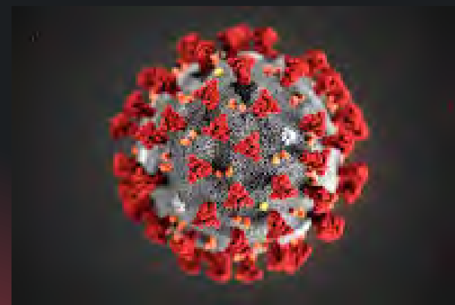
Welcome to the June Issue of the CMS Notes

June 2020 : Vol. 52, No. 3

Issue Contents

Call for Texts



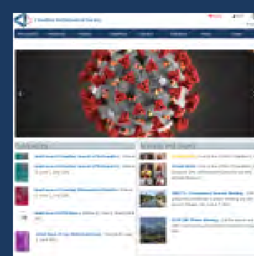
COVID-related texts for *CMS Notes*' Research Notes

If you're doing mathematical modelling, studying genes, working with industry to bring protective equipment into production, analyzing epidemiological data, or applying mathematics to your anti-coronavirus effort, and can spare a little time to write a brief description or a note on methodology, or a preliminary description of tentative results for us – anywhere from a paragraph to a few page – we'd like to hear from you, and will fast-track publication to keep it timely.

Send your texts to Zishad Lak (zlak@cms.math.ca) or to Patrick Ingram (pingram@yorku.ca)

For the latest news of the Canadian mathematical community, activities, research and education resources, deadlines and calls for submission and nomination and much more check out the Canadian Mathematical Society's ***brand new website****!*

www.cms.math.ca



As you will be well aware, Canadian mathematical legend Richard Guy passed away on March 9th, 2020 at the age of 103. To honour his memory, the Canadian mathematics problem solving journal Crux Mathematicorum will have a special issue in fall 2020. We encourage submissions of problems and short articles on topics Richard would have found interesting, provided they are at the high school or early undergraduate level (befitting the purpose and readership of Crux), as well as tributes and reminiscences. If you would like to contribute to the special issue, please send the materials to crux-editors@cms.math.ca by August 1st.

How the CMS is Growing and Changing

Mark Lewis (University of Alberta)
CMS President

Dear members of the Canadian mathematical community,

I greet you warmly and wish you the best as you navigate this interesting year of 2020. This is the end of my term as President of the Canadian Mathematical Society (CMS). It has been a great pleasure to serve the community in this role. I have learned a great deal about the quality and diversity of our Canadian mathematical community, and my time as President has been rewarding personally. Indeed, it has been a great pleasure to work with a group of highly motivated, hardworking individuals, both in the CMS administrative office and outside of it, as we have moved forward on shared goals. We are truly fortunate to have a cadre of staff and volunteers who are dedicated to serving mathematics in Canada, and they are crucial to making the ideas, initiatives, and resources a reality.

We live in interesting times. The mathematical landscape is changing quickly in many ways that I will attempt to describe below. Also, the recent emergence of COVID-19 has affected every aspect of the CMS and its operations. More on this to come.

One of the biggest changes during my tenure was the hiring of Executive Director Dr. Termeh Kousha, who started in September 2018. She came from the University of Ottawa, with an outstanding record of teaching and education. She has grown into her role of Executive Director and has put her stamp on the CMS, bringing forward many new ideas and finding new efficiencies in our operations. She has considerably improved our budgetary situation, putting us on a solid foundation to deal with the financial shocks we are now facing from COVID-19. It has been a great pleasure to work with her.

During the last two years the CMS has strongly focused on promoting equity, diversity, and inclusiveness at all levels. This includes developing two new committees that are essential to the future of the CMS. Following on from the report from the Truth and Reconciliation Commission of Canada, we developed terms of reference for a new Reconciliation in Mathematics Committee and are in the process of forming the committee. This committee is responsible for (i) coordinating the contributions of the mathematical community to the reconciliation process, and (ii) devising a strategy to eliminate educational and employment gaps in mathematics between Indigenous and non-Indigenous Canadians. Recognizing that diversity takes many forms, we also have a new Committee on Equity, Diversity and Inclusiveness. I am happy to say that we had our first Equity and Diversity Lunch during our Summer 2019 Meeting in Regina and our first LGBTQ lunch during our Winter 2019 meeting in Toronto.

In terms of making CMS meetings as open and accessible as possible, we have a new policy for child-care, which commits to providing this essential service at summer and winter meetings. We also have a new code of conduct, focusing on the highest standard of conduct, fairness, and integrity in all activities, including semi-annual and other meetings. Many of the developments and events listed here were long overdue, and I am happy they have become a reality with the help of the Executive Committee as well as regular CMS members, who provided constant support and assistance to do more, and I give them a heart-felt thank you. I feel like my role as President has been very much to help facilitate the vision provided by these highly motivated individuals.

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Another area of change has been with respect to developing and implementing a new CMS Fellows Program. The Fellows Program was instituted to recognize mathematicians who have made very significant contributions to the profession and to the Canadian Mathematical Society. The Fellowship recognizes CMS members who have made excellent contributions to mathematical research, teaching, or exposition as well as having distinguished themselves in serving Canada's mathematical community. It was a great personal pleasure to help recognize the 60 inaugural CMS Fellows welcomed at the Winter Meeting Banquets in December 2018 and 2019, and I look forward to seeing more new fellows at meetings to come (whether in person or virtual).

Each year the CMS has the opportunity to recognize outstanding research, teaching and service in mathematics across Canada by presenting awards. These included the 2019 Graham Wright Award for Distinguished Service to Karl Dilcher (Dalhousie), the 2019 G. de B. Robinson Award for publication of excellent papers to Lars Louder (University College London) and Henry Wilton (University of Cambridge), the 2019 Adrien Pouliot Award for mathematics education to Tiina Hohn (MacEwan), the 2020 Doctoral prize to Duncan Dauvergne (Princeton), the 2020 Coxeter-James Prize for young mathematical researchers to Jacopo De Simoi (Toronto), the 2020 Krieger-Nelson Award for outstanding contributions in the area of mathematical research by a female mathematician to Sujatha Ramdorai (UBC), the 2020 CMS Excellence in Teaching Award to Joseph Khoury (Ottawa), and the 2020 Jeffery-Williams Prize for outstanding contributions to mathematical research to Juncheng Wei (UBC). I am proud to congratulate this amazing group for their inspiring contributions to mathematics in Canada.

As government officials try to develop policy for battling COVID-19, the role of mathematical modelling has come to the fore. Models are needed to predict possible outcomes long before the data is in. For example, the need for social distancing and its impact on infectious outcomes has been analysed mathematically, providing guidance for policy makers. During the pandemic, mathematical models are being broadly integrated into the public discussion. This has been exciting to witness, but it is unusual to see mathematics play such a central role in broader society. Indeed, because of its highly technical nature, the importance of mathematics has often remained unrecognized. Too often the power of mathematics to effect change in business, communication, humanities, industry, science and technology is hidden from view and we need to do more to communicate the value of the subject we love. Because of this, I am very happy to share news of the new MITACS Innovation Lecture, to be held yearly at the CMS Winter Meeting, starting in Winter 2020. With generous support from MITACS, the purpose of the lecture is to illuminate the mathematical underpinnings of significant new innovative developments that are impacting our world and the way we relate to it. This lecture is meant for the public, for general academics, and for mathematicians at all stages and from all backgrounds.

The current COVID-19 pandemic has forced the CMS to re-evaluate and readjust every aspect of its operations. Office staff are now working from home. While we had an amazing line-up for our summer 2020 meeting in Ottawa, designed to celebrate the 75th anniversary of the CMS, we will have to wait until next year before celebrating: the meeting has now been postponed to 2021. We are also currently working with the Scientific Directors of the Winter 2020 Meeting (Montreal) to adjust the structure to our new COVID-19 reality.

In June 2020, Prof. Javad Mashreghi (Laval) will take the reins of the CMS as my term comes to an end. I have worked closely with him over the last few years and am confident in saying that I could not leave things in better hands. I thank all CMS members for having given me the opportunity to serve and wish all a happy and healthy remainder of 2020.

