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The Australian Mathematical Society

Gazette

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- Reviews of books, particularly by Australian authors, or books of wide interest
- Classroom notes on presenting mathematics in an elegant way
- Items relevant to mathematics education
- Letters on relevant topical issues
- Information on conferences, particularly those held in Australasia and the region
- Information on recent major mathematical achievements
- Reports on the business and activities of the Society
- Staff changes and visitors in mathematics departments
- News of members of the Australian Mathematical Society

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Please send contributions to gazette@austms.org.au. Submissions should be fairly short, easy to read and of interest to a wide range of readers.

Please typeset technical articles using \LaTeX or variants. In exceptional cases other editable electronic formats such as plain text or Word may be accepted. Please do not use definitions in your \TeX files, as they may conflict with our style files. If you find such definitions convenient, please use a text editor to reinstate the standard commands before sending your submission.

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More information can be obtained from the *Gazette* website.

Deadlines for submissions to 45(2), 45(3) and 45(4) of the *Gazette* are 1 April 2018, 1 June 2018 and 1 August 2018.

- 2 Editorial
David Yost
- 4 President's Column
Kate Smith-Miles
- 7 Puzzle Corner 51
Peter M. Higgins
- 9 Talking Teaching
Edited by Birgit Loch and Sid Morris
- 12 Australia Day Honours
- 13 Australian Mathematical Society Medal 2017
- 15 ANZIAM Medals
- 20 The 2016 Mahony–Neumann–Room Prize
- 21 The 2017 Mahony–Neumann–Room Prize
- 22 The B. H. Neumann Prize, 2017
Katherine Seaton
- 24 End-periodic K -homology
Michael Hallam
- 27 First Annual Debate of the Australian Mathematical Society
- 29 13th Engineering Mathematics and Applications Conference 2017
Richard Clarke and Alys Clark
- 31 Obituary: Malcolm Hood
Neville Fowkes and Cheryl E. Praeger
- 35 Obituary: Alwyn Francis ('Horrie') Horadam
Professor Kathy Horadam
- 39 Book Reviews
Undergraduate Convexity: Problems and Solutions
by Mikkel Slot Nielsen and Victor Ulrich Rohde
Reviewed by Guillermo Pineda-Villavicencio
Creating Symmetry: The Artful Mathematics of Wallpaper Patterns
by Frank A. Farris
Reviewed by Katherine Seaton
- 43 Mathematical Research Institute MATRIX
Jan de Gier
- 47 WIMSIG News
Kimberly Becker
- 49 News
- 61 AustMS



Editorial

Sid and I welcome you to the first edition of the *Gazette* for the new year.

Several weeks into the semester now, and many of us will have noticed the diminishing number of students in our classrooms. The evolution of teaching methods to deal with this phenomenon will be an issue for discussion well into the future. For some helpful thoughts on how to implement online and blended learning in mathematics, see the Talking Teaching article by Birgit Loch in this issue. On the other hand, the role of the (black)board is not to be forgotten; at least this seems to be the conclusion of the Society's first debate held at the Annual Meeting at Macquarie University in December. A summary of this debate is given by Sid in a separate article here. The Society will be taking a greater interest in these issues, with the decision to establish a new position of Vice-President (Learning and Teaching) and two annual Teaching Excellence Awards.

The debate is a new feature of AustMS meetings, and may provide an additional attraction. In general, we go to conferences of all sorts for a variety of reasons: to meet and collaborate with other participants; to be inspired by the speakers; to learn of new developments; to advertise our own work. Another interesting perspective is given by Kim Becker in her report from the WIMSIG conference in September. Needless to say, we want to feel safe; in her President's column Kate Smith-Miles notes concerns about sexual harassment at some statistics conferences, and the role the soon to be established Equity, Diversity and Inclusion Committee can play regarding this important issue. Amongst other topics, Kate also gives a link to an interesting talk about the process of ARC grants.

Another area of our profession undergoing significant evolution is publication. Traditional publishers claim to add value to scholarly articles, by coordinating reviews and enhancing their presentation. A recent article in *International Journal on Digital Libraries* <https://doi.org/10.1007/s00799-018-0234-1> initiates an analysis of how much effect they really have. Recent years have seen the rise of open access journals: some of these are excellent, but many can most politely be described as predatory. With a strong push from many quarters for open access publishing, e.g. <https://www.wikitribune.com/story/2018/01/08/europe/germany/german-scholars-seek-open-access-in-academic-papers-deal/33444/> we do not want to concede more influence to the latter group.

Four Australians with a mathematics background were honoured in the recent Australia Day awards. We report their citations in a short article. We also report on honours awarded by the Society at recent conferences; this includes both research awards and student prizes. A new award is the Mahony–Neumann–Room Prize for outstanding publications in the Society's journals; we give details of the 2016 and 2017 prizes.

Obituaries of Malcom Hood of UWA and Horrie Horadam from UNE give an account of their lifetime achievements.

Amongst our regular features are a conference report, two book reviews, the Puzzle and the News articles.

We hope that you find plenty of food for thought here.

David Yost, Centre for Informatics and Applied Optimisation, Faculty of Science and Technology, Federation University Australia, Ballarat, VIC 3353.

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David Yost is a graduate of the University of Melbourne, the Australian National University and the University of Edinburgh. He has lived in eight countries and ten cities, returning to Australia in 2003, where he has now completed 14 years at Federation University Australia and its predecessor institution, the University of Ballarat, including a three-year period as Deputy Head of School. While most of his research is in functional analysis, he has lately been interested in convex geometry.



President's Column

Kate Smith-Miles*

My last column was penned just before the AustMS annual meeting at Macquarie University in December. Congratulations to Paul Smith and Xuan Duong and their team for organizing such an enjoyable event. Besides the great plenary talks, a wonderful conference dinner, and many fascinating contributed talks from academics and students, for me the highlight was the inaugural annual debate, chaired wonderfully by Adam Spencer, on the topic 'The traditional mathematics blackboard lecture is dead!' Both teams presented humorous and engaging arguments, and it was a fun way to spend the lunch hour. Many thanks to the affirmative team (Birgit Loch, Marty Ross and Dan Mathews) and the negative team (John Roberts, Adrienne Jenner, and Heather Lonsdale) for all of their tremendous efforts coordinating and preparing their arguments and performance for our entertainment. In the end, the audience was unanimous in their support for the negative team, and I think we will continue to see mathematicians arguing with university management for blackboard lecture theatres to be retained for many decades to come! Preparations are underway already for the next debate at the annual meeting in Adelaide in December 2018. Unless I hear a better suggestion, we are likely to run with the topic proposed by Federation University's David Yost: 'Mathematicians should boycott the ARC!' That should be a lively topic indeed! If anyone would like to join one of the teams, or has other debate topics we could consider, please let me know.

Moving on to matters discussed at the December AustMS Council meeting held at Macquarie that week, I'd like to update members on a number of resolutions that were passed. The first is the formal establishment of a new Equity, Diversity and Inclusion Committee, following the recommendations of the working party established last year and chaired by Aidan Sims. A call for nominations has been circulated and closed, but we are still seeking additional people to fill a few of the vacancies. Please contact the Secretary, Peter Stacey, if interested. This committee will be charged with reviewing all society practices to ensure compliance with the London Mathematical Society's Best Practice Scheme for Gender Equity, and to make recommendations to Council. Of course this is all very timely, with other issues emerging in recent times that have a gender equity dimension to them. Some of you will have seen the recent concerns raised about sexual harassment at some statistics conferences (see <https://medium.com/@kristianlum/statistics-we-have-a-problem-304638dc5de5>).

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The American Statistical Association (ASA) and the International Society for Bayesian Analysis (ISBA) have both set up task forces targeted at personal safety of conference participants, and the ISBA taskforce is led by Professor Kerrie Mengersen (QUT). The issue was also discussed at the recent ANZIAM conference in Hobart in February, and a working party has formed to draft a Code of Conduct for ANZIAM events. We expect that these various task forces will be working quickly, and that ultimately there will be a common Code of Conduct and set of policies that all societies in the mathematical sciences may jointly adopt. Certainly, AustMS and AMSI have a duty to ensure that any conferences we support are safe for all participants. Our newly established Equity, Diversity and Inclusion Committee will be reviewing our practices around this important issue, including developing statements about codes of conduct for professional behavior at conferences and policies about repercussions from breaches of such a code of conduct. While I have not heard of anything like this affecting AustMS events, it is important that we have policies that protect all conference participants so we can ensure the events are about the mathematics, and are inclusive and supportive for all who wish to attend. Please contact me if there are concerns you would like to discuss in confidence on this matter.

Another significant resolution passed by Council at the December meeting was the establishment of a new Vice-President (Learning and Teaching) position. A call for expressions of interest has now passed and the Nominations and Publications Committee (which Council also resolved to augment) will be considering the nominations shortly. This new position will be very important for AustMS moving forward, and gives appropriate recognition for the fact that high quality teaching of mathematics is a concern for many members of the society, and there is no doubt more the society can be offering by way of support for this important endeavor. Related to this, Council also resolved to establish two annual Teaching Excellence Awards, each of \$1,000, one of which is to be restricted to early career teachers including sessional teachers and PhD students. Details will be circulated by email to members when guidelines have been established.

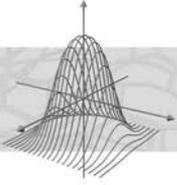
Of course there were many other decisions made by Council as well, including approval of over \$140,000 expenditure on conference support, prizes, and travel grants, as well as sponsorship of the International Mathematical Olympiad team, etc. A full summary of decisions made by council was reported at the AGM, and details can be seen in the AGM minutes.

So that was a busy week at Macquarie University in December, and after a couple of weeks of relaxation, I'm sure that everyone is back to the usual summer routine of preparing grant proposals, revising lecture notes, and attending more conferences.

To assist with the ARC grant writing, I'd like to share a video recorded during a presentation I gave at QUT in January, offering some tips based on my experience on the ARC College of Experts (<https://youtu.be/uhOqwJqQdhM>). I hope you find it useful, and I look forward to reading some outstanding proposals again this year!



Kate Smith-Miles is a Georgina Sweet Australian Laureate Fellow, and Professor of Applied Mathematics at The University of Melbourne. She is also a Chief Investigator in the ARC Centre of Excellence in Mathematical and Statistical Frontiers (ACEMS). She was previously Head of the School of Mathematical Sciences at Monash from 2009–2014, and Head of Engineering and IT at Deakin from 2006–2009. Kate is a member of the ARC College of Experts, Chair of the Advisory Board for the AMSI CHOOSEMATHS program, serves on the MATRIX Advisory Board, and is a member of the Federal Government's Knowledge Nation 100 group. She is a Fellow of the Australian Mathematical Society, and Fellow of Engineers Australia. She was awarded the Australian Mathematical Society Medal in 2010 and the EO Tuck Medal from ANZIAM in 2017.



Puzzle Corner

Peter M. Higgins*

Welcome to Puzzle Corner 51 of the *Gazette* of the Australian Mathematical Society. I will start with a *Triangle Teaser* and then include the solution of Puzzle Corner 50, *Cycles in Squares*, from the November issue of the *Gazette*.

One of the earliest mathematical facts linking algebra with geometry was the discovery of the ancient Egyptians and Sumerians that the $(3, 4, 5)$ triangle has a right angle. This famous trigon provides the first illustration of Pythagoras's theorem that we meet as school students. The next example in line is often the $(6, 8, 10)$ triangle as certainly $6^2 + 8^2 = 10^2$. We soon learn however that this is not a truly new example for all we have done is taken the basic $(3, 4, 5)$ triangle and doubled all its lengths, resulting in a similar triangle. The change is only a matter of scale but not shape. We then observe that in general if (a, b, c) is a *Pythagorean triple*, meaning that a, b , and c are integer lengths with $a^2 + b^2 = c^2$, then the same holds for the triple (ka, kb, kc) for any positive integer k . For this reason, when reading the solution in any algebra text to the classical problem of finding all Pythagorean triples, the task is reduced at the outset to that of finding all the *coprime* Pythagorean triples (a, b, c) , by which is meant triples in which the three integers a, b and c have no common factor apart from 1.

However, the $(6, 8, 10)$ triangle T is yet deserving of respect for it has a special property that its smaller parent lacks. The perimeter of T , $6 + 8 + 10$, is equal to its area $\frac{1}{2}(6)(8)$. This is the basis of the first of today's two related problems:

1. Find all triangles T with sides of integer lengths for which the perimeter and area are equal in numerical value.

Of course the question does not say the triangles need to have a right angle and indeed it transpires that there are exactly four solutions in addition to the one given above, only one of which is also right-angled.

