Welcome to the September Issue of the CMS Notes

Issue Contents

September 2020 : Vol. 52, No. 4

The Canadian House of Mathematics

Javad Mashreghi (Université Laval)
CMS President

This summer, we were supposed to come together and celebrate the 75th anniversary of the creation of the Canadian Mathematical Society in Ottawa. The early enrolments and proposed sessions clearly indicated that it would have been the largest gathering of Canadian mathematicians in history. We were proud and ready to narrate the accomplishments of our society from the time of the founding fathers to the present day. Many gifts and prizes were prepared to award a wide spectrum of Canadian mathematicians for their scientific, educational and administrative achievements in the Society. And then, all of a sudden, the whole world was faced with a new reality. We were hit by an unknown virus, COVID-19, and our regular daily life came to a halt! Quarantine, a word which until then we probably had to look up in dictionaries to grasp its full meaning, became our regular civil duty. In fact, we are still grappling with the aftermaths of the global pandemic.

In its 75 years of activity, the CMS has been through many ups and downs. However, it seems that it is facing its most difficult challenge at a mature age. Like many other organizations and institutions, the CMS had to adapt to the new reality, the first of which was the postponement of the 75th anniversary meeting. This was a very difficult decision to make since the chief scientific directors as well as session organizers and the CMS staff had put a lot of time and energy into creating a memorable meeting. Nevertheless, we went forward and we are enthusiastically prepared and expect to celebrate the 75+1 anniversary of CMS in summer 2021. COVID-19 has also had an impact on CMS publication revenues. There are several important issues under discussion at the Publication Committee. The development of an online, open-access publication, creation of a new journal, and the publication of CMS journals in house are among our major goals in coming years. In particular, the CMS is inviting members with a knowledge of the publication industry, its infrastructure, and necessary hardware and software to provide us with feedback and recommendations.

Despite the hard times, there are numerous positive and encouraging news. The CMS turned the undesirable situation into an opportunity to reach out to educators and students, listen to them and expand its education programs. With the lockdown in place, students were confined to the walls of their rooms and most of their communications with their peers and educators were drastically reduced, if not completely disrupted. Parents, who already wear many hats, had to add homeschooling to their daily duties. Among the subjects that most parents were struggling with or felt intimidated to teach was mathematics. Equally, mathematics educators, both at K-12 and university level, were now faced with the new reality of online teaching and mentoring and the myriad of uncertainties that it entailed. The CMS came forward and posted more math problems, education material and pedagogical strategies on social media and worked hard behind the scenes to organise two major events. While material on teaching abound on the internet, educators were looking for ways to connect, discuss and find a way to come up with a strategy that worked for them. The Society, and its members, many of whom were in the same boat and were experiencing the same anxiety, organized the CMS first ever virtual meeting focusing on education and research. Moreover, while online mathematics education was as uncertain as ever, mathematical graphs were dictating our daily activities and all of a sudden math had become important for the mainstream media and had to concern itself with messaging. Mathematicians gathered to discuss all this and much more during a 4-day online meeting which to many felt like a breath of fresh air after months of isolation. It was equally rewarding for the staff and organisers who had been looking for ways to better serve the community during these challenging times. The second education event put together by the CMS during the lockdown was the launch of the Society's first ever competition for elementary school students, the Canadian Mathematical Gray Jay Competition, in an amusing and engaging format and on a friendly online platform. Although the competition itself will take place in October, its conception and preparation has taken a colossal effort by staff and Competitions Committee. Thus, while many of our programs had to be cancelled due to a global pandemic, much to our disappointment, we have found new ways to serve the community. This would not have been possible without the help of our partners and sponsors.

> *[Another] education event put together by the CMS during the lockdown was the launch of the Society's first ever competition for elementary school students, the Canadian Mathematical Gray Jay Competition, in an amusing and engaging format and on a friendly online platform.*

The CMS has also had time to reflect on how to be a better representative of Canada and further include and engage different voices inside Canada. In partnership with the RBC Foundation, the CMS has dedicated a fund to waive the competition registration fee for 400 Black and Indigenous students participation in the Canadian Open Mathematical Challenge (COMC) and Canadian Mathematical Gray Jay Competition (CMGC). This, we think, is a great way to foster the students' interest in mathematics from a young age and make sure all mathematical talents are recognised regardless of factors that might normally pose barriers during a student's academic trajectory. The Reconciliation and Mathematics Committee and the Diversity and Inclusion Committee are both freshly created and working hard with the staff to conceptualise programs that make our community more diverse and more inclusive.

At this critical moment, the rental lease of CMS office in Ottawa is also going to be expired in October 2020. Yes, at the age of 75, the CMS still does not have its own house! At this age, one hopes to have paid off all debts and mortgages and resides in a stable place. Unfortunately, this is not the case for the CMS. There is absolutely no doubt that this spatial instability does not reflect the prestige and glory, which should accompany such a Canadian entity. We are in a difficult period and it sounds contradictory to break the 75 years of leasing tradition by purchasing a place that the Canadian community can call home. However, in difficult times there are great opportunities too. On one hand, the prices are reasonable and even lower than the projected market figures. On the other hand, when life returns to normal, the prices will hike up so that for many years to come we could still not afford to buy such a building. Therefore, I enthusiastically relaunch the idea of buying the Canadian House of Mathematics. I personally see at least two phases for this project. During the first phase, we want to have a permanent and stable place for the Canadian Mathematical Society. After 75 years, the CMS deserves this gratitude. In the second phase, we should go further and think of the Canadian House of Mathematical Sciences to host CMS as well as several other scientific societies in Canada which are devoted to different aspects of mathematical, statistical and actuarial sciences. We can all share the same roof, collaborate more closely and provide a better service for all Canadians.

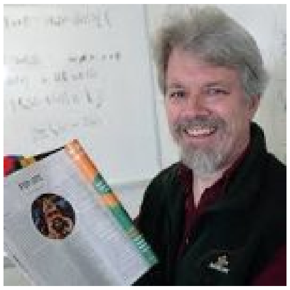
Our fellow Canadian mathematicians, this is the time to make the first phase of this project a reality! We need to put our hands and heads together to establish the *Canadian House of Mathematics*. We are numerous. With so many active members from coast to coast, the CMS count on your generous donations in order to initiate this project. As a matter of fact, one great donor is enough to come forward and put the whole house under his/her name, and if this is too ambitious, several major donors may share this honour. An *ad hoc* committee has been formed to study the feasibility and creation of the Canadian House of Mathematics. The committee is pleased to receive your questions and comments regarding this project.

Interesting Times

Editorial

September 2020 (Vol. 52, No. 4)

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



As I write this, it's late July: and this week I'll be teaching in person.

Only for one morning: and not mathematics, but a creative writing class for young teenagers: I write fiction in my spare time. Only half a dozen students will be there, spaced out in a full-sized classroom. But I'm going to make the most of it, because it may be my last opportunity for a long time.

Come September, my first-year calculus section will have something like two hundred students. Many of them will be from outside the province, some from outside Canada. There is no way to space that many students out in a classroom. In some cases, there may not even be a safe way for them to travel to Nova Scotia. We're going to have to put that class on remotely. I'm not holding my breath for winter courses, either.

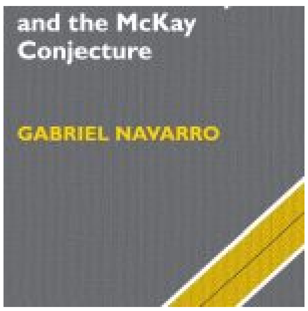
Like many universities, Saint Mary's University has summer school courses that are mostly taught by part-time instructors. As a result of this, many of our part-time faculty will have taught two full courses and their labs or recitations online by September, while the full-time faculty will have done no more than finish up an abbreviated version of their winter courses. This creates a humbling situation in which I, and many of my full-time colleagues, will be learning (if we are wise) from the example and experience of the part-time faculty. Of course, smart assistant professors have known all along that seasoned sessional instructors are specialists in lower-year courses, and pay attention to any graciously-offered advice, in the same way that subalterns who want to learn their trade listen to the NCOs. But this summer I find myself listening carefully even to the doctoral students whose hiring I recommended so recently. They've been there, and I haven't yet.

To everybody else who's preparing for the same experience: good luck, and please be properly appreciative of your department's sessional instructors. They deserve it now more than ever.

And to all sessional instructors reading this: thank you!

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)*



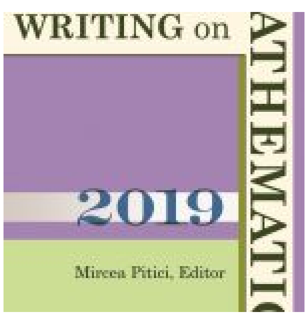
Character Theory and the McKay Conjecture
by Gabriel Navarro
Cambridge University Press, 2018
ISBN: 978-1-108-42844-6
Reviewed by Gerald Cliff, University of Alberta

To state McKay's Conjecture, for a prime p and a finite group G, let $m_p(G)$ denote the number of irreducible complex characters of G whose degree is not divisible by p. Let $N_G(P)$ denote the normalizer of a Sylow p-subgroup of G. The conjecture is that

$$m_p(G) = m_p(N_G(P)).$$

This conjecture was made in the early 1970s, and has become one of the main problems in the representation theory of finite groups. In the 2000s, an effort was made by Navarro and collaborators to reduce this problem to the case that G is a finite simple group, and then use the classification of finite simple groups. There is a stronger conjecture which implies McKay's, and which would hold if it holds for all finite simple groups. At this time it is not known that the stronger conjecture does indeed hold for all finite simple groups, except for $p = 2$, so that McKay's conjecture is true for $p = 2$.

In this book, the author gives a good presentation of the theory of characters of finite groups, including some recent interesting results. He shows how to reduce the stronger conjecture to simple groups. The book could be read by graduate students and non-experts.



The Best Writing on Mathematics, 2019
Edited by Mircea Pitici
Princeton University Press, 2019
ISBN: 978-0-691-19835-4
Reviewed by Karl Dilcher

This is the tenth volume in a remarkable series of annual anthologies. A year ago in this space I addressed some general features shared by all volumes. I will not repeat these remarks here; the interested reader will find them in the September 2019 issue. Instead, I will quote from the overview of this volume:

> *To start the selection, Moon Duchin explains that the Markov chain Monte Carlo method, a geometric-statistical approach to the analysis of political districting, guards against the worst of many possible abuses currently taking place within elective political processes.*
> *Theodore Hill describes the recent history of the fair division of a domain problem, places it in wider practical and impractical contexts, and traces the contributions of a few key mathematicians who studied it.*
> *Paul Campbell examines some of the claims commonly made on behalf of learning mathematics and finds that many of them are wanting in the current constellation of teaching practices, curricula, and competing disciplines.*

Roice Nelson introduces several puzzles whose ancestry goes back to the famous cube invented and commercialized by Ernő Rubik.

Kokichi Sugihara analyzes the geometry, the topology, and the construction of versatile three-dimensional objects that produce visual illusions when looked at from different viewpoints.

Kevin Hartnett traces the recent developments and the prospects of mathematical results that establish mirror symmetry between algebraic and simplectic geometry---an unexpected and only partly understood correspondence revealed by physicists.

James Propp presents a fresh approach to problems of discrete probability and illustrates it with examples of various difficulties.

Neil Sloane details some of the remarkable numerical sequences he included in the vast collection of integers he has organized and made available over the past several decades.

Alessandro Di Bucchianico et al. point out specific theoretical advances in various branches of mathematics, which have contributed powerful applications to recent technologies and services.

Toby Cubitt et al. tell us how they explored the connections between certain open questions in quantum physics and classical results on undecidable statements in mathematics formulated by Kurt Gödel and Alan Turing.

Jeremy Avigad places in historical context and illustrates with recent examples the growing use of computation, not only in proving mathematical results but also in making hypotheses, verifying them, and searching for mathematical objects that satisfy them.

With compelling examples and well-chosen arguments, Reuben Hersh makes the case that mathematics is pluralistic on multiple levels: in content, in philosophical interpretation, and in practice.

Mary Leng subtly defends a position highly unpopular among mathematicians and in a small minority among the philosophers of mathematics, namely, the thesis that certain mathematical statements are questionable on the ground that they imply the existence of objects that might not exist at all—for instance abstract numbers.

Tiziana Bascelli and her collaborators discuss an episode of 17th-century nonstandard analysis to argue that clarifying both the historical ontology of mathematical notions and the prevalent procedures of past times is essential to the history of mathematics.

Noson Yanofsky invokes two paradoxes from the realm of numbers and a famous result from the mathematical theory of complexity to speculate about their potential to inform our understanding of daily life.

Andrew Gelman recommends several practices that will make the communication of statistical research, of the data, and of their consequences more honest (and therefore more informative) to colleagues and to the public.

Michael Barany narrates a brief history of the early Fields Medal and reflects on the changes that have taken place over the decades in the award's stated aims, as well as in the manner in which awardees are selected.

To conclude the selection for this volume, Melvyn Nathanson recalls some originalities of one of the most peculiar mathematicians, Paul Erdős.

No, We're Not There Yet: Teaching Mathematics at the Time of COVID-19 and Beyond

Kseniya Garaschuk and Veselin Jungic

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.

