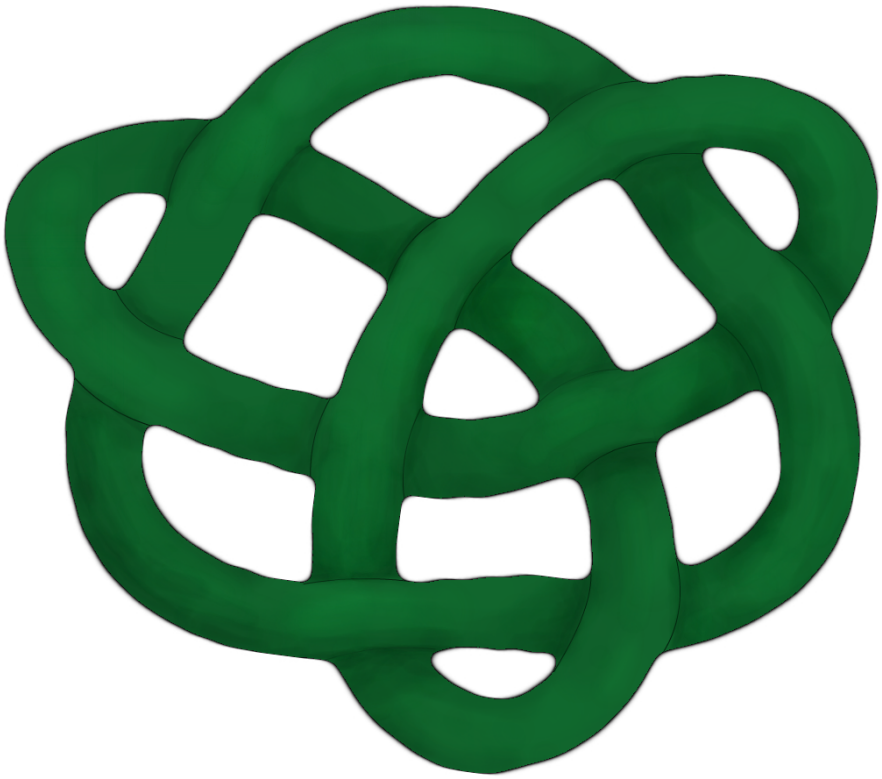

University of Alberta

Canadian Undergraduate Mathematics Conference

2015

Congrès canadien des étudiants en mathématiques

June 17 - 21 2015
Le 17 à 21 juin 2015

CONTENTS

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HOUSEKEEPING / ORDRES ADMINISTRATIFS

1.1 WELCOME / BIENVENUE

Welcome to the Canadian Undergraduate Mathematics Conference (CUMC) 2015! We are very excited to have brought the CUMC to Edmonton.

Bienvenue au Congrès canadien des étudiants en mathématiques (CCÉM) de 2015! Nous sommes très éxcités d'avoir amener le CCÉM à Edmonton.

1.2 WIFI

You have two ways of accessing the internet on campus:

- If your university takes part in the "eduroam" network, choose that network and input your usual university email and password like: egalois@ualberta.ca, TOOSOON
- Otherwise, you can use "Guest@UofA."

Vous avez deux façons d'accéder à l'internet sur le campus:

- Si votre université participe au résau "eduroam," il faut choisir ce résau et saisir votre identifiant et mot de passe comme ceci: egalois@ualberta.ca, TROPTOT
- Sinon, vous pouvez utiliser "Guest@UofA."

1.3 SPECIAL EVENTS

IMPROVAGANZA The opt-in event for the CUMC this year will be attending Improvaganza, Canada's largest improvised comedy festival. It will take place on the evening of Thursday, June 18th. We have secured a number of discounted tickets and will be providing transportation to and from the event.

IMPROVAGANZA L'événement optionel pour CCÉM cette année sera aller au Improvaganza, le festival d'improvisation théâtrale comique le plus grand du Canada. Nous allons aller le soir du jeudi, le 18 juin. Nous avons obtenu des billets au rabais et nous allons fournir le transport à destination et en provence de l'événement.

GENDER DIVERSITY IN MATH EVENING On Friday, June 19th, we are holding a series of events centered around providing a supportive safe space for women-identifying and non-binary people and promoting gender diversity in mathematics. We will also be providing food in the form of tapas and dessert.

SOIRÉE POUR LA DIVERSITÉ DE GENRE EN MATHÉMATIQUES Le vendredi, le 19 juin, nous allons organiser une série d'événements se concentrée sur fournir un espace sécuritaire supportif pour eux qui s'identifé comme une femme ou quelqu'un nonbinaire. Aussi, nous allons offrir du nourriture en forme de tapas et dessert.

CLOSING BANQUET Our closing banquet will be held at Reed Bazaar in Fort Edmonton Park, a centre for education on Edmonton's history. We will not have access to the park itself during the banquet, but we would recommend checking it out after the conference should you have spare time.

BANQUET DE FERMETURE Notre banquet de fermeture sera à Reeds Bazaar dans Fort Edmonton Park, une centre pour l'histoire d'Edmonton. Vous n'aurez pas accès au parc pendant le banquet, mais nous recommandons que vous allez si vous avez du temps après le congrès.

1.4 FOOD AND DRINK / ALIMENTATION

The majority of your meals during CUMC will be provided by us, but it's reasonable that you will need nourishment outside of that. Here is a list of our favourite spots.

- Coffee on campus: Various Starbucks in Cameron Library, ECHA, and CCIS, Daily Grind in SUB, Tim Horton's in CAB
- Coffee off campus: Remedy, Cafe Leva, Good Earth Cafe, Tim Hortons, Transcend
- Food very close to/on campus: various establishments in HUB Mall and SUB, Rodeo Burger, Earl's, Booster Juice, Burrito Libre, Cafe Leva (upscale cafe)

- Along 109th Street: Remedy (Indian and Pakistani, vegetarian options), McDonalds, Mucho Burrito, Urban Diner, Sugarbowl, High Level Diner, Transcend
- Along Whyte Ave: Remedy, Cafe Mosaics (vegetarian and vegan), Boston Pizza, Da-De-O (New Orleans Diner), V Sandwiches (banh mi), Daawat (Indian), Block 1912 (Cafe), Famoso (best pizza in Edmonton)

La majorité des repas pendant CCÉM seront fournis par nous, mais c'est raissonable que vous avez besoin d'alimentation hors de ceux-ci. Voici une liste de nos destinations préférées.

- Cafés sur le campus: les Starbucks dans Cameron Library, ECHA, et CCIS, Daily Grind dans SUB, Tim Horton's dans CAB
- Cafés hors du campus: Remedy, Cafe Leva, Good Earth Cafe, Tim Hortons, Transcend
- Près de l'université ou sur le campus: la restauration rapide dans HUB et SUB, Rodeo Burger, Earl's, Booster Juice, Burrito Libre, Cafe Leva (un café haut de gamme)
- Sur la rue 109: Remedy (Indien et Pakisatni, options végétariens), McDonalds, Mucho Burrito, Urban Diner, Sugarbowl, High Level Diner, Transcend (un café excellent)
- Sur l'avenue Whyte: Remedy, Café Mosaics (végétarien et végétalien), Boston Pizza, Da-De-O (café-restaurant au style de la Nouvelle-Orléans), V Sandwiches (banh mi), Daawat (Indien), Block 1912 (Café), Famoso (la meilleur pizza d'Edmonton)

1.5 transportation / transport

You can find schedules at takeets.com. If you would like to know when a bus arrives at a certain spot, you can send a text to 31100 with the bus stop number as the message body.

L'université est très proche .Les horaires sont à takeets.com. Si vous voulez savoir quand un autobus arrive à un arrêt, il faut envoyer un texto à 31100 avec le numéro de cet arrêt.

1.6 cumc 2016 ccém

The bidding process for next year's CUMC is detailed at the Studc website at `http://studc.cms.math.ca/cumc.html`. Be sure to read the transition manual before putting together an application. The bid is due two weeks after the last day of the CUMC,

July 5th, at which point anonymous public feedback will be collected for the two weeks following.

Le processus de mise en candidature pour le CCÉM prochaine est expliqué en detail au site web de Studc à `http://studc.cms.math.ca/cumcfr.html`. Assure que vous lirez le manuel d'exploitation avant commencer votre soumission. Le formulaire est à échéance deux semaines après le dernier jour du CCÉM, le 5 juillet, et à ce moment là les commentaires anonymes des étudiants seront collectioner pour les deux semaines suivantes.

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KEYNOTE SPEAKERS / CONFÉRENCIERS PRINCIPAUX

Vincent Bouchard
University of Alberta

As a Rhodes scholar, Vincent Bouchard obtained his D.Phil. in Mathematics from Oxford University in 2005, after pursuing undergraduate studies in Physics at Université de Montréal. He then held postdoctoral positions in U.Penn., MSRI (Berkeley), Perimeter Institute and Harvard University, before joining the faculty at University of Alberta in 2009. His research centers around the fascinating interconnections between string theory, geometry, topology, number theory, quantum field theory and gauge theory. Besides Mathematics and Physics, Vincent loves to spend time in the mountains; either backcountry skiing, scrambling, or running very long distances...

Karen Buro
MacEwan University

Dr. Karen Buro is an Associate Professor and Chair of the Department of Mathematics and Statistics at MacEwan University in Edmonton. She studied mathematics at the University of Aachen and received her Ph.D. for her work in statistical designs. Dr. Buro was a member of the Institute for Advanced Studies in Princeton, NJ, before she came to Edmonton and joined MacEwan University. She is passionate about teaching mathematics and statistics and has many years of experience collaborating with researchers from many different disciplines providing statistical expertise to the joined projects.