The second question is a generalisation that is not difficult once you have solved the first.

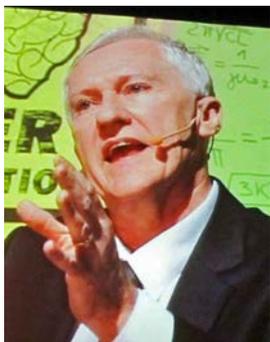
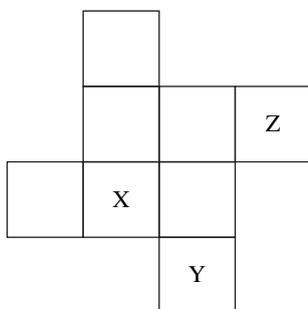
2. How many triangles have integer sides with the perimeter P and area A satisfying $P = kA$, for some integer k ?

This pair of questions was relayed to me by Dr James East of Western Sydney University. In his paper 'Integer polygons of given perimeter', (joint with Ron Niles, <https://arxiv.org/abs/1710.11245>), the problem is attributed to Whitworth and Biddle (1904).

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Solution to Puzzle Corner 50

Consider that 8-square board below, start at the square marked X and apply the word *LURD* (reading from left to right) repeatedly. We discover that we then move in a 3-cycle: $X \mapsto Y \mapsto Z \mapsto X$. This looks very odd indeed — the symmetry suggests that if a cycle emerged, it would have length dividing 4, or at least be some power of 2, but no, it's a 3.



Peter Higgins is a Professor of Mathematics at the University of Essex. He is the inventor of Circular Sudoku, a puzzle type that has featured in many newspapers, magazines, books, and computer games all over the world. He has written extensively on the subject of mathematics and won the 2013 Premio Peano Prize in Turin for the best book published about mathematics in Italian in 2012. Originally from Australia, Peter has lived in Colchester, England with his wife and four children since 1990.



Talking Teaching

Edited by Birgit Loch* and Sid Morris**

The opinions expressed here are those of the author and not necessarily of the Editors of this column or the Editors of the Gazette or the Australian Mathematical Society.

When I was thinking about what to write for this column, I came up with a list of topics that have been on my mind for the last few months. One is ‘ghost students’: the invisible and intangible cohort of students who are enrolled at the start of semester, and still at the end of semester, they don’t turn up for classes and don’t sit exams. There are reports that they have been sighted, however not in the online space where tracked log-ins indicate no access to the LMS that holds study material and assessment information.

These reports of potential sightings are therefore unconfirmed. They receive a grade of DNA, NA, or similar — whatever it may be at your university. They have not attempted anything, which is why we may question their existence. We would really like to unenrol them in some way, to prevent them from affecting our success rate. But we can’t. This topic I plan to discuss in a later column. In the meantime, I would be very interested in thoughts from others as to how they deal with the ghostly cohort. How does one catch a ghost and make it materialize? Is this an impossible task?

Another topic I’ve been thinking about extends Sid’s previous column. Sid highlighted how he would approach teaching of third- and fourth-year students majoring in mathematics. He suggested reducing lecture time and introducing shorter videos, and placing emphasis on a (free) textbook as a study resource, possibly supplemented by printed or online notes. I will move this discussion on towards implementing blended learning for students not majoring in mathematics; in this particular example second year engineering students.

Let me give an overview of an approach I took a few years ago at a previous university. The university had made it a mandate that 50% of teaching was to be delivered online. I’m sure this sounds familiar to many readers of the *Gazette*. No clear definition of ‘online learning’ was provided, instead ‘blended learning’ was used quite a bit as the way to go ahead.

Blended learning encountered concerns from a range of disciplines. Mathematics was one of them, particularly given the large cohort of engineering students who were service-taught (and often under-prepared and/or under-motivated), and

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the feeling that face-to-face learning benefits students more in mathematics than blended learning with an online component.

To investigate what blended learning could look like in mathematics I started a research project with the Faculty's Educational Designer, Rosy Borland, and my co-lecturer, Nadia Sukhorukova. The outcome was to be the redevelopment of a second-year engineering mathematics subject into blended mode.

I feel I should give my definition of blended learning at this point. Blended learning is the careful alignment of online and face-to-face learning, where the two components complement each other, benefitting from the best each has to offer. Moving to blended learning is also an opportunity to rethink your approach and better target it to your audience.

Aligned with this statement, we approached the redevelopment in a different way from how blended learning is often implemented. We looked at what worked and what didn't work in the subject, what we liked about it and what we didn't, and what we really wanted to improve. Of course there were limitations to what we could change, as our aim was not to update the curriculum, just its delivery.

A main consideration was to create a subject that was not employing 'pet ideas' one may find in the literature which are so labour intensive or benefiting certain individual teaching styles that they will not survive a change of lecturer. We wanted to make sure it was flexible enough so that any lecturer could pick it up to teach, no matter how comfortable they were with technology or how student-centred their approach was in the classroom. It wasn't until we had composed this list of requirements, that we started to think about where technology could be used to help us achieve our goals.

In addition, we also involved our students who had just completed the subject. We asked for volunteers to participate in a focus group, which gave us the opportunity to bounce off some of our ideas. We learnt that their understanding of online learning was limited to watching videos with no interaction. It appeared that they had no idea what blended learning can offer. We learnt from this that we needed to explain to the students why we were teaching in blended mode, and what exactly we wanted them to do online, and offline.

I will not give details here on how we implemented our ideas, apart from that we put a lot of effort into providing very clear navigation of material on the LMS, arranged by week, and with guidance as to what needed to be done by when. While helpful to students, this also meant that we as the lecturers had to think about how all online and face-to-face activities were aligned so they complemented each other.

What I believe was particularly effective was our communication with the students to explain to them why we were teaching in blended mode, that we had listened to student feedback, and that this had not been a cost cutting exercise. In response, the student feedback on the subject included comments that blended learning had been the best aspect of the subject.

The above is a brief overview of our approach to implementing blended learning in second year engineering mathematics. My two collaborators Rosy, Nadia and I are planning to write a classroom notes article in the *Gazette* to describe in more detail how we went about blending the subject and what our outcomes have been. I would love to hear how others have approached blended learning implementation in mathematics.



Birgit Loch has taught first and second year mathematics mostly to service students at four universities, in traditional, blended as well as online modes for the last 14 years. She has won numerous teaching awards for her use of technologies to engage students, and for convincing her colleagues to reconsider their practice. Her research interests are in technology approaches to teaching mathematics and supporting students in the learning of mathematics, including learning from video, blended learning, and teaching with tablet technology. She has held leadership roles in learning and teaching at three universities. She is currently the Teaching Chair in the College of Science, Health and Engineering at La Trobe University.



Communications

Australia Day Honours

Three Australian Mathematicians received honours in the 2018 Australia Day awards.

Professor Trevor John McDougall AC

Trevor McDougall, from the University of New South Wales, has been made a Companion of the Order of Australia for eminent service to science, and to education, particularly in the area of ocean thermodynamics, as an academic, and researcher, to furthering the understanding of climate science, and as a mentor of young scientists.

Emeritus Professor Michael Newton Barber AO

Michael Barber has been made an Officer of the Order of Australia for distinguished service to higher education administration, and in the field of mathematical physics, particularly statistical mechanics, as an academic and researcher, and through contributions to science policy reform.

Dr David Christopher Hunt OAM

David Hunt, from the University of New South Wales, was awarded the Medal of the Order of Australia for service to education, and to mathematics.

In addition, another recipient of the highest honour in the Australia Day awards has a background in mathematics.

Professor Rhys Jones AC

Rhys Jones, Emeritus Professor of Engineering at Monash University, completed a PhD in applied mathematics at the University of Adelaide, supervised by Professor Jagannath Mazumdar, and was the inaugural recipient of ANZIAM's Thomas Cherry Prize. He has been made a Companion of the Order of Australia for eminent service to mechanical and aerospace engineering, and to education as an academic, researcher and author, particularly in the area of aircraft structural mechanics, corrosion repair and airworthiness.

Our congratulations to all four of them!

Australian Mathematical Society Medal 2017

The Australian Mathematical Society Medal is awarded to a member of the Society under the age of 40 years for distinguished research in the mathematical sciences. A significant portion of the research work should have been carried out in Australia.

In 2017 the Australian Mathematical Society Medal was shared by Dr Richard Garner and Dr Anthony Licata. Below are the citations for each of the Medal winners.

Citation for Richard Garner

Richard Garner, a Senior Lecturer and ARC Future Fellow in the Department of Mathematics at Macquarie University, is a category theorist whose research also has applications in logic, topology and theoretical computer science. He is acknowledged as the world-leading expert on the branch of logic known as intensional type theory, and has uncovered important connections between this and other areas of mathematics such as axiomatic homotopy theory and higher-dimensional category theory. His 2015 paper ‘On combinatorial structure of type dependency’ has proved to be foundational for the emerging area of dependent type theories.

As a researcher, Richard is both prolific and highly creative: it has been said that every one of his papers opens up a new point of view. One particularly influential contribution is an improvement to Quillen’s classical concept of a model category. The original definition, although widely used by topologists and others, relied on an unsatisfactory ad hoc construction. In his paper ‘Understanding the small object argument’, Richard modified this construction so that it satisfied a universal property, and thus initiated the study of what are now called algebraic model categories. Apart from research, Richard is highly respected for his energetic contributions to his university and the broader discipline.

Citation for Anthony Licata

Anthony (Tony) Licata, a Senior Lecturer in the Mathematics Sciences Institute, ANU, has a research profile that has been described as ‘impressively broad’. His main interests are geometric representation theory and categorification, and their applications to low-dimensional topology, symplectic geometry and algebraic combinatorics. His ability to make connections between disparate fields has enabled him both to solve outstanding problems and to open new research directions. One highly influential discovery relates to the link invariants arising from the representation theory of quantum $\mathfrak{sl}(n)$. These invariants have categorifications due to Khovanov, whose representation theoretic meaning was first explained in Tony’s joint work with Cautis and Kamnitzer, published in *Inventiones*, in which they introduced what is now called ‘geometric skew Howe duality’. A second highlight of Tony’s research achievements is his joint work with Cautis on the categorification

of the Heisenberg algebra, which they have recently extended to affine Lie algebras and vertex algebras, opening up the possibility of applications to conformal field theory. Another of Tony's discoveries, with strong connections to theoretical physics, is the concept of 'symplectic duality', which he has developed in a large joint project with Braden, Proudfoot and Webster, culminating in an entire volume of the journal *Asterisque*. Tony has been described as 'a model mathematician', one who enthusiastically shares his ideas and participates in collaborative teams working towards truly ambitious projects.

ANZIAM Medals

ANZIAM Medal

Citation for Phil Howlett

Professor Phil Howlett has made sustained and outstanding contributions to both the theory and applications of mathematics, particularly in the development of control theoretic methods in the transport industry. In addition, he has been an effective and passionate advocate of ANZIAM over a long period and has held a number of key positions including ANZIAM Chair, Director of the Mathematics in Industry Study Group (MISG) and chair of the ANZIAM Student Support Scheme. Also, he has trained and mentored a cadre of young capable applied mathematicians who are terrific ambassadors, both in industry and the research community, worldwide, for the kind of mathematical thinking that embodies the spirit of ANZIAM.



Phil Howlett (right) receives his award from Frank de Hoog.

The ANZIAM Medal is our society's most prestigious medal and recognises research achievement, wide-ranging activities enhancing the discipline of applied and industrial mathematics, and contributions to ANZIAM. Phil's outstanding contributions in these three areas make him a most worthy recipient of the ANZIAM medal.

Contributions to Applied and Industrial Mathematics Research

Phil graduated with honours in Mathematics from the University of Adelaide in 1965 and then obtained a position as tutor with the South Australian Institute of Technology (SAIT — now University of South Australia). While a tutor, Phil embarked on research on approximation theory under the supervision of Jim Michael at the University of Adelaide and was awarded a PhD in 1971. In 1979 he was a Visiting Fellow at the Control Theory Centre at the University of Warwick where

he worked on his initial publication on control theory. This was the first of his many contributions to this area.

