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Issue Contents

December 2021 : Vol. 53, No. 6

The Light at the End of the Tunnel

Cover Article December 2021 (Vol. 53, No. 6)

Termeh Kousha (Canadian Mathematical Society)
Executive Director

As I write these lines for the December issue of the *Notes*, I feel both proud and sleep-deprived. I had been gradually getting more involved with the CMS towards the end of my maternity leave and my return in September was after an extremely successful Summer Meeting with over 1000 registrants celebrating the 75th+1 anniversary of the CMS. The CMS was also still basking in the excellent news from Team Canada's glorious performance at the International Mathematical Olympiad and Girls' Math Team Canada's first gold in the history of its participation at the European Girls' Mathematical Competition. Despite what we had anticipated, COVID-19 had minor side effects, but the strong will, talent and hard work of our young mathematicians offset all difficulties.

I would like to take this opportunity to thank all those involved in the training of both teams, namely Robert Garbary, Anna Krokhine, Elnaz Hessami Pilehrood, Dorette Pronk, James Rickards, Mariya Sardarli, Alex Song, and Dani Spivak.

Upon my return, I thought my biggest task would be to secure a place for my soon-to-be 1-year-old at a daycare centre. But as I succeeded in doing so, the CMS went through some unexpected changes. Unfortunately, two key members of our staff went on sick leave and the newly hired staff had no choice but to plunge in head first into the thick of things with the competition season afoot and Winter Meeting preparations pressing. The task in front of us seemed insurmountable and at times and we had to work long hours to make the competitions a possibility. I am so grateful for the hard work and dedication of our new and old staff members and everyone who helped us organising another successful competition season.

We are also grateful to the RBC Future Launch program and Actuarial Foundation of Canada for funding the CMS Inclusion Initiative that provided an opportunity for Black, Indigenous and female-identifying students to participate in the competitions at no costs. We would have liked to be able to better advertise and implement our new initiative for female-identifying students. But we have built the foundation and will improve upon it in the years to come. We firmly believe at the CMS that all students should be given a chance to discover and develop their love and talent for mathematics.

I am also happy to report that participation in the Gray Jay competition increased by 50% this year and we were able to form partnerships with 17 new countries to have international students write the competition. The Canadian Mathematical Gray Jay Competition was conceived in 2020 to engage students in stimulating mathematical activities from a young age.

This year too, some math camps had to be cancelled due to COVID-19 restrictions. Others went ahead with an online format. The CMS is also proud to have sponsored a brand new Math Week for Black Students in Nova Scotia this year. I would like to take this opportunity to thank the organisers of this initiative for their creativity and their hard work.

We were not able to take a break since we had to do a fast transition from competitions to the meeting planning. The list of sessions, speakers, and mini-courses promise another enriching gathering, albeit virtual, of the Canadian and International mathematicians.

I am proud to announce that this year, thanks to funding from RBC Future Launch program, we have put in place a new inclusion initiative for 2021 Winter Meeting, in addition to offering free registration to the meeting and mini-courses. This year, the CMS will be offering a good number of free registrations to female-identifying, non-binary and LGBTQ+ student registrants and to registrants with disabilities. We strongly believe that lifting barriers for the participation of equity-seeking groups will result in a richer and more diverse community that can offer new exciting perspectives and value different knowledge systems.

We hope to see you all on December 2-7 on Zoom.

In the end-of-the-year tradition, I wish us all a COVID-free 2022, where we can come together in person again and hold spaces for K-12 students to see their math-y peers and foster their mathematical interests. That said, we are ready for anything and if the COVID pandemic has shown us anything it is that our community is resilient and adaptable.

At the end, I would like to take the opportunity to thank Dr. Javad Mashreghi and Dr. Monica Nevins for their guidance and words of encouragement that have helped me during this difficult fall session. Last but far from least, I would like to thank one more time the great CMS staff (old and new) for their hard work and dedication. A very special thank you to Yvette Roberts: it would not have been possible to pass this season without her help and dedication.

Stay well and stay safe!

Robert Dawson (Saint-Mary's University)
Editor-in-Chief

The singer/songwriter Tom Lehrer (a mathematician himself) once wrote:

When you attend a funeral
It is sad to think that sooner or later
those you love will do the same for you.

But indeed they will; and one of the many functions of *the Notes* is to remember those of our fellowship who have left us.

We have, I think, a rather special role to play in this regard. Families or friends often arrange for an obituary in the local newspaper, or on a funeral home's web page. But, as may be imagined, these tributes concentrate on the side of the deceased best known to their family, to neighbours, and to members of their church, curling club, or klezmer band. A few of our readers may be privileged to know them through these circles, but to most of us the late Dr. Mehitabel O'Lafferty will be the woman who taught us ring theory, who organized that great conference at BIRS, or who gave that memorable talk on presubmersive duomodular graphs. Those aspects of her life won't always be uppermost in the mind of a bereaved relative to whom she was Aunt Mitty who liked trail-riding.

So, when we can, we run obituaries in *the Notes*, giving a mathematician's-eye-view of the life that our late colleague lived. It's our privilege to do this; unlike the local paper, we do not charge. Our usual policy is to concentrate on Canadian mathematicians, loosely defined, and on members of the CMS, past or present. If we tried to run an obituary for everybody, worldwide, who has contributed to mathematics in some way, they would dominate the journal and we'd have to rename it the *CMS Obits*. But we can certainly provide a place where the Canadian mathematical community can say farewell to its own.

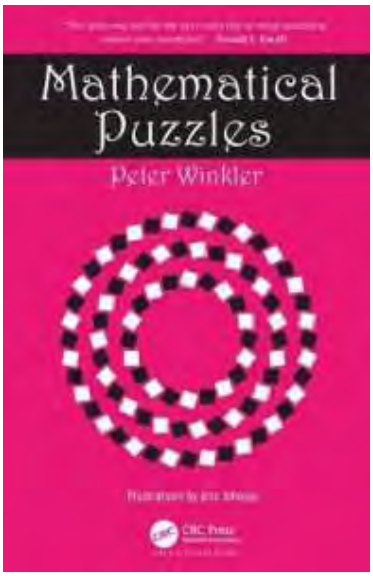
Like any local newspaper, though, we depend on readers' input to do this. When a colleague dies, please make sure we find out (not every academic's departure makes the national news.) If you are able to write a tribute yourself, we'd be very grateful; a suggestion of somebody else who might will also be appropriate. Even helping us round up a good photograph is always much appreciated. Since we went paperless, there is no page count problem; we can almost always run an obituary in the next issue.

I was recently asked an excellent question: what is the desired balance among lay biographical detail, a summary of professional work, and personal reminiscences? I would say the first should probably be in the mathematical tradition of the minimal object that will do the job properly, as it's already been done elsewhere. The second, like a good review of a paper, should be economical but not scant; and the third should partake of the spirit of a wake, conjuring up and passing on good memories freely. But the important thing is that you write what you'd like people to recall (or, for those not fortunate enough to have made their acquaintance, learn) about your late colleague. Write what seems good to you: there is no fixed template.

And may you – and your colleagues – not need this information for many years to come!

Book Reviews bring interesting mathematical sciences and education publications drawn from across the entire spectrum of mathematics to the attention of the CMS readership. Comments, suggestions, and submissions are welcome.

Karl Dilcher, *Dalhousie University (notes-reviews@cms.math.ca)*



Mathematical Puzzles
by Peter Winkler
A K Peters/CRC Press, 2021
ISBN: 978-0367206925
Reviewed by David Wolfe, Verisk Analytics

I wished I'd refused the assignment to review Peter Winkler's Mathematical Puzzles. As a reviewer, I felt compelled to read the puzzles and the solutions, but I was too addicted to the puzzles to *want* to see the solution to a tantalizing puzzle I had yet to solve. This is the greatest collection of puzzles I've encountered, and is excellent reading for all ages of mathematically minded individuals from teenagers through experienced researchers. Whoever you are, do not expect to solve them all!

Peter Winkler's excellent taste in puzzles comes through in both his selection and his presentation. Many puzzles are framed in a mini-story with captivating language or characters; and there are a few non-mathematical teasers thrown in. They include old classics like, "Brothers and sisters I have none, but that man's brother is my father's son," and "How can you get a 50-50 decision by flipping a bent coin?" But the real attraction for me was the number of puzzles from the last decade or two which are sure-to-be classics.

Like many of Peter Winkler's own creations, this pair of puzzles spread through the mathematical community like wildfire:

- Alice and Bob each have $100 and a biased coin that comes up heads with probability 51%. At a signal, each begins flipping his or her coin once a minute and bets $1 (at even odds) on each outcome, against a bank with unlimited funds. Alice bets on heads, Bob on tails. Suppose both eventually go broke. Who is more likely to have gone broke first?"
- Suppose now that Alice and Bob are flipping the same coin, so that when one goes broke, the second one's stack will be $200 [but will keep playing]. Same question: Given that they both go broke, who is more likely to have gone broke first?"

Of course, since Winkler poses both questions, you can correctly infer that the answers differ!

Winkler's choice of organization is a bit unusual. The puzzles are enumerated 4 times. The first lists the puzzles in an order that doesn't divulge the technique of solution. The second section of the book gives hints. The third, and largest, section of the book provides solutions to all the puzzles grouped by technique used; each of these sections ends with a well-chosen *bonus* theorem related to the technique. In the closing portion of the book, Peter Winkler describes what he knows of each puzzle's source or history.

Most who pick up the book will no doubt want to work the puzzles as initially presented in the lead section. The first puzzles are easiest, but are plenty interesting and fun. Otherwise, they are well-mixed in both style and mathematical methods required. If, on the other hand, you are a person who prefers to use the book to study techniques, you may choose to jump straight into the third presentation of the puzzles. Each puzzle is repeated verbatim from the first section, so the solutions stand on their own. And the puzzles are sorted by difficulty, so the reader can build confidence in using the technique and stop when the waters get too deep. Each technique-specific chapter ends with a bonus theorem, one which is just the sort of theorem I might not have seen before but which I sure wish I knew years ago.

Thank you, Peter, for assembling this magnificent potpourri!

David Wolfe is co-author of several books on combinatorial game theory, most recently of the second edition of "Lessons in Play: An Introduction to Combinatorial Game Theory" (with Michael H. Albert and Richard J. Nowakowski), A K Peters/CRC Press, 2019.

A Graduate Student Instructor Training Seminar

Education Notes December 2021 (Vol. 53, No. 6)

Carmen Bruni (David R. Cheriton School of Computer Science, University of Waterloo)

Education Notes bring mathematical and educational ideas forth to the CMS readership in a manner that promotes discussion of relevant topics including research, activities, issues, and noteworthy news items. Comments, suggestions, and submissions are welcome.