Shaun Fallat
University of Regina

Dr. Shaun Fallat is a Professor of Mathematics at the University of Regina. Dr. Fallat has made outstanding contributions in the field of total positivity – including co-authoring a recent book on this topic, and is a leader in the development of algebraic parameters associated with graphs. He has published over 65 research articles widely in international journals, and has been an invited speaker at many universities throughout North America and the World. He is the recipient of a university teaching award and delivered the prestigious Olga Taussky-Todd Lecture at the 2014 International Linear Algebra Society conference in Seoul, Korea last summer.

Terry Gannon
University of Alberta

I am interested in the interactions of algebra (especially representation theory), number theory (especially modular forms), and/or mathematical physics (especially conformal field theory). I have written a book on Monstrous Moonshine, which you are all encouraged to buy. In short, I enjoy math which spills over boundaries, and I love to learn new stuff.

Mark Lewis
University of Alberta

Dr. Mark Lewis received his PhD from the University of Oxford in 1990. He is a Senior Canada Research Chair in Mathematical Biology and a professor in Mathematical and Statistical Sciences and Biological Sciences at the University of Alberta. Dr. Lewis' research focus is spatial ecology. He has published He has published 6 books and 180 papers, and has supervised over 50 graduate students and postdocs. He has held positions at the University of Utah, and University of Washington and visiting positions at University of Oxford, University of Minnesota, and Princeton University. He serves on the editorial boards of many of the top journals in his area and is Chief Editor of the Journal of Mathematical Biology. Dr. Lewis is a former President of Society for Mathematical Biology

Lorna Stewart
University of Alberta

Lorna Stewart is a professor of computing science at the University of Alberta. Her research is in algorithmic graph theory and her Erdős number is 2.

3

SCHEDULES / HORAIRES

3.1 GENERAL SCHEDULE / HORAIRE GÉNÉRAL

Wednesday, June 17th / Mercredi, le 17 juin

12:30 - 3:30 PM	CAB 528	Registration / Enregistrement
3:30 - 4:00 PM	CAB 528	Coffee break / Pause de café
4:00 - 5:00 PM	ED N2-115	Opening keynote / Conférencier principal d'ouverture: Vincent Bouchard
5:00 - 5:30 PM	ED N2-115	Opening remarks / Discours d'ouverture
5:30 PM	CCIS	Group photo / Photo de group
6:00 - 8:00 PM	Quad	Opening banquet / Banquet d'ouverture (BBQ)
8:00 PM - 10:00 PM		Optional outing / Sortie optionelle
8:00 PM - 10:00 PM		Movie / Film

Thursday, June 18th / Jeudi, le 18 juin

7:30 - 8:30 AM	SUB 0-40	Breakfast / Déjeuner
9:00 - 11:00 AM	CAB	Student talks / Conférences étudiantes
11:00 -11:20 AM	ED N2-115	Coffee break / Pause de café
11:20 AM - 12:20 PM	ED N2-115	Keynote speaker / Conférencier principal: Shaun Fallat
12:20 - 2:00 PM	SUB 0-40	Lunch / Diner
12:45 - 1:30	SUB 0-40	Roundtables / Tables rondes
	SUB 0-31	Roundtables / Tables rondes
	SUB 0-33	Roundtables / Tables rondes
2:00 - 4:00 PM	CAB	Student talks / Conférences étudiantes
4:20 - 5:20 PM	ED N2-115	Keynote speaker / Conférencier principal: Mark Lewis
7:30 - 10:00 PM		Improvaganza

Friday, June 19th / Vendredi, le 19 juin

7:15 - 8:15 AM	SUB 0-40	Breakfast / Déjeuner
9:20 AM	McM 1-08	Opening remarks / Discours d'ouverture
9:30 - 11:00 AM	McM 3rd	Student talks / Conférences étudiantes
11:00 -11:20 AM	McM 2-12	Coffee break / Pause de café
11:20 AM - 12:20 PM	McM 1-08	Keynote speaker / Conférencier principal: Lorna Stewart
12:20 - 2:00 PM	McM 2-12	Lunch / Diner
2:00 - 4:00 PM	McM 3rd	Student talks / Conférences étudiantes
5:00 - 9:30 PM	CAB 528	Gender Diversity in Math event // Soirée pour la diversité de genre en mathématiques
5:00 - 6:00 PM	CAB 528	Safe space discussion // Espace sécuritaire
6:00 - 7:00 PM	CAB 528	Tapas and socializing / Tapas et socialisation
7:00 - 8:30 PM	CAB 528	Gender Diversity in Math panel / Le comité sur la diversité de genre en mathématiques
8:30 - 9:30 PM	CAB 528	Dessert

Saturday, June 20th / Samedi, le 20 juin

7:30 - 8:30 AM	SUB 0-40	Breakfast / Déjeuner
9:00 - 11:00 AM	CAB	Student talks / Conférences étudiantes
11:00 -11:20 AM	ED N2-115	Coffee break / Pause de café
11:20 AM - 12:20 PM	ED N2-115	Keynote speaker / Conférencier principal: Karen Buro
12:20 -1:30 PM	SUB 0-40	Lunch / Diner
1:30 - 3:00 PM		Free time / Tour of campus
3:00 - 5:00 PM	CAB	Student talks / Conférences étudiantes
6:30 - 9:00	Fort Edmonton Park	Closing banquet / Banquet de fermeture

Sunday, June 21st / Dimance, le 21 juin

11:20 AM - 1:00 PM	SUB 0-40	Brunch
11:45 AM - 12:30 PM	SUB 0-40	Roundtables / Tables rondes
11:45 AM - 12:30 PM	SUB 0-31	Roundtables / Tables rondes
11:45 AM - 12:30 PM	SUB 0-33	Roundtables / Tables rondes
1:00 PM - 2:00 PM	ED N2-115	Keynote / Conférencier principal: Terry Gannon
2:00 PM - 3:00 PM	ED N2-115	Closing remarks / Remarques de fermeture

3.2 STUDENT TALK SCHEDULE / HORAIRE DES CONFÉRENCES DES ÉTUDIANTS

Thursday, June 18th / Jeudi, le 18 juin

9:00 AM	CAB 657	Nolan Peter Shaw	*Can You Paint With All the Colours of a Graph?*
	CAB 528C	Jessa Marley	*Using ODEs to analyze the impact of climate change on cyclic predator-prey systems*
	CAB 528B	Anton Borissov	*Toric Varieties*
9:30 AM	CAB 657	Skylar Nicol	*An Introduction to Ramsey Numbers*
	CAB 528C	Tobias Bernstein	*Power Residues Beyond Quadratics, for Prime Fields and p-adics*
	CAB 528B	Jackie Baek	*Introduction to Scheduling*
10:00 AM	CAB 657	Adam Borchert	*Palindromic Pair Factors of Finite Words*
	CAB 528C	Kari Eifler	*An Introduction to Persistent Homology*
	CAB 528B	Samer Seraj	*Kakeya Conjecture for Finite Fields*
10:30 AM	CAB 657	Ethan White	*Breaking Symmetry in Colour*
	CAB 528C	Yasha Pushak	*An Introduction to Non-Smooth, Convex Optimization Algorithms*
	CAB 528B	Michael Yu	*A Banach Space and its Dual*
2:00 PM	CAB 657	Reginald Lybbert	*Ideal Exponentiation in Real Quadratic Fields*
	CAB 528C	Hannah Brown	*The Scariest Word in Academia*
	CAB 528B	Kelvin Chan	*Colouring Invariance of Arithmetic Progressions and Large Sets*
2:30 PM	CAB 657	Alan Wong	*Computing the Tutte Polynomial of a Graph*
	CAB 528C	Alfred Ye	*High Quality Mathematical Visualizations*
	CAB 528B	Sasha Zotine	*Projective Toric Varieties of Integer Lattice Polytopes*
3:00 PM	CAB 657	Zachary Karry	*Absolute Galois Group*

	CAB 528C	Darshan Crout	*Leaders of True Believers: An Exploration of Opinion Dynamics with Open-Mindness Norm*
	CAB 528B	Hongfeng (Cynthia) Huang	*The Bin Packing Problem*
3:30 PM	CAB 657	Massey Cashore	*Bayesian Optimization: Computing Optimal Multi-Step Policies*
	CAB 528C	Hyunjae Moon	*Distinguish Points by Colour ID*
	CAB 528B	Mengxue Yang	*The Math Behind the Picture Hanging Problem*

Friday, June 19th / Vendredi, le 19 juin

9:30 AM	McM 3-22	Matthew Sunohara	*Combinatorial Reciprocity Theorems*
	McM 3-26	Isabella Lin	*Gaming the game: the mathematics behind optimal play*
	McM 3-28	Tyler Hofmeister	*Seasonal and Perodic Autoregressive Models for Daily Electricity Demand*
10:00 AM	McM 3-22	Daniel Krumer	*The Topological Dual of a Vector Space*
	McM 3-26	Jacob Garber	*Periodic Billiard Trajectories in Triangle*
	McM 3-28	Chloe Lampman	*A case for an alternative definition of Independent Broadcasts*
10:30 AM	McM 3-22	Alexander Liwoch	*Wittgenstein's Tractatus*
	McM 3-26	Mitchell Haslehurst	*Fourier Series*
	McM 3-28	Anthony McCormick	*The Difficulty with Assigning Dimension*
2:00 PM	McM 3-52	John Sardo	*Arithmetical Functions: basic properties and the magnitude of Euler's phi function*
	McM 3-22	Darrell Aucoin	*Programming Paradigms in the Age of Big Data*
	McM 3-26	Zachary Zanussi	*An Overview of Burnside's Theorem*
	McM 3-28	Justine Gauthier	*Extensions of Stern's Diatomic Sequence*
2:30 PM	McM 3-52	Mohammad Kidwai	*Zeros and Irreducibility of Stern Polynomials*