John McLoughlin, *University of New Brunswick (johngm@unb.ca)*
Kseniya Garaschuk, *University of Fraser Valley (kseniya.garaschuk@ufv.ca)*

Where are we now as a community of teaching practitioners? Can we anticipate what teaching will look like, for teachers and students, in the foreseeable future? The purpose of this note is to reflect on the post-secondary mathematics teaching community's recent experience and plans for remote teaching during the ongoing pandemic.

There is no doubt that our community's reaction to the pandemic has had several positive outcomes. Over the last several months, post-secondary mathematics instructors from coast to coast have come together to support each other. We have witnessed well-attended teaching related events ranging from multiple day conferences, to pan-Canadian seminars, to locally run seminars and ad-hoc events. Here are only a few examples of events that the authors of this note have been involved in as organizers and attendees:

- The CMS COVID-19 Research and Education Meeting (CCERM), July 13-16, 2020
- The First Year Mathematics and Statistics in Canada (FYMSiC) Online Meet Ups, a biweekly seminar series occurring in summer 2020
- The Teaching Matters Seminar series, a grassroots faculty-led initiative out of Simon Fraser University.

These three initiatives, obviously very distinct from each other, have a lot in common. Perhaps the most apparent commonality is the fact that they all attracted large audiences.

The panel discussion on the topic of contract cheating hosted by the SFU Teaching Matters Seminar attracted 300 (the capacity of the Zoom meeting room) post-secondary instructors from all across the country. In the words of one of the panelists, Dr. Sarah Eaton from the University of Calgary, "As far as I know, the webinar you organized was the largest event (virtual or otherwise) on academic misconduct in Canadian history."

FYMSiC Online Meet Ups are organized to focus specifically on topics of remote teaching and have attracted over 60 participants at every session, some attending from as far as Germany.

The presence of mathematical education and its presence at CMS meetings has grown over the past few years, but its importance and relevance has been greatly highlighted by COVID-19. The recent CMS COVID-19 Research and Education Meeting demonstrated that educational sessions, workshops, panels and discussions are a key part of the Canadian Mathematical community's interests as the majority of the 212 registrants came to attend educational events during this packed four-day virtual conference. Looking to the future, we hope that many of the aforementioned activities become regular events as we engage in a more consistent improvement of teaching practices. Specifically, we hope that educational sessions become a key part of each CMS meeting's organization and a component of faculty development.

The pandemic has highlighted that, although we may have different research interests and our jobs have more than one focus, our shared vocation is teaching. This pandemic has put a stop to status quo teaching as it is no longer physically possible. In turn, questioning and reconsidering the teaching process has resulted in previously unimaginable levels of interest into all components of teaching: from the class preparation to the creation of the learning resources to the course delivery to the critical rethinking of our learning assessment practices.

The main reason for this swarm activity is our collective wish to do whatever it takes to support our students. The well-being of our students and our responsibility to create a learning environment in which each student will get a fair chance to explore their talents and interests and gain necessary skills have been dominant themes in all of the conversations that we witnessed. The pandemic has showcased a real strength in our community and the commitment of mathematics faculty to provide our students with the best education possible, under any given circumstances.

Another reason is that as mathematicians we are by definition problem solvers. And we are facing a big problem: how do we, under the given circumstances, communicate both the big mathematical ideas and our own passion for our beloved subject to our students? How do we build meaningful relationships with our students and among our students in a virtual environment? How do we convince our students, without looking straight into their eyes and through one-on-one chats, that the learning of mathematics is necessary and of the utmost importance in this phase of their personal and academic lives? We are also united in our more practical fears and concerns: effectively running synchronous sessions, especially with large classes, dealing with student questions and potential technical issues; picking the "right" platforms for facilitating learning, while not overwhelming students with all the different tools and technologies; working with students new to the university; establishing a sense of community and cultivating peer-to-peer and instructor-to-peer relationships; supporting students struggling academically or mentally; and, yes, developing and administering assessments online.

In the search for solutions, our teaching community (out of necessity but still somewhat spontaneously) has turned to methods and practices that characterize a common approach in mathematical research in recent years: the use of technology and community collaboration. Think of the Polymath Project, for example. Only half-jokingly do we call our current collective experience: The Polymath Teaching Project 1. Similar to the Polymath Project, the numerous initiatives are driven by the community's wide-spread interest and already existing high-level of the personal investment in the search for solutions by many individuals. Another similarity is the incredible amount of talent that we have seen among our, particularly younger, colleagues. Most importantly, the spirit of academic generosity in sharing resources, practices, knowledge, and ideas has been a common attitude across the board.

The crucial difference between *The Polymath Teaching Project* and its research counterpart is in the outcome that all of the involved are hoping for. *The Polymath Project 16*, for example, is looking into the problem of finding the chromatic number of the plane. We do not know if it is 5, or 6, or possibly 7, but we know that it is one of those three numbers. Contrary to this, one of the main objectives of our discussions about teaching university math courses in Canada in fall 2020 is to provide an array of only partially structured answers to the questions arising from the family of problems stated above. This way, each instructor, or a group of instructors from a particular department or school, will be able to apply and adjust commonly accepted principles to their own teaching styles and goals and their students' learning needs.

In the process of community collaboration, we have come upon an interesting juxtaposition and that is the process of personalization (from instructor's point of view) of teaching and learning in the Canadian postsecondary mathematical community. Re-using already existing resources appears to provide a natural solution to many of our problems. However, while we have witnessed rich discussions and idea sharing, it seems that nearly every instructor wants to create their own resources from scratch. A case in point is the most time-consuming online course component: asynchronous video recordings. Nearly every member of our community is or will be recording their own fall lectures.

A countless number of hours has been spent learning new technologies, making decisions about using the best software, purchasing the best recording devices, and choosing the best hosting platforms — with all of the strings attached. And this comes even before we started thinking about the best structure for our recordings. Suddenly, we are struggling with decisions such as: how long should our recordings be? should we go with the voiceover only or should we include our images there as well? should we write on the board or on a tablet? This will be followed by long hours of recording and editing. We are discovering that we often make mistakes and that we would say one thing and write another, for example. We are faced with painful dilemmas while watching our not-so-perfect recordings: to re-record or not to re-record, that is the question!

We have been eager to share what we have learned with our colleagues across the country. (Interestingly enough, we learned that Alice and Bob from the university three provinces over are recording their lectures as a dialogue between them. Maybe we should ask Carol, who is teaching another section of the same course that we teach, if we should we do something similar!) But one thing we have not done is to consider using existing lesson recordings, beautifully made and professionally edited by our colleagues. Although math is a universal language, it seems that each of us wants to teach it our own way, with our own idiosyncrasies, time-consuming and plagued with imperfections, but infused with our personalities. While online teaching offers many efficiencies, we want to see ourselves in our courses and we are willing to pay the price. It is reasonable to assume that our students will also be more engaged in our courses if they see those courses were specially made by their instructor, for them and with them in mind.

> *The recent CMS COVID-19 Research and Education Meeting demonstrated that educational sessions, workshops, panels and discussions are a key part of the Canadian Mathematical community's interests as the majority of the 212 registrants came to attend educational events during this packed four-day virtual conference. Looking to the future, we hope that many of the aforementioned activities become regular events as we engage in a more consistent improvement of teaching practices.*

But what is that we really know about our students?

The authors of this note, as part of their preparation for the CMS COVID-19 Research and Education Meeting, had the privilege to talk to several incoming first-year students. We were more than impressed with these young people. The students, all of them 17-18 years old, presented themselves as thoughtful, hard-working and ambitious youth, but also as quite realistic, well-informed, and already engaged in some of the contemporary issues that our society faces. We are fully aware that we met with some of the best and the brightest former high schools that are out there. Still, the fact that many of them came from the public-school system and from schools that have been serving communities with their own sets of urban life challenges, gives us this hope that the next generation of the first-year students is capable to go successfully, with our help, through an important life transition.

For example, here is a message that the second author received recently from a former student:

> *Speaking honestly, this semester has been difficult for me. I find it much harder to schedule my time at home; I find myself more easily distracted by leisure activities when I can't attend classes in person. However, I have found live, synchronous lectures much easier to stay focused on than prerecorded lectures, probably because they always happen at a particular time of day (it's easier for me to schedule my studying when I know that a lecture will happen at 1:30, for example, as opposed to a recorded lecture which I tend to procrastinate watching.) In spite of these difficulties, I have been enjoying Calculus III and Linear Algebra this semester and am excited to see how these mathematical concepts will help me understand the material in MATH303 (assuming I do manage to get through the waitlist!)*

At the July 27th FYMSiC session that served as a panel for high school teachers to share their experiences with the transition to remote teaching and learning, we heard the same sentiments passed down from their students. We have also heard similar concerns from students at the graduate level.

Staying focused and creating and maintaining an in-house school bubble may be a bigger challenge for many of our students, at any level of studies, than the academic challenges that we will present to them. Part of our preparation for teaching in the fall should be listening to students who are currently taking online courses. Part of our ongoing teaching practice in the fall should be conducting regular surveys about our courses: what components work, what can be improved, and what needs to be abolished. Those communications should serve as our reality checks.

This leads us to a recurring theme in the discussions among post-secondary math instructors: Do we teach mathematics, or do we teach students who study mathematics? Both of the authors of this note are strong believers in the latter. But what is it that we can realistically do in these remote-teaching-pandemic-driven circumstances to efficiently teach students? It seems that the community consensus is to create a safe environment for students and a supportive community, so that they can raise their academic and non-academic concerns with you, the instructor, and with their peers. Perhaps equally importantly, don't be afraid to share with your students, in a professional manner, your own imperfections and possible struggles addressing multiple unknowns brought forward by the pandemic.

Let us not forget that if the more experienced of us are struggling with the new normal, then those who are new to teaching will likely be under even more pressure. During the best of times, professional teaching development for our current and future teaching assistants has been scarce; in the current circumstances, this supporting teaching community is not just lacking the appropriate level of training and support to teach remotely, but also the clarity with what is expected from them by their institutions, course instructors, and students in the upcoming semester.

In this vein, the outcomes of our own teaching significantly depend on the work of the entire support system that consists of academic advisers, IT technicians, departmental secretaries and other supporting staff. We are still waiting to see any kind of proof that those colleagues are getting both the recognition for the work that they have done over the last several months and the substantial support to come in the upcoming months. Our own experiences this summer with the university teaching support staff have been very positive. Our requests for help from our librarians, technicians, course developers, and particularly our departmental administrators were resolved quickly and efficiently. The pandemic has put us physically apart, but it also has brought us, as colleagues, closer together.

But we also live in the shadow of some dark and stormy clouds.

The scariest of them is this huge, dark, ever-shape-changing body attached to the issues related to academic integrity. Since our last note, we learned about the existence and seeming omnipresence of the academic cheating industry. Suddenly, on top of all of our other worries we have a responsibility to try to protect our students from this predatory, hundreds of millions of dollars strong, international industry (for an extensive discussion of this topic please visit https://canvas.sfu.ca/courses/14940/pages/tm-contract-cheating). Our colleagues that are teaching this semester are telling us that we should educate our students and keep reminding them about the importance of academic integrity for their general well-being.

We need to spend more time thinking about how to de-motivate cheating, eliminating it at the root rather than dealing with its consequences. So, the first question to ask is why do students cheat in the first place? One framework we found useful was presented in the webinar organized by the Center for Teaching and Learning at the University of British Columbia (UBC):

1. Pressure/necessity: "Do I need to cheat?" When the grade depends heavily on high stakes exam(s), there seems to be no other way to succeed. Students fail to see that they can learn by actually going through the course materials (since they aren't worth much, so clearly the instructor doesn't think they are that important) and are more motivated to think that the risk is worth the reward. One way to fight this is to create an array of the frequent and low stake assessments.
2. Opportunity: "Is it easy to cheat?" In most practical terms, cheating takes time. Making questions more substantial, requiring explanations and discussion (such as stimulus questions) means you can't just ask a peer for "the answer". They will need the time to read someone else's and come up with a meaningful variation.
3. Rationalization: "Is it ok to cheat?" Students don't know what counts as cheating and a little help from the friends seems innocent to them. So, we need to explicitly educate them on it. Still this is not an ordinary 'If p, then q' proposition, where p is "The instructors explains to her students that cheating on exams is bad for their academic growth" and q is "students do not cheat on exams." It is rather, as Frank Ramsey explained a hundred years ago, 'If p, q might result' or 'q would probably result'. Here the degree of probability is not a degree of our belief in 'Not-p or q' (try it, it is logically equivalent to 'If p, then q') but rather a degree of our belief in q given p. And our colleagues are telling us that it is quite reasonable (and maybe our only hope) to hold such a belief.

The second cloud that concerns us is the future of the general well-being of the members of our post-secondary teaching community. We have no doubt that as a group we have invested more hours in preparing for our fall courses than we would normally, possibly multiple times more. Still, deep inside, we know that this may be not quite enough for the challenge that we are facing and that we will, very possibly, have to be on our toes throughout the whole semester. Add to this that with their own children taking remote classes and their aging parents being more vulnerable than ever, our younger colleagues will have to stretch on a daily basis to manage serving as day care and in-home-schooling providers to elderly care providers to caring spousal partners to the responsible, well prepared, and focused university instructors. It sounds like too much and it is too much. We are worried that this mountain of commitments and responsibilities may negatively affect both the mental and physical health of many members of our community.