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Teaching is a cornerstone in the career of any academician. For mathematicians especially, teaching can play a huge role in shaping one's professional career. For this reason, it is necessary that we give the next generation of mathematicians a solid foundation for teaching mathematics courses. In this article, I want to outline one such endeavour currently underway at the University of Waterloo.

The Big Picture – A Three Stage Program to Graduate Student Training

Graduate students at the University of Waterloo are expected to take on Graduate Teaching Assistant duties over the course of their graduate degree. These include grading assignments and examinations, proctoring examinations, running tutorials and possibly teaching courses. As such, the need for several training programs for each of the main tasks a graduate student might undertake is vital for quality control purposes.

The idea at the University of Waterloo, originally due to Brian Forrest, was to have three stages of training. The first stage would be a session to discuss basic graduate student expectations, give training on how to grade papers and inform them on some policies relating to examinations, work training modules and so on. This is done in the very first week students are on campus. The second stage is a training session preparing students to give tutorials in the classroom where topics including basic presenting skills, scenario training and content preparation are discussed. Stage three is the Instructor Training Seminar which is the focus of the paper. This was an idea I had come up with independently from Brian and approached him about it in 2017 (based on something similar done at the University of British Columbia – see [2] for more details).

Stage Three – Instructor Training Seminar

The idea was to create a seminar that really delved deep into the nuances of teaching. The seminar itself is broken down into 12 weeks where we meet for 1.5 hours per week. Vital to the success of this seminar is the focus on practical advice and in-classroom practice. The seminar was primarily focused on graduate students, though occasionally post-doctoral fellows and some novice instructors with no prior teaching experience also participated. For the purposes of this article, we will call those participating in the seminar *participants*.

In the three offerings of this seminar that have been completed, participation has ranged between 20 and 30 participants. Participant disciplines have varied across the 5 major departments of the faculty of Mathematics at the University of Waterloo, namely Applied Mathematics, Actuarial Science, Combinatorics and Optimization, Computer Science, Pure Mathematics.

The following section outlines the 12-week seminar with descriptions of some weekly activities.

Week 1: Introduction and Good Teaching

In this week, we introduce everyone and discuss what good teaching is. One important thing we want participants to realize is that good teaching isn't always about a person standing at a board lecturing. This can be a part of good teaching, but in fact good teaching is so much more than what is done in front of a class. It involves selecting good and meaningful assignment and examination questions, having a broad vision for a course, and even picking engaging activities to do in the classroom. Good teaching has many different components, and we spend some time in this first week identifying some of these points in preparation to go into further detail later.

One task we do in week 1 is discuss the Wason Selection Task [6]. Briefly, students are presented four cards each having a letter on one side and a number on the other. Students are told that they want to verify whether or not the following statement is true:

"If there is a vowel on one side of the card, there is an even number on the other"

The four cards display a consonant, a vowel, an even number and an odd number, and students are asked which cards must one flip over in order to determine whether or not the above statement is true.

(If you've never seen this before – it might be a good time to pause and try to solve the above problem!)

We arrange the activity for our graduate students much like we would do in a classroom using the Think Pair Share method – think for a minute, discuss with your neighbour, share as a class. Most graduate students get the above answer (that you should flip the vowel and the *odd* number!) However undergraduate students at all levels often make mistakes here. Additionally, there is a video that we show them from the *College Math Video Cases* site that shows how an organic discussion might work in a classroom [3]. A fun twist to the above is changing the problem context to drink orders at a bar with people who may or may not be minors in a city with a minimum drinking age and using this exercise as a lesson in abstraction. While it is effectively the same problem, students do much better when reasoning about alcohol (for reasons I'll let the current reader ponder!).

Lastly, we show two examples of real live lecturers in the classroom and discuss some of the things they did right and some they did wrong. This exercise is also extremely valuable as it provides many great insights into watching a class not for learning content but rather to really focus on how to present. The videos can be found in the references below [4][5].

Week 2: Presentation Skills

If you have never treated yourself to a Dan Wolczuk lecture, I highly recommend you once again stop reading this article now and open the link from the BIRS conference in Innovations in New Instructor Training in the references [1]. The aforementioned link gives you a sense at how dynamic Dan is in the classroom. His talk on presentation skills is enlightening and helps novice and even experienced instructors to think critically about their presence in the classroom. His talk includes notions about using one's voice (including paralanguage, pitch, pauses, intonation, annunciation), knowing your lines, movement and positioning, eye contact and overall body language. To many of us who are currently university instructors, a lot of this is second nature but to a novice, these insights can be extremely important. Again, I highly recommend listening to Dan's talk even if you are experienced as it can very much improve one's own classroom teaching.

Week 3: Mini lectures Part 1

Many of my colleagues who have helped in this project were invaluable resources for helping to administer the mini lectures. Participants broke out into groups of 3 participants and one or two invigilators. Participants would take turns giving 15-minute talks and then receiving 15 minutes of feedback from the other participants and instructors. Participants choose topics based on a course they think they might teach in the future (which at Waterloo can be anything from Calculus to Group Theory). In the first mini lecture, we get participants to focus on the first 15 minutes of a lecture near the beginning of the term (we focus our feedback on presentation skills at this point).

Week 4: Assessments Part 1

In this talk, we discuss assessments and present two different viewpoints. One is from the perspective of Bloom's Taxonomy – writing an assignment or exam that hits many different levels of learning. The second viewpoint, which I first learned from Brian Forrest, is one that assessments can be used to foreshadow upcoming topics (that is, looking at the course more holistically instead of as isolated modules). We do this with the intent that participants can use this information to come up with problems for next week's activity.

Week 5: Assessments Part 2

Participants between weeks 4 and 5 will write their own sample assignment to bring this week. In groups of 3 with one instructor per group, we discuss the pros and cons of the assignment. We probe why certain problems were chosen and how they fit together in the grand vision of the course. This feedback is meant only for the small groups that participate together.

Week 6: Mini lectures Part 2

In the second mini lecture, we get participants to focus on the middle 15 minutes of a lecture (here we focus on keeping or regaining student attention). Students focus on the feedback received in the first mini lecture and work to improve on their second talk.

Week 7: Visit a lecture

This week, we encourage participants to visit a first-year lecture. We ask that participants of the seminar watch the undergraduate students to see what they're doing, how they're responding to the instructor, how are they asking questions and what questions they're asking, how are they interacting with the instructor and any different technologies the instructor is using. Participants are also asked to watch the instructor to see some of the skills we are teaching them be put into action. Given that there is not a need for participants to be focusing on the content, this provides a great opportunity for students to get a sense of what the classroom is like from an undergraduate's perspective and to focus more on the pedagogical aspects of the classroom. This kind of activity is even good for seasoned professionals to partake in by going to visit, and be visited by, colleagues to debrief their teaching.

Week 8: Round Table Discussion

Here we discuss the previous week as a group. Participants discuss what happened in their classroom observations including but not limited to noting what the undergraduate students were doing, what the lecturer was doing, the interactivity of the instructor and so on. Important to this are some subtle things like bring a water bottle to class (stopping for pauses in class) and how the instructor reacted to something bad happening (if anything bad did happen). Discussions are always enlightening but vary based on what was observed.

Week 9: Mini lectures Part 3

The last 15-minute mini lecture is given for the last 15 minutes of a topic near the end of the course (we focus on answering questions and classroom feedback). Extra challenges can sometimes be inserted into lectures here (for example, most participants in computer science will have a slide deck they must cover and sometimes this is added as a restriction here).

Week 10: Practicum

We pair up each of our participants with an instructor teaching a similar course to the one our graduate student participant has been thinking about and we get the graduate student to deliver a live lecture in front of real students. Seeing 200 people in a classroom, answering real student questions, making live mistakes, trying to recover and so on: there is no substitute for an in-classroom experience. We debrief the student afterwards on their lecture and give them constructive feedback on what to focus on next time.

Week 11: Scenarios

In this week, we discuss a variety of situations (see [1] for some more examples). Some topics include handling student complaints, reacting to poor midterm performance, getting teaching assistants to mark on time and other important topics. This activity can be run as a gallery walk – break up participants into small groups say of size 3 or 4 and give them each a chunk of chalkboard space to write down their answers to what they would do in a select collection of scenarios. Then have participants move around the room until they have attempted each scenario.

Week 12: "How to Get a Job"

In this final week, we discuss next steps for participants with a focus on how to set themselves up for a competitive job market. We discuss creating a webpage, a *curriculum vitae*, a teaching dossier, asking people for reference letters (and in particular getting people to watch you actually teach a real class) and activities you should participate in to help boost your chances of getting hired.

Future Steps for the Seminar

In terms of content, the above outline has worked very well for the needs of the University of Waterloo. One of the biggest downfalls to the above is the issue of scaling. As we have somewhere in the neighbourhood of 800 mathematics graduate students (across all 5 departments), we have a large desire to want to make this bigger without adding too many additional resources. The current model can handle 20-30 students per term offered which pales in comparison to the potential demand.

Another perhaps bigger issue is the voluntary nature of the project for everyone involved. Currently no one involved in the project is getting much credit for participating. Participants are now starting to get some credit for the Certificate in University Teaching program our Centre for Teaching Excellence offers (peer review classroom observations are part of the program). The Combinatorics and Optimization department has been allowing students to take the program in lieu of their in-house training workshop required before they can teach a class. Otherwise, students are there primarily because they want to learn how to become better instructors.

Further, those organizing the seminar and those doing mini lecture reviews are given no credit whatsoever. Many do it simply because they realize that a program like this is something they wished they had and want to contribute to the betterment of the seminar. The plan moving forward is to elevate the status of this seminar as an official course (as a partial credit course) which would serve several important purposes. First, it would allow students to get overt credit on their transcripts for the course (that is, there would be proof that they took a course and passed it). Second, it would allow those organizing the seminar to get some sort of recognition for the work that they have done. Additionally, adding it to the calendar necessarily means we would need to find someone to teach it each term which would ensure the seminar doesn't collapse should some key members find themselves too busy to participate in it. For longevity purposes, having this course on the books is an extremely meaningful step and is one we hope to accomplish in the near future.

The seminar took a year off in the midst of the COVID-19 pandemic (2021). Since most of the work involved is volunteer work and the pandemic increased many of our workloads, the team thought it best to take a year off and try to wait out the pandemic. The plan is to resume offering the seminar in 2022. We had discussed ways to adapt the seminar to the online medium, however decided that taking time off to focus on other projects was in the best interest of everyone involved.