	McM 3-22	Hao Wang	*Nonparametric Bayesian Statistics*
	McM 3-26	Charlayna McGill	*Detecting Entangle States*
	McM 3-28	Adam Morgan	*Friction with Fractions: A Variational Approach to Nonconservative Systems*
3:00 PM	McM 3-52	Emma Carline	*C*-algebras of the 1-D crystal groups : Initial explorations*
	McM 3-22	Taras Kolomatski	*Rational Embeddings of Planar Graphs*
	McM 3-26	Darrick Lee	*Non-orderability of the Twofold Branched Cover of an Alternating Link*
	McM 3-28	Chen Xie	*On local profiles of tournaments*
3:30 PM	McM 3-52	Heather Topping	*Introduction to Algebraic Topology and its Applications*
	McM 3-22	Gaia Moravcik	*The Metric and Strong Metric Dimension of a Graph*
	McM 3-26	Jamie Nordio	*Dynamical Systems Modelling of an HIV Epidemic*
	McM 3-28	Rene Bidart	*A Comparison of Machine Learning Algorithm for Mixed Martial Arts Fight Prediction*

Saturday, June 20th / Samedi, le 20 juin

9:00 AM	CAB 657	Nickolas Rollick	*Squaring the Circle*
	CAB 528C	Pratyush Sarkar	*The Kerr Metric*
9:30 AM	CAB 657	Jonathan Earl	*Well-Covered Circulant Graphs*
	CAB 528C	Matthew Myrah	*Applications of Mathematics to Origami*
	CAB 528B	Cameron Ruether	*How to Optimally Gossip*
10:00 AM	CAB 657	Jesse Frohlich	*Blossoms: Representing Polynomials with Multilinear Maps*
	CAB 528C	Freid Tong	*Hodge Theory on Kahlar Manifolds*
	CAB 528B	Guo Xian Yau	*Tic-Tac-Toe*
10:30 AM	CAB 657	Sam Jaques	*Deutsch's Algorithm and Quantum Computing*

	CAB 528C	Dario Brooks	*The equivalence problem and three-dimensional Szekeres metrics*
	CAB 528B	Raymond Cheng	*Space of Spaces*
3:00 PM	CAB 657	Philip Lafrance	*An Introduction to the Probabilistic Method for Graphs*
	CAB 528C	Nora Nahornick	*Beyond the Financial Crisis: Modelling the Spread of Risk*
	CAB 528B	Yuan Yao	*Classical Mechanics and Symplectic Geometry*
3:30 PM	CAB 657	Chantelle Hanratty	*Introduction to Algebraic Geometry: A Collaboration between Topology and Ideals*
	CAB 528C	Joseph Salkeld	*An innovative agent based modeling approach to calculating intersection level of service*
	CAB 528B	Henry Liu	*Mathematical Foundations of Quantum Mechanics*
4:00 PM	CAB 657	Cristian Dumistrescu	*Shaping Algebra: A Glimpse of Sheaf Theory*
	CAB 528C	Andrej Vuković	*Squaring the Pyramid*
	CAB 528B	Ben Moore	*Graph Colouring Reconfiguration*
4:30 PM	CAB 657	Brandon Elford	*An Introduction to Combinatorial Game Theory*
	CAB 528C	Brydon Eastman	*Genetic Algorithms: Aka How I used Evolution to Help Make Cheap Drugs*
	CAB 528B	P. Colin Street	*An Introduction to Group-based Cryptography*

4

ABSTRACTS / RÉSUMÉS

4.1 KEYNOTE ABSTRACTS / RÉSUMÉS DES CONFÉRENCIERS PRINCIPAUX

Why physics is better than math :-)

Vincent Bouchard
University of Alberta

The number of fascinating results (many of them still conjectural) in various areas of mathematics, such as geometry, topology and number theory, that have been obtained via string theory in recent decades is mind-boggling. In this colloquium I will try to explain how theoretical physicists think, and why all these conjectural results coming out of string theory should not really come as a surprise. As an example, I will explore new captivating connections between enumerative geometry, a mysterious recursive structure that originated in random matrix theory, and the WKB asymptotic method for solving ordinary differential equations. While these topics may seem quite distant at first, it turns out that they are closely related via string theory; moreover, the resulting interconnections may shed light on some important conjectures in mathematics, such as the AJ conjecture (also known as "quantum volume conjecture") in knot theory. By the end of the talk, you should hopefully be convinced of "the unreasonable effectiveness of string theory in mathematics!"

Statistics is Beautiful

Karen Buro
MacEwan University

Bertrand Russell observed almost a century ago "Mathematics, rightly viewed, possesses not only truth, but supreme beauty". This talk aims to highlight beauty in mathematical and applied statistics and to discuss why statistics is not only beautiful but also very useful and should be considered an important skill for students of mathematics.

Making Connections: My (short) Journey Navigating Mathematical Research...

Shaun Fallat
University of Regina

I have always been fascinated by some of the links and connections formed in all branches of mathematical investigations. For me, deriving such interrelations has propelled my research program in many different directions – both positive and negative!

My lecture will highlight, by example, some connections that have successfully driven by own research. For instance: Zero forcing, graph colourings and multiplicities; tridiagonal matrices and interlacing; and the enhanced principal rank characteristic sequences.

Moonshine for beginners

Terry Gannon
University of Alberta

It has been claimed that 196884=196883+1. That this is indeed true, is a corollary to a theorem which won someone a Fields Medal. In my talk I'll try to explain what this is all about, and also describe a more recent variation on the same theme.

Mathematical models for territories

Mark Lewis
University of Alberta

Mathematical models can help us understand the formation of complex spatial patterns, including the territories of wolves and coyotes. Here scent marks provide important cues regarding the use of space. In this talk I will show how biologically-based mechanistic rules can be put into a mathematical model which predicts the process of territorial formation as individuals create and respond to scent marks. The model predicts complex spatial patterns which are seen in nature, such stable 'buffer zones' between territories which act as refuges for prey such as deer. The mathematical work is supported by detailed radio-tracking studies of animals. I will also employ the approach of game theory, where each pack attempts to maximize its fitness by increasing intake of prey (deer) and while decreasing interactions with hostile neighboring packs. Here the predictions are compared with radio-tracking data for wolves and coyotes. Finally I will show how a version of the territorial model has been applied to human populations in understanding spatial patterns arising from conflict between urban gangs.

Games on interval and permutation graph representations

Lorna Stewart
University of Alberta

We examine the idea of playing impartial two-person games on interval and permutation graph representations. Although the games are PSPACE-complete in general, some of them can be solved efficiently when the input graph is a tree.

4.2 student abstracts / résumés des étudiants

Programming Paradigms in the Age of Big Data

Darrell Aucoin
Statistics / Computational Math (University of Waterloo)
06/19 2:00 PM McM 3-52

Big Data is typically defined as data that is too big to fit into memory of a single computer. Usually, this means that a set (or cluster) of computers will need to work a portion of the data in parallel, and will require different programming paradigms for working with this kind of data. This talk will be about various programming paradigms (and some of the tools) with working with Big Data to create statistical models.

Recommended background: Basic programming

Introduction to Scheduling

Jackie Baek
Optimization (University of Waterloo)
06/18 9:30 AM CAB 528B

Scheduling is a study of assigning set of jobs to set of machines under constraints to maximize an objective function. In this talk, we will focus on problems with independent jobs and parallel identical machines. Two common objective functions used in scheduling are average waiting time and makespan (time when the last job finishes). When looking at these functions independently, the former can be minimized simply by sorting, while the latter has been shown to be NP-hard. We can also combine these two functions by aiming to minimize makespan from all possible schedules with optimal waiting time. In this talk, I will give a brief introduction to scheduling, and then focus on optimizing both average waiting time and makespan using efficient approximation algorithms.

Recommended background: First year mathematics

Power Residues Beyond Quadratics, for Prime Fields and p-adics

Tobias Bernstein
Algebra, p-adics (Trent University (summer research at University of Ottawa))
06/18 9:30 AM CAB 528C

It is commonly known that for odd prime p, $\mathbb{F}_p$ splits evenly into quadratic residues and quadratic non-residues, and thus that $(\mathbb{F}_p^\times)/(\mathbb{F}_p^\times)^2 \cong \mathbb{Z}/2\mathbb{Z}$. How does this generalize to other powers? We will prove, using primitive roots, that for odd prime p,

$$(\mathbb{F}_p^\times)/(\mathbb{F}_p^\times)^n \cong \mathbb{Z}/m\mathbb{Z} \tag{1}$$

where $m = gcd(n, p-1)$. We will then very briefly introduce the field of p-adic numbers, $\mathbb{Q}_p$. Using Hensel's Lemma, which we will take as a given, the previous result implies

$$(\mathbb{Q}_p^\times)/(\mathbb{Q}_p^\times)^n \cong \mathbb{Z}/n\mathbb{Z} \times \mathbb{Z}/m\mathbb{Z} \tag{2}$$

for $m = gcd(n, p-1)$, so long as $gcd(n, p) = 1$.

Recommended background: Isomorphisms, Elementary Number Theory

A Comparison of Machine Learning Algorithms for Mixed Martial Arts Fight Prediction

Rene Bidart
Statistics (Carleton University)
06/19 3:30 PM McM 3-28

Machine learning algorithms have been applied extensively to outcome prediction in almost all mainstream sports, but there has been limited research into using this for mixed martial arts. In my talk I will compare the effectiveness of common machine learning algorithms for predicting the outcome of MMA fights. My talk will include a quick introduction to these standard machine-learning algorithms.

