

Pacific Institute *for the*
Mathematical Sciences

Annual Report 2021

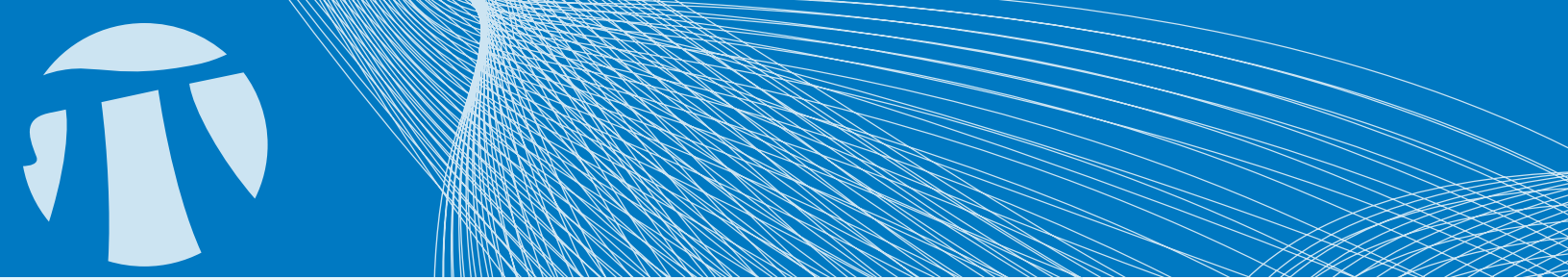


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ANNUAL PROGRESS REPORT

CTRMS-342044-2014

Pacific Institute for the Mathematical Sciences

January 1–December 31, 2021



I. OVERVIEW OF 2021

2021 was a year that was heavily influenced by the pandemic, but PIMS was able to rise to the challenges and flourish. We increased our capacity for virtual and hybrid collaboration, striving to make all online events adhere to universal accessibility principles including enabling live transcription for online events and meetings. Here are some of the highlights of our year.

1. HIGHLIGHTS

1. **Math[^]Industry:** Math[^]Industry (Math to power industry) is a professional development program positioned to benefit the Canadian economy and industry while linking highly trained personnel to industry jobs. The program starts with a training bootcamp (software best practices, coding, business, communications, project management) taught by experts from PIMS and Mitacs. Industry partners then submit math problems for group collaborations with industry and faculty. Partner companies and organizations in 2021 included: IOTO International, CSTS Healthcare, City of Winnipeg and Natural Resources Canada. The problems were varied and included: analytics and visualization of political data; personalized medicine; modelling mosquito populations; and modelling mountain pine beetle invasions by long distance dispersal.
2. **Summer School on Inclusive Pathways in Number Theory:** The goal of this event was to introduce students to number theory research topics while promoting positive cooperation and collaboration amongst students and bringing light to equity, diversity and inclusion issues within the study of mathematics. Courses included: Prime Numbers and Riemann Zeta Function; Roth's Theorem, Subspace Theorem and some Applications; and An Introduction to Global Function Fields.
3. **Women in Mathematics Day:** Movie and Panel Discussion – Picture a Scientist: This documentary chronicles researchers, leading viewers on a journey deep into their own experiences in the sciences, overcoming brutal harassment, institutional discrimination, and years of subtle slights to revolutionize the culture of science. They also provide new perspectives on how to make science itself more diverse, equitable and open to all. A panel discussion on issues affecting women and marginalized groups in the mathematical sciences followed.
4. **Math Summer School for Elementary School Teachers (Online):** Participating teachers have the opportunity to: improve their mathematical knowledge and skills, broaden their understanding of mathematics and its applications, develop strategies for teaching, develop exemplary lessons that can be used by other teachers and enhance their professional networks. This 4 week program sees groups of 3 teachers per school working together so they are later able to develop an enthusiastic culture around math at their school, and support each other.
5. **PIMS Network-Wide Graduate Online Courses:** In 2021 PIMS offered 12 graduate online courses to the PIMS Network. Students from PIMS member universities were able to receive credit for these courses through the Western Deans' Agreement. Courses included: Optimal Transport and Machine Learning; Scientific Computing; Vortex Algebras; Comparative Prime Number Theory and Algebraic Topology.