Final Thoughts

Such a project really couldn't have been possible without the fantastic collection of colleagues we have here at Waterloo. I've asked for many favours of people and every time it seems like the call for help has been answered by a plethora of eager and willing members of the community! I cannot overstate how fortunate this project has been to have such a great set of people who are passionate about teaching working behind the scenes to make everything possible.

Another key component to making this work is having someone with institutional knowledge. I often colloquially refer to this as **clout**, having some influence and know-how to be able to get things done at a university. For this I cannot thank Brian Forrest enough for all his advice and support in helping to realize this shared vision we had for graduate student instruction.

For those of you interested in trying this out in your home institution, I encourage you to reach out as I am happy to share any of the above resources you want to repurpose. I also encourage you to try to start off with incremental change. This project has required somewhat of a culture shift to get off the ground but once more and more people see the value of giving some basic instructional tips to future professors of our trade, the snowball effect rolls into motion and it becomes easier and easier to make more and more meaningful and impactful changes to the way we train future generations.

Acknowledgements

This is a joint project with Brian Forrest and was done in collaboration with several outstanding members at the University of Waterloo over a number of years, including Andrew Beltaos, Diana Castaneda Santos, Cecilia Cotton, Zack Cramer, Edward Dupont, Paul Kates, Blake Madill, Nicholas Rollick, Victoria Sakhnini, Diana Skrzydlo, Caelan Wang and Dan Wolczuk and many others that have helped in some way with the project.

I would also like to thanks the CoMInDS (College Mathematics Instructor Development Source) community, part of the MAA, for the opportunity to take part in their on-boarding for helping to rethink parts of the seminar. If the reader is interested in doing this at their home institute, the resources this community provides can be a great starting point.

Carmen Bruni is a lecturer at the University of Waterloo and has been since 2015. He started with the Centre for Education in Mathematics and Computing and moved to the David R. Cheriton School of Computer Science in 2017. He obtained a Ph.D. in Mathematics from the University of British Columbia studying extension of Fermat's Last Theorem.

Reference

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A Mathematical Centennial: The December 1921 Toronto Meeting of the AAAS

CSHPM Notes December 2021 (Vol. 53, No. 6)

David Orenstein (Danforth Collegiate and Technical Institute, Toronto (retired))

CSHPM Notes bring scholarly work on the history and philosophy of mathematics to the broader mathematics community. Authors are members of the Canadian Society for History and Philosophy of Mathematics (CSHPM). Comments and suggestions are welcome; they may be directed to either of the column's co-editors:

Amy Ackerberg-Hastings, *Independent Scholar (aackerbe@verizon.net)*
Hardy Grant, *York University [retired] (hardygrant@yahoo.com)*

2021 has offered Canadians the opportunity to celebrate several centennials. For instance, insulin was discovered in the summer of 1921 at the University of Toronto by Frederick Banting and Charles Best. Births that year included game show host Monty Hall and singer and actress Deanna Durbin. On May 28–29, the Communist Party of Canada was founded in Guelph, Ontario. Mackenzie King became prime minister on December 29 after the December 6 election awarded his Liberals 116 seats and the agrarian Progressive Party 65 seats.

For mathematicians, though, December 1921 may be more notable for the "National" Meeting of the American Association for the Advancement of Science (AAAS) held at the University of Toronto from the 27th to the 31st. Canadians already had ample precedent for hosting international scientific congresses, including meetings of the:

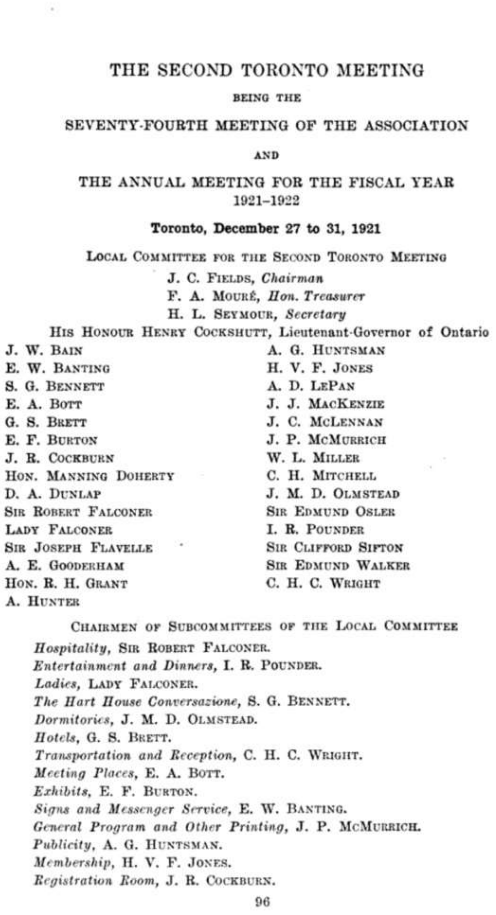
- AAAS in Montreal in 1857 and 1882, followed by its first Toronto meeting in 1889;
- British Association for the Advancement of Science (BAAS) in Montreal (1884), Toronto (1897), and Winnipeg (1909);
- British Medical Association (BMA) in Montreal (1897) and Toronto (1906);
- International Congress of Americanists in Quebec City (1906);
- American Astronomical Society (AAS) in Ottawa (1911);
- International Geological Congress in Toronto (1913).

Figure 1. John Charles Fields before 1912. Wikimedia Commons

Also in 1913, University of Toronto (U of T) Mathematics Professor "John Charles Fields [1863–1932] was asked by U of T President Robert Falconer [1867–1943] to extend an invitation to the American Association for the Advancement of Science to hold its 1915 meeting in Toronto" [11, p. 77]. World War I interrupted the planning, but after the war the AAAS was invited once more. Its leadership accepted for the 1921 Winter Meeting. The University and the Royal Canadian Institute, of which Fields was President, were designated the official co-hosts. Even the general public anticipated the event, as the day before the meeting began (Monday, December 26, 1921), the front page of Toronto's *The Globe* trumpeted: "EMINENT MEN TO VISIT CITY" for a "FOUR-DAY CONVENTION," a "Great Gathering in Toronto of Scientists of This Continent," noting that the previous "Toronto Meeting took place the summer before the King's College fire in 1890" [1].

Fields served as chair of the Local Arrangements Committee, while another leading mathematician, Eliakim Hastings Moore (1862–1932) of the University of Chicago, then the AAAS President, chaired all the plenary sessions. His duties thus included the address of the retiring President, Leland Ossian Howard (1857–1950), which was delivered in the University's Convocation Hall on the evening of Tuesday, December 27, in two parts: "On Some Presidential Addresses" and "The War Against Insects" [5, p. 36].

While the overall framework and some of the program highlights were provided by the Association's Washington, DC, headquarters and Fields and the Toronto organising committee, the bulk of the scientific programming had to come from the Sections themselves, their local representatives, and their related societies. These sections ran from Section A Mathematics, through Sections B Physics and D Astronomy, to finally N Medical Sciences and Q Education.



THE SECOND TORONTO MEETING

BEING THE

SEVENTY-FOURTH MEETING OF THE ASSOCIATION

AND

THE ANNUAL MEETING FOR THE FISCAL YEAR
1921–1922

Toronto, December 27 to 31, 1921

LOCAL COMMITTEE FOR THE SECOND TORONTO MEETING

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CHAIRMEN OF SUBCOMMITTEES OF THE LOCAL COMMITTEE

Hospitality, SIR ROBERT FALCONER.
Entertainment and Dinners, I. R. POUNDER.
Ladies, LADY FALCONER.
The Hart House Conversazione, S. G. BENNETT.
Dormitories, J. M. D. OLMSTEAD.
Hotels, G. S. BRETT.
Transportation and Reception, C. H. C. WRIGHT.
Meeting Places, E. A. BOTT.
Exhibits, E. F. BURTON.
Signs and Messenger Service, E. W. BANTING.
General Program and Other Printing, J. P. MCMURRICH.
Publicity, A. G. HUNTSMAN.
Membership, H. V. F. JONES.
Registration Room, J. R. COCKBURN.

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Figure 2. The local organising committee. *Summarized Proceedings of the American Association for the Advancement of Science* (Washington, DC, 1925).

The strength of Canadian participation varied from Section to Section. For example, presentations in Section A Mathematics, which met in Toronto jointly with the American Mathematical Society (AMS) and the Mathematical Association of America (MAA), were largely by Americans. Attendance at Section D Astronomy, since AAS did not come to Toronto but rather met instead at Strathmore College in Pennsylvania, was predominantly Canadian. The Royal Astronomical Society of Canada (RASC) took up most of the slack and provided ample reporting in the *Journal of the RASC*.

The Astronomy section held four sessions. The first, on Wednesday morning, December 28, was officially a Section D-RASC joint session, chaired by the Vice-President for Section D, Samuel Alfred Mitchell (1874–1960), Director of the University of Virginia's Leander McCormick Observatory. The retiring Vice-President of Section D, Joel Stebbins (1878–1966) of the University of Illinois, spoke on "Observation versus Experimentation," and Clarence Augustus Chant (1865–1956), U of T's Professor of Astronomy, gave an address titled "Popularizing Astronomy" [7, p. 37]. Otto Klotz, then of Preston, Ontario, was elected as Stebbins's successor [6, p. 68].

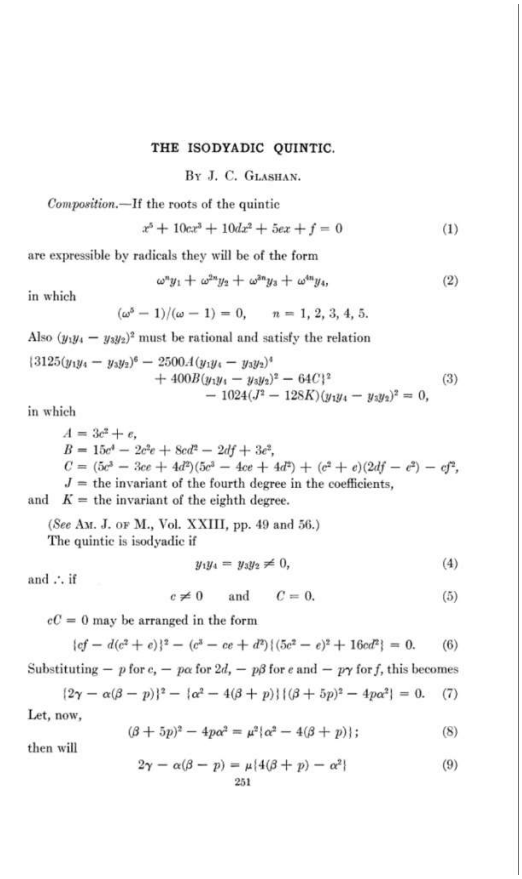
The remaining sessions, held Wednesday afternoon and all day on Thursday, featured 23 papers; these were exclusively by RASC speakers. Six of the talks were by U.S.-based astronomers, including Mitchell's "Comparison of trigonometric and spectroscopic parallaxes" and "The present status of meteor observations," by another Leander McCormick astronomer, Charles Pollard Olivier (1878–1975), now best known as the founder of the American Meteor Society. We note that although he was employed by Johns Hopkins University in Baltimore, Mitchell was a Canadian by birth (Kingston, Ontario) and education (Queens University, MA 1894 and honorary LLD 1924).

