

Invited Speakers

- Richard Brualdi - University of Wisconsin
Alternating sign matrices and their patterns
- Peter Dukes - University of Victoria
A survey of asymptotic existence results on block designs and graph decompositions
- William Martin - Worcester Polytechnic Institute
New results on cometric association schemes
- Joy Morris - University of Lethbridge
The normal quotient method and strongly regular graphs
- Bryan Shader - University of Wyoming
Centralizers and signed digraphs
- Brett Stevens - Carleton University
Optimizing an imperfect tournament

Conference Sponsors

The Pacific Institute for the Mathematical Sciences (PIMS)
Faculty of Science, University of Regina
Department of Mathematics and Statistics, University of Regina
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Conference Organizers

- Robert Bailey, PIMS Post-Doctoral Fellow, University of Regina
- Shaun Fallat, Professor, University of Regina
- Karen Meagher, Associate Professor, University of Regina

Aims and Scope

Graph theory and design theory have emerged as two major areas of research in discrete mathematics. Many “real world” problems are best modelled as a design or a graph and often such problems are easy to state but difficult to solve. Because of this, many researchers and graduate students have been attracted to these areas.

One aspect common to both graph theory and design theory is the variety of techniques that can be applied in the field. One approach that is particularly appealing is an algebraic approach. For example, both graphs and designs can be represented as a matrix and this representation allows us to use matrix theory and linear algebra to solve problems. This is not only mathematically very interesting, but has also produced strong (and sometimes surprising) results. Also, many interesting designs and graphs exhibit strong symmetry properties; such designs and graphs can be examined using techniques from group theory. Conversely, many interesting groups arise naturally in the context of graphs and designs.

The main objective of this conference is to bring together researchers in design and graph theory to share new methods and results with an algebraic flavour. This conference will also serve to establish connections between both individual researchers and between research areas, and as such will also promote interdisciplinary collaboration and research.

List of Speakers and Abstracts

Fatemeh Alinaghipour

University of Regina

Zero Forcing Number of Graphs

Recently, the study of matrices described by a graph has been of great importance and interest to combinatorial matrix theory. A family of matrices that can be determined by a graph is the family of matrices whose zero-nonzero pattern follows the adjacency matrix of the graph. A *minimum rank problem* is to determine the minimum among the ranks of the matrices in one of these families.

Considerable progress has been made on the minimum rank problem for the family of symmetric matrices described by a simple graph, although the problem is far from solved. In this presentation, we will give a brief introduction on the graph parameters *zero forcing number* and *positive semidefinite zero forcing number* which are powerful tools to approach the minimum rank problem. We will also mention some of the relationships between these parameters and graph parameters and present some new results.

Bahman Ahmadi

University of Regina

Versions of the Erdős-Ko-Rado Theorem

The Erdős-Ko-Rado (EKR) theorem is a fundamental theorem in combinatorics which has been key in the development of extremal set theory. This theorem provides an upper bound on the size of an intersecting family of k -subsets on an n -set and classifies the intersecting families which meet the bound. By defining an appropriate graph, one can interpret this problem as the problem of classifying the maximum independent sets in the graph. Similar questions arise when one replaces concepts of sets and set intersections with other mathematical objects and a relevant concept of intersection. In this presentation, we will talk about some versions of EKR for some Cayley graphs, namely the Cayley graphs on the symmetric group generated by derangements and the ones generated by cyclic permutations.

Robert Bailey

University of Regina

Recent results on metric dimension of distance-regular graphs

The *metric dimension* of a graph is the smallest size of a distinguished set of vertices, chosen so that the list of distances from any vertex to those in the set uniquely identify that vertex.

Recently, the speaker and others have been studying this problem for various classes of distance-regular (and related) graphs, including Johnson, Kneser, Grassmann and bilinear forms graphs, as well as the incidence graphs of projective spaces and symmetric designs. This talk will attempt to summarise these results.

This work is joint work with too many others to mention.