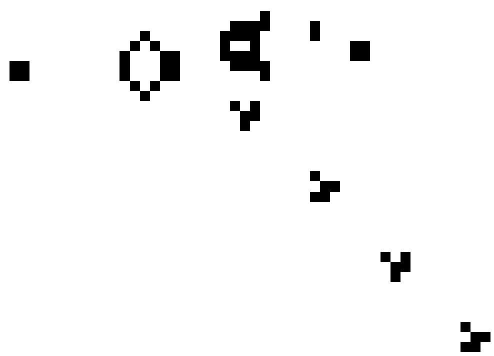
Math in the Time of the Coronavirus

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

Last week we lost John Conway, one of the mathematical community's most original thinkers, to COVID-19. He left a lifetime of sometimes strange and often wonderful mathematics behind him, and he will be sorely missed. He got the ultimate nerd accolade of a memorial XKCD cartoon, and I hope he would have been pleased by that (though at times he seemed to feel about the "Game Of Life" the way Ron Hynes, in later years, said he felt about "Sonny's Dream.")

When somebody dies, it suddenly makes makes it clear why we're all acting out E.M.Forster's classic SF story "The Machine Stops." We're not isolating ourselves as a stunt – this virus kills people, and this is how we prevent it from killing more of us, until we've got a vaccine or an antiviral drug to act more directly against it. But life has certainly become strange as a result.

Thousands of people who, a month ago, had never taken part in an online video conference are becoming seasoned veterans. No, it's not the same as a face-to-face meeting over coffee, but my department has had various meetings and an entire hiring process, with some success. (If anybody was wearing pajama pants or none at all, it didn't show.) And in the last month I got plenty of research done by email: that, at least, works as well as ever. Getting together in front of a blackboard for serious brainstorming? That will, alas, have to wait.



A single Gosper's Glider Gun creating "gliders" in Conway's Game of Life

> *At times [Conway] seemed to feel about the 'Game of Life' the way Ron Hynes, in later years, said he felt about 'Sonny's Dream.'*

With amazing foresight (for which read luck), I had done an overload in the fall term and had no teaching in the winter. My colleagues who had classes to finish off did an impressive job of it; and we're standing by now for our first term of classes taught entirely online. It was not so long ago that the Maritime Provinces Higher Education Commission deemed our proposal to put one ten-course certificate program online such a major change that we had to go through the entire program approval process all over again. In the last month, our whole program changed over – at a week's notice.

Was it successful? It may depend what you mean by success. Various instructors noted drily that the (unproctored) online exams were so successful that hardly anybody failed. I doubt whether future employers and graduate schools would welcome this as the new normal! We've had promises of AI software than can watch students' eyes and tell if they are cheating: some people in online chat rooms seem quite sure they have already learned how to game that system. I don't think we've heard the end of this story.

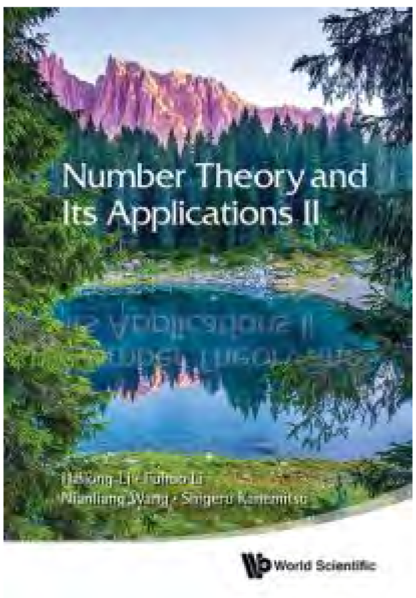
Once more, everybody – stay isolated, stay well. You're all irreplaceable.

Prominent mathematician and game of life theoretician, John Conway, passed away on 11 April 2020 at 82 from COVID-19. He will be missed by the mathematical community.

Keith Johnson (Dalhousie University)

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)*



Number Theory and its Applications
by Fuhuo Li, Nianliang Wang, Shigeru Kanemitsu
World Scientific, 2013
ISBN 978-981-4425-63-6

Number Theory and its Applications II
by Hailong Li, Fuhuo Li, Nianliang Wang, Shigeru Kanemitsu
World Scientific, 2018
ISBN 978-981-3231-59-7

Reviewed by Keith Johnson, Dalhousie University

In the preface of the first of these two books about number theory the authors describe their intent as "starting from the very basics and warp into the space of of new interest; from the ground state to the excited state". By the latter they mean certain parts of analytic number theory. Each book is organized into six chapters, with two chapters of introductory material followed by four more or less independent advanced topics. An unusual feature of the books is that the second, published 5 years after the first, not only covers much of the same material as the first, but about one quarter of it is selected sections reprinted verbatim from the first book. The result is that the second book is more than a second edition but less than a second volume.

The first book starts with a chapter of elementary material on algebra and algebraic number theory, but with examples and exercises (most with included solutions) looking forward to analytic number theory. Emphasis is placed on the "gcd principle" that if a family of statements P(n) is such that P(n) and P(m) implies P(gcd(n,m)) then the minimal f for which P(f) has the property that P(n) implies f divides n. this is used as the basis for a discussion of arithmetic functions, and so as a means of introducing Dirichlet characters at an early stage. The second chapter, on algebraic number theory, states the basics of Galois theory, describes the structure of modules over a Dedekind domain, and then concentrates on algebraic number fields. The basic facts about trace and norm and about valuations are given, and then three specific examples are developed: the quadratic field with golden ratio unit, cyclotomic fields (which leads to the statement of Dirichlet's prime number theorem), and fields with the dihedral group as Galois group.

Following these two chapters of "basics", the book has four chapters of "interesting" material. First is a chapter on arithmetic functions with material on asymptotic formulas, on generating functions, and an application to sequences in Hilbert spaces. Next is achapter on quadratic reciprocity including a discussion of Hecke's theorem on the quadratic reciprocity law in algebraic number fields, although without a complete proof. This is followed by a chapter dedicated to Dirichlet L-functions, mostly concentrating on those with primitive characters. There is another proof of quadratic reciprocity using the theta transformation formula, material on Lambert series and character sums, and a discussion of the discrete mean square of special values of L-functions. The final chapter describes some connection between analytic number theory and control theory. The basics of control theory are sketched and then the application of analytic methods to find controllers satisfying specified stability and bound conditions are described.

As mentioned earlier, the second book follows the same six chapter format with two basic chapters followed by four interesting ones. Chapter one adds material about number fields by emphasising the use of techniques from linear algebra. Chapter two emphasises the use of results from group theory and develops the Galois theory of number fields more completely. The examples of number fields from the first book are reprinted here and additional material such as L-functions associated to elliptic curves is added. Chapter three reprints four sections of material about arithmetic functions and then gives a variety of results about average values of arithmetic functions and error estimates for these. Chapter four develops further results about Lambert series, continuing from chapter three of the first book, and looks at various results of Riemann including his example of a continuous nondifferentiable function. Chapter five continues the study of the connections between number theory and Hilbert spaces, reprinting the corresponding section from the first book and then developing and proving Kuznetsov's trace formula. Chapter six continues the number theoretic study of control theory, reprinting several sections from the first book and adding several illustrative examples from electrical engineering.

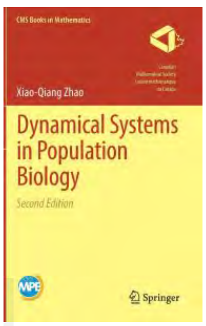
These books present a wide range of interesting number theoretic topic and the reader most likely to enjoy them and benefit from their study would be someone already well versed in analytic number theory. I don't think either would be successful as a textbook, in spite of the excellent solved exercises scattered throughout, because of the diversity of topics and the lack of a central organizing theme. Instead its most likely user will be an instructor using it as a source of ideas to supplement some other, more coherent, textbook.

Short Reviews – COVID-19

Karl Dilcher (Dalhousie University)

This column features three recent books related to a very topical subject, written (or co-authored) by Canadian researchers. Xiao-Qiang Zhao is Professor of Mathematics at Memorial University; his book, now in its second edition, was recently reviewed in the Notes. Fred Brauer is Honourary Professor in the Mathematical Biology group at UBC Vancouver. Michael Y. Li is Professor of Mathematics at the University of Alberta. Full reviews of the second and third of these books may be published in future issues of the Notes.

