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NEWSLETTER

OF THE

NEW ZEALAND MATHEMATICAL SOCIETY

Contents

PUBLISHER'S NOTICE

This newsletter is the official organ of the New Zealand Mathematical Society Inc. This issue was edited by Fabien Montiel and Melissa Tacy. Editorial enquiries and items for submission to this journal should be submitted as plain text or LaTeX files with "NZMS newsletter" in the title of the email to nzmsnews@maths.otago.ac.nz. LaTeX templates are available upon request from the editors.

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EDITORIAL

Our first newsletter as editors last year came in the wake of the Christchurch shooting. A year on and the world, let alone NZ, is affected by another tragedy. Although all our lives have been shaken up by recent events, the number of fatalities in NZ due to COVID-19 is so far well lower than that of the Christchurch shooting. Amazingly, a number of key people in our mathematics community are to thank for contributing to the containment and elimination effort in NZ. Mike Plank, Alex James and our president Shaun Hendy are among a team of scientists at Te Pūnaha Matatini who have provided key modelling work to inform the government's response to the pandemic. Many others have been vocal on the mainstream and social media to explain mathematical epidemiology concepts to the general public, such as *exponential growth*, *flattening the curve*, *basic reproduction number*, *SIR models*, ... If any silver lining is to be found during this crisis, mathematics education of the general public has to be near the top of the list.

Although academia is relatively fortunate to still be able to operate at a non-negligible level during the near-shutdown of our society, important aspects of our jobs have been affected. Research visits and conferences are cancelled or delayed. To only name a few, Mathematics-in-Industry NZ (MINZ) 2020 has been delayed to 2021, the International Congress on Mathematical Education has been delayed to 2021 and the AMSI Winter School on *New Directions in Representation Theory* is cancelled for the time being. If our work is so dependent on face-to-face interactions and international travel, how can we minimise the impact of travel restrictions on our ability to work? Zoom seems to work reasonably well as a substitute for research visits and departmental seminars. Conferences are more tricky, although there is evidence that online alternatives to cost- and carbon-intensive events can work. In January 2020, an international photonics conference was held literally around the world, with 1,100 participants from 37 countries joining in remotely. The organisers reported their experience of organising such an event in a *Nature Reviews Materials* paper. Well worth a read!

At time of writing, New Zealand is preparing to move into Level 3 in the national alert system. We all hope that this move will be successful and eventually followed by moves into lower and freer alert levels. Even as that happens, the way we teach and research has been dramatically changed. The increase in online conferences and seminars creates an opportunity for us to offset the effect of "tyranny of distance" in our research. But there are also dangers. Even before COVID, we saw Massey launch their Digital Plus strategy, a development that risks the jobs of a number of members of our community. Carlo Laing has provided us with a detailed description of these developments and the responses to date. Now is perhaps a good time to reflect, as a community of mathematicians, on which parts of this new online world do **we** want to keep?

Fabien Montiel and Melissa Tacy

PRESIDENT'S COLUMN

It has been a difficult year for mathematics in New Zealand. Late last year, we learned of the possibility of redundancies in mathematics at the University of Otago, purportedly due to declining EFTS. Then in February, Massey University announced its plans to consolidate its teaching of mathematics to its Palmerston North campus, with consequential job losses at its Albany campus. The University had proposed that engineering, computer science, physics, and plant sciences no longer be taught at Palmerston North. Both these changes stood to undermine teaching and research in mathematics at Massey.

The NZMS Council wrote to Massey University's Council, and also made a submission on the proposal itself. According to the University's own website, "Massey University has some of the highest-ranked mathematics and statistics groups in New Zealand". Professor Ray Geor, Massey's College of Sciences Pro-Vice Chancellor, states that the proposed restructure was "not about research, researchers or research quality", yet it very evidently impacts on research in mathematics. The NZMS Council believes that if the proposal were followed, it would do irreparable harm to mathematics in New Zealand and we have told Massey so.

The impact of the devastating COVID-19 pandemic on the mathematics community remains to be seen. Even if it is eliminated in New Zealand, as now seems possible, the pandemic is still going to have a devastating impact globally and travel restrictions will remain in place for some time. All of our universities are dependent on income from international student fees to an extent and it is unlikely international student numbers will return to pre-COVID-19 levels any time soon. This will no doubt accelerate the cost pressures that have caused Otago and Massey to start considering redundancies, even if the coming economic turbulence drives New Zealanders back into higher education.

Still, mathematics has shown its value in this crisis. New Zealand-based mathematicians Mick Roberts (Massey), Mike Plank (Canterbury), Alex James (Canterbury), and Dion O'Neale (Auckland) have all made key contributions to government decision-making in the last few weeks. Indeed, Mick's job is one of those that is at risk in the Massey restructure. If our Vice-Chancellors had paid as much attention to their mathematicians as they did their accountants, they would not have been penning op eds as late as mid-February demanding the return of their international students. Whose jobs should be on the line here?

Shaun Hendy

DEVELOPMENTS AT MASSEY UNIVERSITY

Massey University has announced a new strategy called Digital Plus. The logic behind this strategy is that having the same course taught by different people on different campuses (often in different semesters) is an unnecessary duplication of resources. It is proposed that this "duplication" be removed by having a given course taught face-to-face on a single campus by one person, with students on other campuses provided with a "world-class digital online offering." How this would work for laboratory-based courses is questionable, as is Massey's ability to provide such an experience within the proposed timeframe (starting in 2021). This strategy ignores the differences between student cohorts at the three different campuses.

Each College has been asked to respond to the proposed implementation of this strategy. On the first day of semester one the PVC College of Sciences released a discussion document which notes the financial underperformance of the college, exacerbated by the current Vice-chancellor's goal of producing a 5% surplus each year, in contrast to the TEC's expectation of a 3% surplus, which has now been removed in light of the Covid-19 pandemic. In summary the PVC proposes to effectively close the BSc degree at Albany, with most science subjects being taught only by staff in Palmerston North.

In more detail it has been proposed that majors in Chemistry, **Mathematics** and Zoology, currently taught at both Albany and Palmerston North, be taught only from Palmerston North. BSc majors in Data Science, Ecology and Sustainability, Integrative Biology, Marine Biology, and Molecular and Cellular Biology, currently taught at only Albany, will be closed. Majors in Physics and Plant Science, currently offered in Palmerston North only, will be converted to minors. Conversely, it is proposed that the Bachelor of Information Sciences and all Engineering degrees be taught from only Albany, with all Computer Science courses being part of the BInfSc degree. This will effectively close the School of Natural and Computational Sciences (SNCS) at Albany.

The mechanism for closing a subject is that no new enrolments will be allowed from the end of 2020, and students currently enrolled in that subject will either be taught out at that campus or offered a transfer to the "anchor" campus. PhD students affected by these proposed changes will be "facilitated to complete their PhD studies on a case-by-case basis."

The complete closure of courses in Ecology and Sustainability, Integrative Biology, Marine Biology, and Molecular and Cellular Biology is not consistent with the strategy of teaching from only one campus, as these subjects are currently taught at only one campus — Albany. It is however consistent with what seems to be an unspoken "no science at Albany" policy.

There has been a strong universally critical reaction to the PVC's proposal, including much media coverage and a petition which was signed by over $10,000$ people in just 8 days (see http://chng.it/Vx2fZBHQ). The PVC's proposal completely ignores research, both by staff and by graduate students. As for the rationale of closing SNCS in order to save the College money in the short term, using the implementation of Digital Plus as a mechanism to do so, out of 6 Schools within the College SNCS returns the second highest percentage teaching surplus. Massey should instead expand science at Albany, taking advantage of the rapid current and projected population growth to the west and north of the largest city in the country.

Regarding the mathematics group at Albany, they have a strong record in both teaching and research. For example, out of the nine staff, five currently hold Marsden grants (four as Principal Investigators), one holds a Rutherford Discovery Fellowship, one holds a Catalyst Seeding Grant, and two are Fellows of the Royal Society of New Zealand. Of interest to NZMS members, four have won the Research Award of the Society, one has won the Society's Early Career Award, and six are fellows.

The mathematics group at Albany has been profoundly upset by this proposal, as have our colleagues in Palmerston North. We disagree with many aspects of the proposal, such as the complete lack of analysis of the financial consequences of such a decision. Should this proposal go ahead it will result in potential job losses of 50-100 staff across the sciences, and disruption to the studies of approximately 100 graduate students. Staff were given three weeks (later extended to four) to give feedback on this proposal, which was announced on the first day of semester one. Further announcements are expected in late April.

Carlo Laing

EDUCATION

Swan Delta Conference 2019: New Zealand Perspectives

The Delta conferences are a series of biennial southern hemisphere symposia committed to improving undergraduate mathematics and statistics education. Delta attracts a wide international audience of mathematicians, educators and researchers. Delta conferences have been held in New Zealand at Queenstown (2003) and Rotorua (2011). The most recent conference, Swan Delta, was held in Fremantle Australia and had 20 participants from universities throughout NZ along with more than 90 other participants from throughout the world. New Zealand will be hosting Herenga Delta 2021 in Auckland.

There is always a great selection of workshops and talks at Delta conferences and Swan Delta was no different, with an impressive line-up of plenary speakers and three parallel streams of seminars and workshops. Following are highlights from some of the NZ participants:

"Swan Delta was the second Delta conference that I attended. The first was the 2015 Elephant Delta in Port Elizabeth which resulted in a cross-country research project (South Africa and New Zealand). This is one conference that I will continue to be involved in because of its focus on current matters in mathematics education from a global perspective. For me, the highlight of Swan Delta was being able to partake in discussions from the banquet of research ideas that were on offer from so many countries. Being a relatively small conference, it provides the platform for collaborative research to develop across countries and nurtures a networked community of tertiary mathematics educators and researchers. The mid-conference break Day was fabulous too, my drive to the Pinnacles gave me an opportunity to experience this wonder of Australia."

Jyoti Jhagroo, Senior Lecturer, School of Education, Auckland University of Technology

"It was great to have research-informed sessions that made me think about my practice. I came away with some practical ideas to improve teaching/learning in our first-year courses."

Anne Lawrence, Senior Tutor in Statistics, Massey University.