2. WHAT'S NEW

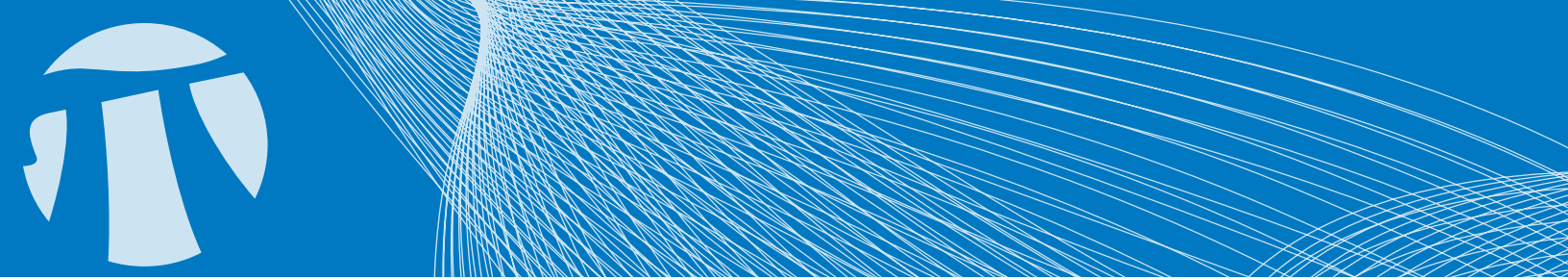
- Jayadev Athreya became Interim Director of PIMS. Ozgur Yilmaz became Interim Deputy Director of PIMS.
- Stephanie Portet became Site Director at the University of Manitoba.
- PIMS welcomed CNRS visitor Ismael Bailleul to the University of British Columbia.

- **Indigenous Engagement Committee:** A crucial initiative in 2021 was constituting an Indigenous Engagement Committee, chaired by Melania Alvarez, PIMS BC Education Coordinator, and made up of distinguished scientists and industrialists from Indigenous backgrounds to help us identify and support Indigenous-led efforts in the mathematical sciences.
- **Postdoctoral Fellow Orientation:** PIMS inaugurated a virtual annual orientation to be held at the start of each academic year, introducing the postdocs to their cohort, providing resources for professional development and EDI training, and creating online channels for interaction within the cohort.
- **Memorandum of Understanding with Quantum Algorithms Institute (QAI):** This partnership is designed to leverage BC's existing quantum computing cluster within academia and industry while building a talent pipeline with capabilities in developing quantum computing software and algorithms and the application of quantum technology to real world problems. A defined goal is to develop the Math to Power Quantum (M2PQ) program, an industry-academic training and collaboration program focused on quantum science. QAI will participate in the PRIMA 2022 Congress.
- **Collaborative Research Group on Movement and Symmetry in Graphs:** Graph theory is at the interface of computer science and pure mathematics. The strengths of this group are in the overlapping and complementary areas of algebraic graph theory, combinatorial matrix theory, graph and hypergraph infection and percolation, and extremal combinatorics. In 2021, this CRG, organized by an all-female team, hosted Connecting Women in Mathematics Across Canada (CWIMAC) to support the development of junior female-identified academics in the Canadian mathematics community.
- **Collaborative Research Group Pacific Interdisciplinary Hub on Optimal Transport (PIHOT):** This group examines the research and applications of optimal transportation across a wide audience of researchers, students, industry, policy makers and the general public. In 2021 they organized the PIHOT CRG Seminar series and held the workshop Entropic Regularization of Optimal Transport and Applications at BIRS.
- **EDI Training:** PIMS and CANSSI began collaborating on EDI training and mentoring for leaders throughout our networks. This includes sessions on implicit bias, hiring and admissions practices and other EDI issues relevant to the mathematical sciences.
- **PIMS 25th Anniversary Network-Wide Colloquium:** In honor of PIMS 25th anniversary, a distinguished lecturer series was created. Speakers included John Baez (UC, Riverside), Ben Green (Oxford), Maryanthe Malliaris (Chicago), Rafe Mazzeo (Stanford), Assaf Naor (Princeton), and Lauren Williams (Harvard).

3. PROGRAMS, ACTIVITIES AND NUMBER OF USERS

PIMS has built an international reputation for excellence and has transformed the conditions of mathematical research in Canada. PIMS funds Collaborative Research Groups and Postdoctoral Fellowships, as well as individual events on a competitive basis. In 2021, most of our events were hosted virtually in response to the pandemic.