Recommended background: First year linear algebra and some statistics

Palindromic Pair Factors of Finite Words

Adam Borchert
Combinatorics on Words (University of Winnipeg)
06/18 10:00 AM CAB 657

For a finite word w denote the reverse of w as w^R. We call w a *palindrome* if $w = w^R$. We call w a *palindromic pair* if w is the concatenation of two (not necessarily non-empty) palindromes (e.g., 1101100 is a palindromic pair as 11011 and 00 are palindromes). I will present current progress in my research classifying finite binary words containing the greatest possible number of palindromic pairs.

Recommended background: Any

Toric Varieties

Anton Borissov
Geometry (University of Waterloo)
06/18 9:00 AM CAB 528B

In algebraic geometry projective space is simple enough to get your hands dirty with computations but also rich enough to be a playground for many algebro-geometric endeavours. Toric varieties, objects constructed out of combinatorial data, are in many ways a generalization of projective space and they play an important role in many subjects such as combinatorics, geometry, and physics to name a few! In this talk, we will find out what these varieties are, how to construct them, and realize why they have so many connections to other areas of mathematics and beyond.

Recommended background: Linear algebra (dual spaces), basic algebraic geometry

The equivalence problem and three-dimensional Szekeres metrics

Dario Brooks
Differential Geometry (Dalhousie University)
06/20 10:30 AM CAB 528C

The problem of determining whether or not two mathematical objects are the same under a change of coordinates has been of interest to mathematicians for several centuries. What was originally of interest to pure mathematicians, the question of equivalence of mathematical objects has become of concern to applied mathematicians, physicists, and computer scientists. In this talk, I will first give an introduction to the equivalence problem and illustrate some methods used to determine equivalence of objects through the presentation of several digestible examples. I will then discuss the problem in differential geometry concerned with determining equivalence of (pseudo)-Riemannian manifolds and give an overview of my most recent research where I am concerned with obtaining a local invariant classification of 3-D Szekeres metrics, a class of solutions to Einstein's field equations of general relativity. Time permitting, the aim is to introduce Cartan's method of moving frames.

Recommended background: A little analysis and geometry

The Scariest Word in Academia

Hannah Brown
Algebra (University of Alberta)
06/18 2:00 PM CAB 528C

Most students share the mutual dread of university math courses; they can cause people to question their very sanity, and yet are often required to graduate. Many people avoid math beyond the classroom: people just don't like it very much, for various reasons. Yet math builds up our society and even our art. People need to be reminded of this so that they can appreciate one of humanity's most basic building blocks. So what

can be done to show others the power and joy that comes with an enriched understanding of math? What are we doing to turn people off and what can we do to prevent this? How can we win them over and what will it do for us, for the world? The following presentation will explore these questions and attempt to shed some light onto what needs to change about the public perspective on math.

Recommended background: A general appreciation of math

C*-algebras of the 1-D crystal groups : Initial explorations

Emma Carline
Dalhousie University
6/19 3:00 PM CAB 657

What do the reduced group C*-algebras look like for symmetry groups of the 1-D crystals and what are they good for?

Bayesian Optimization: Computing Optimal Multi-Step Policies

Massey Cashore
Bayesian Optimization (University of Waterloo)
06/18 3:30 PM CAB 657

Bayesian Optimization is a powerful tool for optimizing expensive, unknown functions (for example, it can be used to find the optimal configuration of parameters on a website). Typical Bayesian Optimization algorithms employ one-step-lookahead methods, iteratively sampling points that maximize some reward in the short term. However, these algorithms do not take into account the fact that in practice, multiple points will need to be sampled, and are thus suboptimal. Calculating the optimal multi-step algorithm is possible in principle as the result of a large dynamic program, but so far has been considered computationally intractable. In this talk I will give a thorough explanation of one-step-lookahead policies, and if time permits I will show that the optimal multi-step policy is computationally tractable for a certain class of one-dimensional problems.

Recommended background: Some statistics

Colouring Invariance of Arithmetic Progressions and Large Sets

Kelvin Chan
Ramsey Theory (Simon Fraser University)
06/18 2:00 PM CAB 528B

Van der Waerden's theorem, a celebrated Ramsey-type result, says that every finite colouring of the positive integers admits arbitrarily long arithmetic progressions all of the same colour. In this talk, I will present a generalization which asks to what extent one can exercise control on the arithmetic progressions produced by van der Waerden's theorem. A set $D \subseteq \mathbb{N}$ is said to be r-large if van der Waerden's theorem still holds for r colours when the arithmetic progressions are restricted to those with common differences in D. I will also briefly discuss the 2-large conjecture which asks if a 2-large set is also r-large for every $r \in \mathbb{N}$.

Recommended background: Basic discrete math

Spaces of Spaces

Raymond Cheng
Algebraic Geometry (University of Waterloo)
06/20 10:30 AM CAB 528B

A curious, yet common, situation in algebraic geometry is that the set of all objects of a particular type itself forms an algebraic geometric object. This allows one to do geometry on the space of spaces, from which properties about families of objects can be understood. Primarily through examples, I hope to illustrate how this rather abstract notion is interesting in studying geometry.

Recommended background: Faith in the speaker

Leaders of True Believers: An Exploration of Opinion Dynamics With Open-Mindedness Norm

Darshan Crout
Applied Mathematics (Simon Fraser University)
06/18 3:00 PM CAB 528C

In the last decade, there has been a surge of interest on the mathematical modeling of opinion formation, also known as Opinion Dynamics, most notably time-continuous based models with bounded confidence. These models can describe phenomena such as the voter model, gossip, as well as Wikipedia "edit wars." A model of particular interest is a recent heterogeneous model that describes opinion formation between two distinct groups of individuals: ones who behave "closed-minded" and those who behave "open-minded". This heterogeneity in the model introduces interesting dynamics that have not been previously observed. In this study, we try to generalize the model further as well as explore potential applications to this model and the data sets required.

Recommended background: First year calculus

Shaping Algebra: A Glimpse of Sheaf Theory

Cristian Dumitrescu
Abstract Algebra (University of Alberta)
06/20 4:00 PM CAB 657

One of the first aspects of math that we are usually introduced to is geometry, the study of shape. To many people that is appealing as we can see exactly what we are working with and what is happening. As we delve deeper into the abstract, mathematics can at times lose this feeling of visualisation and concreteness. However, it turns out that many instances of "higher abstract thinking" lend themselves to a visual interpretation, via what are known as sheaves of spaces. For example, one of the main results from complex analysis states that a function is completely determined by its Taylor series at any point. Hence, we can think of the complex plane as locally encoding holomorphic functions. In this talk, we explore the idea of sheaves in various contexts. I will briefly touch upon tangent spaces, differentiable and measurable functions, operators, as well as distributions, and see how they may be interpreted as sheaves. In closing, we talk about how this generality can give us some powerful computational methods and results.

Recommended background: Group/ring theory (required), topology (preferred), and an overall level of mathematical maturity

Well-Covered Circulant Graphs

Jonathan Earl
Graph Theory (Redeemer University College)
06/20 9:30 AM CAB 657

I describe what it means for a graph to be "well-covered" as well as the independence complex of a graph. These concepts are explained in the context of circulant graphs. My focus is on determining when well-coveredness is inherited from some richer algebraic structure of the independence complex of a graph

Recommended background: Graph theory

Genetic Algorithms: Aka How I Used Evolution to Help Make Cheap Drugs

Brydon Eastman
Combinatorics and Optimisation (Redeemer University College)
06/20 4:30 PM CAB 528C

Finding the absolute minimum or maximum of a multivariate function can be really hard, especially when the function describes some discontinuous process. Genetic Algorithms take a lesson from nature and employ the concepts of reproduction, mutation, and fitness to accomplish these optimisations. In this talk I will describe how genetic algorithms work and discuss how I am making use of them in my current research project.

Recommended background: Any first year maths

An Introduction to Persistent Homology

Kari Eifler
Topological Data Analysis (University of Alberta)
06/18 10:00 AM CAB 528C

Persistent homology is a relatively new theory used to deduce high dimensional structure from low dimensional representations, namely, point cloud data sets. This unordered set of data points can be represented by a simplicial complex, $\mathcal{K}$, which approximates the topology of the higher dimensional structure. We may filter this simplicial complex by either the Čech or Vietoris-Rips methods. Persistent homology employs the idea that the more persistent features (features that are present over a longer period of time) represent true topological features rather than noise.

The k-dimensional betti number, β_k, is equal to the number of k-dimensional holes and can be used to distinguish topological spaces and give a coarse characterization of the space in question. We visually represent these betti numbers in either barcodes or persistence landscapes, which can then be compared, matched and classified to categorize the space in question.

Recommended background: A basic grasp on topology

An Introduction to Combinatorial Game Theory

Brandon Elford
Combinatorial Game Theory (Dalhousie University)
06/20 4:30 PM CAB 657

This talk begins by defining what a combinatorial game is and then look at different types of play (i.e. normal, misery, scoring). We will then examine games in using each type of play and determine winning strategies of each game.

Recommended background: Any

Blossoms: Representing Polynomials with Multilinear Maps

Jesse Frohlich
Computer Graphics (University of Alberta)
06/20 10:00 AM CAB 657

In computer graphics, one often looks for compact methods to describe curves in $\mathbb{R}^2$ or $\mathbb{R}^3$. Since they can be easily approximated by straight lines, Bézier curves are widely used for rendering. These polynomial curves are described by a set of control points that provide a *net* approximating the desired curve. The curve itself can be computed through a sequence of linear interpolations. We encapsulate this sequence in a multilinear function known as a *blossom*.

I will discuss the information provided by blossoms including function values, derivatives, and subdivision (via domain re-parametrization). In addition, I will look into the powerful algorithms they provide for rendering and intersection. Blossoms can also be used to construct Bézier triangles, the natural generalization of Bézier curves to surfaces.