"The Delta conferences give me the opportunity to meet others from throughout the world who are focused on the same issues we are. It helps to give a broader perspective on our daily work in teaching students mathematics and the NZ situation: is there something about the NZ school curriculum that is making the students in our classrooms today different from 5 years ago or are there others having similar issues in other countries? There is not a simple answer, but being a part of broader conversations and gaining insights from a variety of presenters helps shape my perspective on this."

Cami Sawyer, Senior Tutor Maths, Massey University.

"I enjoyed attending the Swan Delta conference in Fremantle and it will remain a very memorable conference to me as I had the pleasure and honour of giving the Opening Plenary - this was my first plenary... and possibly the last one! I was particularly impressed to see many amazing presentations from mathematics and statistics lecturers showcasing their innovative teaching and learning endeavours - the scope of notable changes in higher education is extensive! It was also remarkable to see the ever increasing engagement in educational research by mathematics lecturers - those at the coalface of university mathematics education! Their ability to use educational research methods in conducting research along-side of their innovative practices contributes to building research capacity in university mathematics education - a field of research that, in my opinion, needs rapid development. I look forward to the next Delta conference in Auckland with high hopes and expectations!"

Tanya Evans, Lecturer, Department of Mathematics, University of Auckland.

"Janine Sprakel, Program Manager at AMSI Schools at the Australian Mathematical Sciences Institute, was a plenary speaker who described a project to raise awareness of Mathematics with female students in Australia: CHOOSEMATHS. They had an extensive advertisement campaign, developed a large number of resources, and held a student video competition on 'Why is Maths important in my life?'. An impressive outreach programme was also conducted to upskill teachers and families in Mathematics. She mentioned that marketing is a problem for Mathematics as few job titles actually include Mathematics. The aim of the programme is to encourage more Australians to enjoy and study mathematics."

Rachel Passmore, University of Auckland.

"I certainly enjoyed my first Delta Conference. I enjoyed meeting new people and having some time to talk to those I already knew. I enjoyed the variety of talks, especially the plenary talks. My favourites were 'Playfulness and a Mathematical Education for the Twenty First Century' by Chris Sangwin, 'The Catch-22 of Teaching' by Harry Wiggins and 'Why CHOOSEMATHS?' by Janine Sprakel. I also appreciated seeing how others taught geometry and made use of colour in phase portraits. I loved the Mathscraft workshop and plan on introducing some origami, knitting and crocheting with my students. This will depend on my own success in upskilling! I am also reminded to make sure we have fun and demonstrate the relevance of the maths we teach in lectures. I am also thinking about the use of quizzes in various situations."

Catherine Sweatman AUT.

"Swan Delta was great, it reaffirmed that the direction we are going in with our new 100-level course has sound evidence-based research backing it up. On a personal note, my favourite part was crocheting a hyperbolic plane, or two, using the instructions from the Maths Craft Australia session lead by Julia Collins and Katherine Seaton."

Debbie Leader, Senior Tutor, Massey University.

If you missed the conference or have colleagues you think would want to attend, in late November 2021, Herenga Delta will once again be an opportunity for all of us to bring Maths and Stats teaching and learning to the fore, and to connect to other southern hemisphere educators . More details will follow later this year.

Cami Sawyer

Pictures from Swan Delta

Zanele Ngcobo (UKZN South Africa) and Jyoti Jhagroo (AUT New Zealand).

A crocheted hyperbolic plane made by Debbie Leader.

Debbie Leader and Anne Lawrence (both from Massey University, New Zealand).

Swan Delta conference attendees.

Assessment in Pāngarau (Mathematics) and Tauanga (Statistics)—putting Māori students at the centre

On Thursday 23 January, Cami Sawyer (NZMS Ed Group and Massey U) and Pania Te Maro (Institute of Education, Massey U) organised a one-day wānanga (school) on the themes of Assessment and Matauranga Māori (Māori knowledge) in Mathematics and Statistics. Also in attendance were Lauren Burr from the Ministry of Education; Glenda Anthony, Peter Rawlins, and Brian Tweed, from the Institute of Education, Massey U; Anne Lawrence and Tammy Lynch, School of Fundamental Sciences, Massey U; Te Rā Moriarty, Te Putahi-a-Toi; Katherine Murray, Māori Learning mentor, Massey U; Brigit Kerr, Karori West Normal School; Robin Averill, Faculty of Education, VUW; Pip Arnold, Karekare Education & NZMS Ed Group; Sione Ma‘u, U of Auckland Mathematics and NZMS Ed Group; David Pomeroy, School of Teacher Education, Canterbury; and students Ngarimu Te Maro-Doran and Tahu-Potiki Te Maro-Doran.

Background

In 2019, the Minister of Education announced seven changes to NCEA (National Certificate of Educational Achievement), our national secondary qualification:

1. Make NCEA more accessible
2. Mana ōrite mō te mātauranga Māori
3. Strengthen literacy and numeracy requirements
4. Have fewer, larger standards
5. Simplify NCEA's structure
6. Show clearer pathways to further education and employment
7. Keep NCEA Level 1 as an optional level

The changes are subject to cabinet approval and budget. Details about the NCEA Change Package can be found at https://conversation.education.govt.nz/conversations/ncea-review/change-package/.

The intentions for this wānanga were to collect thoughts and to make a set of recommendations, guidelines, and suggestions for the Maths and Numeracy review groups. I will go into some detail about what we talked about, because I believe the ideas are worth sharing among the wider mathematical community.

Learning and assessment discussions

Grades based on assessment are meant to measure students' learning in an objective way. But assessment has other consequences. To open discussion, Cami Sawyer shared a quote from *The Hegemony of Mathematics*, by Brian Greer and Swapna Mukhopadhyay:

"One way of looking at assessment is that it affords communication of various kinds. It is the instrument par excellence for communicating intellectual inferiority of individuals and groups. Typically, assessment items also communicate, in subtle and not so subtle ways, that mathematics has nothing to do with reality, even when a question appears to be framed in a context."

We reflected on our basic ideals and values in Maths and Stats Education; how assessment fits into it; and how we can engage with the reality of the current system.

Every student ought to see themselves as a mathematical thinker and learner, and own their mathematics learning. Ideally, they have a positive disposition towards mathematics, and learn in a social, inclusive and collaborative environment. Mathematics would not be compulsory—students take it because they enjoy it, find it useful, and see how it links to their other interests and passions. For some, mathematics is not a separate discipline but integrated into their other learning in school.

Student well-being is paramount for creating the best learning environment. Each day, students should feel good about themselves. The enchantment and joy in learning mathematics should not be blocked by a toxic learning environment or assessment experience.

A traditional role of mathematics assessment is to rank students based on academic ability. Individuals and groups are pigeonholed and stereotyped. A generally accepted view in society is that only top academic students can do mathematics successfully. Even if that were true, mathematics assessment should not tell students what they are worth. But, we do not believe it is true—mathematics can be done by *anyone*.

The idea that maths is exclusively for a privileged group of students needs to disappear. Teacher beliefs and expectations can be impediments, but system-wide issues also create and reinforce inequalities: streaming classes; focus on formulae, procedures, and 'teaching to the test'; the expectation (among both teachers and students) that many students will inevitably stop understanding the maths after a certain point.

Teachers need strong professional development and support to drive changes in the system. We want teachers who engage their students with mathematics; who use a wide range of teaching strategies; and focus on teaching the person rather than just covering content. Students should have time for understanding and exploration; the disposition to approach their mathematics problems with confidence; and demand high expectations from their teachers.

Learning ought to be mutual across students, teachers, and whānau. Students need useful conversations about what they are learning and how it relates to their future. When are they leaving school? Where are they going? And what do we want them to take away as they continue their journey?

Curriculum first, then assessment

The meeting agreed that the main role of assessment should be for learning—a tool that informs student and teachers where they are at and where they need to go. The focus should be on the curriculum. We support the move to standards-based assessment (has a student mastered the material to the required level?) over norms-based assessment (where does the student stand compared to their peers?). Assessment should maintain the mana[1] and dignity of each student.

Assessment (broadly interpreted) ought to be integrated into teaching and learning. Students can be assessed informally and internally by teachers. The role of formal assessment, then, is to give students academic credentials that can be used elsewhere. NCEA Level 1 qualification was recently made optional for schools, and its use will depend on the needs of the school/ākonga and its students. Those leaving school after year 11 need Level 1, but those returning in year 12 do not. The teachers themselves know their students best, and what they are ready to handle.

We want students to have the time and space for exploration; to experience challenge, and develop resilience, perseverance and creativity. Struggle and failure should be normalised as part of the learning process. Including aspects of the history of mathematics and mathematicians into the curriculum can give students an idea of the struggles earlier generations went through to attain this knowledge.

We discussed how students could use project and cross-curricular learning, and issues around this that we need to consider. Teacher workload related to assessment needs to be kept manageable. Teachers also need proper support and training to help ensure that the intent of NCEA assessment is met; we cannot simply change the type of assessment on paper and expect teachers to magically change the way they teach. Another issue with cross-curricular projects is that they can lose the mathematics focus. For example, one can do a project on mathematics and art, but the maths needs to be intentionally pulled out and delved into, otherwise the students are just doing art. Teachers need the expertise to guide students to what is mathematically important and significant.

Mana ōrite mō te matauranga Māori (Equal mana for Māori knowledge)

Matauranga Māori and educating Māori students was the other main theme of our wānanga. By matauranga Māori is meant the body of knowledge originating from Māori ancestors, including the Māori world view and perspectives, Māori creativity, and cultural practices. Most schools follow the (English-based) standard NZ system, but some follow *kura kaupapa Māori* (the Māori school system), based on matauranga Māori, with subjects taught in te reo Māori. In keeping with the Treaty of Waitangi, part of our responsibility as a nation is to preserve our indigenous language and culture. The kura kaupapa system plays a key role in this preservation.[2] To continue in mathematics, a student has to make the transition from kura kaupapa to university. It is like the gap between secondary and tertiary level mathematics. Even with the language shift (to English), kura kaupapa students tend to have an easier time transitioning to university compared to Māori students in mainstream classes, because of their sense of mana and confidence gained from learning in their community. Changes to NCEA are meant to assess students from both systems (kura kaupapa and mainstream) on an equal footing.

If we want prioritise the needs of Māori students, what issues need to be addressed? Māori learners need to see mathematics and statistics as relevant to them, and to feel comfortable and at home in mathematics learning. One particular thing I found helpful in our discussions was the idea of students moving between different worlds.