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



Dynamical Systems in Population Biology, 2nd Edition
by Xiao-Qiang Zhao
CMS Books in Mathematics, Springer, 2017
ISBN 978-3-319-56432-6
Reviewed by Karl Dilcher

A full review, written by Frithjof Lutscher, was recently published in the March/April 2020 issue of the *Notes*. The following paragraph is worth repeating here:

> *Chapter 11 is devoted to a quantity of great interest in epidemiology: the basic reproduction ratio. This quantity is abstractly defined as the number of secondary infections that a single infective organism in a completely susceptible population will generate. Defining this quantity in models of great complexity, i.e. models that include spatial structure, delays, and interacting populations, is highly nontrivial. Proving that this number has the same properties as in the simple ODE models for which it was originally introduced, namely that it is the threshold between disease extinction and persistence, is very hard. It requires the tools and techniques introduced in the first chapters and several additional ideas. Chapters 12–14 then consider more applications of this basic reproduction ratio to populations with periodic delays, with spatial structure, and for the complicated dynamics of Lyme disease.*

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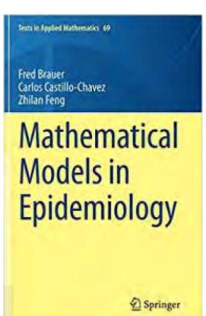

Mathematical Models in Epidemiology
By Fred Brauer, Carlos Castillo-Chavez, and Zhilan Feng.
With a foreword by Simon Levin.
Texts in Applied Mathematics, 69. Springer, New York, 2019.
ISBN: 978-1-4939-9826-5
Reviewed by Karl Dilcher

Publisher's description:

> *The book is a comprehensive, self-contained introduction to the mathematical modeling and analysis of disease*

> *transmission models. It includes (i) an introduction to the main concepts of compartmental models including models with heterogeneous mixing of individuals and models for vector-transmitted diseases, (ii) a detailed analysis of models for important specific diseases, including tuberculosis, HIV/AIDS, influenza, Ebola virus disease, malaria, dengue fever and the Zika virus, (iii) an introduction to more advanced mathematical topics, including age structure, spatial structure, and mobility, and (iv) some challenges and opportunities for the future.*
>
> *There are exercises of varying degrees of difficulty, and projects leading to new research directions. For the benefit of public health professionals whose contact with mathematics may not be recent, there is an appendix covering the necessary mathematical background. There are indications which sections require a strong mathematical background so that the book can be useful for both mathematical modelers and public health professionals.*

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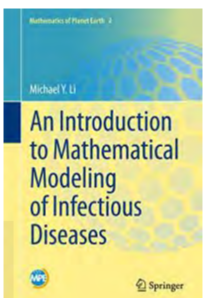

An Introduction to Mathematical Modeling of Infectious Diseases
By Michael Y. Li
Mathematics of Planet Earth Collection, Springer, 2018.
ISBN 978-3-319-72122-4

Publisher's Description:

> *This text provides essential modeling skills and methodology for the study of infectious diseases through a one-semester modeling course or directed individual studies. The book includes mathematical descriptions of epidemiological concepts, and uses classic epidemic models to introduce different mathematical methods in model analysis. Matlab codes are also included for numerical implementations.*
>
> *It is primarily written for upper undergraduate and beginning graduate students in mathematical sciences who have an interest in mathematical modeling of infectious diseases. Although written in a rigorous mathematical manner, the style is not unfriendly to non-mathematicians.*

The individual chapters are: "Important Concepts in Mathematical Modeling of Infectious Diseases"; "Five Classic Epidemic Models and Their Analysis"; "Basic Mathematical Tools and Techniques"; "Parameter Estimation and Nonlinear Least-Squares Methods"; and "Special Topics".

Assessments in the Time of COVID-19 and Beyond

Kseniya Garaschuk (University of Fraser Valley)
Veselin Jungic (Simon Fraser University)

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)*

This article is first and foremost a product of the authors' experiences, but we would like to acknowledge many colleagues in the mathematics community who have shared with us their stories, their frustrations and successes, their opinions, support and feedback.

The dramatic developments during the COVID-19 pandemic have changed many well-established teaching practices, protocols, and principles, literally overnight. In this note, we reflect on two interrelated issues that have been strongly highlighted by those changes: final exam practices and the principles of academic integrity.

The current pandemic interrupted all of our daily routines. In mid-March, most universities informed their faculty that instruction would be remote for the rest of the term. Some institutions gave their instructors a week to move courses online; others gave them a couple of days. Teaching and Learning Centres across the country have never seen such high demand for their support and assistance. Departments scheduled additional meetings, funds were allocated to support technical requirements to move teaching online, dozens of targeted professional development workshops were put together overnight and attended the next day. We received expedited introductions to *Blackboard Collaborate* and discussion boards, *Blue Jeans* and *Zoom*, *piazza*, *Kaltura*,... Classes stumbled into online mode, our students met each other's pets and children, we asked "can you hear me now" too many times in the first week, but we figured it out. The last day of classes came and went. Then we needed to think about the final exams.

Having to administer remote unsupervised exams, mathematics instructors across Canada faced a difficult question: What (if anything) had to change? Most of us had given final exams, but never online ones. Should we adjust the format, the intent, the goals? Should we be concerned with students cheating using the Internet, or class notes, or each other? And if so, what should we do to prevent it?

Our recent conversations with colleagues across the country left us with the impression that for many members of our community the Spring 2020 examination period was a very stressful experience. Marking exams and deciding about final grades is the most unpleasant part of each instructor's job in the most normal of times. This spring, many of us were hit hard by the fact that some of our students were taking advantage of unsupervised final exams to blatantly cheat. For example, we heard a story about our colleague watching on-screen how their exam questions popped up on the *Chegg* website shortly after the exam started. Or a story about an instructor who found a cluster of several identical answer sheets to the test with a long list of multiple-choice questions. True, there are some funny elements to those stories: one of the postings on *Chegg* was with the student's name on the uploaded image; in the other incident, the students didn't realize that the order of questions was not identical for each student.

Still, it was disappointing and really painful to realize that in our classes we have students who, for any reason, didn't follow their teachers' and institutions' advice about academic integrity. We know colleagues for whom this examination period turned into a true nightmare complete with multiple academic dishonesty reports and long conversations with students who stubbornly denied obvious cases of cheating. Possibly the most disheartening story that we heard over the last several weeks was from an instructor who caught cheaters in their "Mathematics for elementary teachers" class. The class is designed for future teachers, where the instructor's task is to facilitate learning of mathematical concepts and planning for their instruction as well as to showcase some basic pedagogical values. For us, it is totally mind-blowing that a prospective teacher would cheat on an exam and thus completely disrespect the core values of the program they signed up for (or plan to enter). While the lesson learned from this experience will likely stay with the students forever, it will also remain with their instructor.

Overall, our feeling is that the math teaching community's trust in our students has been one of the collateral damages of COVID-19.

Before we examine how this experience will affect our future teaching, let us consider why we have encountered these problems in the first place: have our teaching practices and particularly our assessment practices contributed to this mismatch between our expectations and reality?

In our experience, most traditional first-year math final exams have a similar structure: an exam consists of a combination of skill testing, problem solving, and extension questions. Skill testing questions, like finding a derivative of a given function, are one-liners, they target a particular skill or concept. Problem solving questions, like using a linear approximation, tend to be application questions that test solving strategies and standard algorithmic approaches. Extension questions (like using the Intermediate Value Theorem and the Mean Value Theorem to establish the number of solutions of a transcendental equation in the given interval and then using Newton's method to estimate those solutions) are intended for A students to complete as they test both the depth and breadth of a student's knowledge. Unsurprisingly, it is mainly in the last category that we tend to see interesting, inventive, challenging questions. The rest of the test is composed of fairly standard, predictable questions.

Standard, predictable questions were exactly what made our lives difficult during the spring 2020 examination period. They were easily *Google*-able; *WolframAlpha* would provide a step-by-step solution that, if presented on an exam paper, received full marks; when asked, an "expert" from one of several popular sites would post solutions to all of those questions within 30 minutes. And voila, we were scratching our heads wondering how Alice and Bob, students who had struggled throughout the course, were able to correctly use the chain rule multiple times and obtain such a perfectly simplified expression as their identical final answers! It seems that the issue is two-fold: we both don't trust our students to not cheat and we also don't trust our exams to be not easily cheatable.