In 1982, Ian Milroy formed the Transport Control Group at the SAIT and Phil developed rigorous mathematical justification for the heuristic strategies used by Metromiser, the control system for short journeys that had been developed by the group. At the same time he produced the first theoretical confirmation that speed-holding should be used if the journey time is relatively large. This work had immediate impact for future work on long-haul strategies by the group. In 1990 the Transport Control Group was renamed the Scheduling and Control Group. Phil led this Group from 1992–2011. Under Phil’s leadership, and by virtue of his long-standing collaboration with Peter Pudney, the achievements of this group include:

- development of a complete mathematical theory for the calculation of optimal train-driving strategies for trains under discrete control
- major contributions to the theory of optimal train-driving strategies under continuous control
- development of a mathematical theory for optimal driving strategies for solar-powered racing cars
- development of rail technology software Freightmiser and Energymiser in collaboration with rail industries.

In addition to national competitive grant awards, the work by the Scheduling and Control Group has been recognised by the following awards:

- control strategy team for Aurora 101 — winner World Solar Challenge (1999)
- winner, Australia Technology Award, Technology Development from the Government Sector, University of South Australia with Siemens and ICT for Development of Metromiser Technology (2000)
- winner, Australasian Railway Association Rail Industry Awards for Excellence; for the Freightmiser Program for TMG International (2004)
- TTG Transportation Technology — National Export Award: Environmental Solutions Category (2014)
- TTG Transportation Technology — Supplier Export Achievement Award: Australasian Railway Association (2015)
- TTG Transportation Technology — Innovation & Technology Achievement Award: Australasian Railway Association (2015)
- Australian Society for Operations Research: Ren Potts medal for outstanding contributions to OR in Australia (2015)
- Société Nationale des Chemins de fer Français (SNCF): winner ‘Enterprise of the Year’, awarded by Directors of Energy Departments in France, for deployment of the Energymiser[®] (Opti-conduite) train driver advice system (DAS) as a smart phone app for 2000 TGV train drivers in France. The DAS software was developed by the Scheduling and Control Group in collaboration with TTG Transportation Technology during 1994–2017 and has been deployed around the world (2017).

In addition to his work associated with control theory, Phil has also made important contributions to the following areas:

- theoretical analysis of the fundamental equations for the inversion of matrix and operator pencils in collaboration with various colleagues including Amie Albrecht, Konstantin Avrachenkov, Jerzy Filar and Charles Pearce
- water storage and rainfall modelling in collaboration with various colleagues including Jonathan Borwein, Charles Pearce and Julia Piantadosi
- operator approximation and estimation of random signals in collaboration with Anatoli Torokhti and Charles Pearce.

Contributions to Applied and Industrial Mathematics

Phil is an outstanding supporter of mathematics in general and applied and industrial mathematics in particular. He has successfully supervised 14 PhD scholars, participated in numerous direct interactions with industry and facilitated industrial problem-solving through the University of South Australia and the Mathematics in Industry Study Group. A partial list of the leadership positions is:

- 1994–2003: Assistant Editor, Proceedings of the Australian Mathematics in Industry Study Group
- 1998–2004: Director, Centre for Industrial and Applied Mathematics, University of South Australia
- 2000–2002: Director, Australian Mathematics in Industry Study Group
- 2003: Deputy Director, Australian Mathematics in Industry Study Group.

Contributions to ANZIAM

Phil has been and continues to be a passionate advocate for ANZIAM and has devoted a considerable amount of energy and time in contributing to its success. His contributions include:

- 1998–1999, 2006–2007: Executive Committee Member, ANZIAM
- 2007, 2010: Deputy Chair, ANZIAM
- 2008–2009: Chair, ANZIAM
- 2010–2018: Chair CSIRO/ANZIAM Student Support Scheme.

The ANZIAM Medal selection panel unanimously recommends that Professor Phil Howlett be awarded the ANZIAM Medal for 2018.

On behalf of ANZIAM:

Frank de Hoog (CSIRO)

Kerry Landman (University of Melbourne)

Robert McKibbin (Massey University)

The E.O. Tuck Medal

In honour of the late Ernest Oliver Tuck, FAustMS, FTSE and FAA, ANZIAM has instituted a mid-career award for outstanding research and distinguished service to the field of Applied Mathematics.

Citation for Yvonne Marie Stokes

Professor Yvonne Stokes, from the University of Adelaide, is an exceptionally gifted applied mathematician who has made fundamental contributions to industrial and applied mathematics.



Peter Taylor and Yvonne Stokes.

Yvonne's research is focussed on two main areas: viscous fluid mechanics and mathematical biology. The former topic has been the subject of her work since her PhD, which she received in April 1999. Her collaboration with the Institute of Photonics and Advanced Sensing on the modelling of the fabrication of micro-structured optical fibres has been truly world-leading. This is evidenced by a US Patent together with a series of papers of stunning originality. Yvonne has developed a strong research record in suspension flows, focusing on curved geometries. Simultaneously she has applied her considerable abilities to various biological problems including the simulation of the growth of plant roots and the calcium signalling and travelling wave response to oocyte fertilisation.

Over the years, Yvonne has written a number of high-impact papers in highly-regarded journals such as the *Journal of Fluid Mechanics* and *Physics of Fluids*. Her work is well-cited. She has been very successful in obtaining Category 1 funding, having been awarded two ARC Discovery grants as lead Chief Investigator, two Linkage projects and a Future Fellowship, which runs through to 2020. Yvonne has developed and consolidated fruitful international collaborations with world-renowned researchers, such as Professor Andrea Bertozzi and Professor Darren Crowdy, which have become a central pillar in her research portfolio. She has been especially productive in the last five years with about twenty papers in top

quality journals while supervising five PhD students, four of whom have already completed. In addition in 2007 she was awarded the J.H. Michell Medal.

Yvonne has built up an outstanding service record both within her home university and the wider mathematical community.

In December 2016, she was elected Chair of the Women in Mathematical Sciences Special Interest Group (WIMSIG) of the Australian Mathematical Society, a position she took up early in 2017. This leadership role builds on a long record of outstanding leadership in the promotion of women in mathematics at high school level: highlighting of STEM opportunities for women, promoting the Marta Sved scholarship, organising of the annual Women and Mathematics workshop to promote the study of university mathematics to students in Year 12, and initiating the South Australian GEM (Girls Enjoy Maths) day under the auspices of AMSI and BHP Billiton.

In addition, Yvonne is an exceptional mentor to young mathematicians, as evidenced by the careers of former students.

Yvonne has also demonstrated exemplary service to applied and industrial mathematics. She has been a member of the Australian Academy of Sciences National Committee for Mechanical Sciences since 2012. Over 2005–2006 and 2014–2015 she served on the Executive Committee of ANZIAM and from 2015–2017 was a member of the selection committee for the J.H. Michell medal including one period as Chair. She was the Director of the ANZIAM conference held in February 2017 in Hahndorf that was a highly successful and enjoyable event. She also has been very active in the South Australian branch of ANZIAM.

In other service achievements, Yvonne has been a moderator at three Mathematics in Industry Study Groups, as well as being a valued participant over many years. Yvonne taught an extensional flows subject at the AMSI summer school at Monash in 2018.

To summarise, Yvonne is an outstanding applied mathematician known for the very high quality of her research and service. She has been recognised by the award of the Future Fellowship, her numerous grants and a steady stream of PhD graduates. She possesses an exceptional service record, including substantial work for ANZIAM and AustMS.

The selection panel unanimously recommends that Professor Yvonne Stokes be awarded the ANZIAM E.O. Tuck Medal for 2018.

On behalf of ANZIAM:

Shaun Hendy (University of Auckland)

Kerry Landman (University of Melbourne)

Peter Taylor (University of Melbourne)

The 2016 Mahony–Neumann–Room Prize

To be eligible for the 2016 Prize, the paper must have been published in the *Journal of the Australian Mathematical Society* during the period 2010–2015 (volumes 88–99).

The initial list of candidates was based on citations. Cambridge University Press provided a list of 32 papers published during the period 2010–2015 having at least three citations, which was thought by the co-editors to be a reasonable threshold to win the prize. This list naturally had a preponderance of papers from earlier years but did include papers from later years. Since the Prize is offered every three years with a six-year window, high quality papers from the last three years not meeting this threshold may be considered the next time the Journal prize is awarded. The list was circulated to the Associate Editors who were asked to nominate papers from it. A shortlist of six papers and short descriptions was made for consideration by the Prize Committee. The authors of the short-listed papers were advised by email.

The following paper was chosen from this list as the Mahoney–Neumann–Room Prize winner for 2016. Important considerations in this decision were the significance of the results and that it continued to be well cited in 2016.

M.V. Lawson, ‘A noncommutative generalization of Stone duality’, *Journal of the Australian Mathematical Society*, **88** (2010), 385–404.

Here is a brief description of the paper.

The category of boolean inverse monoids is shown to be dually equivalent to the category of boolean groupoids. This generalizes the classical Stone duality between boolean algebras and boolean spaces. As an instance of this duality, it is shown that the boolean inverse monoid C_n associated with the Cuntz groupoid G_n is the strong orthogonal completion of the polycyclic (or Cuntz) monoid P_n . The group of units of C_n is the Thompson group $V_{n,1}$.

The recommendation from the Associate Editor was as follows.

Stone duality is the duality between Boolean rings and totally disconnected locally compact spaces that assigns to each Boolean ring the space of Boolean-ring homomorphisms into the 2-element Boolean ring, and assigns to each totally disconnected locally compact space the Boolean ring of locally-constant binary-valued functions on the space. Lawson’s work establishes a powerful generalisation of this for suitable inverse semigroups and groupoids. The close connection between groupoids and inverse semigroups is well-known, but Lawson’s functorial approach is new and quite powerful. Since inverse semigroups and groupoids show up in a vast variety of situations, including symbolic dynamics and coding, abstract algebra, operator algebras (particularly von Neumann algebras and C^* -algebras) his results have many potential applications.

The 2017 Mahony–Neumann–Room Prize

The 2017 Mahony–Neumann–Room Prize was awarded for the best paper published in the *Bulletin of the Australian Mathematical Society* during the period 2011–2016 (volumes 83–94). The Prize Committee comprised John Loxton (chair), George Willis and Andrew Bassom.

The initial list of candidates for the Prize came from two sources. Cambridge University Press provided a list of the most highly cited papers published during the period 2011–2016. John Loxton supplemented this with a list of papers published during the period 2014–2016 which had at least one citation and were most highly regarded by the referees. The rationale for these two approaches is that the more recent papers have not had much time to amass citations but had at least attracted some attention. Altogether, this produced a list of 29 papers.

The papers covered a wide variety of fields and styles and were not easy to compare. However, a clear pattern emerged after consultation with the Associate Editors. Criteria applied to produce the ranking included citations (modified by elimination of self-citations), quality of exposition and motivation to appeal to non-specialists, breadth of ideas or other measures of significance, and take-up of the results and techniques by others.

The 2017 Mahony–Neumann–Room Prize was awarded to **Jason P. Bell**, **Michael Coons** and **Kevin G. Hare** for their paper ‘The minimal growth of a k -regular sequence’, *Bulletin of the Australian Mathematical Society* **90**(2) (2014), 195–203.

Citation

The paper gives a lower bound for the growth of an unbounded integer-valued k -regular sequence. The ideas are applied to answer a question of Borwein, Choi and Coons on the sums of completely multiplicative automatic functions. There is a connection with a famous problem of Erdős in this area. The paper attacks a concrete and nontrivial problem and gives a very comprehensive solution, including both an asymptotic lower bound and examples to demonstrate that this estimate is best possible. The paper sheds light on important conjectures about automatic sequences. The exposition is excellent. The paper is well-cited and continues to be cited.

The B. H. Neumann Prize, 2017

Katherine Seaton*

The B.H. Neumann Prize is awarded for the most outstanding talk given by a student at the Australian Mathematical Society meeting (conference) each year. From the inception of the prize in 1985, until just a few weeks before his death aged 93 in 2002, Bernhard Neumann presented the prize himself. The number of students speaking at the conference is much greater than it was in 1985 (when a panel of four could attend all the student talks), so since 2008 honourable mentions have also been given. There is information about the criteria for the prize, together with advice to students, and a list of all past awardees to be found at: <http://www.austms.org.au/The+Bernhard+Neumann+Prize>.

The job of the B.H. Neumann Prize Committee is always pleasantly hard, due to the high standard of talks. At the 2017 conference, there were joint winners, and two honourable mentions given.

Honourable mentions:

- Becky Armstrong, University of Sydney, for a talk in the Functional Analysis special session
- Harry Crimmins, UNSW, for a talk in the Dynamical Systems and Ergodic Theory session.