- **Collaborative Research Groups:** Collaborative Research Groups (CRGs) consist of researchers sharing a common interest and desire to collaborate in developing their research programs for 3-4 years. Groups organize focus periods, workshops, summer schools, seminars and other events and they also make joint postdoctoral fellowship (PDF) appointments. CRGs are designed to promote and support long-term, multi-event, multi-site coordinated activities.
- **Conferences and Workshops:** PIMS organizes and funds a variety of meetings around the world each year. These range from small one-day workshops to multi-week conferences involving hundreds of participants. PIMS also hosts



or cosponsors various meetings by professional societies. During the pandemic, we worked closely with our event organizers to help them adapt and find the best arrangements for their events.

- **Summer Schools:** Every year PIMS runs a number of topical summer schools. They are intended to educate graduate students and early career researchers on current developments. In 2021, Summer School on Inclusive Paths Toward Number Theory introduced students to advanced number theory topics being researched in Alberta.
- **Lecture and Seminar Series:** PIMS supports various seminar series at member universities and industrial centres throughout the year. Some of these are for specialists, while others are geared towards the general public. In 2021, PIMS helped seminar organizers continue their events online and provided additional exposure for their events through our video service - Mathtube.org Two examples are Emergent Research: PIMS Postdoctoral Seminar Series and PIMS Network-Wide Colloquium.
- **PIMS Syzygy Platform:** PIMS provides a platform called syzygy where students and researchers can build Jupyter notebooks which combine code, text, equations, images and videos to produce compelling narratives in their browsers. PIMS, Compute Canada and Cybera collaborated to create the syzygy service which is used to provide computational infrastructure for PIMS events and is widely available at 26 Canadian universities. People at these universities can use syzygy to create notebooks supporting their teaching or research, and can easily share them with colleagues. To date, the syzygy platform has been used by over 40,000 people.
- **Federal CanCode Grant:** The Callysto project, launched by PIMS and Cybera, is closely related to Syzygy. It is an all-in-one educational program, combining a computational platform with curriculum-based learning and skill development materials, all accessible from any device with an internet connection. An important component of the Callysto project is the partnership between higher education and the K-12 community, which produces a rich library of open-access materials for teaching computational thinking. By using a train-the-trainers approach, PIMS and Cybera have introduced Callysto to nearly 80,000 students and teachers. In 2021 Callysto supported classroom learning activities including Real World Robotic Learning, developed lesson plans including Arctic Sea Ice Levels, and implemented a module on Tidal Patterns and Fish Traps during the Diversity in Mathematics camp.
- **Network-Wide Graduate Online Courses:** These courses utilize the PIMS network to deliver a rich variety of graduate level courses in the mathematical sciences to PIMS member universities. This program benefits instructors by reaching a larger potential audience and students by offering a broader variety of courses. 38 students received credit for these courses using the Western Deans' Agreement in 2021.

Activity	2019		2020		2021		2022 (Expected)	
	Activities	Users	Activities	Users	Activities	Users	Activities	Users
Conferences/Workshops	43	3,391	13	1,464	15	2,080	18	2,500
Summer Schools	3	142	1	25	2	177	2	200
Collaborative Research Groups	3		3		4		5	
Lecture-Seminar Series	29	1,143	30	1,479	27	1,615	30	1,800
Industrial Activities	2	190	5	417	1	116	2	200
Syzygy	18	25,000		40,000		40,000		40,000
Callysto	26	20,223	26	26,000		20,000		20,000
Other	8	898	12	687	5	647	10	800

II. ACCESS TO THE RESOURCE

1. COMMUNICATIONS PLAN

Objectives and Communication Priorities:

Build a consistent communications framework to raise the profile of PIMS in the global scientific community. Demonstrate to existing and potential sponsors, as well as the global scientific community, that PIMS has given thought and priority to communicating with them. Make education a top priority in terms of awareness, program organization and fundraising. Build the PIMS community through regular, consistent and targeted formal and informal communications.

Key Messages:

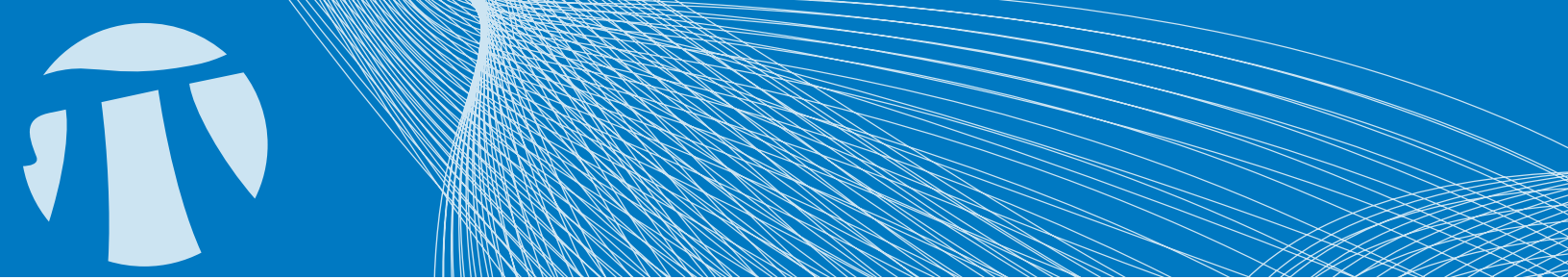
PIMS is a leading mathematical institute in North America, with worldwide influence on research and industry. It has established innovative programs which continue to have a transformative impact on the mathematical sciences and the training of HQP. The PIMS community is inclusive: From K-12 to research faculty, we strive to provide the best environment for nurturing mathematical talent. PIMS' distributed structure enables our community to engage locally while benefiting from the full extent of the PIMS network. PIMS is nurturing the pipeline of younger generations in Western Canada, including those with Indigenous backgrounds. We promote numeracy as an integral part of development and learning. PIMS encourages and promotes diversity in mathematics.

Strategies:

Create and manage the consistency, clarity and regularity of communications. Be proactive and opportunistic when promoting PIMS to stakeholders. Understand their needs and preferences and share information accordingly. Add a more human touch by creating and telling stories that create engagement. This is done through photos, personal stories and testimonials. Increase internal and external community building opportunities.es.

Tools:

- **PIMS website** offers easy access to information on all PIMS activities, recent news and resources. In 2022, this site is being refreshed to provide a richer experience for the PIMS community.
- **Mathtube.org** is a dedicated resource which increases the global exposure of PIMS by archiving and publishing recordings of our events. Videos and other media are indexed and searchable on mathtube.org for people to experience past PIMS activities. In 2021 we added 214 videos to the collection, more than two times the number in 2020. We had more than 1500 viewers attend our online meetings.
- **PIMS Connection, monthly e-newsletter:** This brief email highlights upcoming events, updates and new items. Its circulation is over 5,200.
- **Social media:** PIMS uses Twitter, Facebook, LinkedIn and Medium to connect with and provide all of our updates and news to the PIMS community. Our posts cover a range of content from event photo highlights to weekly event updates and more.
- **Pi in the Sky** is a publication aimed at high-school students and teachers, with the main goal of providing a cultural landscape for mathematics. It also connects with a broader audience from junior high school students to undergraduates with articles that put curriculum topics in a different context. Pi in the sky is produced once a year and mailed to various institutes and private subscriptions throughout Canada and the world (estimated circulation is 1,700) and can be downloaded from the PIMS website: pims.math.ca/resources/publications/pi-sky.
- **Advertising:** PIMS-funded events and opportunities are advertised both electronically and in print. We advertise through websites and publications at institutions such as AMS, CAIMS, CMS, and SIAM and by offering custom-designed event posters that are distributed to the major mathematical departments and institutes in Canada and the US. We also produce an annual poster highlighting all of PIMS main events for the year, which is distributed to over 200 of the top scientific institutions worldwide.



- **Reports:** Conference proceedings, abstracts, lecture notes, websites and final event reports are all made available for download from the PIMS website. (See pims.math.ca). Conference materials are attached to the corresponding event, which are listed chronologically and are searchable by keyword for ease of access. PIMS produces an annual report which can be viewed at pims.math.ca/resources/publications/annual-reports and a Year in Review which can be viewed at pims.math.ca/resources/publications/pims-year-review.
- **Open Source:** PIMS shares the source code for as many of our projects as possible, including all of the infrastructure for the syzygy.ca and callysto.ca projects. The educational resources developed as part of the Callysto project are also shared openly on GitHub.
- **Audio/Video Facilities:** PIMS offers seminar organizers and affiliated researchers a selection of technologies and support to help them include participants at remote sites. The selection includes traditional videoconferencing as well as software-based alternatives such as BlueJeans, Teams and Zoom. PIMS has created a dedicated “presentation studio” at the UBC site which can be used for giving online lectures or pre-recording talks. We are exploring adding more of these facilities throughout the PIMS network as “hybrid” models become more popular.