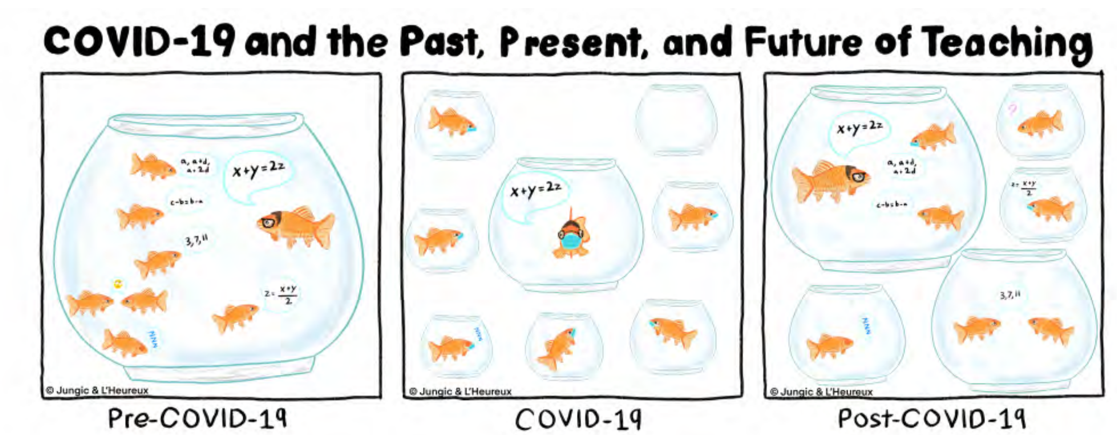

Illustration by Bethani L'Heureux*, idea by Veseli Jungic

The inability to supervise students writing exams in remotely managed courses has become one of the biggest concerns for faculty and administration.

In response to that, in a somewhat extreme manner, the dominant sentiment at this moment appears to be to use technology to do the policing of the remote written exams. The authors of this note belong to the group of academics who are still learning about the various artificial intelligence driven proctoring platforms, like ExamSoft and Proctortrack, for example. We listen, with uneasy feelings, about the proctoring platforms that follow students' eyeball movements as a way of preventing or reporting cheating. With our colleagues, we are discussing how we may start using a videoconferencing platform to monitor our students' actions during examination. And we have no doubt that our institutions will find funds to license one or more proctoring platforms, to hire technicians who will manage software from our side of the table, reshuffle the current job descriptions of the education developers (maybe there will be even need for another associate director position) to make sure that we have in-house experts on distance proctoring. And let us not forget the consulting fees of the experts who will help us choose the right platform and the legal fees of the lawyers who will make sure that our policies are aligned with the relevant privacy laws. At the end, a math instructor will be assured that the probability of Alice and Bob doing all the work on their own to find a derivative is reasonably high. But that comes at a high cost as it shifts the expectation from shared trust to rigid and possibly intrusive preventative measures.

We wonder if our institutions will invest similar amounts of energy and resources in educating our students that cheating on exams is not good for them on both professional and personal levels. Yes, in our course outlines we post a paragraph about academic integrity, but do we really expect students to read it and take it seriously? Our math classes, particularly those at the entry level, are diverse in any way one can think of. Do we have a reason to believe that each of our students has had the opportunity to fully understand that the very essence of academic integrity is to be the glue that keeps us all — students, faculty and administration — on the same side? What do we really do to ensure that students adhere to the fundamental values of academic integrity: honesty, trust, fairness, respect and responsibility?

There are many reasons why students may cheat and there is a large body of research literature examining all types of factors. But what is universally true is that our reaction to academic misconduct is always punitive. We diligently include links to a university's academic misconduct policy on our syllabi, we warn students of the consequences, and we follow the steps in the procedure to report academic misconduct. But we do not seem to educate them on why academic misconduct is not acceptable to us and why it should not be acceptable to them. In the worst possible way to teach, we list academic integrity rules without explaining them, so no wonder that some of our students don't follow them.

Here is an example from an episode of the Teaching in Higher Ed podcast, inspired, in turn, by Cheating Lessons by James Lang, who asks faculty members a simple question: have you sped on the way to work today? We all know it's breaking the rules, but the majority of us do it if we know we can get away from it. Moreover, the more we don't understand or don't disagree with the specific rule, the more incentivised we are to break it. After all, going with the flow of traffic even though it's 20 km/h above the speed limit is "safer" and why is it a 60 km/h zone in the middle of farmlands anyways? Same goes for academic integrity: not only are the definitions and boundaries not universally self-evident, rules that come without explanations tend to acquire alternative interpretations and get broken in support of those self-provided justifications. In terms of mathematical content of our courses, we strongly advocate for explaining and for making sense of rules and laws, and this should include other course components, such as academic integrity.

It appears that when academic integrity becomes part of the culture and a norm, it is not as likely to be broken as can be seen in the case of institutions that rely on honour codes. Several large studies (most notably, Bowers' "Student Dishonesty and its Control in Colleges" published in 1964 and subsequent recent works of McCabe and Trevino) find that there is a lot less cheating in honour system environments, albeit still far from zero. Can we instill similar values and expectations in our publicly funded institutions? Or even in the span of one course?

What worries us is that in our conversations about academic integrity, our colleagues are overwhelmingly concerned about students' cheating without considering the possible responsibility of the larger academic community for this situation. Academic integrity is an ethical policy not specific to students. It includes students, faculty members, staff, administration and institution as a whole.

For example, do our institutions follow the spirit of our own academic integrity policies when we enroll students who are not ready to take a fast-paced topic-packed math course and then jam them into a few-hundred-student strong class? Or when they hire a large number of contract faculty and expect them to teach under the stress of their expiration date looming? Or when they put inadequately prepared teaching assistants in the position to advise or teach students or mark their assignments?

Maybe on a more personal level, have we always followed the fundamental values of academic integrity ourselves? Has it happened that a math instructor was late for their class or went to the class unprepared? Broke a promise to students or didn't follow the institutional guidelines? Showed their own biases, cultural, or gender related, for example, when communicating with students or when evaluating students' work? Or got in a habit of recycling old assessments year after year? Or teaching in the same way for years and putting no efforts to learn about new teaching techniques and technologies and thus re-evaluating their own teaching practices? Or towards colleagues, on hiring committees, allowing racial or gender biases to be present in decision making?

In short, our view is that by only investing into meaningful education of all involved in the learning and teaching processes may our communities move towards the full implementation of the principles of academic integrity.

In short, our view is that by only investing into meaningful education of all involved in the learning and teaching processes may our communities move towards the full implementation of the principles of academic integrity.

Back to last term's final exams, we mainly saw two approaches to minimize student academic misconduct.

Some instructors focused on preventing students from cheating, with measures from extreme to mild. We have heard of students being asked to install two cameras so the instructor has a view of them, their desk, and their computer screen. We have heard of instructors imposing rigid time constraints and releasing questions one at a time to be submitted within a short timeframe. Some instructors purchased access to Chegg and other similar websites to monitor posted questions. Some compared students' handwriting to previously submitted work. Some held post-exam oral sessions asking students to explain one question from the test in real time. Some asked the students to sign an integrity contract that they promised to uphold.

The authors of this note are among those instructors who tried to make their exams less cheatable. Our main idea was to include in our exams a number of conceptual problems of various levels of difficulty. Motivated by the fact that over the last several weeks, members of the general public have been forced to pay unprecedented attention to various forms of mathematics (think about the endless mentioning of "flattening the curve", for example) we included in our exams problems that were inspired by current events. For example, a large portion of one final exam was designed around the analysis of the spread of COVID-19 and its representation in the news; a big portion of the other final was built on the publicly available data on the 2000 transmission of West Nile virus. This gave us an opportunity to state our calculus questions through only the verbal and graphical representations of the related functions. We want to emphasize here that these scenarios are not one long-answer or extension question; rather, they are broken up into parts each with a series of questions — some technical, some conceptual, some interpretive. So even our questions that aimed to test students' procedural knowledge were presented as parts of the story. Our message to students was simple: we would much rather have you to show us that you are able to analyse (mis)information using mathematical tools than that you can recite the limit definition of a derivative.