The 2017 Bernard Neumann prize was awarded jointly to:

- Michael Hallam (University of Adelaide) for a talk in Category Theory, Algebraic Topology and K-Theory session, entitled ‘End-periodic K-homology and positive scalar curvature’.
- Adrienne Jenner (University of Sydney) for a Mathematical Biology talk: ‘Modelling heterogeneity in biology: how do cancer-killing viruses interact with tumour cells?’.

The Blue Hat Award

The students demanded the ‘right of reply’ and have awarded The Blue Hat Award for the best non-student talk since the 2011 meeting held at the University of Wollongong. There appear to be no advertised criteria or public records for this award, but previous winners have included Fields Medallist Manjul Bhargava. The name does not, disappointingly, refer to Bernhard’s blue bicycle helmet. Rather, on the first occasion of the award, the locals had worn identifying blue baseball caps with AustMS logo throughout the conference. On the spur of the moment, a hitherto unused blue hat became the prize, and a tradition was born. Sometimes

*Chair of the 2017 B.H. Neumann Prize Committee

the blue hat has been purchased from a \$2 shop and has featured glitter or flashing lights. The 2017 hat was a very stylish satin number, the students having access to a large shopping centre close to Macquarie University! The award was given to Professor Georgia Benkart, who was, coincidentally, the Hanna Neumann lecturer and by all reports a delighted recipient.



Left to right: Katherine Seaton, Kate Smith-Miles, Harry Crimmins, Adrienne Jenner, Michael Hallam, Becky Armstrong, Georgia Benkart

End-periodic K -homology

Michael Hallam*

Index theory is a field of mathematics which links geometry, topology and analysis. The central result in this field is the Atiyah–Singer index theorem, which for a Dirac operator D on a compact even-dimensional spin manifold M takes the form

$$\text{Ind}(D^+) = \int_M \hat{A}(M).$$

Here $\text{Ind}(D^+) = \dim \ker(D^+) - \dim \ker(D^-)$ is the *index* of the Dirac operator on M , and $\hat{A}(M)$ is the A -hat characteristic class. It is extremely difficult to solve the equation $D\psi = 0$, however it is much easier to calculate $\int_M \hat{A}(M)$ through various topological and geometric methods. Thus the power of the theorem lies in being able to deduce the existence of solutions to differential equations without ever having to solve any. For instance, if we compute $\int_M \hat{A}(M) = 2$ then we know $\dim \ker(D^+) \geq 2$, and so there are at least two linearly independent solutions to the differential equation $D^+\psi = 0$.

The Atiyah–Singer index theorem applies to compact manifolds without boundary. If one considers a compact even-dimensional spin manifold M with non-empty boundary ∂M , there is an analogous theorem called the Atiyah–Patodi–Singer index theorem [1]:

$$\text{Ind}(D^+, P_{\geq 0}) = \int_M \hat{A}(M) - \eta(D_{\partial M}).$$

Here the index is taken with respect to a certain boundary condition $P_{\geq 0}\psi = 0$, and notably there is a new correction term $\eta(D_{\partial M})$ appearing due to the boundary. This correction term is called the *eta invariant* of the Dirac operator on ∂M ; it measures the asymmetry about 0 of the (real, discrete) spectrum of $D_{\partial M}$.

The eta invariant is a highly sensitive object, depending on data such as the metric on M . However, if one twists the Dirac operator by two unitary representations $\sigma_1, \sigma_2: \pi \rightarrow U(N)$ and a map $f: M \rightarrow B\pi$, obtaining Dirac operators D_1 and D_2 on ∂M , then subtracting the eta invariants of these twisted operators yields a more robust invariant $\rho(\sigma_1, \sigma_2)(D_{\partial M})$ called the *rho invariant*. It turns out that the mod \mathbb{Z} reduction of the rho invariant is independent of the choice of Riemannian metric on M . Furthermore, it induces a well-defined map on geometric K -homology [3]:

$$\rho(\sigma_1, \sigma_2): K_1(B\pi) \rightarrow \mathbb{R}/\mathbb{Z}.$$

This elegantly encapsulates many mod \mathbb{Z} invariance properties of the rho invariant, including bordism invariance and invariance under the choice metric.

Performing analysis on non-compact manifolds is a much more difficult task, and one must impose some restrictions on the manifold in order to obtain an index

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problem which is tractable. Recently, Mrowka, Ruberman and Saveliev [4] proved an index theorem for certain non-compact manifolds called *end-periodic manifolds*. These manifolds consist of a compact piece Z , and one or more ‘ends’ which repeat themselves periodically off to infinity; see Figure 1. All objects over the periodic end (e.g. Dirac operators) are required to repeat themselves periodically.

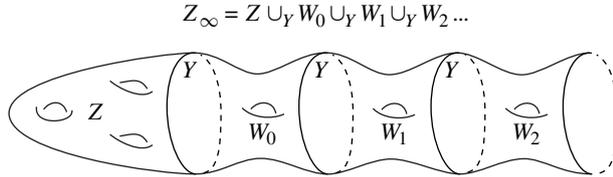


Figure 1. An end-periodic manifold with one end

In this case, the index theorem takes a similar form to the Atiyah–Patodi–Singer index theorem, including a correction term which appears for the non-compact periodic ends:

$$\text{Ind}_+(D^+) = \int_Z \hat{A}(Z) - \eta^{\text{ep}}(D_X).$$

The index is now interpreted in a regularised sense, since an elliptic operator on a non-compact manifold may not have a finite index. The term $\eta^{\text{ep}}(D_X)$ is called the *end-periodic eta invariant*, and X is a manifold which is cut open to form the repeating end pieces (the W_i in Figure 1).

In work with my supervisor Mathai [2], we develop a new analogue of K -homology $K_1^{\text{ep}}(B\pi)$ that is tailored to the setting of end-periodic manifolds. As in the Atiyah–Patodi–Singer case, one can define end-periodic rho invariants and show that they induce a well-defined map

$$\rho^{\text{ep}}(\sigma_1, \sigma_2): K_1^{\text{ep}}(B\pi) \rightarrow \mathbb{R}/\mathbb{Z}$$

on the end-periodic K -homology groups. What’s more, there is a natural isomorphism $K_1^{\text{ep}}(B\pi) \cong K_1(B\pi)$ such that the following diagram commutes:

$$\begin{array}{ccc} K_1^{\text{ep}}(B\pi) & \xleftrightarrow{\sim} & K_1(B\pi) \\ \rho^{\text{ep}}(\sigma_1, \sigma_2) \searrow & & \swarrow \rho(\sigma_1, \sigma_2) \\ & \mathbb{R}/\mathbb{Z} & \end{array}$$

The usual K -homology groups encode information on odd-dimensional manifolds, whereas the end-periodic K -homology groups contain information on even-dimensional manifolds. The diagram therefore allows one to transfer information from the odd-dimensional setting to the even-dimensional setting. For example, one can take obstructions to positive scalar curvature for odd-dimensional manifolds and transfer them to obstructions for even-dimensional manifolds satisfying certain conditions.

References

- [1] Atiyah, M.F., Patodi, V.K. and Singer, I.M. (1975). Spectral asymmetry and Riemannian geometry. I. *Mathematical Proceedings of the Cambridge Philosophical Society* **77**, 43–69.
- [2] Hallam, M. and Mathai, V. Positive scalar curvature via end-periodic manifolds. Preprint. Available at <http://arxiv.org/abs/1706.09354>.
- [3] Higson, N. and Roe, J. (2010). K -homology, assembly and rigidity theorems for relative eta invariants. *Pure and Applied Mathematics Quarterly* **6**, 555–601.
- [4] Mrowka, T., Ruberman, D. and Saveliev, N. (2016). An index theorem for end-periodic operators. *Compositio Mathematica* **152**, 399–444.



Michael Hallam is a masters student in pure mathematics at The University of Adelaide, studying under Professor Mathai Varghese. His research is on index theory for non-compact manifolds having periodic ends, in particular how a recent index theorem for such manifolds fits into the setting of geometric K -homology and bordism. The theory involves a blend of topology, geometry and analysis on manifolds. He enjoys learning about different areas in pure mathematics and hopes to develop his skills to be as broad and diverse as possible.

First Annual Debate of the Australian Mathematical Society

Professor Kate Smith-Miles, President of the Australian Mathematical Society, introduced the idea of a debate to be held at each Annual Meeting of AustMS. She chose the provocative title: ‘Is the traditional blackboard lecture dead?’.

The first annual debate was held at the 2017 Annual Meeting of the Australian Mathematical Society at Macquarie University in Sydney.

In the light-hearted debate in parliamentary style, arguments were presented by three speakers on each side. In the end the audience voted nem. con for the negative!

Probably the telling point is that university senior management had caused blackboards to be removed from lecture theatres without support from academics, especially the mathematicians.

A legalistic argument in favour of the negative was that some dusty older buildings still have some blackboards.

Left-wingers argued for blackboards on the grounds of cost and availability of electricity in third world countries.

The debate moderator, Adam Spencer, who shamelessly advertised his book *The Number Games*, frivolously declared one of the debaters was ineligible as she is a dual citizen.

In short it was strongly felt by the audience that the marriage of blackboards and mathematicians should not be dissolved while love was still evident.

The debate winners received the abacus trophy.

Postscript by Sid Morris: It was noticeable that those arguing for the negative brought along a blackboard the size of an iPad Pro! Also, they were happy to regard whiteboards as a type of blackboard. And on the positive side, one speaker

used her iPad in the same way blackboards were used in the past. In the language of my first Talking Teaching article in the *Gazette* speakers argued in favour of 'speed limited' lecturing (via a blackboard, whiteboard or ipad) rather than a prepackaged PowerPoint®-style lecture.



Left to right: Birgit Loch, Dan Mathews, Marty Ross, Kate Smith-Miles, Adam Spencer, Adrienne Jenner, Heather Lonsdale, John Roberts

13th Engineering Mathematics and Applications Conference 2017

**University of Auckland
29 November to 1 December 2017**

Richard Clarke* and Alys Clark**

The 13th Engineering Mathematics and Applications Conference (29 November to 1 December 2017) was the first EMAC to be held in New Zealand. The venue was the Science Centre on the University of Auckland's city campus. The conference opened on Tuesday 28 November with a welcome reception on campus. The formal conference program began on Wednesday morning, with a welcome from conference co-chairs Alys Clark (Auckland Bioengineering Institute) and Richard Clarke (Department of Engineering Science). The conference dinner was held on Thursday evening, in the Fale Pasifika on the University campus.

There were 57 registered delegates (including invited speakers) consisting of 36 from NZ, 14 from Australia, 2 from Taiwan, 1 from Indonesia, 1 from Oman, 1 from Fiji, 1 from Japan, and 1 from Korea. There were 50 contributed presentations, 25 of which were student talks. There were 20 sessions during the two and half days of the conference.

There were five excellent plenary speakers:

- Graham Weir (Massey University): Conceptual models for porous media theory
- Caroline Yoon (University of Auckland): Cutting through the fake 'real' world of mathematics tasks
- Louise Olsen-Kettle (Swinburne): Bridging the macro to the mesoscale: modelling damage and fracture propagation in anisotropic materials
- Phillippa Martin (University of Canterbury): Tiptoeing along the edge of stability
- Michael Forbes (University of Queensland): Benders decomposition and lazy modelling for integer programming problems

Many thanks to the invited speakers committee, chaired by Scott McCue (QUT), for recommending such high calibre plenary speakers. Also our gratitude to Bradley Horton and Jonathan Koay from Mathworks, who ran a well-attended two -hour MATLAB[®] workshop on the final day.

Through the ANZIAM Student Support Scheme, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and ANZIAM contributed AUD\$2275 to the conference costs of five students from Adelaide, Monash, Auckland, Griffith and Newcastle, enabling them to attend the conference.

*Engineering Science, University of Auckland

**Auckland Bioengineering Institute, University of Auckland

As at previous EMACs, the best student prize was determined by a committee of judges. The committee was chaired by Bronwyn Hajek (UNISA). The William Finlay Blyth Prize for the best student talk was awarded to Michael Gravatt (University of Auckland), with James Cavallo (Monash), Alison Schroeder (University of Auckland), Win Min Tun (University of Auckland) and Faheem Zaidi (Massey) being highly commended. The winner received \$500, whilst the highly commended students received \$100, and all four students received a certificate.



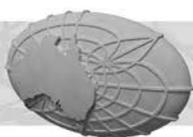
Left: Top Student Talk Awarded to Michael Gravatt by EMAC Chair Bronwyn Hajek. Centre: Highly Commended Student: Win Min Tun. Right: Highly Commended Student: James Cavallo. (Photo credit: Mark McGuinness.)