Eleven of the presentations were provided by Ottawa's Dominion Observatory, although three of these were delivered by one man, Ralph Emerson DeLury (1878–1956), the brother of U of T Chair of Mathematics Alfred Tennyson DeLury (1864–1951): "Systematic errors in micrometer measurements," "Second note on Cepheid variation," and "Measurements of the distance of the sun deduced from its spectrum." The last was co-authored with John L. O'Connor. Only three and a half years after the May 6, 1918, first light of the 72-inch reflecting telescope at Victoria's Dominion Astrophysical Observatory (DAO), Harry H. Plaskett (1893–1980), son of DAO director John Stanley Plaskett (1865–1941), and future director William Edmund Harper (1878–1940) travelled to deliver "The Pickering series in O-type stars" and "Three spectroscopic orbits [of binary stars], each based on component spectra," respectively. Also from Western Canada was the University of Alberta's John Willliam Campbell (1889–1955), who spoke on "Orbit of the spectroscopic binary H.R. 5942," using 20 plates from the DAO [7, pp. 37–38]. Although he did not present any papers in Section A Mathematics, Campbell —who had studied at Queen's University before earning a PhD on the three-body problem at the University of Chicago in 1915 [3, pp. 119, 137]—was a member of both the AMS and the MAA.

City of Toronto Archives, Fonds 1231, f1231_it0306

Figure 3. University College in 1917. City of Toronto Archives

The Mathematics section, which was obviously especially dear to Fields, held a joint session with the AMS and MAA on the afternoon of Thursday, December 29, in Room 8 of University College. Oswald Veblen (1880–1960) of Princeton, the Section A Vice-President, presided, while retiring Vice-President R. D. Curtiss (Northwestern University) gave the lecture, "A Mechanical Analogy in the Theory of Equations." Next, R. M. Yerkes of the U.S. National Research Council discussed the agency's "research information service," and H.E. Slaught (University of Chicago) explained a program for "subsidy funds for mathematical projects." Arnold Dresden (University of Wisconsin) read the abstract for R. D. Carmichael's (University of Illinois) "Algebraic guides to transcendental problems." The sectional committee nominated George Abram Miller (1863–1951), also from the University of Illinois, to be the Vice-President for Section A Mathematics at the December 1922 AAAS Meeting in Boston.



THE ISODYADIC QUINTIC.

By J. C. Glashan.

Composition.—If the roots of the quintic

$$x^5 + 10cx^3 + 10dx^2 + 5ex + f = 0 \qquad (1)$$

are expressible by radicals they will be of the form

$$\omega^n y_1 + \omega^{2n} y_2 + \omega^{3n} y_3 + \omega^{4n} y_4, \qquad (2)$$

in which

$$(\omega^5 - 1)/(\omega - 1) = 0, \qquad n = 1, 2, 3, 4, 5.$$

Also $(y_1y_4 - y_3y_2)^2$ must be rational and satisfy the relation

$$\{3125(y_1y_4 - y_3y_2)^6 - 2500A(y_1y_4 - y_3y_2)^4 + 400B(y_1y_4 - y_3y_2)^2 - 64C\}^2 - 1024(J^2 - 128K)(y_1y_4 - y_3y_2)^2 = 0, \qquad (3)$$

in which

$A = 3c^2 + e$,
$B = 15c^4 - 2c^2e + 8cd^2 - 2df + 3e^2$,
$C = (5c^3 - 3ce + 4d^2)(5c^2 - 4ce + 4d^2) + (c^2 + e)(2df - c^3) - cf^2$,
$J =$ the invariant of the fourth degree in the coefficients,
and $K =$ the invariant of the eighth degree.

(*See* Am. J. of M., Vol. XXIII, pp. 49 and 56.)

The quintic is isodyadic if

$$y_1y_4 = y_3y_2 \neq 0, \qquad (4)$$

and ∴ if

$$c \neq 0 \quad \text{and} \quad C = 0. \qquad (5)$$

$cC = 0$ may be arranged in the form

$$\{cf - d(c^2 + e)\}^2 - (c^3 - ce + d^2)\{(5c^2 - e)^2 + 16cd^2\} = 0. \qquad (6)$$

Substituting $-p$ for c, $-p\alpha$ for $2d$, $-p\beta$ for e and $-p\gamma$ for f, this becomes

$$\{2\gamma - \alpha(\beta - p)\}^2 - \{\alpha^2 - 4(\beta + p)\}\{(\beta + 5p)^2 - 4p\alpha^2\} = 0. \qquad (7)$$

Let, now,

$$(\beta + 5p)^2 - 4p\alpha^2 = \mu^2\{\alpha^2 - 4(\beta + p)\}; \qquad (8)$$

then will

$$2\gamma - \alpha(\beta - p) = \mu\{4(\beta + p) - \alpha^2\} \qquad (9)$$

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Figure 4. The first page of J.C. Glashan's 1923 *AJM* paper.

On the preceding day, AMS had held its own regular sessions, which served as the 28th AMS annual meeting. Eighty-four members heard 32 papers from 30 contributors. For instance, Miller delivered two talks on group theory, "Substitutions which are commutative with every substitution of an intransitive group" and "Seeming contradic

For instance, Miller delivered two talks on group theory: "Substitutions which are commutative with every substitution of an intransitive group" and "Seeming contradictions in the theory of groups." Canadian presenters included Ottawa's J.S.C. Glashan (1844–1932), who prepared twinned papers on isodyadic equations, and the U of T's Samuel Beatty (1881–1970), who had been Fields's sole PhD student and spoke on one of Fields's favorite subjects: "The algebraic theory of algebraic functions" [9, pp. 600–601]. At 77 years of age, Glashan was a senior member of the discipline. He had retired from the School Inspectorate in 1910, and Glashan Intermediate School (established in 1888), in the downtown Glebe neighbourhood of Ottawa, was renamed for him in 1905. He was a charter subscriber to the *American Journal of Mathematics* (*AJM*) in 1878 and published a paper on Taylor Series in the first volume. Klotz was the only other Canadian charter subscriber [4, p. i]. Both of Glashan's 1921 papers would be published in *AJM*: "The Isodyadic Quintic" in 1923 and "On the Isodyadic Septimic Equations" in 1924.

Figure 5. Louise D. Cummings. "Canadian Women in the Public Eye," *Saturday Night* (August 24, 1924).

Only two women contributed to the mathematics sessions: Olive Clio Hazlett (1890–1974) of Mount Holyoke College, who spoke on "A symbolic theory of expansions in orthogonal functions," and Louise Duffield Cummings (1870–1947) of Vassar College, whose talk was entitled "Hesse's associated points and the Weddel surface" [9, pp. 600–601].

Hazlett grew up in Boston and received her bachelor's degree from Radcliffe College in 1912. At the University of Chicago, she earned a master's degree in 1913 and a PhD in 1915. Her thesis director was Leonard E. Dickson (1874–1954). Her dissertation, "On the Classification and Invariantive Characterization of Nilpotent Algebras," was published in *AJM* in 1916. She accepted a position as assistant professor at Mount Holyoke in 1918 and was promoted to associate professor in 1924. In 1925, she moved, as an assistant professor with a salary of $3,000, to the University of Illinois, where she remained for the rest of her professional career [10].

Originally a Canadian, Cummings came from Hamilton to U of T, receiving her BA in mathematics in 1895, followed by graduate studies there and at the University of Pennsylvania, the University of Chicago, and Bryn Mawr College. She taught at Toronto's St. Margaret's College in Toronto while completing an MA at U of T under DeLury. She joined the Vassar mathematics faculty in 1902. Her 1914 Bryn Mawr PhD thesis, "On a Method of Comparison for Triple-Systems," appeared in the AMS *Transactions*. Cummings remained at Vassar until her retirement in 1936 as a full professor [2].

Cummings and Hazlett were two of the eleven women present among the 110 members in attendance for the MAA sessions. Eight others had also traveled from the United States: Clara L. Bacon and Florence P. Lewis, Goucher College; Sister Mariola Dobbin, St. Clara College; Mrs. F.W. Owens—there with her husband F.W. Owens, both of Cornell University; Mrs. Anna J. Pell, Bryn Mawr College; Mary E. Sinclair, Wellesley College; and Jessica M. Young, Washington University [12, pp. 97–98].

The only woman currently living in Canada was Jennie A. Kinnear (ca 1890–1965) from Port Colborne, Ontario. She was likely in Toronto on her Christmas/New Year's break from teaching mathematics at Port Colborne Collegiate Institute. She had graduated from Queen's University in 1913, where "the allurements of Queen's were too great for Jennie. Ignoring Toronto, she came straight from Port Colborne to take a Mathematical Specialist course here. Her mathematical tendencies haven't spoiled her genial nature, as is shown by her election to the Presidency of the Residence in her final year. The future before her looks bright. 'A picture of health and hospitality'" [8, p. 51]. In 1939 the *Queen's Review* noted she had retired from the teaching profession to become the financial comptroller in her sister's law office. The 1965 *Review* noted her passing that April 11 at Port Colborne.

On Friday evening, December 30, the mathematicians joined the physicists for a celebratory dinner at Victoria College's gothic Burwash Hall, on the east side of campus, although Kinnear and others may have instead attended the Women's Dinner, held in the Great Hall of Hart House. At Burwash Hall there likely was informal discussion about whether the exclusion of mathematicians from Germany (and from the other Central Powers) made Leonard E. Dickson's offer to host the 1924 International Congress of Mathematicians in the United States a big mistake. And Fields overheard the casual suggestion that the Congress be moved to Toronto [11, p. 81].

Precisely a year later, on December 26, 1922, at a meeting of the Council of the AMS, he—confident from the overwhelming success of the 1921 AAAS Meeting—outlined a plan for an international mathematical congress in Toronto for 1924, in conjunction with a meeting of the BAAS that was already under preparation [11, pp. 134–135].