Te ao Māori (the Māori world(view)) has its own values, knowledge and status which are the domain of matauranga Māori; and then, there is the world of mathematics—te ao Pāngarau. Mathematics and statistics have their own discipline-specific rules, independent of any particular culture. We can use culturally-embedded contexts for teaching and assessing mathematics, but we need to be careful not to identify or focus only on the mathematics in any cultural artefact or activity.

Those deeply embedded in te ao Māori may find such use of their taonga[3] either trivialises or misrepresents it, or fails to suitably acknowledge its owners. (Conversely, those less deeply connected to te ao Māori may feel some discomfort and shame, if they do not know what they feel they are expected to know about their culture.) For example, looking at tukutuku[4] under a mathematical gaze can send the message that we are only giving it status

[1] prestige, significance, authority

[2] There is no automatic process by which language and culture are transmitted from one generation to the next. Education (in the broadest sense) is the only way.

[3] cultural treasure

[4] a type of Māori art for decorating whare

because it contains mathematics. In contrast, we should acknowledge that we can see mathematics in the product, while keeping in mind that the makers were thinking in terms of their own tikanga[5]. With a bit of care, one can avoid labels that subjugate the mana of cultural processes and knowledge.

Connections between cultural activities and mathematics can provide a bridge from one to the other. The context is a hook to engage students and make mathematics relevant, but once students enter the mathematical world, they ought to learn maths on its own terms. Pania Te Maro shared a pipi[6] example: how do you distribute n pipi among m individuals of your hapu[7]? That depends on who is distributing the pipis, and to whom. One can properly acknowledge and discuss the Māori context with students before moving on to mathematics, putting in the additional condition—distribute the pipis equally. From there, one can move to the abstract: to division, to divisibility, to prime numbers. How can you compute the prime numbers? Pipis are now irrelevant; we are well and truly in te ao Pāngarau. The students still retain their identity, but the fact that they are Māori is no longer central. In the world of mathematics they are building their mathematical identity.

Mathematics relies on teaching, collaboration and communication. Te ao Pāngarau is accessed through people—educators, fellow students, mathematicians. We discussed how the social background of students can contribute to them feeling 'not good enough' to do mathematics. They have a higher tendency to give up when they encounter challenges. Increasing diversity in mathematics is important for providing role models. In the long-term, diversity will increase as social barriers and attitudes are broken down—this is inevitable because mathematics is universal.

In the meantime, we can remove unnecessary barriers in curriculum and assessment. Levels 6–8 of the mathematics curriculum are embedded in te ao pāngarau (and tauanga), and care needs to be taken to connect it to matauranga Māori. There is a strong focus in the curriculum on modelling and problem solving and we need to make sure that students are not tripped up by the context. (Lauren Burr gave an example of a shopping mall question given to students in Niue[8], where there are no shopping malls.) But to avoid tokenistic engagement with culture, we need to listen to Māori students and whānau. Are they asking for Māori cultural contexts in mathematics teaching, learning and assessment? Adding contexts will not necessarily make a particular topic more accessible. When drawing from culturally embedded contexts, how can we privilege both cultural and mathematical aspects? What depth is needed and how can the mathematics be drawn out? There was general discussion about how the NCEA review panels will be helped to better understand mātauranga Māori. There would be benefits of English-medium and Māori-medium panels and curriculum writers working in association with one another.

Many of the issues discussed are similar to those affecting other underrepresented groups in maths (e.g. women, students from other minorities). So while our discussions put Māori students at the centre, we can make changes to accommodate these students that will benefit all students.

Conclusions

We concluded with the following recommendations to the maths and stats achievement standards review groups.

1. Whatever comes out of the review work must be consistent with and supportive of culturally sustaining pedagogies and processes.
2. Take a broad view of assessment in order to give teachers space and scope to allow students to show their knowledge in different ways.
3. Re-compartmentalising mathematics can be a good idea as it could allow exploration across domains.
4. Prioritise internal assessments that encourage teaching less material (but better), and assessing less often but meaningfully.
5. Consider whether the standards promote thinking or rote memorisation.
6. Think about potential unintended consequences of the new design.
7. Work to ensure that assessment for qualifications showcases students' learning, and is not demoralising or soul-crushing.

[5] methods
[6] a kind of shellfish
[7] clan
[8] an NZ island territory 3000 km to the northeast

8. Ensure that design empowers students and discourages imposter syndrome in their mathematics learning and assessment.
9. Look to make creative, holistic, qualitative solutions consistent with student feedback.
10. Demand and provide advice regarding suitable face-to-face, written, discussion and video-based professional development for teachers to minimise unintended consequences and ensure assessment literacy for great teaching and learning.
11. Demand clear exemplars of student work that are accessible to all students, and provide other ways of empowering students to self-evaluate and control their learning.
12. Ensure the review rationale document has sufficient detail so that it can be used to inform everyone involved in learners' assessment for qualifications (learners, teachers, parents, whānau, school management and administration), enabling them to support and implement the changes with unintended consequences minimised.

Further reading

Link to NCEA panels https://conversation.education.govt.nz/conversations/ncea-review/review-of-achievement-standards/feedback-pilot-phase/

Rukuhia Rarangahia (Teaching and learning in Māori medium contexts). http://tmoa.tki.org.nz/Mataiako/Rukuhia-Rarangahia

Sione Ma'u

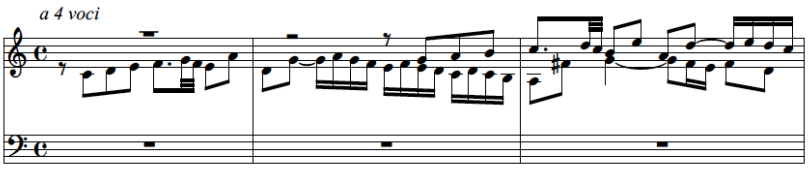
MATHEMATICAL MINIATURE

MM50: Bach and scales

What do the 48 preludes and fugues of J. S. Bach have to do with mathematics? The language in which much of Western music is written is the major scale based on a succession of intervals chosen from the Major tone **M** (a frequency ratio of 9/8), the Minor tone **m** (a frequency ratio of 10/9) and the Semi tone **s** (a frequency ratio of 16/15). In the major scale, the intervals are **MmsMmMs** so that the relative frequencies for the notes of the scale are as shown in row A below, with decimal approximations in row B. In row C, the so-called "equally-tempered scale" is shown. In this scale, both **M** and **m** are replaced by $2^{1/6}$ and **s** by $2^{1/12}$. This means that the octave comes out exactly right but, in between, there are slight errors.

	do	re	mi	fa	so	la	ti	do
A	1	$\frac{9}{8}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{5}{3}$	$\frac{15}{8}$	2
B	1	1.125	1.250	1.333	1.500	1.667	1.875	2
C	1	1.122	1.260	1.335	1.498	1.682	1.888	2

The way that humans perceive musical sounds somehow finds simple ratios more sonorous than non-simple ratios, which are regarded as discordant. On the other hand, the brain processes collections of notes so that they seem to be concordant when they are not exactly right, but are close enough. Bach advocated the tuning of keyboard and other instruments to the equally tempered scale so that certain chords and melodic sequences can sound pleasant and at the same time, can sound equally pleasant when transposed to different keys. The two books, each of 24 preludes and fugues, were written partly to illustrate and promote the idea of equal temperament.



If there is anything to feel good about in the current emergency, it is the strength of the medical and biological sciences in this country, as well as the strength of Applied Mathematicians, whose modelling skills find an important application in understanding the dynamics of epidemics. At Massey University in Albany, life sciences, and chemical and physical sciences, as well as computing and mathematics are in a single institute. This is a great arrangement and long may it continue. One of the people in this institute I know reasonably well, is Mick Roberts. He is an expert in the modelling of infections and all I can do is try to think like he does. I think that to understand epidemics we have to divide the population into three sets (S) the set of susceptible people, (I) the set of infectious people and (R) the set of people who have recovered and are no longer infectious. I am sure there are finer divisions than this but I am keeping it simple, for myself. As I understand it, the draconian protocols that have been introduced are mainly aimed at keeping the S people safe from the I people as much as possible. When contacts take place we want them not to be *close* contacts; so that the probability of an S person becoming an I person is low. When all these risks are combined together we can ask what is the expected number n of new I people being generated from each existing I during the time from infection to recovery. If $n > 1$, we would expect exponential growth but if $n < 1$ we can expect exponential decay. This is the limit of my poor understanding. Please tell me where I have got it wrong. As mathematicians we need to understand epidemics like this.

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MATHEMATICAL MISEPONYMY

The Chabauty or Fell Topology

When an early mathematician introduces an idea and that is followed by a chain of generalisations until someone reaches the ultimate, who should be given credit? Sometimes several names are attached to the idea and sometimes just one, but not necessarily the one who has made the greatest contribution, as I have tried to show in previous columns. I suppose that when names are attached they should somehow reflect the significance of the contributions in the chain of developments; I do, however, concede that it is not always easy to give a precise meaning to 'significance' in this context! This time I shall list the main contributors to a chain.

For a century or more topologists have been interested in imposing some sort of natural topology on a useful collection of subsets of a given topological space. Declare the collection of non-empty closed subsets of a space X to be useful and denote it by $\mathscr{C}(X)$. (As we go along it might be noticed that the empty set sometimes is anomalous so we exclude it.)

An early example is the Hausdorff[9] metric imposed on $\mathscr{C}(X)$ for a metric space (X,d). Define the distance $d(x,A)$ between a point $x \in X$ and a non-empty subset $A \subset X$ to be $\inf\{d(x,y) \,/\, y \in A\}$. Then the distance between two non-empty closed subsets of X is

$$\hat{d}(A,B) = \max\left\{\sup_{x\in A} d(x,B), \sup_{y\in B} d(y,A)\right\}.$$

In effect it is the amount (in terms of distance) that you must enlarge each of A and B so as to contain the other. Hausdorff introduced this distance in 1914, [3], and showed that it is a metric when X is compact.

Probably the first big step in generalising Hausdorff's idea was due to Vietoris[10], who in his 1921 doctoral dissertation considered the topology on $\mathscr{C}(X)$ having as base sets of the form

$$\{C \in \mathscr{C}(X) \,/\, C \subset \cup_{i=1}^{n} U_i \text{ and } C \cap U_i \neq \varnothing \text{ for each } i\}$$

as $U_1, \ldots, U_n$ range through the open subsets of X; see [4, p 259]. When (X,d) is a compact metric space this topology agrees with Hausdorff's metric topology.

