Welcome to the March/April Issue of *CMS Notes*

Issue Contents

March 2021 : Vol. 53, No. 2

Cover Article
March 2021 (Vol. 53, No. 2)

Malabika Pramanik (University of British Columbia)
VP Pacific

A lot has changed over the last year. Death, disease and fear have become the backdrop of our existence, interspersed with frustration, impatience and anger. Cancelled events, immigration snarls, online teaching, cheating in virtual exams are common a airs – but mere trivialities compared with far more serious outcomes, like the loss of loved ones, separation from family afar or in a care facility, struggles with mental health or addiction challenges stemming from isolation. Masks and personal protective equipment are now part of standard gear. Hugs and handshakes are out. Foot bumps and Vulcan salutes are in. Even our vocabulary has changed. There is a lot of "coronaangst"; everyone is "overzoomed".

They say the end is near. As vaccines roll out across the world, as restaurants, daycare centres, museums and concert houses reopen and the economy rebounds, the memories of the past year and a half will become (one hopes!) a distant nightmare, joining the ranks of the plague, Spanish flu and SARS as a topic of conversation over the coffee table, or as a historical narrative for future generations alongside tales of war, famine and natural disasters. We just can't wait for *normal* to be back.

What would post-pandemic normal look like in academia? Probably similar in many ways to what it was before 2020. The bustle of campus life teeming with students, rushing around between classes and meetings, fighting a losing battle against deadlines, diving into seasonal letter-writing and grant-writing frenzies, preparing for lectures, planning to attend conferences, dreaming of a quiet spell away from the daily grind to complete a long overdue research project.

Before turning away to better days ahead, were there any silver linings in the COVID stormcloud, any positives at all worth carrying forward?

- *Mathematicians in the news*. We knew mathematics was important; it was hard convincing the public that it was more than just university calculus. COVID has changed that perception. Our colleagues across the country (like Professors Chris Bauch (Waterloo), Caroline Colijn (SFU), Dan Coombs (UBC), Jane Heffernan (York) to name only a few), and indeed across the world, have made compelling commentaries on the pandemic in national [1] and international media; not just educating the public about the spread of infectious diseases, but using their expertise to guide policy decisions on public health measures and travel restrictions. They have brought increased attention to the role of mathematical sciences in epidemiology and health sciences, and the role of mathematical modelling in public health. Their conversations with the media have re-emphasized the need of mathematical education and numeracy for the general public to better understand the policies, the details and the rationale of vaccine rollout. Most importantly, mathematics is now being used in issues that would have previously fallen under the jurisdiction of ethics or social justice. Nuances of how vaccines ought to be rolled out in order to optimally control COVID among the population, the order of different age groups and different professions in the priority queue for vaccination are critical yet sensitive debates where mathematicians have made impactful, evidence-based contributions [2].

- *Women and visible minorities in leadership roles*. Despite severe challenges faced by certain demographics in many professions, there are now a number of inspiring role models from under-represented groups in the upper echelons of science, technology, academia and industry leading the charge against COVID. Scientists, drug developers and policymakers like
  - Dr. Theresa Tam (Canada's Chief Public Health Officer [3]),
  - Dr. Bonnie Henry (British Columbia's Provincial Health Officer [4]),
  - Dr. Supriya Sharma (Canada's Chief Medical Adviser [5])
  - Dr. Kizzmekia Corbett (Leader of COVID Vaccine Development team at Moderna [6])
  - Dr. Akwatu Khenti (Leader of Black Scientists Task Force on Vaccine Equity [7]),

  existed before the pandemic. But they made life-saving pharmacological breakthroughs or policy decisions in relative obscurity. Now they are much more visible in the media, their work recognized and appreciated more widely, inspiring many young women and youth from under-served communities to consider careers in STEM. The pandemic should fade away, but not our appreciation of such role models.

- *Teaching and research online*. One of the most dire consequences of COVID has been the loss of physical contact. A semblance of work and activity has come about through the universal adoption of online meetings. While certain dynamics of in-person interactions may not be easy to replicate in an online setting, new avenues have opened up for sharing of thoughts and ideas. The shift to online meetings has welcomed the world to join a common platform, sidestepping immigration hassles, eliminating airfares, and most importantly giving access and opportunities to people with geographical, physical, financial or personal constraints that prevent them from travelling to conferences or pursuing a degree in a foreign land. I am reminded powerfully of a fellow mathematician who, as primary caregiver of a family member with special needs, had not been able to attend a conference in decades, and who can now participate in as many virtual talks and workshops as their time and interest will allow. Even with all the goodwill to build an inclusive conference, there was no pre-pandemic mechanism to include people with such challenges; they were marginalized, their requirements deemed too expensive, too specialized to provide meaningful support. Before the pandemic, you had to be at the right place at the right time to be part of a research breakthrough or enjoy the benefits of a great educational program. Not any more.

  One hopes, at least in this case, for some positive change once the pandemic ends. In fact, this shift had already happened outside academia before the pandemic. Large scale research and development teams at tech companies like Google and Amazon solved problems (many of them mathematical!) working remotely. The pandemic has merely demonstrated that collaboration is possible even without physical proximity. As conferences and workshops start up again, as mainstream academics revel in the joy of human contact and in-person intellectual exchange, let us leave a channel of participation open to members of our communities who, by choice or circumstance, may not be able to physically join in the celebration. Let's go hybrid.

The pandemic has put a spotlight on many things, among them the power of science and technology, international collaboration and human resilience. It has also highlighted the stark realities of inequity, in gender [8, 9], in race [10, 11], and mostly in socio-economic privilege. Amidst millions of lost jobs, most university faculty are still employed. Most of us have not needed to put ourselves at risk on the frontlines every day. Many of us have the ability to work from home, migrate our meetings and courses online, work on problems that do not rely on field data. Others have not had that luxury. Young people such as our students and postdocs have also faced a very different reality. Not at liberty to put their academic progress or career trajectories on hold, they have made a virtual entry into post-secondary institutions or into the job market, and have had to adapt to a life completely at odds with their dreams and expectations. Many have done so with a growing sense of isolation, lack of human contact or adequate infrastructural or emotional support. They deserve at the very least empathy and understanding. Thanks to technology, windows have opened as doors have closed, providing glimpses into worlds that were invisible to us before the pandemic. As we move towards a COVID-free future, let us not lose sight of these worlds.

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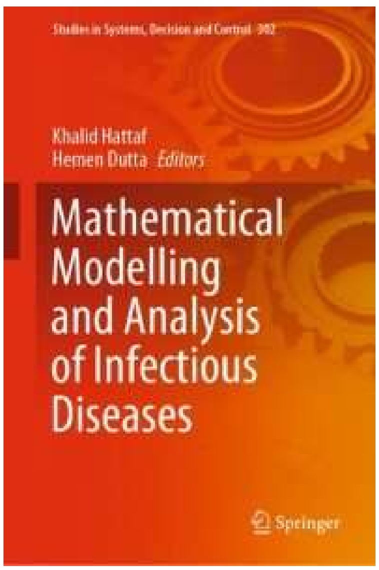
In the June, 2020, issue I featured three books on this very topical subject, written (or co-authored) by Canadian researchers. Three of the five books presented in this column go a bit further afield, but Ping Yan, co-author of "Quantitative Methods for Investigating Infectious Disease Outbreaks" is a Research Manager at the Public Health Agency of Canada, and Robert Smith?, author of "Modelling Disease Ecology with Mathematics", is a Professor of Biomathematics at the University of Ottawa. In the interest of a timely publication of this column, only the publishers' descriptions, rather than actual reviews, are provided below.

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



Mathematical Modelling and Analysis of Infectious Diseases
Edited by K. Hattaf and H. Dutta

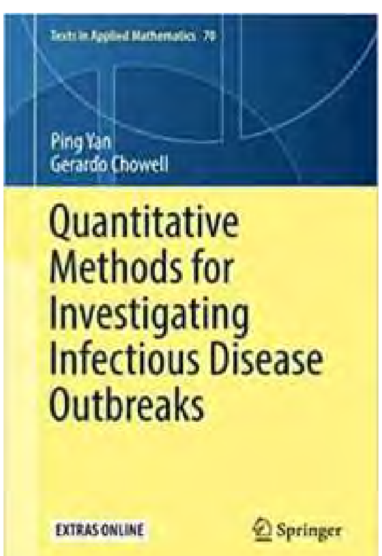
Studies in Systems, Decision and Control 302, Springer, 2020
ISBN 978-3-03049895-5

Publisher's Description:

This book discusses significant research and study topics related to mathematical modelling and analysis of infectious diseases. It includes several models and modelling approaches with different aims, such as identifying and analysing causes of occurrence and re-occurrence, causes of spreading, treatments and control strategies. A valuable resource for researchers, students, educators, scientists, professionals and practitioners interested in gaining insights into various aspects of infectious diseases using mathematical modelling and mathematical analysis, the book will also appeal to general readers wanting to understand the dynamics of various diseases and related issues.