But that's another story.

David Orenstein is in his tenth year of retirement from teaching mathematics at an inner-city Toronto high school. Inclement days are generally spent in online and (pre-pandemic) archival research into the history of Canadian science and mathematics (which he enjoys blogging about at cstha-ahstc.ca). More welcoming days are devoted to Toronto's parks and socially-distanced patios.

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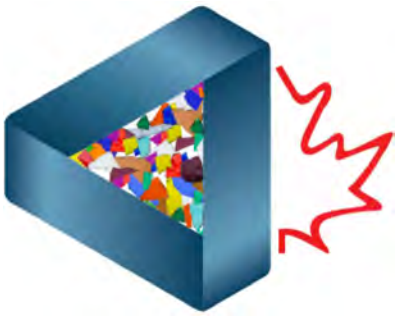
Field Notes from Diversity and Equity Committee Work

Herng Yi Cheng (University of Toronto)



MOSAIC, Outreach, Society, Accessibility, and Inclusiveness Column is directed by the CMS EDI committee and touches upon issues concerning equity, diversity, and inclusion in mathematics. Comments, suggestions and submissions are welcome.

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Herng Yi Cheng (given name: Herng Yi) is a Ph.D. student in the Department of Mathematics at the University of Toronto, whose research interests include Riemannian geometry and quantitative aspects of topology.

It was the summer of 2020, and I was holed up in my flat in my home country of Singapore, sitting out the pandemic. It was the first summer of my PhD studies in mathematics at the University of Toronto, and I was gingerly trying out a research project with a potential research advisor. Isolating myself for fear of the virus, I felt like I was orbiting the Earth from space, with news reports being my only link to civilisation. That was when I learned about the Black Lives Matter protests in the United States that had been ignited by the murder of George Floyd, but which had erupted from longstanding racial injustices. Those protests spread to Canada as well.

The protests sparked more discourse around racism and other forms of discrimination in academia. I was especially intrigued by the #ShutDownSTEM movement, which urges academics to stop doing "business as usual", to educate themselves about racism in academia, and to take action against racism. After wondering how I could promote racial justice and inclusivity in my own department, I reached out to my Department Chair. Over a call, we discussed the ways in which our department was trying to increase the representation of under-represented groups, and the challenges it was facing along the way.

Little did I know that he would soon invite me to represent graduate students in a newly formed Diversity and Equity Committee in the department. I accepted and served in the committee from September 2020 to August 2021, alongside four faculty members. We discussed accounts of racist and sexist comments, incidents of harassment, feelings of isolation, and unwanted attention. These issues spanned the range of career stages from undergraduates to faculty, and are hardly unique to the University of Toronto. As a committee we studied the diversity and equity issues in the department, educated ourselves and the department on these issues through various initiatives, and made recommendations to the Department Chair.

In this article I hope to "lift the veil" by surveying some of the committee work that I did and by explaining how change can happen, so as to encourage other graduate students to also take up the mantle. In a way, this article is also a letter from one graduate representative to the aspiring graduate representatives out there, to share my personal journey and some suggestions in the hope that it will help them succeed and thrive as a representative. My personal experience has included the highs of achieving some progress with the lows of burnout, and it has forced me to examine some complex questions. These include the questioning of my own role, the challenges of speaking up to faculty, and the responsibilities of those who interview students about potentially traumatic memories. I hope that committees in any department will find my description of successes and challenges useful in calibrating their approach to seeking student input.

What We Did

I am proud of what our brand-new committee achieved over the past year. Much of it was crucial behind-the-scenes work: debating about our mission and role in our department, and building connections in the department and beyond.

Our outward-facing work has had a more visible impact. We engaged an external presenter to conduct diversity training for our department's hiring committee. We also founded a recurring and well-attended seminar series, called the Equity Forum that has regularly engaged external speakers to present on equity-related issues with audience discussion. The topics have included humanizing mathematics departments, the ethics of mathematics research applications, and indigenizing mathematics. Commendably, the department sponsored an honorarium for each speaker; these speakers should be compensated for their emotional labour in presenting about equity issues. One speaker, Prof. Aris Winger, encouraged the nearly 60 students, faculty and postdocs in his audience to anonymously share the challenges that they face as teachers. I vividly recall that experience of collective vulnerability and anonymous mutual encouragement that cut across all career stages.

My own mandate was to "represent graduate student voices to the committee", which I was free to interpret and elaborate on. I interpreted my role as one that seeks out and listens to the voices of graduate students on diversity and equity issues in order to relay them to departmental leadership. As my job scope was not clearly defined, I followed my own compass and expanded my role whenever I felt that more needed to be done for graduate students. I have laid out the types of work that I did in Table 1, estimating the time I spent on each.

Table 1: Time spent on committee-related work, rounded off to the nearest 5 hours. More detailed descriptions of each category can be found in the Appendix.

Category of Work	**Estimated Time Spent (hrs)**
Publicity and Communications	25
Succession Planning and Search	25
Committee Discussions	20
Event Organizing and Hosting	10
Interviewing	10
External Liaising	10
Meeting the Department Chair	5
Self-Education	5
Total	**110**

Looking back, I feel that I had shouldered too much work and responsibility by myself, partly because of the open-ended mandate that I had been handed, and partly due to factors like a sense of isolation and perfectionism. That contributed to my burning out at some point during my year of committee service. I hope that future graduate representatives will be able to share their workload with a broader community of likeminded graduate students, so that the labour can be more equitably distributed.

Who "deserves" to represent the marginalised?

I would like to explain how I situated myself relative to diversity and equity work. The first question I asked myself after being invited to the committee was whether I "deserved" to represent graduate students on diversity and equity issues. Much discourse traces these issues back to a heavy history of discrimination in the US or Canadian context, where I felt out of my depth. Could "Canadian issues" be handled by non-Canadian citizens?

Furthermore, I had grown up as part of the racial majority in Singapore, where I had not been unduly denied opportunities overall. Could I be sensitive enough to those for whom barriers are the norm? My fear of being wrong, of being judged by others, and of inadvertently hurting those who have been marginalised, gave me pause before accepting the invitation from the Department Chair.

In the end, I accepted the role for several reasons. I felt that in principle, marginalised people should not bear the entire burden of righting wrongs by themselves. I also thought that I could amplify the voices of the marginalised using my privilege. This privilege includes a level of comfort with speaking to faculty and senior leadership stemming from committee work during my undergraduate studies.

Furthermore, I predicted—correctly, in hindsight—that much of the work would involve setting up new initiatives, in which my previous leadership experience could prove helpful. I would be satisfied if my groundwork could serve as a template for future generations of graduate representatives, to help them avoid starting from scratch. My final reason to accept was my worry that if I did not, then graduate student voices would not be represented. I could not accept that as the work was necessary and somebody needed to do it.

Over the course of my committee work, I saw ways in which racism extended past national borders into something far exceeding "just a Canadian issue". Strands of my identity were bound to marginalised groups, and to diversity and equity work, by historical anti-Asian racism—such as the Chinese Exclusion Act in Canada—and current instances of racism like the model minority myth and the stereotypes that fuelled violence against Asians during the pandemic.

In the end, however, I was never able to completely shake my imposter syndrome—my suspicion that someone else would have done a better job in my shoes. What helped me to keep moving forward was the maxim that *something is better than nothing; someone is better than no-one*. I hope that it can help someone else as well.

It Takes a Village

My role as a committee member was to push for change from the "inside" of the departmental system. Over a year's work, I have concluded that change can happen, but it often happens slowly as information takes time to filter through layers of leadership. As a graduate representative, I accepted that I could not expect most of the advocacy by the committee to bear fruit until after my departure, if at all.

To illustrate how different leaders and advocates in a department can collaborate to make change happen, here are two examples that arose from a forum for graduate students to discuss diversity and equity issues in our department. I co-hosted that forum with Reila Zheng, a graduate student in my department who also serves on the CMS Equity,

Diversity and Inclusiveness Committee.

In the first example, forum attendees highlighted that information and opportunities are often shared by word of mouth, which makes them less accessible to those who are less well-connected in the department, particularly those from under-represented communities. Prior to this forum, the Graduate Administrator, Jemima Merisca, had had an idea for a newsletter for graduate students; the forum prompted her to initiate it and it continues to this day, run by the departmental staff. Every week this newsletter informs graduate students of important announcements, workshops, training opportunities, and recruitment for various initiatives. Occasionally the newsletter even includes wedding announcements, which are always fun to read!

In the second example, graduate students asked for more transparency in the process of assigning teaching assistant roles. They also raised questions about whether graduate students from different backgrounds have equal opportunities to work as a teaching assistant for certain types of courses. I relayed these concerns to the President of the Mathematics Graduate Student Association, who then highlighted them at a roundtable discussion that was organized by our department's Associate Chair, Graduate and attended by faculty, staff and student leaders. These concerns dovetailed into an explicit priority of the Associate Chair, Graduate to improve the experiences of teaching assistants and course instructors.

My experiences in committees during my undergraduate and graduate studies have taught me that advocacy and change happen faster when committee members are more passionate about it. On the other hand, change also requires cooperation and assent from other parts of the leadership in the department or beyond. Leaders and their priorities influence the speed of change. In any case, I'm glad to have played a role in forwarding the concerns of graduate students to departmental leadership.

Levelling the Playing Field

During committee meetings, the four faculty committee members and I would discuss issues that we had noticed in the department, brainstorm countermeasures, plan events and initiatives, and strategize our publicity and communications. I also tabled concerns that I had heard from graduate students, and sometimes even undergraduates. This required a measure of personal courage as I perceived the faculty as having more authority.

The courage to raise my views did not come to me right off the bat. I recall spending most of my first committee meeting quiet as a clam, as I smiled and gently nodded at the others in agreement. In my perception, the faculty members had sound and eye-opening opinions; somehow my own opinions had less value. Thankfully, the welcoming and friendly atmosphere helped me to share my thoughts openly, and even to disagree, by the end of that meeting. The power differential between me and the faculty had intimidated me at the onset, but their openness and trust in me helped to dissolve that barrier.

I had in fact enjoyed a head start in getting comfortable to debate with faculty, as I had spent the third and fourth years of my undergraduate studies representing undergraduates in committees that largely consisted of faculty. It had taken my entire third undergraduate year to open up and feel comfortable speaking my mind. Any other student could potentially take a similarly long time to feel comfortable in their first committee role. The faculty and staff in the committees I was in during my fourth undergraduate year took extra care to include me and treat me as an equal. That experience empowered me and gave me the confidence to speak up in the Diversity and Equity Committee shortly after joining it. Such an environment would nourish any student interaction with faculty, and would be important to help any graduate representative on any committee scale the power differential between them and faculty.

