and Mathematicians. Recently, Doris Schattschneider called attention to a combinatorial technique used by Escher to create periodic patterns in the plane. Ultimately, a square tile is decorated by a finite set of overlapping polygonal regions that intersect the boundary of the tile symmetrically and aesthetically. The plane is then tiled by standard horizontal and vertical translations, yielding a doubly periodic wallpaper pattern. That the original tile is made up of overlapping regions lends an air of mystery to the final outcome. Escher deepened the mystery by adding color to the mix, and in doing so aroused the curiosity of Rick Mabry, Stan Wagon, and Doris Schattschneider. Their question: is there a rectangular prototile (concatenated copies of the square tile), which can be colored so that colors on the sides and top and bottom match appropriately? Can this be done so that overlapping components in the resulting plane pattern always receive different colors? The answer : "yes," such a prototile always exists. The proof is a constructive algorithm that draws from geometry, graph theory, and number theory. The output of the algorithm: the dimensions of the prototile together with coloring instructions. Moreover, a classification of all prototiles for a given square tile is underway, and uses tools from computational and classical number theory, graph theory, and graph algorithms.

Room E113

On the Hierarchy of Tolerance, Probe, and Interval Graphs

Martin Charles Golumbic*, Bar-Ilan University and Haifa University, Israel
Marina Lipshteyn, Bar-Ilan University, Israel

Tolerance graphs and interval probe graphs are two generalizations of the well known class of interval graphs. All three families are defined in terms of being able to assign an interval on the line to each vertex of the graph such that there is an edge between two vertices if and only if the intersection of their intervals is non-empty and satisfies an "extra" condition. For interval graphs, there is no extra condition. For probe graphs, the vertices are partitioned into two sets P (probes) and N (non-probes), and the extra condition is that at least one of the two vertices of an edge must be in P. For tolerance graphs, the vertices are assigned positive real numbers (tolerances), and the extra condition is the requirement that the size of the intersection of the two intervals must be greater than or equal to the minimum of the two tolerances in order to produce an edge. It is known, and easy to show, that every interval graph is a probe graph (by choosing N to be empty), and that every probe graph is a tolerance graph (by assigning infinite tolerance to each member of N and a small ϵ to each member of P.) Moreover, for all three models, we can place additional restrictions of requiring that all intervals be of unit length or that no interval properly contains another. Clearly, a unit interval representation is also a proper representation. Conversely, however, it is well known that unit tolerance graphs do not equal proper tolerance graphs, but unit interval graphs do equal proper interval graphs. In this talk, we present the complete hierarchy of all nine subclasses taken from <unit, proper, general> × <interval, probe, tolerance> together with examples separating different classes. Thus, we survey these which are known and prove those which are new. Finally, we also present the new result that the graph sandwich problem for probe graphs is NP-complete.

Room 48A–B

The Inverse Domination Number of a Graph

Gayla S. Domke*, Georgia State University
Jean E. Dunbar, Converse College
Lisa R. Markus, De Anza College

Let G be a graph with n vertices, and let D be a minimum dominating set of G. If $V - D$ contains a dominating set, D', of G, then D' is called an *inverse dominating set with respect to* D. The *inverse domination number*, $\gamma'(G)$, is the order of a smallest inverse dominating set of G. In this paper, we characterize all graphs where $\gamma(G) + \gamma'(G) = n$. We also give a lower bound for the inverse domination number of a tree.

Room 50

Some Sequences Related to the Catalan Numbers

Charles A. Anderson, University of Colorado at Denver

We show that a natural extension of a problem considered by Grimaldi and Moser at a previous Southeastern Conference leads to a natural extension of the sequence of Catalan numbers. These “new” sequences have clear combinatorial interpretations and simple, elegant formulas. We consider some properties of these sequences and describe them using generating trees.

Wednesday, 3:00–3:15

Room 148

A Class of Graphs with χ^* Close to $\chi - 1$

Peter C. B. Lam*, Hong Kong Baptist University
W. C. Shiu, Hong Kong Baptist University

The star chromatic number $\chi^*(G)$ of a graph G, a natural generalization of the chromatic number $\chi(G)$ of G, was introduced by Vince in 1988. It has been shown that $\chi(G) - 1 < \chi^*(G) \leq \chi(G)$. In this, we give a class of graphs G with $\chi^*(G)$ determined. Moreover, this class of graphs may be arbitrarily close to $\chi(G) - 1$.

Room E113

New Vertex Partitions Properties of Graphs and Digraphs

Anthony Bonato*, Wilfrid Laurier University, Canada
Peter Cameron, Queen Mary and Westfield College, United Kingdom
Dejan Delić, Vanderbilt University
Stéphan Thomassé, Université Claude-Bernard Lyon I, France

A graph G has the pigeonhole property, written $(\mathcal{P})$, if whenever the vertex set is partitioned into two parts, then the subgraph induced by one of the parts is isomorphic to G. In 1996, Peter Cameron proved the surprising result that the only countable graphs with $(\mathcal{P})$ are the trivial graph, the countably infinite complete graph and its complement, and the countably infinite random graph. Last summer, at a conference in honour of Roland Fraïssé, Cameron posed the following problem: which countable graphs G have the property that whenever the vertex set is partitioned into three parts, the subgraph induced by the union of some two of the parts is isomorphic to G? This new vertex partition property is called $\mathcal{P}(3, 2)$.

In this talk, we answer Cameron's problem and present a classification of the countable graphs with $\mathcal{P}(3, 2)$. A classification of the countable digraphs with $\mathcal{P}(3, 2)$ will also be presented.

Room 48A–B

Size and Domination in Graphs

Peter Dankelmann, University of Natal, South Africa

Vizing determined the maximum number of edges in a graph of given order and domination number. In our talk we present analogous results for the total domination number and the independent domination number. We also determine the maximum number of edges in a bipartite graph of given order and domination (total domination, independent domination) number. This is joint work with Gayla Domke, Wayne Goddard, Paul Grobler, Johan Hattingh and Henda Swart.

Room 50

Diagonal Lattice Paths

Wen-jin Woan, Howard University

We consider those lattice paths in the Cartesian plane running from $(0,0)$ that use the steps from $S = \{(k,k) \text{ or } (k,-k) : k \text{ positive integer}\}$ and never go below the x-axis. Let $D(n)$ be the set of paths that end at $(n,0)$ and $d(n) = |D(n)|$ be the number of such paths. Then the first few terms are $d(0) = 1, 1, 5, 29, 185, 1257, 8925, ...$ and the generating function $g(x) = \sum_{n=0}^{\infty} d(n)x^n = \frac{1+3x-\sqrt{9x^2-10x+1}}{8x}$.

Wednesday, 3:20–3:35

Room 148

Distribution of In-Degree in Random Digraphs

Chao Gui*, University of Central Florida
Ronald D. Dutton, University of Central Florida

Random digraphs are an extension of random graph model introduced by Erdös. For any node of a random digraph, the number of out-links is treated as a random variable X. Properties of random digraphs are of interest, especially for those with fairly large number of nodes. In the traditional random graph model, the degree of any given node has *Poisson* distribution. This paper provides proof that the same is true for the in-degree of nodes in random digraphs. The number of in-links to any given node is treated as another random variable Y. We show that, as $n \to \infty$, Y follows the *Poisson* distribution $Po(\lambda)$, where λ is equal to the expected value of X. Further, we show the distribution of X does not affect that of Y when n is sufficiently large.

Room E113

Pan-Central Graphs

D. Aulicino*, Byram Hills High School, New York
M. Lewinter, Purchase College SUNY

Abstract: A graph G is called pan-unicentral if given any vertex v in $V(G)$, there exists a spanning tree T of G such that $C(T) = \{v\}$. A graph is called pan-bicentral if given any pair of adjacent vertices u, v in $V(G)$, there exists a spanning tree T of G such that $C(T) = \{u, v\}$. A graph which is pan-unicentral and pan-bicentral is called pancentral. Two dimensional meshes, with the exception of ladders are pancentral. Various theorems and infinite classes will be presented.

Room 48A–B

Location with Dominating Sets

John Gimbel*, University of Alaska
Mihaela Nicolescu, Salk School of Science
Cherie Umstead, High School of Legal Studies
Nicole Vaiana, Curtis High School
Brian D. Van Gorden, Port Allegany High School

We consider dominating sets of minimum cardinality which have the property that distinct vertices are dominated by distinct subsets of the dominating set. We characterize graphs which have such a set and develop bounds on the minimum cardinality.

Room 50

A 'dot' Product and Lattice Paths

Seyoum Getu, Howard University

Let S be a tridiagonal Stieljes matrix and L be a lower triangular matrix associated with it. It is shown algebraically and combinatorially that the 'dot' product of row n and row m of L, with appropriate weights, is equal to the first entry of row $(n+m)$ of L. Using this fact it follows that the diterminant of an n by n Hankel matrix, formed from the first column of L, is the successive products of the entrees of one of the diagonals of S.

Wednesday, 4:00–4:15

Room 148

Three- and Four-Coloring Nearly Triangulated Surfaces

Joan P. Hutchinson, Macalester College

We consider generalizations of the so-called Heawood's theorem that a planar triangulation can be 3-colored if and only if every vertex has even degree. We give a short proof that a plane graph with no two nontriangular faces incident is 3-chromatic if and only if a local neighborhood of each face is 3-colorable. And if a graph embeds on an orientable surface of genus $g > 0$, there is a constant $c(g)$ so that if all noncontractible cycles have length at least $c(g)$, if no two nontriangular faces are incident, and if each face has a 3-colorable local neighborhood, then the graph is 4-colorable. These results generalize the 4-color theorem for locally planar Eulerian triangulations in "Colouring Eulerian triangulations," obtained with B. Richter and P. Seymour.

Room E113

The Weighted-Edge Case of Strength and Fractional Arboricity in Graphs

Arthur M. Hobbs*, Texas A&M University
Louis Petingi, College of Staten Island

In the study of packings and coverings of graphs by trees, the functions $\eta = \min_{S \subseteq E(G)} \frac{|S|}{\omega(G-S)-\omega(G)}$ (strength) and $\gamma = \max_{H \subseteq G} \frac{|E(H)|}{|V(H)|-\omega(H)}$ (fractional arboricity) were shown by Tutte and Nash-Williams to be very important. In many published papers, these functions were studied with weights on the edges, and in others they were studied without weights, apparently leaving the weighted case open to further examination. In this paper we develop simple formulas for the weighted-edge case of these functions in terms of their unweighted values. Using these formulas, we demonstrate how known unweighted-edge results can be easily translated into weighted-edge results.

Room 48A–B

The Total Domination Number of Graphs of Maximum Degree 3

David C. Fisher, University of Colorado at Denver
Suzanne M. Seager*, Mount Saint Vincent University, Canada

The total domination number $\gamma_t(G)$ of a graph G is the minimum size of a set $D \subseteq V(G)$ such that every node of G is adjacent to a node in D. We show that if G has maximum degree at most 3 and no K_1 or K_2 components, then $\gamma_t(G) \leq n - \frac{1}{3}e$, where G has n nodes and e edges. It follows that if G is a cubic graph, then $\gamma_t(G) \leq \frac{1}{2}n$.

Room 50

Competition Between Geometric Random Variables I: One-Dimensional Results

D. Elizabeth “Betsy” Sinclair*, University of Redlands
Julia Eaton, University of Rochester

Each player has a p-coin and flips until he or she flips heads. If two players have the same number of flips, the round is declared a tie, so that we seek a strict ordering of the contestants. Once a player flips heads, only that player ceases to flip, the other players must continue to flip until they too have flipped heads. The player with the greatest number of flips is declared the winner. We consider results that compute and/or bound the probability of a tie; and the total number of rounds. We also study the distribution of X, defined as $\sum_{i<j} I_{i,j}$, where $I_{i,j}$ equals one or zero according as the i^{th} and j^{th} players flip heads on the same toss; clearly we have a strict ordering if $X = 0$. The second part of this research, to be presented by Julia Eaton, will examine the fine structure of multiple ties between contestants, and explore the connections with graph theory.

Wednesday, 4:20–4:35

Room 148

b-Colorings of Graphs

Jan Kratochvíl, Charles University, Czech Republic
Zsolt Tuza, Hungarian Academy of Sciences
Margit Voigt*, Technical University, Germany

A *b-coloring* of a graph G by k colors is a proper coloring of the vertices of G such that in each color class exists a *dominating vertex* that is a vertex having neighbors in all other $k-1$ color classes. The *b-chromatic number* $b(G)$ of a graph G is the maximum k for which G has a b-coloring by k colors.

The concept of b-colorings was introduced in 1999 by Irving and Manlove. The talk presents this new graph coloring concept and gives results on bipartite graphs, algorithmic problems and the asymptotic behavior of the b-chromatic number.

Room E113

Partitioning the Edges of $2K_{c,d}$ into Copies of $K_{a,b}$

Dean Hoffman, Auburn University
Mark Liatti*, Auburn University

We investigate partitioning the edges of the 2-fold complete bipartite graph $2K_{c,d}$ into copies of $K_{a,b}$.

Room 48A–B

Colored Domination in Graphs

Teresa Haynes, East Tennessee State University
Debra Knisley*, East Tennessee State University

A vertex set S is a dominating set if it's closed neighborhood is the entire vertex set. The minimum cardinality among all dominating sets is the domination number of a graph and is denoted by $\gamma(G)$. The minimum cardinality among all independent dominating sets is the independent domination number of a graph and is denoted by $i(G)$. These two parameters are well known and have been highly studied. Of course, $\gamma(G) \leq i(G)$. Recent attention has been given to the question; what domination parameters are between $\gamma(G)$ and $i(G)$? We define the colored domination number, denoted by $cd_k(G)$ as the minimum cardinality among all $k - colorable$ dominating sets. Thus we obtain $i(G)$ when $k = 1$ and $\gamma(G)$ for sufficiently large k. We give an upper bound for $cd_k(G)$ in terms of $\gamma(G)$, we show $|cd_k(G) - cd_j(G)|$ can be arbitrarily large for $i \neq j$ and we give a sufficient condition for $cd_k(G) = \gamma(G)$.

Room 50

On the Profile of the Tensor Product of Paths with Complete Bipartite Graphs

Yung-Ling Lai, National Chiayi University, Taiwan, ROC

It is known that determination of the profile for arbitrary graphs is NP-complete. The *tensor product* of graphs G_1 and G_2, denoted $G_1(T_p)G_2$, is the graph with vertex set $V(G_1) \times V(G_2)$ in which (u_1, v_1) is adjacent to (u_2, v_2) if $(u_1, u_2) \in E(G_1)$ and $(v_1, v_2) \in E(G_2)$. In this paper, we provide linear time algorithms to achieve the profile of the tensor product of paths with complete bipartite graphs.

Wednesday, 4:40–4:55

Room 148

Critically Edge Colourable Planar Graphs

Andrea Hackmann, Technische Universität Braunschweig, Germany

The chromatic index $\chi'(G)$ of any graph $G = (V, E)$ with maximum degree Δ either equals Δ or $\Delta + 1$ (Vizing's theorem). G is called critical with respect to edge colouring, if $\chi'(G) = \Delta + 1$ and $\chi'(G - e) = \Delta$ for every edge $e \in E$. Since every graph with chromatic index $\Delta + 1$ contains a critical subgraph of the same maximum degree, results about graphs with chromatic index $\Delta + 1$ are often obtained by considering critical subgraphs.

The talk is about the structur of planar critical graphs and a method to construct all planar critical graphs of order $|V| \leq 12$.