2. EQUITY, DIVERSITY, AND INCLUSIVITY (EDI)

We are currently examining all of our programs from an EDI perspective. We have built an EDI committee to develop strategies to monitor and improve the EDI impacts of PIMS activities and drive change in the wider mathematical sciences community. They have created a Code of Conduct to ensure that our events are as safe, welcoming and inclusive as possible.

One of our largest institute expenditures is the postdoctoral fellow program. This program plays an important role in the shaping of future faculty membership, and hence thoughtful demographic representation for PIMS PDFs is important. Historically, we have observed a low participation rate of women which has remained flat at around 10% over 25 years. This has led to a restructuring of the candidate evaluation procedures. The 2021 cohort was 30% women. The 2022 cohort will be 40% women which is far closer to female representation in the elite doctoral pool. Representation of other equity seeking groups is under study hindered by the lack of historical data. We are working to revamp our intake survey to better track our actions.

To build on the progress made in diversifying the PIMS PDF program, we have created a recruitment fund, to provide supplemental salary to help make attractive and competitive offers to PDF applicants from diverse backgrounds. This program recognizes that many of these candidates face additional barriers in academia and seeks to address those inequities.

In June, PIMS hosted an EDI Panel discussion on Effective Allyship in STEM. This event looked at ways in which effective allyship can build a better and stronger community in the mathematical sciences. Being an ally is a conscious engagement and active advocacy for those whose voices may be stifled, unheard, or underappreciated. The panelists looked at actionable steps we can take to be better champions in academia.

III. CONTRIBUTIONS TO RESEARCH

More information about PIMS can be obtained under “PIMS News/Press” at pims.math.ca and in our annual report at www.pims.math.ca/resources/publications/annual-reports

IV. DISTRIBUTION OF USERS*

In 2021, the total number of attendees was 4,635. This is slightly higher than 2020 as quality of online/hybrid events improve. We hope 2022 will have a return to in-person events.

68% were from Canadian institutions, of which:

14% were from Alberta

42% were from British Columbia

6% were from Manitoba

4% were from Atlantic Provinces

26% were from Ontario and Quebec, and

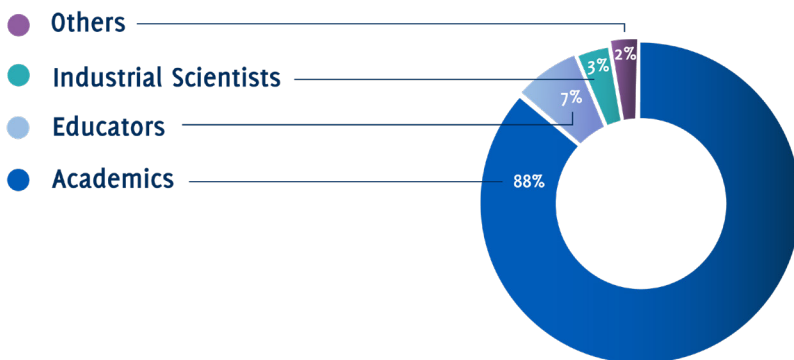
8% were from Saskatchewan

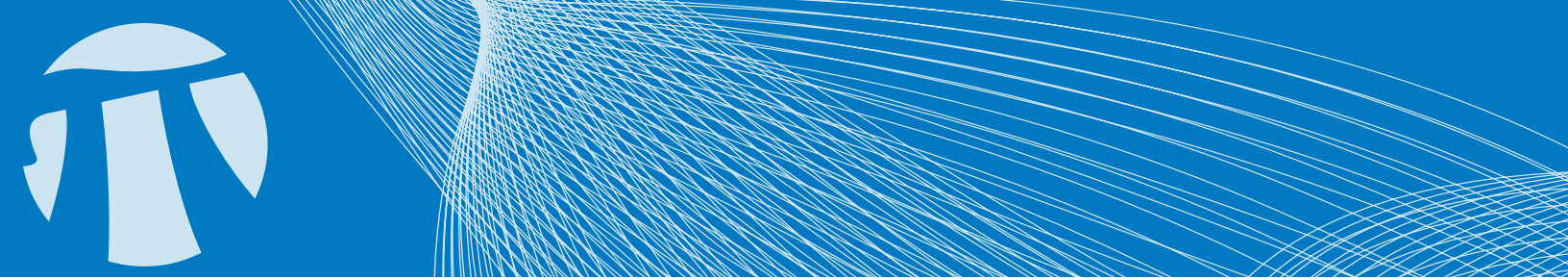
12% were from North American institutions, and

20% were from elsewhere.

