

# Prairie Discrete Math Workshop

University of Regina

July 22 to July 23, 2011

## Conference Program

### Conference Sponsors

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

## Invited Speakers

- **Richard Brewster**  
Thompson Rivers University  
*Colour extensions and mixing problems*
- **Shonda Gosselin**  
University of Winnipeg  
*Cyclic decompositions of complete hypergraphs*
- **Ben Li**  
University of Manitoba  
*Combination labellings of graphs*
- **Karen Seyffarth**  
University of Calgary  
*Distinguishing Colourings and Labellings of Graphs*
- **Chris Soteros**  
University of Saskatchewan  
*Lattice Models of Polymer Entanglements*
- **Sandra Zilles**  
University of Regina  
*Combinatorial Parameters in Computational Learning Theory*

## 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

The main objective of the Prairie Discrete Mathematics Workshop (PDMW) is to bring together researchers in discrete mathematics in the prairie region (Manitoba, Saskatchewan and Alberta), as well as neighbouring provinces and states, with the goal of providing opportunities for networking and joint research.

Various forms of the PDMW have been held since 1995, and the first workshop in its current form was at the University of Regina in 2003. Since then it has been held annually (except for 2007) at universities across the prairies, and is returning to Regina for the first time since 2003.

For 2011, the workshop will cover a range of different areas of discrete mathematics and related areas of computer science. We have invited six speakers from the prairie region, whose interests include graph theory, design theory, applied combinatorial enumeration, combinatorial algorithms, and computational learning theory.

# University of Regina and Discrete Mathematics

The Mathematics and Statistics department at the University of Regina has a long tradition of teaching and research in discrete mathematics and combinatorics. This department has employed at least ten professors who have worked and continue to study within the AMS subject classification 05. Over the years this group has been an integral part of starting two regional conference series, the Western Canadian Linear Algebra Meeting and the Prairie Discrete Mathematics Workshop. (Regina was the inaugural host for both meetings.) In addition to an active seminar series devoted to discrete mathematics, Regina has also hosted a MITACS major project on searching in graphs. More recently, discrete mathematics researchers have developed a working research group dedicated to studying unresolved research problems in this area and to foster young talent in this subject area. To date this group, which over the past two years has involved at least five graduate students, three postdoctoral fellows, visitors, and four faculty members, continues to work on interesting open problems. Some of the issues that have been considered include: Covering arrays and generalized covering arrays, sample compression and VC-dimension, minimum rank of graphs, and minimum universal rank of a graph. This meeting, along with the Graphs, Designs and Algebraic Combinatorics conference are just another indication of the active, energetic and enthusiastic group of researchers in discrete mathematics here at the University of Regina.

# List of Speakers and Abstracts

**Mahshid Atapour**

*York University*

## **Ratio Limit Theorem and Shape Results for Pattern-Avoiding Permutations**

In this talk I will present some recent results about pattern-avoiding permutations. A permutation  $X$  of length  $N$  is said to contain a pattern (a relatively short permutation)  $P$  of length  $k$  ( $k < N$ ) if there is a subsequence of  $k$  elements of  $X$  that appears in the same order as  $P$ . The permutation  $X$  is called  $P$ -avoiding if it does not contain  $P$ . A brief proof of the Ratio Limit Theorem/Conjecture for some specific patterns will be given. We discuss some results regarding the typical shape of pattern-avoiding permutations drawn at random from the set of  $P$ -avoiding permutations. For some specific patterns, we show that (with high probability) a randomly selected  $P$ -avoiding permutation stays in or avoids a specific region. This is a joint work with Neal Madras.

**Richard Brewster**

*Thompson Rivers University*

## **Colour extensions and mixing problems**

In 1997 Thomassen asked if a collection of vertices in a planar graph are pre-coloured, under what conditions can this precolouring be extended to a colouring of the entire graph? A series of papers by Albertson (with various co-authors) answers Thomassen's original question, plus looks at many generalizations. In particular, Albertson and West studied extensions of circular colourings. We will survey these results and present some new work with an emphasis on circular colourings and the concept of mixing. This is joint with Jon Noel.