Recommended background: Basic knowledge of calculus

Periodic Billiard Trajectories in Triangles

Jacob Garber
Geometry (University of Alberta)
06/19 10:00 AM McM 3-26

Consider a frictionless billiard ball bouncing around inside a triangle. For some triangles, it is possible to find a trajectory for the billiard ball that is periodic; the trajectory repeats itself after a certain number of bounces. However, do such trajectories exist for all triangles? For acute and right triangles, the answer is affirmative, but for obtuse triangles it is unknown. In this talk, I present a strategy for potentially showing that all obtuse triangles have a periodic trajectory. Determining whether an obtuse triangle has a periodic trajectory involves solving systems of polynomial equations; we describe the derivation and numerical analysis of these polynomials using the Sage mathematical software.

Recommended background: High school algebra

Extensions of Stern's Diatomic Sequence

Justine Gauthier
Number Theory (Dalhousie University)
06/19 2:00 PM McM 3-28

In Stern's diatomic sequence, the nth term denotes the number of hyper- binary representations of n, or the number of ways n can be written using powers of 2, where no power is used more than twice. This paper will explore the properties of Stern's

diatomic sequence, as well as extend the sequence such that the n + 1th term represents the number of ways n can be written using powers of an integer $v > 1$, no more than v times. Many of the properties of Stern's diatomic sequence will be carried over to the generalized sequences. An analysis of the properties which remain in the extended sequences, as well as those which are lost, will follow.

Recommended background: Knowledge of elementary number theory may be useful, but not necessary

Introduction to Algebraic Geometry: A Collaboration between Topology and Ideals

Chantelle Hanratty
Algebraic Geometry (University of Alberta)
06/20 3:30 PM CAB 657

This talk will be an introduction to Algebraic Geometry based on the first chapter in Hartshorne's text on the subject. We work with an algebraically closed field k and consider two different structures associated to it. First we consider the polynomial ring $k[x_1, ..., x_n]$ and its ideals. Secondly we define a space A_n as k^n endowed with what is called the Zariski topology. Our goal is to develop a correspondence between the ideals of $k[x_1, ..., x_n]$ and the closed subsets in A_n. This correspondence is significant as it creates an interplay between topology and ring theory, allowing us to prove surprising results, such as non-trivial solutions to certain systems of polynomial equations.

Recommended background: Topology and ring theory

Fourier Series

Mitchell Haslehurst
Analysis and Topology (Nipissing University)
06/19 10:30 AM McM 3-26

In the 18th century, prominent mathematicians such as d'Alembert, Euler and Riemann are known to have dabbled with a new way of representing more general functions as infinite series (besides using the well-known Taylor series expansion), but they doubted its legitimacy. In wasn't until 1807 that this idea was brought to complete fruition by Joseph Fourier, who was attempting to solve a problem regarding diffusion of heat. Fourier thus opened a new field of study which reveals itself to be very useful in other fields of applied mathematics and science, particularly partial differential equations.

This talk is intended to be a basic introduction to representing an arbitrary function as a Fourier series, and to give an idea of just how arbitrary the function in question can be.

Recommended background: Calculus (Integration and Series) is recommended

Seasonal and Periodic Autoregressive Models for Daily Electricity Demand

Tyler Hofmeister
Time Series Analysis (University of Calgary)
06/19 9:30 AM McM 3-28

Deregulation of electricity production in Alberta has created an hourly auction conducted by the province to determine the price of this commodity. The hourly price formation resulting from this auction combined with the fact that electricity is prohibitively costly to store create a time series that is notoriously difficult to model.

Various time series models, namely Autoregressive models (AR), Seasonal AR, Periodic AR; and their usefulness in relation to modelling electricity prices is discussed. Using daily average demand for electricity in Alberta as a proxy, the three models are applied to the Alberta demand data from January 1st 2000 to December 31st 2014 to highlight the benefits and issues with each model in relation to modelling electricity prices.

Recommended background: Linear univariate regression, introductory statistics

The Bin Packing Problem

Hongfeng (Cynthia) Huang
Combinatorial Optimization (University of Waterloo)
06/18 3:00 PM CAB 528B

The bin packing problem (BPP) is a well-known NP-hard combinatorial problem in which objects of different sizes are backed into bins of certain capacity, in a way that minimizes the number of bins used. In this talk, we will briefly introduce some approximation algorithms for the bin packing problem and look into the Gilmore-Gomory's formulation. The famous Modified Integer Round Up Conjecture will also be discussed.

Recommended background: Basic discrete combinatorial optimization

Deutsch's Algorithm and Quantum Computing

Sam Jaques
Quantum Information Theory (University of Regina)
06/20 10:30 AM CAB 657

Quantum computing uses the distinct properties of quantum mechanics to achieve results that are impossible for classical computers. In this talk I'll outline some of the mathematical framework and notation used to describe quantum computing and then use this framework to explain Deutsch's algorithm, which is one of the simplest examples of how to utilize the advantages of quantum computing.

Recommended background: Linear algebra

Absolute Galois Groups

Zachary Karry
Algebraic Geometry (University of Toronto)
06/18 3:00 PM CAB 657

The absolute Galois group of a field F is defined as the group of all isomorphisms from the algebraic closure of F to itself which fix F. In this talk, the absolute Galois group will be explained in easy to understand terms, and a few examples will be given, including one of the most mysterious structures in mathematics: $Gal(\bar{\mathbb{Q}}/\mathbb{Q})$. Finally, it will be proven that the only finite absolute Galois groups are $\{e\}$ and $(\mathbb{Z}/2\mathbb{Z}, +)$.

Recommended background: First year linear algebra

Zeros and Irreducibility of Stern Polynomials

Mohammad Kidwai
Dalhousie University
6/19 2:30 PM McM 3-52

Stern's diatomic sequence was extended to a polynomial sequence, and a number of conjectures were raised from a study of its arithmetic properties. After establishing some preliminaries, I will talk about progress on the conjecture that Stern polynomials with prime subscripts are irreducible, and the related problem of the zero distribution of the Stern polynomials.

Recommended background: Polynomial rings irreducibility

Rational Embeddings of Planar Graphs

Taras Kolomatski
Analysis (University of Waterloo)
06/19 3:00 PM McM 3-22

A well-known result in graph theory is that a planar graph admits a straight line embedding, i.e. an injective map from the vertex set into $\mathbb{R}^2$ such that any line segments formed from the images of vertex pairs of edges in the graph intersect only at their endpoints. By specifying a fine enough ϵ, any ϵ perturbation of an embedding will preserve planarity and non-degeneracy. A rational embedding is one in which distances between the images of vertex pairs in the edge set are rational. I am concerned with finding rational ϵ perturbations for planar graph embeddings. I will present a proof for maximum degree four but not 4-regular planar graphs, and touch on recent efforts in the 4-regular case.

Recommended background: Any

The Topological Dual of a vector space

Daniel Krumer
Functional Analysis (University of Regina)
06/19 10:00 AM McM 3-26

Given a topological Vector space X,It is natural to discuss its dual space which is defined as the set of bounded linear functionals on it.In this talk, I will briefly introduce some of the topological properties of a dual space and its importance. Some examples will be given, and its uses in some fields in mathematics will also be discussed.

Recommended background: Basic analysis, basic topology

An Introduction to the Probabilistic Method for Graphs

Philip Lafrance
Graph Theory (University of Winnipeg)
06/20 3:00 PM CAB 657

Let (Ω, P) be a probability space, where the sample space Ω is the set of all possible graph structures under consideration, and P is some probability function. Given some graph property $\mathcal{P}$, can one verify the existence of a graph structure G in Ω such that G is guaranteed to have property $\mathcal{P}$? This question is the basis for the probabilistic method for graphs. The legendary Paul Erdős is the mathematician generally given credit for being the first to use this method; in particular, when he established a lower bound for the diagonal Ramsey numbers in 1947. The intent of this talk is to give the audience a foundational understanding of the probabilistic method, and to reinforce it with examples from various topics in graph theory.

Recommended background: Basic graph theory, elementary statistics

A case for an alternative definition of Independent Broadcasts

Chloe Lampman
Graph Theory (University of Victoria)
06/19 10:00 AM McM 3-28

A *broadcast* on a graph $G = (V, E)$ is a function $f : V \to \{0, 1, ...\text{diam(G)}\}$ such that $f(v) \leq e(v)$ for all $v \in V$. We say that a broadcast is *dominating* if every vertex of G is within distance $f(v)$ from a vertex v with $f(v) > 0$. Optimization problems involving broadcast domination and its variants appear in numerous real-world scenarios. In this talk, an alternative definition of an *independent broadcast* will be presented along with a case for its superiority over the current widely-used definition.

Recommended background: Some introduction to the basics of Graph Theory

Non-orderability of the Twofold Branched Cover of an Alternating Link

Darrick Lee
Topology (University of British Columbia)
06/19 3:00 PM McM 3-26

The fundamental group is a tool that allows us to view topological spaces as algebraic objects. It is a group that contains the set of all possible loops on the space starting from some base point, and is a topological invariant. Orderability is the question of whether or not it is possible to place an order $<$ on the group such that certain properties of the order are satisfied.

Current research in topology is interested in the connection between the orderability of these fundamental groups and the topological properties of the underlying manifold. In this presentation, I will introduce the concept of orderability and a class of manifolds called branched covers. The main topic will be a proof of the non-orderability of the fundamental groups of these manifolds using fairly rudimentary graph theoretic arguments, so no topology background is necessary.

Recommended background: Elementary group theory

Gaming the game: the mathematics behind optimal play

Isabella Lin
Applied Mathematics (University of Alberta)
06/19 9:30 AM McM 3-26

What does it mean to play optimally in a game, and how can we determine this using mathematics? We may approach this question by using mathematical modelling techniques. We will begin with an overview of several types of games and their associated gameplay strategies. Building on this, we can derive appropriate models for other

games. This process takes into consideration the game mechanics and desired outcomes, and can be extended to include other factors. These models can then be used to inform gameplay decisions. Finally, we briefly discuss the objective and subjective shortcomings of this approach.