Key Features

- Mathematical models that describe population prevalence or incidence of infectious diseases
- Mathematical tools and techniques to analyse data on the incidence of infectious diseases
- Early detection and risk estimate models of infectious diseases
- Mathematical models that describe the transmission of infectious diseases and analyse data
- Dynamical analysis and control strategies for infectious diseases
- Studies comparing the utility of particular models in describing infected diseases-related issues such as social, health and economic



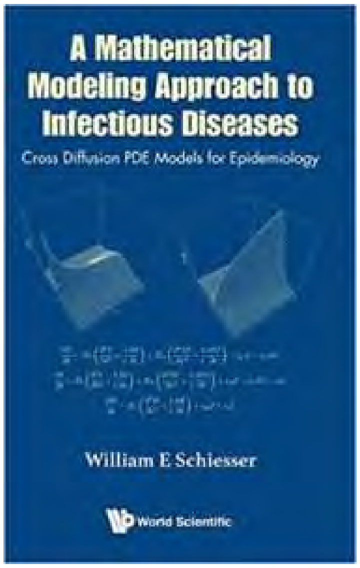
Quantitative Methods for Investigating Infectious Disease Outbreaks
By P. Yang and G. Chowell
Texts in Applied Mathematics 70, Springer, 2019
ISBN 978-3-030-21922-2

Publisher's Description:

This book provides a systematic treatment of the mathematical underpinnings of work in the theory of outbreak dynamics and their control, covering balanced perspectives between theory and practice including new material on contemporary topics in the field of infectious disease modelling. Specifically, it presents a unified mathematical framework linked to the distribution theory of non-negative random variables; the many examples used in the text, are introduced and discussed in light of theoretical perspectives.

The book is organized into 9 chapters: The first motivates the presentation of the material on subsequent chapters; Chapter 2-3 provides a review of basic concepts of probability and statistical models for the distributions of continuous lifetime data and the distributions of random counts and counting processes, which are linked to phenomenological models. Chapters 4 focuses on dynamic behaviors of a disease outbreak during the initial phase while Chapters 5-6 broadly cover compartment models to investigate the consequences of epidemics as the outbreak moves beyond the initial phase. Chapter 7 provides a transition between mostly theoretical topics in earlier chapters and Chapters 8 and 9 where the focus is on the data generating processes and statistical issues of fitting models to data as well as specific mathematical epidemic modeling applications, respectively.

This book is aimed at a wide audience ranging from graduate students to established scientists from quantitatively oriented fields of epidemiology, mathematics and statistics. The numerous examples and illustrations make understanding of the mathematics of disease transmission and control accessible. Furthermore, the examples and exercises, make the book suitable for motivated students in applied mathematics, either through a lecture course, or through self-study. This text could be used in graduate schools or special summer schools covering research problems in mathematical biology.



A Mathematical Modeling Approach to Infectious Diseases
Cross Diffusion PDE Models for Epidemiology
By W. E. Schiesser
World Scientific, 2018
ISBN 978-981-3238-78-7

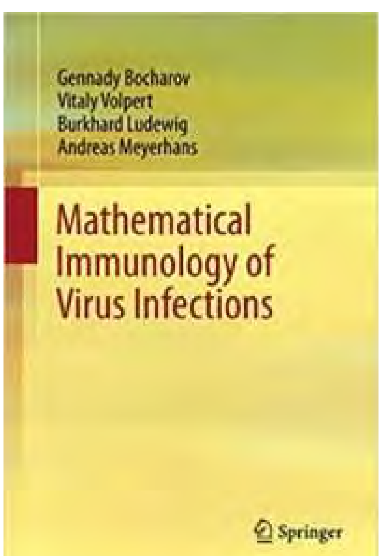
Publisher's Description:

The intent of this book is to provide a methodology for the analysis of infectious diseases by computer-based mathematical models. The approach is based on ordinary differential equations (ODEs) that provide time variation of the model dependent variables and partial differential equations (PDEs) that provide time and spatial (spatiotemporal) variations of the model dependent variables.

The starting point is a basic ODE SIR (Susceptible Infected Recovered) model that defines the S,I,R populations as a function of time. The ODE SIR model is then extended to PDEs that demonstrate the spatiotemporal evolution of the S,I,R populations. A unique feature of the PDE model is the use of cross diffusion between populations, a nonlinear effect that is readily accommodated numerically. A second feature is the use of radial coordinates to represent the geographical distribution of the model populations.

The numerical methods for the computer implementation of ODE/PDE models for infectious diseases are illustrated with documented R routines for particular applications, including models for malaria and the Zika virus. The R routines are available from a download so that the reader can reproduce the reported solutions, then extend the applications through computer experimentation, including the addition of postulated effects and associated equations, and the implementation of alternative models of interest.

The ODE/PDE methodology is open ended and facilitates the development of computer-based models which hopefully can elucidate the causes/conditions of infectious disease evolution and suggest methods of control.

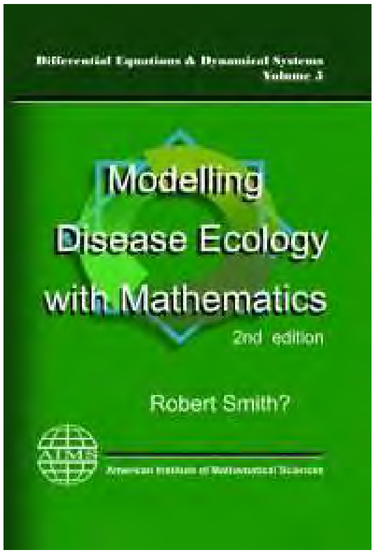


Mathematical Immunology of Virus Infections
By G. Bocharov, V. Volpert, B. Ludewig, and A. Meyerhans
Springer, 2018
ISBN: 978-3-319-72316-7

Publisher's Description:

This monograph concisely but thoroughly introduces the reader to the field of mathematical immunology. The book covers first basic principles of formulating a mathematical model, and an outline on data-driven parameter estimation and model selection. The authors then introduce the modeling of experimental and human infections and provide the reader with helpful exercises. The target audience primarily comprises researchers and graduate students in the field of mathematical biology who wish to be concisely introduced into mathematical immunology.

Modelling Disease Ecology with Mathematics, 2nd Ed



Modelling Disease Ecology with Mathematics, 2nd Ed.
By Robert Smith?
AIMS Series on Differential Equations & Dynamical Systems, 5
American Institute of Mathematical Sciences, 2017
ISBN: 978-1-60133-020-8

Publisher's Description:

"Modelling Disease Ecology with Mathematics" is a self-contained introduction to the basics of mathematics for students and researchers in the areas of biology, epidemiology, medicine and public health. Diseases covered include malaria, yellow fever, measles, influenza, Guinea-worm disease and AIDS.

a) Mathematical models representing current diseases are formulated and analysed in an easy-to-follow manner, often humorously.

b) MATLAB exercises provide the reader with the ability to develop control strategies, test hypothetical interventions and explore disease-management options.

c) Case studies provide worked examples of applying theoretical tools to real-life problems (and also prepare the world for a zombie apocalypse).

This monograph is especially suited to those without a background in mathematics, who are interested in learning about the way that mathematics can organise, analyse and enlighten when tackling biological problems in disease control and management.

Some Stories from My Journey

Kseniya Garaschuk (University of the Fraser Valley)

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.

Kseniya Garaschuk, *University of the Fraser Valley (kseniya.garaschuk@ufv.ca)*

I moved to Canada when I was 18, so I am acutely aware of the learning experiences and adjustments one has to make in the education system that does not reflect your own cultural and linguistic backgrounds. To this day, my processes of learning do not always align with what is so familiar to my students. For example, the learning via "memorization by abbreviation" (FOIL, CAST, SOHCAHTOA) is a completely foreign approach to me, yet the one that many of my students will be most comfortable with. Furthermore, in my current role as a mother to a bilingual multicultural child, I am faced with various challenges when it comes to teaching my daughter. As such, cultural relevance is important to me as a person and as a teacher.