More generally, decisions made by faculty and other departmental leaders are difficult for students to question, because the authority behind those decisions imbues them with an unimpeachable aura and a sense of finality. This authority can discourage students from raising their concerns, or from persevering in their pursuit of change before those with higher perceived authority. To level the playing field, faculty and leaders bear a responsibility to seek student input on decisions with broad impact, to be welcoming to students and their input, and to treat their input seriously.

The Weight of Trust

When trying to amplify the voices of the marginalised, I had to depend on their difficult and poorly recompensed act of speaking up and revisiting traumatic memories. I conducted confidential interviews with graduate and undergraduate students with the hope of anchoring committee discussions to students' actual lived experiences. I am very grateful for the acts of trust and courage of those who shared their emotionally difficult stories with me and relived those memories, which can be especially trying for those who have faced discrimination or harassment.

This awareness was underscored when one potential respondent politely but firmly turned down my request for an interview. They pointed out that they had already highlighted certain issues and suggested changes to department members. I completely understood their decision; for the interviewee, sharing requires vulnerability and emotional labour, which may or may not be rewarded by change.

In acknowledging and affirming this refusal, I explicitly stated that I did not need a further reply from the student as even replying to my email could be a stressful engagement with bad memories. I am very grateful to the Committee Chair for teaching me this method of accommodation, which was eye-opening and has underscored for me the gravity of interview requests. Interviewers have a great responsibility to prevent interviews from becoming exploitative. This interview refusal also deepened my belief that there will be many issues that I will never get to hear about.

Concluding Reflections

My work as graduate representative has been rewarding. I'm glad to have played a role in bringing about some small changes and setting other changes in motion. I am also deeply grateful for the time, effort, and heart poured into improving the department by other students, staff and faculty. By co-facilitating discussion forums, I felt that I had carved out a small space for students to come together and talk about sensitive equity-related issues more openly—a space that had not usually been available.

I am also heartened to hear diversity and equity mentioned more frequently in conversation. Seeing a consistent set of graduate students attend each Equity Forum has added to a sense of camaraderie. Many individuals have taught me how to listen better, speak more respectfully about diversity and equity issues, and create safer conversation spaces. It

a sense of camaraderie. Many individuals have taught me how to listen better, speak more respectfully about diversity and equity issues, and create safer conversation spaces. It gives me a great sense of fulfilment to know that my work can serve as a template for others to expand upon or modify.

On the flipside, a sense of isolation may have combined with my personal tendencies and the open-ended nature of my role to undermine the balance between my committee service and my research work. Healthy boundaries between service work and research are crucial and should be protected by students and supported by the department.

I hope that future graduate representatives on diversity and equity committees seek out stories about challenges faced by other students, while treating them with respect and sensitivity as it is so difficult to share those stories. I also urge those who consider themselves to be privileged against ruling themselves out of equity-related work. The responsibility for advocacy must be shared by all, and all of us have unique strengths that we can bring to the table. Finally, I ask faculty in committees to create a welcoming and nurturing environment for student representatives—to value their perspectives and solicit their opinions often, as it will help to bridge a power differential, freeing them to contribute to their fullest.

Acknowledgements

I would like to express my gratitude to the members of the Diversity and Equity Committee for the great experience working together, and for teaching me to be a better advocate. I would also like to thank the Department Chair for giving me the opportunity to represent graduate students on the committee and for his support of the committee. I am grateful to many graduate students for their suggestions and feedback.

I thank the CMS Equity, Diversity and Inclusiveness Committee for the opportunity to write this article, and Reila Zheng for encouraging me to write it. Special thanks go to Reila and Mun Yi Cheng for giving incredibly helpful feedback during my writing process.

Appendix: Committee-related Work by Category

The specific kinds of committee-related work that I did within each category in Table 1 are described as follows.

*Publicity and Communications***.** Helping to draft the mission statement and website text for the committee; helping to design the committee's logo; mass-emailing graduate students to publicize events and to summarize concerns raised at events; summarizing graduate student concerns in an annual report.

Succession Planning and Search. Planning a system to select future graduate representatives to the committee by discussing with the committee and the Mathematics Graduate Student Association (MGSA); implementing the system and selecting two graduate students to succeed me as graduate representatives; giving them an on-boarding briefing; drafting a proposal to financially compensate future graduate representatives for their time; soliciting feedback on that proposal from student leaders, staff, and faculty.

Committee Discussions. Attending committee meetings; discussing over email; forwarding concerns from students; summarizing for the committee the information that I had collected from graduate students and departmental leaders.

Event Organizing and Hosting. Planning, executing, and hosting events for members of the department; recording and summarizing the discussions at the event; soliciting feedback for the event.

Interviewing. Drafting invitations for confidential interviews; conducting the interviews; transcribing notes from each interview.

External Liaising. Contacting other equity-related organizations in the university; attending their meetings; forwarding their resources to the Diversity and Equity Committee; conveying student concerns to the MGSA.

Meeting the Department Chair. Meeting the Department Chair to advocate for various proposals for change.

Self-Education. Attending workshops and reading articles to learn more about how to combat discrimination, and how to organize events centred around diversity and equity in a safer and more respectful way.

Nominations of individuals or teams of individuals who have made significant and sustained contributions to mathematics education in Canada are solicited. Such contributions are to be interpreted in the broadest possible sense and might include: community outreach programs, the development of a new program in either an academic or industrial setting, publicizing mathematics so as to make mathematics accessible to the general public, developing mathematics displays, establishing and supporting mathematics conferences and competitions for students, etc.

CMS aims to promote and celebrate diversity in the broadest sense. We strongly encourage department chairs and nominating committees to put forward nominations for outstanding colleagues regardless of race, gender, ethnicity or sexual orientation.

Nominations must be received by the CMS Office **no later than April 30, 2022**.

Please submit your nomination electronically, preferably in PDF format, to apaward@cms.math.ca.

Nomination requirements

- Include contact information for both nominee and nominator.
- Describe the nominated individual's or team's sustained contributions to mathematics education. This description should provide some indication of the time period over which these activities have been undertaken and some evidence of the success of these contributions. This information must not exceed four pages.
- Two letters of support from individuals other than the nominator should be included with the nomination.
- Curricula vitae should not be submitted since the information from them relevant to contributions to mathematics education should be included in the nomination form and the other documents mentioned above.
- If nomination was made in the previous year, please indicate this.
- Members of the CMS Education Committee will not be considered for the award during their tenure on the committee.

Renewals

Individuals who made a nomination last year can renew this nomination by simply indicating their wish to do so by the deadline date. In this case, only updating materials need be provided as the original has been retained.

2021 Adrien Pouliot Award Recipient

Joseph Khoury
University of Ottawa

Dr. Khoury is the most recent recipient of the award. Please read the Media Release. For a list of past recipients and to read their citations, please visit the official Adrien Pouliot Award page.

2022 CMS Blair Spearman Doctoral Prize

The **CMS Blair Spearman Doctoral Prize** recognizes outstanding performance by a doctoral student. The prize is awarded to one recipient of a Ph.D. from a Canadian university whose overall performance in graduate school is judged to be the most outstanding. Although the dissertation will be the most important criterion (the impact of the results, the creativity of the work, the quality of exposition, etc.) it will not be the only one. Other publications, activities in support of students and other accomplishments will also be considered.

Nominees must have their Ph.D. conferred by a Canadian university in the year (January 1st to December 31st) preceding the nomination deadline. Nominations that were not successful in the first competition will be kept active for a further year (with no possibility of updating the file) and will be considered by the Doctoral Prize Selection Committee in the following year's competition.

The CMS Blair Spearman Doctoral Prize will consist of an award of $2,000, a two-year complimentary membership in the CMS, a framed certificate and a stipend for travel expenses to attend the CMS meeting to receive the award and present a plenary lecture.

Nominations

Candidates must be nominated by their university and the nominator is responsible for preparing the documentation described below, and submitting the nomination to the email address below.

CMS aims to promote and celebrate diversity in the broadest sense. We strongly encourage department chairs and nominating committees to put forward nominations for outstanding colleagues regardless of race, gender, ethnicity or sexual orientation. The deadline for the receipt of nominations is **January 31, 2022**.

The documentation shall consist of:

- A curriculum vitae prepared by the student.
- A resumé of the student's work written by the student and which must not exceed ten pages. The resumé should include a brief description of the thesis and why it is important, as well as of any other contributions made by the student while a doctoral student.
- Three letters of recommendation of which one should be from the thesis advisor and one from an external reviewer. A copy of the external examiner's report may be substituted for the latter. More than three letters of recommendation are not accepted.

All documentation, including letters of recommendation, should be submitted electronically, preferably in PDF format, **no later than January 31, 2022**, to **docprize@cms.math.ca**.

About the Award

The CMS Doctoral Prize is renamed as the CMS Blair Spearman Doctoral Prize in honour of the late mathematician, Dr. Blair Kenneth Spearman thanks to the Spearman Family who has generously pledged an endowment to the Canadian Mathematical Society in 2019 to fund the CMS Doctoral Prize.

Dr. Spearman was born on September 29, 1951, in Ottawa, Ontario. Although he did not discover the divine beauty of Mathematics until he was a third-year student at Carleton University, once he did, he devoted his life to it, finishing his Ph.D. at Penn State University in record time. He was a professor at University of British Columbia – Okanagan, receiving UBC Okanagan's first Teaching Excellence and Innovation Award, and consistently winning the same award year after year. He touched and changed so many of his students' careers and lives with his tireless effort and devotion. He was not only an exceptionally talented, first-rate mathematician who published over 115 mathematical papers in well-known journals, but also an absolutely wonderful and humble human being. His legacy will live on in those he left behind and will inspire young mathematicians to follow in his footsteps, strive for excellence, and be humble human beings.

In 1995, the Society established this award to recognize individuals who have made sustained and significant contributions to the Canadian mathematical community and, in particular, to the Canadian Mathematical Society. The award was renamed in 2008, in recognition of Graham Wright's 30 years of service to the Society as the Executive Director and Secretary.

CMS aims to promote and celebrate diversity in the broadest sense. We strongly encourage department chairs and nominating committees to put forward nominations for outstanding colleagues regardless of race, gender, ethnicity or sexual orientation.

Nominations should include a reasonably detailed rationale including three support letters and be submitted **by March 31, 2022**.