This combination of hard work, intense learning, critical hope, and justifiable fear that we, the authors of this note, share when we think about teaching in the upcoming semester reminds us about a statement attributed to Charles Darwin:

> *A mathematician is a blind man in a dark room looking for a black cat which is not there.*

And you know what, Mr. Darwin? With the help of our students and our colleagues and a bit of luck, we will find the cat!

CMS NOTES

Ada Lovelace: New Light on Her Mathematics

Adrian Rice (Randolph-Macon College)

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)*

Figure 1. Ada Lovelace (1815–1852).

On July 25, 2018, in a rare display of consensus, the Senate of the United States passed a resolution "honoring the life and legacy of Ada Lovelace" and "designating October 9, 2018, as 'National Ada Lovelace Day'." This was a somewhat belated recognition, not only of Lovelace herself, but also of the fact that in every year since 2009, the second Tuesday in October has been celebrated worldwide as "Ada Lovelace Day". The brainchild of Suw Charman-Anderson, Ada Lovelace Day has become an international celebration of the achievements of women in science, technology, engineering and mathematics (STEM) that aims to increase the profile of women in STEM subjects and to encourage more young women into scientific careers.

Today, the name of Ada Lovelace is as recognizable as those of other famous female scientists, including Marie Curie and Rosalind Franklin, and, to the general public, better known than other female mathematicians such as Emmy Noether and Sophie Germain. Yet Lovelace made no famous scientific discovery, proved no mathematical theorem, and died at the age of 36, having published only one paper—which credited her not by name but merely by the initials "A.A.L." In fact, in her lifetime and for many years after it, the lady whose full name was Augusta Ada King, Countess of Lovelace (see Figure 1) was famous primarily for being the sole legitimate child of the poet Lord Byron.

Her fame today derives from the paper she published in 1843 in a journal called *Taylor's Scientific Memoirs* [6]. Strictly speaking, this was a translation of someone else's paper. The original article, entitled "Notions sur la machine analytique de M. Charles Babbage," had been published the previous year in French by the Italian engineer Luigi Menabrea, and contained a discussion of a machine, as yet unbuilt, called the analytical engine. This theoretical contraption had been devised by the famous Victorian mathematician, inventor, and polymath Charles Babbage in the 1830s. Had it ever been built, it would have been the world's first general-purpose computer—100 years before the work of Alan Turing and John von Neumann. Menabrea's article was intended to explain and promote Babbage's ideas to the European scientific community; Lovelace's translation performed the same task for a British audience. But she also wrote seven lengthy appendices, or "Notes" to her translation which, at a total of 41 pages, amounted to more than one-and-a-half times the length of the original paper.

It is the last of these notes, Note G, on which her current fame rests. In it, she outlined an iterative process by which Babbage's machine, via a series of steps, could compute the Bernoulli numbers, an irregular sequence of rational numbers, highly useful in number theory and analysis. Although the algorithm she devised was never run and the computer for which it was intended was never built, if Ada Lovelace is remembered for anything today, it is for having written the world's "first computer program". (This is despite the fact that what she actually published was closer to what we would call an execution trace than an actual program. See Figure 2.) Perhaps unsurprisingly, interest in Lovelace and her work re-surfaced as the era of modern computing began in the 1940s and 1950s. Pioneers such as Alan Turing referenced her paper, and other early writers on computer science paid tribute to her ability. Perhaps the most tangible display of the esteem in which she was held was the choice of the name "Ada" by the U.S. Department of Defense for its new programming language in 1979.

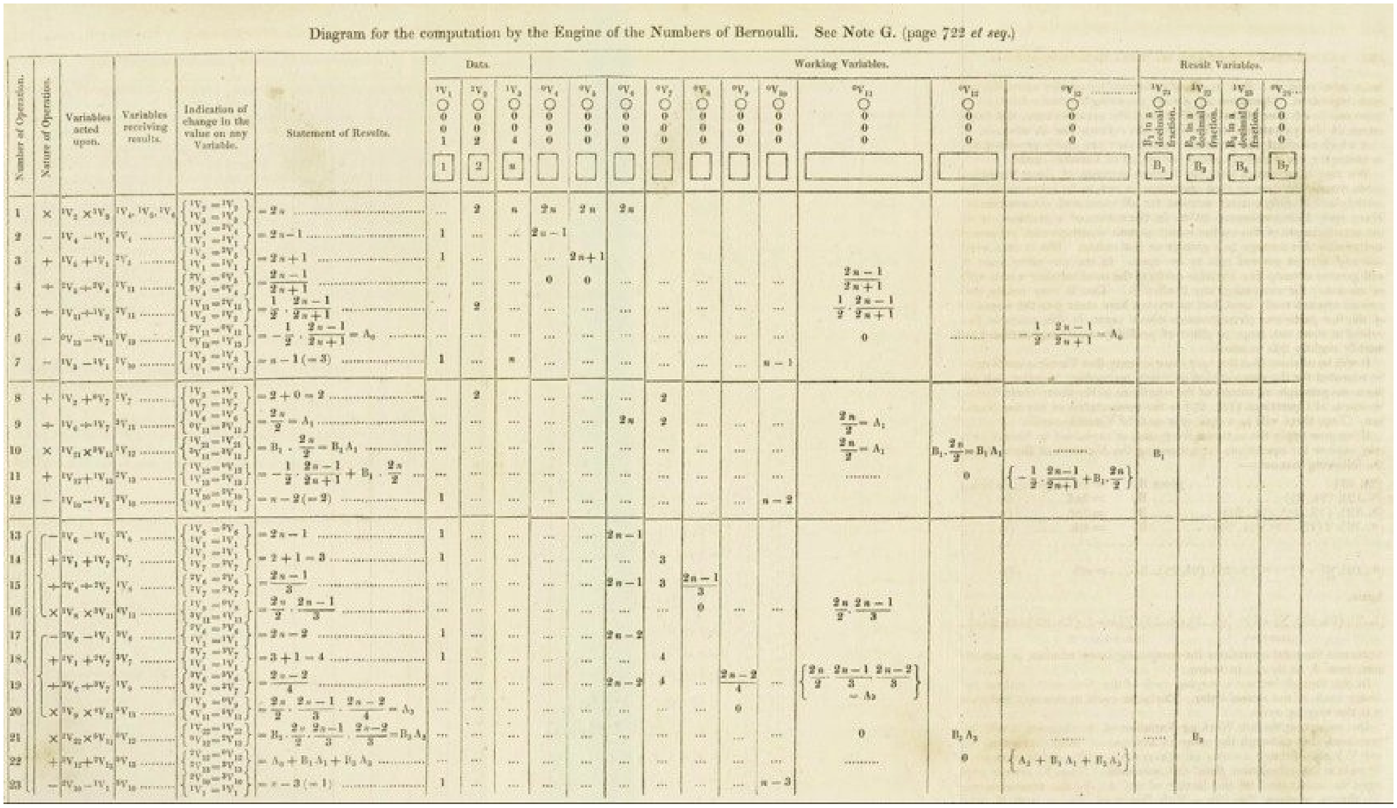


Figure 2. Chart that accompanied Note G in Lovelace's translation of Menabrea's paper.

Since the 1980s, though, evaluations of Lovelace's scientific ability have been more mixed, with some authors claiming that her command of mathematics was actually rather limited and pointing to various algebraic errors as "evidence of the tenuousness with which she grasped the subject of mathematics" [7, p. 90]. The most forthright even described Lovelace as "mad as a hatter . . . with the most amazing delusions about her own talents", calling her "the most overrated figure in the history of computing" [2, preface]. Yet for every study in which she is portrayed as a charlatan, there is another in which she is described as "a synthesizer and a visionary [who] saw the need for a mathematical and scientific language which was more expressive and which incorporated imagination" [8, p. 2]. To provide a more balanced estimation of Lovelace's mathematical abilities, recent research has aimed to shed more light on precisely what mathematics Ada Lovelace actually studied in order to ultimately produce her famous paper of 1843.

This research, undertaken by a team comprising Chris Hollings and Ursula Martin from the University of Oxford and myself, focused on the 66 surviving letters from an eighteen-month-long correspondence course undertaken by Lovelace in 1840–41 under the tutelage of the British mathematician and logician, Augustus De Morgan. During this period, De Morgan introduced Lovelace to a large segment of what then comprised an undergraduate course in mathematics—since no women were actually allowed to receive a formal university education at that time. From basic algebra and trigonometry, she progressed through functional equations, calculus, and differential equations, even reading some of De Morgan's own research papers. The letters between them at this time show her to have been a tremendously keen and capable student, although certainly prone to the usual beginner's mistakes and misapprehensions. But our study seems to differ from others in delving into the actual details of the mathematics that Lovelace was studying with De Morgan. It reveals that, far from being mathematically limited, she did in fact have very strong mathematical skills together with an inquiring mind that led her to pose questions and speculations quite unlike the usual sort of enquiries to which De Morgan was accustomed from his (male) students.

For a start, Lovelace had a keen eye for detail, spotting several typos and other errors in De Morgan's published works. Charles Babbage later recalled that, during the composition of the 1843 paper, when he provided the underlying algebra for the Bernoulli numbers algorithm, Lovelace had "detected a grave mistake which I had made in the process" [1, p. 136]. This critical eye resulted in significant independence of thought throughout her studies, for example when she refused to accept De Morgan's proof of the binomial theorem because of its reliance on the so-called "Principle of the Permanence of Equivalent Forms", an unproved (and now discredited) assumption then commonly used in algebra. It also led her to a prescient speculation, prompted by her introduction to the two-dimensional representation of complex numbers: "It cannot help striking me that this extension of Algebra ought to lead to a further extension similar in nature, to Geometry in Three-Dimensions; & that again perhaps to a further extension into some unknown region, & so on ad-infinitum possibly" [3, p. 219]. This was a strikingly accurate prediction, foreshadowing by two years the discovery of quaternions, which in turn gave rise to vectors, now used in the study of n-dimensional space. For a relative beginner in mathematics, Lovelace showed remarkable foresight.

Lovelace's correspondence course with De Morgan appears to have ended in late 1841, or possibly early 1842, but by that time she had learned all the mathematics necessary for her computational algorithm for the Bernoulli numbers: the algebra of functions, infinite series, and the calculus of finite differences. By the summer of 1843, as she wrote in a letter to Babbage, she was working "like the Devil" [8, p. 216] on her paper on his analytical engine. It was published in September, and Lovelace wrote excitedly about what further mathematical projects she would like to undertake in the future. She had already expressed an interest in the mathematical analysis of games like solitaire, and in 1844 she wrote of her hope to "bequeath to the generations a Calculus of the Nervous System" [3, p. 228]. But none of these grand ideas were realized. Her subsequent years were plagued by ill health and financial worries. By 1852, her condition had worsened and it was discovered that she was suffering from cancer of the uterus. She finally succumbed on 27 November of that year.

Our research into Ada Lovelace has not only revealed far more detail about the actual mathematics she studied, but our study of the original manuscripts has also helped to restore her mathematical reputation by revealing some key historical errors made by earlier scholars. The details can be found in our two papers [3] and [4], while those looking for an easy read (or a gift for a non-mathematical friend!) might enjoy our expository book [5], lavishly illustrated with over 50 color images relating to her life and work (see Figure 3). Finally, for those who really like to get their hands dirty, high-quality images (plus transcriptions) of all of the letters in the Lovelace-De Morgan correspondence may be viewed online at: https://www.claymath.org/content/correspondence-de-morgan-0.

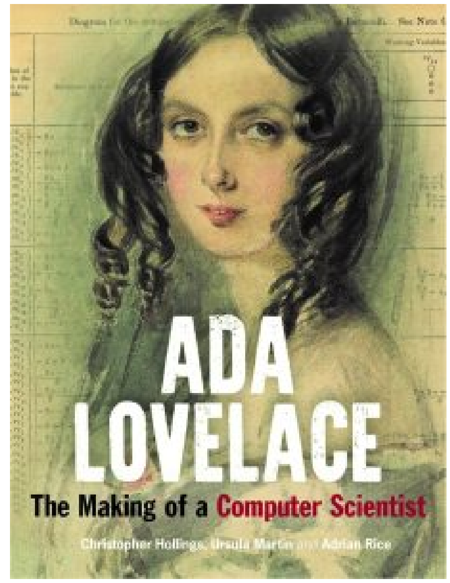


Figure 3. Cover of *Ada Lovelace: The Making of a Computer Scientist*.

This recent research—plus the many other publications that continue to appear on the subject—attests to the fact that the life and work of Ada Lovelace are still of great interest to mathematicians, computer scientists, and the public at large. So perhaps her greatest mathematical achievement is that she continues to attract scholarly attention, not only in the mathematics she actually produced, but in the possibilities of what might have been.

Adrian Rice *is the Dorothy and Muscoe Garnett Professor of Mathematics at Randolph-Macon College in Ashland, Virginia, USA. His research focuses on the history of mathematics, specifically the development of algebra, analysis and logic in 19th- and early 20th-century Britain. He was awarded the Paul R. Halmos-Lester R. Ford Award for expository excellence by the Mathematical Association of America in 2019 for his article "Partnership, Partition, and Proof: The Path to the Hardy-Ramanujan Partition Formula", published in* The American Mathematical Monthly *in 2018.*

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R. Scheidler and R. Woodrow

Richard Guy at Mount Assiniboine on his 90th Birthday, 2006.