Left: Highly Commended Student: Alison Schroeder. Right: Highly Commended Student: Faheem Zaidi. (Photo credit: Mark McGuinness.)



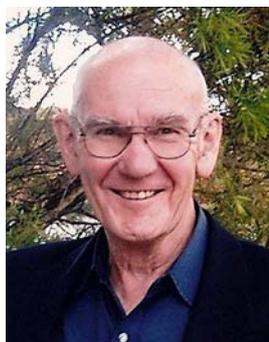
Conference Dinner at the Fale Pasifika.



Obituaries

Malcolm Hood

1931–2017



Summary of academic work and life activities

Malcolm Hood served (on and off) at The University of Western Australia (UWA) from 1952 until his retirement in 1996. At the time of his retirement he was one of the longest serving staff members at UWA. He was an inspiring teacher of applied mathematics, much loved by students and highly respected by his colleagues. His own passion for mathematics inspired an enthusiasm for learning amongst his students at UWA and also among the high school students at the National Mathematics Summer School for exceptional students held annually at the Australian National University (ANU). He recently told a friend that his favourite student at the summer school was Fields Medallist Terry Tao who attended the School at the age of 10. Apart from being a champion of applied mathematics he was a skilled wood worker, a lover of classical music, an avid reader, a lively raconteur, just to name a few of his pursuits and passions.

Early life in Perth and Adelaide

Malcolm was born on 1 December 1931 in Claremont, Western Australia. His father James Chalmers Hood, born in Glasgow Scotland, was an analytical chemist, and after arriving in Perth, met and married Malcolm's mother Mabel Maud Moyes in Claremont on 18 December 1922. They had four sons: Bryan Earnest (b. 1923, d. 2004, a wine Research Chemist in Seppeltsfield), Colin Alexander (b. 1925, d. 1993, a bank employee), Malcolm James, and Graham Moyes (b. 1936, an Account Manager with Bird Cameron). Malcolm attended Perth Modern High School and went on to study Science at UWA. He completed his bachelor degree with first class honours in mathematics in 1952, and in fact he had already been working as a 'recently appointed graduate assistant' when A.L. (Larry) Blakers

took up The Chair in Mathematics at UWA in August 1952. Malcolm's graduate assistantship finished at the end of 1953, and in January 1954, Malcolm moved to an appointment at the newly-formed Weapons Research Establishment (WRE) at Salisbury in South Australia.

At that time the WRE was world renowned for its experimental and theoretical work in aeronautics, and in particular its work in ballistics, the area in which Malcolm was involved. For applied mathematicians in those days aerodynamics was 'the' area to work in, and many of the applied mathematicians who would later occupy chairs and positions in Australian Universities received their initial postgraduate training at WRE. Several mathematicians from WRE would later come to work at UWA: Harry Levey, Phil Silberstein, John Mahony, David Hurley, Peter Wynter, Peter Chapman, and, of course, Malcolm. During Malcolm's time at WRE he was seconded for two years to the Royal Aircraft Establishment in Farnborough. Recently, Malcolm's long-time neighbour and friend Richard Werren had a rare glimpse into Malcolm's work on weapons research, during a visit they made together to the Aircraft Museum at Bull Creek in WA. They were looking at the big Lancaster bomber display when Malcolm suddenly exclaimed 'That's my bomb!' pointing to a large bomb on display — with a flat nose — not a normal pointed one. It turned out that one of Malcolm's projects at Farnborough was to determine the trajectory of a bomb with a flat nose — as they thought it would fly differently and needed to know how — that was the bomb! Malcolm was so pleased to see his bomb!

Marriage and family

Malcolm met his wife-to-be Mirlwyn Eunice Cross in July 1952 at the local Presbyterian Fellowship of Australia (PFA) group at Ross Memorial Presbyterian Church (West Perth). Mirlwyn (born 15 April 1926 in Wangaratta) was the only child of George and Byrle Cross. She grew up in Victoria as her father George was a local Council Health Inspector in Benalla and later in St Kilda (Melbourne). Mirlwyn worked in the Bank of New South Wales and then the Royal Insurance Company where she became Private Secretary to the State Manager. Her love of travel brought her eventually to Perth and the post of office manager at Watsonia Ltd. Then a couple of months after Malcolm moved to Adelaide she obtained a job in the Adelaide City Treasurer's Office. She and Malcolm married in Adelaide on 2 April 1955, and at the end of May 1955 they set off from Fremantle by ship for Malcolm to take up the two-year post at Farnborough.

The time in the UK proved a wonderfully stimulating period for both Malcolm and Mirlwyn. Malcolm completed in 1957 a Master of Science with Distinction from the University of London specialising in aerodynamics. In addition his supervisor at the Royal Aircraft Establishment, Dr Gwylim Richards, suggested that it might be of value to learn something about computers which were just coming into use. So Malcolm undertook a two-week residential course at Cambridge University, learning to program the then state of the art machine Edsac. They returned to Adelaide and Malcolm's job at WRE in July 1957. The combination of research and early experience in computing led to Malcolm's being offered, and accepting,

a position as full-time Lecturer in mathematics at UWA in 1960. He was promoted to Senior Lecturer in 1972, and remained at UWA until his full retirement in 1999; he was employed as a casual lecturer from 1997 to 1999.

Mirlwyn was totally supportive of Malcolm, and Malcolm was devoted to her. Many new recruits to the Department of Mathematics at UWA were welcomed on arrival by Mirlwyn and Malcolm and immediately fitted snugly into a Department that was a most happy place to be and very welcoming. Mirlwyn and Malcolm had one son, Lindsay Malcolm, born 16 February 1964 in Devonleigh Hospital, Cottesloe, WA. In 1986 Lindsay went to Canberra to undertake a PhD at the ANU, and became an expert in High Performance Computing. In Canberra he met Patricia (Trish) McCauley, a senior University administrator: their partnership lasted for 22 years until Lindsay's early and tragic death from a combination of ventricular tachycardia and cardiomyopathy on 6 February 2011. Malcolm was rightly very proud of Lindsay and his death was a very great blow both for him and Mirlwyn. Out of great tragedies sometimes come great gifts. After Lindsay's death Malcolm maintained a strong connection with Patricia's family in Canberra and he and Patricia became close friends. Sadly Mirlwyn had senile dementia and spent many years in nursing homes with her memory fading, to her death on 16 June, 2015. The continued attention Malcolm showed Mirlwyn during these long years with daily trips to the nursing home to bring her morning tea was truly heroic.

Teaching and enrichment activities UWA and nationally

The UWA Department of Mathematics grew rapidly after Larry Blakers took up the Mathematics Chair and entered a golden age, with many department appointments as well as visiting appointments. Many leading international mathematicians stopped off at UWA for periods of a year; funding was no problem in those days and the Department had a well-deserved international reputation across applied mathematics, pure mathematics and statistics. For more than 20 years Malcolm acted as assistant to the Head of Maths and was the Director of Undergraduate Studies (from 1966 to 1989, and again in 1992–1993 during Cheryl Praeger's term as Head). He also was the leaving certificate mathematics examiner for many years and was on the High School mathematics syllabus committee. Malcolm was involved in mathematics enrichment programs locally and nationally. He was also an enthusiastic supporter of the development of industrial mathematics in Australia and at UWA in particular.

After Malcolm returned to UWA as lecturer, Larry Blakers had pointed out to Malcolm the need for outstanding mathematics teaching. As a result Malcolm moved his focus away from aerodynamics, and PhD research, towards teaching of such high quality that it turned him into a 'legend'. His exceptional teaching ability was soon known throughout the country through the establishment of the National Mathematics Summer School for gifted students at the ANU where Malcolm gave lectures for many years. He was also well known nationally because the Hood and Storer Mathematical Tables were on every Australian mathematics student's 'desk'. Locally, Malcolm was co-organiser with Phil Schultz of the annual Blakers

Mathematical Competition in WA for its first 10 years. This was a competition for undergraduate students in which talented students would address challenging mathematical questions. Malcolm would set questions on the applied side that inevitably involved a context familiar to the students. One such problem was the wheelie bin problem: ‘how should one design the bin in such a way that it didn’t stray when full and being pushed?’ This is an archetype stability problem of great general interest, but Malcolm put it in an every-day setting. Malcolm had many tools/toys that he used to illustrate mathematical principles: tippy tops that flipped with high rotation speeds, and various geometric shapes (plastic cones cut with planes, cardboard Platonic solids). But it was his pure enjoyment of, and enthusiasm for, mathematics that captured the students’ imaginations. They could sense his generosity of spirit and the caring respect that he had for each of them individually. Even in large classes he knew the names of all the students and he always had time for a chat; he was a gifted teacher and great ambassador for mathematics.

Malcolm did however find time to do research and worked with many applied mathematicians both within the department and overseas. To mention a few contributions: He worked with David Hurley on gravitational and internal waves, with Nev Fowkes and Hilary and John Ockendon on industrial mathematics problems, with John Mahony on a range of asymptotic problems, with Grant Keady on problems in classical dynamics, and with Graeme Wake on combustion and special functions.

Friend and colleague

Malcolm was a very engaging person, always cheerful. He made many, many friends, among the oldest of whom were Ian and Judy Tweedie, and David and Paula Tunley. Malcolm was a truly good man in all ways: hard working, totally sincere, honest and reliable, a loyal friend, respectful and kind to all, plain speaking and a man of his word, with integrity beyond reproach. He was a wise and knowledgeable man but still humble and always gentle. He was a man who gave of himself to all with whom he came in contact and he never stinted in support and assistance. He was also able to accept without complaint the difficulties presented to him in life (the death of his only son, Mirlwyn’s long fight with dementia), but he had a sense of humour, enjoyed the company of his colleagues and many life-long friends. He was actively involved in his local community, including the Friends of the University Library, the Australian Seniors Association, the Friends of the ABC, and the WA Theatre Organ Society. Death, like life, held no fear for him. In the last hours of his life he said to Nev: ‘I have had a very fortunate life and I am content’.

Malcolm, you enriched all you touched, you spread goodwill and good cheer to all, regardless of who they were. You inspired many.

Thank you Malcolm.

Neville Fowkes (neville.fowkes@uwa.edu.au)
Cheryl E. Praeger (cheryl.praeger@uwa.edu.au)

Obituary: Alwyn Francis ('Horrie') Horadam
22 March 1923 to 22 July 2016



Alwyn was born on 22 March 1923, to parents who were dairy farmers in the rural settlement of Scotts Flat near Singleton in the Hunter River Valley, NSW, Australia. He died at 93 in Armidale after several years of serious physical incapacity but with his mind undimmed and ever interested, keeping to his ideal of 'a kind heart and a tranquil mind'.

His primary school education began at the outpost of Roughit, a one-room school where the teacher was his mother's father, and continued in Singleton. For high school he travelled 70 miles daily by train (milking the cows before and after) from Singleton to Maitland Boys High School, where he became School Captain and Dux. He won numerous school prizes, chief of which was the Waddy-Portus plaque for outstanding scholarship, sporting ability and citizenship. He was a talented and proud cricketer. At about 16, he scored his first batting century in adult competition, playing with the local team Glendon, and made 720 runs for the season in 15 completed innings—a major achievement and perhaps the top performance in the district. For the Combined High Schools Cricket team he was selected as the reserve, and later at UNE he was Cricket Captain, Club President and a 'blue'.

A Teacher's College bursary allowed him to enrol at the New England University College (NEUC—UNE since 1954) in 1940, where his life-long passions for English, Classics, History and Mathematics flourished. As a student in a reserved occupation course he undertook basic army training and dug trenches on campus as required. On graduation in 1944 with B.A. (First Class Hons.) in Mathematics and Dip. Ed. from U. Sydney, Alwyn was sent to country high schools to serve out his bond for three happy and busy years. Teaching gave Alwyn great joy all his life; he was deeply committed to his craft and to the transforming and enriching power of mathematics in uncounted outreach courses to secondary students and teachers and lectures to the public. A student of mine asked if I was related to 'this extraordinary mathematician . . . He spent a few days teaching us roughneck high-school students at a campground in Bonny Hills in 1977. He made such an

impression I easily recall the event nearly 40 years later.' He wrote a series of high-school text books and served on the NSW Junior School Mathematics Committee for 25 years continuously, as well as writing articles such as [4] for teachers, combining history and mathematics. Even when he was Head of Department and Dean of Science at UNE his door was always open, with a notice 'Students may see me at any time'.