Room E113

On Well-Covered 5-Connected Triagulations

Art Finbow*, Saint Mary's University, Canada
Bert Hartnell, Saint Mary's University, Canada
Richard Nowakowski, Dalhousie University, H Canada
Michael D. Plummer, Vanderbilt University

A graph is said to be *well-covered* if every maximal independent set of vertices has the same cardinality. A planar (simple) graph in which each face is a triangle is called a *triangulation.* In this talk, we determine which 5-connected triangulations are well-covered.

Room 48A–B

Paired-Domination in Grid Graphs

Kenneth Proffitt*, East Tennessee State University
Teresa W. Haynes, East Tennessee State University
Peter J. Slater, University of Alabama in Huntsville

For a graph $G = (V, E)$, a set $S \subset V(G)$ is a dominating set if every vertex $v \in V(G) \setminus S$ is adjacent to at least one vertex in S. A *paired-dominating set* is a dominating set whose induced subgraph has a perfect matching. We present results on paired-domination in grid graphs.

Room 50

The Bandwidth of a Random Graph

Dorea Claassen, University of Nebraska–Lincoln

Label a graph on n vertices with the integers 1 through n. Call this labeling f. Now take the absolute difference between the endpoints of every edge in the graph. The maximum such edge difference is the *f-bandwidth*, denoted $B_f(G)$. The minimum f-bandwidth over all possible labelings is the *bandwidth* $B(G)$ of graph G. While the problem of computing the bandwidth of a graph is NP-complete, surprising results can be found for the random graph $G(n, p)$ on n vertices where each edge is placed with probability p. We will present new results that bound $B(G(n, p))$.

Wednesday, 5:00–5:15

Room 148

Comparing the Hall Ratio and the Chromatic Number

Mathew Cropper*, Eastern Kentucky University
Andras Gyarfas, Hungarian Academy of Sciences
Jeno Lehel and Mike Jacobson, University of Louisville

The chromatic number of a graph G is certainly at least its number of vertices ($n(G)$) divided by its independence number ($\alpha(G)$). Moreover, for any subgraph H of G, the chromatic number of G is at least $\frac{n(H)}{\alpha(H)}$. The Hall Ratio of G is $\rho(G) = \max\left\{\frac{n(H)}{\alpha(H)}\right\}$ where the maximum is taken over all subgraphs. We show that there are families of graphs with bounded Hall ratio and unbounded chromatic number. We also explore this parameter for other families of graphs and offer problems.

Room E113

On Generalizations of the Oberwolfach Problem

Saad I. El-Zanati, Illinois State University

We report on some recent results on 2-factorizations of complete graphs generalizing the Oberwolfach problem. Included are some results on the Hamilton-Waterloo problem, an investigation of all possible 2-factorizations of K_n (or K_n minus a 1-factor), $n \leq 12$, as well as an investigation of factorizations of K_{2^n} into combinations of uniform 2-factors.

Room 48A–B

Signed Domination Number of a Graph and Its Complement

Ruth Haas*, Smith College
Thomas Wexler, Cornell University

Let G be a graph on vertex set V and define a function $f : V \to \{-1, 1\}$. The function f is a signed dominating function if for every vertex $x \in V$, the closed neighborhood of x contains more vertices with function value 1 than with -1. The weight of f, denoted $w(f)$, is the sum of the function value of all vertices in G. The signed domination number of G $\gamma_s(G)$ is the minimum weight of a signed dominating function on G. We give some results on the sum of the signed domination number of a graph and its complement. In particular, we characterize the graphs for which both the signed domination number of the graph and its complement are maximum.

Room 50

Sampling the Web Graph With Random Walks

Narsingh Deo, University of Central Florida
Pankaj Gupta*, University of Central Florida

The World Wide Web can be modeled as a directed graph in which a node represents a Web page and a directed edge represents a hyperlink. This gigantic Web graph is currently estimated to have over three billion nodes and is growing by more than seven million nodes a day—without any centralized control. Recent studies suggest that despite its chaotic appearance, the Web is a highly structured digraph, in a statistical sense. The study of this graph is important in the design of Web algorithms for crawling, searching, and ranking Web resources. The graph-theoretic structure of the Web can also be exploited for attaining efficiency and comprehensiveness in Web navigation.

A random walk on a regular, connected, undirected graph generates a close to uniformly distributed sample of nodes (Bar-Yossef *et al.*, VLDB conference, 2000). An accurate sampling of the Web pages (obtained with random walks) is valuable in determining the domain-name distribution of Web pages, coverage of search engines, and other important properties such as average number of links per page and average size of a Web page. In this paper, we present the empirical study of sampling a synthetically- generated Web graph through random walks.

Wednesday, 5:30–6:00

Room 148

Graphs and Their Games

Frank Harary, New Mexico State University

Many concepts from graph theory can be converted into two-person games in which one of the two players, A (the first player) or B is the winner. Space does not permit to list all of these games. Only one of the games will be indicated; the others have corresponding rules of play. Given a connected graph G, the game of Pathfinder has A removing the edges of a path from G. Then B removes (the edges of) a path from the resulting subgraph. The two players continue to alternate their moves until no edges remain. In the achievement game, the last player to move is the winner. In the avoidance game, he is the loser. Other catchy game names are Trailblazer, Blockbuster, Do and Don't connect-it, Kingmaker for tournaments, Color my points, Make a BIBD, etc. At the talk, these games will be played as time permits.

Thursday

9:00–10:00

148 Alexander Schrijver, *Permanents and Edge-Colouring*

10:00–10:20

Coffee break

10:20–10:35

148 Ralph P. Grimaldi, *Compositions without the Summand* 1

E113 Paul Balister, Béla Bollobás, Jonathan Cutler*, Luke Pebody, *The Interlace Polynomial of Graphs at* -1

48A-B Yoshihiro Kaneko*, Stephen Locke, *Minimum Degree Approach for Paul Seymour's Conjecture*

50 Galen E. Turner III, *Subdivisions of Wheels*

10:40–10:55

148 Alain Plagne*, Laurent Habsieger, *Improved Bounds for* $B_2[2]$ *Sets*

E113 Rao Li, *Hamiltonicity of* 3*-Connected Quasi-Claw-Free Graphs*

48A-B Darren A. Narayan, *Powers of Directed Hamiltonian Paths as Feedback Arc Sets*

50 Larry Cummings, *Connected Components of Comma-Free Codes*

11:00–11:15

148 Ingo Schiermeyer, *New Ramsey Numbers for Cycles*

E113 Mahmoud El-hashash, *On the Hamiltonicity of Two Subgraphs of the Hypercube*

48A-B M.A. Fiol, J. Gimbert*, *On Almost Moore Bipartite Digraphs with Odd Diameter*

50 Narsingh Deo, Paulius Micikevicius*, *Comparison of Prüfer-like Codes for Labeled Trees*

11:20–11:35

148 Konrad Piwakowski, Stanisław P. Radziszowski*, *Towards the Exact Value of the Ramsey Number* $R(3,3,4)$

E113 Anant Godbole*, Debra Knisley, Rick Norwood, *Alphabet-Overlap Graphs are Hamiltonian*

48A-B Cora Neal, 2*-Primitive Tournament Digraphs*

50 Suk Jai Seo*, Ashok T. Amin, *On Extremal Oriented Trees*

11:40–11:55

148 Ermelinda DeLaVina, *Connected Triangle-Free Ramseyan Properties of Graphs*

E113 Bill Linderman, *Minimum Graphs with Complete Closure*

48A-B Michelle Foster*, Peter Johnson, *An Existence Theorem in Information Theory*

50 Jens-P. Bode, *Triangular Polyomino Set Achievement*

12:05–12:35

148 Presentation of the 2000 Medals of the Institute of Combinatorics and its Applications

12:35–1:30

Lunch

1:30–2:30

148 Alexander Schrijver, *Graph embedding and Eigenvalues*

2:40–2:55

148 Van Vu, *Set Systems with Even Multi-Intersections*

E113 Chris Rodger*, Darryn Bryant, Y. Chang, R. Wei, *Two Dimensional Balanced Sampling Plans Excluding Contiguous Units*

48A-B Krystyna T. Balińska, Michael L. Gargano, Louis V. Quintas*, *An Edge Partition Problem Concerning Hamilton Paths*

50 Yolando B. Beronque, *On the Structure of a Distance-Regular Graph from a Maximal-Distance Subgraph*

3:00–3:15

148 Yuejian Peng*, Vojtech Rödl, Jozef Skokan, *Small Cliques in* 3*-Uniform Hypergraphs*

E113 K.T. Arasu, Yu Qing Chen, Alexander Pott*, *New Results on Non-abelian Relative Difference Sets*

48A-B Jay Bagga, John Emert*, J. Michael McGrew, *Visibility Graphs on the Sphere*

50 R.D. Baker, G.L. Ebert*, T. Penttila, *Hyperbolic Fibrations and Flocks of a Quadratic Cones*

3:20–3:35

148 Yulia Dementieva*, Penny Haxell, Brendan Nagle, Vojtěch Rödl, *On Characterizing Hypergraph Regularity*

E113 Ben Wehrung, *Maximum Packings of K_n with Eulerian Graphs*

48A-B Marek Kubale, *The Smallest Hard-to-Color Graph for Sequential Coloring Algorithms*

50 Keith Mellinger, *Constructing Mixed Partitions of* $\mathcal{PG}(3, q^2)$

3:35–4:00

Coffee break

4:00–4:15

148 Roger B. Eggleton*, James A. MacDougall, *Minimally Star-Saturated Graphs*

E113 Isidoro Gitler, *Coloring the Angles of Embedded Graphs*

48A-B Thomas Boehme*, Bojan Mohar, *Domination, Packing and Excluded Minors*

50 Gilles Caporossi*, Pierre Hansen, *Variable Neighborhood Search for Extremal Graphs, 1 to 7: a Short Survey*

4:20–4:35

148 József Balogh*, Béla Bollobás, Miklós Simonovits, *Estimates for the Number of L-Free Graphs*

E113 Terry McKee, *Recognizing Dual-Chordal Graphs*

48A-B B.L. Hartnell*, P.D. Vestergaard, *Dominating Sets with At Most k Components*

50 Pierre Hansen*, Mustapha Aouchiche, Gilles Caporossi, *Variable Neighborhood Search for Extremal Graphs,* 8*: Variations on Graffiti* 105

4:40–4:55

148 John Goldwasser, *Erdos-Ko-Rado with a Bound on the Maximum Degree*

E113 Guoli Ding, Jinko Kanno*, *Splitter Theorems for Cubic Graphs*

48A-B Bert L. Hartnell, Douglas F. Rall*, *Dominating the Cartesian Square of a Tree*

50 Dan Pritikin, *The Upper Bound for Pancake Sorting*

5:00–5:15

148 Sergei L. Bezrukov, Thomas J. Pfaff, Victor P. Piotrowski*, *A New Approach to Macaulay Posets*

E113 Nair Maria Maia de Abreu*, Patricia Erthal de Moraes, Samuel Jurkeiwicz, *Graphs with Homogeneous Density in (a, b)-Linear Classes*

48A-B	John Villalpando*, Renu Laskar, *Degree Weighted Domination*
50	Dionysios Kountanis, Sathya Priya Durairaju*, *Optimal Connection of Networks with a Backbone Interconnection Network*

5:20–5:35

148	Matt Walsh*, Peter Johnson, *Another Network Vulnerability Parameter*
E113	Jay S. Bagga*, Lowell W. Beineke, Badri N. Varma, *Line Completion Numbers of Graphs*
48A-B	David Erwin, Daryl Findley, John McKenzie*, Ben Phillips*, *Results on a Lower Bound on the Domination Number: I*
50	N. Sankaranarayanan, Francis Suraweera*, Narsingh Deo, *Two Protocols for Multicast Communication*

5:40–5:55

148	Salar Y. Alsardary, *An Upper Bound on the Basis Number of the Powers of the Complete Graphs*
E113	Geir Agnarsson, *On Powers of Some Geometrically Represented Graphs*
48A-B	David Erwin, Daryl Findley*, John McKenzie, Ben Phillips, *Results on a Lower Bound on the Domination Number: II*
50	Anton Colijn, *The Master Timetabling Problem: Comparison of Two Approaches*

8:00–9:30

Survivor's Dessert Party

Invited Instructional Lectures

Thursday 9:00–10:00, Room 148

Permanents and Edge-Colouring

Alexander Schrijver, CWI and University of Amsterdam

The permanent of an $n \times n$ matrix $A = (a_{i,j})$ is defined by

$$\mathrm{per}(A) := \sum_{\pi} \prod_{i=1}^{n} a_{i,\pi(i)},$$

where π ranges over all permutations of 1, 2, …, n.
Van der Waerden (1926) asked if the permanent of any doubly stochastic $n \times n$ matrix is at least $n!/n^n$, which was proved in 1981 by Falikman.
Related is the question of Erdős and Rényi (1968) for the maximum value α_k such that $\mathrm{per}(A) \geq \alpha_k^n$ for each nonnegative integer $n \times n$ matrix A with each row and column sum equal to k. So α_k^n is a lower bound on the number of 1-factors in a k-regular bipartite graph on $2n$ vertices.
Voorhoeve found in 1978 that $\alpha_3 = \frac{4}{3}$. Recently we found the exact value of α_k for general k. It implies the currently best lower bound 0.44007584 for Kasteleyn's dimer problem in 3 dimensions.
The methods also imply an $O(km)$ time algorithm to find a perfect matching in a k-regular bipartite graph. This gives an $(m\Delta)$ time algorithm for colouring the edges of a bipartite graph, sharpened by Cole, Ost, and Schirra to $O(m \log \Delta)$ (m = number of edges, Δ = maximum degree).
In the lecture we give an introduction to the results and methods.

Wednesday 1:30–2:30, Room 148

Graph Embedding and Eigenvalues

Alexander Schrijver, CWI and University of Amsterdam

In 1990, Colin de Verdiére characterized planar graphs by means of a graph parameter $\mu(G)$ based on the largest multiplicity of the second eigenvalue of matrices associated with a graph G: $\mu(G) \leq 3$ if and only if G is planar. The parameter is motivated by estimating the multiplicity of the second eigenvalue of of Schrödinger operators on dRiemann surfaces.
With L. Lovász we proved in 1998 that $\mu(G) \leq 4$ if and only if G is linklessly embeddable. The proof is based on a Borsuk theorem for antipodal links, that might be of independent interest.
Recent results of Lovász suggest a close connection between the matrices associated with a graph, and its representation as the skeleton of a convex polytope.
In the lecture, we give an introduction to the above, and we explain the methods.

Thursday, 10:20–10:35

Room 148

Compositions Without the Summand 1

Ralph P. Grimaldi, Rose-Hulman Institute of Technology

Given a positive integer n, the number of compositions of n is counted by F_{n-1} (the $(n-1)$-st Fibonacci number). For a given $n > 0$ we consider all of these compositions and determine, among other things, (i) the total number of times a given summand appears; (ii) the total number of summands; and (iii) the total number of plus signs. Continuing with these ideas we then focus on those compositions (without the summand 1) that are palindromes.

Room E113

The Interlace Polynomial of Graphs at -1

Paul Balister, University of Memphis
Béla Bollobás, University of Memphis
Jonathan Cutler*, University of Memphis
Luke Pebody, University of Memphis

In this paper we give an explicit formula for the interlace polynomial at $x = -1$ for any graph, and as a result prove a conjecture of Arratia, Bollobás and Sorkin that states that it is always of the form $\pm 2^s$. We also give a description of the graphs for which s is maximal.