We mourn the loss of Richard Kenneth Guy who passed away on March 9, 2020, at the impressive age of 103. Richard was a mathematical giant who made enormous and lasting contributions to our discipline. Active till the end, he was a distinguished researcher, a passionate educator, a generous philanthropist and an avid mountaineer. To us, he was also a valued colleague, mentor and friend.

This collection of contributions from colleagues and former students at the University of Calgary recounts some of Richard's involvement in research and mentorship, with special emphasis on the more than 13 years of his life after ninety. Richard's interests were too diverse and his contributions too numerous to do them all justice in one article. As a result, we chose to focus on three main areas of mathematics, drawing from experts in these fields for their recollections and perspectives on Richard's impact. A section on combinatorial game theory was provided by Richard's former doctoral student Richard Nowakowski. Richard's University of Calgary colleague Tibor (Ted) Bisztriczky supplied a section on geometry. A section on number theory was written by Richard's Calgary colleagues Mike Jacobson, Hugh Williams and the first author. Outreach and mentorship were equally important to Richard as research, and he has inspired many young scholars. We solicited input from two of his former University of Calgary protégés, Alex Fink and Julian Salazar, with whom he kept in contact until the last weeks of his life. We have also included a brief itemized biography and a short epilogue offering insight into other aspects of Richard's life both in and outside mathematics.

We thank all the contributors and are indebted to Claude Levesque (Université Laval) for providing the French translation of the English original. The photographs herein are courtesy of the University of Calgary, Ted Bisztriczky, Yanmei Fei, Jane Lancaster, Chic Scott, Hugh Williams and the first author.

This brief itemized biography highlights milestones in Richard's life. Much of it is drawn from the delightful book Young at Heart – The Inspirational Lives of Richard and Louise Guy (The Alpine Club of Canada, Canmore 2012) by Chic Scott, author, mountaineer and long-time friend of the Guys.

- Richard is born on September 30, 1916, in Nuneaton, Warwickshire (UK)
- BSc 1938 and MSc 1941 from Cambridge; Teacher diploma in 1939 from Birmingham
- Taught at Stockport Grammar School near Manchester 1939-1941
- Married Nancy Louise Thirian on December 21, 1940; three children (Elizabeth Anne, Michael, Peter)
- Meteorologist with the Royal Air Force (rank of Flight Lieutenant) 1941-1946; posted in Scotland, Iceland and Bermuda
- Taught again at Stockport Grammar School 1946-1947
- Taught at Goldsmith's College (a teacher training college) in London 1947-1951
- Faculty member at the University of Malaya, Singapore, 1951-1961
- Faculty member at IIT Delhi 1962-1965
- Faculty member at the University of Calgary 1965-1982, Professor Emeritus since 1982
- Honorary Doctor of Laws degree from University of Calgary 1991
- Richard and Louise Guy Lecture Series endowed as a gift from Louise to Richard for his 90th birthday, 2006
- Louise passes away at age 92 on September 30, 2010, on Richard's 94th birthday
- Richard and Louise Guy Hut in Yoho National Park opens its doors to overnight backcountry skiers, 2016
- City of Calgary Top 7 Over 70 Award and Immigrants of Distinction Lifetime Achievement Award, 2017
- Last "Climb for Wilderness" for the *Alberta Wilderness Association* on April 27, 2019
- Richard passes away on March 9, 2020

Renate Scheidler *is a Professor in the Department of Mathematics and Statistics and the Department of Computer Science at the University of Calgary. Her area of research is number theory, with a particular interest in algorithms and computations in global fields in the context of algebraic number theory, arithmetic geometry and cryptography.*

Robert Woodrow *is a Faculty Professor and Professor Emeritus in the Department of Mathematics and Statistics at the University of Calgary. His research interests include logic and graph theory, specifically the theory of relations, homogenous structures, ordered sets and Ramsey theory.*

R. Nowakowski

Richard K. Guy is chiefly responsible for the existence of Combinatorial Game Theory. Although he was not as prolific in game theory as in his other fields, he was a promoter behind the scenes and a mentor to many people.

Extending the Impartial Theory. Through his interest in chess, in 1947, Richard met T. R. Dawson who showed him a chess puzzle with pawns, now known as Dawson's Chess. Dawson proposed it as a misère problem (last player to move loses). Richard mis-remembered and solved the last-player-to-move-wins game. (This is a well-traveled path for starting a research career. As a 3rd year undergraduate, I misunderstood one of Richard's number theory homework problems. Richard turned my solution into my first research paper.) At that time, Richard didn't know about the work of Grundy or Sprague on impartial games. Independently, he went on to develop the theory. He was advised to contact C. A. B. Smith. Smith knew about the Sprague-Grundy theory and realized that Richard had shown that the theory was not just a curiosity but applied generally. Moreover, Richard had discovered octal games: essentially, the rules define what a player can remove from a heap and when the remainder can be split into two heaps. This class generated many intriguing conjectures and created combinatorial game theory as a research topic. Indeed, the most important conjecture—the sequence of values for every finite octal game is periodic—is still unsolved today. Richard was still pushing the boundaries of game theory at 90 [Fink and Guy 07].

Richard at work at Amiskwi Lodge near Golden, British Columbia, 1998

Assembling the Cast and Winning Ways. John H. Conway knew Richard's son Michael, who was also at Cambridge. Michael passed on to John all he knew about games. John was keen to learn more and a lifetime friendship and collaboration started. John asked about partizan games but it was many years before anyone had an answer. Elwyn Berlekamp had used the Guy-Smith paper [Guy and Smith 56] to further the analysis of Dots-and-Boxes. In 1967, Elwyn suggested that they write a book about games and Richard suggested John Conway be included. Winning Ways [Berlekamp et al 82] was finally published in 1982. This book is still as inspirational today as it was then and a must-read for any 'serious' student of combinatorial games. It contains many nuggets of wisdom, insights that have not been fully explored, and questions that direct research today. Of course, the book is not 'serious'. It contains much of Richard's (and John's) word play. Richard firmly believed that the right terminology and phraseology were important for motivation and to help people remember and understand concepts.

Promotion. After the publication of Winning Ways, Richard was involved in expounding the theory. In addition to innumerable talks, he organized and edited the Lecture Notes of the 1990 AMS Short Course on Combinatorial Games [Guy 92]. He helped organize the first MSRI and BIRS conferences on the subject. These led to the book series Games of No Chance which continues today. Richard wrote two of the first expository articles in the first book [Guy 96a, Guy 96b] and they are still well-worth reading. He also collated problems and wrote the first four Unsolved Problems in Combinatorial Game Theory articles for the series [Guy 96c]. A little known and hard-to-get gem is Richard's book Fair Game [Guy 89] which is an excellent introduction to impartial games.

Final Note. Richard K. Guy was great to be around. He was enthusiastic, always willing to roll up his sleeves and get stuck in. I owe my outlook on how and why to do mathematics, and the enjoyment I have obtained from my career, to him.

Richard Nowakowski, *Professor Emeritus in the Department of Mathematics and Statistics at Dalhousie University and a foremost expert on combinatorial game theory, obtained his PhD from the University of Calgary in 1978 under Richard Guy's supervision.*

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T. Bisztriczky

Richard Guy's research in Geometry was motivated by (1) the connections between elementary number theory and geometry, and (2) the many geometrical problems that are intuitive (in the sense of easy to state) or appealing to students and teachers (in math camps and competitions). His contributions to the field follow the style of such British geometers as D.M. Sommerville and H.F. Baker. The latter is best known to us via his six volume Principles of Geometry [Baker 10] and An Introduction to Plane Geometry [Baker 71]

As examples of (1), we have *The Lighthouse Theorem, Morley & Malfatti — a budget of paradoxes* [Guy 07] and *Triangle-rectangle pairs with a common area and a common perimeter* [Bremner and Guy 06]. In the former, Richard notes that "the combination of geometry and number theory is dear to my heart", and the combination here is between integer-edge triangles and primes $p > 7$ with the property that $p = 3n+1$ and $p^6 = a^2+4762800b^2$ for unique integers $|a|$ and $|b|$. In the latter, he and Andrew Bremner show that such triangle-rectangle pairs are parametrized by a family of elliptic curves.

Special Session on Discrete Geometry and Convexity, Joint Math Meetings, Atlanta 2017

Regarding (2), we refer to Richard's many contributions to the Problem Sections of the A.M.Monthly and the Math. Magazine, and to his book with H. Croft and K. Falconer, *Unsolved Problems in Geometry* [Croft et al 94]. As W. Moser foretold in his AMS review of the text [Moser 94], the volume became a sourcebook for anyone wishing to do research in intuitive (convex, discrete and combinatorial) geometry.

Richard K. Guy was an ideal colleague: very knowledgeable, always supportive and unfailingly kind. With his office door always open and his ever willingness to provide counsel and exchange ideas, he was very much an epitome of the cinematic venerable professor. We are grateful for the many decades that he was with us.

Tibor (Ted) Bisztriczky *is a Faculty Professor and a Professor Emeritus in the Department of Mathematics and Statistics at the University of Calgary. His research interests include convex and discrete geometry, particularly the study of polytopes. He and Richard were colleagues for over forty years, and shared a corridor for the last thirty.*

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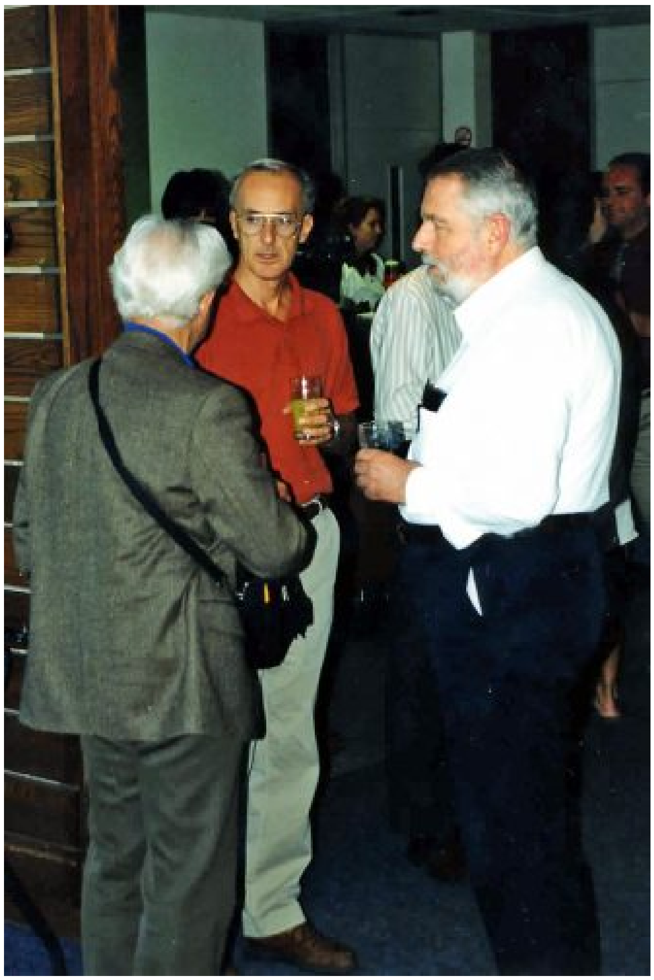
Richard Guy and Number Theory

Richard Kenneth Guy (1916 - 2020) September 2020 (Vol. 52, No. 4)

M. J. Jacobson Jr., R. Scheidler and H. C. Williams

Even as a small child Richard Guy was fascinated by numbers. When he was 17, he purchased a copy of Dickson's encyclopaedic *History of the Theory of Numbers* [Dickson 66] and fell under its spell. The cost of this book at the time was 6 guineas, a lot of money—more than he paid for his Master's degree from Cambridge. Dickson's history continued to exert a strong influence on Richard throughout his academic life. He published his first significant paper in number theory in 1958 [Guy 58]. Arguably, no work of Richard's exemplifies his love of numbers more than his wonderful *Book of Numbers*, joint with John H. Conway [Conway and Guy 96]. Richard's substantial volume of published works in number theory include some 50 coauthors, among them Elwin Berlekamp, John Conway, Paul Erdös, Derrick Lehmer, Yuri Matiyasevich, Alexander Oppenheim, John Selfridge, and Daniel Shanks. His predominant number theoretic interest was in integer sequences in any form or context, including their appearance in combinatorics, geometry and Diophantine problems. Richard's contributions to the field are too numerous to allow a complete account here, so we only provide some examples of his work, with special attention to research he conducted in his late 90s and beyond.