Appointed to NEUC as Lecturer in Mathematics in 1947, Alwyn progressed to Senior Lecturer (1959) then Associate Professor of Mathematics (1963). Along the way, he earned a B. Ed. from U. Melbourne and an M.A. (Hons) from U. Sydney. In 1957 he obtained his PhD from U. Sydney for the thesis 'Clifford geometry in complex projective spaces of two, five and eight dimensions', taken under the supervision of T.G. Room. Projective geometry was his initial field and the substance of his second book [3]; the first was an encyclopaedic pure mathematics first year text [2] which remains a treasurehouse for any young lecturer searching for inspiration and example.

In 1950, Alwyn married Mollie Spedding, a fellow Mathematics lecturer at UNE, who had degrees from London and Cambridge Universities ('a bluestocking', he said). They had three daughters; Kathryn, a mathematician, Kerry and Alanna, both medical practitioners, and six grandchildren. Some aspects of Mollie's brilliant career and her half-century of happy life with Alwyn — 'a marriage of true minds' — appear in [6, 9]. During the last eight years of her life (she succumbed, cruelly, to Alzheimer's dementia), Alwyn was her constant companion and carer.

Alwyn's earliest publications (of which there are about 180 refereed, mostly in overseas journals and many co-authored) were in algebra and geometry. The two seminal, most cited papers were in number theory, and that is likely to be where his mathematical legacy holds strongest. The second of these papers [1] generalised the Fibonacci and other sequences and introduced the notation now in common use, by considering the sequence $W_n = W_n(a, b; p, q)$ defined by the second-order linear homogeneous recurrence relation $W_n = pW_{n-1} - qW_{n-2}$, $n \geq 2$, with initial conditions $W_0 = a, W_1 = b$. Thus, the ordinary Fibonacci numbers F_n are the $W_n(0, 1; 1, -1)$. These generalisations, familiar now but novel then, were known as Horadam numbers and sequences by 1999. A survey to 2013 appears in [7] and Google Scholar shows they live and flourish in 2018. For more on this mathematics see [7] and the tributes [10] and [8, 11]. Allied with this research, Alwyn contributed strongly to the international community as a foundation and sustaining member of the Fibonacci Association, on the editorial board of the *Fibonacci Quarterly*, and as co-editor of the *Proceedings of the Biennial International Conferences on Fibonacci Numbers and Their Applications*.

In service to UNE over his 40-year career, he was variously Foundation President of the Alumni Association, President of the Union, Council member elected by Convocation for six three-year terms, Governor of Wright, Robb and Duval residential colleges, University Ombudsman and Esquire Bedell. The longest-serving member in Mathematics, he was Head of the Department of Mathematics, Statistics and Computer Science (by election) on two separate occasions (the position he held on retirement in 1987) and Dean of the Faculty of Science.

As a supervisor he guided over 50 postgraduate students through Litt. B.s and M.A. Hons and five through PhDs.

Alwyn continued to work from his office at UNE for 10 years after retirement, and then from home, with his final papers appearing in 2006. He was an enthusiastic traveller, and Mollie and he were overseas several times a year until she became too unwell. He had an abiding interest in the polar explorers, and cruised to the Antarctic and Arctic several times, once being icebound for a week. The regret of his last trip was that he was too frail to walk to Mawson's hut at Cape Denison.

He offers the following 'distillation of a fortunate life's philosophy'.

People create Mathematics, often with considerable heartache. Thus, historically, the human angle must never be overlooked. Further, an attempt should always be made to introduce innovative teaching techniques by appealing to the imagination and power Mathematics offers, especially for the talented students. Lastly, if only glimpsed by some, an appreciation of the aesthetic attraction of Mathematics is a precious, rewarding and lasting possession, inspiring a love for the subject.

Such a mathematical jewel is the exquisite result due to the consummate Swiss mathematical genius Euler some 300 years ago. It simply asserts that $e^{\pi i} + 1 = 0$. A striking feature of Euler's rather mysterious result is that it clearly connects four basic symbols 0, 1, +, = of elementary arithmetic with three essential numerical ingredients of advanced Mathematics. It is perhaps apt to quote here the maxim of the poet Browning: "A man's reach should exceed his grasp".

This was always Alwyn's favourite piece of mathematics; he was awe-struck by its apparent simplicity (yet depth!) and its sheer elegance and beauty.

Alwyn was an early feminist, to his family's great advantage, and very resilient and flexible through many hard knocks. He always tried to put everyone he met at ease and to leave them with a joke and a smile. He will be remembered as someone of great integrity with a deep commitment to treating people fairly; a civil and gentlemanly scholar.

Acknowledgement. Some of the above comes from Alwyn's own reflections on his life and learning [5], written in his last months.

References

- [1] Horadam, A.F. (1965). Basic properties of a certain generalized sequence of numbers. *The Fibonacci Quarterly* **3**, 161–176.
- [2] Horadam, A.F. (1968). *Outline Course of Pure Mathematics*. Pergamon Press, Oxford.
- [3] Horadam, A.F. (1970). *A Guide to Undergraduate Projective Geometry*. Pergamon Press, Oxford.
- [4] Horadam, A.F. (1975). Eight hundred years young. *The Australian Mathematics Teacher* **31**, 123–134.

- [5] Horadam, A.F. (2016). A testament of life.
- [6] Horadam, K.J. (2002). Obituary: Eleanor Mollie Horadam (29 June 1921 – 5 May 2002). *Austral. Math. Soc. Gaz.* **29**, 224–225.
- [7] Larcombe, P.J., Bagdasar, O.D. and Fennessey, E.J. (2013). Horadam sequences: a survey. *Bulletin of the Institute of Combinatorics and its Applications* **67**, 49–72.
- [8] Larcombe, P.J. (2016). Alwyn Francis Horadam, 1923–2016: A personal tribute to the man and his sequence. *Bulletin of the Institute of Combinatorics and its Applications* **78**, 93–107.
- [9] Lewis, G. (2008). Eleanor Mollie Horadam (1921–2002) – Mathematician and emancipated woman. In *New England Lives III*, eds Ryan, J.S. and Newman, M. UNE with The Armidale and District Historical Society, Armidale.
- [10] Shannon, A.G. (1987). A.F. Horadam – ad multos annos. *The Fibonacci Quarterly* **25**, 100–104.
- [11] Shannon, A.G. (2016). Alwyn Horadam: The man and his mathematics. *Notes on Number Theory and Discrete Mathematics* **22**(3), 1–4.

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Book Reviews

Undergraduate Convexity: Problems and Solutions

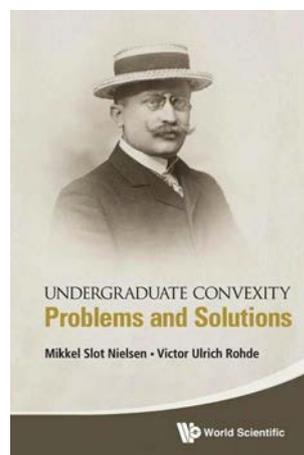
Mikkel Slot Nielsen and Victor Ulrich Rohde
World Scientific Publishing Company, 2016, ISBN 978-9-813-14366-1

While this is a review of the book *Undergraduate Convexity: Problems and Solutions* by Mikkel Slot Nielsen and Victor Ulrich Rohde, it is also concerned with the theory book *Undergraduate Convexity: From Fourier and Motzkin to Kuhn and Tucker* by Niels Lauritzen.

Undergraduate Convexity by Niels Lauritzen covers most of the classical topics in convexity: Fourier–Motzkin elimination, affine spaces, convex subsets, polytopes, linear programming and the simplex method, hyperplane separation, convex functions and convex optimisation. In this regard, it resembles the book *Convexity* by Roger Webster [3]. One may argue that it misses the important classical topic of volumes of convex sets and the Brunn–Minkowski theorem, but then it covers more material than a traditional semester in Australia, which runs for around 12 weeks. In my opinion, the book also resembles Webster’s in the clarity of the exposition and the care that went into writing it. One feature that I like of Lauritzen’s book is the emphasis on examples and computations to motivate the abstract mathematics of the relevant chapter. The book has a hands-on ‘feel’ and approach to convexity, which may be attractive not only to mathematics but also to computer science students. The number of exercises per chapter varies; some chapters have around 10 exercises while others have more than 20. All the exercises are well-calibrated to allow for a safe landing at the (exercise) section. I found that the exercises greatly complement the theory introduced in the chapter, with their difficulty going from low to medium. I also think that a course taught with Lauritzen’s book would benefit from modelling some of the exercises in solvers such as CVXPY [2], a Python package to work on convex optimisation.

Niels Lauritzen is an Associate Professor at the department of mathematics of Aarhus University and has used the book to teach introductory convexity to undergraduate students in mathematics, economics and computer science.

All the above brings me to the complementary book *Undergraduate Convexity: Problems and Solutions* by Mikkel Slot Nielsen and Victor Ulrich Rohde. The book grew out of solutions recorded by Nielsen and Rohde during their time as teaching assistants in courses taught with Lauritzen’s book. Solutions to all the exercises in Lauritzen’s book have been provided. Every chapter starts with a brief introduction to the relevant material, following the exact notation and numbering of the result in Lauritzen’s book. The



manual can certainly be used without having the theory text at hand, if the material is known, but it would work much better in conjunction with Lauritzen's book. I found the solutions very clear and easy to follow, as well as diagrams used to illustrate a particular idea.

Those lecturers after an undergraduate hands-on book on convexity should definitively consider Lauritzen's book in combination with Nielsen and Rohde's. This duo is also suitable for a course on convex optimisation, followed or complemented by more advanced materials found in books such as *Convex Optimization* by Stephen Boyd and Lieven Vandenberghe [1]. I also believe the duo would be very appropriate for self-study.

References

- [1] Boyd, S. and Vandenberghe, L. (2004). *Convex Optimization*. Cambridge University Press.
- [2] Diamond, S. and Boyd, S. (2016). CVXPY: A Python-embedded modeling language for convex optimization. *J. Machine Learning Research* **17**(83), 1–5.
- [3] Webster, R. (1994). *Convexity*. Oxford University Press, New York.

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Creating Symmetry: The Artful Mathematics of Wallpaper Patterns

Frank A. Farris

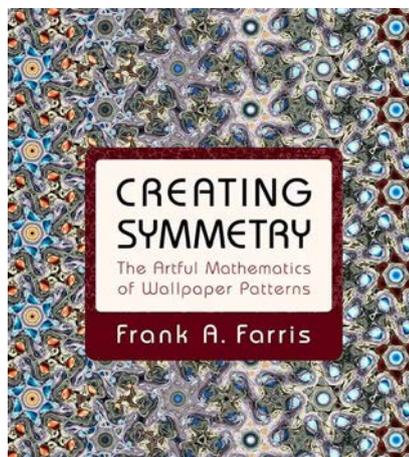
Princeton University Press, 2015, ISBN 978-0-691-16173-0

A Gooseberry/Fibonacci Spiral by Frank A Farris was recently recognised as Best Photograph, Painting or Print in the 2018 Mathematical Art Exhibition Awards for 'aesthetically pleasing works that combine mathematics and art' at the [American] Joint Mathematics Meetings in January 2018. This spiralling artwork is the result of further development of the techniques explained in *Creating Symmetry*, which itself received Honorable Mention for the 2016 PROSE Award in Mathematics, Association of American Publishers.

Farris' creation of rosette and frieze and wallpaper patterns, not by means of 'stamping' them out with motifs, but rather by building them from wave functions written in complex exponential form, incorporates and brings to life many areas of mathematics: Fourier series, complex analysis, symmetry groups, abstract algebra, lattices (in the crystallography sense), vector spaces and more. This book arose from incorporating the ideas he had used in creating his mathematical art into a capstone-type subject of 28 classes—so that the book has 26 short chapters plus epilogue and preface. Each chapter begins with a question, such as *Using the*

rectangular lattice, how many symmetry types are possible? (Chapter 18) or *How do you combine plane waves to make periodic functions with 3-fold symmetry?* (Chapter 10), and then the question is explored and answered in the chapter. The ideas from each chapter are illustrated with numerous coloured photographs of various sizes, there are discussions of the design and aesthetic considerations that arise in making pleasing images in amongst the mathematics, and there are exercises of varying levels of difficulty, placed in the generous margins. Answers to many of these follow on nearby pages. The non-existence of 5-fold rotationally symmetric wallpaper is discussed. The most mathematically intense chapter (Chapter 21) deals with point groups, and using them to establish the completeness of the list of 17 wallpaper symmetries identified in the preceding chapters. What Farris terms the *symmetry recipes* (conditions on Fourier series coefficients) and other key equations from all the chapters are collected for easy reference in an Appendix.