The next big breakthrough came in the paper [1], addressing the restriction to compact spaces. Though in section 3 of his paper Chabauty talks about convergence of nets and sequences of closed sets, one could as well describe what he considered as a topology more directly. For any $A \subset X$ set

$$A^- = \{C \in \mathscr{C}(X) \,/\, C \cap A \neq \varnothing\} \quad \text{and} \quad A^+ = \{C \in \mathscr{C}(X) \,/\, C \subset A\}.$$

Sets in A^- hit A while sets in A^+ miss $X \setminus A$ and using these together leads to what are called 'hit and miss' topologies. The Chabauty topology is a hit and miss topology having base

$$\{U^+ \cap (\cap_{i=1}^{n} U_i^-) \,/\, U \text{ and each } U_i \text{ is open and } X \setminus U \text{ is compact}\}.$$

While Vietoris and Chabauty both might have restricted their spaces X of interest somewhat, all the basic work was done. Then in 1962, Fell in [2] explicitly defined what he called the H-topology for any topological space X just as I have described it in the previous paragraph, and studied many of its properties. Many subsequent authors called this topology the Fell topology while some have called it the Chabauty topology and occasionally the Chabauty-Fell topology. This topology is also closely related to the geometric topology considered by Thurston in his ground-breaking Princeton lectures on the geometry and topology of 3-manifolds.

[9] Born in 1868, Felix Hausdorff was one of the pioneers in the development of topological spaces in general and also made fundamental contributions to Set Theory, Measure Theory and Analysis. Ordered to report to a Nazi concentration camp in early 1942, he and his wife committed suicide.

[10] Leopold Vietoris was an Austrian mathematician, and one of those rare people who was born in the 19th century and died in the 21th century, having been born in 1891 and died in 2002: at almost 111 years of age he was the oldest recorded man ever in Austria. He is probably best known for the Mayer-Vietoris sequence of homology theory but is also known for many other contributions to topology yet I remember attending a conference where one speaker mentioned the sequence then, a bit like Lewis Carroll's Humpty Dumpty, added that though Vietoris lived a long time he never made any other useful contributions to mathematics.

References

[1] Claude Chabauty, *Limite d'ensembles et géométrie des nombres*, Bull. de la S. M. F., 78(1950), 143–151.

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[3] Felix Hausdorff, *Grundzüge der Mengenlehre*, Leipzig, Teubner, 1914.

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David Gauld

PROFILE

Maths Craft

A Maths Craft volunteer (in red shirt) explains the topology of the Mobius strip to curious visitors at the Martinborough Maths Craft Day in 2019.

Maths Craft was born out of a collaboration between Jeanette McLeod, from the Department of Mathematics and Statistics at the University of Canterbury and an investigator in Te Pūnaha Matatini, the Centre of Excellence for Complex Systems and Networks, and visiting UK academic Julia Collins. Combining their love of craft and mathematics, Jeanette and Julia first came up with the idea for a public event in early 2016. When Jeanette approached Te Pūnaha Matatini for sponsorship for an event later that year, they told her to "think big" and agreed to underwrite the first festival. It has now become the most successful mathematics outreach programme in recent New Zealand history.

The first event was held at the Auckland Museum in September 2016. Jeanette and Julie brought together a team that included Nicolette Rattenbury from the University of Auckland, Phil Wilson, another mathematician at Canterbury, Sarah Mark, a PhD student at Canterbury, and a small army of student volunteers. But despite offering the venue for free, the Museum wasn't quite sure what to make of the event. It was quite unlike anything they had hosted before.

Jeanette and her team set up a series of craft stations around a room at the Museum, each staffed by one or two volunteers. At one station you could learn how to French knit a tube, learn about the mathematics of knots, and then use your French knitting to make those knots. Other stations involved activities ranging from origami to the crochet of Mobius strips. I went along on the Saturday of that weekend and was amazed to watch an audience of pre-teens and teens listen intently to a 45-minute talk on the proof of the four colour theorem, while their parents knitted or did origami. Jeanette and her team had tapped into a completely new audience for mathematics in a very different way.

It turned out that the Maths Craft festival was the most successful externally organised event held at the Museum that year. It attracted more than 1800 visitors that weekend, making it one of the largest mathematics outreach events to take place in New Zealand. The Museum later told us it was also the largest and most diverse audience they had had for an outside event that year. It even made the evening news on Television New Zealand. It was a revelation.

The team was invited back to the Auckland Museum in 2017, and were given the Museum's largest exhibition space, the Event Centre, for three days, once again for free. This festival attracted more than 3,400 people. The team has also run day-long events around the country: the 2017 and 2018 Christchurch Maths Craft Days in The Great Hall, the 2018 Dunedin Maths Craft Day at the Otago Museum, and the 2019 Martinborough Maths Craft

Day in the Martinborough Town Hall. These events have attracted more than 5000 people. More recently the team has begun to build a relationship with Ngāi Tahu, a highlight of which was co-organising an ethno-mathematics wānanga at the Te Wheke Marae in Rāpaki in 2019.

In 2018, in response to requests from school teachers, the team ran Maths Craft in Class, a pilot programme of professional development for school teachers, to help them bring Maths Craft to their maths class. Workshops were held at the 2017 Primary Mathematics Association Seminar Day in Auckland with 60 participants. Maths Craft has produced over 30 instructional handouts on the mathematics of a range of crafts; these are the cornerstone of their events and are available from their website (see www.mathscraftnz.org/resources).

The depth of engagement that Maths Craft events achieve is unmatched by any other medium for science communication. Adults and children spend hours at events, learning mathematics and participating in hands on crafting. The learning that takes places is not limited to facts and concepts – participants actually learn what it is like to do advanced mathematics, and often learn how mathematics underpins things they already know or are skilled at. It is difficult to think of a comparable medium for mathematics outreach (even science outreach for that matter) that blends learning and engagement in this way.

Maths Craft has now become a flagship public engagement programme, having reached more than 10,000 people and continuing to grow in popularity. The team has obtained several Unlocking Curious Minds grants to build on their early success and it can now claim to have a national profile. Jeanette and Phil won the New Zealand Association of Scientists Cranwell Medal for Science Communication in 2019, and later that year Jeanette was invited to be one of four plenary speakers at the New Zealand Maths Colloquium. Julia is now based at the Australian Mathematical Sciences Institute, where she now runs Maths Craft Australia, while Jeanette and Phil are still running the original Maths Craft here in New Zealand.

It is also important to note Maths Craft's influence on a wide range of young mathematicians and scientists who volunteer at the event. For many, this is their first experience in science outreach and communication, and several have gone on to excel at further outreach activities. Tristan Pang, an undergraduate physics student at the University of Auckland, was one of Jeanette's volunteers for the 2017 Maths Craft event in Auckland. He went on to become one of forty finalists in the global Breakthrough Junior Challenge out of ten thousand entries. Through Maths Craft, Jeanette and Phil have trained and motivated an army of young science communicators.

The team also has a commitment to a rigorous evaluation of each Maths Craft event. For something that is largely organised in their spare time, it would be very easy to forgo evaluation of the events. However, participants are surveyed before and after they participate in an event to gauge impact on their perceptions of mathematics and to improve the way the next festival is run.

Maths Craft is motivated by a desire to share a passion for mathematics with a wide range of people, both adults and children. Maths Craft events have resonated with a very diverse audience, in terms of age, ethnicity, gender, and socio-economic background. It should not be underestimated how much time and energy has gone into making Maths Craft work: for events of this size, their budgets have been small and the logistics have been formidable. Only a team with real dedication and drive could have pulled these festivals off and made them the success they have become. It is remarkable that Jeanette, Phil, and their team have done this largely out of work hours, taking annual leave to prepare and organise the major events, and giving up entire weekends to run them.

Shaun Hendy

LOCAL NEWS

AUCKLAND UNIVERSITY OF TECHNOLOGY

SCHOOL OF ENGINEERING, COMPUTER AND MATHEMATICAL SCIENCES

New Colleague

Dr Patricio Maturana-Russel has recently joined the Department of Mathematical Sciences at Auckland University of Technology as a Lecturer. Patricio completed his PhD in Statistics at the University of Auckland, supervised by Dr Steffen Klaere and Dr Brendon Brewer. He continued in the same department as postdoctoral research fellow for 2 years, working with Professor Renate Meyer. His research interests involve mainly the development and the computational implementation of Bayesian statistical methods, in particular with application in gravitational wave data analysis and phylogenetics.

Figure 1: *Dr Patricio Maturana-Russel*

Events

The department of Mathematics Science hosted the 2020 Forder Public Lecture by *Dr Julia Wolf* (University of Cambridge) on 11 March. This exchange program is arranged between the London Mathematical Society and the New Zealand Mathematical Society. Julia gave a seminar talk "What Fourier analysis can and cannot tell us about the integers" and a public lecture "The power of randomness". The public lecture was a remarkable success with many favorable comments from the participants.

Travel and Conference Participation

In November 2019, five members of the AUT Certificate in Science and Technology teaching team attended

Figure 2: *Public lecture by Dr Julia Wolf*

and presented at the Swan Delta Conference in Fremantle, Western Australia. This was funded by an AUT Excellence in Teaching Award. Renu Choudhary, Jeff Nijsse, Heather Ricketts, Kerri Spooner and Cathy Hassell Sweatman enjoyed five days of varied and interesting presentations and made many new contacts. They look forward to the Delta Conference in Auckland in 2021.

Dr Hyuck Chung presented his work on "MATLAB online integration in engineering mathematics courses" at ANZIAM 2020. At AUT, MATLAB is used as a teaching tool for computation and coding. Hyuck's trip to the conference was supported by MathWorks Australia. Hyuck attended KOZWaves (Australasian Conference on Wave Sciences) at the University of Melbourne. This is a biennial conference series on all things waves founded by the applied mathematicians in Australia and NZ. Hyuck presented his work on sound absorbers made from layers of cylindrical resonators, which can absorb low frequency sound by combining slotted cylinders in layers.