Richard, Andrew Bremner and John Selfridge at CNTA-VI, Winnipeg, 2006

Arguably, no work of Richard's exemplifies his love of numbers more than his wonderful Book of Numbers, joint with John H. Conway

Aliquot sequences were a particular life-long passion of Richard's. These are iterates n, $s(n)$, $s(s(n))$, … , $s^{(k)}(n)$ of the sum of proper (or aliquot) divisors function $s(n) = \sigma(n) - n$, for n a positive integer. Catalan [Catalan 88], later corrected by Dickson [Dickson 13], conjectured that all aliquot sequences terminate or become periodic and are hence bounded. The smallest integer for which this conjecture remains unsettled is $n = 276$; as of the time of writing this article, its aliquot sequence has been computed to 2139 terms and the 2140th term is composite and known to have a(n as yet unfactored) divisor of 213 decimal digits. In a series of reports published in the 1970s, Richard and John Selfridge discovered that under certain conditions aliquot sequences can become quite long. This led them to propose a counter-conjecture in 1975 [Guy and Selfridge 75] that many, perhaps almost all, sequences for even n diverge. The question of which conjecture is correct remains unresolved.

Richard was keenly interested in evangelizing his conjecture and continued to work on it to the end. A 2012 result of Bosma and Kane [Bosma and Kane 12] shows that the geometric mean (over all n) of the *amplification* $s(2n)/2n$ is less than 1, thus suggesting that the terms of an aliquot sequence tend to decrease on average. Richard believed that this finding does not capture the true nature of aliquot sequences because it does not take into account how frequently (if ever) an integer occurs as a value $s(2n)$, and it fails to account for the *guides* and *drivers* described in [Guy and Selfridge 75]. These are certain divisors of $s^{(k)}(n)$ that persist from one term to another with high probability and that in almost all cases cause the sequence to increase. Indeed, Pomerance [Pomerance 18] showed that the geometric mean of $s(n)/n$ for $n \equiv 2 \pmod 4$ is less than 1, whereas it exceeds 1 for $n \equiv 0 \pmod 4$.

With further analytic results seemingly out of reach for the time being, Richard instead turned to a quest for stronger numerical evidence supporting his point of view. Mike Jacobson recounts how Richard began to subtly recruit him to join in this cause, beginning with an e-mail with the rather cryptic subject line "Would you like to factor a number?" The number was of course factored, and when asked what this was about, Richard gladly offered an explanation that began as follows:

> *I'm calculating an aliquot sequence. This is rather a lost cause, but it has grabbed me from even before a bright young undergrad named Jeff Lagarias was introduced to me by Danny Kleitman long years ago at MIT. Selfridge and I devoted thousands of hours on two Olivettis, and Mike Williams used a more sophisticated machine down in the basement of this building [the Mathematical Sciences building at the University of Calgary], when it was only four stories high.*

Jacobson describes how at any time, Richard's office computer showed at least one open window actively computing terms of some aliquot sequence and performing the necessary factorizations. At the time of the initial request to Jacobson, Richard was using Pari/GP to manually iterate the aliquot sequence for $n = 99225$ because, again in his words, "the smallest odd number which shows any signs of getting to infinity is 99225". He had extended this sequence to well over 700 terms and regularly needed to factor integers of over 100 decimal digits. Jacobson eventually automated the factorization process for Richard and helped him extend the sequence to more than 3400 terms, which led to an even more ambitious project. In 1976, Richard had written a survey of then state-of-the-art integer factorization methods [Guy 76] that became very influential with the advent of the RSA cryptosystem in 1978. Following earlier computations undertaken by Richard's former Master's student Stan Devitt in 1976 [Devitt 76] that were surely inspired by Richard's survey, Richard, Jacobson and then Calgary students Kevin Chum and Anton Mosunov performed extensive computations of the geometric mean of $s(n)/n$ by modeling an aliquot sequence as a Markov chain [Chum et. al. 18]. To Richard's delight, along with a variety of other related numerical results capturing data of actual aliquot sequences, these computations provide empirical evidence that the geometric mean of $s(n)/n$ in fact exceeds 1, exactly as he had hoped and predicted. Work on the Guy-Selfridge conjecture by Jacobson and his students is ongoing.

Richard was fond of finding arrangements of numbers subject to certain constraints governing neighbour relationships. He was intrigued by the simplicity of such questions and the frequent immense difficulty of proving even the simplest existence or counting results on such arrangements. Richard was convinced that for all sufficiently large n, there exist permutations of the integers 1, 2, … , n such that any two adjacent entries sum to a square, cube, triangular or pentagonal number, or any "reasonable" polynomial in n. The square case was only recently settled by R. Gerbitz [Gerbitz 2018] who established an affirmative answer for all $n \geq 25$ ($n \geq 32$ for circular arrangements). All other cases remain wide open. In a delightful manuscript entitled "Fibonacci plays Billiards" [Berlekamp and Guy 03], Elwin Berlekamp and Richard gave a complete characterization of values n that admit permutations of the first n positive integers such that any two neighbours sum to a Fibonacci or Lucas number. The title stems from a methodology that facilitates the search for number arrangements by placing the numbers 1, 2, … , n on the perimeter of a billiard table and considering paths of billiard balls as they bounce off the corresponding points on its cushions at a 45 degree angle. In the summer of 2017, then centenarian Richard, with help from Calgary colleague Renate Scheidler, recruited Ethan White, an undergraduate student at the time, to look into analogous problems where sums are replaced by absolute differences. Eventually, they settled on the question of circular arrangements where the absolute difference of any two adjacent terms takes on one of two fixed given values a or b. Aided by White's computations, they employed Richard's number wall [Conway and Guy 96, pp. 85-89] to try to discover linear recurrences for the counts $N_{a,b}(n)$ of such arrangements of length n. They found explicit recurrence relations for the pairs $(a,b) = (1,2)$, $(1,3)$, $(2,3)$, $(1,4)$ and eventually employed the graph theoretic transfer matrix method to prove that $N_{a,b}(n)$ satisfies a linear recurrence relation whenever such arrangements exist for a given pair (a,b) [White et al 20].

Richard was also interested in Diophantine problems, particularly the question of whether integers could be represented by certain types of equations. A *Diophantine equation* is an equation for which solutions are restricted to the integers or rational numbers; for example, $(x,y) = (8,3)$ is a solution to the Diophantine equation $x^2 - 7y^2 = 1$. Richard began a long-term collaboration in this area with Andrew Bremner in the late 1980s that lasted more than 15 years. In 1993 Bremner, Richard and Richard Nowakowski settled the question, first posed by Melvyn J. Knight, of which integers n can be represented in the form

$$n = (x+y+z)(1/x+1/y+1/z),$$

with integers x, y, z [Bremner et al 93]. For example, for $n = 62$, we have the solution $x = 5075$, $y = 128050$, $z = 160602$. They found that this question reduces to the problem of finding integer points on a certain elliptic curve with rational 2-torsion and computed the Mordell-Weil rank of this curve for all n with $|n| \leq 1000$.

Integer sequences in the context of geometry also appealed to Richard. An example of a question of this flavour is the problem of tiling a $4\times(n-1)$ rectangle with dominos (1×2 tiles). Richard knew that the sequence $(A_n)_{n\geq 0}$ representing the number of distinct such tilings satisfies the fourth order linear recurrence

$$A_k = A_{k-1} + 5A_{k-2} + A_{k-3} - A_{k-4}$$

with $A_0 = 0$, $A_1 = 1$, $A_2 = 1$, $A_3 = 5$, $A_4 = 11$, $A_5 = 36$, etc. He noticed that the sequence $(A_n)_{n \geq 0}$ seemed to be a divisibility sequence (A_n divides A_m whenever n divides m). This observation led to a collaboration with Hugh Williams and his former doctoral student Eric Roettger that produced a series of papers [Roettger et al 13, Roettger et al 15, Williams and Guy 15], culminating with a solution to Lucas' unsolved problem of generalizing the Lucas sequences to the setting of higher order recurrences.

Over several decades, somewhat simultaneously with the conception and writing of John Conway's renowned *Triangle Book* [Conway and Sigur 15], Richard compiled and proved a comprehensive body of results in a monograph simply entitled *The Triangle* [Guy 20]. In addition to a wealth of number theoretic and geometric facts about triangles, this 240 page work contains a collection of exquisite figures, all meticulously produced through Richard's wizard mastery of LaTeX. Richard was captivated in particular by the following construction, explained and beautifully illustrated on pp. 43 ff [Guy 20]. For a triangle *ABC*, take any point *P* on its circumcircle and reflect it on the edge *BC* to obtain a point *A'* that defines a new triangle *A'BC*. Intersect the perpendicular to the edge *BC* with the circumcircle of this new triangle to obtain a point *P'*. Similarly, reflect *P* on the edges *AB* and *BC* to obtain triangles *AB'C* and *ABC'* and points *Q'*, *R'*. The three points *P'*, *Q'*, *R'* lie on a *Steiner line* parallel to the *Wallace line* of *P* and twice its distance to *P*. Repeat the entire process starting with *P'*, *Q'*, *R'* to generate 9 further points etc. Richard likened this construction to computing scalar multiples of a given fixed point on an elliptic curve and was curious about the behaviour of this *trisequence*, particularly the possibility of periodicity. Richard credits Andrew Bremner with the discovery of four 3-cycles and subsequently Alex Fink, whom he mentored during Alex's undergraduate years at Calgary, for observing that every starting point *P* leads to three 6-cycles.

The University of Calgary's Department of Mathematics and Statistics celebrates Richard's 100th birthday, 2016

Richard had a phenomenal gift for pattern recognition and an uncanny ability of separating the grain of beautiful number theoretic structure from the chaff of coincidental similarities. In the course of his investigations of various sequences, Richard discovered what he wittily referred to as "The Strong Law of Small Numbers". In his very engaging and influential paper of the same title [Guy 88], he discussed 35 examples of patterns that seem to appear when we check small values of *n*. Some work, but many don't. He concluded that there aren't enough small numbers to meet the many demands made of them. He followed this paper two years later with his second law [Guy 90] which states "When two numbers look equal it ain't necessarily so." Both these papers should be required reading by any graduate student of mathematics.

One of Richard's most lasting contributions to the field is his monograph *Unsolved Problems in Number Theory* [Guy 04]. A marvellous compilation of number theoretic problems and commentary that has gone through three editions and is instantly infectious, this remarkable book has stimulated generations of aspiring number theorists, several of whom have gone on to have stellar careers, and continues to be a source of inspiration for scholars and in the field.

Michael J. Jacobson, Jr. *is a Professor in the Department of Computer Science at the University of Calgary, conducting research in cryptography and computational number theory, with particular focus on algorithms in global fields.*

Hugh C. Williams *is a Professor Emeritus in the Department of Mathematics and Statistics and the former iCORE Chair in Algorithmic Number Theory and Cryptography at the University of Calgary as well as Professor Emeritus in the Department of Computer Science at the University of Manitoba. His research interests include computational number theory, cryptography and the history of mathematics and computation.*

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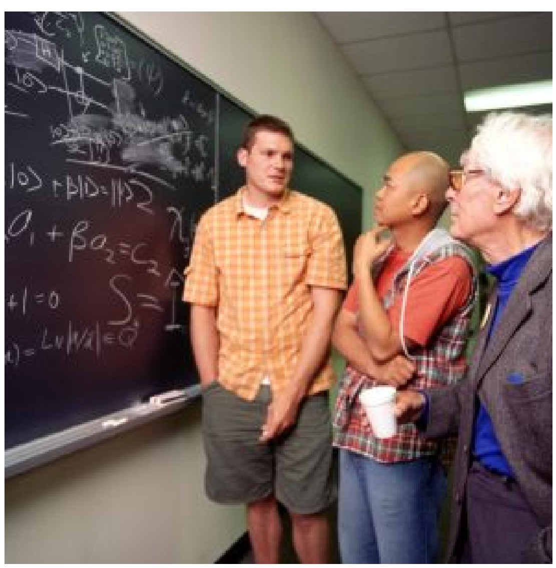
R. Scheidler, based in part on accounts by A. Fink and J. Salazar

Richard Guy was a dedicated educator and mentor to students of all ages. He considered his efforts in this area at least as important as his research contributions. He supervised graduate students until 2002, when he was 86, and undergraduates until the age of 101. Even as a centenarian, Richard participated in the weekly gathering of the Calgary number theory faculty and students, where he would pose problems, ranging from challenging to recreational, and gently but inevitably tempt at least one student into pursuing the problem further or crunching some numbers for him.

Until well into his 90s, Richard was a regular at Wednesday's Calgary *Math Nites*, a weekly enrichment program where faculty members and graduate students expose grade 7-10 students to mathematical discovery and engage them in problem solving. It was there that Richard met two of his most successful charges who kept in contact and collaborated with him until the end: Alex Fink, now a faculty member at Queen Mary University of London, and Julian Salazar, who obtained a BA in Mathematics and a secondary concentration in computer science from Harvard in 2017 and went on to embark on a career in machine learning with Amazon.