All documentation should be submitted electronically, preferably in PDF format, by the appropriate deadline, to gwaward@cms.math.ca.

Renewals

Individuals who made a nomination last year can renew this nomination by simply indicating their wish to do so by the deadline date. In this case, only updating materials need be provided as the original has been retained.

2021 Graham Wright Award for Distinguished Service Recipient

Kseniya Garaschuk
University of the Fraser Valley

Dr. Garaschuk is the most recent recipient of the award. Please read the Media Release. For a list of past recipients and to read their citations, please visit the official Graham Wright Award page.

Adrien Pouliot Award

Joseph Khoury (University of Ottawa)

Over the last two decades, Joseph has worked tirelessly to promote mathematics and mathematics education at the University of Ottawa, within the local community, and on the national level. An extremely talented and dedicated teacher, Joseph was also awarded the 2020 Canadian Mathematical Society's Excellence in Teaching Award and the 2017 Graham Wright Award for Distinguished Service. Beyond the classroom, Joseph has produced a wealth of resources for both students and colleagues alike.

Joseph has also played a diverse and very significant role in promoting mathematics at the national level. Amongst his many valuable contributions, Joseph has served multiple terms as the Chair of the Canadian Mathematical Society's Education Committee and the Chair of its bilingualism committee. He leveraged his considerable experience gained in organizing highly successful math camps in Eastern Ontario to guide him as the Society's national coordinator of nearly two dozen camps held annually across all regions of the country.

In addition, Joseph co-authored of *The Mathematics that power our world*, *How is it made?* and *Jim Totten's Problems of the week* : two books dedicated to the beauty of Mathematics and the central role in plays in our modern society.

For his unwavering dedication to our discipline, Dr. Joseph Khoury is a most deserving recipient of this year's Adrien Pouliot Award.

Graham Wright Award for Distinguished Service

Kseniya Garaschuk (UFV)

Kseniya Garaschuk has made distinguished contributions to the Canadian mathematical community and, in particular, to the Canadian Mathematical Society (CMS) in numerous ways. She served on the CMS Student Committee (StudC) as Chair from 2009 to 2015, as Student Director on the CMS Board of Directors from 2009 to 2013, as Associate Editor of A-Taste-Of-Mathematics Editorial Board from 2016 to 2020, has been on the CMS Notes Editorial Board since 2018 and on the CMS Education Committee since 2014, where she has also participated in many Teaching in Excellence and Adrien Pouliot award selection committees. One of Kseniya's most important roles within the CMS has been her involvement with Crux Mathematicorum. She works tirelessly on this project because she believes in the importance of the publication within the international mathematical community.

As a graduate student, Kseniya began organizing and running annual CMS Math Camps in addition to other university outreach events. Many of the large StudC intitatives (all of which continue to this day) were founded by Kseniya, including the poster sessions held at CMS semi-annual meetings, *Notes from the Margin* (the StudC newsletter) and the introduction of *Guidebook*, the electronic conference brochure which is still used at CMS meetings.

Kseniya was one of the lead organisers of the Fraser Valley Math Education Sq'ep (2019 and 2020), a community-building event that explores Indigenous ways of learning and knowing with connections to mathematics. She was also a lead organiser of CMS COVID-19 Research and Education Meeting held last July.

G. de B. Robinson Award

Catalin Badea (Lille I)
Vincent Devinck (Artois)
Sophie Grivaux (Laboratoire Paul Painlevé)

The recipients are receiving the award for their joint paper "Escaping a Neighborhood along a Prescribed Sequence in Lie Groups and Banach Algebras" (Canadian Mathematical Bulletin; 63(3), 2020 pp. 484-505.)

The paper makes significant connections between many fields of analysis and algebra. It concerns a class of sequences of integers with remarkable properties, the so-called Jamison sequences, and provides various equivalent characterizations of Jamison sequences in terms of Lie groups, normed algebras, and Hilbert space operators. This work is a great example of 'hard analysis'. The authors exploit all the above-mentioned theories to provide a thorough description of Jamison sequences, a topic important by itself, and some of their applications.

Dr. Catalin Badea studied Mathematics for three years at the University of Bucharest in his native Romania and then continued his studies in France, at University Paris-Sud, Orsay (now University Paris-Saclay). He earned his PhD in 1995 under the supervision of Jean-Pierre Kahane. Badea is currently Full Professor at University of Lille. He has published more than sixty papers, supervised eight PhD students, taught a variety of courses and did administrative and service work.

Dr. Vincent Devinck wrote his PhD thesis under the supervision of Catalin Badea and Sophie Grivaux, and defended his dissertation at Lille University in 2012. He has since been teaching "preparatory courses" (in classes designed to prepare high-flying students for the "grandes écoles" entrance exams) in selective postgraduate (i.e. post-"Baccalauréat") classes (MPSI class, currently at Lycée Mariette in Boulogne-sur-Mer). He is also an associate researcher at Artois University (Laboratoire de Mathématiques de Lens).

Dr. Sophie Grivaux is a senior researcher at CNRS, and currently works at the Laboratoire Paul Painlevé in Lille, France. She joined CNRS in 2004 after completing her PhD at the Institut de Mathématiques de Jussieu in Paris under the supervision of Gilles Godefroy. Her mathematical interests concern various aspects of functional analysis and dynamical systems, and she is especially interested in problems which lie at the crossroad of these two topics.

CMS Blair Spearman Doctoral Prize

Christopher Liaw (Toronto)

Christopher Liaw is an outstanding researcher whose work has contributed fundamentally to mathematical foundations of machine learning. His dissertation addresses two important problems in theoretical machine learning.

The first problem is on identifying the sample complexity of learning mixtures of Gaussians — a long-standing open problem, with previous solutions requiring extra assumptions. Working together with several collaborators (Hassan Ashtiani, Shai Ben-David, Nick Harvey, Abbas Mehrabian, and Yaniv Plan), Dr. Liaw gave a precise characterization with minimal assumptions. Moreover, this work developed a new tool for distribution learning, which has since been applied to give the sample complexity for learning other classes of distributions. This resulted in a "best paper award" at NeurIPS 2018, an extraordinary distinction.

On another line focusing on online learning, Christopher Liaw considers online predictions with expert advice, which is a classic model in learning theory. The problem is to find an optimal algorithm to choose a probability distribution over experts where at each day each expert receives a reward and the algorithm receives the expected reward under the chosen distribution. The goal is that, at all times, the total reward earned by the algorithm so far must nearly equal the maximum total reward of any expert by that time. It has been known for decades that there is an algorithm whose reward is only $O(\sqrt{t \ln n})$ smaller than the best expert's reward and this is optimal up to constants. The open question of finding the optimal constant has been posed as early as 1997. Liaw's work (joint with Nick Harvey, Ed Perkins, and Sikander Randhawa) resolved this question exactly for n = 2.

Liaw completed his PhD at the University of British Columbia in 2020 under the supervision of Nicholas Harvey. He has received several awards including a NeurIPS Best Paper Award as well as CGS-M, PGS-D and PDF fellowships from NSERC. He has an excellent publication record with three journal papers and ten papers in computer science conferences. He is currently a postdoctoral fellow at the University of Toronto.

Krieger-Nelson Prize

Anita Layton (Waterloo)

Dr. Layton has been recognized as a distinguished figure in the applied mathematics research at the interface of mathematical computation and biomedical sciences with direct impact in clinical health care. She is the author of over 170 publications that include top journals in applied mathematics, physiology, and medicine.

In addition to Dr. Layton's ground breaking work in mathematical biology, she has also published many impactful and well-cited studies in computational fluid dynamics; in particular, computational methods for fluid-structure interaction problems. Here, a deformable object is immersed in an incompressible fluid so that the object moves with the fluid and also exerts forces on it. These problems are notoriously hard to solve, both analytically and computationally. Dr. Layton has been at the forefront of studying and developing numerical methods which preserve the sharp fluid-boundary interface. For example, with then colleague Tom Beale, she was the first to present a rigorous analysis of the immersed interface method of Li and LeVeque.

Dr. Layton's expertise on systems of nonlinear advection-diffusion equations coupled with algebraic equations has, in part, furnished her long-standing program of research on kidney function, and specifically on the kidney's ability to concentrate salt and other products in the outflow. Here she has addressed important problems in physiology and medicine, and corrected several misconceptions about kidney function that have plagued the textbooks for years. By working with renal physiologists, Layton was able to develop a model of fluid and solute exchange in the kidney that accounts for its concentrating ability. She developed a fast numerical solver that proved to be vital as it allowed for parameter sensitivity studies that are based on many repetitions of otherwise time-consuming and costly simulations.

It is worth noting that Dr. Layton's work has inspired new experimental and clinical studies in the area of renal physiology and associated medical care. Her work has also highlighted the importance of sex differences in mathematical models for biological systems.

Coxeter-James Prize

Luke Postle (Waterloo)

Dr. Postle established himself as a leading researcher in graph theory. He published in the top journals such as *Journal of Combinatorial Theory B* (JCTB), *Combinatorica, and Journal of Graph Theory*, and gave talks at conferences and universities around the world. He made ground-breaking progress on many famous conjectures in graph colouring, including Hadwiger's Conjecture, the Goldberg-Seymour Conjecture, Reed's Conjecture, and Jaeger's Conjecture.

Luke Postle has launched a new paradigm in graph coloring with his introduction of a new generalization of coloring. Namely in 2015, Luke Postle and his collaborator Zdenek Dvorak introduced correspondence colouring in article published in JCTB, now referred to as DP-colouring by the community after their surnames. Correspondence colouring is a generalization of list colouring. List colouring, itself a generalization of colouring, was first introduced by Erdos, Rubin and Taylor in the 1970s and is now the subject of over a thousand journal

articles. In list colouring each vertex has its own list from which it must be coloured. In correspondence colouring, they abstracted this by removing any `global' notion of colour and rather only using a `local' notion, individual to each vertex. Such a generalization can actually be used for inductive purposes to solve list colouring problems, namely they used the concept to solve a 15-year-old conjecture that planar graphs without 4 to 8 cycles are 3-list-colourable. Since then, their article has garnered 86 citations in 3 years according to Google Scholar and indeed the article is listed on JCTB's own website as its most cited article published since January 2018. Correspondence colouring has been used both to solve open colouring problems and been studied in its own right as a natural form of colouring. For example, correspondence colouring proved a key ingredient in Luke Postle's research on Reed's conjecture.

Jeffery-Williams Prize

Joel Kamnitzer (Toronto)

Dr. Kamnitzer is a world leader in the field of geometric representation theory. He has had some of the most original and influential contributions of the past 20 years in his field.