**Dean Crnkovic**

*University of Rijeka*

**Codes from orbit matrices of symmetric block designs**

Harada and Tonchev recently presented a construction of self-orthogonal codes from orbit matrices of symmetric designs with fixed-point-free automorphisms. Using this method we construct self-orthogonal codes from orbit matrices of some symmetric designs of Menon type. Further, we describe a construction of self-orthogonal codes from orbit matrices of symmetric designs admitting certain automorphisms with fixed points (and blocks).

**Shonda Gosselin**

*University of Winnipeg*

**Cyclic decompositions of complete hypergraphs**

A *cyclic  $q$ -partition* of a hypergraph is a partition of its (hyper)edge set into  $q$  parts which are permuted cyclically by some permutation of its vertex set. Cyclic  $q$ -partitions of complete uniform hypergraphs may be constructed from permutations called  *$q$ -antimorphisms*, which are characterized by their cycle type, and each of the  $q$  parts in such a partition is called a  *$q$ -complementary* hypergraph, since these generalize the self-complementary hypergraphs. When the parts of a cyclic partition of a complete uniform hypergraph are regular or vertex-transitive, it corresponds to a large set of designs. We will construct both regular and vertex-transitive cyclic partitions of complete uniform hypergraphs, and present necessary and sufficient conditions on their order.

**Ben Li**

*University of Winnipeg*

**Combination labelings of graphs**

In 2006, a paper by Hedge and Shetty introduced the idea of combination labelings of graphs. Let  $G = (V, E)$  be a simple, undirected graph. If there is a bijection  $f : V \rightarrow \{1, 2, \dots, |V|\}$  such that the values  $\binom{f(u)}{f(v)}$  are pairwise distinct, where  $uv \in E$  and  $f(u) > f(v)$ , then  $G$  is a *combination graph* and the  $f$  is called a (valid) *combination labeling* of  $G$ .

In this talk, we will consider several classes of graphs and see if they have combination labelings. I will show that certain rooted trees, wheel graphs, generalized Peterson graphs are combination graphs while complete bipartite graphs are not. In addition, I will state some bounds on the number of edges in any combination graph.

# Julian Sahasrabudhe

*Simon Fraser University*

## Promoting inequality in infinite words

If  $w$  is a combinatorial word over a finite subset of the integers, define the sum of a block of  $w$  to be the sum of the entries of  $w$ . In 1994, Pirillo and Varricchio (and independently Halbeisen and Hungerbühler in 2000) asked if there exists an infinite word over a finite subset of the non-negative integers with the property that no two consecutive blocks have both the same length and the same sum. This problem is a recent and enigmatic variant of a long lineage of pattern avoidance problems for combinatorial words. Despite considerable attention from researchers in the area, the equal length-equal sum problem remains open and has been a guiding force for new developments in the area. In this talk we will survey some of what is known about the problem as well as some related open problems.

# Karen Seyffarth

*University of Calgary*

## Distinguishing Colourings and Labellings of Graphs

Graph colouring problems have a long history and many variations. The classic *graph colouring problem* is to assign colours to the vertices of a graph  $G$  so that adjacent vertices receive different colours, and so that the total number of colours used is minimum. This minimum is the *chromatic number* of  $G$ , denoted  $\chi(G)$ .

In a 2006 article, Karen Collins and Ann Trenk introduce a variation of the chromatic number, called the *distinguishing chromatic number*. A colouring of the vertices of a graph  $G$  is *distinguishing* provided no automorphism of  $G$ , other than the identity, preserves the colours of the vertices. The distinguishing chromatic number of  $G$ ,  $\chi_D(G)$ , is the minimum number of colours required to colour the vertices of  $G$  so that the resulting colouring is distinguishing.

The distinguishing chromatic number can be viewed as a refinement of the *distinguishing number* of a graph. A labelling of the vertices of a graph  $G$  is *distinguishing* if the identity is the only automorphism of  $G$  that preserves vertex labels (here, adjacent vertices need not receive distinct labels). The *distinguishing number* of  $G$ , denoted  $D(G)$ , is the minimum number of labels required to produce a distinguishing labelling. Determining the distinguishing number of a graph turns out to be a generalization of the problem *The Blind Man's Keys* posed by Frank Rubin in a 1979 issue of the *Journal of Recreational Mathematics*.