Alex Fink attended *Math Nites* starting in grade 4. While in high school, Richard invited him to attend his reading course in combinatorial game theory. Fink went on to train with Richard for the Putnam exam and, supported by two NSERC USRAs, conduct research under Richard' supervision. After completing his undergraduate education at the University of Calgary, he continued to keep in touch with Richard in person and online. "There was a lot to finish at that point", Fink comments. Between 2006 and 2017, he and Richard co-authored three research papers [Fink and Guy 07, Fink et al 08, Fink and Guy 17] and two expository articles [Fink et al 06, Fink and Guy 09]. Fink paraphrases some of the lessons learned from Richard early on:

> *"Have multiple balls in the air: it's good to have somewhere to turn when you hit a wall on project A, and your subconscious will be chipping away at project B in the meantime anyhow."*
>
> *"Write it all down. The easiest way to edit is to cut things out."*
>
> *"Go to conferences even before you have the background: it won't be a waste, you'll absorb some of the language and be better prepared for the next one."*
>
> *"Be careful of making (even implicit) assumptions that might alienate some of your audience. Hence never 'well-known', always 'well-known to those who well know it'."*



Richard with two University of Calgary graduate students, 2003

Julian Salazar recalls feeling welcome from Richard's first e-mail reply and describes their meetings as socratic. "He [Richard] just patiently described what he was thinking about, I'd ask questions, he'd ask them back. After 1-2 years of casual chats, he asked a question which I proved (our Theorem 7) on the train home. That moment, of devising something new, has defined much of my adult life." The work Salazar refers to is [Guy et al 14], published when he was 20 and Richard was 98. Richard provided financial support for Salazar to attend and present at MathFest and took him for dinner with Noam Elkies who later became Salazar's senior thesis advisor at Harvard. Salazar notes that Richard "pursued problems because they were interesting; not because they were technically challenging or trendy" and credits Richard with the lesson to "do what you enjoy, independent of the credentials or the default path".

Alex Fink *is a Reader in Pure Mathematics at Queen Mary University of London. His research centres on algebraic combinatorics, with emphasis on applications of commutative algebra or algebraic geometry to the field, including matroid theory and tropical geometry. He obtained BSc Honours degrees in Pure Mathematics and Computer Science from the University of Calgary in 2006 and a PhD from UC Berkeley in 2010.*

Julian Salazar *is a Machine Learning Scientist at Amazon AWS AI, working on deep learning for human language, especially speech recognition (ASR) and natural language processing. Academically, he is interested in the intersection of pure math with other fields, including computer science, neuroscience and string theory. He grew up in Calgary.*

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Richard and Louise at Assiniboine Lodge in British Columbia on Richard's 90th birthday

While this collection of contributions focused on Richard's years as a mathematician at the University of Calgary, it would be amiss not to include a few observations about other aspects of his rich and multi-faceted life. Richard's other great love, besides mathematics, was Louise, his wife of some 70 years. Richard and Louise were pioneers in many ways. In the 1950s and 60s, at a time when — contrary to today — academic career moves across countries and continents were highly unusual, they spent 13 years in Singapore and India where Richard taught university mathematics. Louise and Richard were outspoken pacifists during Cold War times when such sentiments were not always welcome. They were ardent mountaineers and shared a passion for nature and conservation long before the modern environmental movement received traction. Many of the much younger colleagues hired during Richard's tenure as Head of Calgary's Department of Mathematics and Statistics recall back-country hikes in the Canadian Rockies where they would see Louise and Richard zip past them on the trail.

Richard and Louise were also generous philanthropists who supported many causes in service of mathematics and life outdoors. They were life-long active members of the Alpine Club of Canada and the Calgary Mountain Club. In 2016, a backcountry ski hut in Yoho National Park named in honour of the Guys opened its doors to backcountry skiers, thanks in large part to a substantial donation by Richard in memory of Louise. Their participation in the annual Calgary Tower climbs to raise funds for the Alberta Wilderness Association, continued by Richard on his own until the age of 102, carrying along a photo of Louise after her death, are legendary in Calgary and among the Alberta outdoors community. During the 1980s, through the dedication and generosity of the Guys, the University of Calgary acquired the Eugene Strens Recreational Mathematics Collection of books, periodicals, puzzles and manuscripts dating from the 17th to the 20th century. In 2006, as a gift to Richard for his 90th birthday, Louise endowed the Richard and Louse Guy Lecture Series, featuring annual public talks by an impressive collection of the world's finest mathematicians.

A memorial scholarship in Richard's name was endowed by his friends and colleagues in March 2020. We leave the reader with some links to what others have said about Richard's life in and outside mathematics.

- Richard's obituary in the Calgary Herald
- University of Calgary remembers Richard Guy
- Chic Scott's chronicle of Richard's life for the Alpine Club of Canada
- Top 7 over 70 – Richard's last Calgary Tower Climb 2019
- Antony Bonato's 2017 interview of Richard
- Richard and Louise Guy Lecture Series
- Strens Recreational Mathematics Collection
- Dr. Richard Guy Memorial Scholarship in Mathematics

The CMS Research Committee is inviting nominations for three prize lectureships. These prize lectureships are intended to recognize members of the Canadian mathematical community.

Coxeter-James Prize

The **Coxeter-James Prize** recognizes young mathematicians who have made outstanding contributions to mathematical research. The recipient shall be a member of the Canadian mathematical community. Nominations may be made up to ten years from the candidate's Ph.D. A nomination can be updated and will remain active for a second year unless the original nomination is made in the tenth year from the candidate's Ph.D. The selected candidate will deliver the prize lecture at the 2021 Winter Meeting.

Jeffery Williams Prize

The **Jeffery-Williams Prize** recognizes mathematicians who have made outstanding and sustained contributions to mathematical research. The recipient shall be a member of the Canadian mathematical community. A nomination can be updated and will remain active for three years. The prize lecture will be delivered at the 2021 Summer Meeting.

Krieger-Nelson Prize

The **Krieger-Nelson Prize** recognizes outstanding research by a female mathematician. The recipient shall be a member of the Canadian mathematical community. A nomination can be updated and will remain active for two years. The selected candidate will deliver the prize lecture at the 2021 Summer Meeting.

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 for research in the mathematical sciences regardless of race, gender, ethnicity or sexual orientation. A candidate can be nominated for more than one research prize in the applicable categories; several candidates from the same institution can be nominated for the same research prize.

CMS research prizes are gender-neutral, except for the Krieger-Nelson prize, which is awarded to women only. Nominations of eligible women for the general research prizes in addition to the Krieger-Nelson Prize are strongly encouraged.

The Research Committee of the CMS reserves the right to consider a nomination for one of the three research prizes for any other, applicable prize.

Nominations Requirements

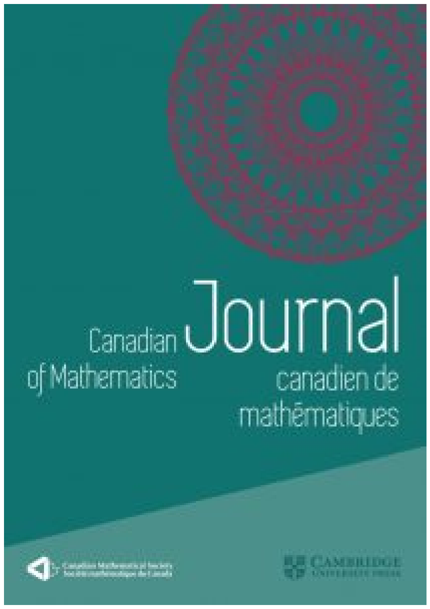
The deadline for nominations, including at least three letters of reference, is **September 30, 2020**. Nomination letters should list the chosen referees and include a recent curriculum vitae for the nominee. Some arms-length referees are strongly encouraged. Nominations and the reference letters from the chosen referees should be submitted electronically, preferably in PDF format, to the corresponding email address and **no later than September 30, 2020**:

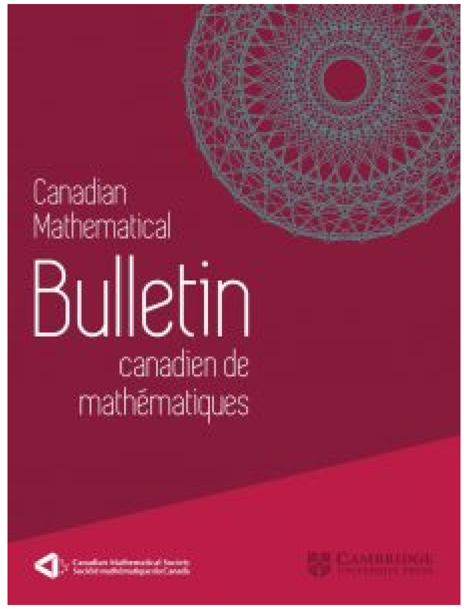
Coxeter-James: cjprize@cms.math.ca

Jeffery-Williams: jwprize@cms.math.ca

Krieger-Nelson: knprize@cms.math.ca

2021 CJM/CMB Associate Editors



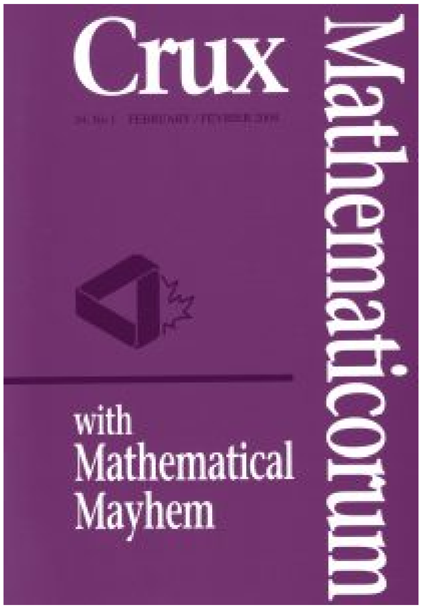


The Publications Committee of the CMS solicits nominations for Associate Editors for the *Canadian Journal of Mathematics* (CJM) and the *Canadian Mathematical Bulletin* (CMB). The appointment will be for five years beginning January 1, 2021. There are eight associate editors on the CJM/CMB Editorial Board whose mandates are ending at the end of December.

For over fifty years, the *Canadian Journal of Mathematics* (CJM) and the *Canadian Mathematical Bulletin* (CMB) have been the flagship research journals of the Society, devoted to publishing original research works of high standard. The CJM publishes longer papers with six issues per year and the CMB publishes shorter papers with four issues per year. CJM and CMB are supported by respective Editors-in-Chief and share a common Editorial Board.

Expressions of interest should include your curriculum vitae and your cover letter and sent electronically to: cjmcmb-ednom-2020@cms.math.ca **before September 15, 2020**.

2020 CRUX Associate Editors



Note: Deadline extended.

The CMS invites expressions of interest to fill Associate Editor positions for *Crux Mathematicorum (CRUX)*, the CMS international problem solving journal. *CRUX* is in the process of expanding the current compliment of editors on its editorial board to help with the growing number of submissions.

Anyone with an interest in problem solving is invited to forward an expression of interest, including a covering letter with, curriculum vitae, and an expression of views regarding the publication. The appointment will begin on October 1, 2020 until December 31, 2024.

Please submit your expression of interest to the Editor-in-Chief at **crux.eic@gmail.com** **no later than September 30, 2020**.

Nominations are invited for the inaugural 2021 Cathleen Synge Morawetz Prize for an author(s) of an outstanding research publication. A series of closely related publications can be considered if they are clearly connected and focused on the same topic. The recipient(s) shall be a member of or have close ties to the Canadian mathematical community, and will receive a commemorative plaque.

The Cathleen Synge Morawetz Prize will be awarded according to the following 6-year rotation of subject areas:

1. Geometry and Topology *(2021, and every six years thereafter)*,
2. Combinatorics, Discrete mathematics, Logic and foundations, and Mathematical Aspects of Computer Science *(2022 , and every six years thereafter)*,
3. Applied mathematics, including but not limited to Numerical Analysis and Scientific Computing, Control Theory and Optimization, and Applications of Mathematics in Science and Technology *(2023, and every six years thereafter)*,
4. Probability and Mathematical Physics *(2024, and every six years thereafter)*,
5. Algebra, Number theory, Algebraic geometry (2025, and every six years thereafter),
6. Analysis and Dynamical systems *(2026, and every six years thereafter)*.

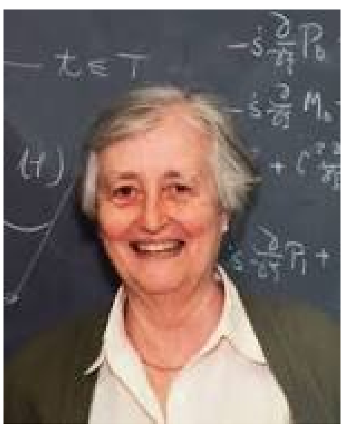
All of the above fields will be understood most broadly, to ensure that any outstanding publication can be considered under at least one of the categories. A paper (or a series of papers) which has significantly impacted more than one of the listed fields can be nominated more than once in the six-year rotation. The nomination must focus on a single topic, rather than a broad body of work by the nominee.

This inaugural call for nominations is for an author(s) of a publication or a series of closely related publications in the field of Geometry and Topology.

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 for research in the mathematical sciences regardless of race, gender, ethnicity or sexual orientation.

The nomination letter should highlight the research paper(s) being nominated, providing evidence of its impact and significance. The nomination letter should list the chosen referees, and should include a recent curriculum vitae of the nominee(s), if available. Up to three reference letters in support of the nomination should be sent directly to the CMS. All documents should be submitted electronically, preferably in PDF format and **no later than November 15, 2020**, to **csmprize@cms.math.ca**.