As we recently discovered, these types of questions appear to be known in history and philosophy as "stimulus questions": students are provided with a situation or context and are asked to demonstrate their critical thinking skills by analysing the particular scenario using the course's core concepts. Not only are these stimulus questions targeting learning outcomes we want to assess, they also present a learning opportunity for the student to yet again hone their skills in applying mathematical thinking in an authentic setting. More importantly for this discussion, these problems are also highly non-cheatable: they will be hard for a non-student or a generic online tutor, unfamiliar with the exact course content and who generally tends to be proficient in standard techniques rather than used to analysing math in context. One drawback is the creation of these problems. These problems are time-consuming to design and they cannot be re-used once released; but it is our responsibility as instructors to put in the time and effort into developing the course, whether it is our first iteration or the 20th.

We should note that course assessments should be aligned with the spirit in which the material is taught throughout the term, so students can practice those skills and not perceive the exam as unfair or unreasonable. As we exercised broader mathematical thinking throughout the course, we were told by a number of students that word problems were better because "you know whether your answer is way off or not". We trusted our students to buy into a "stimulus exam" and our students indeed reacted well to this format. There were parts of the exam that were best done by students who were generally weaker in procedural questions during the term. This is not terribly surprising and confirmed our belief that while procedural fluency requires a lot of practice, conceptually rich questions are actually more intuitive for students (and their instructors), particularly when presented in actual real-life settings.

The pandemic did not create new issues with how we structure our final exams, it simply highlighted what has been present in our practices for a long time. It is also important to understand the situation we find ourselves in and the difference between an emergency switch to online teaching and actual online learning. As a popular, now folklore, Tweet circulating over the last couple of weeks points out: we are not working from home, we are staying home during a pandemic trying to work. So our solutions to emerging issues with giving final exams online for Spring/Winter 2020 term were definitely ad-hoc. Moving forward, however, we find ourselves in the new reality of planning fully online courses for summer and possibly fall terms. Instead of doing damage control, we need to consider a more wholesome approach to our future practices. General recommendations from online educators suggest replacing high stakes exams with frequent smaller assessments, which not only provide continuous feedback to students, but also reduce the pressure and perceived necessity for students to cheat. Is a traditional final exam worth 40-60% of the total grade necessary? What are some other effective and efficient options for grade distribution and/or comprehensive course assessment? Let's not dismiss this question as quixotic because of large class sizes, lack of TA support, time and other constraints. Instead, let us entertain some alternative thoughts, engage in creative thinking we so often ask of our students and come up with reasonable solutions. We are, after all, professional problem solvers.

In summary, the COVID-19 pandemics changed our everyday and professional routines. In our view, the pandemics also have underlined the urgent need that our mathematics teaching community re-think how we assess our students' academic progress and how we educate them and ourselves to fully accept and follow the fundamental values of academic integrity: honesty, trust, fairness, respect and responsibility.

**Illustration co-created, Bethani L'Heureux, is a young Cree artist. She recently graduated from Alpha Secondary school in Burnaby, BC and eventually plans to pursue a career in voice acting or art.*

Editors and authors would love to hear your responses and comments to this article. Please email us at kseniya.garaschuk@ufv.ca, vjungic@sfu.ca and johngm@unb.ca

CMS NOTES

An Homage to Gauss and His Model of the Earth's Magnetic Field

John de Boer (Royal Military College of Canada)
Roger Godard (Royal Military College of Canada)

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)*

Carl Friedrich Gauss (1777–1855) was not only the prince of mathematicians, but also an applied mathematician who contributed to the development of the least squares method, numerical solutions of systems of linear equations, numerical solutions of integrals, the theory of interpolation, the Fast Fourier Transform (FFT), systems of ordinary differential equations, and more. He was also a mathematical physicist and a talented experimenter who conducted research in astronomy, geodesy, and geomagnetism [1, 2, 4, 6, 8]. In this study, we are interested in Gauss's work on the terrestrial magnetic field. He was the first to model mathematically the magnetic field at the surface of the Earth, and to find numerical results. His model proved to be the most ambitious project of applied mathematics of its time. It is a perfect example of Joseph Fourier's view of natural philosophy: "Profound study of nature is the most fertile source of mathematical discoveries" [3, p. 7]. However, this particular contribution by Gauss has been largely overlooked by the historians of mathematics, although it has been noted by geophysicists.

Erroneous explanations of the terrestrial magnetic field had existed for centuries. Christopher Columbus believed that the Polar star attracts a magnetic needle. Others thought that a magnetic mountain exists in the Arctic. William Gilbert, the physician of Queen Elizabeth I, destroyed all previous hypotheses when in 1600 he published *De Magnete*, theorizing that the Earth is a gigantic magnet with a north pole and a south pole.

Although Gauss became interested in the Earth's magnetic field by 1803, it was not until 1839 that he published "Allgemeine Theorie des Erdmagnetismus" (on the mathematical modeling of the Earth's magnetic field). This appeared in a very obscure journal [5]—a fact that may help explain the historians' neglect. Gauss examined William Gilbert's hypothesis that the Earth is a magnet, and he further postulated that the magnetic potential obeys Laplace's equation at the surface of the Earth as well as outside of the Earth. Gauss thus needed to solve the Laplace equation in spherical coordinates for a heterogeneous spherical terrestrial surface. Therefore, he required a magnetic map as a boundary condition at the surface of the Earth. Unfortunately for Gauss, the magnetic potential was not measurable. Only the components of the magnetic field were observable. The model is [6]:

$$\nabla^2 V = 0, \quad V(r \to +\infty) = 0, \quad \frac{\partial V}{\partial r}(a,\theta,\phi) = Z,$$

$$\frac{1}{r}\frac{\partial V}{\partial \theta}(a,\theta,\phi) = X, \quad -\frac{1}{r\sin\theta}\frac{\partial V}{\partial \phi}(a,\theta,\phi) = Y,$$

$$V(r,\theta,\phi+2\pi) = V(r,\theta,\phi).$$

Here V is the potential, r the radial distance, and a the earth's radius. Therefore the declination is given by $D = \arctan(Y/X)$, the inclination will be $I = \arctan(Z/H)$ and the horizontal intensity is $H = \sqrt{X^2+Y^2}$.

Gauss used the method of separation of variables for the Laplace equation. He wrote the equation for the spherical harmonics, the formula to obtain the associated Legendre polynomials P_n^m, and arrived directly—without any explanations or references—at the correct solution in the form of a series of trigonometric functions and associated Legendre polynomials:

$$Y^{(n)} = g^{n,0}P^{n,0} + (g^{n,1}\cos\phi + h^{n,1}\sin\phi)P^{n,1} + (g^{n,2}\cos 2\phi + h^{n,2}\sin 2\phi)P^{n,2} + \cdots \quad + (g^{n,n}\cos n\phi + h^{n,n}\sin n\phi)P^{n,n}.$$

This equation represents fundamental progress over Legendre's and Laplace's 18th-century results on the theory of gravitation. The coefficients g and h came to be called the Gauss coefficients. In modern notation, we have for the complete series of the potential [5]:

$$V(r,\theta,\phi) = a\sum_{n=0}^{N}\left(\frac{a}{r}\right)^{n+1}\sum_{m=0}^{n}P_n^m(\theta)[g_n^m\cos m\phi + h_n^m\sin m\phi].$$

Gauss limited himself to $N = 4$, or 24 Gauss coefficients for the derivatives of the potential. He already had observations from magnetic stations all around the terrestrial globe. By a technique of interpolation, he brought back the information to the nodes of a grid where the increments of θ and ϕ are constant [5, pp. 631–632]—creating one of the first examples of tessellation! This technique of bringing the information to the nodes of a grid is now called an objective analysis. Gauss selected 12 nodes on each of seven circles of latitude, for a total of 84 nodes. He then decomposed the problem by working from the colatitudes $\theta =$ constant, and by doing a harmonic analysis. For example, he had:

$$X = \sum_{n=1}^{4}\sum_{m=0}^{n}(g_n^m\cos m\phi + h_n^m\sin m\phi)\frac{dP_n^m}{d\theta},$$

$$i.e., \quad X = \sum_{m=0}^{4}(\alpha_{mx}\cos m\phi + \beta_{mx}\sin m\phi).$$

Consequently, he calculated nine Fourier coefficients α_m, β_m per circle of latitude. In α_{mx}, the subscript x refers to the component X of the magnetic field. These calculations had to be repeated for the seven circles of latitude, for a total of 63 coefficients. But he had to do the computations for the three components of the magnetic field, for an overall total of $63 \times 3 = 189$ coefficients. By identification, he had [4]:

$$\begin{Bmatrix}\alpha_m\\ \beta_{mx}\end{Bmatrix} = \sum_{n=m}^{4}\begin{Bmatrix}g_n^m\\ h_n^m\end{Bmatrix}\frac{dP_n^m(\theta)}{d\theta}.$$

Gauss used the 189 values to solve by least squares these systems of equations in order to find the 24 Gauss coefficients. In Figures 1 and 2 we have recreated, with a computer, Gauss's model and his results for the declination and the total intensity for the year 1835. His map of the intensity corresponds well to modern numerical results.