Room 48A–B

Minimum Degree Approach for Paul Seymour's Conjecture

Yoshihiro Kaneko*, Gifu University, Japan
Stephen Locke, Florida Atlantic University

Paul Seymour's conjecture is as follows. Let D be a simple oriented graph. Then D contains a vertex v such that $d_{++}(v) \geqq 2d_{+}(v)$, where $d_{++}(v)$ is the number of vertices with out-distance 1 or 2 from v, while $d_{+}(v)$ is the number with out-distance 1 from v. In this talk, we approach the problem by considering the minimum degree, δ. We prove the conjecture is true if δ is 7 or less. Then we generalize this proof to give some sufficient conditions.

Room 50

Subdivisions of Wheels

Galen E. Turner III, Stephen F. Austin State University

Dirac proved that a simple graph with chromatic number at least four contains a subgraph that is a subdivision of K_4. This paper extends his result by proving that if G is a simple graph with chromatic number $n \geq 4$, then G contains a subgraph that is a subdivision of the n-vertex-wheel.

Thursday, 10:40–10:55

Room 148

Improved Bounds for $B_2[2]$ Sets

Alain Plagne*, Ecole polytechnique, France
Laurent Habsieger, Universite Bordeaux 1, France

A set of integers A such that for any n, the equation $n = a + b, a, b \in A$ has at most 2 solutions is called a $B_2[2]$ set. Let $F_2(N, 2)$ be the maximum cardinality of a $B_2[2]$ set included in $\{1, 2, \ldots, N\}$. We improve the known bounds on this quantity by showing that $4/\sqrt{7} \lesssim F_2(N, 2)/\sqrt{N} < 2{,}3218\ldots$

Room E113

Hamiltonicity of 3-Connected Quasi-Claw-Free Graphs

Rao Li, Georgia Southwestern State University

A graph G is *quasi-claw-free* if it satisfies the property: $d(x, y) = 2 \Rightarrow$ there exists a vertex $u \in N(x) \cap N(y)$ such that $N[u] \subseteq N[x] \cup N[y]$. Let G be a 3-connected quasi-claw-free graph of order $n \geq 30$. If the minimum degree of G is at least $(n + 5)/5$, then G is hamiltonian.

Room 48A–B

Powers of Directed Hamiltonian Paths as Feedback Arc Sets

Darren A. Narayan, Rochester Institute of Technology

A minimum feedback arc set of a digraph is a smallest sized set of arcs that when reversed makes the resulting digraph acyclic. Given an acyclic digraph D, we seek a smallest sized tournament T that has D as a minimum feedback arc set. The reversing number of a digraph is defined to be $r(D) = |V(T)| - |V(D)|$. We use methods from integer programming to investigate reversing numbers where D is a power of a directed Hamiltonian path. It was shown by Isaak in 1995 that $r(T_n) = 2n - 2 - \lfloor \log_2 n \rfloor$ when $n = 2^k - 2^t$. We will show the reversing number for T_{2^k} actually suffices for all digraphs on n vertices containing $P_{2^k}^{2^{k-1}}$.

Room 50

Connected Components of Comma-Free Codes

Larry Cummings, University of Waterloo, Canada

The vertices of the de Bruijn graph are all strings of length $n-1, (n > 1)$, over a fixed finite alphabet. The edges are all strings of length n over the same alphabet. A directed edge $a_1 \cdots a_n$ of the de Bruijn graph joins vertex $a_1 \cdots a_{n-1}$ to vertex $a_2 \cdots a_n$. A block code is comma-free if it does not contain any overlap of codewords. Representing the codewords of comma-free codes as directed edges of the de Bruijn graph for $n > 2$ we characterize the connected components of subgraphs of the de Bruijn graph determined by comma-free codes using the Fine-Wilf theorem.

Thursday, 11:00–11:15

Room 148

New Ramsey Numbers for Cycles

Ingo Schiermeyer, Technische Universität Bergakademie Freiberg, Germany

Conjecture 1 (Bondy and Erdös, 1971)
For all odd natural numbers $k \geq 5$,

$$r(C_k, C_k, C_k) = 4k - 3.$$

Together with R. Faudree and A. Schelten we have proved this conjecture for $k = 7$, i.e. $r(C_7, C_7, C_7) = 25$.

Conjecture 2 (Erdös, Faudree, Rousseau and Schelp, 1978)
For all natural numbers $m \geq n \geq 3$ (except $r(C_3, K_3) = 6$),

$$r(C_m, K_n) = (m - 1)(n - 1) + 1.$$

This conjecture holds for $3 \leq n \leq 5$. We will present a proof for $n = 6$ and for all $n \geq 7$ with $m \geq n^2 - 2n$.

Room E113

On the Hamiltonicity of Two Subgraphs of the Hypercube

Mahmoud El-hashash, Bridgewater State College

A Hamiltonian cycle in a graph G is a cycle that contains each vertex of G exactly once, except for the starting and ending vertex that appears twice. The n-dimensional hypercube Q_n is a graph that has $N = 2^n$ vertices and $n2^{\{n-1\}}$ edges. The vertices may be represented as the binary strings of length n. Two strings are considered adjacent if they differ in exactly one position. Alternatively, each binary string may be identified with a subset of $\{1, 2, \ldots, n\}$, with the string $(x_1, x_2, \ldots, x_n)$ corresponding to the subset $\{i/x_i = 1\}$. Then two subsets are adjacent when their symmetric difference has exactly one element. The weight of a string is the number of 1's in it. Weight of a subset is its cardinality. In this paper, Hamiltonian cycles of two induced subgraphs of the n-dimensional hypercube Q_n are studied. For $n = 2k + 1$, we define these subgraphs as follows: R_n is the subgraph of Q_n induced by all the vertices of Q_n except two, the first of weight zero and the second of weight n. H_n is the subgraph of Q_n induced by all the vertices of weights k and $k+1$. We prove by induction that for $n = 2k + 1$, R_n is Hamiltonian. We introduce some new results, which are relevant to the structure of H_n. We also study Hamiltonian cycles of H_n and find that H_5 has exactly 48 oriented Hamiltonian cycles and H_7 has at least 2112 oriented Hamiltonian cycles. We implement a program to find a Hamiltonian cycle of H_n for smal n and we use those results to set up a heuristic technique to reduce the time requirement to make the program work for larger n (9, 11, and 13).

Room 48A–B

On Almost Moore Bipartite Digraphs with Odd Diameter

M.A. Fiol, Universitat Politecnica de Catalunya, Spain
J. Gimbert*, Universitat de Lleida, Spain

In the context of the degree/diameter problem for directed graphs, it is known that the number of vertices of a strongly connected bipartite digraph satisfies a Moore-like bound in terms of its diameter k and the maximum out-degrees (d_1, d_2) of its partite sets of vertices. It has been proved that, when $d_1 d_2 > 1$, the digraphs attaining such a bound, called Moore bipartite digraphs, do only exist when $2 \leq k \leq 4$. This suggests to study the problem of the existence of bipartite digraphs, with diameter $k \geq 5$, which miss the (unattainable) Moore-like bound by just one vertex on each partite set. In this paper we derive some necessary conditions for the existence of such digraphs, called *almost Moore bipartite digraphs*, in the case of odd diameter. As a consequence, we prove that any almost Moore bipartite digraph of diameter $k = 5$ and out-degrees (d_1, d_2) is the second-order line digraph of a Moore bipartite digraph of diameter three, apart from the particular case $d_1 d_2 = 2$ for which there are two other digraphs.

Room 50

Room 148

Comparison of Prüfer-like Codes for Labeled Trees

Narsingh Deo, University of Central Florida
Paulius Micikevicius*, University of Central Florida

In 1918 Prüfer showed a one-to-one correspondence between n-node labeled trees and (n - 2)-tuples of node labels. The proof employed a tree code, computed by iteratively deleting the leaf with the smallest label and recording its neighbor. Since then new tree codes were proposed, based on different node deletion sequences. These codes have different properties, interesting in graph theory and computer science. In this paper we survey Prüfer-like tree codes, compare their properties and algorithms for encoding/decoding.

Thursday, 11:20–11:35

Room 148

Towards the Exact Value of the Ramsey Number $R(3, 3, 4)$

Konrad Piwakowski, Technical University of Gdańsk, Poland
Stanisław P. Radziszowski*, Rochester Institute of Technology

The classical Ramsey number $R(r_1, \ldots, r_k)$ is the least $n > 0$ such that there is no k-coloring of the edges of K_n, which does not contain monochromatic complete subgraph K_{r_i} in color i, for all $1 \leq i \leq k$. In the multicolor case ($k > 2$), the only known nontrivial value is $R(3, 3, 3) = 17$. The only other case whose evaluation does not look hopeless is $R(3, 3, 4)$, which currently is known to be equal to 30 or 31 by an earlier work of the authors. We report on progress towards deciding which of these two is the correct value. Using computer algorithms we show that any critical coloring of K_{30} proving $R(3, 3, 4) = 31$ must satisfy several additional properties, beyond those implied directly by the definitions, further pruning the search space. This progress, though substantial, is not yet sufficient to launch the final attack on the exact value of $R(3, 3, 4)$.

Room E113

Alphabet-Overlap Graphs are Hamiltonian

Anant Godbole*, Tennessee State University
Debra Knisley, Tennessee State University
Rick Norwood, East Tennessee State University

Consider a graph with vertices consisting of all k-letter words over an alphabet of size d, with an edge between vertices i, j iff the last (resp. first) $m < k$ letters of j coincide with the first (resp. last) m letters of i. We prove that such *alphabet-overlap* graphs are hamiltonian. Connections to DNA sequencing are given.

Room 48A–B

2-Primitive Tournament Digraphs

Cora Neal, Utah State University

The notion of primitive matrices has been extended to a pair of matrices. This can be translated to graph terminology, thinking of positive entries from the first matrix as red directed arcs in a digraph and positive entries from the second matrix as blue directed arcs in the same digraph. It will be shown that if you start with a primitive tournament and randomly color the arcs red or blue, the resulting 2-colored digraph corresponds to a matrix pair which is almost always primitive.

Room 50

On Extremal Oriented Trees

Suk Jai Seo*, University of Alabama
Ashok T. Amin, University of Alabama

Let T_n denote a tree on n vertices. Consider the problem of orienting the edges of T_n so as to maximize the number of directed paths of length at least two. Such an orientation is referred to as an optimal orientation, and the number of directed paths of length two or more is denoted by $\eta^*(T_n)$. A known algorithm is presented for determining an optimal orientation for a tree T_n. Clearly for all trees T_n, $l(n) \leq \eta^*(T_n) \leq h(n)$. We determine $l(n), h(n)$, and extremal trees for which equalities are obtained.

Thursday, 11:40–11:55

Room 148

Connected Triangle-Free Ramseyan Properties of Graphs

Ermelinda DeLaVina, University of Houston - Downtown

Given a graph G, with property T of connected and triangle-free, color an edge e of the complement of G red if $G + e$ does not have property T, and blue otherwise. Let $T(r, b)$ be the smallest n such that every connected triangle-free graph on at least n vertices contains either an r element red clique or b element blue clique. An upper bound is obtained for $T(r, b)$ and for the special case $r = 4$ upper and lower bounds are obtained. Further, a summary of similar results for other properties of graphs will be presented.

Room E113

Minimum Graphs with Complete Closure

Bill Linderman, King College,

Ryjacek has described a neighborhood closure for claw-free graphs which affects neither the claw-freeness nor the length of the longest cycle of the graph. Thus, a claw-free graph with a complete closure of this type is hamiltonian. We determine minimum graphs with a complete closure of this type.

Room 48A–B

An Existence Theorem in Information Theory

Michelle Foster*, Wingate University
Peter Johnson, Auburn University

A probabilistic finite state source automaton (pfssa) with alphabet $S = \{s_1, \dots, s_m\}$ is a finite directed graph whose arcs are labeled with probabilities and with members of S, satisfying the condition that the sum of the probabilities on the arcs leaving any node is one. The automaton is thought to generate *source text*, emitting the letter on the arc traveled along as the "source gremlin" travels among the nodes, with each "next" arc chosen probabilistically.
If the underlying digraph is strongly connected, the relative frequencies $f(i_1, \dots, i_k)$ of the different blocks $s_{i_1} \dots s_{i_k}$ of k consecutive letters (k-grams) in the source text are well defined, for each $k = 1, 2, \dots$. Here we give elementary necessary and sufficient conditions on a function $f : \{1, \dots m\}^k \to [0, 1]$ for the existence of a strongly connected pfssa with an m-letter alphabet such that f gives the relative k-gram frequencies for the text emitted by that source.

Room 50

Triangular Polyomino Set Achievement

Jens-P. Bode, Technische Universität Braunschweig, Germany

In a set achievement game two players alternately color the cells of a game board. The first player wins the game if he achieves one of the polyominoes of a given set with his moves. If the first player can always win the game regardless of the moves made by the other player, then the set is called a winning set. Otherwise it is called a losing set. It is the question whether a given set of polyominoes is a winning or losing set. First results for triangular polyominoes are presented.

Thursday, 2:40–2:55

Room 148

Set Systems with Even Multi-Intersections

Van Vu

Sometime in the 60s, Erdos asked the following question: How many subsets of a ground set of n elements can one choose so that the intersection of every pair has even cardinality. This problem has become well-known as the "even town" problem and the answer was provided by Berlekamp and Graver, independently.

In this talk, we answer a more general question: How many subsets of a ground set of n elements can one choose so that the intersection of every k of them has even cardinality.

Room E113

Two Dimensional Balanced Sampling Plans Excluding Contiguous Units

Chris Rodger*, Auburn University
Darryn Bryant, University of Quensland, Australia
Y. Chang, Northern Jiaotong University, China
R. Wei, Lakehead University, Canada

A balanced sampling plan excluding contiguous units (or BSEC for short) was first introduced by Hedayat, Rao and Stufken in 1988. These designs can be used for survey sampling when the units are arranged in one-dimensional ordering and the contiguous units in this ordering provide similar information. In this paper, we generalize the concept of a BSEC to the two dimensional situation and give constructions of two dimensional BSECs with block size 3. The existence problem is completely solved in the case where $\lambda = 1$.

Room 48A–B

An Edge Partition Problem Concerning Hamilton Paths

Krystyna T. Balińska, The Technical University of Poznań, POLAND
Michael L. Gargano, Pace University
Louis V. Quintas*, Pace University

We consider a problem concerning edges contained in a Hamilton path.
Let G be a connected graph. An edge e in G is called *path-hamiltonian*, if there exists a Hamilton path in G that contains e. Since every edge in G is either path-hamiltonian or not, the edge set $E(G)$ of G is partitioned into two sets $Y(G)$ and $N(G)$, where $Y(G)$ is the set of path-hamiltonian edges of G. The two extreme cases are when every edge of G is path-hamiltonian, $Y(G) = E(G)$ and when G does not contain a Hamilton path, $N(G) = E(G)$.
We first determine sufficient conditions for a graph G to satisfy $Y(G) = E(G)$ and note that a characterization of such graphs is not known. Constructions of graphs are given for which $Y(G) = E(G)$ and of graphs having various proportions of path-hamiltonian edges. Since the Hamilton path problem is NP-complete, the determination of $Y(G)$ for an arbitrary graph is also NP-complete. However, it is still of interest to ask about algorithms which determine $Y(G)$ efficiently for special cases.

Room 50

On the Structure of a Distance-Regular Graph from a Maximal-Distance Subgraph

Yolando B. Beronque, De La Salle University, Philippines

Let Γ be a distance-regular graph with diameter d and let $\Gamma_d(\alpha)$ be the set of points at distance d from a vertex α. By a maximal-distance subgraph we mean $\Gamma_d(\alpha)$ for some α in Γ. We will determine the structure of Γ from the structure of $\Gamma_d(\alpha)$ where $\Gamma_d(\alpha)$ is isomorphic to a small strongly regular graph of order at most 27.