About the Award



The prize was established in 2020 in honour of Cathleen Synge Morawetz (1923-2017), to reflect the remarkable breadth and influence of her research achievements in pure and applied mathematics. Professor Morawetz completed her undergraduate studies at the University of Toronto. She was encouraged to pursue a PhD in Mathematics by Cecilia Krieger (of Krieger-Nelson Prize). She went to MIT for a master's degree, and then got her PhD at NYU, where she would spend the bulk of her career, becoming the director of Courant Institute in 1984. Her main research contributions were in the field of partial differential equations. Cathleen Synge Morawetz was a recipient of the Jeffery-Williams Prize in 1984 (the only woman to win the Prize up to date), the National Medal of Science (1998), the Leroy P. Steele Prize for Lifetime Achievement (2004) and the George David Birkhoff Prize in Applied Mathematics (2006). Through its explicit rotation among subject areas, this prize highlights the enormous spectrum of research in the Canadian mathematical sciences community.

2021 Excellence in Teaching Award

The CMS Excellence in Teaching Award Selection Committee invites nominations for the **2021 Excellence in Teaching Award**.

The **Excellence in Teaching Award** focuses on the recipient's proven excellence as a teacher at the undergraduate level, including at universities, colleges and cégeps, as exemplified by unusual effectiveness in the classroom and/or commitment and dedication to teaching and to students. The dossier should provide evidence of the effectiveness and impact of the nominee's teaching. The prize recognizes sustained and distinguished contributions in teaching at the post-secondary undergraduate level at a Canadian institution. Only full-time teachers or professors who have been at their institution for at least five years will be considered. The nomination will remain active for three years, with a possibility to update.

The 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.

A nomination will consist of:

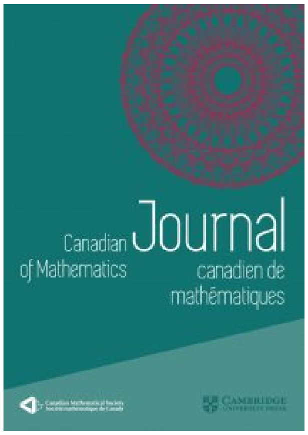
- a signed nominating statement from a present or past colleague, or collaborator (no more than three pages) having direct knowledge of the nominee's contribution;
- a curriculum vitae (maximum five pages);
- three letters of support, at least one from a former student (who has followed a course more than a year ago) and one from the chair of the nominee's unit. The letter of the Chair of the nominee's unit could include a one-page summary on information from student evaluations, or similar information;
- other supporting material (maximum 10 pages).

Nominations and reference letters should be submitted electronically, preferably in PDF format, to: **etaward@cms.math.ca** no later than the deadline of **November 15, 2020**.

2020 Excellence in Teaching Award Recipient

Joseph Khoury
University of Ottawa

Prof. Khoury is the most recent recipient of the award. For a list of past recipients and to read their citations, please visit the official Excellence in Teaching Award page.



The CMS invites expressions of interest for the Editor-in-Chief (EIC) of the *Canadian Journal of Mathematics* (CJM); **two Editors-in-Chief are being solicited**, with a five-year term to commence January 1, 2022 and some partial funding support from the CMS is available for both these EIC positions.

Since 1949, the *Canadian Journal of Mathematics* has been committed to publishing original mathematical research of high standard following rigorous academic peer review. New research papers are published continuously online and are collated into print issues six times each year. CJM and CMB (*Canadian Mathematical Bulletin*) are supported by respective Editors-in-Chief and share a common Editorial Board.

Expressions of interest should include a cover letter, your curriculum vitae, and an expression of views regarding the publication. Since being EIC of CJM is a large responsibility that may require a lessening of responsibilities in an individual's normal work, individuals should review their candidacy with their university department and include a letter of support.

Please submit your expression of interest electronically to: CJM-EIC-2020@cms.math.ca **before April 15, 2021**.

For more information, please contact us at the email address above.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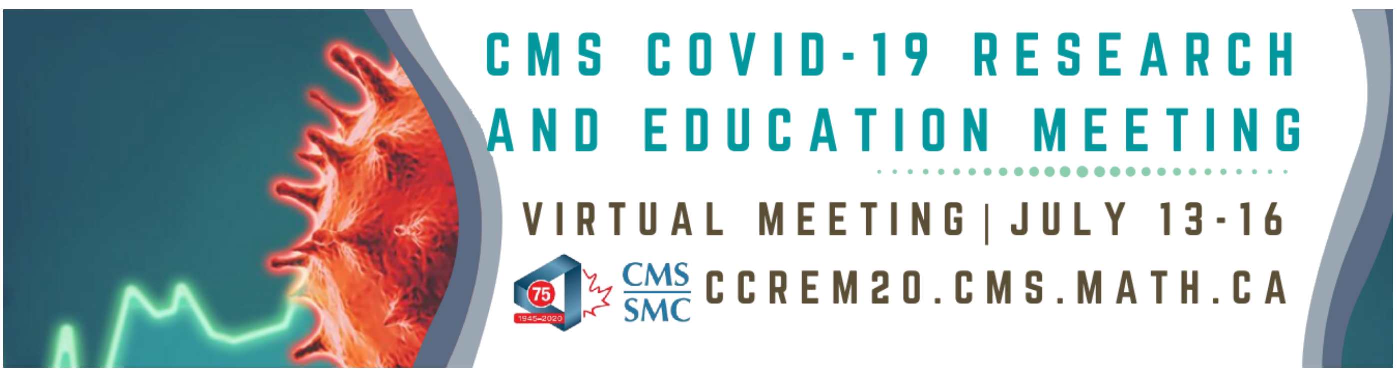
Summary of CMS COVID-19 Research and Education Meeting (CCREM)

Sarah Watson (CMS)
Meeting planner

The CMS had to postpone the 2020 CMS Summer Meeting planned for June due to the COVID-19 pandemic. In the absence of a physical meeting, and in light of the uncertainties in mathematics research, teaching and funding, the CMS wanted to provide a virtual platform for mathematicians to come together, share their concerns, anxieties, suggestions and learn together during this difficult time. We felt that a meeting focused on the changes caused by COVID-19 to the way we plan, teach and do research would be of great benefit to the Canadian mathematical community.

A committee was formed very quickly and the meeting was put together in 2 months thanks to the hard work and dedication of the organizing committee and the CMS office. The meeting was attended by 212 attendees and featured 4 plenary speakers including Stan Matwin (Dalhousie), Daniel Coombs (UBC), Pauline van den Driessche (Victoria), and Jim Fowler (Ohio State University). What made this meeting distinct was the prevalence of education sessions and the large presence of the math education community.

6 sessions and 2 panel sessions were held during the 4-day meeting. One of the panels was a joint session with Canadian Mathematics Education Study Group (CMESG) discussing What COVID might teach us about the broad strokes of student assessment. The CMESG/CMS session was co-hosted by Peter Taylor (Queen's) and Richelle Marynowski (Lethbridge) and had some focused thinking about student assessment. The other panel Voices of Diversity: Students in a University Math Classroom served as a forum to hear students' voices and discuss student support in this time of crisis. The panels encouraged attendees to turn on their video and join in the discussion. Indeed many did, and the participation in the discussion was so large that some sessions will be continued at the 2020 CMS Winter Meeting.



The other sessions included COVID-19 and Public Policies, The creative fallout from the Pandemic, K-12 Education Sessions, Design and Teaching of Online and Remote Mathematics Courses, Academic Integrity in the Remote Classroom, and Modelling in Biomathematics: COVID-19 and beyond.

To add to the virtual meeting experience, CCREM offered a Math Escape Adventure which came out with a new puzzle each day and a Math Code Names Social. In addition to these, there were virtual lounges set up for breaks and networking and an NSERC information session on NSERC's response to the COVID-19 pandemic including new funding opportunities and changes in policies for the NSERC discovery grants and scholarship fellowship programs.

The CMS would like to thank the lead organizers, Kseniya Garaschuk (UFV) and Julien Arino (Manitoba). We deeply appreciate their enthusiasm and the generosity with which they offered us their time. We would also like to thank the organizing committee for their dedication and hard work in such a short amount of time. Additionally, a big thank you to the sponsors including Fields Institute, Centre de recherches mathématiques (CRM), Pacific Institute for Mathematical Sciences (PIMS), Bolster Academy, Digital Ed and Wizedemy. We hope to see the you all in a few months at the 2020 CMS Winter Meeting, which will be held virtually this year.

We have been inundated with positive feedback from the attendees and are grateful for their participation and their enthusiasm. Below are some of the comments from the attendees the CMS received through our post-meeting survey:

I prefer the virtual meeting over a traditional meeting! Yes, we lose a little bit, but think how much more accessible the virtual meeting was. An in-person meeting has a strong cost in terms of money, time, and energy. In addition, I was only interested in a subset of the conference. I would not have considered attending if I had to travel (and have big expenses) but as a virtual meeting I was able to attend. I am glad I did.

Great selection of topics, compact scheduling, lively discussions: great event!

Wonderful way to bring the community together in this challenging time. excellent technical assistance.

It was pulled off well in the circumstances and I liked that even with the online platform there was still a sense of community.

I liked that it was all on one platform; my other online conferences this summer often relied on people emailing out links to attendees.

2020 CMS VIRTUAL Winter Meeting
December 3-8, 2020
Deadline: September 30

The Canadian Mathematical Society (CMS) welcomes and invites session proposals and mini course proposals for the 2020 CMS Virtual Winter Meeting in from December 3-8. For the safety of all members CMS has decided to make this meeting virtual. Given the capacity for additional sessions in a virtual meeting we are putting out a call for additional sessions. More information about the virtual meeting can be found on the meeting website: http://winter20.cms.math.ca.

CALL FOR SESSIONS

Proposals should include (1) names, affiliations, and contact information for all session co-organizers, (2) title and brief description of the focus and purpose of the session, (3) a preliminary list of potential speakers, with their affiliations and if they have agreed to participate, along with a total number of expected speakers.

Sessions will take place December 4, 5, 6, 7, and 8 for a half day (due to time zones). The meeting schedule will accommodate 11 speakers per full day on Friday, Monday and Tuesday, and 4 on Saturday, Sunday and Monday. Sessions will be advertised in the *CMS Notes*, on the web site and in the *AMS Notices*. Speakers will be requested to submit abstracts, which will be published on the web site and in the virtual meeting program. Those wishing to organize a session should send a proposal to the Scientific Directors and copy the CMS office. Those submitting proposals are encouraged to pay attention to the diversity of both the session invitees and the proposed session organizers.

New proposals should be submitted by September 30, 2020.

CALL FOR MINI COURSES

The CMS is organizing three-hour mini-courses to add more value to meetings and make them attractive for students and researchers to attend.

The mini-courses will be held on Thursday, December 3rd, before the public lecture, and include topics suitable for graduate students, postdocs and other interested parties.

Proposals should include names, affiliations, and contact information for all the mini course co-organizers and title and brief description of the focus of the mini course. Mini course facilitators do not need to pay a registration fee if they are not attending the remainder of the meeting.

Scientific Director:

Michael Lipnowski (McGill University) michael.lipnowski@mcgill.ca

Brent Pym (McGill University) brent.pym@mcgill.ca

CMS Office: meetings@cms.math.ca

Elmer Melvin Tory (1928-2020)

Dr. Elmer Melvin Tory, a life member of the CMS, passed away in May 2020. The Canadian mathematical community is saddened by this news and the Society offers its sincere condolences to his loved ones. We reproduce his obituary (which he wrote himself) for our readers.

Elmer Melvin Tory died unexpectedly at the age of 91. He was born in Vermilion Alberta on December 10, 1928 and spent the first years of his life on a farm north of Wainwright. The family moved to Wainwright where he obtained his elementary and high-school education. A high-school yearbook described him as the small boy with the huge brain.

He attended the University of Alberta, graduating with first-class honors in Chemistry. He won three honor prizes and the Scholarship of the Council of Jewish Women for the highest average in first-year Arts and Science. An I.O.D.E. Coronation Bursary paid almost all of his tuition for three years. Additional funds came from summer jobs and part-time work as a laboratory demonstrator.

He worked as a chemist at Aluminium Laboratories in Arvida (now part of Saguenay), Quebec, where he met Audrey Upton. They married in 1956. In 1958, he entered the graduate program at Purdue University, graduating in 1961 with a Ph. D. in Chemical Engineering with minors in Chemistry and Mathematics. He worked as an Assistant Professor of Chemical Engineering at McMaster University (1960-63) and Associate Chemical Engineer at Brookhaven National Laboratory (1963-65).

For the rest of his life, he was associated with the Department of Mathematics and Computer Science at Mount Allison University (Associate Professor 1965-73, Professor 1973-90, O. E. Smith Professor 1990-95, Professor Emeritus 1995-2020). Though he appreciated his contacts with students, his great passion was research. From his initial effort (published in the ATA Magazine when he was 17) to a jointly authored paper in his 87th year, he applied mathematics to explain natural phenomena. These included the propagation of concentration gradients in sedimenting suspensions, the nature of settling in compression, a Markov model for sedimentation, and random packing of circles, squares, and spheres. Especially notable are Tory plots, the Pickard-Tory process, and the Jodrey-Tory algorithm. The latter, published in 1985, is still a standard method for simulating dense random packing of spheres. He gave the Blundon Lecture at Atlantic Math Days in 1993.