Over the period 6-10 January 2020, Prof Jiling Cao and Wenjun Zhang attended the 2nd International Symposium on PDEs & Stochastic Analysis in Mathematical Finance, held in Sanya, China. Each of them presented a talk at the symposium on their recent work in financial mathematics. This symposium, chaired by Prof Song-Ping Zhu from The University of Wollongong, attracted over a hundred participants of academics and financial practitioners.

PhD Completions

In November 2019, Reza Moosavi Mohseni successfully defended his PhD theses. The title of Reza's PhD thesis "Mathematical analysis of the chaotic behavior in monetary policy games", supervised by Prof Jiling Cao and Dr Wenjun Zhang.

Wenjun Zhang

UNIVERSITY OF AUCKLAND

DEPARTMENT OF MATHEMATICS

Staffing

Kim Locke and Cris Hasan are temporary lecturers for the first half of the year.

We welcome Sudeep Stephen and Nicolau Sarquis Aiex as fixed-term lecturers for one year.

Our teaching fellow for this year is Annie Rajan. She takes a break for one year from teaching Mathematics at Southern Cross Campus in Mangere and is teaching Mathematics for us.

Julia Novak, Vivien Kirk and Sina Greenwood all continue their Associate Dean roles in the Faculty of Science. Julia has been leading all matters related to the impact of COVID-19 on undergraduate teaching in the Faculty of Science, including accommodating students unable to travel to New Zealand and, more recently, planning to move all teaching online.

James Sneyd and Stephen Taylor had their research and study leave visits to the USA curtailed by COVID-19. Pedram Hekmati was nearly stranded in Brazil, as he was visiting IMPA in Brazil in March when the travel restrictions started to bite. They are all happy to be home. It was suggested that now would be a unique opportunity to take a department photo with everyone present, but of course we are all in lockdown.

Events/Visitors etc

We held a departmental "Talking about Teaching" event on Friday 8th November 2019, organised by Julia Novak and Tanya Evans.

Dr. Dustin Mixon (Ohio State) visited Shayne Waldron on a Kalman Visiting Fellowship in November. He gave a wonderful lecture on "The mathematics of gerrymandering".

Sione Ma'u, together with Ivan Cheltsov (Edinburgh) and Frederic Mangolte (l'Université d'Angers), organised a conference "Algebraic Geometry in Auckland" on 16-20 December, 2019.

Professor Ed Witten (IAS, Princeton) visited in January. Pedram Hekmati organised a workshop "Geometry of Quantum Fields and Strings" featuring talks by Witten and also Clifford Taubes (Harvard University), Mina Aganagic (University of California, Berkeley), Stavros Garoufalidis (Georgia Institute of Technology), Michael Freedman (Microsoft Station Q), Rafe Mazzeo (Stanford University), and Mathai Varghese (University of Adelaide). Professor Witten gave a sold-out public lecture "New observations of black holes" to a packed lecture room on Sunday, 12 January, introduced by Professor Sir Vaughan Jones.

The Michael Erceg Senior Visiting Fellow Professor Alex Lubotzky (Hebrew University in Jerusalem) visited in February/March. Jeroen Schillewaert organised a very successful two day workshop on "Arithmetic groups" with invited speakers Alex Lubotzky, Gaven Martin, Dave Witte Morris, Uri Onn and Francois Thilmany. Professor Lubotsky also gave an algebra seminar on "The product replacement algorithm and Kazhdan property (T)" and a public lecture on "High dimensional expanders".

Dr. Chad Higdon-Topaz (Williams College) visited the University of Auckland for the last 2 weeks of February and conducted himself with the energy and enthusiasm of a piece of lithium thrown into a swimming pool. He gave wonderful colloquium talks on "Inclusive Teaching" and "Quantitative Approaches to Social Justice", ran a workshop on "Advocating for Students", and gave an Applied Maths seminar on "A Topological View of Collective Behavior".

The NZMS Forder lecturer Dr Julia Wolf (Cambridge) gave a colloquium talk "Additive number theory through the model-theoretic lens" and a seminar talk "Ramsey multiplicity of patterns in finite abelian groups".

For the International Day of Mathematics on March 14, Nicolette Rattenbury organised a program of events including a "Mathematical Scavenger hunt" for undergraduate students and a public screening of the documentary "Secrets of the Surface: The Mathematical Vision of Maryam Mirzakhani". The screening was followed by a Q&A with Bernd Krauskopf and Hinke Osinga.

Professor Michael Proctor (Cambridge) visited on a Hood Fellowship, hosted by Claire Postlethwaite. He gave a short course "Formation and instabilities of patterns: the role of symmetry", but sadly had to cut his visit short due to travel restrictions.

Fanny Kassel (IHES) was supposed to visit in April, on a Kalman Fellowship. But this trip has been postponed due to COVID-19.

Other News

Paddy Bartlett was on TV news in November about a confusing NCEA mathematics exam question.

John Butcher hosted Dr Adrian Hill (University of Bath) in February.

Marston Conder and Gabriel Verret organised a conference in Rotorua in the week 9-14 February, on "Symmetries of Discrete Objects", as a sequel to two conferences on the same theme held at Queenstown in 2012 and 2016. Despite a few participants having to withdraw at a late stage because of travel restrictions related to the coronavirus, the conference was a great success. Invited speakers were Anneleen De Schepper (Belgium), Dimitri Leemans (Belgium), Joy Morris (Canada), Primož Potočnik (Slovenia) and Jozef

Širáň (UK/Slovakia), and there were 25 other talks on a range of topics, by participants from China, Japan, Malaysia, Mexico, New Zealand, Poland, Slovakia, Slovenia, South Korea, Spain, Switzerland, the UK and the USA. A highlight was the conference dinner, held at the historic Blue Baths. A number of participants visited the UoA Maths Department before and after the conference.

Graham Donovan is one of the PIs of an Australian National Health and Medical Research Council research grant on "Unravelling a clinical paradox: why does bronchial thermoplasty work in asthma and how can we improve patient outcomes?"

Tanya Evans gave an opening plenary at the 12th Delta conference - the Southern Hemisphere Conference on Teaching and Learning of Undergraduate Mathematics ad Statistics (Fremantle, Australia) in November - titled "Who is tasked with modernisation of university mathematics education? Research mathematicians and mathematics education researches bridging the disciplinary gap". She was subsequently invited to present at the University College Dublin - which occurred on 17 Jan, 2020, conveniently timed prior to her planned visit to the Mathematics Education Centre at Loughborough University, UK in late January. Earlier in 2019, Tanya had been appointed to lead a NZ team, which, as an external partner, joined a large European project: PLATINUM funded by Erasmus Plus https://platinum.uia.no/. The project brings together eight teams from seven EU universities with an aim to establish partnerships for learning and teaching in university mathematics. Tanya was an invited speaker at the PLATINUM project meeting, which was held at Loughborough University, 23-26 Jan, 2020.

Pedram Hekmati was the Butcher-Kalman lecturer at the NZMS Colloquium.

Steven Galbraith is part of a multi-university MBIE-funded project on Cyber Security. He is leading a project on "Post-Quantum cryptographic schemes". He was also supposed to be running the Algorithmic Number Theory Symposium (ANTS) in July, but this will be cancelled and probably take place as an online event.

Vivien Kirk was presented with a glass trophy at the NZMS Colloquium dinner signifying her Miriam Dell Award from the Association for Women in the Sciences, NZ, for excellence in Science mentoring.

Sione Ma'u has been invited to serve on an NCEA Subject Expert Group on Numeracy.

Eamonn O'Brien participated in a program "Groups, representations and applications: new perspectives" at the Newton Institute in Cambridge in January and February.

Jeroen Schillewaert has be awarded the Hall Medal of the Institute of Combinatorics and its Applications, to recognize outstanding achievements by members who are not over 40.

Tom ter Elst has hosted Professor El Maati Ouhabaz (University of Bordeaux) and Dr. Manfred Sauter (Ulm University).

Our postgraduate students achieved many accolades at the NZMS Colloquium in Palmerston North in December:

- The NZMS Aitken Prize for the best contributed talk by a student was awarded to Martin Bachraty for his talk "Skew morphisms of finite groups".
- Valerie Jeong was awarded an Honourable Mention in the Aitken Prize for her talk "A heteroclinic cycle and evolutionary robotics".
- Nelson Wong was awarded the ANZIAM Prize for best poster. Nelson was also awarded the Best Presenter Prize at the New Zealand Mathematics and Statistics Postgraduate Conference 2019.

PhD student Kevin Stitely won two awards for best poster at the International Conference on Laser Spectroscopy (ICOLS) in Queenstown. He also won the People's choice presentation award at the Conference on Optics, Atoms, and Laser Applications (KOALA), in Dunedin.

Steven Galbraith

MASSEY UNIVERSITY

SCHOOL OF NATURAL AND COMPUTATIONAL SCIENCES

The Mathematics group is hosting the Auckland North Mathematics Olympiad cluster workshops this year. The purpose is to augment the other groups operating around NZ. The aim of these workshops is to foster the mathematical skills of high achievers in pre-tertiary mathematics. The 2-hour sessions are held twice in each month and are part of the program of the NZ Mathematics Olympiad Committee. Some 29 local students attended the first session in March led by Mohsen Hashemi — a PhD student — and Graeme Wake, plus some teachers. Last year one Year 12 student from our district got into the reserve list for the NZMO competition in July 2020 in Russia. The NZ team for this year will be announced in April.

Jason Archer, Carlo Laing, Mick Roberts and Winston Sweatman attended the ANZIAM 2020 meeting in the Hunter Valley, NSW, 2-6 February. They all gave contributed talks:

- Jason Archer: The roles of scale and biodiversity in infectious disease transmission.
- Carlo Laing: Degree assortativity in networks of spiking neurons.
- Mick Roberts: What is a reservoir of infection?
- Winston Sweatman: Few-body fun

Before the meeting Winston attended MISG 2020 in Newcastle.

The mathematics group is in shock after it was proposed that face-to-face teaching here be closed in favour of teaching from Palmerston North only. See the article elsewhere.

Carlo Laing

VICTORIA UNIVERSITY OF WELLINGTON

SCHOOL OF MATHEMATICS AND STATISTICS

We welcome 3 new staff members. Susan Jowett has started a postdocoral position working with Geoff Whittle. Our new Assistant Lecturer, Jasmine Hall, has a special brief to conduct outreach and diversity work while she continues to work on her PhD. Becky Armstrong is with us for 1 year as a Lecturer; her expertise is in operator algebra.