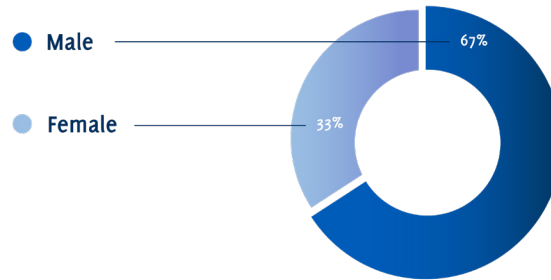


ATTENDEE SECTOR DEMOGRAPHICS

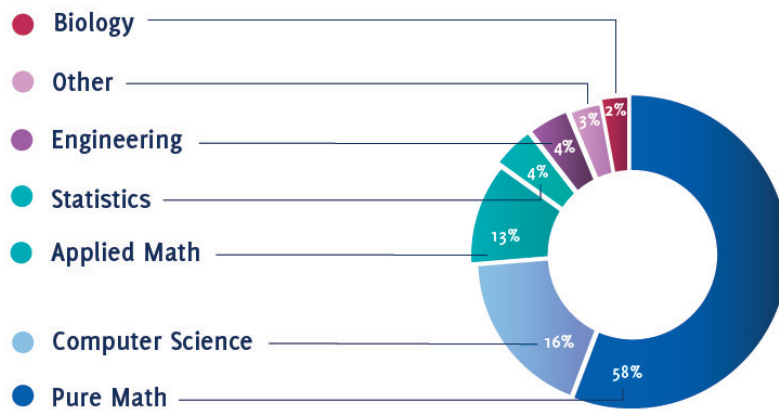




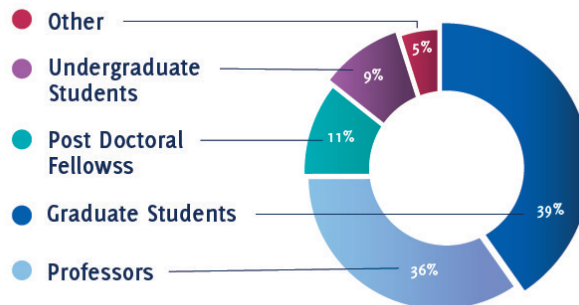
ATTENDEE GENDER DEMOGRAPHICS



SUBJECT MATTER



ACADEMIC ATTENDEE DEMOGRAPHICS



*The distribution of users reported here does not include the syzygy.ca or Callysto projects.

V. TRAINING AND DEVELOPMENT OF HIGHLY QUALIFIED PERSONNEL

1. POSTDOCTORAL FELLOWS & CNRS/PIMS SCIENTISTS

The Postdoctoral Fellow program (PDF) is one of PIMS most important operations. In 2021 we sponsored 45 PDFs (44 in 2020 and 40 in 2019) distributed throughout the PIMS sites on a competitive basis. These PDFs are vital in building new research programs at and between PIMS sites and many go on to become faculty members at leading universities. Candidates associated with a CRG are inducted into the appropriate research group and candidates from institutions in France are also eligible for PIMS/CNRS fellowships. PIMS PDFs receive \$25,000 per year from PIMS in salary and this amount must be matched by the site. Fellowships are for 2-3 years. PIMS Central holds yearly one-day workshops on professional development topics such as Postdoc/Grad Student Job Forum. PIMS also hosts Emergent Research: PIMS Postdoctoral Seminar Series.

VI. PARTNERSHIPS AND OUTREACH

1. NATIONAL

PIMS has a national mandate to support the mathematical sciences in Canada. In partnership with the Fields Institute (FI) and the Centre de Recherches Mathématiques (CRM), it has created major national programs such as the Atlantic Association of Research in the Mathematical Sciences (AARMS). Together with the Mathematical Sciences Research Institute (MSRI), PIMS also created the Banff International Research Station (BIRS) which is now the premier mathematical research station in North America.

PIMS coordinates with AARMS, BIRS, CRM and Fields to support Canadian activities such as meetings of the societies (CAIMS, CMS and SSC), and the Séminaire de Mathématiques Supérieures in Montreal. PIMS and the other institutes commit significant resources to support the Canadian Statistical Sciences Institute (CANSSI).