Richard Brualdi

University of Wisconsin–Madison

Alternating Sign Matrices and Their Patterns

An alternating sign matrix (ASM) is an $n \times n$ $(0, +1, -1)$ -matrix such that in each row and column the $+1$ s and -1 s alternate beginning and ending with $+1$. An example (where we use \pm in place of ± 1) is

$$\begin{bmatrix} 0 & 0 & + & 0 & 0 \\ 0 & + & - & + & 0 \\ + & - & + & - & + \\ 0 & + & - & + & 0 \\ 0 & 0 & + & 0 & 0 \end{bmatrix}.$$

ASMs have been extensively studied for their enumerative properties and their connections with other combinatorial constructs, as well as their application in statistical mechanics. In this talk we discuss properties of ASMs and their zero-nonzero patterns. (This talk is based on joint work with K.P. Kiernan, S.A. Meyer, and M.W. Schroeder.)

Andrea Burgess

Ryerson University

The Erdős-Lovász Tihany Conjecture and block colourings of Steiner triple systems

The Erdős-Lovász Tihany Conjecture posits that for any graph G with $\chi(G) > \omega(G)$, and any integers $s, t \geq 2$ with $s + t = \chi(G) + 1$, the vertices of G can be

partitioned into two sets, S and T , such that the subgraphs of G induced by S and T have chromatic numbers $\chi(G[S]) \geq s$ and $\chi(G[T]) \geq t$. This conjecture has been proved for certain classes of graphs, including line graphs and quasi-line graphs. We consider the problem of determining whether the conjecture holds for block intersection graphs of Steiner triple systems, noting that vertex colourings of such graphs correspond with block colourings of the associated triple systems, and discuss progress we have made towards its solution in certain cases.

Peter Dukes

University of Victoria

**A survey of asymptotic existence results
on block designs and graph decompositions**

The Kirkman schoolgirls problem asks whether n students can, over several days, walk to school in unordered triples such that: (i) every pair of students is together in exactly one such triple; and (ii) each day, every student belongs to exactly one such triple. Of course, n must be odd from (i) and divisible by 3 from (ii). Originally, this was a puzzle for $n = 15$ (and the poor girls had to walk to school all $\frac{n-1}{2} = 7$ days of the week!)

In the early 1970s, Richard Wilson and his supervisor Dijen Ray-Chaudhuri solved Kirkman's problem in the affirmative for all admissible values of n . Wilson went on to initiate an attack on several variations of this kind of problem, where 'all admissible values' is replaced by 'almost all admissible values'.

Today, there is a growing meta-theory of asymptotic existence of pairwise balanced block designs and edge-decompositions of graphs. I will survey the highlights of the current status, including some interesting open questions.

Yi-Zheng Fan

University of Regina

Bipartiteness and Least Eigenvalue of Graphs

In this talk we introduce some parameters reflected by three types of graph bipartiteness: the vertex bipartiteness, the edge bipartiteness and one involved with cut set. We build some connections between these parameters and the least eigenvalue of the signless Laplacian of graphs.

Shaun Fallat

University of Regina

On Two Colin de Verdiere Parameters of Chordal Graphs

Two important graph parameters, developed by Colin de Verdiere, are connected with the maximum nullity of certain real symmetric matrices associated with a given graph. In this talk, these parameters, called μ and ν , are calculated for chordal graphs.

Krystal Guo

University of Waterloo

Quantum Walks on Regular Graphs

A quantum walk is a quantum process on graph. It is proposed by Emms, Hancock, Severini and Wilson in 2006, that the spectrum of a matrix based on the amplitudes of walks in the quantum walk, distinguishes strongly regular graphs. We will try to represent this matrix in terms of the incidence matrices of the graph and investigate the spectra of related matrices. We will also look at regular graphs on which this invariant fails.