In the past four years, I have been very lucky to live and work in the community with close ties to its local First Nations people. The various resources and opportunities available have allowed me to explore the meaning behind reconciliation and indigenization and to incorporate Indigenous knowledge into my teaching. In most practical terms, indigenizing the curriculum can be through as approached in two ways: through content and through delivery. Introducing Indigenous content involves familiarizing yourself with and promoting local context and history. Indigenizing your delivery means exploring First Peoples principles of learning, knowing and being.

It is encouraging to see the interest universities have been showing in Indigenizing their curriculum and the serious steps K-12 curriculums have been taking in that direction. However, practitioners often struggle to find existing resources, don't know how to establish connections (internal and external) and hence are reluctant to explore. Reconciliation is a process, it takes time and deliberate practice, so there are no easy and fast ways, no checkboxes to fill it and hence "pass" the indigenization of curriculum test. One needs to find their own approach and their own identity within this process.

But let's talk about content, it's the visible way to engage and likely an easier entry point to the process. On the surface, the introduction of genuine Indigenous content is easier done in historical and exploratory courses. But while content is easy to find, one has to be purposeful in pursuing meaningful application of it. For example, in my History of Math class, exploring development of mathematics across different civilizations, we kept coming back to oral traditions of First Nations and the use of rhetoric for mathematical problems in other cultures. A major topic in the course is different cultural approaches to learning and the functions that knowledge served within those communities. While indigenous number systems can be a vessel for introducing content, you need to find the wind and the current to carry this vessel forward.

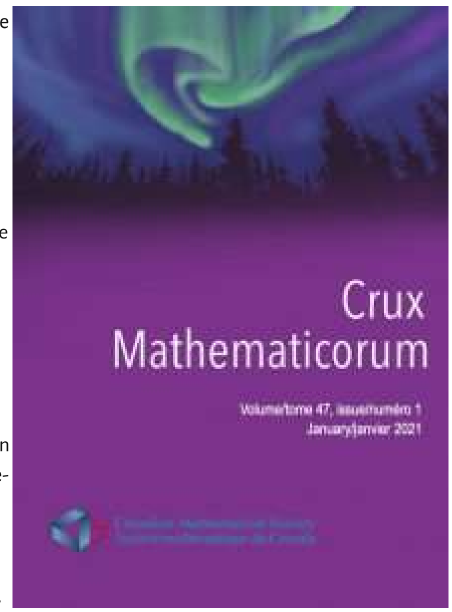
What about service courses, where the mathematical curriculum seems to dictate the content of every class? Here is one example of a calculus problem based on local (to me) context involving the construction of Coast Salish bentwood boxes: boxes that are made out of a flat cedar plank that is steamed and bent to form a box. A natural question to ask is how do we need to bend the plank to create a box of largest volume. Mathematically, it is a standard question. Contextually, students engage in this problem by exploring local traditions (what were the boxes used for?), materials (would any wood or plank do?) and crafts (how do we physically bend the wood?). The latter part emphasizes the simplifying assumptions we make to create a mathematical model: we assume that the thickness of the wood is negligible, while the craftsman carves a groove at the corners. As students generally struggle with 3-dimensional objects, this problem serves as a good opportunity for experiential learning as I ask students to construct and submit their "bentpaper" boxes together with their solution. Students who identify with this particular application find inspiration and a sense of belonging in this project, which results in inspiring submissions.

Even in this small example it is clear that content cannot be considered without context and the indigenous approach to knowledge that requires a more thorough reevaluation of one's teaching practices to align them with First Peoples principles of learning. In any course, I emphasize the human and personal nature of mathematics as well as learning itself as a historical and cultural endeavour. I very intentionally situate all content in time and place as well as tie it to particular people and their stories. Sometimes these stories find me!

Last June, I started preparing my Calculus I for LIfe Sciences materials. In this class, one of the first applications I talk about is Michaelis-Menten kinetics, which is a rational function model describing enzyme reactions. I like this model for a number of reasons: it has wide applications in chemistry, physiology and beyond, most of the first year students will encounter it in their chemistry classes but don't get a chance to analyze it rigorously, while fairly straightforward mathematical analysis reveals some intuitive chemical properties. Now, whenever I can, I always talk about people behind discoveries, and in this case it's particularly pertinent (one of the other reasons I like this model) because Maud Menten was a Canadian physician and one of the first women in Canada to obtain a medical degree. She has quite an interesting biography, had to travel outside of Canada to US and Germany because in early 1900 women couldn't do research in Canada, but she came back in the 50s and her final academic post was in BC. As I was re-reading her biography, I found a new (to me) source with her biography that includes the following info:

> *By the end of her life Menten was fluent in six languages, not only English, French, Italian, German and Russian, but also Halkomelem, which she learned this as a child growing up in British Columbia, Canada, as it was the language of some of her friends at school.*

What a wonderful unexpected connection to the people whose land I was teaching my course on! These connections are waiting to be discovered. There's no royal road to geometry and there's no shortcuts to indigenization: it is a journey each individual has to build for themselves. But as teachers, we can offer our students a peek into other people's journeys.



In fall 2020, I taught Math for Elementary Teachers. I got very luck: CMS organized Closing the Gap webinars and one of the presenters was Lisa Lunney Borden talking about "Math Elders Knew". The webinar was at the same time as my class, so I asked my students to join in, which they mostly all did. I could talk for a while about the wonderful insights and activities that Lisa shared, but instead I ask you to watch the video; I ensure you that you will learn a lot. What I will share is one of my student's reactions to the talk. My student, let's call her Amanda, has already graduated with Bachelor degree in Anthropology with minor in Indigenoius Studies, and was taking Math for Elementary Teachers to enter the teacher education program. Amanda was both amazed and confused: in her entire Bachelor's degree noone has ever talked about mathematics as it arises in everyday lives, in art and in culture. How is it possible that cultural and social anthropology completely skipped over what Amanda now realised was an essential part of the study of humans? As educators, we need to address the gaps created by curriculum divides to create a truly universal experience for our students.

In my other role as Editor-in-Chief of Crux Mathematicorum, I am truly excited that this year we will be starting a new column "Explorations in Indigenous Mathematics". The column, led by Edward Doolittle, will explore cultural mathematics, allow the readers to experience the discipline through a broader humanizing approach, and engage in mathematics with societal context and history. The first column in Crux Volume 47, issue 1 focuses on starblanket design, rich in culture and mathematics. Crux now features a new cover, designed by Indigenous artist Rebekah Brackett. Rebekah is one of the people that provided inspiration and guidance in my own journey to understand and embrace First People's principles of knowing and learning. As we were organizing Fraser Valley Math Education Sq'ep (Sq'ep meaning a meeting, gathering in Halq'eméylem), we explored the connections between math, language, art, land. With the help of Tasheena Boulier and her family, consisting of the few last fluent speakers of Halq'eméylem, we created a counting booklet featuring number words in Halq'eméylem and images of the lands of the Sto:lo people. Take a look at the booklet, explore the numbers and enjoy the views of the beautiful Fraser Valley. Let us begin to explore each other's mathematics together.

Math Catcher Festival

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.

Kseniya Garaschuk, *University of the Fraser Valley (kseniya.garaschuk@ufv.ca)*

It is my experience that many students, at almost all levels, when encountering abstract thinking, struggle to connect mathematical concepts to everyday life. Storytelling, on the other hand, is naturally interwoven with lived experiences and opportunities for connection.

Rina Sinclair, an Elder of the Siksika Nation, showed us just how powerful storytelling can be at the First Nations Math Education Workshop in 2009. Following the workshop, I set out to create an initiative that would apply the Indigenous tradition of storytelling as a vehicle to both communicate and promote mathematical concepts. Thus, began the Math Catcher Outreach Program, which aims to link mathematics to the "real world" through problem-solving, stories, and hands-on activities.

Over the past 10 years, in cooperation with Mark Mac Lean we have worked to create a series of short stories and animated films that teach math skills and problem-solving within cultural contexts. The main character in all stories is a boy called Small Number, who has an impressive aptitude for mathematics—and a proclivity for getting into mischief. Through these stories, we show students that young people, like Small Number, encounter mathematics and require knowledge of it daily. The stories highlight how mathematics can be interesting and applicable in real life situations.

The Small Number stories and films incorporate problem-solving and aim to promote Indigenous culture. Of course, Indigenous culture is not a singular cohesive set of beliefs and practices, but a myriad of traditional and modern values and practices. As a result, Small Number's adventures take place in different settings and in different Indigenous communities. The stories are available in nine First Nation languages, as well as English and French.