His field of research can be described as an interface between algebra, geometry and modern mathematical physics. Among his recent interests are the categorification program and algebraic problems in modern mathematical physics.

One particular strand of Dr. Kamnitzer's research is a novel approach to knot homology based on the study of the affine Grassmannian, an infinite-dimensional manifold which is one of the main objects of modern geometric representation theory. In particular, he developed a geometric approach to categorification of knot homology.

Another important contribution of Dr. Kamnitzer is his work on symplectic duality, which involves the quantization of certain slices of the affine Grassmannian.

Joel Kamnitzer is a world-class mathematician whose influence significantly advanced a big portion of modern mathematics. The CMS is proud to award him the 2021 Jeffery-Williams Prize. Dr. Kamnitzer will give the Jeffery-Williams Prize Lecture at the Summer Meeting of the CMS in Ottawa.

Cathleen Synge Morawetz Prize

Ailana Fraser (UBC) and **Marco Gualtieri** (Toronto)

Ailana Fraser is an outstanding mathematician in the fields of differential geometry and geometric analysis. She has been awarded the Cathleen Synge Morawetz Prize for her sequence of works which connect the theory of minimal surfaces with free boundary conditions and extremal problems for the Steklov eigenvalues on the space of Riemannian metrics. Highlights of the work include, but are not limited to, three major publications:

1. Ailana Fraser and Richard Schoen, The firs Steklov eigenvalue, conformal geometry, and minimal surfaces, *Advances in Mathematics* 226 (2011), no. 5, 4011-4030.
2. Ailana Fraser and Richard Schoen, Sharp eigenvalue bounds and minimal surfaces in the ball, *Inventiones Mathematicae* 203 (2016), no. 3, 823-890.
3. Ailana Fraser and Richard Schoen, Shape optimization for the Steklov problem in higher dimensions, *Advances in Mathematics* 348 (2019), 146-162.

Marco Gualtieri is an outstanding mathematician the fields of differential geometry and complex geometry. He has been awarded the Cathleen Synge Morawetz Prize for his work on the foundations of generalized complex structures. This work opens up new connections between symplectic geometry and complex geometry, by initiating the study of a class of manifolds which interpolates between symplectic manifolds on the one hand, and complex manifolds on the other. Applications to Mirror Symmetry and String Theory abound. The principal paper the prize is awarded for is

Marco Gualtieri, Generalized complex manifolds, *Annals of Mathematics* 174 (2011), no. 1, 75–123.

Excellence in Teaching Award

Alfonso Gracia-Saz (Toronto)

Alfonso Gracia-Saz (UofT) has been named the 2021 recipient of the CMS Excellence in Teaching Award.

It is said that when Dr. Gracia-Saz teaches, he reinvents teaching. His work with the University of Toronto's legendary MAT137 (Calculus with Proof) is an excellent example of his dynamic teaching style; his reorganization, his attention to detail, his famous problem sets, and his inspiring lectures and videos have given this challenging course a new level of energy–particularly significant in this recent time of pandemic challenge. A second example is found in his design of the instructor training program at the University of Toronto, a program that has now been extended to all Teaching Assistants in the Mathematics Department.

According to his Toronto colleague, Professor Galvao-Sousa, Professor Gracia-Saz "belongs to this rare breed of born teachers that possess not only the knowledge and creativity but also the warm and dynamic personality that allows him to teach students in such a natural way that the barrier between teacher and student ceases to exist."

Over the past 13 years, Alfonso has served as an instructor and the Academic Coordinator of the Canada/USA Mathcamp. His calculus YouTube channel with 200 videos has over 10,000 subscribers and well over 3 million views. He is active in mathematics outreach through competitions, math camps, science fairs and undergraduate research. He has worked in a prison university project (currently Mount Tamalpais College) and has written a mathematical play. He and his partner, Nick, enjoy contra dancing, cooking and complex board games.

The Canadian mathematical community lost Dr. Gracia-Saz to COVID-19 in 2021. He was a mentor and an inspiration to many math educators. The CMS will continue to honour his memory."

Christopher Kribs (University of Texas at Arlington) and Jianhong Wu (York University)

Photo taken from
https://personal.math.ubc.ca/~cytryn/MathBio/images/

Fred Brauer, who grew up with mathematics in his family, received his Ph.D. from MIT in 1956 under Norman Levinson. After teaching at the University of Chicago and the University of British Columbia, he joined the University of Wisconsin in 1960. During his tenure in Madison he became a cornerstone of the department, serving several years as chair, and instituting the departmental seminar in « spherical trigonometry » to show that mathematicians can also play basketball. (He continued to do so well into retirement.) In two terms as associate chair he made important developments to the undergraduate curriculum, including sequences of precalculus courses and mathematics courses for biologists as well as the infusion of differential equations into multivariable calculus, linear algebra and the upper-level curriculum. It was in Madison that he formed a long-term collaboration with John Nohel, also a student of Levinson; in the early 1960's the two wrote what has become a classic textbook on qualitative theory of ODEs, still in print today, more than fifty years later. Hans Schneider, also in the department, joined them on a later book. It was also in Madison that Fred and his wife Esther raised their three children, David, Deborah, and Michael.

In 1997 Fred and Esther retired to Vancouver, British Columbia. There Fred took up an emeritus position at UBC (which thus bookended his career), where he remained quite active in research and mentoring student researchers for another two dozen years. During the same period Fred was also a regular visitor and mentor at the Mathematical and Theoretical Biology Institute, a research institute founded by his former Ph.D. student Carlos Castillo-Chavez and housed first at Cornell University and later at Arizona State University, where hundreds of student researchers, largely from groups historically underrepresented in the sciences, trained and later went on to earn doctorates. MTBI alumni are now tenured faculty at institutions like Oxford, Brown, and the University of Michigan, and Fred—approachable and always generous with his time—played an important role in their mentoring. In this vein he and Carlos published in 2001 a textbook on mathematical population biology which, now in its second edition, also became a classic reference.

Fred's research in mathematical biology was fundamental and groundbreaking. After about fifteen years publishing on the mathematical properties of differential and integral equations (during which time he published five books with John Nohel), he became interested in population biology, and wrote landmark modeling studies in population management and predator-prey systems in the 1970s and 1980s, notably in collaboration with A.C. Soudack and with David Sanchez. In the late 1980s Fred made one last transition, into mathematical epidemiology, in which over the next thirty-plus years he published over 100 articles. Many of his most topical papers, studying then-recent epidemics such as HIV/AIDS, SARS, the 2009 H1N1 influenza pandemic, and COVID-19, were written with two or three co-authors each, leading to an incredibly diverse set of collaborations. Fred's solo papers in recent decades focused on revisiting important topics in epidemiology using simple models and techniques as elementary as possible, in order to be accessible to a wider audience, or on providing perspective on the overall direction of the field. His work continues to have a profound impact on mathematical biology (in 2020 alone it was cited over 1600 times), and his legacy continues in those who benefited from his mentoring.

CK:

When I first met Fred Brauer, he was warning a class of first-semester calculus students about the dangers of applying techniques without thinking. As an example, he wrote on the chalkboard the expression $\sin x / n$. He then proceeded to cancel the n's from numerator and denominator, leaving *six*. At the time, I, a first-semester graduate student, knew nothing of the vast body of work he had produced in rather more advanced mathematics, but his thoughtful approaches to solving problems, coupled with his dry humor, appealed to me. He later encouraged those same calculus students, "Lions in the Serengeti Desert solve optimization problems—and they don't even know calculus." (Fred attributed this observation to Colin Clark.) When, a year later, I went to him in search of a Ph.D. advisor, his kindness and admirable tranquility, and the richness of both the mathematics and the population biology that he showed me, made the decision an easy one. I became Fred's last Ph.D. student at Wisconsin, finishing just weeks before his move to Vancouver.

Over the more than two decades that followed, I continued to enjoy Fred's mentoring but also came to know him in two additional capacities: as colleague and friend. He invited me to co-author with him an introductory book on dynamical systems and mathematical biology. I was determined to make the text approachable to students of biology as well as mathematics, by the infusion of biological research (including photos and data) into every section, and to this day remain grateful for both his patience (the project took, in the end, over a decade) and his support for my pedagogical beliefs. At the same time, I came to know him and Esther more socially, not only at conferences and MTBI but on visits to Vancouver. In 2015 I was able to take them up on a longstanding offer to bring my children (then in junior high) to stay with them and explore at more leisure the incredible natural beauty of the area. Fred and Esther were keen to hear my children's impressions of our adventures each evening, as well as what was going on in their daily lives back in Texas. My children, for their part, listened with rapt attention to Fred's accounts of his family's immigration to the US and Canada in his youth. Although the pandemic prevented us visiting in person the past two years, I am grateful to have been able to keep in touch with Fred and Esther during that time. In one of my last email messages from Fred this year, he wrote, in reply to news of a birth in the family. "Some people are saying that this is a difficult time to bring a child into the world, but others say that children are the hope for a better world."

JW:

Fred's retirement and returning to Canada has been a great fortune to the Canadian mathematical biology and epidemiology, specially before the SARS. Fred's unselfish dedication to the research field and the public health, to his colleagues and his students, was an inspiration for Canadian modellers' collective rapid response to a unique call to establish a national team, and his wisdom and scientific work was the insurance of our collective success. Fred was a highly influential founding member of a Canadian national group, the MITACS disease modeling team, and played a major role in developing a reciprocal linkage between mathematical modelers and public health experts and decision making in Canada, and in establishing international collaborations including the North American Pandemic Modeling Consortium and the Canada-China collaboration.

Fred's work has influenced multiple generations. He was the first organizer and speaker of the Mitacs Infectious Disease Summer School, and his most recent lecture was delivered at the Fields mini-thematic program Mathematics for Public Health May 11, 2021. With his influence, this summer school series provided a common language for a new generation of disease modelers and end-users of disease modelling to communicate and collaborate effectively. Fred co-edited with Pauline van den Driessche and Jianhong Wu the Springer Lecture Notes "Mathematical Epidemiology" based on these summer schools.

Many of us grow up in our careers by reading Fred's work and his books, many of us benefit from his unconditional support. Many of us shaped our careers by following his examples as both a scientist and a human being, the real GENTLEMEN!

Using his most favourite phrase « In theory, Fred passed away; in practice, he is living with us through his mathematics, his friendship ».

CMS Notes

The editors welcome articles, letters and announcements. Indicate the section chosen for your article, and send it to *CMS Notes* at the appropriate email address indicated above.

No responsibility for the views expressed by authors is assumed by the *CMS Notes*, the editors or the CMS.

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