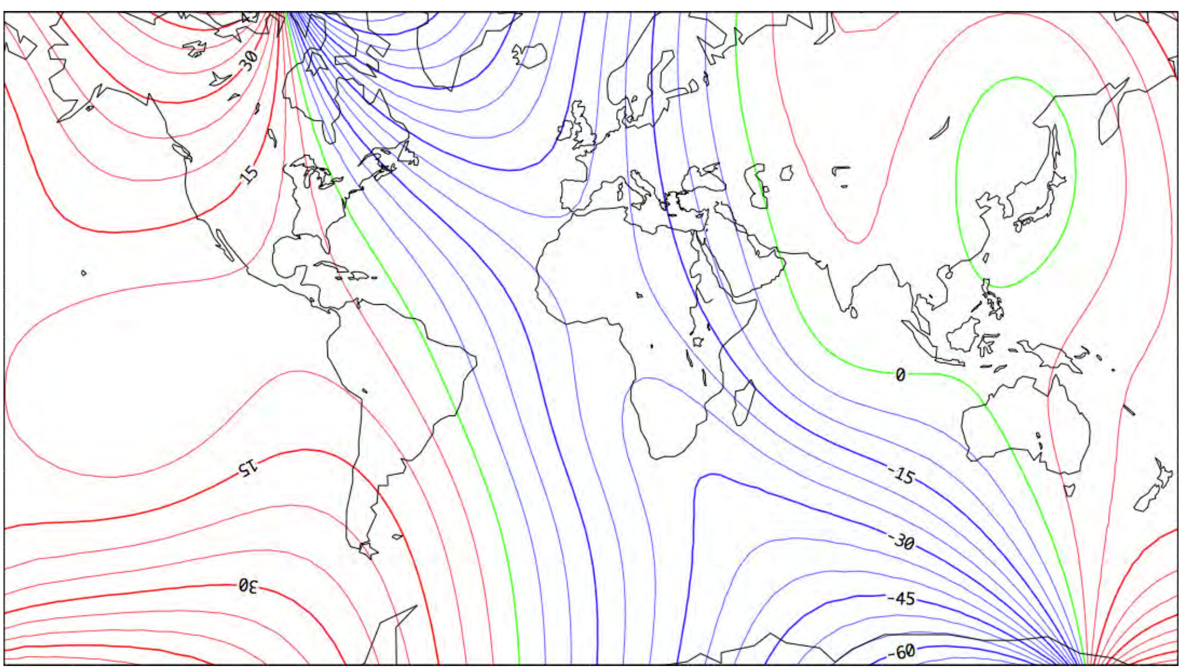

Figure 1. Declination [in degrees] according to Gauss's model for the year 1835, degree and order 4. The map corresponds to a Mercator projection.

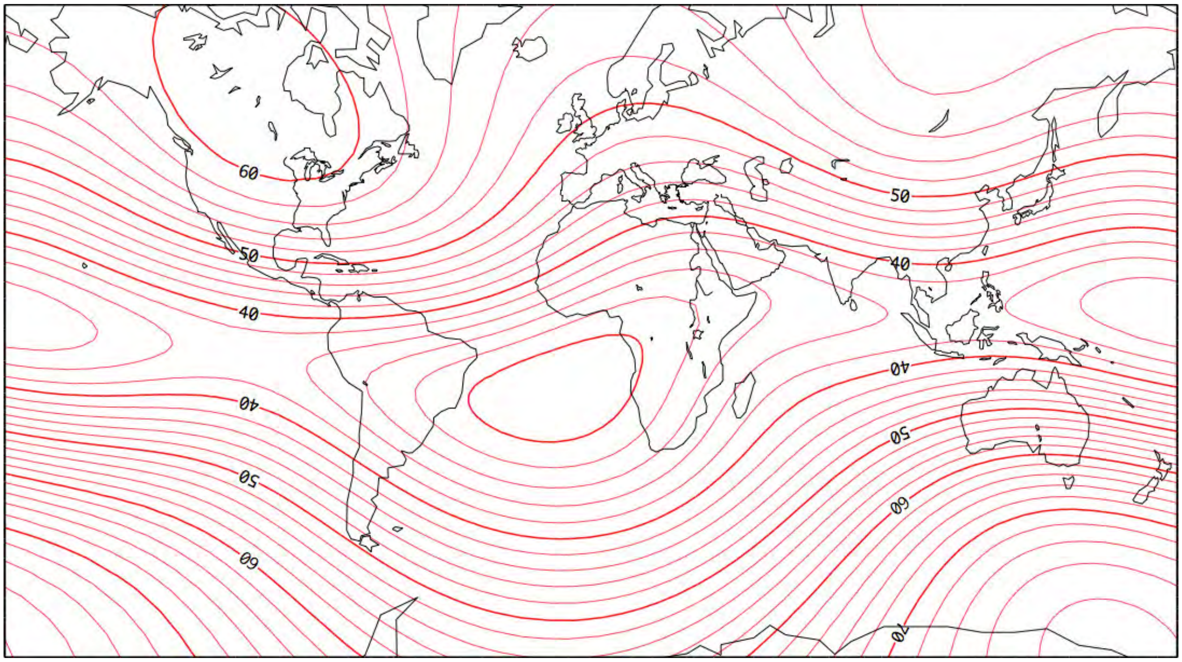

Figure 2. Intensity of the magnetic field [in microtesla] according to Gauss's model for the year 1835, degree and order 4. The map corresponds to a Mercator projection.

In conclusion, Gauss's memoir of 1839, by using spherical harmonics, gave a mathematical form to Gilbert's hypothesis. It was also a major contribution to applied mathematics. Let us quote James Clerk Maxwell, who wrote in 1873 [7, p. viii]:

> *Gauss, as a member of the German Magnetic Union, brought his powerful intellect to bear on the theory of magnetism, and on the methods of observing it, and not only added greatly to our knowledge of the theory of attractions, but reconstructed the whole magnetic science as regards the instruments used, the methods of observation, and the calculation of the results, so that his memoirs on Terrestrial Magnetism may be taken as models of physical research by all those who are engaged in the measurement of any of the forces in nature.*

Geomagnetism remains a very active field of observation and theory, not least for its continuing utility for orientation and navigation, but also due to interest in ongoing changes within the Earth. The wandering of the magnetic poles over recent decades is one example, and outside the scope of this article, but it is worth noting that geomagnetic field data continue to be assimilated and distributed in the form of spherical harmonic coefficients, so that creating any map from historical or modern data involves tables of harmonic coefficients in the manner that Gauss began.

The International Geomagnetic Reference Field (IGRF) presents its model using spherical harmonics of degree and order 13. NOAA also has a series of models extending in some cases to degree and order 720. The terrestrial and lunar gravitational fields are reported and modelled using spherical harmonics, as are such diverse data as the cosmic microwave background. Gauss was visionary in his identification and application of a methodology critical to so many modern endeavours.

Roger Godard is an emeritus professor at Royal Military College, Kingston, Ontario, who has contributed regularly to CSHPM since 1991. John de Boer is a retired Major from the Department of National Defence and a professor at RMC. His field is mainly numerical simulations of auroral events and mathematical physics.