The program's latest initiative, the Math Catcher Festival, aims to continue our work in the same direction. The festival and associated activities are based on the belief that storytelling, accompanied by pictures and open-ended questions, helps students experience mathematics in action and encourages them to enjoy math.

This initiative was inspired by the teaching practices of Ms. Alana Underwood, an elementary school teacher from Coquitlam, BC. Alana describes her practices in an article that is available here.

The Math Catcher Festival was envisioned as a celebration of students' imagination and creativity and their knowledge of mathematics and Indigenous cultures and traditions.

- In September 2020 the Math Catcher Program invited Grade 4–5 students to create, over the Fall 2020 semester, their own Small Number stories and present them in the format of their choice: a picture book, a comic, a video, a PowerPoint presentation with a voice over, a play, a poster, an animation, a computer game, or any other medium that would fit their interests.

We asked that the stories be playful and promote kin and friendship and demonstrate the following:

- that mathematics is applicable in real life;
- that young people like Small Number encounter mathematics and require knowledge of it on a daily basis;
- that mathematics can be interesting;
- that mathematics can be used to solve real-life problems.

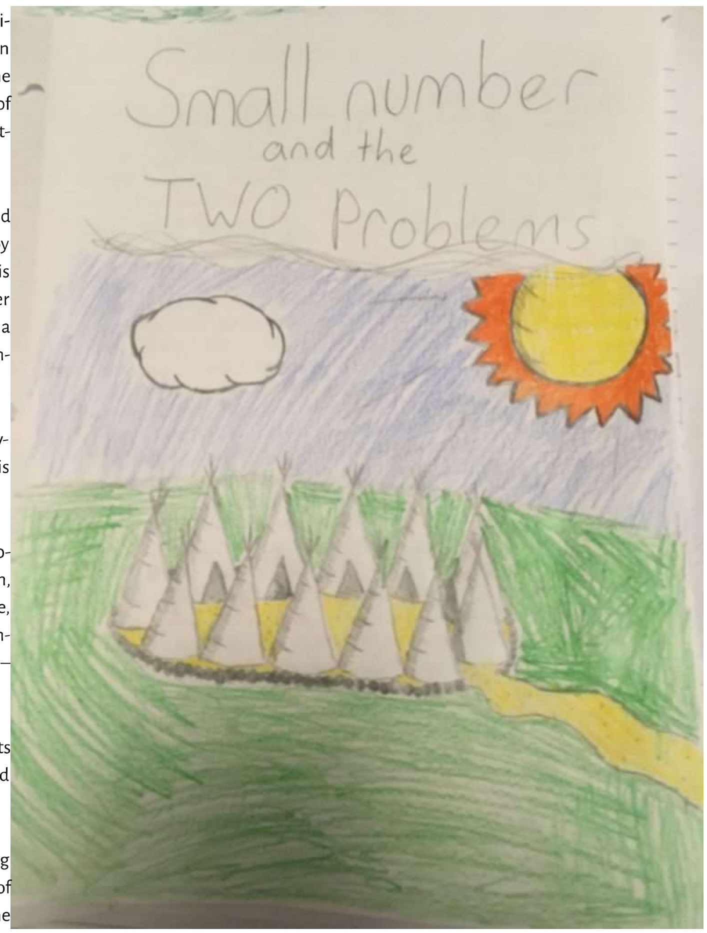
It should be noted that the Festival took place in extraordinary times, when the classroom routines were altered by the ongoing pandemic. Just the fact that the Festival was able to proceed is a testament to the dedication of the participating students, teachers and organizing committee.

The Festival participants came from 14 schools from seven BC communities, Grand Forks, Coquitlam, Powell River, Prince George, Rock Creek, Surrey, and Vancouver. Some schools submitted work by individual students, some of the submissions were collaborations of small groups of students, some were class projects. Based on my communications with teachers, my estimate is that about 250 students participated in the Festival related activities during the months of October and November 2020.

The submissions differed in their format, from a written story to a graphic novel to a play; the length, from a several lines long story to a few PowerPoint slides to a several minutes long video; the choice of the story plot, from what happened to Small Number on the first day in a new school to how Small Number played basketball to Small Number's trip to a potlach; the languages, from the Tla'amin language to English to French; and so on. There is even a story with a talking stone!

What was common for all of the stories was the impressive level of students' imagination and creativity and their ability to see and describe mathematics around them and to include mathematics in their storytelling.

For me, as a math teacher, probably the most valuable learning experience from reading and watching students' submissions to the 2020 Math Catcher Festival was the realization that even young students[1] can talk about various mathematical topics in the context of the plot of their own story. The range of the mathematical topics addressed in the Festival submissions was quite wide, from counting and applying arithmetic operations to pattern recognition to presenting the elements of mathematical thinking in some of the Indigenous traditions.



As a consequence, I am even more determined that in my own teaching I continue to minimize presenting of mathematical topics in isolation. In other words, I believe that even when talking about the most abstract mathematical topics, the teacher should provide the opportunity and motivation to discuss the topic, clearly explain its importance as part of the bigger idea, and also acknowledge its connections with other mathematical and not-so-mathematical ideas and the existing or possible applications.

Another strong impression was that in many of the contributed stories, the authors had identified with Small Number's character. For example, in one story, Small Number is a boy who has no friends and has to play by himself; in another Small Number is worried that his mom will would get upset because "he ripped the elbow out of his hoodie." Small Number is a city resident but also, he lives "at Bear Lake." There is a story in which Small Number is a member of the Tla'amin Nation, in another he is an Inuit. In a couple of stories Small Number is a girl, and so on.

I believe that through their identification with Small Number and the process of storytelling, the students were able to actually make mathematics personal, something that is part of their lives.

Finally, I list some of the mathematical concepts that were included in the submitted stories: mathematical thinking; problem solving; counting; algebraic operations – addition, multiplication, division; pattern search and recognition; measuring; money; time – age, scheduling; dimensions – distance, area, height, depth; sequences; geometry – shapes, angles; game theory – a fair division of a cake; approximation; mathematics and other fields – environment in particular, sports, chemistry, art.

In their feedback, teachers told us that they particularly appreciated "watching my students light up with creativity and excitement for the project" and "the freedom to explore and work together." We also learned that "[Students] enjoyed creating stories for Math."

The Festival was held online through Zoom, on Friday, December 11, 2020. All participating schools attended the event. In addition, we had several guests including Mr. Drew Blaney of the Tla'amin Nation, Mr. Ron Johnston of the Squamish Nation, and Mr. Gary George of the Wit'suwit'en Nation. Dr. Paul Kench, Dean of Science, welcomed all participants and guests.

Afterwards, one of the members of the organizing committee commented: "What an inspirational morning! So grateful to be part of this festival."

I finish with the message from one of the teachers: "My students were so excited to share their stories and really enjoyed hearing the other students' submissions. I hope that we can participate again in the future!"

For further information about the Math Catcher Festival 2020 and to enjoy the submissions please visit https://www.sfu.ca/mathcatcher/math-catcher-festival.html.

[1] Grade 4-5 students are 9-10 years old.

A Collaborative Research Project in the History of Mathematics: The History of Canonical Transformations in Hamilton-Jacobi Theory

Craig Fraser (University of Toronto) and Michiyo Nakane (Seijo University)

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)*

The authors met at a conference on the history of mathematics that was held in the summer of 1990 in Tokyo. Both of us worked on the history of analysis and mechanics, with Fraser focusing more on the 18th century and Nakane on the 19th century. We had a common interest in the intellectual or technical development of science with a particular focus on the interplay between mathematics and physics. This common interest led over the following years to a collaboration that resulted in 2003 in an article on the early history of Hamilton-Jacobi theory [11].

The present project developed from a survey that we also published in 2003, in an Italian encyclopedia, on mathematical methods in 19th-century celestial mechanics [6]. What was initially a plan to write an English version of this essay evolved over the years into a rather different project centered on the history of the concept of canonical transformation. We discussed our research at the International Congresses of the History of Science held in 2009 in Budapest and in 2017 in Rio de Janeiro, and corresponded occasionally in the years between. The research really got underway in earnest early in 2018, and the collaboration has involved many emails and multiple drafts exchanged since then between Toronto and Tokyo. The authors presented some of the preliminary results of their research at the joint meeting of the AMS and MAA in Denver in January 2020. Talks have also been given at the annual meeting of the CSHPM (Vancouver 2019) and the winter meetings of the CMS (Montreal 2015 and online 2020). The projected date of publication of the study is later in 2021 or early 2022.