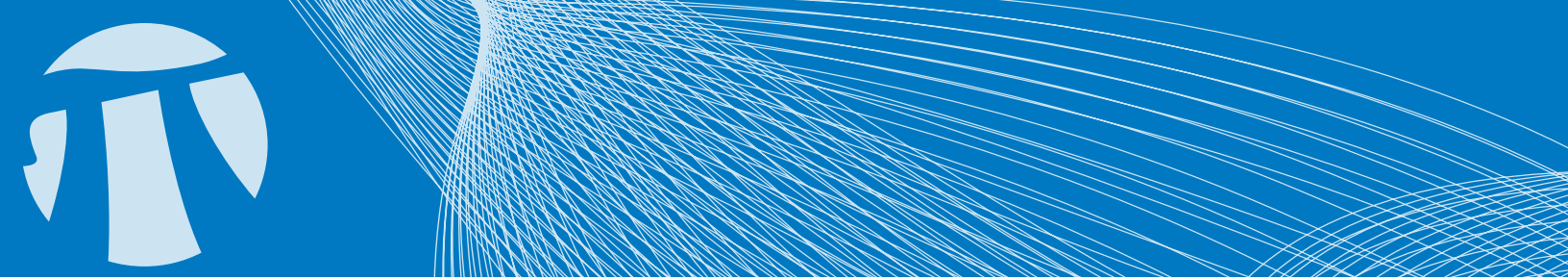
PIMS and Mitacs, a national not-for-profit research and training organization, have partnered to help graduate and postdoctoral researchers solve challenges using mathematical sciences in collaboration with industry and not-for profit organizations. Through internships, companies in Western Canada have access to leading mathematical scientists in order to support the development of technologies and services in all sectors. Graduate students and postdoctoral fellows have opportunities to transfer their skills from theory to real-world application, while companies gain competitive advantages by accessing high-quality research expertise.

PIMS and Cybera have worked closely together to create Callysto, which contributes strongly to the PIMS mandates for research, training and educational outreach.

2. INTERNATIONAL

Part of the PIMS mandate is to establish international partnerships in order to provide mechanisms for Canadian researchers to participate in activities outside Canada and attract visitors from abroad. The establishment of the Centre National de la Recherche Scientifique (CNRS).

International Research Lab at PIMS (the first in mathematics in North America) has led to year-long visits by more than 41 researchers from France since 2007, fully funded by CNRS. Similarly, the leadership role played by PIMS in establishing



the Pacific Rim Mathematical Association (PRIMA) provides ample opportunities for Canadian exchanges with countries in this region. PIMS will host the next PRIMA Congress in Vancouver in 2022.

The PIMS-Globalink Student Mobility Program, in partnership with Mitacs, supports visits by students from Mitacs partner countries to carry out research at PIMS member universities and for Canadian students from PIMS member universities, to study in Mitacs partner countries. This award provides CAD \$6,000 for senior undergraduates, graduate students and postdoctoral fellows to conduct 12-24 week research projects in the host country.

3. EDUCATION AND OUTREACH

PIMS vigorously pursues our mandate to promote mathematics in Canada at all levels; and our mission to train current and future generations of teachers, scientists and engineers for success. We have many active educational outreach programs including Math Circles and Math Mania which seek to convey the excitement of discovery and learning in mathematics and which bring together students, teachers and parents to learn. We also engage through Science Fairs and other activities. PIMS strongly advocates for the participation of people from all backgrounds in mathematics and we have developed partnerships with First Nations schools and schools with a substantial percentage of Indigenous students. These activities include summer events for students and specialized teacher training sessions.

Many teachers, especially in elementary schools, do not have the necessary knowledge or experience to feel comfortable teaching mathematics. To address this, PIMS developed a 4-week Summer School for in-service teachers. The goal is to create teams of teachers, within schools, which can foster a cultural and academic shift in the learning and enjoyment of mathematics.

Colleges and universities within the Western Canada post-secondary systems that do not qualify for regular membership in PIMS may become PIMS Education Associates. The PIMS educational network allows for the exchange of successful practices in outreach, teaching, and professional development amongst its members. Currently PIMS has 17 educational associates.