In December, Lisa Orloff Clark gave a plenary lecture at the New Zealand Mathematical Society Colloquium in Palmerston North. Her talk was entitled "Equivalence relations, topology and C*-algebras". In her talk, she used Kakapo to represent the classes of C*-algebras that can be modelled by topological equivalence relations.

In February, the University celebrated John Haywood's 25 years of service at the University with a morning tea hosted by the Vice Chancellor. John joined the University as a Lecturer in Econometrics in October 1994 and in 2001 moved to the role of Senior Lecturer in Statistics, where he is currently Programme Director. He was the inaugural Programme Director of Actuarial Science, establishing a subject then offered nowhere else in New Zealand. John has served on multiple School, Faculty and University committees and is in his fourth term as a Science Faculty Representative on Academic Board, where he is an active contributor. John has also served as Secretary of the New Zealand Statistical Association for several years. John has the remarkable skill of always asking a good question of any seminar speaker, no matter how arcane the presentation, and we are enormously grateful to him for this.

Geoff Whittle gave a lecture for the Royal Society in Whangarei in February. To celebrate 25 years of Marsden funding, the Society put on a series of regional lectures, online profiles and videos to highlight the depth and breadth of research excellence supported by this funding. Geoff's lecture was titled "Mathematical magic and the digital revolution".

The Forder Lecturer, Julia Wolf visited the University during March and presented two talks, including a well-received public lecture "The usefulness of useless (mathematical) knowledge".

Mark McGuinness and his collaborator Andrew Fowler (University of Limerick) have published with Springer a new textbook called "Chaos". The book which is about nonlinear dynamics for applied mathematicians, and is aimed at upper-level undergraduates and beginning graduate students.

Mark also attended a Mathematics in Industry Study Group in Newcastle, Australia, where he worked on the design of a furnace used to soften steel bars before they get shaped into suspension coils. He also gave a talk on Modelling Steaming Surtseyan Ejecta, with alternative title "CLOUDY with a chance of steaming bombs".

Astrid an Huef

UNIVERSITY OF CANTERBURY

SCHOOL OF MATHEMATICS AND STATISTICS

Congratulations to *Elena Moltchanova* on her promotion to Professor, to *Miguel Moyers Gonzalez* on his promotion to Associate Professor and to *Fabian Dunker*, *Geertrui Van de Voorde*, *Rachael Tappenden* and *Varvara Vetrova* on their promotions to Senior Lecturer.

Congratulations to *Varvara Vetrova* who received the NZSA Worsley Early Career Research Award at the NZSA conference in November and to *Rick Beatson* who was awarded a NZMS Fellowship in December.

After ten and a half years as Head of School *Jennifer Brown*'s term came to a close at the end of last year. Since January *Clemency Montelle* is our new Head of School.

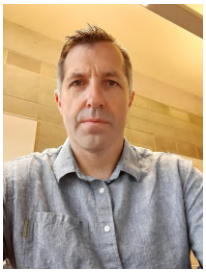
In December the School farewelled *Irene David* who retired after 17 years in the School. She and Tim moved north to Ruby Bay and are looking forward to gardening. Irene recently trained as a yoga teacher and intends to continue with this second career in Marlborough.

Late last year *Nick Ward* was appointed to a continuing position. Nick had been in the School on contract for two years.

In January the School welcomed two new continuing staff, *Mark Hooper* and *James Bartlett*. Mark has been teaching Mathematics and Statistics in the high school

sector, most recently at Otago Boys' High School in Dunedin for the last 9 years. He has been involved in leading programmes teaching scholarship Calculus and Statistics. Mark has an interest in modelling educational achievement data and in due course would like to build on this at Canterbury University. He is playing squash and is involved in cricket through coaching and umpiring. He also has a deep seated ambition to hike some (or all, if Division 1 comes up one day) of the Pacific Crest and Appalachain Trails in the USA.

James also has a teaching background, teaching at Christ's College, a local high school, for the last six years. He has developed an interest in geometry, and its role as a tool for visualizing concepts in a wide range of mathematical contexts. In his office he keeps a wooden puzzle version of Tutte's squares (a solution to the mathematical challenge, apparently first posed by the Trinity Mathematical Society in the mid-1930s, of dividing up a square into smaller squares of different sizes) that he wood-worked himself. James with his wife Rachel is in the thick of parenthood with their two children ages 2 years and 3 months, respectively.



Mark Hooper (left) and James Bartlett

Congratulations to *Mike Plank* and Jenny on the birth of their first child, Luke Owen Plank, in early December, and to *Brendan Creutz* and Nika on the birth of their second child, Kira Liepa Creutz in late December

At the end of December the School welcomed Magnus Bordewich as an Erskine Fellow from the Department of Computer Science at Durham University, United Kingdom. Magnus has visited New Zealand previously, originally as a postdoctoral fellow in 2004, and most recently as an Erskine Fellow in 2015. His research interests include analysis of algorithms, computational complexity, and combinatorics with applications of these to phylogenetics. Magnus was hosted by *Charles Semple* during his three month long visit and, during term 1, taught the cryptography part of our 200-level discrete mathematics course MATH220.

In early February Katherine St. John from the Department of Computer Science at Hunter College of the City University of New York arrived on an Erskine fellowship. Her research interests lie in the intersection of biology, computing, and mathematics, focusing on tree structures used to model evolutionary histories, binary search trees, and ways to compare and visualize these structures. During her two months long visit Katherine was hosed by *Mike Steel* and taught into our 200-level statistics course STAT211 Random Processes.

Günter Steinke

Mike Plank, Jenny and Luke (above) and Brendan Creutz and Kira

UNIVERSITY OF OTAGO

DEPARTMENT OF MATHEMATICS AND STATISTICS

Quite obviously, the lives of everyone at the Department and the University — like everywhere in all of New Zealand and the rest of the world — have dramatically changed due to Covid19. Currently we are facing our first experience with online teaching, and it is still completely unknown how the situation will have developed by the time this newsletter is published. Let's just keep our hopes up and see what the future brings. For now, we focus on some mostly "normal" news.

Warmest congratulations to **Dominic Searles** and his wife Katya on the birth of their daughter Holly Josephine, born 16 December 2019. All the best to you, in particular, in these difficult times!

We are very sorry that **Melissa Tacy** is going to leave us after the first semester. However, we also very much understand that recent indications of possible "Management of Change" plans of Otago's university management make it desirable to work elsewhere with increased job security. Hence, while we regret to lose her, we are also very happy that Melissa can take up a position at the University of Auckland. All the best for your remaining months at Otago and your future in Auckland, and congratulations on your new position, Melissa!

Holly Searles with her parents and sister Ruby

Congratulations to the recipients of several awards and grants. **Phil Wilcox** received a University of Otago School of Biomedical Sciences award for his contributions in Māori-related research. Phil's research also featured in the latest edition of *He Kitenga*, the University's research highlight magazine. Moreover, two University of Otago Teaching Development (CALT) Grants were awarded to members of the department. **Boris Baeumer** and two co-PIs received a grant for the project "A sustainable model of support for students with low numeracy". The second grant was awarded to **Katrina Sharples**, **Lisa Avery**, **Megan Drysdale** and **Phil Wilcox** for the development of an eLearning environment to enhance the teaching and learning of introductory statistics.

Jörg Hennig

PhD SUCCESS

Naeimeh Abi (University of Canterbury)

Title: Spatially balanced sampling methods in household surveys

Supervisors: Jennifer Brown, Elena Moltchanova, Blair Robertson, Richard Penny

Abstract: Household surveys are the most common type of survey used for providing information about the social and economic characteristics of a population of people. In these surveys, information is usually collected by sampling the houses where people live and then enumerating one or more persons at each home. Current sampling methodologies used in designing household surveys generally do not take into account the spatial structure of populations. This may lead to selection of units (i.e., households, individuals) near to each other that usually provide similar information in the sample. As a result, the selected sample tends to be less efficient than a sample that reflects all attributes of the population.

Spatially balanced sampling is a popular design for selecting samples from natural resources and environmental studies, which avoids selecting neighbouring units in the same sample. Spatially balanced sampling design ensures the selection of a representative sample by providing a spatial coverage of a region corresponding to the population of interest.

This doctoral thesis aims to assess the possibility of applying spatially balanced sampling in designing household surveys. After investigating spatially balanced methods available in the literature, balanced acceptance sampling (BAS), developed by Robertson et al (2013) is considered for further investigation in this study.

This research comprises two main parts: (1) exploring the characteristics of BAS from a practical perspective, (2) promoting the application of spatially balanced sampling in household surveys. The first part looks into the advantages of the BAS method in practical cases. It aims to highlight the potential advantages of the BAS method for selecting samples in practical situations in environmental studies. The flexible characteristics of BAS and its practical benefits (e.g., being able to accommodate missed sampling units and the ability to add extra sampling units during survey implementation) discussed in the first part, show that BAS has the potential to be extended for application in other surveys, specifically, household surveys.

In the second part, the applicability of spatially balanced sampling in household surveys is assessed. A technique for selecting a spatially balanced sample from a discrete population, called BAS-Frame, is introduced. The spatial and statistical properties of the proposed method are investigated through conducting simulation studies using the census 2013 meshblocks of selected regions in New Zealand. The results from these simulation studies show that the proposed method is sufficiently robust in spreading the sample over the population of interest. In addition, it is seen that applying spatially balanced sampling in selecting samples for household surveys provides more precise estimates when compared to non-spatially balanced sampling methods.

The feasibility of spatially balanced sampling methods to deal with some practical aspects of designing a household survey is also investigated in the second part (e.g., designing a primary sampling unit (PSU) which meet a pre-specified minimum number of sampling units, designing longitudinal surveys, and selecting a sample in the presence of auxiliary variables). A method on the basis of the BAS-Frame is developed to merge undersized units with their nearby units as much as possible to define PSUs. A simulation study shows that the proposed method is more powerful than the conventional method (i.e., the Kish method) in combining the undersized units with their undersized neighbours. The application of the BAS-Frame for controlling overlap between rotation groups in the longitudinal designs is discussed. Finally the performance of the BAS-Frame in spreading the sample over the space of the auxiliary variables available in the frame is investigated. This study shows that in the case of the existence of a small number of auxiliary variables (fewer than five variables), the BAS-Frame can provide a good spread, not only over the geographical space of the population, but also over the space of the auxiliary variables.