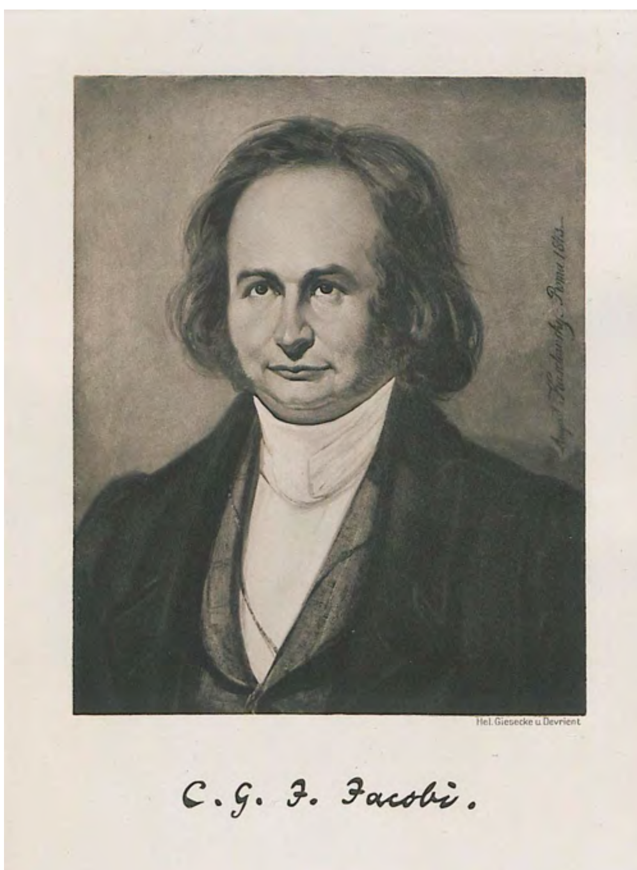


Figure 1. Carl Gustav Jacobi (1804-1851) in 1843. Public domain.

Hamilton-Jacobi theory is composed of three major parts: the canonical ordinary differential equations, the Hamilton-Jacobi partial differential equation, and the concept of canonical transformation. The first two elements were established by William Rowan Hamilton and Carl Gustav Jacobi in the 1830s. The concept of a canonical transformation was introduced by Jacobi in 1837 [9], but really only became a central part of the theory more than fifty years later. The present research project follows the original formulation and subsequent development of Jacobi's results on transformations until about 1950.

Consider the *2n* variables $q_i = q_i\left(t\right)$ and $p_i = p_i\left(t\right)$ *(i=1,..., n)* where the time *t* is the independent variable. The Hamiltonian *H* is a function of *t*, q_i and p_i:

$$H = H\left(t, q_i, p_i\right) \qquad (1)$$

The system is governed by Hamilton's equations for the problem:

$$\begin{aligned} \frac{dp_i}{dt} &= -\frac{\partial H}{\partial q_i}, \\ \frac{dq_i}{dt} &= \frac{\partial H}{\partial p_i}. \end{aligned} \qquad (2)$$

(2) are also known as the "canonical equations," terminology that originated with Jacobi.

Suppose now that we transform q_i and p_i to new variables Q_i and P_i:

$$q_i = q_i\left(Q_i, P_i\right),\ p_i = p_i\left(Q_i, P_i\right) \qquad (3)$$

The Hamiltonian then becomes a function of *t*, $\left(Q_i\right)$ and $\left(P_i\right)$, $H = H\left(t,\ Q_i, P_i\right)$. Suppose the given transformation has the property that equations (2) transform to the equations

$$\begin{aligned} \frac{dP_i}{dt} &= -\frac{\partial H}{\partial Q_i}, \\ \frac{dQ_i}{dt} &= \frac{\partial H}{\partial P_i}. \end{aligned} \qquad (4)$$

which are canonical in the variables Q_i and P_i. A transformation with such a property is said to be "canonical." The goal is to transform to variables that are integrable and thereby obtain a solution to the problem.

Consider any function $\psi = \psi(q_i, Q_i)$ of q_i and Q_i. ψ is what is called a "generating function" in modern textbooks. We require that the variables q_i, p_i and Q_i, P_i satisfy the equations:

$$p_i = \frac{\partial \psi}{\partial q_i},\ P_i = -\frac{\partial \psi}{\partial Q_i} \qquad (5)$$

(5) serves to define a transformation between the old and new variables, expressing q_i and p_i as functions of Q_i and P_i. For a transformation defined in this way equations (4) hold and the transformation is canonical. This is Jacobi's fundamental theorem on canonical transformations.

As noted above, Jacobi stated this result in a note published in 1837 in the *Comptes rendus* of the Paris Academy of Sciences. He provided no proof but somewhat misleadingly suggested it is not difficult to give one. Jacobi died in 1851, but a detailed proof of the theorem was only published in an appendix to his famous 1866 lectures on dynamics [10]. Jacobi is believed to have written this essay in the late 1830s, although the exact dating is uncertain. The 1866 lectures themselves were originally delivered in the winter semester of 1842–43 at the University of Königsberg. Jacobi's proof (generalized to include time-dependent generating functions) was adopted by the Swedish astronomer Carl Charlier in volume two (1907) of his influential treatise on celestial mechanics [3]. (When the generating function $\psi = \psi(t, q_i, Q_i)$ is also a function of time the transformation equations (3) involve the time and H is replaced by $K = H + \frac{\partial \psi}{\partial t}$ in (4).)


COMPTE RENDU

DES SÉANCES

DE L'ACADÉMIE DES SCIENCES.

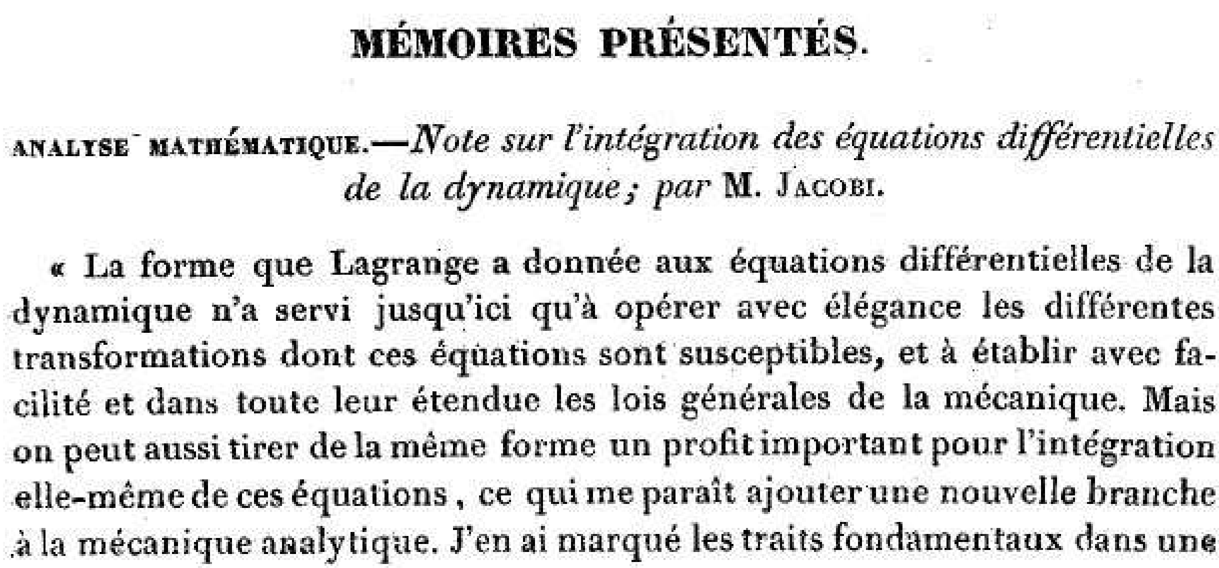
SÉANCE DU LUNDI 17 JUILLET 1837.

PRÉSIDENCE DE M. MAGENDIE.

MÉMOIRES ET COMMUNICATIONS

DES MEMBRES ET DES CORRESPONDANTS DE L'ACADÉMIE.

Figure 2. The beginning of Jacobi's 1837 paper.

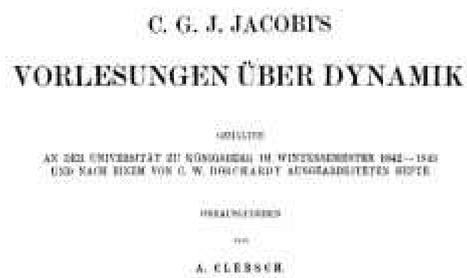


MÉMOIRES PRÉSENTÉS.