Recommended background: First-year calculus

Mathematical Foundations of Quantum Mechanics

Henry Liu
Mathematical Physics (University of Waterloo)
06/20 3:30 PM CAB 528B

Much of modern physics relies on the underlying framework of quantum mechanics, a theory which describes the behavior of particles at extremely small length scales. In this talk I want to present the basic ideas behind quantum mechanics in an axiomatic but somewhat motivated manner. It turns out that quantum mechanics can be (mostly) formulated in the language of linear algebra, requiring only a little high-school physics, and aside from the linear algebra prerequisite I will try to make this talk as self-contained as possible. If time permits, I may also ramble a bit about Heisenberg's uncertainty principle and quantum field theory.

Recommended background: First year intro to linear algebra, first year intro to calc.

Wittgenstein's Tractatus

Alexander Maximilian Liwoch
Logic, Philosophy of Language (University of Alberta)
06/19 10:30 AM McM 3-22

The early 20th century saw the start of the so-called 'linguistic turn' in philosophy. There was a sense in which philosophy, unlike mathematics and science, did not seem to be going anywhere, with philosophers seemingly using vague language to address equally vague philosophical problems. In an attempt to clarify philosophy and place it on an equal footing with the sciences, philosophers became increasingly interested in a formal study of language use. This talk will be on one of the influential early works from the linguistic turn: Ludwig Wittgenstein's Tractatus Logico-Philosophicus. By looking at language as serving the purpose of representing our pictures of the world, and by looking at logic as a sort of mesh that fits over these pictures, Wittgenstein systematically concludes that there is no significant notion of a philosophical problem: philosophy is either the result of us being confused by the logic of our language, or it is an attempt to transcend our picture of the world to talk about what we cannot sensibly talk about (and of what we cannot talk about we shall remain silent). We will end by taking a brief look at the later Wittgenstein's own objections to the Tractatus.

Recommended background: Some symbolic logic may be helpful

Ideal Exponentiation in Real Quadratic Fields

Reginald Lybbert
Algebraic Number Theory (University of Calgary)
06/18 2:00 PM CAB 657

The infrastructure in a real quadratic field is a structure proposed for use in a number of public-key cryptosystems. The main cryptographic operation in this setting is the exponentiation of ideals. For this reason, we would like to have fast algorithms for this process. There is a wide variety of exponentiation algorithms in the literature; however, few have been adapted for ideals in real quadratic fields. One of the challenges for the development of these algorithms is the lack of a unique reduced representative for these ideals, thus more advanced techniques are required to uniquely identify each ideal with an equivalent reduced ideal. These techniques must then be implemented in each exponentiation algorithm to ensure the results are consistent. In this talk, a summary of the challenges involved in adapting potentially more efficient exponentiation methods to this setting will be given.

Recommended background: Intro to Abstract Algebra

Using ODEs to analyze the impact of climate change on cyclic predator-prey systems

Jessa Marley
Mathematical Biology (University of British Columbia Okanagan)
06/18 9:00 AM CAB 528C

The relationship between predator and prey is fundamental to natural ecosystems. Anticipating how predator-prey systems will respond to climate change is critical for the management of species in danger of extinction. Populations suffering from extremely low numbers can struggle to reproduce, resulting in a faster population decline (i.e. the Allee effect). This effect coupled with changing climatic patterns could be enough to endanger more species than is currently expected. I have developed a mathematical model, using ordinary differential equations, that incorporates low density extinction into a cyclic predation-prey system and introduce simple perturbations that simulate a variable environment in order to quantify extinction risk as a function of changing climatic conditions. At the present, I have found that predator-prey systems are very sensitive to climate change and have variable responses to the strength of the effects.

Recommended background: 1st year calc, 2nd year differentials

The Difficulty with Assigning Dimension

Anthony McCormick
Fractal Geometry (University of Waterloo)
06/19 10:30 AM McM 3-28

First, we will explore the problems that arise when trying to consistently define the dimension of subsets of a Euclidean space. Then, I will give the intuition behind the Hausdorff dimension before demonstrating why non-integer dimensions are actually useful. Namely, we consider singularity sets of potentials with respect to a mass or charge distribution.

Recommended background: Third year real analysis

Detecting Entangled States

Charlayna McGill
Quantum Information (University of Regina)
06/19 2:30 PM McM 3-26

In this talk I will look at separable and entangled quantum states, their criterion, and entanglement witnesses. A state ρ in quantum physics is modeled by a density operator in a Hilbert space in mathematics. Although the application of my research is based in quantum information, my talk will explore the mathematics of the subject. Ultimately, I will discuss the answer to the question: if ρ is a state on $\mathcal{H}_a \otimes \mathcal{H}_b$, how can one determine whether it is entangled or separable?

Recommended background: Linear Algebra

Distinguishing Points by Colour ID

Hyunjae Moon
Graph Theory (University of Calgary)
06/18 3:30 PM CAB 528C

In graph theory, a graph is made up of a set of points, called vertices, and lines that connect particular pairs of vertices, called edges. For example, if we let vertices represent communication centres and the edges be the links between them, then that would form a graph. Other applications include travel networks, computer networks and computer chip design. The important thing about graphs is not the shape or the geometry of the vertices and edges, but rather the pattern of the connections between them. By studying the structure of a graph and its mathematical properties, mathematicians can develop general theories. One such property is the distinguishing chromatic number, which is defined to be the minimum number of colours needed to colour the vertices of a graph so that the coloured graph has no symmetries and such that any two vertices connected by an edge are coloured differently. In particular, we discuss the distinguishing chromatic number of trees.

Recommended background: Any

Graph Colouring Reconfiguration

Ben Moore
Graph Theory (Thompson Rivers University)
06/20 4:00 PM CAB 528B

The Graph Colouring decision problem is the following: I give you a graph, and ask you if it has a proper k-colouring. It is known for non-bipartite graphs, this problem is NP-complete. I look at the reconfiguration varient of this problem. Given a graph G and two k-colourings of G, can we create a path from one k-colouring to the other changing one vertices colour at a time, continually maintaining a proper colouring. I will discuss the complexity of this problem as well as extentions of this problem into the domain of circular colouring and the closely related mixing problem.

Recommended background: Some Graph theory would be useful.

The Metric and Strong Metric Dimension of a Graph

Gaia Moravcik
Graph Theory (University of Winnipeg)
06/19 3:30 PM McM 3-22

In this talk, I will present an interesting problem that has application to the navigation of robots in a network space and to network security. A vertex w is said to distinguish two vertices u and v in a network if u and v are different distances from w. A metric basis for a network is a smallest set S of vertices with the property that every pair of vertices is distinguished by some vertex in S. The number of vertices in a metric basis is the metric dimension of the network. Closely related to the metric dimension is the strong dimension of a network. A vertex w strongly distinguishes vertices u and v in a network if either d(w,v)=d(w,u)+d(u,v) or d(w,u)=d(w,v)+d(v,u). A strong basis is a smallest set S of vertices with the property that every pair of vertices is strongly distinguished by some vertex in S and its cardinality is the strong dimension of the network. Every strong basis is a metric basis but not conversely. I will focus on comparing these two invariants.

Recommended background: A little graph theory

Friction with Fractions: A Variational Approach to Nonconservative Systems

Adam Morgan
Mechanics and Applied Mathematics (University of Alberta)
06/19 2:30 PM McM 3-28

Analytical mechanics usually treats nonconservative systems, such as those including friction, through the machinery of D'Alembert's Principle and generalized forces. However, techniques from fractional calculus have been adapted to allow for the study of nonconservative systems via the calculus of variations. In this talk, the basic operations of fractional calculus will be introduced and the Euler-Lagrange equations will be generalized to derivatives of fractional order. Using these results, we will see that including a 'half-derivative' in the Lagrangian of a certain system leads to an equation of motion that includes velocity-dependent friction! Finally, the benefits and detriments of both the generalized force and fractional approaches to nonconservative systems will be addressed. This lecture will be fun little excursion for those wish to see why not even the truth is stranger than friction!

Recommended background: Second-year calculus,intermediate classical mechanics,and a bit of familiarity with complex numbers

Applications of Mathematics to Origami

Matthew Myrah
Origami, Geometry (University of Waterloo)
06/20 9:30 AM CAB 528B

The topic of this talk is the application of mathematics to origami. We will discuss the Huzita-Hatori axioms, 7 axioms which completely define which folds (lines) and points of intersection that can be made on a piece of paper using only origami folds. We compare these axioms with the axioms used in compass and straightedge constructions, and will prove that the origami axioms define a strictly stronger geometry. We then will carry out some constructions that can be done using origami (doubling the cube, angle trisection). When carrying out the constructions, there will be animations to visualize the axioms being applied in terms of origami folds. Time permitting, we will discuss results relating to flat foldability(given a set of creases made on a paper, can those folds be made in such a way that the paper lies flat?), and computational techniques for designing and folding origami models.

Recommended background: Will make use of field theory, but will state the required knowledge in talk.

Beyond the Financial Crisis: Modelling the Spread of Risk

Nora Nahornick
Mathematical Finance (University of Alberta)
06/20 3:00 PM CAB 528C

The 2008 financial crisis showed that the default of one company may affect other companies so that default risk is spread among companies, like an infectious disease. Default intensity refers to the probability that a company defaults. We model the default intensity through two main components: systemic and idiosyncratic risk. Systemic risk refers to the influence of other companies: if a company defaults, the default risk of other companies increases. Idiosyncratic risk is the impact of a company's own stock performance on its default probability. This talk will analyze a calibration of default intensity to market data and look at different methods for finding a well-fitted model using Monte Carlo simulation and geometric Brownian motion. Solving the calibration, we can see that systemic risk plays a vital role. The calibrated model can then be used to analyze how trading strategies are affected by the default risk of the companies and identify which companies are key influencers.