The underlying idea introduced by Farris is his *domain-colouring algorithm*. Put simply, the domain colouring algorithm is a two-step artistic solution to the problem of portraying a complex-valued function of a complex variable. The complex plane is first coloured using a photograph, so that to each point z a colour is assigned (non-uniquely). Then the depiction of the function f is to colour each point z with the colour assigned initially to $f(z)$. If the function has symmetry or periodic properties, these will show up as regions of the same colour in the depiction of f . Farris shies away from using photos containing human figures (which can become comical); he prefers scenery, flowers and cut-up vegetables (carrots and avocado, red peppers and purple cabbage — or his dinner, as another reviewer has put it). Creating images with colour gives rise to further possibilities for underlying structure, and these Farris terms *colour turning* symmetries, a generalization of colour-reversing. Appendix C provides a visual and mathematical catalogue of the 46 colour-reversing wallpaper types.



As well as being readable, *Creating Symmetry* is a visually appealing book. It has an unusual shape, being almost square (23×25 cm), which gives it the feel of an art or coffee table book, although it contains so much solid undergraduate-level mathematics. The layout of text, coloured photos, diagrams and exercises is attractive; one is not overwhelmed on any one page, and neither are there many pages in a row that all look the same. The dust jacket is illustrated with a morphing frieze (think Escher) called *Kaiser Peach*, created from a photo of a peach that the author ate on Mount Kaiser. To find out how to create a morphing frieze, you will have to read to Chapter 26; if you are content with making hyperbolic wallpaper, you can stop at Chapter 25.

Am I going to start teaching from this book? I wish I could! As someone who dabbles in mathematical art, I have enjoyed having it in my hands. I will reluctantly lend it to a colleague who is incorporating a project assessment into a Complex Analysis subject. (But I will borrow it back for ideas for maths outreach.) There are three pages of errata, mostly typographical, available from the publisher's homepage for the book; if one did adopt this book in a project or capstone subject, this should certainly be consulted to avoid unnecessary frustration.

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MATRIX News

Jan de Gier*

Mathematical Research Institute MATRIX

MATRIX is Australia's international residential mathematical research institute. Programs at MATRIX aim for strong international participation and/or participation from business and industry. Research programs at MATRIX have ample time for interaction and active research, and are different from a traditional, talk-intensive conference. MATRIX is an institute where new research is conducted, and everyone can apply for hosting a program.

New financial support for MATRIX

MATRIX benefits greatly from external support for specific workshops and programs, such as from ACEMS, AMSI, APCTP, AustMS, CARMA, Compositio, NSF and NTF.

MATRIX is pleased to announce that recently it has received general donations from two new supporters. These are a private donor as well as the School of Mathematics and Physics of The University of Queensland. If you are interested in supporting research in the mathematical sciences through MATRIX, please get in contact with us.

MATRIX Annals

The 2016 MATRIX Annals will be published by Springer in hardcopy shortly, and is available online at <https://www.matrix-inst.org.au/2016-matrix-annals/>.

The MATRIX Book Series document scientific activities at MATRIX. The Editorial Board consists of David Wood (Editor-in-chief), Jan de Gier, Cheryl Praeger, and Terence Tao. Papers in the 2017 MATRIX Annals are posted online at <https://www.matrix-inst.org.au/2017-matrix-annals/> as they become available. Articles can be peer-reviewed, containing original results or reviews on a topic related to the program, or non-peer-reviewed expository articles based on talks or activities at MATRIX.

Recent programs

MATRIX has hosted several exciting research programs in recent months:

- *Mathematics of Risk*,
20 November – 8 December 2017

*MATRIX, Creswick, <http://www.matrix-inst.org.au/>

Organisers: Kostya Borovkov (Melbourne), Kais Hamza (Monash), Masaaki Kijima (Tokyo), Alex Novikov (UTS), Peter Taylor (Melbourne)

- ***Tutte Centenary Retreat,***

26 November – 2 December 2017

Organisers: Marston Conder (Auckland), Graham Farr (Monash), Dillon Mayhew (Wellington), Kerri Morgan (Monash), James Oxley (Louisiana State), Gordon Royle (UWA)

- ***Geometric R-Matrices: from Geometry to Probability,***

17–22 December 2017

Organisers: Rick Kenyon (Brown), Andrei Okounkov (Columbia), Anita Ponsaing (Melbourne), Paul Zinn-Justin (Melbourne)

- ***Non-equilibrium systems and special functions,***

8 January – 2 February 2018

Organisers: Vadim Gorin (MIT), Tomohiro Sasamoto (Tokyo Institute of Technology), Ole Warnaar (University of Queensland), Michael Wheeler (University of Melbourne)

- ***Algebraic geometry, approximation and optimisation,***

5–16 February 2018

Organisers: Enrico Carlini (Politecnico di Torino), Jochen Garcke (University of Bonn), Wolfgang Hackbusch (Max Planck Institute), Markus Hegland (Australian National University), Vera Roshchina (RMIT University), Nadezda Sukhorukova (Swinburne University of Technology), Julien Ugon (Federation University Australia), David Smyth (Australian National University).

Upcoming programs

- ***On the Frontiers of High Dimensional Computation,***

4–15 June 2018

Organisers: Frances Kuo (UNSW), Hans De Sterck (Monash), Josef Dick (UNSW), Mahadevan Ganesh (Colorado), Mike Giles (Oxford), Markus Hegland (ANU), Dirk Nuyens (Leuven), Ian Sloan (UNSW), Clayton Webster (Oak Ridge), Henryk Wozniakowski (Warsaw and Columbia).

- ***Month of Mathematical Biology,***

27 June – 20 July 2018

Organisers: Ruth Baker (Oxford), Kevin Burrage (QUT), Helen Byrne (Oxford), Edmund Crampin (Melbourne), Mark Flegg (Monash), Alexander Fletcher (Sheffield), Edward Green (Adelaide), Samuel Isaacson (Boston), James Osborne (Melbourne), Hans Othmer (Minnesota)

- ***Dynamics, Foliations, and Geometry in Dimension,***

3–14 September 2018

Organisers: Jonathan Bowden (Monash), Steven Frankel (Yale), Andy Hammerlindl (Monash), Rafael Potrie (Uruguay)

- ***Recent Trends on Nonlinear PDEs of Elliptic and Parabolic Type***,
5–16 November 2018
Organisers: Yihong Du (New England), Daniel Hauer (Sydney), Angela Pistoia (Sapienza, Roma)
- ***Functional Data Analysis and Beyond***,
3–14 December 2018
Organisers: Aurore Delaigle (Melbourne), Frederic Ferraty (Toulouse), Debashis Paul (Davis)
- ***Geometric and Categorical Representation Theory***,
10–21 December 2018
Organisers: Clifton Cunningham (Calgary), Masoud Kamgarpour (UQ), Anthony Licata (ANU), Peter McNamara (UQ), Sarah Scherertzke (Bonn), Oded Yacobi (Sydney)

Submission

The MATRIX Scientific Committee selects programs on scientific excellence as well as on the participation rate of high profile international participants and/or business and industry partners, among other criteria.

MATRIX programs tend to have ample unstructured time to encourage collaborative research rather than having a traditional conference format. Longer term programs, lasting three weeks or more, could have an embedded conference or lecture series. Shorter workshops focussing on a special theme are also welcome. MATRIX offers additional support to participants with families through the MATRIX Family Fund.

**The next deadline for program proposals
in 2019–2020 is 6 April 2018.**

Guidelines for proposals and expressions of interest (which may be submitted at any time) are available at <https://www.matrix-inst.org.au>.

MATRIX Minors

MATRIX Minor programs are self-funded visits to MATRIX to make use of the available office space and facilities at the Creswick Campus outside program times, for example to work intensively in a small group. Such visits are subject to the approval of MATRIX but can be arranged by sending an email request that briefly outlines the proposed research and timings.

Questions

Comments, suggestions and requests are always welcome. Please send these, as appropriate to:

Directors	Jan de Gier (jdg@matrix-inst.org.au) David Wood (davidw@matrix-inst.org.au)
Executive Officer	Sally Zanic (sallyz@matrix-inst.org.au)
Chair of the Advisory Board	Tony Guttman (guttman@unimelb.edu.au)

MATRIX is a partnership between Monash University and The University of Melbourne, with the ARC Centre of Excellence for Mathematical and Statistical Frontiers (ACEMS) as an associate member.

Jan de Gier
Co-Director MATRIX



Professor De Gier's research interests are in mathematical physics and statistical mechanics, in particular in the theory and application of solvable lattice models as well as special functions in stochastic processes and combinatorics. Jan is a former Editor of the *Gazette*, organised an AMSI summer school and was inaugural Chair of the Australia and New Zealand Association of Mathematical Physics (ANZAMP). He is currently Head of the School of Mathematics and Statistics at The University of Melbourne and co-Director of MATRIX.



WIMSIG News

My time at WIMSIG: a student's perspective

Kimberly Becker*

I have been putting off writing this article for a long time, now. The blank document staring back at me begs the question — why have I been avoiding this? It's unlike me to procrastinate. Not only that, but this shouldn't be a difficult article to write! I have nothing but good things to say about the WIMSIG conference. I was, for the first time in my life, in a room filled with all of my role models — which gives me butterflies just to *think* about. I had the privilege of listening to talented women with a passion for mathematics, in a quantity I have never before seen. The free food was fantastic (how 'bout those cupcakes?), I got career advice from people who have all 'been there' — I even understood some technical talks. So why don't I want to write this article? Naturally, I have a hypothesis. Perhaps this is far too deep an analysis, and the truth is that I'm a lazy university student. But I'd like to give myself more credit than that. My hypothesis is that behind the fabulous morning teas, the room full of talent, and the exciting talks, there was an underlying sadness to this conference that I still don't want to confront. A sadness that, although I just consider myself a 'mathematician', I am not *just* that. I am a *female* mathematician, and my experiences as such are distinct from a majority of people in my field. A similar sentiment was shared by several of the WIMSIG speakers I interviewed. But with this melancholy also came a profound sense of pride amongst the women I spoke to. Pride for their mathematics, their students, and the lives they have made for themselves. And while it can be easy to focus on the bad, under Lesley Ward's guidance, the WIMSIG conference did a terrific job of acknowledging diversity problems in mathematics while remaining optimistic for the future. This conference celebrated today's women in mathematics, and I left it with a newfound excitement to be part of this wonderful community.

The first woman I met at the WIMSIG conference introduced herself as someone who had 'been fighting the power for the past fifty-odd years' — and it was at this exact moment I realized this was not going to be your typical conference. It's hard to pinpoint what made WIMSIG feel so special — there was an atmosphere of excitement all around. Professor Christine O'Keefe said what impressed her most was 'the sense of community and fun at WIMSIG'. And she wasn't alone. Professor Yvonne Stokes said that WIMSIG was one of the most fun conferences she had ever been to. Although I've been to comparatively few conferences, I have to agree. WIMSIG was quite simply lots of fun. I feel very lucky to have experienced a conference like this so early in my career. I now have a tangible idea of what a more diverse maths community could look like, and why it is we should all strive for this. It's one thing to be told why diversity is important — and it's another thing to experience it. The WIMSIG conference showed me how beneficial — and *fun* — a more diverse maths community would be for all of us.

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The WIMSIG conference fostered a supportive environment that saw mathematicians of all backgrounds sharing their stories. Stories that ranged from daily frustrations to very personal tales of blatant segregation. Many of us were reminded of just how harsh the current landscape is for diversity in maths. Though these discussions were at times disheartening, I was inspired by the statisticians and maths psychologists dedicated to solving gender equity problems in maths. With more researchers like this, and the engagement of the whole mathematical sciences community, it feels like progress can be made. To paraphrase Professor Nalini Joshi, we are on the cusp of great disaster or opportunity. With conferences like WIMSIG, I really do believe we are heading in the direction of great opportunity, and I hope we keep it up.