ANALYSE MATHÉMATIQUE.—*Note sur l'intégration des équations différentielles de la dynamique; par* M. Jacobi.

« La forme que Lagrange a donnée aux équations différentielles de la dynamique n'a servi jusqu'ici qu'à opérer avec élégance les différentes transformations dont ces équations sont susceptibles, et à établir avec facilité et dans toute leur étendue les lois générales de la mécanique. Mais on peut aussi tirer de la même forme un profit important pour l'intégration elle-même de ces équations, ce qui me paraît ajouter une nouvelle branche à la mécanique analytique. J'en ai marqué les traits fondamentaux dans une

Figure 3. Writing in French was unusual for him.



C. G. J. JACOBI'S

VORLESUNGEN ÜBER DYNAMIK

A. CLEBSCH

Figure 4. Portions of the title page of Jacobi's lecture, published in German in 1866 and read much more widely in the late 19th century than his 1837 paper.

In articles that fell into historical obscurity, proofs of Jacobi's theorem on canonical transformations were published by two mathematical astronomers, Adolphe Desboves in 1848 and William Donkin in 1854 [4; 5]. However, the concept of a such a transformation really only became a central part of the theory in the 1890s in the writings of Henri Poincaré, in successive editions of his lectures on celestial mechanics. In particular, Poincaré in 1899 presented what would become the standard proof of Jacobi's result that one finds in all textbooks today [13]. This demonstration deploys a variational principle to produce an elegant structural proof that is much simpler than the derivations of Jacobi, Desboves and Donkin. It was also Poincaré and his contemporary Edmund Whittaker who hit upon the idea of using a solution of the Hamilton-Jacobi partial differential equation as the generating function for a canonical transformation [15].

Figure 5. Henri Poincaré (1854-1912).

LES MÉTHODES NOUVELLES

MÉCANIQUE CÉLESTE

H. POINCARÉ,

TOME III.

PARIS,

1899

Figure 6. Title page for the 1899 edition of Poincaré's lectures on celestial dynamics.

From the beginning various forms of the three-body problem in astronomy were the primary physical focus of Hamilton-Jacobi theory. In the second decade of the 20th century the methods of Hamilton, Jacobi, Poincaré and Charlier were adopted by German quantum physicists and became central to the new theories of matter that they were constructing. One might say that these events constitute a striking example of the unreasonable effectiveness of mathematics in natural science. In 1919 physicist Arnold Sommerfeld wrote

> Up to a few years ago it was possible to consider that the methods of mechanics of Hamilton and Jacobi could be dispensed with for physics and to regard it as serving only the requirements of the calculus of astronomic [sic] perturbations and the interests of mathematics.

Sommerfeld draws attention to the key place these methods had come to occupy in physics, observing that

> it seems almost as if Hamilton's method was expressly created for treating the most important problems of physical mechanics [14].

An exposition of Hamilton-Jacobi theory was given by Max Born in 1925 in his famous book on atomic physics [1]. Two years later Lothar Nordheim (a student of Born and an assistant of David Hilbert) and Erwin Fues composed a critical distillation of the theory for the *Handbuch der Physik* [12]. Their account became the source for such standard textbook accounts as Herbert Goldstein's *Classical Mechanics* (1950) in physics [8] and Israel Gelfand and Sergei Fomin's *Calculus of Variations* (1963) in mathematics [7]. The subject of canonical transformations was also explored in a somewhat more abstract mathematical form by Constantin Carathéodory in his authoritative 1935 book on analysis [2].

Poincaré was familiar in a general way with some of the standard results in dynamical analysis, particularly as these had been presented in writings of astronomers such as Félix Tisserand on perturbations. However, he wrote with a limited historical sense for the work of his predecessors in mechanical science. Research that became standard in the 20th century took off from Poincaré and Charlier and was even less rooted in the older historical sources. One of the challenges of our study has been to identify, understand and document the byways of 19th-century research in analytical dynamics and analysis. The interplay of celestial mechanics and mathematical subjects such as the calculus of variations and theory of partial differential equations was a fascinating arena for some of the most advanced natural science of the period.

Craig Fraser teaches the history of mathematics and astronomy at the University of Toronto. He is President of the Canadian Society for History and Philosophy of Mathematics and a full member of the International Academy of the History of Science. He recently published "Mathematics in Library and Review Classification Systems: An Historical Overview" in Knowledge Organization *47, no. 4 (2020), 334–356.*

Michiyo Nakane is a part-time lecturer at Seijo University in Tokyo. An historian of the mathematical sciences, she investigates the development of theoretical mechanics and celestial mechanics in the 19th and early 20th centuries. She is currently studying the reception and development in Japan of mathematical methods of quantum physics. She recently published "Yoshikatsu Sugiura's Contribution to the Development of Quantum Physics in Japan" in Berichte zur Wissenschaftsgeschichte *42 (2019), 338–356.*

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[1] Born, Max. (1925) *Vorlesungen über Atommechanik*. With the assistance of Friedrich Hund. Berlin: Springer.

[2] Carathéodory, Constantin. (1935) *Variationsrechnung und partielle Differentialgleichungen erster Ordnung*. Leipzig and Berlin: B. G. Teubner.

[3] Charlier, Carl Ludwig. (1907) *Die Mechanik des Himmels*. Vol. 2. Leipzig: Veit & Comp. Jacobi's transformation theorem is given in the 11th section.

[4] Desboves, Adophe H. (1848) Démonstration de deux théorèmes de M. Jacobi – Application au problème des perturbations planétaires. *Journal de mathématiques pures et appliquées* 13, 397–411. Thesis presented to the Paris Faculty of Sciences, 3 April 1848.

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[6] Fraser, Craig, and Michiyo Nakane. (2003) La meccanica celeste dopo Laplace: la teoria di Hamilton-Jacobi. In *Storia della scienza*, editor-in-chief Sandro Petruccioli, vol. 7, 234–243. Roma: Istituto della Enciclopedia Italiana.

[7] Gelfand, Israel M., and Sergei V. Fomin. (1963) *Calculus of Variations*. Revised and translated by Richard A. Silverman. Englewood Cliffs, NJ: Prentice-Hall Inc.

[8] Goldstein, Herbert. (1950) *Classical Mechanics*. Reading, MA: Addison-Wesley Publishing Company, Inc.

[9] Jacobi, Carl Gustav J. (1837) Note sur l'intégration des équations différentielles de la dynamique. *Comptes rendus de l'Académie des Sciences de Paris* 5, 61–67. Reprinted in Jacobi's *Gesammelte Werke*, vol. 4 (1886), 129–136.

[10] Jacobi, Carl Gustav J. (1866) Über diejenigen Probleme der Mechanik, in welchem eine Kräftefunction existiert und über die Theorie der Störungen. Supplement to *Vorlesungen über Dynamik* (1866, 303–470). Reprinted with minor editorial emendations in Jacobi's *Gesammelte Werke*, vol. 5 (1890), 217–395.

[11] Nakane, Michiyo, and Craig Fraser. (2003) The Early History of Hamilton-Jacobi Theory. *Centaurus* 44, 161–227.

[12] Nordheim, Lothar, and Erwin Fues. (1927) Die Hamilton-Jacobische Theorie der Dynamique. In *Handbuch der Physik*, edited by Hans Geiger and Karl Scheel, vol. 5, 91–130. Berlin: Springer.

[13] Poincaré, Henri. (1899) *Les Méthodes nouvelles de la mécanique céleste*. Vol. 3. Paris: Gauthier-Villars.

[14] Sommerfeld, Arnold. (1919) *Atombau und Spektrallinien*. Braunschweig: Wieweg & Sohn. The English translation by Henry L. Brose published in 1923 is of the German third edition, also published in 1923. The passages quoted above are the same in the different German editions and appear as quoted on pp. 555–556 of the English translation.

[15] Whittaker, Edmund Taylor. (1904) *A Treatise on the Analytical Dynamics of Particles and Rigid Bodies: With an Introduction to the Problem of Three Bodies*. Cambridge: Cambridge University Press.

The CMS Fellows program recognises CMS members who have made excellent contributions to mathematical research, teaching, or exposition; as well as having distinguished themselves in service to Canada's mathematical community. In exceptional cases, outstanding contributions to one of the below areas may be recognised by fellowship.

- Making significant contributions to the profession and to the Canadian mathematical community.
- Increasing the relevance and visibility of the CMS.

For a nomination to be complete, all nomination requirements and eligibility should be included. A CMS member may nominate a maximum of two Fellows in a calendar year. Any person who is nominated and is not selected a Fellow will remain an active nominee for a further two years.