Recommended background: First year calculus and statistics. Basic financial knowledge is recommended, but not necessary.

An Introduction to Ramsey Numbers

Skylar Nicol
Graph Theory (University of Winnipeg)
06/18 9:30 AM CAB 657

We define the Ramsey number $R(s,t)$ to be the minimum number n such that any graph on n vertices contains either a clique of size s or an independent set of size t. The Ramsey number is the solution to the famous "Party Problem", which asks for the minimum number of people that must be invited to a party such that at least s people all know each other or at least t people will not know each other. We will discuss the history of this problem, introduce some known Ramsey numbers, and demonstrate how to compute the Ramsey number for certain cases.

Recommended background: Basic Graph Theory

Dynamical Systems Modelling of an HIV Epidemic

Jamie Nordio
Dynamical systems, bifurcation theory, mathematical modelling (Simon Fraser University)
06/19 3:30 PM McM 3-26

Panama has the highest HIV prevalence in Latin America and infection rates continue to rise. HIV prevalence in female sex workers, trans individuals and men who have sex with men is 1.6%, 37.6% and 16.8%, respectively. Dynamical systems models, consisting of systems of ODEs, were developed to assist the Panama Ministry of Health in expanding access to treatment, which prevents HIV transmission. The model is calibrated to

data at the endemic equilibrium point using nonlinear least squares optimisation. Once calibrated, a black box function is constructed out of the ODEs, which is optimised to find treatment rates which reduce incidence within 15 years. We found that targeting treatment in only female sex workers and trans individuals and not their sexual partners, also reduced new infections in sexual partners at the same rate. This is extremely useful as sexual partners groups are difficult to identify and target through public health programs.

Recommended background: calculus 1+2, some differential equations, interuniversal teichmueller theory

An Introduction to Non-Smooth, Convex Optimization Algorithms

Yasha Pushak
Numerical Optimization (University of British Columbia Okanagan)
06/18 10:30 AM CAB 528C

The gradient is a tool commonly used in optimization of smooth or 'nice' functions. In the case of non-smooth optimization the gradient is no longer well-defined, which requires the introduction of new tools, such as the sub-differential. Convex functions are a class of functions with properties that can be exploited in optimization algorithms. This talk introduces the theory, and geometric interpretation of the sub-differential, convex functions, and their applications in non-smooth optimization. Many algorithms, such as Steepest Descent, Cutting Planes, and Bundle Methods, have been developed to use the sub-differential to optimize convex functions. The prior two, while natural in concept, are historical algorithms which are not commonly used due to poor performance in practice. We will provide examples of some of the pitfalls of these algorithms, leading to bundle methods and how they overcome these challenges.

Recommended background: First Year Intro to Calculus

Squaring the Circle

Nickolas Rollick
Geometry and Abstract Algebra (University of Calgary)
06/20 9:00 AM CAB 657

Given a circle in the plane, is it possible to construct a square with the same area as the given circle using only a compass and straightedge? Like all good problems, it is easily stated but notoriously difficult to solve. This problem was known to the ancient Greeks, but remained open for more than 2000 years before it was settled by Ferdinand von Lindemann. The problem of squaring the circle is an excellent illustration of the fruitfulness of translating a difficult problem into a different context, in which the route

to the answer becomes startlingly clear. In this talk, we will discover the connection between straightedge and compass constructions and abstract algebra, sketching the proofs of all the algebraic results needed to understand how von Lindemann's result settles the problem of squaring the circle.

Recommended background: Vector spaces, bases, dimension

How to Optimally Gossip

Cameron Ruether
Discrete Mathematics (University of Alberta)
06/20 9:30 AM CAB 528B

Consider a group of people, each of whom know a secret. Unable to resist the urge to gossip, these people wonder how to optimally inform everyone else of what they know. Secrets are shared in rounds during which the people are grouped into pairs and inform each other of all the secrets they know. What is the minimum number of rounds required so that all people know all secrets? We examine both the case where each person knows a unique secret, and the case where for each secret there may initially be multiple people who know it. We will describe the parameters which affect the optimal number of rounds, prove why these numbers are optimal, as well as provide secret sharing schemes which achieve these optimal numbers. This talk is recommended for anyone who wants to tell friends about CUMC after the conference, and wishes to do so optimally.

Recommended background: Very Preliminary Number Theory

An innovative agent based modeling approach to calculating intersection level of service.

Joseph Salkeld
Applied Mathematics (University of British Columbia Okanagan)
06/20 3:30 PM CAB 528C

Traffic congestion that occurs around all way stop intersections is common and often frustrating; with lines of cars on each side and tedious delays during peak rush hours. The Ministry of Transportation measures intersection performance through a level of service. This indicator quantifies how long an average vehicle is potentially delayed when making an action through an intersection. If the vehicle is turning right, left, or proceeding straight through, the delay is traditionally predicted through field measurements of traffic flow volumes and Bayesian statistics; however, this method does not consider obscure intersection geometry. I have developed an agent based model that uses GIS systems data to generate the intersection and calculate the level of service of the intersection by measuring the delay of each car as it makes its action. In the case study I

am finding that the model represents the measured delays experienced by drivers more accurately than the traditional methods.

Recommended background: Any

Arithmetical Functions: basic properties and the magnitude of Euler's phi function

John Sardo
Number Theory (University of Waterloo)
06/19 2:00 PM McM 3-52

We will begin with a brief summary of arithmetical functions and some of their basic properties, which we will illustrate with a number of examples. Next, we will go into detail about the magnitude of the phi function. In particular, we will look at its bounds and the role that the shape of a prime factorization plays in its size.

Recommended background: Introductory real analysis

The Kerr Metric

Pratyush Sarkar
General Relativity/Black Holes (University of Toronto)
06/20 9:00 AM CAB 528C

General relativity is a very interesting topic especially because of the many science fiction-like consequences, among which black holes are the most well known. The simplest nontrivial solution of Einstein's equations is the Schwarzschild metric which gives a description of the spacetime for a nonrotating uncharged black hole. The Kerr metric is a generalization for the case of a rotating uncharged black hole. In the talk, I will give some background information, introduce the Kerr metric, and talk about some of the interesting features.

Recommended background: Basic math is enough but the more Riemannian geometry you know the better.

Kakeya Conjecture for Finite Fields

Samer Seraj
Additive Combinatorics (University of Toronto)
06/18 10:00 AM CAB 528B

In 1917, Sochi Kakeya formulated the space dominated by a samurai's sword during battle as: a subset of the plane in which a unit line segment may be continuously rotated all the way around. An n-dimensional Besicovitch set is the weaker notion of a subset of $\mathbb{R}^n$ containing a unit line segment in every direction. The Kakeya Conjecture predicts the 'dimension' of the contents of Besicovitch sets.

While this conjecture remains far out of reach, an analogue in finite fields was proposed by Wolff in 1999, and independently came up in computer science in 2003. It was finally resolved by Dvir in 2008 using a short elegant technique. We will present this proof and construct the smallest known Kakeya sets in every finite field.

Recommended background: A semester of linear algebra and the definition of a finite field.

Can You Paint With All the Colours of a Graph?

Nolan Peter Shaw
Graph Theory (University of Calgary)
06/18 9:00 AM CAB 657

A 'graph,' as it pertains to mathematics, is a structure formed by a set of elements (called vertices), and their pairwise relationships (called edges). A 'colouring' of a graph is a labeling of the vertices such that no two vertices which share an edge have the same colour. The most famous example of a graph colouring problem is the 4-colour theorem, which proves that any planar graph can be properly coloured with, at most, four colours.

Recently, graph theorists have begun to examine the graph of vertex colourings for a given graph, G, where each vertex represents a unique colouring of G, and two vertices share an edge if their colourings differ at exactly one vertex. Inspired by the study of Grey Codes in other fields of combinatorics, graph theorists have taken a specific interest in when a graph of vertex colourings is Hamiltonian. I will be introducing these concepts as well as illustrating some results that have been found regarding the graph of vertex colourings

Recommended background: Any

An Introduction to Group-based Cryptography

P. Colin Street
— (Carleton University)
06/20 4:30 PM CAB 528B

A brief survey of some group-based protocols will be presented along with their strengths and weaknesses. The introductory ideas of cryptography will also be presented so no background in that is required.

Recommended background: Basic Group Theory

Combinatorial Reciprocity Theorems

Matthew Sunohara
Combinatorics (University of Toronto)
06/19 9:30 AM McM 3-22

A counting function of a class of combinatorial objects is often naturally the restriction to the natural numbers of some function defined on the real numbers, such as a polynomial. A surprising fact is that there are sometimes combinatorial interpretations for the values of the counting function when evaluated at negative integers. If this is the case we obtain a combinatorial reciprocity theorem relating the counting functions of two (perhaps quite unrelated) combinatorial objects. We will look at a few examples of these charming theorems and prove R. P. Stanley's theorem that given a finite simple graph $\mathcal{G}$ on n vertices, $(-1)^n\chi(-1)$ counts the number of acyclic orientations of $\mathcal{G}$, where $\chi(k)$ denotes the chromatic polynomial of $\mathcal{G}$.

Recommended background: Basic graph theory

Hodge Theory on Kahler Manifolds

Freid Tong
Differential Geometry (University of Toronto)
06/20 10:00 AM CAB 528C

I will introduce Kahler Manifolds and briefly discuss some notions of Hodge Theory on Kahler Manifolds. Due to time constraints I will most likely stray away from proofs of any kind.