Bill Martin

Worcester Polytechnic Institute

New results on cometric association schemes

Cometric (or Q-polynomial) association schemes have not been very well studied to date, in spite of rich connections to design theory, coding theory, finite geometry and other areas. In this talk, we will survey new examples, new results, and many open problems related to these amazing objects.

Karen Meagher

University of Regina

The Erdős-Ko-Rado Theorem

In 1938 Paul Erdős, Chao Ko and Richard Rado proved an elegant result, known as the Erdős-Ko-Rado (or EKR) theorem, that has since become a corner stone in the field of extremal set theory. This theorem remained unpublished until 1961, partly due to the lack of interest in discrete math at the time, but, when this result finally appeared in the literature it sparked a flurry of mathematical activity.

Part of the appeal of this theorem is that the problem is simple to understand and that the solution is exactly what a mathematician would wish it to be. The

problem is given a fixed set, determine the size and structure of the the largest system of subsets, all of the same size, with the requirement that any two of the sets must have non-empty intersection. Provided that the size of the subsets is small relative to the fixed set, the solution is any system comprised of all subsets that contain a fixed element.

Currently there are several radically different proofs of this result, many extensions and generalizations of the theorem and even some applications. But the aspect of this theorem that is the most intriguing to me is that results analogous to the EKR theorem hold for many objects other than subsets. For example versions of this theorem hold for permutations, integer sequences, partitions and vector spaces over a finite field. In this talk I will give an overview of the EKR theorem and outline some of the generalizations and describe my favourite extensions of the result.

Dave Morris

University of Lethbridge)

On Hamiltonian paths in 2-generated solvable Cayley digraphs

Some connected Cayley digraphs on solvable groups do not have hamiltonian paths, but no examples are known on nilpotent groups. The talk will describe some new examples of connected, 2-generated Cayley digraphs on solvable groups that do not have hamiltonian paths, and outline a proof that every connected, 2-generated Cayley digraph on any nilpotent group does have a hamiltonian path.

Joy Morris

University of Lethbridge)

The normal quotient method and strongly regular graphs

When trying to analyse the structure of a family of graphs, one natural approach to try is inductive: try to find some sort of structural reduction that when applied to any graph in the family, generally reduces the number of vertices (for example), but the resulting graph must still be in the family. If such a reduction method can be found, and the irreducible graphs can be structurally analysed, this may provide considerable information about every graph in the family.

In the past 10–15 years, Cheryl Praeger and her group at the University of Western Australia have developed the “normal quotient” method of reduction, and have successfully applied it towards analysing the structure of many families of highly symmetric graphs. In this talk, I will explain this method and give an overview of some of the results that have been achieved. One of the families of graphs to which this method has most recently been applied, is the family of vertex- and edge-transitive strongly regular graphs. This family has been examined in joint work with Cheryl Praeger and Pablo Spiga, and I will discuss some of our results.

Alison Purdy

University of Regina

An(other) Erdős-Ko-Rado theorem for multisets

The Erdős-Ko-Rado Theorem is a fundamental result in extremal set theory. It describes the size and structure of the largest collection of subsets of size k from a set of size n having the property that any two subsets have at least t elements in common. In this talk, I will present an Erdős-Ko-Rado type theorem for intersecting collections of k -multisets containing elements from an m -set. The proof of the result for $k > m$ makes use of a graph homomorphism from the Kneser graph.

Bryan Shader

University of Wyoming

Centralizers and Signed Digraphs

We discuss a new, highly combinatorial criteria for an $n \times n$ sign-pattern A to be spectrally arbitrary; that is to have the property that for each monic real polynomial $r(x)$ of degree n there exists a matrix with sign-pattern (respectively, zero-nonzero pattern) A that has $r(x)$ as its characteristic polynomial. This criteria leads to the of study of signed digraphs D with the property that if A is a matrix with sign pattern D , and B is a matrix such that $A \circ B^T = O$ and B is in the centralizer of A , then $B = O$. (Here \circ denotes the entry-wise product).