The CMS aims to promote and celebrate diversity in the broadest sense. Nominations for outstanding colleagues are encouraged regardless of race, gender, ethnicity or sexual orientation.

All documentation, including letters of support, should be submitted electronically, preferably in PDF format, to fellows@cms.math.ca **no later than March 31, 2021**.

For the full program description, please visit here.

Second Inaugural Class of Fellows

2019 Winter Meeting Banquet, Toronto, ON

First Inaugural Class of Fellows

2018 Winter Meeting Banquet, Vancouver, BC

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

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

Nominations should include a reasonably detailed rationale including three support letters and be submitted **by March 31, 2021**.

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

Renewals

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

2020 Graham Wright Award for Distinguished Service Recipient

Claude Levesque
Laval University (retired)

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

2021 Adrien Pouliot Award

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

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

Nominations must be received by the CMS Office **no later than April 30, 2021**.

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

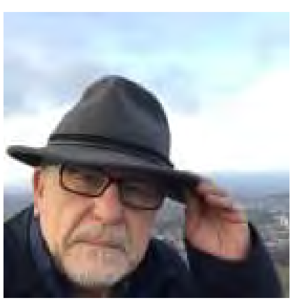
Nomination requirements

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

Renewals

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

2020 Adrien Pouliot Award Recipient



Veselin Jungic
Simon Fraser University

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

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 2022 Winter Meeting.

Jeffery Williams Prize

The **Jeffery-Williams Prize** Lectureship 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 2022 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 2022 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, 2021**. Nomination letters should list the chosen referees and include a recent curriculum vitae for the nominee. Some arms-length referees are strongly encouraged. **New: the nominator most include a full citation of approximately 500 to 700 words.** 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, 2021**:

Coxeter-James: cjprize@cms.math.ca

Jeffery-Williams: jwprize@cms.math.ca

Krieger-Nelson: knprize@cms.math.ca

Nominations are invited for the 2022 **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 *(2027, 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)*.

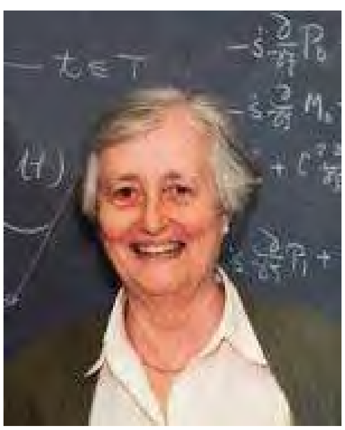
All of the above fields will be understood most broadly, to ensure that any outstanding publication can be considered under at least one of the categories. A paper (or a series of papers) which has significantly impacted more than one of the listed fields can be nominated more than once in the six-year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

This call for nominations is for an author(s) of a publication or a series of closely related publications in the field of Combinatorics, Discrete Mathematics, Logic and Foundations, and Mathematical Aspects of Computer Science.

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.

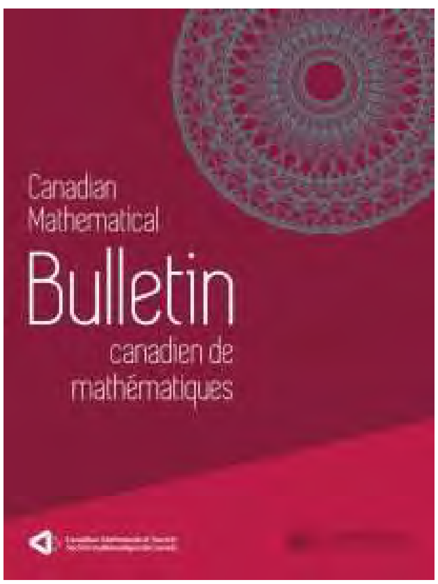
The nomination letter should highlight the research paper(s) being nominated, providing evidence of its impact and significance. The nomination letter should list the chosen referees, and should include a recent curriculum vitae of the nominee(s), if available. Up to three reference letters in support of the nomination should be sent directly to the CMS. All documents should be submitted electronically, preferably in PDF format and **no later than September 30, 2021**, 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.

2022 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, 2022. 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-2021@cms.math.ca **before September 15, 2021**.

Closing the Gap – Canadian Mathematical Association’s Inclusion Initiative

As part of Canadian Mathematical Society’s Inclusion Initiative, the Society will invite 400 Black and Indigenous students to participate in the Canadian Open Mathematics Competition (COMC) and Canadian Mathematical Gray Jay Competition at no cost. This is an opportunity for students to engage with mathematics and STEM activities and have their mathematical talent recognized.

We invite all math teachers, school principals, and any other willing proctors to nominate students identifying as Black or Indigenous to take part in this competition.

Eligibility

- Students who identify as Black or Indigenous;
- Students must be Canadian citizens or Permanent Residents;
- Students must fulfill the COMC eligibility criteria or the Gray Jay eligibility criteria.

Prizes and Awards

In Addition to various COMC prizes, students who take part in the Closing the Gap Initiative are automatically entered in a random draw to win on of 4 $500 prizes for their school to be spent on math and STEM resources.

Free Webinars

In 2020, the CMS organised a series of free preparatory webinars for Black and Indigenous students taking part in the Canadian Open Mathematics Competition. Students and teachers and find these webinars and other information about this initiative on CMS’ Closing the Gap page.

You can register your students at any time, even before the competition registrations open, here.

If you have any questions about the program please contact the CMS Competition team: contests@cms.math.ca


Canadian Mathematical Society
Société mathématique du Canada
2021 CANADIAN MATHEMATICAL
GRAY JAY
COMPETITION
2ND ANNUAL COMPETITION
October 2021
CREATED BY MATHEMATICIANS FROM ACROSS CANADA
HTTPS://CMS.MATH.CA/COMPETITIONS/CMGC

SAVE THE DATE

Canadian Mathematical Society
Société mathématique du Canada

WINTER 2021

Vancouver, British Columbia - Sheraton Wall Centre - December 3-6

SUMMER 2022

St. John's, Newfoundland - Memorial University - June 3-7

WINTER 2022

Toronto, Ontario - December 2-5

SUMMER 2023

Halifax, Nova Scotia - June 2-5

WINTER 2023

Montreal, Quebec - Hilton Double Tree - December 1-4

SUMMER 2024

Saskatoon, Regina, University of Saskatoon - June 2-5

The Canadian Mathematical Society (CMS) welcomes and invites new session proposals for scientific sessions for the 2021 CMS Summer meeting in Ottawa from June 7-11, 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

1. names, affiliations, and contact information for two (or more) session co-organizers,
2. a title and brief description of the focus and purpose of the session,
3. a preliminary list of potential speakers with their affiliations, along with a total number of expected speakers.

Potential organizers are encouraged to consider diversity in their selection of session invitees.

Sessions will take place June 7-11. 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 website 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
Mateja Šajna (University of Ottawa) msajna@uottawa.ca

Proposals should be submitted by **April 1, 2021**.

The Editors of the Notes *welcome letters in English or French on any subject of mathematical interest but reserve the right to condense them. Those accepted for publication will appear in the language of submission. Readers may reach us at the Executive Office or at notes-letters@cms.math.ca.*

Letter to Editor

The most recent issue of the CMS Notes included an editorial in the form of a letter to a student that begins

> *How did I grow to understand mathematics? What a great question! There's the story about a tourist in New York, lost and about to be late to a concert, who stops his car, rolls down the window, and asks a traffic cop, 'Hey, officer, how do you get to Carnegie Hall?'*
>
> *The cop shrugs. 'Practice, practice, practice.'*

Good story. But it reminded me of advice that one of my professors at Penn (Robert Ellis, who spent most of his career at U. Minn.) gave me and other graduate students. How do you do mathematics? More than likely he was advising us how to write a thesis, but his advice has stayed with me my entire career and motivated much of my work.

He said to pick a paper that interested you and learn. Read it deeply until you understand it better than the author. Read it so that if I wake you up in the middle of the night and ask you a question about it you will be able to answer it. At this point some questions will arise. Can you apply the ideas to a larger question? Eventually, one of your questions will get answered.

This has guided essentially my entire research career. In over 100 published papers, there is exactly one idea that I cannot explain as having no connection to any previously published result. (For the record, it is called the shuffle idempotent, a series of connected idempotents in the rational group algebras of the finite symmetric groups, one for each group.)

Although not exactly connected to the above, one further thought is worth mentioning. When I started out, I assumed that a successful day of research was one during which I had proved a theorem. Rather late in my career I realized that a successful day of research was one I which I understood something in the evening that I hadn't understood in the morning. In an exchange with the editor, he wanted to amend that to say that a successful day of research was one in which he understood
something in the evening in a different way from how he understood it in the morning. I won't argue with that but I see no real difference. The name of the game is understanding, not proving. Proof left to the reader.