Thursday, 3:00–3:15

Room 148

Small Cliques in 3-Uniform Hypergraphs

Yuejian Peng*, Emory University
Vojtech Rödl, Emory University
Jozef Skokan, University of Illinois at Urbana-Champaign

Many applications of Szemerédi's Regularity Lemma are based on the following technical fact: If G is an s-partite graph with $V(G) = \bigcup_{i=1}^{s} V_i$, $|V_i| = m$ for all $i \in [s]$, and all pairs (V_i, V_j), $1 \leq i < j \leq s$, are δ-regular of density d, then G contains $d^{\binom{s}{2}} m^s (1 + f(\delta))$ cliques $K_s^{(2)}$, where $f(\delta)$ tends to 0 as δ tends to 0.
B. Nagle and V. Rödl established an analogous statement for 3-hypergraphs. In this talk, we discuss an alternative and somewhat simpler proof of the same result.

Room E113

New Results on Non-abelian Relative Difference Sets

K.T. Arasu, Wright State University
Yu Qing Chen, RMIT Melbourne, Australia
Alexander Pott*, University of Magdeburg, Germany

A relative (m, n, k, λ) difference set D relative to a normal subgroup $N < G$ is a subset of a group G of order mn. The order of N is n, and the list of differences $d - d'$ with $d, d' \in D$ covers every $g \in G \setminus N$ exactly λ times. No nonzero element in N is covered by a difference.
Examples of $(n + 1, 2, n, (n - 1)/2)$ relative difference sets exist whenever n is a prime power. They can be constructed via projections from so called affine difference sets. Not a single example of a difference set where n is not a prime power has been known.
In this talk, I will report about a new construction of nonabelian $(n + 1, 2, n, (n - 1)/2)$ difference sets where n is not a prime power.
Theorem. Relative difference sets with parameters $(n+1, 2, n, (n-1)/2)$ exist whenever n is a prime power or $(n - 1)/2$ is a prime power congruent 3 modulo 4. The latter examples are nonabelian. In some of these cases it can be shown that no abelian examples can exist.

Room 48A–B

Visibility Graphs on the Sphere

Jay Bagga, John Emert*, Ball State University
J. Michael McGrew, Ball State University

The edges of an endpoint visibility graph include a disjoint, planar collection of geodesic segments (the obstacles), together with additional geodesic segments (the visibility edges). Visibility graphs in the Euclidean Plane have been well-studied. We report here our current efforts to extend these concepts to two-dimensional Elliptical Geometry, the geometry of the sphere. We establish certain parameters for these visibility graphs, such as the presence and frequency of *long* (greater than a half-circumference) obstacle and/or visibility segments. For each of several cases, we establish or conjecture minimal and maximal graphs with a fixed number of obstacles. These results differ from those for the Euclidean Plane.

Room 50

Hyperbolic Fibrations and Flocks of a Quadratic Cone

R.D. Baker, West Virginai State College
G.L. Ebert*, University of Delaware
T. Penttila, University of Western Australia

A *hyperbolic fibration* is a partition of the points of $PG(3,q)$ into two lines and $q-1$ hyperbolic quadrics. A *flock* of a quadratic cone is a partition of the nonvertex points of the cone into q conics. The latter have been extensively studied, and numerous examples have been constructed, including several infinite families. We show there is a bijection between regular hyperbolic fibrations with constant back half and flocks of a quadratic cone with a specified conic. This yields a plethora of two-dimensional translation planes of both even and odd order by a "spawning process" from the resulting hyperbolic fibrations.

Thursday, 3:20–3:35

Room 148

On Characterizing Hypergraph Regularity

Yulia Dementieva*, Emory University
Penny Haxell, University of Waterloo, Canada
Brendan Nagle, Georgia Institute of Technology
Vojtěch Rödl, Emory University

Szemerédi's Regularity Lemma is well-known and powerful tool in modern graph theory. An important development regarding Szemerédi's Lemma is the discovery that ϵ-regularity property of a bipartite graph G is implied by an easily verifiable property concerning the neighborhoods of its vertices. This result has led to several interesting applications, including an algorithmic version of Szemerédi's lemma. The object of our paper is to study a similar argument for the Regularity Lemma for 3-uniform hypergraphs first introduced by Frankl and Rödl. In the paper we investigate conditions that can be equivalent to the regularity of a 3-partite 3-uniform hypergraph.

Room E113

Maximum Packings of K_n with Eulerian Graphs

Ben Wehrung, University of Texas at Tyler

A graph g is called eulerian if it contains an Euler tour, a closed walk that traverses each edge of g exactly once. There are three such simple graphs containing exactly seven edges; a 7-cycle, a fish, and a crown.

Let g be a simple eulerian graph with exactly 7 edges. A maximum packing of K_n with copies of g is an ordered triple (S, G, L), where G is a largest collection of edge-disjoint copies of g that can be found in the complete undirected graph K_n with vertex set S and L is the collection of edges in K_n that do not belong to any of the copies of g belonging to G. The collection of unused edges is called the leave.

Examples and constructions are presented to demonstrate the best possible leaves.

Room 48A–B

The Smallest Hard-to-Color Graph for Sequential Coloring Algorithms

Marek Kubale, Technical University of Gdansk, Poland

Let $A(G)$ be the number of colors used by algorithm A to color the vertices of graph G. A graph G is said to be hard-to-color (HC) (resp. slightly HC) if for every (resp. some) implementation of the algorithm A we have $A(G) > ch(G)$, where $ch(G)$ is the chromatic number of G. For a collection of such algorithms graph G is called a benchmark, if it is HC for every algorithm in the collection. The study of HC graphs makes it possible to design improved algorithms trying to avoid hard instances as far as possible. Hard-to-color graphs are also good benchmarks for the evaluation of existing and future algorithms and provide an alternative way of assessing their quality. In this talk we demonstrate the smallest benchmark for six sequential algorithms, namely: LF, SL, DSATUR and their three counterparts with bichromatic interchange procedure.

Room 50

Constructing Mixed Partitions of $\mathcal{PG}(3, q^2)$

Keith Mellinger, University of Delaware

Let $\Pi = \mathcal{PG}(3, q^2)$ denote the 3-dimensional projective space over the finite field $GF(q^2)$. We define a *mixed partition* of Π to be a partition of Π into two different types of objects, lines and Baer subspaces. A Baer subspace in this setting is a subspace of Π isomorphic to $\mathcal{PG}(3, q)$. Such mixed partitions can be used to construct translation planes of order q^4. In this talk we look at some methods of constructing different types of mixed partitions using various group theoretic techniques.

Thursday, 4:00–4:15

Room 148

Minimally Star-Saturated Graphs

Roger B. Eggleton*, Illinois State University
James A. MacDougall, University of Newcastle, Australia

A graph G is minimally S_m-saturated if every edge added to G creates a new m-star (a star of order m, not necessarily induced), but each edge deleted from G leaves a graph which no longer has that property. We characterize such graphs for $m \geq 3$. Any incomplete graph is minimally S_m-saturated for at most one $m \geq 3$. We give a simple recognition algorithm to identify such graphs and to determine the corresponding value of m. The kernel of such a graph is the subgraph induced by vertices of degree $m-2$; it turns out to be the most characteristic part of the graph. We characterize all graphs which are kernels of maximally star-free graphs, and give sufficient conditions for a given graph to be the kernel of some minimally star-saturated graph that is not star-free.

Room E113

Coloring the Angles of Embedded Graphs

Isidoro Gitler, Department of Mathematics, Cinvestav-IPN, Mexico

Given a cellular embedding of a graph in a surface we specify a simple rule to color it angles. We are interested in those graphs for which the angle coloring has the property that all the angles incident to a vertex have different color and all the angles incident to a face have different color (the angles incident to any edge have two colors). These graphs can be seen as circuits of a certain matroid, as partial intercalate matrices or as schemes of simplicial complexes. The coloring rule and some modifications of it are closely related to certain cycle double covers of graphs, important decompositions of the medial graph and evaluations of known transition polinomials. In particular we are interested in classifying graphs that can be angle colored with these properties. We show that the medial graph of any cubic simple planar graph without bridges always has this property and that the coloring is invariant under Delta-Wye transformations. In particular the Delta-Wye family of graphs related to the Petersen graph embedded on the Projective plane also has this property. We briefly discuss some applications to knots.

Room 48A–B

Domination, Packing and Excluded Minors

Thomas Boehme*, Ilmenau Technical University, Germany
Bojan Mohar, University Ljubljana, Slovenia

Let $\gamma(G)$ be the domination number of a graph G, and let $\alpha_k(G)$ be the maximum number of vertices in G, no two of which are at distance $\leq k$ in G. It is easy to see that $\gamma(G) \geq \alpha_2(G)$. In this note it is proved that $\gamma(G)$ is bounded from above by a linear function in $\alpha_2(G)$ if G has no large complete bipartite graph minors. Extensions to other parameters $\alpha_k(G)$ are also derived.

Room 50

Variable Neighborhood Search for Extremal Graphs, 1 to 7: a Short Survey

Gilles Caporossi*, École Polytechnique de Montréal, Canada
Pierre Hansen, GERAD and École des Hautes Études Commerciales de Montréal, Canada

The AutoGraphiX system for computer-aided and automated conjecture-finding in graph theory has been recently developped, applied to a series of problems from graph theory, with applications to chemistry and presented in a series of papers, summarized here. It relies upon parametric optimisation of graphs (with the recent Variable Neighborhood Search metaheuristic), then interactive or automated study of their characteristics, which leads to analytic and structural conjectures. Using this system, several conjectures of Graffiti have been refuted, many strenghtened, and over fifty new conjectures obtained. More than a dozen of them have been proved by various authors.

Thursday, 4:20–4:35

Room 148

Estimates for the Number of L-Free Graphs

József Balogh*
Béla Bollobás
Miklós Simonovits

Given a family L of graphs, let $p = p(L)$ be the maximal integer such that each graph in L has chromatic number at least $p+1$, and for $n \geq 1$ let $P(n, L)$ be the set of graphs with vertex set $[n]$ containing no member of L as a subgraph. Extending a result of Erdős, Frankl, and Rödl (1983), we prove that $|P(n, L)| \leq 2^{(1-1/p)n^2/2+O(n^{2-\gamma})}$ for some constant $\gamma = \gamma(L) > 0$. Our proof of this inequality is based on Szemerédi's Regurality Lemma, the stability theorem of Simonovits and the hypergraph theorem of Erdős. This result is essentially best possible since for all $p \geq 1$ and $t \geq 1$ there is a constant $|P(n, K_{p+1}(t, \ldots, t))| \geq 2^{(1-1/p)n^2/2+c_{t,p}n^{2-2/t}} - 1$.

Room E113

Recognizing Dual-Chordal Graphs

Terry McKee, Wright State University

A *dual-chordal* graph is a 2-connected, 3-edge-connected graph G such that, for every cutset D that consists of at least 4 edges, removing D from G creates a bridge (cut-edge) e (and so D is the symmetric difference of two smaller cutsets, each consisting of e and edges from D). Dual-chordal graphs can be defended as being the correct cycle/cutset duals of chordal graphs (whether planar or not). Dual-chordal graphs have several characterizations, only some of which are analogous to characterizations of chordal graphs. A recognition algorithm involves repeatedly contracting three special kinds of subgraphs, ending with a trivial graph. Counting how many of each of these three kinds of subgraph gets contracted determines three parameters for dual-chordal graphs, and these parameters are associated with structural features of the graphs (including the crossing number and Crapo's beta invariant).

Room 48A–B

Dominating Sets with At Most k Components

B.L. Hartnell*, St. Mary's University, Canada
P.D. Vestergaard, Aalborg University, Denmark

Recall that a connected dominating set S of a graph G has the property that not only does S dominate the graph but the subgraph induced by the vertices of S is connected.

We wish to generalize this by allowing for the possibility of several components. In particular, we define a k-component domninating set of a graph G as a set S of vertices that dominates $V(G) - S$ and has the additional property that the subgraph induced by S has at most k components. Besides the natural question of bounds and extremal situations one might also ask what one can say if the components are isomorphic.

This talk will outline some preliminary investigations and a number of problems.

Room 50

Variable Neighborhood Search for Extremal Graphs, 8: Variations on Graffiti 105

Pierre Hansen*, GERAD and École des Hautes Études Commerciales de Montréal, Canada
Mustapha Aouchiche, École des Hautes Études Commerciales de Montréal, Canada
Gilles Caporossi, École Polytechnique de Montréal, Canada

The conjecture 105 obtained by the automated system Graffiti of Siemion Fajtlowicz is the following: for all trees, the range of degrees of vertices does not exceed the range of transmission of distances (where the transmission of a vertex is the sum of distances from that vertex to all others). A short proof of this conjecture is given. Then several further conjectures, obtained with the system AutoGraphiX, are presented and some of them proved. They use the same parameters as above as well as maximum degree. It is also shown that for general graphs, the range of degrees can exceed the range of transmission of distances by an arbitrarily large amount.

Thursday, 4:40–4:55

Room 148

Erdos-Ko-Rado with a Bound on the Maximum Degree

John Goldwasser, West Virginia University

A set system F of distinct k-element subsets of the n-element set X is called *intersecting* if no pair of sets in F are disjoint. The renowned Erdős-Ko-Rado Theorem says that if $n > 2k$ then the maximum size of an intersecting set system is the binomial coefficient $C(n-1, k-1)$ (with equality iff F is the set of all k-sets through a fixed element, as shown by others). The *maximum degree* $d(F)$ of F is the maximum number of sets in F containing the same element of X. We consider the problem of finding the maximum size of an intersecting set system of k-sets such that $d(F) < m - s + 1$ where m is the size of F and s is a fixed positive integer. The Hilton-Milner Theorem solves the problem in the case $s = 1$. We give a complete solution for all s equal to at most $C(n-3, k-2)$, sharpening results of Anderson, Hilton, and Frankl. We also consider the problem of finding the maximum size of an intersecting set system F such that $d(F)$ is at most cm, where m is the size of F and c is a fixed real number in $(0, 1)$. There are a number of asymptotic results (fixed k, large n) for various values of c (Erdos, Rothschild, Szemeredi, Frankl, Furedi). We have some preliminary exact results.

Room E113

Splitter Theorems for Cubic Graphs

Guoli Ding, Louisiana State University
Jinko Kanno*, Louisiana State University

Let $\Gamma_{k,g}$ be the class of k-connected cubic graphs of girth at least g. For several choices of k and g, we determine a set $\mathcal{O}_{k,g}$ of graph operations, for which, if G and H are graphs in $\Gamma_{k,g}$, $G \neq H$, and G contains H topologically, then some operation in $\mathcal{O}_{k,g}$ can be applied to G to result a smaller graph G' in $\Gamma_{k,g}$ such that, on one hand, G' is contained in G topologically, and on the other hand, G' contains H topologically.

Room 48A–B

Dominating the Cartesian Square of a Tree

Bert L. Hartnell, Saint Mary's University, Canada
Douglas F. Rall*, Furman University

A dominating set D for a graph G is a subset of the vertex set such that each vertex of G belongs to D or is adjacent to a vertex that is in D. The *domination number* of G (denoted $\gamma(G)$) is the minimum cardinality of a dominating set of G. The Cartesian product of graphs G and H, denoted $G \Box H$, has the Cartesian product of their vertex sets as its set of vertices and two vertices are adjacent in the Cartesian product if they are equal in one coordinate and adjacent in the other. In 1963 V.G. Vizing conjectured that the domination number of $G \Box H$ for any two graphs G and H is at least $\gamma(G)\gamma(H)$. The conjecture is known to be true whenever one of the two graphs is a tree. In fact, although there are pairs of trees for which the conjectured lower bound is attained, in general the Cartesian product of two trees will have a domination number somewhat larger than this bound. We prove an improved lower bound for $\gamma(T \Box T)$ for any tree T.