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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** Lectureship 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** Lectureship recognizes mathematicians who have made outstanding 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** Lectureship 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.

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

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:

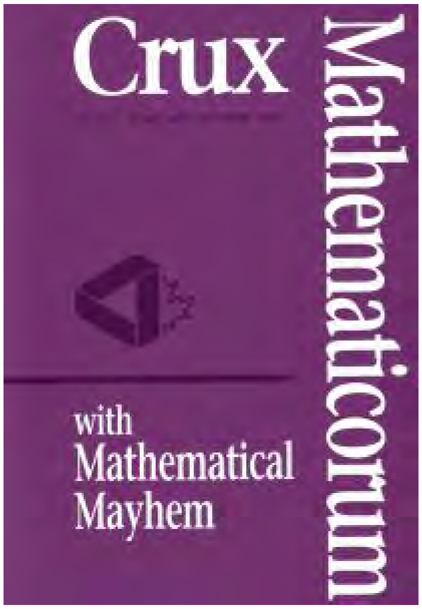
- a signed nominating statement from a present or past colleague, or collaborator (no more than three pages) having direct knowledge of the nominee's contribution;
- a curriculum vitae (maximum five pages);
- three letters of support, at least one from a former student (who has followed a course more 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.

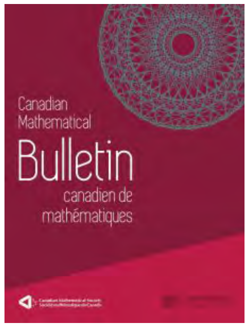


The CMS invites expressions of interest to fill Associate Editor positions for *Crux Mathematicorum (CRUX)*, the CMS international problem solving journal. *CRUX* is in the process of expanding the current compliment of editors on its editorial board to help with the growing number of submissions.

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 August 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 June 30, 2020**.

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**.

2022 Editors-in-Chief of CJM

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.

2020 CMS Winter Meeting in Montreal – Call for Sessions

Sarah Watson
Meetings Manager

The Canadian Mathematical Society (CMS) welcomes and invites session proposals and mini course proposals for the 2020 CMS Winter Meeting in Montreal from **December 4-7**.

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 session, (3) a preliminary list of potential speakers, with their affiliation and if they have agreed to participate, along with a total number of expected speakers.

Session will take place December 5, 6, and 7. The meeting schedule will accommodate 12 speakers per full day, and 5 or 7 per half day. 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 meeting program. Those wishing to organise 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 organisers.

Proposals should be submitted by **August 30, 2020.**

Call for Mini-Courses
The CMS is organising three-hour mini-courses to add more value to meetings and make them attractive for students and teachers to attend.

The mini-courses will be held on Friday afternoon, December 4th, 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.

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

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

CMS Office
meetings@cms.math.ca

Call for New Sessions – 2021 CMS Summer Meeting

The Canadian Mathematical Society (CMS) welcomes and invites proposals for mini-courses for the CMS 75th +1 Anniversary Summer Meeting in Ottawa from **June 4-7, 2021**.

Priority will be given to sessions in complementary areas; new organizers are invited to contact existing organizers of closely related sessions to optimize complementarity. Existing sessions can be found here:

Proposals should include:

- The names, affiliations, and contact information of the main organizers;
- A title and brief description of the focus and purpose of the session.
- 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 June 4-7. They will be advertised in the CMS Notes, on the CMS website, and in the AMS Notices. Speakers will be requested to submit abstracts, which will be published on the web site and in the meeting program.

Those wishing to organize a session should send a proposal to the Scientific Directors:

Ailana Fraser (University of British Columbia)

afraser@math.ubc.ca

Monica Nevins (University of Ottawa)
mnevins@uottawa.ca

Moteja Šajna (University of Ottawa)
msajna@uottawa.ca

European Girls' Mathematical Olympiad- 2020 Report

The Canadian Mathematical Society is pleased to announce that its third team to compete in the European Girls' Mathematical Olympiad (EGMO) has finished a **virtual** EGMO this April which was originally scheduled to take place in Egmond aan Zee, the Netherlands. This year's competition presented some challenges while working in a virtual environment, but the team persevered and enjoyed the competition. The Canadian team finished strongly with one Silver Medal, one Bronze Medal and one Honourable Mention. Unfortunately, there wasn't as much opportunity this year to network with team members from other countries, but both the virtual opening and closing ceremonies gave teams an opportunity to share their pride in their countries and in mathematics. Leaders and deputy leaders shared their students' work on a virtual forum and two of the solutions provided by our team members received special attention, because of their originality and beauty.

The EGMO competition started in 2012 when it was first written in Cambridge, UK and has since grown to include more than 50 countries. Participation in the EGMO is by invitation only. Each student competes individually to solve six questions, in a competition lasting two days, four and a half hours each day. The Girls Math Team Canada was selected largely based on the results of the 2019 Canadian Open Mathematics Challenge (COMC) written in November, as well as a Team Selection Test that was sent to the top 15 female contestants from the 2019 COMC.

The 2020 team was led by CMS Mathematical Competitions Chair, Professor Dorette Pronk (Dalhousie University) and Deputy Leader Diana Castaneda Santos (University of Waterloo). Dorette has also served as Leader for the 2018 EGMO Math Team Canada in Florence, Italy and the 2019 EGMO Math Team Canada in Kiev, Ukraine.

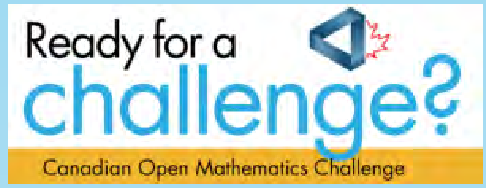
The Canadian EGMO Team was trained at the Fields Institute for Research in Mathematical Sciences, in Toronto from February 6-10. In addition to Professor Dorette Pronk and Diana Castaneda Santos, Jacob Tsimerman, Mike Pawliuk, Dani Spivak and Elnaz Hessami Pilehrood contributed to the training of the team.

Canada's presence at the European Girls' Mathematical Olympiad was made possible in large part due to the financial support of the University of Waterloo's Faculty of Mathematics for which the Society is very grateful. The Society would also like to acknowledge the organizers of the Olympiad Winter Training Camp at York and The Fields Institute for hosting the Girls' training camp. The CMS is also thankful for the support of RBC Foundation, the Actuarial Foundation of Canada, NSERC Young Innovators and PromoScience grants, Samuel Beatty Fund, and many individual donations. This support enabled the Society to allow the Canadian team to participate in this important event and celebrate the achievement of girls in STEM.

Canada's Team consisted of:

- Anna Krokhine, Bronze Medalist – University of Toronto Schools, Toronto, ON
- Siyu (Elaine) Liu, Honourable Mention – Appleby College, Oakville, ON (our Samuel Beatty recipient)
- Jennifer Wang, Silver Medalist – University of Toronto Schools, Toronto, ON
- Amelia Zhou – Marc Garneau Collegiate Institute, Toronto, ON

The CMS is looking for assistance from the Canadian mathematical community in marking the Canadian Open Mathematical Challenge (COMC). The number of students writing the COMC has been growing and we are currently looking for additional marking partners to help with the influx of exams. The Canadian Open Mathematics Challenge (COMC) is Canada's premier national mathematics competition open to any student with an interest in, and grasp of high school math.



Current marking partners are:

- BC – University of British Columbia
- Alberta – University of Calgary; MacEwan University
- Saskatchewan -University of Saskatchewan
- Manitoba – University of Manitoba
- Ontario – University of Toronto and York University (York marks our international papers)
- Newfoundland – Memorial University
- New Brunswick – University of New Brunswick
- Nova Scotia – Dalhousie University
- Quebec – École Polytechnique
- PEI – University of Prince Edward Island

We would like to involve more universities in Canada to become official marking sites in order to accommodate the growing number of students. The CMS can tailor the number of exams an institution may want to mark.

What does being a partner entail?