-Michael Barr

Letter to Editor

On March 8, the world celebrated International Women's Day, and might be forgiven for contemplating the state of women in Canadian mathematics departments.

Since 2010, when less than one in five Canadian mathematics faculty members were women, not that much progress has been made. Extrapolating progress from currently available data suggests that today women represent about 22% of mathematics faculty. At the same time, women represent more than 50% of the Canadian population and have a labour force participation rate of 82%.

While much can be made of support initiatives for women in mathematics, their current state is deserving of some serious contemplation.

-Johan Rudnik

Hot Topics Workshop

APRIL 10-11, 2021

Safety and Security of Deep Learning

Organizing Committee:
Ben Adcock, Simon Fraser University
Simone Brugiapaglia, Concordia University
Anders Hansen, University of Cambridge
Clayton Webster, University of Texas

Deep learning is profoundly reshaping the research directions of entire scientific communities across mathematics, computer science, and statistics, as well as the physical, biological and medical sciences. Yet, despite their indisputable success, deep neural networks are known to be universally unstable. That is, small changes in the input that are almost undetectable produce significant changes in the output. This happens in applications such as image recognition and classification, speech and audio recognition, automatic diagnosis in medicine, image reconstruction and medical imaging as well as inverse problems in general. This phenomenon is now very well documented and yields non-human-like behaviour of neural networks in the cases where they replace humans, and unexpected and unreliable behaviour where they replace standard algorithms in the sciences.

The many examples produced over the last years demonstrate the intricacy of this complex problem and the questions of safety and security of deep learning become crucial. Moreover, the ubiquitous phenomenon of instability combined with the lack of interpretability of deep neural networks makes the reproducibility of scientific results based on deep learning at stake.

For these reasons, the development of mathematical foundations aimed at improving the safety and security of deep learning is of key importance. The goal of this workshop is to bring together experts from mathematics, computer science, and statistics in order to accelerate the exploration of breakthroughs and of emerging mathematical ideas in this area.

This workshop is fully funded by a Simons Foundation Targeted Grant to Institutes.

Confirmed Speakers:

Genevera Allen, Rice University
Emmanuel Candes, Stanford University
Rachel Cummings, Georgia Institute of Technology
Ronald DeVore, Texas A&M University
Gitta Kutyniok, TU Berlin
Aleksander Madry, Massachusetts Institute of Technology
Cynthia Rudin, Duke University

ICERM

Participation
ICERM anticipates that all scientific programming through 2021 will be made available virtually for those unable to travel to the institute, whether due to the pandemic or any other reason.

Most ICERM workshops are aimed at scientists and students who are actively involved in the topic of the workshop. To request an invitation to participate, complete an online application available on our website. Decisions are typically made several weeks before the workshop. Any registrants who are accepted and plan to participate virtually may not receive Zoom credentials until the first day of the program.

ICERM encourages women and members of underrepresented minorities to apply.

About ICERM
The Institute for Computational and Experimental Research in Mathematics (ICERM) is a National Science Foundation Mathematics Institute at Brown University in Providence, RI. Its mission is to broaden the relationship between mathematics and computation: specifically, expand the use of computational and experimental methods in mathematics, support theoretical advances related to computation, and address problems posed by the existence and use of the computer through mathematical tools, research and innovation.

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We are pleased to announce the creation of two postdoctoral positions for the academic years 2021-2022, tenable for one year, with the possibility of renewal for a second year. The starting date of each position is June 1, 2021. These fellowships are in connection with the Focus Program on Analytic Function Spaces and their Applications, to be held from July 1 to December 31, 2021.

The candidates will register either at Laval University or at the University of Toronto to conduct their research activities with advisors at these institutions. The candidates should also participate in the organization of the Focus Program.

Eligibility Requirements

To be eligible for a postdoctoral fellowship, researchers must have obtained a Ph.D. after Jan 1st, 2018. Moreover, their research interests must be compatible with the general scope of the focus program.

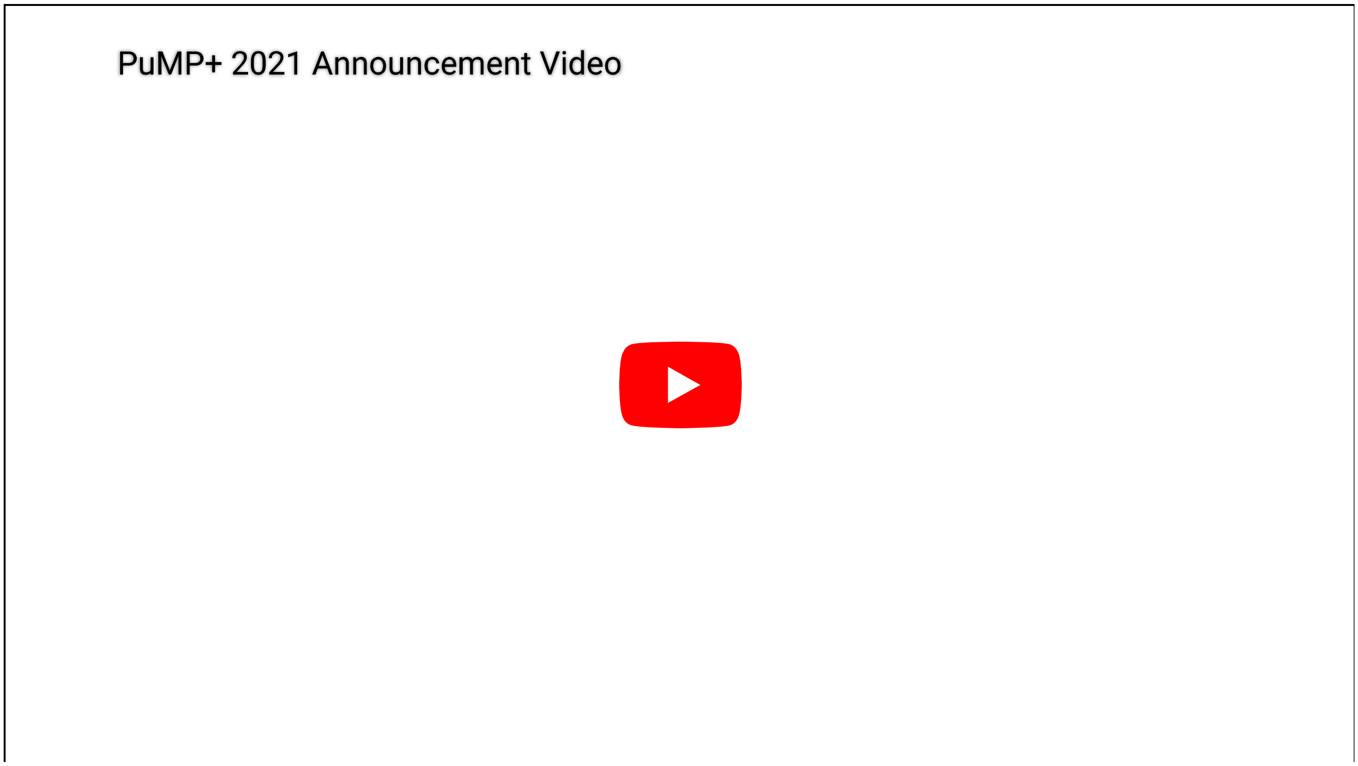
Application Process

The following documents are required:

- curriculum vitae
- research statement
- at least two, and at most four, letters of reference.

To apply, please submit your application (cv and research statement) as one PDF file to jobsmcs.utm@utoronto.ca. The supporting letters of reference should be sent directly to the same email address.

Application Deadline: Friday, April 30, 2021



Want to learn more about opportunities in STEM and how to get involved in your community?

We're excited to introduce PuMP Toronto's 2nd annual STEM fair, PuMP+! Join us on April 15th and hear from booths about research opportunities, educational programs, university programs, summer programs, and much more. Over 20 organizations are participating, including McMaster's Venture Academy, the University of Toronto's Youth Summer Programs, York University's Helix Summer Institute and the STEM Fellowship! We'll be raffling off almost $500 in prizes throughout the afternoon, and the best part? It's all free!

This year the CMS will also be hosting a booth at the PuMP+ event.

Check out @pumptoronto on Instagram for more info and visit bit.ly/pumpplusto to register! Follow us to stay tuned for future webinars and events!

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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.

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