Room 50

The Upper Bound for Pancake Sorting

Dan Pritikin, Miami University

A properly sorted stack of pancakes is a stack in which no pancake is larger than any pancake below it. In sorting an improperly ordered stack, allow in one step that the substack above any pancake be flipped and placed back on that pancake. In 1979, Gates and Papadimitriou proved that any stack of n pancakes can be sorted in at most $(5n + 5)/3$ steps. We consider ongoing research toward improving this bound. Or, with some luck, perhaps we will be treated to an improvement.

Thursday, 5:00–5:15

Room 148

A New Approach to Macaulay Posets

Sergei L. Bezrukov, University of Wisconsin – Superior
Thomas J. Pfaff, University of Wisconsin – Superior
Victor P. Piotrowski*, University of Wisconsin – Superior

We develop a new approach for establishing the Macaulayness of posets representable as cartesian powers of other posets. This approach is based on a problem of constructing an ideal of maximum rank in a poset. Using the relations between the maximum rank ideal problem and the edge-isoperimetric problem on graphs we demonstrate an application of our approach to specification of all posets with a special Macaulay order. We also present a new general construction for additive Macaulay posets and introduce several new families of Macaulay posets.

Room E113

Graphs with Homogeneous Density in (a, b)-Linear Classes

Nair Maria Maia de Abreu*, Universidade Federal do Rio de Janeiro, Brasil
Patricia Erthal de Moraes, Universidade Federal do Rio de Janeiro, Brasil
Samuel Jurkeiwicz, Universidade Federal do Rio de Janeiro, Brasil

We introduce families of graphs, whose number of edges is given by a linear function of the cardinality of vertices deriving from pairs of positive rational numbers. For graphs of these families, we prove certain properties related to the number of vertices and degrees limited to a given number. These properties generalize well-known results of maximal outerplanar graphs, (mops), maximal planar graphs and k-trees. For these classes, we define graphs with homogeneous density, for which we prove spectral properties similar to the ones of regular graphs.

Room 48A–B

Degree Weighted Domination

John Villalpando*, Clemson University
Renu Laskar, Clemson University

A weighted graph (G, w) is a graph $G = (V, E)$ togehter with a positive weight function w on its vertices. The weight of a set of vertices D is the sum of the weights of the vertices of D. The weighted domination number, $\gamma_w(G)$ is the minimum weight $w(D)$ over all dominating sets D of G. We define similarly weighted domination parameters such as weighted irredundance and weighted independence. It is shown that the string of inequalities for domination parameters also holds for wieghted domination parameters. We also investigate, in particular, these parameters where the weight of a vertex is the degree of the vertex.

Room 50

Optimal Connection of Networks with a Backbone Interconnection Network

Dionysios Kountanis, Western Michigan University
Sathya Priya Durairaju*, Western Michigan University

Given a set of N networks with corresponding routing strategies $R1$, $R2$, $\ldots$, RN. Connect the N networks with a Backbone network so that the composite network has a routing strategy R formed with $R1$, $R2$, $\ldots$, RN as its components and also has minimum cost. Backbone connections considered are pairwise, star and ring connections.

Thursday, 5:20–5:40

Room 148

Another Network Vulnerability Parameter

Matt Walsh*, Auburn University
Peter Johnson, Auburn University

A *weighted network* is a pair (G, g), in which G is a finite simple graph, and g a function assigning non-negative weights to the vertices of G. We will say that (the removal of) a set $S \subseteq V(G)$ *dismantles* (G, g) iff the sum over any connected component of $G - S$ of the values of g is less than 1. The Shields–Harary family of parameters have to do with situations in which an enemy of the network suffers a cost for removing a vertex, the cost being a (non-increasing) function of the weight at that vertex. These parameters come out of weighting the network so as to maximise the cost of dismantling it.

Here is a different situation that seems more realistic, in warfare and economics: the enemy suffers no cost in removing a vertex but, on the other hand, the enemy has no knowledge of the network's structure and only a vague idea of its location. The enemy will knock out any vertex that it *detects*; the probability of detection is a non-decreasing function of the weight at the vertex. The aim is to minimise the probability of dismantling (or in other words, to maximise the chance that the network survives) by clever weighting of the vertices. We give a

Room E113

Line Completion Numbers of Graphs

Jay S. Bagga*, Ball State University
Lowell W. Beineke, Indiana Purdue Fort Wayne
Badri N. Varma, University of Wisconsin-Fox Valley

For a graph G, the *line completion number* of G is the least integer r for which the super line graph $\mathcal{L}_r(G)$ is complete. In our earlier work on this topic, we determined this parameter for various families of graphs. In this paper we consider some other classes of graphs including that of complete bipartite graphs. This last family is especially interesting as it involves the combinatorial problem of maximizing, for given integers m and n, the minimum of m_1n_1 and m_2n_2 where $m_1 + m_2 = m$ and $n_1 + n_2 = n$.

Room 48A–B

Results on a Lower Bound on the Domination Number: I

David Erwin, Western Michigan University
Daryl Findley, Western Michigan University
John McKenzie*, Western Michigan University
Ben Phillips*, Western Michigan University

For a graph G of order n and maximum degree Δ, it is well-known that the domination number $\gamma(G) \geq \lceil n/(\Delta+1) \rceil$. This lower bound for $\gamma(G)$ is explored for several classes of graphs.

Room 50

Two Protocols for Multicast Communication

N. Sankaranarayanan, Griffith University, Australia
Francis Suraweera*, University of Central Florida
Narsingh Deo, University of Central Florida

Multicasting is a fundamental communication paradigm in which the communication takes place over a network between a single sending node and multiple receivers. It is used in applications such as video-conferencing, distance learning, transmission of corporate data, and stock market trends. In just less than 10 years, the MBone (Multicast Backbone of the Internet) has grown from a small network used by a few select people into a gigantic network that spans the globe. Multicasting is an active area of research.

This paper proposes two protocols for multicast communication, both based on queueing theory. The first one is a static, sender-based protocol which ensures that all receivers view a multicast packet at the same time. The sender calculates the maximum time taken by a packet to reach the farthest node, and all receivers are forced to wait for that amount of time before viewing the packet. This can be used in applications like transmission of stock market trends, where it is essential that all the clients view the data at the same time. The second protocol employs retransmission buffers to ensure reliability of communication. In this protocol every node in the multicast set will store packets in the retransmission buffer. The duration for which a packet is stored in the buffer depends on the node's distance from the sender and the number of retransmission requests received by it. Thus, the buffering time varies from node to node and will be adapted to accommodate the reliability! of the connection.

Thursday, 5:40–5:55

Room 148

An Upper Bound on the Basis Number of the Powers of the Complete Graphs

Salar Y. Alsardary, University of the Sciences in Philadelphia

The basis number of a graph G is defined by Schmeichel to be the least integer h such that G has an h-fold basis for its cycle space. MacLane showed that a graph is planar if and only if its basis number is ≤ 2. Schmeichel proved that the basis number of the complete graph K_n is at most 3. We generalize the result of Schmeichel by showing that the basis number of the d-th power of K_n is at most $2d+1$.

Room E113

On Powers of Some Geometrically Represented Graphs

Geir Agnarsson, Armstrong Atlantic State University

We first present a short and a constructive proof of the known fact that any odd power of a chordal graph is again chordal. We then define a composition $(G, G') \mapsto G * *G'$ of chordal graphs which will yield an $O(n \log k)$ algorithm to calculate the representation of G^k if k is an odd positive integer and G is a chordal graph on n vertices with a given representation.
We finally consider *m-trapezoid graphs* and *circular m-trapezoid graphs* and give new constructive proofs that both these classes are closed under taking powers.
Some open problems will be presented.

Room 48A–B

Results on a Lower Bound on the Domination Number: II

David Erwin, Western Michigan University
Daryl Findley*, Western Michigan University
John McKenzie, Western Michigan University
Ben Phillips, Western Michigan University

The inequality $\gamma(G) \geq \lceil n/(\Delta+1) \rceil$ is further investigated for regular graphs.

Room 50

The Master Timetabling Problem: Comparison of Two Approaches

Anton Colijn, University of Calgary, Canada

The master timetabling problem continues to be highly problematic: known to be very complex, a number of different approaches have been tried. A particularly complicated situation – that of scheduling lectures and laboratories for Chemistry and Biology courses at the University of Calgary – is examined by two approaches: a “traditional” approach using “hand-crafted” heuristics and a genetic algorithm approach. The results are compared on a number of criteria, such as quality of final results, running times of the programs, and ease/difficulty of implementation.

Friday

9:00–10:00

148 William Cook, *Optimization via Branch Decomposition*

10:00–10:20

Coffee break

10:20–10:35

148 Christopher Carl Heckman, *On the Tightness of the* 5/14 *Independence Ratio*

E113 Fred Buckley, *The Eccentric Digraph of a Graph*

48A-B Marc J. Lipman *, Eddie Cheng, *Connectivity Properties of Unidirectional Star Graphs*

50 Jilyana Cazaran, *A Modification of the Welch-Berlekamp Algorithm for Decoding Reed-Solomon Codes*

10:40–10:55

148 Wendy Myrvold*, Sean Debroni, B. de La Vaissière, P.W. Fowler, M. Deza, *Finding a Maximum Independent Set in the* 120*-Cell*

E113 Gcina Dlamini, *Distances in* $K_{2,l}$*-Free Graphs*

48A-B Eddie Cheng*, Sven De Vries, *Separation Problems of Antiweb-Wheel Inequalities of the Stable Set Polytopes*

50 Cem Guneri, *Two Weight 2-D Cyclic Codes Using Rational Curves*

11:00–11:15

148 Gerd H. Fricke*, Teresa W. Haynes, Sandra M. Hedetniemi and Stephen T. Hedetniemi, Renu C. Laskar, *Excellent Trees*

E113 D.V. Chopra*, M. Bsharat, *Contributions to Some Combinatorial Arrays*

48A-B Nageswara S.V. Rao*, Nachimuthu Manickam, *On General Quickest Path Problem and Path-Tables*

50 Feliu Sagols*, Laura P. Riccio, Charles J. Colbourn, *Dominated Error Correcting Codes with Distance Two*

11:30–12:30

148 William Cook, *The Traveling Salesman Problem*

12:30–1:30

Lunch

1:30–1:45

148 Serge Lawrencenko, Niek Sanders*, *Bipyramids of Arbitrary Genus*

E113 Ernest J. Cockayne, Michael A. Henning*, Christina M. Mynhardt, *Vertices Contained in Every Minimum Total Dominating Set of a Tree*

48A-B Jerzy Wojciechowski, *Minimal Equitability of Hairy Cycles*

50 Soumen Maity, Bimal Roy, Amiya Nayak*, *Identification of Optimal Link Redundancy for which a Given Fault Pattern is Catastrophic*

1:50–2:05

148 Dietmar Cieslik, *The Steiner Ratio*

E113 Sin-Min Lee*, Siu-Ming Tong, *On Super Edge-Magic Deficiencies of Join of Graphs*

48A-B John Holliday* and Peter Johnson, *More on the Shields-Harary Numbers of Two Intersecting Cliques*

50 Nachimuthu Manickam*, Nageswara S. Rao, *Cooperative Terrain Model Acquisition by Robot Teams*

2:10–2:25

148 Edgar Reyes*, Carl Steidley, *Remarks on the Combinatorial Optimization Problem Associated to Global Wiring of Integrated Circuits*

E113 J. Malerba, M. Gargano, M. Lewinter* *Paintable Graphs*

48A-B Sul-young Choi, Puhua Guan*, *On an Erdös' Question Concerning the Existence of a Large Proper Subgraph with Vertices of Degree At Least* 3

50 Dionysios Kountanis*, Changchun Yang, *Improvement of Multiprocessor Scheduling Through Scheduling Graphs*

2:30–2:45

148 Rajneesh Hegde*, Robin Thomas, *Finding* 3*-Shredders Efficiently*

E113 Hovhannes Harutyunyan, *On Optimal Broadcasting in Digraphs*

48A-B David R. Guichard, *Redundance of Grid Graphs*

Friday

Invited Instructional Lectures

Friday 9:00–10:00, Room 148

Optimization via Branch Decomposition

William Cook, Rice University

Robertson and Seymour introduced branch-width as a new connectivity invariant of graphs in their proof of the Wagner conjecture. Decompositions based on this invariant provide a natural framework for implementing dynamic programming algorithms to solve graph optimization problems. In earlier work on the traveling salesman problem we used this framework in a heuristic algorithm to obtain near-optimal solutions to large-scale instances. In this talk we will discuss the computational issues involved in using branch-width as as a general tool in discrete optimization. We will present applications to euclidean steiner tree problems, graph bipartition, maximum cut problems, and maximum stable set problems.

Friday 11:30–12:30, Room 148

The Traveling Salesman Problem

William Cook, Rice University

The traveling salesman problem, or TSP for short, is easy to state: given a number of "cities" along with the cost of travel between each pair of them, find the cheapest way of visiting all the cities and returning to your starting point. We will present a survey of recent progress in algorithms for very large TSP instances, including the solution of a million city instance to within 0.09% of optimality. We will discuss extensions of TSP techniques to other path-routing problems, and present some open combinatorial questions whose solution would lead to improved methods for the TSP.

Friday, 10:20–10:35

Room 148

On the Tightness of the $5/14$ Independence Ratio

Christopher Carl Heckman, Arizona State University

In 1979, Staton proved that every triangle-free graph G with maximum degree at most three has an independent set with size at least $5/14$ of the number of vertices of G. Fraughnaugh (1990) and Heckman and Thomas (1999) provide shorter proofs of the same result. An analysis of the cases of equality for the main results in the latter two papers is presented.

Room E113

The Eccentric Digraph of a Graph

Fred Buckley, Baruch College (CUNY)

The distance $d(u, v)$ between vertices u and v in graph G is the length of a shortest path joining u and v. The eccentricity $e(v)$ of v is the distance to a farthest vertex from v. Vertex u is an eccentric vertex of v if $d(u, v) = e(v)$, that is, u is a farthest vertex from v. The eccentric digraph $ED(G)$ of graph G is the digraph that has the same vertex set as G such that there is an arc from v to u provided that u is an eccentric vertex of v. In this paper, we examine eccentric digraphs of graphs.

Room 48A–B

Connectivity Properties of Unidirectional Star Graphs

Marc J. Lipman *, Oakland University
Eddie Cheng, Oakland University

Useful distributed processor architectures offer the advantage of improved connectivity and reliability. An important component of such a distributed system is the system topology, which defines the inter-processor communication architecture. The star graph is a popular graph topology. Among its many properties, it is maximally connected. Day and Tripathi studied the unidirectional star graph. In this talk, we show that this unidirectional star graph is also maximally connected, and present related results.

Room 50

A Modification of the Welch-Berlekamp Algorithm for Decoding Reed-Solomon Codes

Jilyana Cazaran, Louisiana State University

The Welch-Berlekamp algorithm for decoding Reed-Solomon codes was described in 1983. A modified version of this algorithm was given by T. Liu in 1984 for a specific generator polynomial $g(x)$. This modified version for an arbitrary $g(x)$ was developed in the unpublished thesis [Cazaran91] and is summarized in this lecture. A key equation is given relating the error location polynomial and error evaluation polynomial using a polynomial operator. A series of theorems are given which result in the main decoding algorithm. A numerical example is given for decoding the $(255, 223, 33)$ NASA standard Reed-Solomon code over $GF(2^8)$ using its corresponding reversible generator polynomial.