Despite the demands of teaching, research, and studies, he participated in many other activities. He was editor of the high-school yearbook and class valedictorian. He enjoyed duplicate bridge and despite several long absences from the game, he achieved the rank of Bronze Life Master. He liked to play pool and had a full-size snooker table in his basement.

He was a lifelong supporter of the CCF-NDP and helped out in various capacities in many elections. He also championed many causes with letters to the editor. He contributed generously to local, national, and international charities. While teaching at McMaster University, he was on the executive of the Unitarian Church in Hamilton. At Mount Allison he served on many committees, including the Library Planning Committee, the Tenure and Promotion Committee, and the Joint Liaison Committee. He chaired the committee that produced the 'Tory Report'. He was President of the Federation of New Brunswick Faculty Associations (FNBFA), twice President of the Mount Allison Faculty Association, and twice Chief Negotiator for MAFA. In recognition of these services and his academic stature, he was awarded the Prix Nicole Raymond Award in 1995.

He was predeceased by his wife Audrey, sisters Marjorie Tory and Lucile Peacock, brothers Alan and Cecil, and daughter Heather Austin. He is survived by his son Kevin (Christine), grandsons Pavel and Michael, and several nieces and nephews

An informal time of remembrance will be held at a later date. Donations in memory of Dr. Tory may be made to Live Bait Theatre or Doctors Without Borders at https://bit.ly/3dndHDy

Arrangements are under the care and supervision of **Jones Funeral Home**, 70 Bridge Street, Sackville, NB (506-364-1300). Condolences may be submitted to the family by visiting their website at www.jonesfuneralhome.ca.

Veselin Jungic (Simon Fraser University)

Peter Borwein (1953-2020)

Peter Borwein's death on Sunday, August 23, 2020, will be felt as a personal loss for many mathematicians around the world. He was an exceptional person, a well-rounded intellectual, a creative and productive mathematician, a visionary leader, an inspiring teacher, and a generous mentor and collaborator.

Peter obtained his B.Sc. (1974) at the University of Western Ontario and his M.Sc. (1976) and Ph.D. (1979, under the supervision of David Boyd) at the University of British Columbia. In the spring of 1980, during his post-doctoral studies at Oxford University, Peter was offered a position at Dalhousie University.

It was at Dalhousie that Peter grew into his own as a mathematician. He began working closely with his older brother, Jonathan. Of their time at Dalhousie, Jonathan once commented, "We talked math for the first time in our lives and we made up for lost time." One of the outcomes of their collaboration was the book "Pi and the AGM." In his review, George Andrews wrote: "Fortunately we have the Borweins' beautiful book..." (As a side note, many years later I witnessed Peter proudly but also somewhat mischievously recite the slogan that he created during the 1988 strike at Dalhousie: "Building a better university – sorry for the inconvenience!")

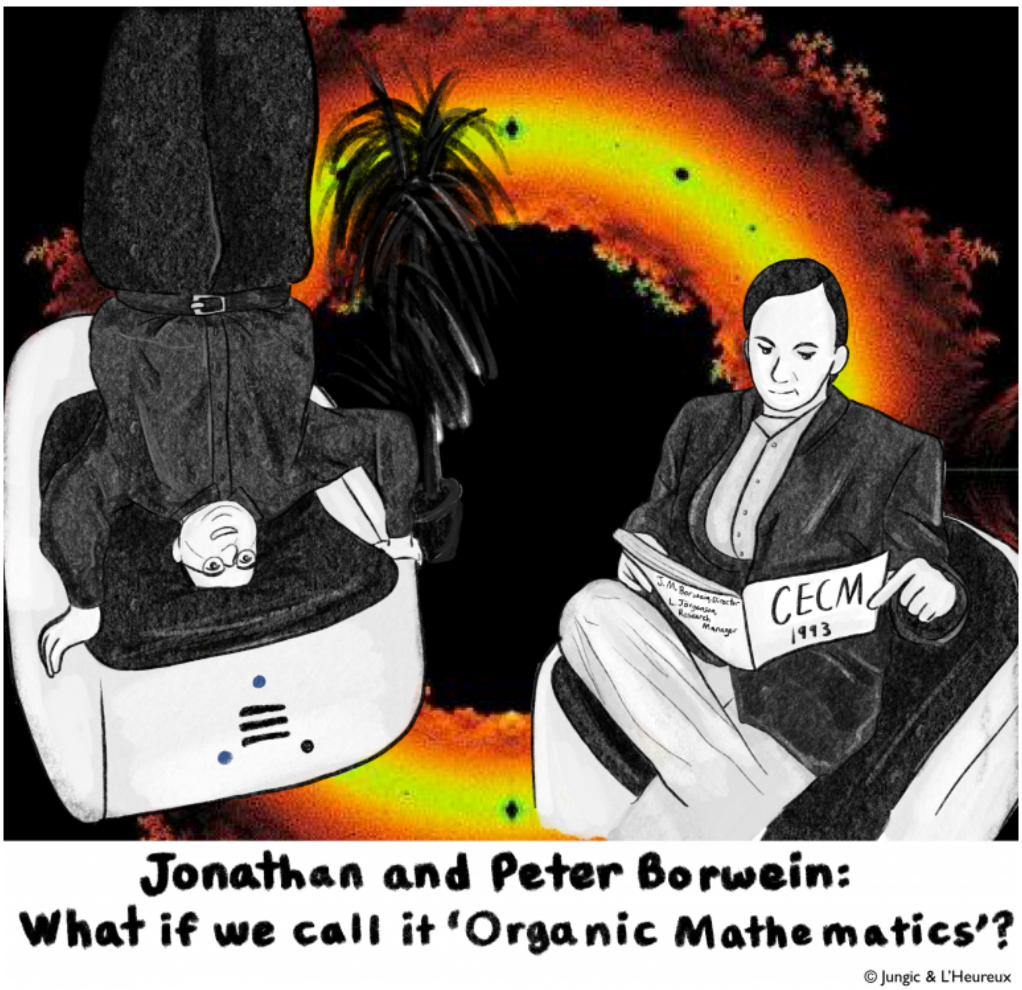


Figure 1 Jonathan (right) and Peter Borwein in CECM cc 1994. The image in the background represents roots of the Littlewood polynomials of degree at most 18 (Art by Bethani L'Hereux)

Both Peter and Jonathan joined Simon Fraser University's Department of Mathematics in 1993. Peter was an exceptional researcher, teacher, and supervisor, who contributed to the SFU community in numerous ways. Together with Jonathan, in 1993 he established the Centre for Experimental and Constructive Mathematics (CECM). In the late 1990s he served as the Pacific Institute for the Mathematical Sciences (PIMS) SFU site director, and in the early 2000s secured over 11 million dollars in Canada Foundation for Innovation (CFI) funding to build and operate the Interdisciplinary Research in the Mathematical and Computational Sciences (IRMACS) Centre, a visionary project with the purpose to, in Peter's words, "host any scientist who uses computers as a tool in their research." Peter was the true heart and soul of the IRMACS Centre.

With video conferencing increasingly becoming our main communication tool as a result of the current pandemic, it is easy to forget that hosting synchronous scientific meetings with speakers and audience members across Canadian universities was in the recent past a pioneering, complex, and in many ways heroic endeavour. Thanks to Peter and Jonathan's vision, the IRMACS Centre and D-Drive at Dalhousie University hosted the first "Coast-to-Coast Seminar" on Tuesday, September 13, 2005, and started accumulating insight into how to deal with issues that we now take for granted, such as scheduling events across multiple time zones, reaching out to scientific communities in different parts of the country, and establishing etiquette for remote collaboration meetings. The series would run for the following 10 years.

Peter has nearly 200 scientific publications, including several books, to his credit. Peter's research interests spanned Diophantine and computational number theory, classical analysis and symbolic computation. He had a central interest in scientific collaboration and computational experimentation technologies. For example, the Bailey-

Borwein-Plouffe (BBP) formula is still one of the major components of the algorithms used to calculate large amounts of the digits of the number Pi.

Over the years, Peter supervised 35 post-doctoral fellows,13 doctoral students, 9 master's students, and 28 undergraduate (USRA) students.

Peter was a member of several editorial boards, including "The Canadian Journal of Mathematics," "Ramanujan Quarterly," and "Electronic Transactions on Numerical Analysis." In addition, Peter was a co-editor of the CMS/Springer Advanced Mathematics Series.

All of these achievements should not come as a surprise for someone who attended his first International Math Congress when he was only five years old. The conference was held in 1958 in Edinburgh, Scotland, and Peter's dad David, a faculty member at the University of St. Andrews at the time, was the secretary of the General Assembly. Peter recently claimed to still have his nametag from the conference; he wore it to his first day of school in St. Andrews

Through Peter's parents' friendship with Paul Erdős, the young Peter was one of "uncle Paul's Epsilons". Peter would write many years later: "My first published paper as a graduate student was on a problem of Erdős'. As were at least a dozen subsequent papers. Erdős touched many mathematicians in this way. I often got 2:00 am phone calls that began in a distinctive Hungarian accent: 'This is Paul, I have a problem for you.'"

Peter was a full professor, a recipient of the Chauvenet Prize and the Hasse prize in 1993 (with Jonathan Borwein and David H. Bailey), and a co-recipient of the 1996 CUFA/BC Academic of the Year Award. He also received the University of Western Ontario National Alumni Merit Award in 1999, the Ford Prize 2002 (with Loki Jorgensen) and held a SFU Burnaby Mountain Chair award.

For many years Peter battled with progressive Multiple Sclerosis, a cruel illness he bore with exceptional grace and courage.

On a personal note, Peter was my friend, mentor, and a role model. On Saturday, March 13, 2004, Peter was the first speaker in the "A Taste of Pi" series of talks and activities that I co-organized with Malgorzata Dubiel for many years. Appropriately, the title of his talk was "A VERY LARGE Piece of Pi."

Peter was born in St. Andrews, Scotland, on May 10, 1953. Peter and his wife Jennifer have three daughters, Alexandra, Sophie, and Tess. Peter would often repeat the words of Bertel van der Waerden: "None of the three of my children had any interest in mathematics."

Due to the COVID-19 pandemic the family will not be having a ceremony in the near future but hope for one in the spring/summer of next year.

Acknowledging Pam Borghart's contribution to this article.

Donations to the Peter Borwein Graduate Scholarship are welcome through here .

Pacific Institute *for the* Mathematical Sciences

Applications are invited for the position of DIRECTOR of the Pacific Institute for the Mathematical Sciences (PIMS) for a term of up to five years, beginning on **July 1, 2021**. This appointment is renewable.

PIMS is a consortium of universities designed to support the mathematical sciences through its distributed structure that includes sites at Simon Fraser University, the University of Alberta, the University of British Columbia, the University of Calgary, the University of Lethbridge, the University of Manitoba, the University of Regina, the University of Saskatchewan, the University of Victoria, and the University of Washington. PIMS is supported by these universities, the Federal Government of Canada through NSERC (the Natural Sciences and Engineering Research Council), and Provincial Governments.

The PIMS Director is expected to have a distinguished record of scholarship in the mathematical sciences and possess superior leadership and management skills. The Director provides leadership at all PIMS sites for all components of the Institute's mandate:

- promotion of research in the mathematical sciences
- support of education, training and communication in the mathematical sciences
- creation of links and partnerships between mathematical scientists in the academic community and the private and government sectors
- enhancement and creation of mathematical partnerships within Canada and with groups throughout the world

The Director is responsible for the administrative management of the PIMS Central Office in Vancouver, is a member of the PIMS Board and Scientific Review Panel, ensures continued good relations with Canada's federal and provincial governments and their appropriate agencies, and continues to explore new opportunities for growth with these and other agencies. The PIMS Director is expected to play a continued leadership role in PRIMA (the Pacific Rim Mathematical Association) and is also Director of the International Research Laboratory of the Centre National de la Recherche Scientifique at PIMS. Comprehensive information on PIMS may be found at: http://www.pims.math.ca/.

The new Director will normally have a faculty position at one of the Canadian PIMS universities. Outstanding external applicants would be considered for a faculty position at one of the PIMS affiliated universities.

A letter of application together with a CV (preferably 10 pages or less in PDF Format) should be emailed to directorsearch2020@pims.math.ca with subject line containing only "Director Search and last name of the applicant". The letter of application should describe your interest and qualifications and should include a statement related to equity, diversity and inclusivity (see further details below). Expressions of interest, enquiries, or nominations are welcome and can also be sent to the same address.

Equity and diversity are essential to academic excellence. An open and diverse community fosters the inclusion of voices that have been underrepresented or discouraged. We encourage applications from members of groups that have been marginalized on any grounds, including sex, sexual orientation, gender identity or expression, racialization, disability, political belief, religion, marital or family status, age, and/or status as a First Nation, Métis, Inuit, or Indigenous person. PIMS welcomes applicants with the experiences and competencies that can contribute to our principles of equity, diversity and inclusion. In your application, please include a statement describing your experience working with diverse groups of colleagues and students, and your contributions to creating/advancing a culture of equity and inclusion within your discipline.

All qualified candidates are encouraged to apply, however Canadians and permanent residents of Canada will be given priority.

The Search Committee will consider dossiers beginning on **October 7, 2020**. After this date, applications and nominations will be considered until the position is filled. Further information about this position may be found at: https://www.pims.math.ca/directorsearch2020.

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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