Pirzada Shariefuddin

University of Kashmir

On scores in hypertournaments

We discuss scores, losing scores in hypertournaments and obtain various inequalities on scores and losing scores.

Brett Stevens

Carleton University

Optimizing an imperfect tournament

A computer science department holds an annual video game olympics with 64 participants playing 8 games. There are 8 rooms each with a fixed video game and there are 8 rounds. In each round 8 people will be in each room. Every person will play each game exactly once. We would like to find a schedule for all the players, rooms and rounds that is as balanced as possible, i.e. no pair of players plays together in the same room too frequently and as few pairs of people playing

together are missed. It can be shown that some pairs must be missed and some pairs must repeat. We set up a combinatorial framework to quantify the repetition and missing pairs and try several different approaches to optimize the tournament. For various criteria we will find solutions constructed from lines in finite planes, ovals in finite geometries and finally a set of solutions that are related to Costas sonar and radar sequences and Almost Perfectly Non-linear functions.

Eric Swartz

Binghamton University

**The locally 2-arc transitive graphs
admitting an almost simple group of Suzuki type**

A graph Γ is said to be locally $(G, 2)$ -arc transitive for G a subgroup of $\text{Aut}(\Gamma)$ if, for any vertex α of Γ , G is transitive on the 2-arcs of Γ starting at α . In this talk, we will discuss recent progress toward the classification of the locally $(G, 2)$ -arc transitive graphs, where $Sz(q) \leq G \leq \text{Aut}(Sz(q))$, $q = 2^{2k+1}$ for some $k \in \mathbb{N}$. In particular, we will discuss seven families of vertex-intransitive locally $(G, 2)$ -arc transitive graphs. Furthermore, for any graph Γ in one of these families, $Sz(q) \leq \text{Aut}(\Gamma) \leq \text{Aut}(Sz(q))$, and the only locally 2-arc transitive graphs admitting an almost simple group of Suzuki type whose vertices all have valency at least three are

- (i) graphs in these seven families,
- (ii) (vertex transitive) 2-arc transitive graphs admitting an almost simple group of Suzuki type, or
- (iii) double covers of the graphs in (ii).

Since the graphs in (ii) have been classified by Fang and Praeger (“Finite two-arc transitive graphs admitting a Suzuki simple group”, *Comm. Alg.*, 27(8):3727-3754, 1999), this completes the classification of locally 2-arc transitive graphs admitting a Suzuki simple group.

Conference Participants

Bahman AHMADI	University of Regina
Ruhi AHMADI	University of Regina
Maram ALBAYYADHI	University of Regina
Fatemeh ALINAGHIPOUR	University of Regina
Robert BAILEY	University of Regina
Darcy BEST	University of Lethbridge
Richard BRUALDI	University of Wisconsin–Madison
Andrea BURGESS	Ryerson University
Collin CARBNO	SaskTel
Peter DUKES	University of Victoria
Shaun FALLAT	University of Regina
Yi-Zheng FAN	University of Regina
Xiaoxia FAN	University of Waterloo
Chris FISHER	University of Regina
Shonda GOSSELIN	University of Winnipeg
Krystal GUO	University of Waterloo
Junbo (Mario) HUANG	University of Waterloo
Hadi KHARAGHANI	University of Lethbridge
Gustavo KRIMKER	University of Regina
Jeremy LANE	University of Regina
Ben LI	University of Manitoba
William MARTIN	Worcester Polytechnic Institute
Karen MEAGHER	University of Regina
Joy MORRIS	University of Lethbridge
Dave MORRIS	University of Lethbridge
Bryce MORSKY	University of Guelph
Shahla NASSERASR	University of Regina
Shariefuddin PIRZADA	University of Kashmir
Alison PURDY	University of Regina
Hugh RAMP	University of Lethbridge
Rahim SAMEI	University of Regina
Bryan SHADER	University of Wyoming
Brett STEVENS	Carleton University
Eric SWARTZ	Binghamton University
Ryan TESSIER	University of Regina