In this talk, I will describe the origins of the problem of determining the distinguishing chromatic number of a graph. I will then present various results and examples illustrating these results. In particular, I will describe results stemming from projects with Claude Laflamme, Cameron Hodgins, and Mike Cavers.

# **Ryan Tessier**

*University of Regina*

## **Forbidden Configurations and Sauer's Lemma**

A simple matrix is a  $(0, 1)$ -matrix with no repeated columns. Given a matrix  $F$  define  $forb(m, F)$  to be the largest integer such that there exists a  $m \times forb(m, F)$  simple matrix with no submatrix that is a row or column permutation of the matrix  $F$ . If we let  $K_k$  denote the simple matrix of all possible columns on  $k$  rows, we have a precise value for  $forb(m, K_k)$ . The exact value of this number is known; this is Sauer's Lemma. Sauer's proof will be the focus of this talk. Because simple  $k$  rowed matrices correspond to families of sets of  $[k] = \{1, 2, \dots, k\}$  then Sauer's lemma is also a result on finite set systems.

# **Chris Soteris**

*University of Saskatchewan*

## **Lattice Models of Polymer Entanglements**

Self-avoiding polygon models have been used to study ring polymers (long closed chain molecules) in dilute solution for over 50 years. For such models, a vertex of the polygon represents a monomer unit and an edge of the polygon joins two monomer units which are chemically bonded together in the polymer. Distinct self-avoiding polygons on a lattice, such as the simple cubic lattice, are used to represent distinct conformations of a ring polymer. At equilibrium in dilute solution, each equal-length polygon is considered to be equally likely as a polymer conformation, and one is interested in the average spatial properties of the polymer as a function of its length. For example, there is much interest in the entanglement complexity of polymers (e.g. probability of being knotted), especially with respect to modelling enzyme action on circular DNA.

In this talk, I will review why polymer entanglements are of interest; then introduce the self-avoiding polygon model for ring polymers described above; and finally give an overview of some of the theoretical and numerical approaches for studying polymer entanglements with this model. Our recent monte carlo results regarding knot reduction for a local strand passage model and our transfer-matrix results for polygons in a lattice tube will be highlighted.



**Sandra Zilles**

*University of Regina*

## **Combinatorial Parameters in Computational Learning Theory**

Computational learning theory is concerned with the complexity of machine learning problems, for instance with the question of how many training examples are needed for a machine to identify a concept in a given class of possible target concepts.

This presentation focuses on the combinatorial structure of concept classes that can be learned from a small number of examples. In particular, we reveal a connection between a combinatorial parameter describing the complexity of learning from random examples (the VC-dimension) and a recently discovered combinatorial parameter describing the complexity of learning from “helpful” examples (the Recursive Teaching Dimension).

Methodologically, this research relates to the study of forbidden configurations and to combinatorial design theory.

# Conference Participants

Bahman AHMADI	University of Regina
Fatemeh ALINAGHIPOUR	University of Regina
Mashid ATAPOUR	University of Saskatoon
Robert BAILEY	University of Regina
Darcy BEST	University of Lethbridge
Richard BREWSTER	Thompson Rivers University
Andrea BURGESS	Ryerson University
Collin CARBNO	SaskTel
Dean CRNKOVIC	University of Rijeka
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
Jeremy LANE	University of Regina
Ben LI	University of Manitoba
Gary MACGILLIVRAY	University of Victoria
Zeinad MAZADI	University of Regina
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
Alison PURDY	University of Regina
Hugh RAMP	University of Lethbridge
Tina RAPKE	University of Calgary
Julian SAHASRABUDHE	Simon Fraser University
Rahim SAMEI	University of Regina
Mehdi SADEQI	University of Regina
Karen SEYFFARTH	University of Calgary
Chris SOTEROS	University of Saskatoon
Ryan TESSIER	University of Regina
Boting YANG	University of Regina
Sandra ZILLES	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.