Friday, 10:40–10:55

Room 148

Finding a Maximum Independent Set in the 120-Cell

Wendy Myrvold*, University of Victoria, Canada
Sean Debroni, University of Victoria, Canada
B. de La Vaissière, University of Exeter, United Kingdom
P.W. Fowler, University of Exeter, United Kingdom M. Deza, Ecole Normale Supérieure, France

The 120-cell is a very special 4-regular graph on 600 vertices. It is vertex transitive and has girth five. A picture of this graph was on the cover of the January 2001 AMS notices. We have determined that a maximum independent set in this graph has order 220. Some interesting techniques were applied to get this result. A fast algorithm for maximum independent set in graphs of maximum degree four, consideration of the antipodal collapse, and an operation for increasing the order of an independent set were used to find examples of independent sets of order 220. Linear programming, fractional colouring, and structural analysis were used to get the upper bound.

Room E113

Distances in $K_{2,l}$-Free Graphs

Gcina Dlamini, University of Natal, South Africa

Let G be a connected graph of order n. The *average distance* of G is defined as

$$\mu(G) = \binom{n}{2}^{-1} \sum_{x,y \in V(G)} d_G(x,y),$$

where $V(G)$ is the vertex set of G and $d_G(x,y)$ is the *distance* between the vertices x and y, i.e., the length of a shortest path from x to y.

Erdős, Pach, Pollack and Tuza gave bounds on the diameter and radius of a C_4-free graph of given order and minimum degree, while Dankelmann and Entringer gave analogous bounds on the average distance. In our talk, we generalise these results to $K_{2,l}$-free graphs. This is joint work with Peter Dankelmann and Henda Swart.

Room 48A–B

Separation Problems of Antiweb-Wheel Inequalities of the Stable Set Polytopes

Eddie Cheng*, Oakland University
Sven De Vries, TU München, Germany

A *stable set* in a graph G is a set of pairwise nonadjacent vertices. The problem of finding a maximum weight stable set is one of the most basic **NP**-hard problems. An important approach to this problem is to formulate it as the problem of optimizing a linear function over the convex hull STAB(G) of incidence vectors of stable sets. Since it is impossible (unless **NP=coNP**) to obtain a "concise" characterization of STAB(G) as the solution set of a system of linear inequalities, it is a more realistic goal to find large classes of valid inequalities with the property that the corresponding *separation problem* (given a point x^*, find, if possible, an inequality in the class that x^* violates) is efficiently solvable.
Some known large classes of separable inequalities are the trivial, edge, clique, cycle, antiweb and wheel inequalities. The (t)-antiweb-wheel inequalities generalize the latter four. In our talk, we discuss its separation problem.

Room 50

Two Weight 2-D Cyclic Codes Using Rational Curves

Cem Guneri, Louisiana State University

Let $F_q = F_{p^m}$ be a finite field, where p is prime and $m > 1$. We study two-dimensional cyclic codes over F_p of area $(q-1) \times (q-1)$ and dimension $2m$ with two basic nonzeros. We represent these codes as traces of other two-dimensional cyclic codes over F_q and relate the weights of codewords to rational curves over F_q via Hilbert's Theorem 90. We show that such codes actually have two nonzero weights and we give formulas to find these weights.

Friday, 11:00–11:15

Room 148

Excellent Trees

Gerd H. Fricke*, Morehead State University
Teresa W. Haynes, East Tennessee State University
Sandra M. Hedetniemi, Clemson University
Stephen T. Hedetniemi, Clemson University
Renu C. Laskar, Clemson University

For a graph $G = (V, E)$, let $\mathcal{P}$ denote a property of sets $S \subseteq V$ of vertices. We call a set S with property $\mathcal{P}$ having {minimum,maximum} cardinality $\mu(G)$ a $\mu(G)$-set. A vertex is called μ-good if it is contained in some $\mu(G)$-set and μ-bad otherwise. A graph G is called μ-excellent if every vertex in V is μ-good. We investigate μ-excellent trees where $\mu(G)$ is a domination, irredundance, or independence invariant.

Room E113

Contributions to Some Combinatorial Arrays

D.V. Chopra*, Wichita State University
M. Bsharat, Wichita State University

An array T with m constraints, N runs (treatment-combinations), and with two levels is merely a matrix with m rows, N columns, and with two symbols (say, 0 and 1). We consider arrays in this paper with the following combinatorial structure: T is called a balanced array (*B-array*) of strength $t (t \leq m)$ if in every t-rowed submatrix T^* of T, every t-vector of weight $i (0 \leq i \leq$t; the weight of the vector is defined to be the number of 1's in it) appears with the same frequency (say) μ_i. The vector $\underline{\mu}^{'} = (\mu_0, \mu_1, \cdots, \mu_t)$ is called the index set of the array. It is quite clear that orthogonal arrays are special cases of *B-arrays*. *B-arrays* are quite useful in statistical design of experiments and combinatorics. We will discuss briefly the importance of these arrays in design and combinatorial theory, and present some conditions necessary for the existence of these *B-arrays* for some specified values of t.

Room 48A–B

On General Quickest Path Problem and Path-Tables

Nageswara S.V. Rao*, Oak Ridge National Laboratory
Nachimuthu Manickam, DePauw Universit

We consider the transmission of a message of size r from a source to a destination with guarantees on the end-to-end delay over a computer network with n nodes and m links. There are three sources of delays: (a) propagation delays along the links, (b) delays due to bandwidth availability on the links, and (c) queuing delays at the intermediate nodes. The delays on various links and nodes are given as functions of the message size. If the delay in (b) is a non-increasing function of the bandwidth, we propose $O(m^2 + mn \log n)$ time algorithm to compute the quickest path with the minimum end-to-end delay for any given message size r. For the general case, we show the size of the path-table, that specifies quickest path for every r, to be infinity. Under the condition that the delay curves are continuous and intersect with each other in no more than τ connected regions, we show that the path-table is of size $O(\alpha^{\tau}(p^*))$, where $p^* \leq 2^n$ is the number of dominant paths and $\alpha(.)$ is the Ackerman's inverse function. We also discuss special cases where the path-table is of significantly smaller size.

Room 50

Dominated Error Correcting Codes with Distance Two

Feliu Sagols*, CINVESTAV, Mexico
Laura P. Riccio, University of California at Berkeley
Charles J. Colbourn, University of Vermont

We study the hamiltonicity of certain graphs obtained from the hypercube as a means to producing a binary code of distance two and length n, whose codewords are ordered so that for each two consecutive codewords, one dominates the other. One vector *dominates* the other if and only if in all the positions where one of them has a zero the other has a zero too. These dominated codes have applications in group testing for consecutive defectives. We also determine when the vectors can be ordered so that every two consecutive vectors have the domination property, and are at distance two; this is a natural generalization of Gray codes.

Friday, 1:30–1:45

Room 148

Bipyramids of Arbitrary Genus

Serge Lawrencenko, Rochester Institute of Technology
Niek Sanders*, Rochester Institute of Technology

We construct a series of new and extraordinary polyhedra with triangular faces. These are generalized bipyramids of arbitrary genus. By a *generalized bipyramid* of genus g, we mean a polyhedron in E^3 whose carrier is homeomorphic to the closed surface of genus g, having the property that all but two of the vertices lie on one plane, the *equatorial plane*. The remaining two vertices are located above and below the equatorial plane and are called the north and south pole, respectively. Furthermore, both poles are adjacent to each vertex on the equatorial plane. We describe our construction and give a method to make computer and paper models of torus and double torus bipyramids. Finally, we will also present computer generated models of arbitrary genus.

Room E113

Vertices Contained in Every Minimum Total Dominating Set of a Tree

Ernest J. Cockayne, University of Victoria, Canada
Michael A. Henning*, University of Natal, South Africa
Christina M. Mynhardt, University of South Africa, South Africa

A set S of vertices in a graph G is a total dominating set of G if every vertex of G is adjacent to some vertex in S. We characterize the set of vertices of a tree that are contained in all, or in no, respectively, minimum total dominating sets of the tree.

Room 48A–B

Minimal Equitability of Hairy Cycles

Jerzy Wojciechowski, West Virginia University

Every labelling of the vertices of a graph with distinct natural numbers induces a natural labelling of its edges: the label of an edge (x, y) is the absolute value of the difference of the labels of x and y. By analogy with graceful labellings, we say that a labelling of the vertices of a graph of order n is minimally k-equitable if the vertices are labelled with $1, 2, \ldots, n$ and in the induced labelling of its edges every label either occurs exactly k times or does not occur at all. For $m \geq 2$, let C'_m (denoted also in the literature by $C_m O K_1$ as a corona graphs) be a graph with $2m$ vertices such that there is a partition of them into sets U and V of cardinality m, with the property that U spans a cycle, V is independent and the edges joining U to V form a matching. Let $\mathcal{P}$ be the set of all pairs (m, k) of positive integers such that $m \geq 3$, k is a proper divisor of $2m$ (different from $2m$ and 1) and k is odd if m is odd. We show that C'_m is minimally k-equitable if and only if $(k, m) \in \mathcal{P}$.

Room 50

Identification of Optimal Link Redundancy for which a Given Fault Pattern is Catastrophic

Soumen Maity, Indian Statistical Institute, India
Bimal Roy, Indian Statistical Institute, India
Amiya Nayak*, Carleton University, Canada

Consider a link-redundant linear array A of processing elements (PEs) in which each PE has a set G of bypass links of different lengths, mainly used to bypass faulty PEs. A fault pattern F (a set of PE faults) is catastrophic for A if and only if the removal of F along with their incident links disconnects the structure. For a given link configuration G, there exist many fault patterns which are catastrophic for the link redundant system. Similarly, a given fault pattern can be catatsrophic for different link configurations.

In this paper, we consider the problem of finding the optimal link configuration for which a given fault pattern is catastrophic. We consider optimality with respect to two parameters: the length of the longest bypass link in G and the number of bypass links in G, that is, the cardinality of G. In the former case, optimality is achieved when the length of the longest bypass link in G, for which the given fault pattern is catastrophic, is maximized. We prove that given a fault pattern of m faults grouped into $n \leq m$ blocks of consecutive faulty processors the problem can be solved in $O(mn)$ times. In the later case, optimality is achieved when the number of bypass links in G, for which the given fault pattern is catastrophic, is maximized. We prove that given a fault pattern of m faults grouped into $n \leq m$ blocks of consecutive faulty processors the problem is equivalent to the following graph problem. Given a graph $G = (V, E)$, $|V| \leq n$, with two specified vertices $s, t \in V$, called the “source” and “terminus” respectively and having each edge (i, j) labeled by L_{ij}, a subset of the set $\{1, 2, \ldots, m\}$, the problem is to find a partition of V into V_1 and V_2 such that $s \in V_1$, $t \in V_2$ and it minimizes $|L|$ where

$$L = \bigcup_{(i,j) \in E : i \in V_1, j \in V_2} L_{ij},$$

which looks some what similar to the min-cut problem.

Friday, 1:50–2:05

Room 148

The Steiner Ratio

Dietmar Cieslik, University of Greifswald

Steiner's Problem is the "Problem of shortest connectivity", that means, given a finite set of points in a metric space (X,ρ), search for a network interconnecting these points with minimal length. This shortest network must be a tree and is called a Steiner Minimal Tree (SMT). It may contain vertices different from the points which are to be connected. Such points are called Steiner points. If we do not allow Steiner points, that means, we only connect certain pairs of the given points, we get a tree which is called a Minimum Spanning Tree (MST).

Observation I. In general, methods to solve Steiner's Problem, that means to find an SMT, are still unknown or hard in the sense of computational complexity. In any case, we need a subtle description of the geometry of the space.

On the other hand,

Observation II. It is easy to find an MST by an algorithm which is simple to realize and fast to run in all metric spaces. The algorithm needs only the mutual distances between the points.

A natural question, derived from these observations, is to ask, what is the performance ratio of an approximation of an SMT by an MST? Consequently, we are interested in the greatest lower bound for the ratio between the lengths of these both trees:

$$m(X,\rho) := \inf \left\{ \frac{L(\text{SMT for } N)}{L(\text{MST for } N)} : N \subseteq X \text{ is a finite set} \right\},$$

which is called the Steiner ratio (of the metric space (X,ρ).
We will discuss this quantity for specific metric spaces. Particularly, we will consider the class of all

- two-dimensional Banach spaces;
- finite-dimensional $\mathcal{L}_p$-spaces;
- Riemannian surfaces;
- graphs; and
- sequence spaces.

Room E113

On Super Edge-Magic Deficiencies of Join of Graphs

Sin-Min Lee*,San Jose State University
Siu-Ming Tong, San Jose State University

A (p,q)-graph G is total edge-magic if there exists a bijection $f : V \cup E \to \{1,2,...,p+q\}$ such that for any $e=(u,v)$ we have $f(u)+f(e)+f(v)$ is a constant. A total edge-magic graph is call super edge-magic if $f(V(G)) = \{1,2,...,p\}$. For any graph G, the smallest number of isolated vertices need to add to G to turn it a super edge-magic graph is called the super edge-magic deficiency of G. Super edge-magic deficiecies of some graphs which are joined of graphs are considered.

Room 48A–B

More on the Shields-Harary Numbers of Two Intersecting Cliques

John Holliday*, Auburn University
Peter Johnson, Auburn University

A weighted network is a simple graph together with a function which assigns non-negative weights to the nodes of the graph. An enemy of the network seeks to dismantle it by removing nodes until the total weight on any component remaining is less than one. The enemy suffers a cost for each removal; this cost is some non-increasing function of the weight at the node removed. The enemy always dismantles the network at the minimum cost. The Shields-Harary number, relative to a given cost function and fixed graph, is the maximum amount the enemy can be made to pay for dismantling the network. It is also of interest to discover the critical weightings that force that maximum cost. Here we prove an elementary result about such critical weightings when the network consists of two intersecting cliques, and use it to find the Shields-Harary numbers, for arbitrary continuous cost functions, when the network consists of two cliques joined at a cut-vertex.

Room 50

Cooperative Terrain Model Acquisition by Robot Teams

Nachimuthu Manickam*, DePauw University
Nageswara S. Rao, Oak Ridge National Lab

We address the model acquisition problem for an unknown planar terrain by a team of robots. The terrain is cluttered by a finite number of polygonal obstacles whose shapes and positions are unknown. The robots are point-sized and equipped with visual sensors which acquire all visible parts of terrain by scan operations executed from their locations. The robots communicate with each other via wireless connection. The performance is measured by the number of sensor operations which are assumed to be the most time-consuming of all robot operations. We employ the visibility graph methods in hierarchical setup. For terrains with convex obstacles the sensing time can be shown to be $1/n$ of that of a single robot case for $n = 2$, 3 and 4.

Friday, 2:10–2:25

Room 148

Remarks on the Combinatorial Optimization Problem Associated to Global Wiring of Integrated Circuits

Edgar Reyes*, Southeastern Louisiana University
Carl Steidley, Texas A&M University - Corpus Christi

This is a continuation of our study of global wiring of integrated circuits. We assume the wires are to be laid out on an n-by-n lattice G. We can think of G as a wafer, shaped as a square, with n^2 points, n columns, n rows, and each column and row has exactly n points. Any pair of two points in G will be connected by a wire exactly when the points do not lie on the same row or same column. Moreover, the shape of the wire must be L-shaped. Let m_v be the number of wires passing through the v^{th} link (a link is the horizontal or vertical segment which connects two adjacent points in the same row or same column, respectively). A wiring configuration is deemed 'best' if it is an optimal solution to the combinatorial optimization problem that minimizes

$$C = \sum_{v=1}^{L} m_v^2 \tag{1}$$

A solution to (1) is a sequence of 1's and/or -1's. When $n = 3$, an optimal solution to (1) is obtained. But for $n = 4$, we present preliminary results. We have employed search techniques of simulated annealing algorithms and genetic algorithms to obtain near-optimal solutions to (1).