VII. CONSULTATION MECHANISMS AND COLLABORATIVE ACTIVITIES WITH AARMS AND CANSSI

As part of a national mandate, PIMS supports mathematical activities in the Maritime Provinces in conjunction with the Atlantic Association for Research in the Mathematical Sciences (AARMS). Together they co-sponsored the following activities in 2021 (PIMS' financial contribution to each activity is listed in parentheses):

- Atlantic Graph Theory Seminar at Acadia University (\$4,741).
- Postdoctoral Fellow (\$21,702) and Administrator (\$11,734)

PIMS also supports statistical activities throughout Canada through CANSSI. In 2021 these included Postdoctoral Fellows and Research Assistants

VIII. MANAGEMENT AND BUDGETS

PIMS CTRMS NSERC Activity Report Jan. 1 to Dec. 31, 2021

<u>Resource Expenditures</u>	<u>Use of the resource (i.e. PIMS) Paid from ALL revenue sources Jan. 1 to Dec. 31, 2021</u>	<u>Planned use of CTRMS/DIS funds Jan. 1 to Dec. 31, 2022</u>
1) Salaries & Benefits		
a) Administrative Staff	503,575	
b) Directors & Site Directors Teaching Releases/Stipends	128,658	
c) Scientific Support Personnel	213,260	190,000
d) Postdoctoral Fellows (inc. CRG PDFs)	570,841	840,000
e) Technical/Professional Assistants (inc. Education)	9,819	
2) Equipment or Facility		
a) Purchase or Rental	13,230	
b) Operation and Maintenance Costs	43,688	
3) Materials & Supplies		
a) Office supplies and expenses	5,376	
4) Meetings/Collaborations/Misc. Travel		
a) PIMS Meetings (SRP, PDF, Board, Admin, Exec)	0	
b) Staff/PDF/Prize Winner/misc. travel	3,454	
c) Director Research Support and Scientific Consultation	9,063	
5) Dissemination Costs		
a) Publication Costs	138	
b) Advertising & Networking	22,413	
6) Scientific Activities (inc. CRGs and IGTC)		
a) Conferences/Symposia	37,762	30,748
b) Summer Schools	66,060	46,000
c) Workshops/Seminars/Colloquia	37,170	32,000
d) Distinguished Visitors/Chairs/Speakers	889	15,000
7) Education Initiatives		
a) General activities	11,091	
b) Callysto	121,025	
8) AARMS Activities		
a) Workshop/seminar	4,741	
b) PDF	21,702	
c) Administrator	11,734	
9) CANSSI		
a) Postdoctoral fellow/Research Assistants	219,900	
TOTAL EXPENDITURES	2,055,589	1,153,748

Resource Revenues (collected during the period Jan. 1 to Dec. 31, 2021)

a)	User Fees (Registration Fees collected)	643
b)	Contributions from Partner Universities	
	UBC	361,636
	Simon Fraser University	80,000
	University of Alberta	77,700
	University of Calgary	67,710
	University of Victoria	66,600
	University of Saskatchewan	50,000
	University of Regina	35,000
	University of Washington	13,912
	University of Lethbridge	35,000
	University of Manitoba	50,000
	Portland State University	5,009
	Athabasca University	5,000
	UNBC	5,000
c)	Private Donations	31,950
d)	Other Contributions	
	UBC Various Depts	75,000
	Other Miscellaneous	29,665
e)	Callysto Grant	217,139
f)	NSERC CTRMS Grant	1,264,293
g)	Carried Forward from Dec. 31, 2020	1,377,852
	TOTAL REVENUES (Jan. 1 to Dec. 31, 2021)	3,849,109
	Revenue less Expenses	1,793,520

GLOSSARY OF ACRONYMS

PIMS	Pacific Institute for the Mathematical Sciences
AARMS	Atlantic Association of Research in the Mathematical Sciences
AMS	American Mathematical Society
BIRS	Banff International Research Station
CAIMS	Canadian Applied and Industrial Mathematics Society
CANSI	Canadian Statistical Sciences Institute
CMS	Canadian Mathematical Society
CNRS	Centre National de la Recherche Scientifique
CRG	Collaborative Research Group
CRM	Centre de Recherches Mathématiques
CWiMAC	Connecting Women in Mathematics Across Canada
EDI	Equity, Diversity and Inclusivity
FI	Fields Institute
K-12	Kindergarten to Grade 12
M2PI	Math to Power Industry
M2PQ	Math to Power Quantum
MSRI	Mathematical Sciences Research Institute
NSERC	National Sciences and Engineering Research Council
PDF	Postdoctoral Fellow
PIHOT	Pacific Interdisciplinary Hub on Optimal Transport
PRIMA	Pacific Rim Mathematical Association
PTCS	PIMS Postdoctoral Training Centre in Stochastics
QAI	Quantum Algorithms Institute
SRP	Scientific Review Panel
SSC	Statistical Society of Canada
STEM	Science, Technology, Engineering and Mathematics