The exam is typically written on the first Thursday in November and the CMS ships out all COMC materials to the writing centres. The schools are provided with a return postage envelope which would go to the Marking Lead designated by the university. Marking Leads recruit volunteers such as faculty members, PhD's, grad students and strong undergraduates to help with the marking. Once the exams have been received (roughly November 10-15) they need to be scanned into Crowdmark which is our collaborative online grading and analytics platform. Markers can be assigned to grade an exam, with Part A and Part B questions taking on average less time because full marks are assigned when the correct answer appears. The data on the front page (student name, email, etc) needs to be entered into a database. This can be done by anyone. The Marking Lead provides access to the tasks by entering the name and email address of the individual on the Crowdmark page. On average, it takes 6.96 minutes (0.116 hours) to grade an exam. Once the exams are received, your team has roughly 15 days to mark the exams, and enter the metadata information. We like to have the preliminary marks back to teachers before the Christmas break. Since the marking platform is online, your volunteers don't have to be in one place to mark the exams. Once the exams are marked and the grades are entered, CMS will select the top 200+ exams from across the country and have them vetted to see who will go on to write the Canadian Mathematical Olympiad (CMO) and to receive public recognition for their efforts.

By being a marking partner, your university will receive a list of all the top students in Canada to use to offer scholarships or recruitment. We will feature your logo on our COMC website and include your logo on every exam that goes to your province.

CMS would like to accommodate the increase in the number of students writing the COMC competition and give them the chance to represent Canada at the International Mathematical Olympiad. If you are interested in this opportunity or would like to discuss this further, please contact the COMC committee chair or the CMS Competition team.

Dr. Robert Woodrow
Chair of COMC Committee
Canadian Mathematical Society

Dr. Termeh Kousha
Executive Director
Canadian Mathematical Society

A Message from the President of the CMS Regarding Anti-Black Racism in Canada and the United States

Mark Lewis (University of Alberta)
President

I write with grief and anger about recent events in United States and Canada where Black people have died during incidents involving police. This follows a long history of similar events, and we are now experiencing widespread societal outrage. The Canadian Mathematical Society (CMS) condemns anti-Black racism and stands in support of Black communities. We join them in demanding justice and equity for all those who are racialized in our society. We must share the responsibility of changing our world for the better and must also examine our own biases as part of that effort.

The CMS is sincere to finding ways to make our world fairer and more inclusive. Recently, the CMS approved the formation of an Equity, Diversity and Inclusiveness Committee and the values of this committee are key to the next steps in moving forward. We have much to do and are proud to be part of a learning and teaching community that is committed to change and is searching for solutions.

—
Mark Lewis FRSC
Canada Research Chair in Mathematical Biology

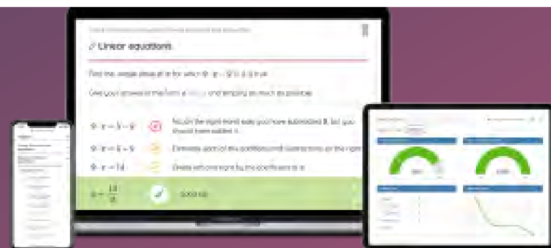
President, Canadian Mathematical Society

Bolster academy

Helping you teach math to non-math majors

The Math Problem

Many programs at college or university require math understanding, even if math isn't the main subject. Students in these math classes have different entry levels, learning styles can struggle with math anxiety or a lack of motivation. On the other side, teachers often don't have enough time to fully support every student due to large class sizes. Add to that the current remote learning situation and it's become quite a challenge to teach math to non-math majors.



Bolster's approach to supporting students

Over the last 10 years, we have been helping teachers and students with our online learning and testing platform, based on principles of guided discovery. Our open math questions allow students to try out different approaches, engaging them to actively discover new knowledge.

The tool is able to interpret and analyze students' answers, by means of mathematical equivalence, and provice personalized feedback accordingly, every step of the way. Add in randomization of questions, and students can practice as much as they want.

Power to the Teachers

Our testing module allows teachers to administer tests remotely and securely from home. The computer algebra system automatically grades assignments, saving teachers a lot of time. Rich learning analytics help to identify red flags.

In our organizations, the math authors outnumber the developers, hence, we are proud to deliver high quality off the shelf (undergraduate) math and stats courses. However, it's also possible to add or customize content. Bolster Academy can be integrated into any LMS.

Trusted by universities worldwide

Learn more at: bit.ly/bolster-academy

Steve LaRocque and the CMS' Digital Transformation

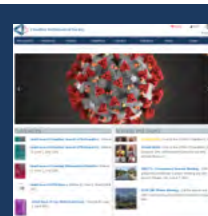
Acknowledgement
June 2020 (Vol. 52, No. 3)


Steve LaRocque

2020 marks a digital turn for the CMS. CMS Notes is now an online-only publication on a new platform. The CMS website has also migrated to a new platform and has been transformed into a more user-friendly site for mathematicians and members to navigate. All these transformations could not have been possible without the generous help of Steve LaRocque, a long-time CMS collaborator. CMS Manager of Electronic Services and Mr. LaRocque's colleague, Alan Kelm had this to say about Steve's role in fashioning the new CMS websites:

> *Steve LaRocque has demonstrated exceptional skill and dedication in piloting the development of the new CMS website and the new CMS Notes website. While it is easy to build simple websites in WordPress, developing complex multilingual sites, like that of the CMS, requires careful selection and integration of plugins, and refining site appearance and behaviour can be challenging. Steve has excelled in all of these tasks and has also simplified back-end administration to enable staff to readily deploy and update all content. Having worked in Electronic Services at the CMS from 2008 to 2018, Steve's intimate knowledge the organization and its systems positioned him well for these projects, and the CMS is appreciative of his work in carrying them to completion.*

The CMS would like to thank Mr. LaRocque for all his work and dedication.



Richard Guy and Me

June 2020 (Vol. 52, No. 3)

Peter Lancaster (University of Calgary)

Richard K. Guy 30 September 1916- 9 March 2020

Richard K. Guy and I were friends and colleagues for about sixty-three years. For the last fity-five of these years we have been faculty members (or emeriti) at the University of Calgary. We first met in 1957 as colleagues in (what was then) the University of Malaya – and is now the University of Singapore.

Richard was an extraordinary character – with an extraordinary career. He was born in 1916 and died on March 9th, 2019. He attended Cambridge University from 1935 to 1938, taught at a secondary school from 1938 to 1940 and married in 1940. He and his charming, indefatigable wife, Louise, had three children in the early 1940's. After his wartime service with the RAF – as a meteorologist, he spent two years (1945-1947) teaching in a secondary school, and his academic career got under way in the late 1940's. For most of the 1950's he was a faculty member of the University of Malaya and, in addition to his research career, devoted time and energy to the teaching profession, pedagogy, and development of the Malayan Mathematical Society and its Bulletin.

Then, in 1961, he took the founding chair of mathematics at the new IIT, New Delhi. However, as a result of health problems, he left in 1965 and went to Calgary accompanied by Louise (who passed away in 2010).

He soon became a tower of strength in his department at the University of Calgary, with extraordinary contributions in terms of service and scholarship – including a term as department head. For example, his broad perspective admitted the development of expertise at the U of C in computer science – which was in its infancy in the 1960's – leading to the creation of the university's first department of computer science in 1975. His commitment to excellence and incredible capacity for work earned the respect of colleagues across the university, as well as the international mathematics community, which led to the award of a University of Calgary Honorary Doctorate. But in terms of service, perhaps his unfailing interest in – and enthusiasm for – the coaching and stimulation of talented school-age students was also remarkable. This included coaching teenage students in preparation for the international Putnam competitions.

His scholarly contributions include collaborations with world-renowned mathematicians whose periodic visits to the University of Calgary have helped to put us "on the map". His own publications were prolific and are largely in areas of mathematics with some popular appeal: game theory, the theory of numbers, graph theory, for example. Problems in these areas are easily posed but they have a correspondingly long, deep history and, being popular, it is difficult to say anything new. But R.K.G. along with young collaborators and eminent scholars, succeeded in doing this and, at the same time, stimulating others – worldwide – to get involved.

I would like to mention another of his passions (which we shared) – the mountains. He was an enthusiastic member of the Alpine Club of Canada as long as he was in Canada. In this context too, he was deeply committed and supportive. For example, he and Louise attended many ACC summer camps, and provided funds for construction of the "Guy Hut" on the Wapta Icefield. Also, their famous annual ascents of the Calgary Tower have provided extraordinary stimulus for the Alberta Wilderness Association.

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