Regina Restaurants by location

1. Near Campus

- (a) The Lazy Owl Riddell Centre (on Campus)
This is the campus bar but you can get more than just beer here. The menu includes standard student fare which means sandwiches, wraps, salads and pizza.
- (b) Trifon's Pizza 1101 Kramer Boulevard · 584-0040
This is your chance to try "Regina-style pizza". The menu also includes pasta and sandwiches and Trifon's has a small lounge just in case you like beer with your pizza.
- (c) Stone's Throw Coffee House 1101C Kramer Boulevard · 949-1404
Good coffee can be found here. They also offer a menu of soups, salads and sandwiches and are open until 9:00 p.m (and 10:00 on Friday and Saturday).

More places can be found on Albert Street (a 30 minute walk)

- (d) Skara 3847 Albert Street · 584-8044
Featuring authentic mediterranean cuisine, steak made from AAA Angus beef, and pizza to die for!
- (e) Ai's Place 4255 Albert Street · 584-3481
Tasty Vietnamese and Canadian Cuisine.
- (f) Earl's Regina South 2606 28th Avenue · 584-7733
- (g) Brewsters Brewing Company 4180 Albert Street · 761-0784
Restaurant and a brew pub.

2. Downtown

To get to downtown you can take the number 3 or the number 4 bus from campus and get off at Victoria Park.

- (a) Crave Kitchen + Wine Bar 1925 Victoria Avenue · 525-8777
Crave is a restaurant and lounge that boasts a full tapas as well as a full dinner menu to compliment an extensive wine and liquid list.
- (b) Hotel Saskatchewan 2125 Victoria Avenue · 522-7691
Located in the beautiful turn-of-the-century Hotel Saskatchewan Radisson Plaza. The menu includes Saskatchewan specialties.
- (c) Beer Bros. 1821 Scarth Street · 586-2337
Beer Bros. offers a terrific menu and an amazing selection of beers.
- (d) O'Hanlon's Irish Pub 1947 Scarth Street · 566-4094
Good Beer and a good irish pizza.

3. Cathedral Area

The Cathedral area is Regina's artsy neighbourhood which means there are several good restaurants and cafés. Most shops are located on 13th Avenue, west of Albert Street. Take the number 4 bus from Campus and get off at Albert and 13th.

- (a) Cathedral Village Freehouse 2062 Albert St · 359-1661
This is a popular spot for those seeking refreshing local ales. They offer a variety of burgers, wood-fired pizzas and local favourites.
- (b) The Creek in Cathedral Bistro 3414 13th Ave · 352-4448
This restaurant has a diverse menu, which offers seafood, chicken, pasta dishes and expertly prepared venison.
- (c) 13th Avenue Coffee House 3136 13th Ave · 522-3111
The place is casual and a little cheaper with lots of vegetarian food.
- (d) Viet Thai Restaurant 2400 Albert St · 569-3833
Good, yet inexpensive Thai, Vietnamese and Chinese food.
- (e) Table Ten 2118 Robinson Street · 543-8836
Restaurant and Cocktail Lounge.
- (f) Orange Izakaya 2136A Robinson St · 779-0779
Fusion Japanese and Korean Cuisine featuring tapas and sake in a relaxing atmosphere.
- (g) La Bodega 228 Albert Street · 546-3660
La Bodega is Regina's first Tapas bar specializing in international fine dining and is home to Regina's best patio.
- (h) The Fainting Goat 2330 Albert Street · 352-4628
Mediterranean cuisine in a contemporary and casual family environment. Winner of "Best Restaurant in Regina".

4. Other Areas

- (a) Bushwakker Brewpub 2206 Dewdney Ave · 359-7276
One of Canada's best brewpubs.
- (b) The Willow on Wascana 3000 Wascana Dr. · 585-3663
This restaurant, located in scenic Wascana Park, focuses on classic Saskatchewan fare.