Room E113

Paintable Graphs

J. Malerba, Pace University
M. Gargano, Pace University
M. Lewinter*, Purchase College

A graph G of order n is called *paintable* if its vertex set can be labeled with the natural numbers $\{1, 2, ..., n\}$ such that for each $i = 1, 2, \ldots, n-1$, it is the case that $(i)(i+1)$ is not an edge of G. We show that G is paintable if and only if the cograph of G is traceable. A paintable graph is called *homogeneous paintable* if every vertex can serve as the initial vertex. Infinite classes are constructed and various theorems are presented.

Room 48A–B

On an Erdös' Question Concerning the Existence of a Large Proper Subgraph with Vertices of Degree At Least 3

Sul-young Choi, Le Moyne College
Puhua Guan*, University of Puerto Rico

Erdös raised the following question: Is there a positive constant c such that, for each n, if a graph G has n vertices, $2n-1$ edges, and all the vertices of G are of degree at least 3, then G has a subgraph with at least cn vertices whose degrees are at least 3? In this paper we show that there exists no such number c by constructing a family of graphs whose subgraphs with vertices of degree at least 3 contains at most $\lceil n \rceil$ vertices where n is the number of vertices in a graph satisfying the above conditions.

Room 50

Improvement of Multiprocessor Scheduling Through Scheduling Graphs

Dionysios Kountanis*, Western Michigan University
Changchun Yang, Western Michigan University

Given is a multiprocessor system and a program to run on the system with minimum time. A dependency graph can be algorithmically obtained from the given program. The dependency graph is mapped to a scheduling graph. The new graph is used to obtain a sheduling of the program components to the multiprocessor system with the objective to minimize the running time (execution plus communication time). Upper and lower bounds are obtained for the scheduling process. The scheduling graph also contains a potential of parallelism. The question of what multiprocessor system better utilizes the parallelism potential of the program is also investigated.

Friday, 2:30–2:45

Room 148

Finding 3-Shredders Efficiently

Rajneesh Hegde*, Georgia Institute of Technology
Robin Thomas, Georgia Institute of Technology

A shredder in an undirected graph is said to be a set of vertices whose removal results in at least three components. A 3-shredder is a shredder of size three. We present an algorithm that, given a 3-connected graph, finds its 3-shredders in time proportional to the number of vertices and edges.

Room E113

On Optimal Broadcasting in Digraphs

Hovhannes Harutyunyan, Brandon University, Canada

Broadcasting is an information dissemination process in which a message is to be sent from single originator to all members of a network by placing calls over the communication lines of the network. This communication pattern finds its main applications in the field of interconnection networks for parallel and distributed architecture. Numerous papers have investigated ways to construct sparse graphs or digraphs (networks) in which this process can be completed in theoretically minimum possible time from any originator. Here we consider the broadcasting problem in directed graphs. We will describe some techniques to construct new (sparser) digraphs in which broadcasting can be completed in minimum possible time from any vertex of the constructed digraph.

Redundance of Grid Graphs

David R. Guichard, Whitman College

The *redundance* of a graph G is the minimum, over dominating sets $S \subseteq V(G)$, of $\sum_{v \in S}(1 + d(v))$. The grid graph $G_{m,n}$ is the product $P_m \times P_n$. We determine the redundance of $G_{m,n}$ for $m \leq 19$ and all n, give an upper bound for the redundance for all m and n, and conjecture that this upper bound is the correct value for the redundance.

Complete Program

Monday

8:45–9:00

Opening

9:00–10:00

148	Herbert Wilf, *Search Engines, Eigenvectors, and Chromatic Numbers*

10:00–10:20

Coffee break

10:20–10:35

148	Jay Adamsson, *The Crossing Number of* $C_m \times C_n$
E113	Michael O. Albertson*, Debra Boutin, *The Isometry Dimension of a Finite Group*
48A-B	A.J.W. Hilton*, M. Mays, C.St.J.A. Nash-Williams, C.A. Rodger, *On the Existence of Pairs of Mutually Orthogonal Symmetric Hamiltonian Double Latin Squares*
50	Li Sheng, *A Characterization for a Tree to be a Unit Probe Interval Graph*

10:40–10:55

148	Michelangelo Grigni, Papa A. Sissokho*, *Apex Planar Graphs Have Bounded Detour Gap Number*
E113	Nisheeth Vishnoi, *Note: An Algebraic Proof of Alon's Combinatorial Nullstellensatz*
48A-B	Tristan Denley, *On a Conjecture of Haggkvist on Filling Partial Latin Squares*
50	S. H. Holliday*, P. D. Johnson, *The Shields-Harary Number of a Tree*

11:00–11:15

148	Robert Cimikowski, *Crossing Number Bounds for the Twisted Cube*
E113	Omer Egecioglu*, C. Ryavec, *Polynomial Families Satisfying a Riemann Hypothesis*
48A-B	J.A. Bate*, G.H.J. van Rees, *Minimal and Near-Minimal Critical Sets in Back-Circulant Latin Squares*
50	Dean Hoffman*, Matt Walsh, *Even Spanning Trees in Bipartite Graphs*

11:20–11:35

148	Reneta Barneva, Valentin Brimkov, Bruno Codenotti, Valentino Crespi*, Mauro Leoncini, *On the Lovász Number of Very Sparse Circulant Graphs*
E113	John C. Wierman, *Site Percolation Critical Probability Bounds for Two Archimedean Lattices*
48A-B	Ian Wanless, *Generalized Transversals of Latin Squares*
50	A. Meir, J.W. Moon*, M.A. Steel, *A Limiting Theorem on* 2-*Coloured Trivalent Trees*

11:40–11:55

148	Dale Daniel, Stephen E. Shauger*, *More Results on the Erdős-Gyárfás Conjecture in Claw-Free Graphs*
E113	Luke Pebody, *Combinatorial Reconstruction*
48A-B	Reinhard Laue*, Anton Betten, Evi Haberberger, *A Simple* 6-*Design on* 14 *Points and* 5-*Designs without Automorphisms from* A_4
50	Frank Van Bussel, 0-*Centred and* 0-*Ubiquitously Graceful Trees*

12:00–12:15

148	Onyeje Bose, Serge Lawrencenko*, *A Note on* g-*Outer Graphs*
E113	Michael Q. Rieck, *On the Intersection Numbers of Association Schemes Based on Isotropic Subspaces*
48A-B	James B. Phillips*, Peter J. Slater, *Colored Distance in Grid Graphs*
50	Nam-Po Chiang, *The Maximum Total Relative Displacement of Permutations of a Path*

12:15–1:30

Lunch

1:30–2:30

148 Herbert Wilf, *The Lean, Mean, Bijection Machine*

2:40–2:55

148 Hunter Snevily, *A Sharp Bound for the Number of Sets that Pairwise Intersect at k Positive Values*

E113 Nathaniel Dean, *Rectilinear Crossing Minimization*

48A-B Phyllis Chinn*, Ralph Grimaldi, Silvia Heubach, *The Frequency of Summands of a Particular Size in Palindromic Compositions*

50 Spencer P. Hurd*, Dinesh G. Sarvate, *Minimal Standard Enclosings of Triple Systems*

3:00–3:15

148 Heiko Harborth, *Smallest Limited Edge-to-Edge Snakes in Euclidean Tessellations*

E113 Christian Thürmann, *Minimum Number of Edges with At Most s Crossings in Rectilinear Drawings of the Complete Graph*

48A-B Silvia Heubach*, Phyllis Chinn, Ralph Grimaldi, *Rises, Levels, Falls and "+" Signs in Compositions and Palindromes*

50 Spencer P. Hurd, Dinesh G. Sarvate*, *On Point Enclosings of Triple Systems*

3:20–3:35

148 Horst Martini, *On Geometric Graphs*

E113 Wai Chee Shiu*, Peter Che Bor Lam, *On the ℓ-Distance Face Coloring of* 6*-Regular Plane Graphs*

48A-B Ke Qiu, *Adjacency Matrix and Eigenvalues of the Hypercube*

50 Robert Hochberg*, Michael Reid, *Tiling with Notched Cubes*

3:35–4:00

Coffee break

4:00–4:15

148 Robin Blankenship*, Bogdan Oporowski, *Book Embeddings of Graphs and Minor-Closed Classes*

E113 Thomas Boehme, Frank Goering, Herwig Unger*, *Random Models for the Propagation of Information in the World Wide Web*

48A-B Edward Dobson, *On Solvable Groups and Cayley Graphs*

50 Sridar Kuttan Pootheri, *Counting Classes of Labeled* 2*-Connected Graphs*

4:20–4:35

148 Matthew Skala*, Wendy Myrvold, *Fast Generation of Graphs Embedded on the Torus*

E113 Louis Petingi*, Jose Rodriguez, *Reliability of Networks with Delay Constraints*

48A-B Tristan Denley, Haidong Wu*, *Long Cycles Through Many Specified Edges*

50 Kimberly S. Kirkpatrick, *Doyen-Wilson Theorem for K_3 with Two Pendant Edges*

4:40–4:55

148 Alex Brodsky, Stephane Durocher*, Ellen Gethner, *Toward the Rectilinear Crossing Number of K_n: New Drawings, Upper Bounds, and Asymptotics*

E113 Daniel Ramras*, Sam Greenberg, *Cliques and Independent Neighbor Sets in Random Graphs*

48A-B Felix Lazebnik and Raymond Viglione*, *A New Infinite Series of Edge- but not Vertex-Transitive Graphs*

50 Clyde P. Kruskal, *The Chromatic Number of the Plane: the Bounded Case*

5:00–5:15

148 Ghidewon Abay-Asmerom, *On Imbeddings of Rejection and Exclusion of Graphs*

E113 Gary Gordon, *Expected Value for Trees and Rooted Graphs*

48A-B Frank Harary, Robert W. Robinson*, *Identity Digraphs of Minimum Size*

50 Linda Valdés, *Edge-Magic K_p*

5:20–5:35

148 Michele Conforti, Gérard Cornuéjols, Kristina Vušković*, *Square-Free Perfect Graphs*

E113 S.M. Hedetniemi, S.T. Hedetniemi*, D.P. Jacobs, P.K. Srimani, *Self-Stabilizing Algorithms for Minimal Dominating and Maximal Independent Sets*

48A-B Steven C. Cater*, Frank Harary, Robert W. Robinson, *One-Color Triangle Avoidance Games*

50 Lou Shapiro*, Frank Schmidt, *The Fibonacci Numbers, Matching Polynomials, and Normality*

5:40–5:55

148 Dionysios Kountanis, Sha Tang*, *Query Optimization for Multilist Files Using Internal Graphs*

E113 J.R.S. Blair, S.M. Hedetniemi, S.T. Hedetniemi, D.P. Jacobs*, *Self-Stabilizing Maximum Matchings*

48A-B Joanna A. Ellis-Monaghan, *Relations for Skein-Type Graph Polynomials*

50 Michael L. Gargano*, William Edelson, *Optimal Sequenced Matroid Bases Solved by Genetic Algorithms*

6:00–8:30

Wine and Cheese Reception

Tuesday

9:00–10:00

148 Paul Seymour, *The Structure of Berge Graphs*

10:00–10:20

Coffee break

10:20–10:35

148 Matt DeVos*, Paul Seymour, *Packing T-Joins*

E113 P.D. Johnson Jr.*, E.B. Wantland, *More Problems Involving Hall's Condition*

48A-B Dalibor Froncek, *Scheduling the Czech National Basketball League*

50 L. Goddyn*, P. Hliněný, W. Hochstättler, *Circular Chromatic Number of an Orientable Matroid*

10:40–10:55

148 E.J. Cockayne*, A.P. Burger, C.M. Mynhardt, *The n-Queens Problem on the Torus*

E113 Gary S. Bloom*, Samer Salame, *Constructing More Graceful Trees*

48A-B Robert C. Brigham, Gary Chartrand, Ronald D. Dutton, Ping Zhang*, *Full Domination in Graphs*

50 Manoel Lemos, *Matroids with Many Common Bases*

11:00–11:15

148 A.P. Burger, C.M. Mynhardt*, *The Queens Domination Problem on the Torus*

E113 Kengo Shirakata, Etsuro Moriya*, *Parallelization in Extended μH Systems and its Universality*

48A-B Varaporn Saenpholphat*, Ping Zhang, *Connected Resolvability of Graphs*

50 Talal Al-Hawary, Jenny McNulty*, *On Closure Matroids*

11:20–11:35

148 Peter Adams, Darryn Bryant, Heather Gavlas*, *Decompositions of the Complete Graph into Small 2-Regular Graphs*

E113 Dorothy Bollman*, Edusmildo Orozco, *A Faster Algorithm for the Solution of the n-Queens Problem*

48A-B Gary Chartrand, Raluca Muntean*, Varaporn Saenpholphat, Ping Zhang, *Graphs and Divisibility of Positive Integers*

50 Allan D. Mills, *Perfect Binary Matroids*

11:40–11:55

148	Andre Kezdy*, Hunter Snevily, *Distinct Sums Modulo n and Tree Embeddings*
E113	Patric R.J. Östergård, Alfred Wassermann*, *A New Lower Bound for the Football Pool Problem for* 6 *Matches*
48A-B	Gary Chartrand, Alice Chichisan*, Ping Zhang, Curtiss E. Wall, *On Convexity in Graphs*
50	Nancy Ann Neudauer*, Brett Stevens, *Enumeration of the Bases of the Bicircular Matroid on a Complete Bipartite Graph*

12:00–12:15

148	Miklós Bartha*, Miklós Krész, *Open Graphs with Perfect Internal Matchings*
E113	L. Eugene Chipman*, Clyde P. Kruskal, *The Complexity of Some Common Strategy Games*
48A-B	David Brown, J. Richard Lundgren*, Cary Miller, *On Probe-Clone Interval Graphs*
50	David Neel, *Modular Contractibility in Binary Matroids*

Wednesday

9:00–10:00

148	Noga Alon, *Polynomials in Discrete Mathematics I: Geometric and Number Theoretic Applications*

10:00–10:20

Coffee break

10:20–10:35

148	Dirk Vertigan*, Matt DeVos, Luis Goddyn, Bojan Mohar, Xuding Zhu, *Near Duality of Circular Coloring and Circular Flow in Orientable Surfaces*
E113	David Cariolaro*, Anthony J.W. Hilton, *Regular Graphs of Even Order and High Degree are* 1*-Factorizable*
48A-B	Peter Horák, David Pike, Michael Raines*, *Hamilton Cycles in Block-Intersection Graphs of Triple Systems*
50	Arundhati Raychaudhuri, *Distance-*2 *Labeling for Strongly Chordal Graphs and* $2-K_2$ *Free Graphs*

10:40–10:55

148	Bruce Reed, Benny Sudakov*, *Asymptotically the List Colouring Constants are* 1
E113	Robert Molina*, Ken Smith, P_n*-Randomly Decomposable Graphs*
48A-B	M.N. Ferencak*, A.J.W. Hilton, *Outline and Amalgamated Triple Systems*
50	D. Pillone, R. Laskar*, *Extremal Results in Rankings*

11:00–11:15

148	Arnfried Kemnitz*, Massimiliano Marangio, *Colorings and List Colorings of Integer Distance Graphs*
E113	Ronald J. Gould, Emily A. Hynds*, *Forbidden Subgraphs and* 2*-Factors*
48A-B	Jeff Bonn, *Ordering Steiner Triple Systems and the Codes of Their Points*
50	David R. Berman, Sandra C. McLaurin, Douglas D. Smith*, *Fair Team Tournaments*