Recommended background: Complex Analysis, a lot of Differential geometry

An Introduction to Algebraic Topology amp; its Applications

Heather Topping
Algebraic Topology (Nipissing University)
06/19 3:30 PM McM 3-52

To show that any two spaces are not homeomorphic, we know that we simply need to find a topological property that one space has and the other does not. Compactness, connectedness and metrizability are examples of such properties that will be preserved under homeomorphism. Another such property is a space's fundamental group, $\pi_1(X, x_0)$, which is defined as the set of homotopy classes of a loop f with basepoint x_0 in a space X. Here we will discuss homotopy theory, in particular introducing the notion of a space's fundamental group and the application of van Kampen's Theorem to solve various problems.

Recommended background: Some familiarity with groups is recommended.

Squaring the Pyramid

Andrej Vuković
Number Theory (Carleton University)
Recommended background: Slight tricks of elementary algebra

The study of elliptic curves has been a central part of number theory for many years as a result of its usefulness in the solution of Diophantine equations. I will introduce the basic notions of this area, such as the (naive) height and rank of an elliptic curve, before describing some recent results by Bhargava, Poonen, Alpoge, and others, and outlining how those results were obtained.

If that doesn't excite you, you'll also learn what the title of my talk means.

06/20 4:00 PM CAB 528C

Nonparametric Bayesian Statistics

Hao Wang
Statistics (Carleton University)
06/19 2:30 PM McM 3-22

Due to its complex nature and intense computational demand, nonparametric Bayesian inferences methods have long been overshadowed by simpler parametric frequentists methods. However, as technology advances and computational power increases, nonparametric Bayesian methods are becoming more widely used. This talk begins with a brief introduction to Bayesian statistics, nonparametric modelling, and some reasons for the transition towards nonparametric Bayes. It will include a well-known process used in nonparametric Bayesian inference, namely the Dirichlet Process. An introduction to some implementations of the Dirichlet Process such as the Chinese Restaurant Process and the Stick-Breaking Process will be discussed. The talk will conclude with applications of nonparametric Bayesian statistics in fields such as biology, specifically in phylogenetic reconstruction using mutation selection models.

Recommended background: Any

Breaking Symmetry in Colour

Ethan White
Graph Theory (University of Calgary)
06/18 10:30 AM CAB 657

A graph is a collection of points (vertices) and lines connecting pairs of vertices (edges), and a colouring of a graph is a labeling of it's vertices such that any two vertices connected by an edge have different colours. The challenge is to find the least number of labels (colours) needed to colour a graph. Graph colouring has a long history going back to the Four Colour Conjecture (now the Four Colour Theorem). A recent variation on graph colouring involves colouring a graph in such a way that all the symmetries of the graph are destroyed. Such a colouring is called a distinguishing colouring of a graph, and the least number of labels needed to accomplish this is called the graph's distinguishing chromatic number. The distinguishing chromatic numbers of various classes of graphs have been studied. Graphs with many symmetries are the most interesting to study with respect to the distinguishing chromatic number. In my talk, some such graphs will be investigated.

Recommended background: Any

Computing the Tutte Polynomial of a Graph

Alan Wong
Graph Theory (Simon Fraser University)
06/18 2:30 PM CAB 657

The Tutte polynomial of a graph G contains interesting information about G, including its connectivity and colourability. It has applications in other fields such as chemistry and theoretical computer science. However, computing Tutte polynomials is very expensive (NP-hard) and can take hours for some relatively small graphs. We present some heuristics which speed up the computation considerably, based on saving and re-using results from intermediate calculations. We also discuss formulas that allow for the computation to be split up in a natural manner and take advantage of parallelism.

Recommended background: Second Year Discrete Math

On local profiles of tournaments

Chen Xie
Combinatorics (University of Waterloo)
06/19 3:00 PM McM 3-28

Abstract: A tournament is an orientation of a complete graph. A k-profile of a tournament T is the induced density vector of k-vertex tournaments. Given the limit set of the 3-profiles of a family of tournaments, what can be said about its 4-profiles? More specifically, given the number of directed 3-cycles in a tournament T, what can be said about its number of directed 4-cycles? We construct upper bounds for the numbers of order 4 subtournaments in T, and conjecture a lower bound on its number of 4-cycles.

Recommended background: Basic graph theory

The Math Behind The Picture Hanging Problem

Mengxue Yang
Group theory (University of Waterloo)
06/18 3:30 PM CAB 528B

Suppose we have a painting, a string, and some nails for hanging the painting on a wall. Suppose there are n nails. Find a way to hang the painting such that removing any one of the n nails makes it fall. This absurd and seemingly simple puzzle is not so easy to wrap our minds around using brute force. Once we see it in the light of group theory, however, we can easily write down the solution.

Recommended background: Basic group theory

Classical Mechanics and Symplectic Geometry

Yuan Yao
Symplectic geometry (University of Toronto)
06/20 3:00 PM CAB 528B

The goal of this talk is to introduce a mathematically rigorous way of thinking about classical mechanics. We will first introduce the definition of a symplectic manifold, then discuss how to define dynamics on a symplectic manifold and show they are equivalent to Newton's laws in R^3 (with tautological forms in cotangent bundle). Finally, using the formalism we developed, we will try to understand aspects of classical mechanics that are not obvious in Newton's formulation, for example Poincare recurrence, Liouville's theorem, and Noether's theorem if time permits.

Recommended background: Manifolds, vector fields, differential forms

Tic-Tac-Toe

Guo Xian Yau
Game Theory (University of Waterloo)
06/20 10:00 AM CAB 528B

Tic-tac-toe is probably the most popular pencil and paper game in the world. The rules are so simple and well known that it is not even worth mentioning. Ever wonder why the default of the game starts on a 3x3 grid? Do you know the winning strategy (if there exists one) for both first and second player? What about the generalisation of the game itself? Can we add more rules and/or change the settings to make it more fun? Come and find out yourself.

Recommended background: Knows how to draw (at least) two geometrical object and an n by n grid.

High Quality Mathematical Visualizations

Alfred Ye
General Mathematics, Mathematics Education (University of Alberta)
06/18 2:30 PM CAB 528C

"A picture is worth a thousand words" is one of the classic recommendations offered to communicators and instructors. So, we need to ask: how do we best turn this suggestion into reality for the purposes of teaching/learning and research in mathematics and natural sciences? We contribute to an answer by providing a tool for the generation of high quality illustrations and animations.

In this talk, I will demonstrate features of this tool in a mathematics education setting by analyzing sample illustrations and animations. We point out, however, that this tool can be just as useful for other purposes, such as the visual studies of certain dynamical systems, visual mathematical modeling, etc. Finally, we will comment on what makes our tool special, namely: the scope of its capabilities in the hands of a mathematically competent author, combined with the quality of its output.

Recommended background: Any

A Banach Space and its Dual

Michael Yu
Real Analysis (University of Toronto)
06/18 10:30 AM CAB 528B

Although a Hilbert space is typically defined in terms of an inner product, its refined properties as a special Banach space are better appreciated when we see that the inner product is merely a specialized formulation of the evaluate-at bilinear scalar product between the dual space and the original space and that its canonical isomorphism with its dual subsumes a generally defined **duality map** from a Banach space to its dual. This duality map sends an element to (normalized) dual functionals that maximize the aforementioned scalar product. However, in the most general Banach space, this map is not even necessarily a function in either direction. We shall see that increasingly nice convexity conditions on the geometry of the dual space give rise to an increasingly proper duality map. A highlighting result is that **uniform convexity** of the dual space implies the total derivative of $\varphi(x) = \frac{1}{2}\|x\|^2$ exists and equals the duality map as a function.

Recommended background: One semester of real analysis

An Overview of Burnside's Theorem

Zachary Zanussi
Operator Algebra (Carleton University)
06/19 2:00 PM McM 3-26

Burnside's Theorem is a fundamental result in the field of noncommutative algebra. Though simply stated, it forms the foundation for many theorems on matrix algebras, and, combined with the Triangularization Lemma, provides many sufficient conditions for the simultaneous triangularization of collections of linear operators on finite-dimensional vector spaces. We will examine the most simple proof of Burnside's Theorem, and walk through several interesting applications.

Recommended background: First year algebra

Projective Toric Varieties of Integer Lattice Polytopes

Sasha Zotine
Algebraic Geometry (Simon Fraser University)
06/18 2:30 PM CAB 528B

This talk presents a brief look at projective toric varieties of integer lattice polytopes. In particular, we will examine the 2-dimensional case, where we consider the toric varieties of polygons in Z^2. If we consider the toric variety as the intersection of some hypersurfaces, the primary objective is to ask when the variety contains only finitely many lines. This problem has been solved but remains open for higher dimensions. An example will be given and the generalized problem will be stated.

Recommended background: Some ring theory, mostly ideals

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THANKS / MERCI

We would like to thank our volunteers, supporting organizations, and generous sponsors for making CUMC 2015 happen. Nous voulons remercier nos volontaires, organisations de soutien, et sponsors généreux pour réaliser CCÉM 2015.

6

CONTACTS

6.1 CONFERENCE CONTACTS / CONTACTS POUR LE CONGRÈS

If you have any questions or concerns during the CUMC, you can contact us through one of the following avenues:

- cumc@cumc.math.ca
- facebook.com/cumc2015ccem
- twitter.com/cumc2015ccem

Si vous avez des questions ou intérêts pendant le CCÉM, vous pouvez nous contacter au moyen d'une de ces modes:

- ccem@ccem.math.ca
- facebook.com/cumc2015ccem
- twitter.com/cumc2015ccem

6.2 FOR EMERGENCIES / D'URGENCE

- Fire/Police/Ambulance: 911
- Protective Services (complaints/information, 24 hrs): 780-492-5050
- Building Emergency (flood, outage, etc.): 780-492-5555
- Edmonton Police Service: 780-423-4567