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Fareeda Begum (University of Canterbury)

Title: Integral means of univalent functions on an annulus

Supervisors: Ngin Tee Koh, Rick Beatson

Abstract: My PhD thesis area is complex analysis. I have studied functions of complex variables on the annulus $\mathbb{A}_\rho = \{z : 0 < \rho < |z| < 1\}$. The Schwarz lemma is a well-known and important result in complex analysis for holomorphic functions on the unit disc $\mathbb{D}$. In the literature there are extensive results that deal with the disc but

less attention is given to the results on the annulus. Therefore, my research area is a fertile subject since it's less explored.

I have worked to derive an analogue of the Schwarz lemma for holomorphic functions on the annulus $\mathbb{A}_\rho$. But counterexamples reveal that a pointwise version of the Schwarz lemma for holomorphic functions on an annulus would not be possible. If holomorphic functions on an annulus are either not univalent or not normalized by having zero constant coefficients in the Laurent series expansion then the pointwise analogue of the Schwarz lemma fails in a more dramatic fashion.

Since a pointwise version of the Schwarz lemma does not hold on the annulus, I have worked to obtain instead an integral means version of the Schwarz lemma for univalent holomorphic functions of an annulus and its relation with normalization and univalence of the functions under consideration. It turns out that an integral means version of the Schwarz lemma also fails for an annulus even when the functions are univalent and normalized. If either the univalence condition or the normalization condition is dropped then the integral means version of the Schwarz lemma fails in a more dramatic way. Finally, I have determined a partial analogue of the integral means version of the Schwarz lemma for univalent holomorphic functions on an annulus.

I also have obtained sharp estimates for the integral means of k^{th}-order derivatives of functions in the class $\mathfrak{R}$ of normalized univalent holomorphic functions with real Laurent coefficients and class $\mathfrak{T}$ of starlike functions on an annulus.

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Reza Moosavi Mohseni (Auckland University of Technology)

Title: Mathematical analysis of the chaotic behavior in monetary policy games

Supervisors: Prof Jiling Cao, Dr Wenjun Zhang

Abstract: This thesis discusses the concept of chaos in monetary policy games, which I believe to be novel. The mathematical framework developed in this thesis addresses two important problems in monetary theory, namely, the time-inconsistency and the complexity in designing, conducting and predicting the impacts of monetary policy on the economy. Considering a noncooperative non-zero-sum differential monetary policy game between the central bank and the public when the coefficients of the system depend on the state and control variables, it is shown that the costate variables of both players are controllable in three solution concepts. The controllability of the costate variables means that the monetary policy is time inconsistent even in the open loop Nash game, which is known as a time-consistent policy game in the literature. In other words, the results confirm that the structural time-inconsistency of monetary policy is almost always unavoidable.

To better understand how monetary policy affects the economy, we need to know the response of the public expectations. This can be achieved if the monetary policy behaves in a systematic manner (Walsh, 2003). To this end, this thesis tests the chaotic dynamics of the trajectories of both players. The results reveal that chaotic dynamics is possible in monetary policy games, and it seems that the source of this complexity comes from the chaotic behavior in the public expectations. Chaotic behavior in the strategy of the public sector creates serious difficulties for the policymaker, who wishes to design a policy that controls the business cycles.

REPORTS ON EVENTS

Isaac Newton Institute, Cambridge: student report

From July to December 2019 I had the pleasure to visit the Isaac Newton Institute of the University of Cambridge (UK) to take part in a scientific programme which aimed to increase interactions between mathematicians working in geometric numerical integration (where I count myself in) and those working in finite element exterior calculus. It was an amazing opportunity to make contact and discuss with the people whose names I knew from the papers I am reading. Presenting my own work, how symplectic integrators help to compute bifurcation diagrams robustly, to the heart of my mathematical community lead to many fruitful discussions and interesting contacts.

Weekly seminars, scientific workshops, spontaneous discussion, and conferences at the Newton Institute provided me with a great overview of my field of research and related topics. As I do not have any teaching duties, I could stay for the whole length of the programme and this earned me the title of the "luckiest PhD student of my field of research". Moreover, I had the opportunity to visit and present at the conference SciCADE at the University of Innsbruck, Austria, and the Bayes Centre of the University of Edinburgh as well as during a research visit at the Karlsruhe Institute of Technology, Germany. This provided me with important feedback for my work and showed me many research directions and ideas.

Furthermore, I attended the Heidelberg Laureate Forum (HLF) at the University of Heidelberg, Germany, which brings together young researchers from around the globe with fields medallists and recipients of the Abel Prize as well as prizes in computer sciences. It was very inspiring to talk to many truly brilliant people. Presenting my research poster and a 2-minutes elevator pitch within the format of the HLF and giving an interview for the PlusMagazine was a great honour. I would like to thank for the generous support of the NZMS student travel grant which helped to fund my travel making me the "luckiest PhD student" in the field of geometric numerical integration.

Christian Offen (Massey University)

Krakow where science and history are merged

The 15^{th} IFToMM World Congress 2019 was hosted by International Federation for the Promotion of Mechanism and Machine Science in a conjunction with AGH University of Science and Technology in Krakow, Poland.

In this conference, I presented a paper which was related to the second core of my PhD thesis — *Input and output singularities for parallel manipulators*. In this work, I discuss how input and output singularities of a manipulator can be determined directly from the configuration space as well as different choices for inputs and outputs may result in different singular configurations.

Hamed Amirinezhad (Victoria University of Wellington)

GENERAL NOTICES

Mathematics-in-Industry NZ (MINZ) 2020

MINZ 2020, scheduled to take place on 22–26 June at the University of Canterbury, will be postponed a year.

Graeme Wake

AMSI Winter School - 29 June - 10 July Brisbane Australia

In light of the evolving COVID-19 situation and implementation of countermeasures by Federal and State Governments, AMSI and Winter School 2020 hosts The University of Queensland are conforming to public health directives aimed at reducing the spread of infection throughout the community.

Health and well-being of our community is of paramount importance to us. Therefore the AMSI Winter School on New Directions in Representation Theory will not be staged in accordance with the intended July 2020 schedule.

We are currently exploring all possibilities to host this program at a later date and will keep you informed of any updates as information becomes available.

In the meantime, we have reached out directly to all students who have submitted applications to issue them a refund on their program fees.

I would like to thank you for your support of the AMSI Winter School and hope to be in contact with you again in future.

Should you have any questions, please do not hesitate to contact me.

Anna Muscara (AMSI)

Postponement of ICME-14 due to COVID-19

The International Commission on Mathematical Instruction (ICMI), a commission of the IMU, has just released the following announcement regarding its big congress ICME-14:

"Due to the global pandemic caused by the new coronavirus disease (COVID-19), ICMI and ICME-14 have decided, after careful discussion and consultation, to postpone ICME-14 by one year until the Northern Hemisphere summer of 2021.

The specific dates of postponed ICME-14 and the details related to the conference organization, including information for those already registered, will be announced as soon as possible. We will publish a "frequently asked questions" fact sheet in the next weeks on the ICME14 and ICMI websites.

Whereas the one-year postponement of ICME-14 poses many challenges, we believe this is the solution to ensure the full-fledged and successful realization of this important conference. We sincerely apologize to everyone for the consequences of this unfortunate and dramatic development.

ICMI plans to hold its General Assembly sometime in September-October 2020 in order to hold its quadrennial meeting and to elect the upcoming ICMI Executive Committee which will take office on 1 January 2021, so as to ensure a smooth transition of authorities as stipulated in the statutes. Details about how the meeting will be conducted (when and where) will follow in the upcoming months, as the global situation will make the planning feasible.

Please distribute this information in your country.

Thanks

Regards Helge Holden

Prof. Helge Holden Secretary General of the International Mathematical Union"

Rua Murray

NZMS NOTICES

Calls for nominations for NZMS Awards and Fellowships

The NZMS recognises excellence in mathematical research and service to the NZ mathematical community through awards and an accreditation (fellowship) scheme. The Council asks that you all actively encourage eligible colleagues to apply for these awards and/or offer to nominate them, especially women, those of Māori ethnicity, or other members of the NZ mathematical community who are under-represented among past awardees and fellows.

Below are calls for nominations for the specific awards and for NZMS fellowships, along with their deadlines. Further details on all the awards, including past recipients, eligibility, and how to nominate someone (or self-nominate), can be found at: http://nzmathsoc.org.nz/?awards. Fellowship information and application forms can be found at: http://nzmathsoc.org.nz/?accreditation.

Changes this year: (1) nominations are invited for the inaugural Gillian Thornley Award for outstanding contribution to the cause or profession of mathematics; (2) eligibility period for the NZMS Early Career Award extended to 10 years post-PhD.

2020 Gillian Thornley Award for outstanding contribution to the cause or profession of mathematics

This annual award was established in 2020 to recognize outstanding contributions to the cause or profession of mathematics in New Zealand. For the purposes of this award, "contribution to the cause or profession or mathematics" could include (but is not limited to) contributions to teaching and education, research leadership, outreach, engagement with government bodies, diversity, service to professional societies, mentoring, and communication of mathematics to a general audience.

Eligibility. Nominees need not be members of the NZMS but the award would normally be given for work that took place in New Zealand and contributed to NZ mathematics.

Nominations should be sent by email to the NZMS President, Prof Shaun Hendy (s.hendy@auckland.ac.nz) by 31 August 2020. Submissions should state clearly that they are for the Gillian Thornley Award.

2020 NZMS Early Career Research Award

This award was instituted in 2006 to foster mathematical research in New Zealand and to recognise excellent research carried out by early-career New Zealand mathematicians. Candidates will be judged on their best three published research outputs and a brief CV. Research outputs could include publications in books, journals, other peer-reviewed venues, or other types of high quality mathematical research.

Eligibility. Candidates may contact the NZMS President in confidence for clarification of how the following eligibility criteria apply to their particular circumstances: candidates should be within ten years of confirmation of PhD, but an appropriate adjustment to this time period can be made to take into account career breaks or periods of reduced workload; and, candidates must have worked or studied in NZ for at least 30 months in the three calendar years immediately prior to the award year, with an appropriate adjustment for career breaks (candidates who leave New Zealand during, or prior to, the award year but satisfy all other conditions remain eligible); and, candidates must be current members of the NZMS; and no person can receive the award more than once.