11:20–11:35

148	Jeannette Janssen, *Partial List Colourings of Graphs with Bounded Degree*
E113	Sam Greenberg, *Multiple Matchings*
48A-B	Tomoko Adachi*, Masakazu Jimbo, Sanpei Kageyama, *Combinatorial Structure of GDDs without Nontrivial* α*-Resolution Classes in Each Group*
50	Richard Anstee, Ron Ferguson*, J.R. Griggs, *Circular Permutations with Low Discrepancy Consecutive* k*-Sums*

11:40–11:55

148 Balázs Montágh, *Anti-Ramsey Theorems on Spanning Trees*

E113 Hong Wang, *Vertex-Disjoint Quadrilaterals in Graphs*

48A-B Yukiyasu Mutoh*, Toshio Morihara, Masakazu Jimbo, *A Grid Design Related to DNA Library Screening*

50 Clifton E. Ealy Jr.*, *On the Genus of Semi*λ*-Partialplanes*

12:00–12:15

148 Maria Axenovich*, Tao Jiang, *Anti-Ramsey Numbers for Small Bipartite Graphs*

E113 John J. Watkins*, Jesse Gilbert, *Packing Caterpillars into Complete Graphs*

48A-B Selda Küçükçifçi*, C.C. Lindner, *The Metamorphosis of* λ*-Fold Block Designs with Block Size Four into* λ*-Fold* $(K_4 \setminus e)$*-Systems,* $\lambda \geq 2$

50 Adrian Bondy, Jian Shen*, Stéphan Thomassé, Carsten Thomassen, *Density Conditions Implying Trangles in* k*-Partite Graphs*

12:15–1:30

Lunch

1:30–2:30

148 Noga Alon, *Polynomials in Discrete Mathematics I: Graph Theoretic Applications*

2:40–2:55

148 Ellen Gethner*, David G. Kirkpatrick, Nicholas Pippenger, *M.C. Escher Inspires a Coloring Problem of a Different Colour: Art, Mathematics, and Computer Science Collide*

E113 Martin Charles Golumbic*, Marina Lipshteyn, *On the Hierarchy of Tolerance, Probe, and Interval Graphs*

48A-B Gayla S. Domke*, Jean E. Dunbar, Lisa R. Markus, *The Inverse Domination Number of a Graph*

50 Charles A. Anderson, *Some Sequences Related to the Catalan Numbers*

3:00–3:15

148 Peter C. B. Lam* and W. C. Shiu, *A Class of Graphs with* χ^* *Close to* $\chi - 1$

E113 Anthony Bonato*, Peter Cameron, Dejan Delić, Stéphan Thomassé, *New Vertex Partitions Properties of Graphs and Digraphs*

48A-B Peter Dankelmann, *Size and Domination in Graphs*

50 Wen-jin Woan, *Diagonal Lattice Paths*

3:20–3:35

148 Chao Gui*, Ronald D. Dutton, *Distribution of In-Degree in Random Digraphs*

E113 D. Aulicino*, M. Lewinter, *Pan-Central Graphs*

48A-B John Gimbel*, Mihaela Nicolescu, Cherie Umstead, Nicole Vaiana, Brian D. Van Gorden, *Location with Dominating Sets*

50 Seyoum Getu, *A 'dot' Product and Lattice Paths*

3:35–4:00

Coffee break

4:00–4:15

148 Joan P. Hutchinson, *Three- and Four-Coloring Nearly Triangulated Surfaces*

E113 Arthur M. Hobbs*, Louis Petingi, *The Weighted-Edge Case of Strength and Fractional Arboricity in Graphs*

48A-B David C. Fisher, Suzanne M. Seager*, *The Total Domination Number of Graphs of Maximum Degree* 3

50 D. Elizabeth "Betsy" Sinclair*, Julia Eaton, *Competition Between Geometric Random Variables I: One-Dimensional Results*

4:20–4:35

148 Jan Kratochvíl, Zsolt Tuza, Margit Voigt*, b*-Colorings of Graphs*

E113 Dean Hoffman, Mark Liatti*, *Partitioning the Edges of* $2K_{c,d}$ *into Copies of* $K_{a,b}$

48A-B Teresa Haynes, Debra Knisley*, *Colored Domination in Graphs*

50 Yung-Ling Lai, *On the Profile of the Tensor Product of Paths with Complete Bipartite Graphs*

4:40–4:55

148 Andrea Hackmann, *Critically Edge Colourable Planar Graphs*

E113 Art Finbow*, Bert Hartnell, Richard Nowakowski, Michael D. Plummer, *On Well-Covered* 5*-Connected Triagulations*

48A-B Kenneth Proffitt*, Teresa W. Haynes, Peter J. Slater, *Paired-Domination in Grid Graphs*

50 Dorea Claassen, *The Bandwidth of a Random Graph*

5:00–5:15

148 Mathew Cropper*, Andras Gyarfas, Jeno Lehel, Mike Jacobson, *Comparing the Hall Ratio and the Chromatic Number*

E113 Saad I. El-Zanati, *On Generalizations of the Oberwolfach Problem*

48A-B Ruth Haas*, Thomas Wexler, *Signed Domination Number of a Graph and Its Complement*

50 Narsingh Deo, Pankaj Gupta*, *Sampling the Web Graph With Random Walks*

5:30–6:00

148 Frank Harary, *Graphs and Their Games*

7:00–10:00

Banquet

Thursday

9:00–10:00

148 Alexander Schrijver, *Permanents and Edge-Colouring*

10:00–10:20

Coffee break

10:20–10:35

148 Ralph P. Grimaldi, *Compositions without the Summand* 1

E113 Paul Balister, Béla Bollobás, Jonathan Cutler*, Luke Pebody, *The Interlace Polynomial of Graphs at* -1

48A-B Yoshihiro Kaneko*, Stephen Locke, *Minimum Degree Approach for Paul Seymour's Conjecture*

50 Galen E. Turner III, *Subdivisions of Wheels*

10:40–10:55

148 Alain Plagne*, Laurent Habsieger, *Improved Bounds for* $B_2[2]$ *Sets*

E113 Rao Li, *Hamiltonicity of* 3*-Connected Quasi-Claw-Free Graphs*

48A-B Darren A. Narayan, *Powers of Directed Hamiltonian Paths as Feedback Arc Sets*

50 Larry Cummings, *Connected Components of Comma-Free Codes*

11:00–11:15

148 Ingo Schiermeyer, *New Ramsey Numbers for Cycles*

E113 Mahmoud El-hashash, *On the Hamiltonicity of Two Subgraphs of the Hypercube*

48A-B M.A. Fiol, J. Gimbert*, *On Almost Moore Bipartite Digraphs with Odd Diameter*

50 Narsingh Deo, Paulius Micikevicius*, *Comparison of Prüfer-like Codes for Labeled Trees*

11:20–11:35

148 Konrad Piwakowski, Stanisław P. Radziszowski*, *Towards the Exact Value of the Ramsey Number* $R(3,3,4)$

E113 Anant Godbole*, Debra Knisley, Rick Norwood, *Alphabet-Overlap Graphs are Hamiltonian*

48A-B Cora Neal, 2-*Primitive Tournament Digraphs*

50 Suk Jai Seo*, Ashok T. Amin, *On Extremal Oriented Trees*

11:40–11:55

148 Ermelinda DeLaVina, *Connected Triangle-Free Ramseyan Properties of Graphs*

E113 Bill Linderman, *Minimum Graphs with Complete Closure*

48A-B Michelle Foster*, Peter Johnson, *An Existence Theorem in Information Theory*

50 Jens-P. Bode, *Triangular Polyomino Set Achievement*

12:05–12:35

148 Presentation of the 2000 Medals of the Institute of Combinatorics and its Applications

12:35–1:30

Lunch

1:30–2:30

148 Alexander Schrijver, *Graph embedding and Eigenvalues*

2:40–2:55

148 Van Vu, *Set Systems with Even Multi-Intersections*

E113 Chris Rodger*, Darryn Bryant, Y. Chang, R. Wei, *Two Dimensional Balanced Sampling Plans Excluding Contiguous Units*

48A-B Krystyna T. Balińska, Michael L. Gargano, Louis V. Quintas*, *An Edge Partition Problem Concerning Hamilton Paths*

50 Yolando B. Beronque, *On the Structure of a Distance-Regular Graph from a Maximal-Distance Subgraph*

3:00–3:15

148 Yuejian Peng*, Vojtech Rödl, Jozef Skokan, *Small Cliques in* 3-*Uniform Hypergraphs*

E113 K.T. Arasu, Yu Qing Chen, Alexander Pott*, *New Results on Non-abelian Relative Difference Sets*

48A-B Jay Bagga, John Emert*, J. Michael McGrew, *Visibility Graphs on the Sphere*

50 R.D. Baker, G.L. Ebert*, T. Penttila, *Hyperbolic Fibrations and Flocks of a Quadratic Cones*

3:20–3:35

148 Yulia Dementieva*, Penny Haxell, Brendan Nagle, Vojtěch Rödl, *On Characterizing Hypergraph Regularity*

E113 Ben Wehrung, *Maximum Packings of* K_n *with Eulerian Graphs*

48A-B Marek Kubale, *The Smallest Hard-to-Color Graph for Sequential Coloring Algorithms*

50 Keith Mellinger, *Constructing Mixed Partitions of* $\mathcal{PG}(3, q^2)$

3:35–4:00

Coffee break

4:00–4:15

148 Roger B. Eggleton*, James A. MacDougall, *Minimally Star-Saturated Graphs*

E113 Isidoro Gitler, *Coloring the Angles of Embedded Graphs*

48A-B Thomas Boehme*, Bojan Mohar, *Domination, Packing and Excluded Minors*

50 Gilles Caporossi*, Pierre Hansen, *Variable Neighborhood Search for Extremal Graphs, 1 to 7: a Short Survey*

4:20–4:35

148 József Balogh*, Béla Bollobás, Miklós Simonovits, *Estimates for the Number of L-Free Graphs*

E113 Terry McKee, *Recognizing Dual-Chordal Graphs*

48A-B B.L. Hartnell*, P.D. Vestergaard, *Dominating Sets with At Most k Components*

50 Pierre Hansen*, Mustapha Aouchiche, Gilles Caporossi, *Variable Neighborhood Search for Extremal Graphs,* 8: *Variations on Graffiti* 105

4:40–4:55

148 John Goldwasser, *Erdos-Ko-Rado with a Bound on the Maximum Degree*

E113 Guoli Ding, Jinko Kanno*, *Splitter Theorems for Cubic Graphs*

48A-B Bert L. Hartnell, Douglas F. Rall*, *Dominating the Cartesian Square of a Tree*

50 Dan Pritikin, *The Upper Bound for Pancake Sorting*

5:00–5:15

148 Sergei L. Bezrukov, Thomas J. Pfaff, Victor P. Piotrowski*, *A New Approach to Macaulay Posets*

E113 Nair Maria Maia de Abreu*, Patricia Erthal de Moraes, Samuel Jurkeiwicz, *Graphs with Homogeneous Density in* (a, b)*-Linear Classes*

48A-B John Villalpando*, Renu Laskar, *Degree Weighted Domination*

50 Dionysios Kountanis, Sathya Priya Durairaju*, *Optimal Connection of Networks with a Backbone Interconnection Network*

5:20–5:35

148 Matt Walsh*, Peter Johnson, *Another Network Vulnerability Parameter*

E113 Jay S. Bagga*, Lowell W. Beineke, Badri N. Varma, *Line Completion Numbers of Graphs*

48A-B David Erwin, Daryl Findley, John McKenzie*, Ben Phillips*, *Results on a Lower Bound on the Domination Number: I*

50 N. Sankaranarayanan, Francis Suraweera*, Narsingh Deo, *Two Protocols for Multicast Communication*

5:40–5:55

148 Salar Y. Alsardary, *An Upper Bound on the Basis Number of the Powers of the Complete Graphs*

E113 Geir Agnarsson, *On Powers of Some Geometrically Represented Graphs*

48A-B David Erwin, Daryl Findley*, John McKenzie, Ben Phillips, *Results on a Lower Bound on the Domination Number: II*

50 Anton Colijn, *The Master Timetabling Problem: Comparison of Two Approaches*

8:00–9:30

Survivor's Dessert Party

Friday

9:00–10:00

148 William Cook, *Optimization via Branch Decomposition*

10:00–10:20

Coffee break

10:20–10:35

148 Christopher Carl Heckman, *On the Tightness of the* 5/14 *Independence Ratio*

E113 Fred Buckley, *The Eccentric Digraph of a Graph*

48A-B Marc J. Lipman *, Eddie Cheng, *Connectivity Properties of Unidirectional Star Graphs*

50 Jilyana Cazaran, *A Modification of the Welch-Berlekamp Algorithm for Decoding Reed-Solomon Codes*

10:40–10:55

148 Wendy Myrvold*, Sean Debroni, B. de La Vaissière, P.W. Fowler, M. Deza, *Finding a Maximum Independent Set in the* 120*-Cell*

E113 Gcina Dlamini, *Distances in* $K_{2,l}$*-Free Graphs*

48A-B Eddie Cheng*, Sven De Vries, *Separation Problems of Antiweb-Wheel Inequalities of the Stable Set Polytopes*

50 Cem Guneri, *Two Weight 2-D Cyclic Codes Using Rational Curves*

11:00–11:15

148 Gerd H. Fricke*, Teresa W. Haynes, Sandra M. Hedetniemi and Stephen T. Hedetniemi, Renu C. Laskar, *Excellent Trees*

E113 D.V. Chopra*, M. Bsharat, *Contributions to Some Combinatorial Arrays*

48A-B Nageswara S.V. Rao*, Nachimuthu Manickam, *On General Quickest Path Problem and Path-Tables*

50 Feliu Sagols*, Laura P. Riccio, Charles J. Colbourn, *Dominated Error Correcting Codes with Distance Two*

11:30–12:30

148 William Cook, *The Traveling Salesman Problem*

12:30–1:30

Lunch

1:30–1:45

148 Serge Lawrencenko, Niek Sanders*, *Bipyramids of Arbitrary Genus*

E113 Ernest J. Cockayne, Michael A. Henning*, Christina M. Mynhardt, *Vertices Contained in Every Minimum Total Dominating Set of a Tree*

48A-B Jerzy Wojciechowski, *Minimal Equitability of Hairy Cycles*

50 Soumen Maity, Bimal Roy, Amiya Nayak*, *Identification of Optimal Link Redundancy for which a Given Fault Pattern is Catastrophic*

1:50–2:05

148 Dietmar Cieslik, *The Steiner Ratio*

E113 Sin-Min Lee*, Siu-Ming Tong, *On Super Edge-Magic Deficiencies of Join of Graphs*

48A-B John Holliday* and Peter Johnson, *More on the Shields-Harary Numbers of Two Intersecting Cliques*

50 Nachimuthu Manickam*, Nageswara S. Rao, *Cooperative Terrain Model Acquisition by Robot Teams*

2:10–2:25

148 Edgar Reyes*, Carl Steidley, *Remarks on the Combinatorial Optimization Problem Associated to Global Wiring of Integrated Circuits*

E113 J. Malerba, M. Gargano, M. Lewinter* *Paintable Graphs*

48A-B Sul-young Choi, Puhua Guan*, *On an Erdös' Question Concerning the Existence of a Large Proper Subgraph with Vertices of Degree At Least* 3

50 Dionysios Kountanis*, Changchun Yang, *Improvement of Multiprocessor Scheduling Through Scheduling Graphs*

2:30–2:45

148 Rajneesh Hegde*, Robin Thomas, *Finding* 3-*Shredders Efficiently*

E113 Hovhannes Harutyunyan, *On Optimal Broadcasting in Digraphs*

48A-B David R. Guichard, *Redundance of Grid Graphs*