All nominations and applications should be sent by email to the NZMS President, Prof Shaun Hendy (s.hendy@auckland.ac.nz) by 31 August 2020. Submissions should state clearly that they are for the NZMS Early Career Award, and should follow the guidelines at http://nzmathsoc.org.nz/?awards.

2020 NZMS Research Award

This annual Award was instituted in 1990 to foster mathematical research in New Zealand and to recognise excellence in research carried out by mathematicians in New Zealand. This Award is based on mathematical research published in the last five calendar years (2015-2019). This could include research published in books, journals, other peer-reviewed venues, or other types of high quality mathematical research. This assessment period may be adjusted to take into account an interrupted career pattern. Candidates may contact the NZMS President in confidence for clarification of how the adjustment of time period applies to the their particular circumstances.

Eligibility. To be eligible for the Award, a candidate must be a current member of the NZMS and must have been a resident of New Zealand for the last three years.

Nominations and applications should be sent by email to the NZMS President, Prof Shaun Hendy (s.hendy@auckland.ac.nz) by 31 August 2020. Submissions should state clearly that they are for the NZMS Research Award, and should follow the guidelines at http://nzmathsoc.org.nz/?awards.

2020 Kalman Prize for Best Paper

The Kalman Prize for Best Paper was instituted in 2016 to recognise excellence in research carried out by New Zealand mathematicians. The Prize will normally be awarded annually for an outstanding and innovative piece of research in the mathematical sciences published by a member or members of the NZMS. The Prize is for a single publication of original research, which may be an article, monograph or book, having appeared within the last 5 calendar years: 2014-2018. The value of the Prize is $5000. The Prize is generously funded by the Margaret and John Kalman Charitable Trust, and recognises the significant contributions to mathematics in New Zealand made by Professor John Kalman.

Eligibility. A publication may be nominated for the Prize by any member of the NZMS who is not an author of that publication. To be eligible, the nominated publication must have at least one author who: (i) is a current member of the NZMS, and was a member in the calendar year of publication of the nominated work; and (ii) is a resident of New Zealand, and was a resident of New Zealand at the time when the research was carried out.

Nominations should be sent by email to the NZMS President, Prof Shaun Hendy (s.hendy@auckland.ac.nz) by 31 August 2020. Submissions should state clearly that they are for the Kalman Prize for Best Paper, and should follow the guidelines at http://nzmathsoc.org.nz/?awards.

Fellowships of the NZMS

The New Zealand Mathematical Society, like many other societies, has an accreditation scheme. In particular, members may be recognised with the award of Fellowship of the NZMS. The NZMS encourages members to consider applying, and additionally, encourages members to nominate colleagues who meet the criteria. The complete criteria follow, all three of which are to be satisfied.

- Shall normally have been a Member of the NZMS for a period in excess of three years.
- Shall have had the qualifications of an Accredited Member for a period in excess of three years (i.e. have completed a postgraduate degree in mathematics at a recognised university or other tertiary institution, or shall have equivalent qualifications, and shall have been employed for the preceding three years in a position requiring the development, application or teaching of mathematics.)
- Shall have satisfied criteria (3.1 or 3.2 or 3.3 or 3.4) and 3.5:
  - 3.1. have made a substantial and sustained contribution to the mathematical sciences;
  - 3.2. have made a substantial and sustained contribution to the profession of mathematical scientist;
  - 3.3. have made a substantial and sustained contribution to the teaching and learning of the mathematical sciences;
  - 3.4. have made a substantial and sustained contribution to the application of the mathematical sciences;
  - 3.5. have made a substantial and sustained contribution to the New Zealand mathematics community.

Members' applications are encouraged before 1 June 2020.

Next deadline for applications for Financial Assistance — 15 May (for travel commencing after June 15, 2020)

The NZ Mathematical Society has quarterly deadlines for financial assistance applications. Applications must be made well in advance (at least one month before the funded activity, but the earlier the better) and retrospective applications will not be considered. The deadlines for applications for 2020 are: 15 February, 15 May, 15 August, and 15 November. You will hear back from the Council within a month of the deadline. The types of grants are as follows.

NZMS Student Travel Grants

The NZMS invites applications from students for financial support for the presentation of research at conferences, attending workshops, and developing new collaborations. Typical grants for travel within NZ and Australia are in the range $200–$600. For travel further overseas, larger grants may be considered. To be eligible, a student must be based at an institution in New Zealand and be active within the New Zealand mathematical community. NZMS Student Travel Grants can contribute to costs including: flights, conference registration, accommodation, and travel-related costs associated with family responsibilities.

NZMS Student Travel Grants are generously supported by an annual grant from the Margaret and John Kalman Charitable Trust .

NZMS Financial Assistance

The NZMS invites applications for financial assistance with the costs of mathematical research-related activity. Any research-related activity will be considered. For example: hosting mathematical visitors; organising conferences, workshops, or outreach activities; and conference attendance, including costs associated with family responsibilities.

Further information and application details can be found on the NZMS website: http://nzmathsoc.org.nz/?assistance.

SIAM Books

Foundations of Applied Mathematics
Volume 2: Algorithms, Approximation, Optimization
Jeffrey Humpherys and Tyler J. Jarvis

Geared toward advanced undergraduate and beginning graduate students in mathematics, data science, and machine learning, this textbook presents the foundations of algorithms, approximation, and optimization—essential topics in modern applied and computational mathematics. The authors provide a unified treatment of several topics that do not usually appear together, and when used in concert with the free supplemental lab materials, this book teaches not only the theory but also the computational practice of modern mathematical methods.

2020 • xviii + 788 pages • Hardcover • 978-1-611976-05-2
List $94.00 • SIAM Member $65.80 • OT166

Solving Problems in Multiply Connected Domains
Darren Crowdy

This one-of-a-kind book describes a novel mathematical framework for solving problems in two-dimensional, multiply connected regions. The framework is built on a central theoretical concept: the prime function, whose significance for the applied sciences, especially for solving problems in multiply connected domains, has been missed until recent work by the author. It is the first monograph to focus on solving applied problems in multiply connected domains.

April 2020 • xxii + 434 pages • Softcover • 978-1-611976-14-4
List $89.00 • SIAM Member $62.30 • CB97

Interpolatory Methods for Model Reduction
Athanasios C. Antoulas, Christopher Beattie, and Serkan Güğercin

Interpolatory methods are among the most widely used model reduction techniques, used to replace large systems of coupled differential and algebraic equations that constitute high fidelity system models with substantially fewer equations that are crafted to control the loss of fidelity that order reduction may induce in the system response. This textbook is the first comprehensive analysis of this approach available in a single, extensive resource. It introduces state-of-the-art methods and covers both classical projection frameworks for model reduction and data-driven, nonintrusive frameworks.

2020 • xii + 232 pages • Softcover • 978-1-611976-07-6
List $79.00 • SIAM Member $55.30 • CS21

Complex Variables and Analytic Functions
An Illustrated Introduction
Bengt Fornberg and Cécile Piret

This is the first primary introductory textbook on complex variables and analytic functions to make extensive use of functional illustrations. Aiming to reach undergraduate students entering the world of complex variables and analytic functions, the authors utilize graphics to visually build on familiar cases and illustrate how these same functions extend beyond the real axis. The book covers several important topics that are omitted in nearly all recent texts, including techniques for analytic continuation and discussions of elliptic functions and of Wiener–Hopf methods. It presents current advances in research, highlighting the subject's active and fascinating frontier.

2019 • x + 361 pages • Softcover • 978-1-611975-97-0
List $84.00 • SIAM Member $58.80 • OT165

Handbook of Writing for the Mathematical Sciences
Third Edition
Nicholas J. Higham

Handbook of Writing for the Mathematical Sciences provides advice on all aspects of scientific writing, with a particular focus on writing mathematics. Its readable style and handy format, coupled with an extensive bibliography and comprehensive index, make it useful for everyone from undergraduates to seasoned professionals. This third edition revises, updates, and expands the best-selling second edition to reflect modern writing and publishing practices and builds on the author's extensive experience in writing and speaking about mathematics.

2019 • xxii + 353 pages • Softcover • 978-1-611976-09-0
List $69.00 • SIAM Member $48.30 • Student $34.50 • OT167

Approximation Theory and Approximation Practice
Extended Edition
Lloyd N. Trefethen

This is a textbook on classical polynomial and rational approximation theory for the twenty-first century. Aimed at advanced undergraduates and graduate students across all of applied mathematics, it uses MATLAB to teach the field's most important ideas and results. It differs fundamentally from other works on the topic in that its emphasis is on topics close to numerical algorithms; concepts are illustrated with Chebfun; and each chapter is a PUBLISHable MATLAB M-file, available online.

2019 • xii + 363 pages • Hardcover • 978-1-611975-93-2
List $64.00 • SIAM Member $44.80 • OT164

An Introduction to Compressed Sensing
M. Vidyasagar

Compressed sensing is a relatively recent area of research that has applications to signal/image processing and computer algorithms, and it draws from a variety of mathematical techniques such as graph theory, probability theory, linear algebra, and optimization. The author presents significant concepts never before discussed as well as new advances in the theory, providing an in-depth initiation to the field of compressed sensing. The text contains substantial material on graph theory and the design of binary measurement matrices, is the only book to thoroughly study the problem of matrix recovery, and supplies relevant results alongside their proofs in a compact and streamlined presentation that is easy to navigate.

2019 • xii + 341 pages • Softcover • 978-1-611976-11-3
List $89.00 • SIAM Member $62.30 • CS22

Theory and Numerical Approximations of Fractional Integrals and Derivatives
Changpin Li and Min Cai

Fractional calculus has gained momentum in industry and academia, and this monograph is the first to include both fundamental information on fractional calculus and a detailed treatment of existing numerical approximations. It presents an inclusive review of fractional calculus in terms of theory and numerical methods and systematically examines almost all existing numerical approximations for fractional integrals and derivatives. The authors consider the relationship between the fractional Laplacian and the Riesz derivative, a key component absent from other related texts, and highlight recent developments, including their own research and results.

2019 • xiv + 312 pages • Softcover • 978-1-611975-87-1
List $89.00 • SIAM Member $62.30 • OT163

Order online at *bookstore.siam.org*

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