The WIMSIG conference allowed minorities in maths from around the world to meet each other. As Professor Ami Radunskaya would say—or sing, rather—let’s build a network! But aside from the connections we made, and the fantastic speakers we heard, as a student, there was another very special element to WIMSIG—and that was simply *seeing* women doing some very cool maths. Perhaps it sounds silly, but as a student who has had but two female lecturers in the duration of my degree, I love seeing talks from female mathematicians. I was so enthused by Dr Zsuzsanna Dancso’s talk, that I declared I was going to be a knot theorist for an entire week afterward (I’ve since changed my mind several times...). Then when I saw Professor Malabika Pramanik speaking at WIMSIG I thought—perfect! I’ll move to Canada and work with her for my PhD—she’s awesome! To me, the most inspiring thing of all is when I see female mathematicians speaking passionately about their work. It is in these moments that I think to myself, maybe this whole academia thing is possible after all. As Dr Christine O’Keefe told me, ‘remember that we were all in the same boat at some stage, and there is always a helping hand’. I can only hope that one day I’ll be giving a talk at a conference where I’ll inspire some young mathematicians, like all the incredible speakers from WIMSIG 2017 have done for me. As a student, what I will take away from WIMSIG is an excitement to pursue my career to the fullest, and a pride at calling myself a female mathematician.

To Lesley Ward and all the people who made the WIMSIG conference possible, to Giang Nguyen for her encouragement to write this, and to the women I interviewed—thank you.



Kim Becker is currently undertaking a Master of Philosophy at Adelaide University, under the supervision of Professor Michael Murray and Professor Daniel Stevenson. Her research focuses on bundle gerbes, which provide a geometric representation of degree three cohomology. Kim is passionate about creating a diverse mathematics community and has recently founded a Women in STEM Society at Adelaide University.



News

General News

University of New South Wales

Chris Tisdell continues his fun, educational and popular mathematics songs on YouTube that are designed to inspire a general audience. Chris follows up his hit 'e is a magic number' with a mathematical parody of the song 'Thunder' by pop band Imagine Dragons, who are touring Australia this year. 'Thunder' features in Microsoft's Surface Laptop advertising campaign. Entitled 'Number Song', the work expresses a love of numbers, mathematics and learning.

<https://www.youtube.com/watch?v=JzAcXg1uz0Y>

Number Theory Down Under

Effective September 2017, Mumtaz Hussain of La Trobe University is president of the AustMS Special Interest Group Number Theory Down Under.

Mathematics in the Media

Murray Batchelor from ANU and Bruce Henry from UNSW are amongst the authors of a recent Nature article (Scientific Reports (2018) 8:559, DOI:10.1038/s41598-017-18908-4) which developed a mathematical model for the growth of oolitic limestone. As this has been used in a number of iconic buildings, it attracted some media attention.

<https://www.telegraph.co.uk/science/2018/01/18/buckingham-palace-riddled-ancient-fossils-scientists-confirm/>

<http://www.dailymail.co.uk/sciencetech/article-5283957/Fossils-really-live-Buckingham-Palace.html>

<http://maths.anu.edu.au/research/programs/highlights/buckingham-palace-built-mineralised-microbes-jurassic>

Completed PhDs

Curtin University

- Dr Norah S.A. Almalki, *The existence of diameter-edge-critical graphs*, supervisor: Lou Caccetta.
- Dr Francisca Angkola, *A generalized fractal dynamics option pricing model with transaction costs*, supervisor: Yong Hong Wu.
- Dr Elayaraja Aruchunan, *The new variants of modified weighted mean iterative methods for Fredholm integro-differential equations*, supervisor: Yong Hong Wu.

- Dr Siti Chotijah, *The minimum energy problem for positive linear systems*, supervisor: Yong Hong Wu.
- Dr Shuang Li, *Study of various stochastic differential equation models for finance*, supervisor: Yong Hong Wu.
- Dr Shuqi Ng, *Proximal monitoring in landscape environments*, supervisor: Lou Caccetta.
- Dr Piau Phang, *Modelling of human behaviour and response to the spread of infectious diseases*, supervisor: Yong Hong Wu.
- Dr Jimmi Phangestu, *Optimisation models for medium-long term logistics planning in mining*, supervisor: Lou Caccetta.
- Dr Dewi Tjia, *Statistical methods for history matching of hydrological model*, supervisor: Ritu Gupta.

Griffith University

- Dr David Ives, *Assessing the impact of genetically modified canola cultivars on the biology of soil*, supervisor: Gurudeo Anand Tularam.
- Dr S.M. Rajibur, *Financial mathematics*, supervisor: Gurudeo Anand Tularam.

Murdoch University

- Dr Ross Bowden, *Modelling Joint Autoregressive Moving Average Processes*, Supervisors: Dr Brenton Clarke and Dr Nicola Armstrong

Royal Melbourne Institute of Technology

- Dr Sargon A. Gabriel, *The influence of haemodynamics on the mechanics of atherosclerosis growth*, supervisors: Yan Ding, John A. Gear, Dr Yuqing Feng.

Swinburne University of Technology

- Dr Behrooz Bodaghi, *Optimisation approaches for scheduling disaster emergency operations with multiple resources*, supervisors: Palaneeswaran Ekambaram, Nadezda Sukhorukova.

University of Melbourne

- Dr Ada Wing Chi Yan, *Influenza viral dynamics models to explore the roles of innate and adaptive immunity*, supervisors: James McCaw, Jodie Mcvernon and Sophie Zaloumis.
- Dr Chao Zheng, *Variable selection confidence sets for high dimensional data*, supervisor: Davide Ferrari.

University of New South Wales

- Dr Stephanie Clark, *Advances in self-organizing maps for spatiotemporal and nonlinear systems*, supervisor: Scott Sisson.
- Dr Yuehua (Veronica) Li, *Exploring roles of small-scale thermohaline structure on mixing and transport in the ocean*, supervisor: Trevor McDougall.

- Dr Stefan Riha, *Methods for forming approximately neutral surfaces in the ocean*, supervisor: Trevor McDougall.
- Dr Damien Wee, *Estimation of observation driven volatility models with intractable likelihoods — a sequential Monte Carlo approach*, supervisors: William Dunsmuir and Feng Chen.

University of New South Wales Canberra

- Dr Lucia-Marie Billie Ganendran, *Climatic and oceanographic effects on survival of little penguins in south eastern Australia*, supervisors: Leesa Sidhu, Harvi Sidhu and Peter Dann.
- Dr Zhejun Huang, *Mathematical analysis of combustion waves in competitive exothermic reactions*, supervisors: Harvi Sidhu, Zlatko Jovanoski and Isaac Towers.
- Dr Rachael Elizabeth Quill, *Statistical characterisation of wind fields over complex terrain with applications in bushfire modelling*, supervisors: Jason Sharples and Leesa Sidhu.

University of Sydney

- Dr Kamil Bulinski, *Interactions between ergodic theory and combinatorial number theory*, supervisor: Alexander Fish.
- Dr Shila Ghazanfar, *Statistical approaches to harness high throughput sequencing data in diverse biological systems*, supervisor: Jean Yang.

Awards and other achievements

Australian National University

- PhD student Jordan Pitt received a MODSIM Student Award at the 22nd International Congress on Modelling and Simulation, which was held in Hobart in December 2017. This was awarded for his paper ‘Importance of Dispersion for Shoaling Waves’.

Central Queensland University

Three maths staff received the 2017 CQU Student Voice Commendation Award, which is determined by the student unit evaluation data:

- Dr Roland Dodd, Foundation Mathematics;
- Professor William Guo, Applied Calculus;
- A/Professor Ross Shepherd, Calculus and Linear Algebra A.

Royal Melbourne Institute of Technology

- Associate Professor Sergei Schreider was recently elected as a Fellow of the Modelling of Simulation Society of Australia and New Zealand (MSSANZ). See <http://www.mssanz.org.au/awards/fellows.html>.

University of New South Wales

2018 Australia Day Awards to two staff:

- Professor Trevor John McDougall, Companion of the Order of Australia For eminent service to science, and to education, particularly in the area of ocean thermodynamics, as an academic, and researcher, to furthering the understanding of climate science, and as a mentor of young scientists.
- Dr David Christopher Hunt, Medal of the Order of Australia For service to education, and to mathematics.

Prizes:

- ARC DECRA Fellow, Zdravko Botev has been awarded the Australian Academy of Science 2018 Christopher Heyde Medal. Zdravko was awarded this medal for his ground-breaking research into new methodologies for understanding the probabilities underlying high-cost, hard-to-predict events, for instance in communication and computer network design, digital watermarking, and safety assessment of debris collision in space.
- Professor Sue Wilson has been awarded the inaugural Australian Bioinformatics and Computational Biology Society (ABACBS) Honorary Senior fellow Award in recognition of sustained excellence in bioinformatics based on contributions to the field in research, contributions to the research community, and leadership.

University of New South Wales Canberra

- Jason Sharples was recently elected a Fellow of the Modelling of Simulation Society of Australia and New Zealand.

Jason Sharples was recently awarded the following grants: ‘Preparing New Zealand for Extreme Fire’ (NZ Ministry of Business, Innovation and Employment and New Zealand Forest Research Institute Limited/Scion), and ‘Fire Coalescence and Mass Spot Fire Dynamics’ (Bushfire and Natural Hazards Cooperative Research Centre).

University of Sydney

- Alistair Senior, Haotian Wu and Rachel Wang were awarded DECRA by the ARC.
- Georg Gottwald, Anne Thomas, Samuel Mueller, Martin Wechselberger, Peter Kim, Alex Molev, Oded Yacobi and Kevin Coulembier were awarded ARC Discovery Projects.
- Professor Nalini Joshi has been named one of the five inaugural recipients of a Payne-Scott Professorial Distinction.
- Becky Armstrong and Alex Casella were awarded the Gordon Preston Prize for the best presentation at the Australian Algebra Conference given by a current student based at an Australian university.
- Kevin Wang was awarded a prize for the best student presentation at the Biometrics by the Border conference.

- Professor Jacqui Ramagge is now President-elect of the Australian Mathematical Society.
 - Professor Norman Dancer was awarded the Juliusz Schauder Medal for 2017.
-

Appointments, departures and promotions

Central Queensland University

The math team in higher education at CQU has stabilised, with five full-time academic staff members since 2014, namely:

- Professor William Guo (Rockhampton, engineering and education mathematics),
- Associate Professor Ross Shepherd (Brisbane, Statistics and education mathematics)
- Associate Professor Saleh Wasimi (Melbourne, Statistics and financial mathematics),
- Dr Roland Dodd (Rockhampton, Math discipline leader and engineering mathematics),
- Dr Yucang Wang (Rockhampton, engineering and education mathematics).

This small team collectively develops, coordinates and teaches 10 maths units and 2 statistics units for 18 offerings over three terms in a year to support engineering, education, business, and other programs at CQU. A couple of staff from other disciplines occasionally teach the repeated math and statistics units when required.

Applied mathematics used to be a research focus and strength at CQU. This small maths team, carrying a heavy teaching load, will focus on mathematics education in the future.

Charles Sturt University

- Dr Dmitry Demskoy has been promoted to Senior Lecturer.
- Dr Michael Kemp has been promoted to Senior Lecturer.
- Dr Robert Wood has been promoted to Senior Lecturer.

Curtin University

- Dr Ryan Loxton has been promoted to Professor.
- Dr Elham Mardaneh has been promoted to Senior Lecturer.
- Dr Ian van Loosen has been promoted to Senior Lecturer.
- Curtin University has a new academic structure, and Mathematics and Statistics is now part of the new School of Electrical Engineering, Computing and Mathematical Sciences.

Deakin University and Federation University Australia

- Dr Julien Ugon left Federation University in January 2018, to take up a position at Deakin University.

La Trobe University

- Dr Natalie Karavarsamis started in February as a Lecturer for three years.
- Deputy Head of Department (Bendigo) A/Professor Simon Smith retired at the start of 2018.
- Andriy Olenko has been promoted to Associate Professor.
- A/Professor Agus Salim started a 0.6 secondment to the Baker Institute for three years.
- Geoff Prince has been made an Emeritus Professor at a graduation ceremony in December, at which he delivered the occasional address.

Swinburne University of Technology

- Dr Paul Hernandez Martinez joined Swinburne on 1 November 2017 (Senior Lecturer).
- Dr Andriy Pototsky has been promoted to level C.
- Dr Nadezda Sukhorukova has been promoted to level C.

University of Melbourne

- Peter McNamara (pure mathematics) has been appointed as Senior Lecturer.
- Susan Wei (data science) has been appointed as Lecturer.
- Volker Schlue (pure mathematics) has been appointed as Lecturer.

University of New England

- Dr Thomas Malinowski joined the School as Lecturer in Applied Mathematics on 22 January.
- Associate Professor Gerd Schmalz was promoted to Professor.

University of New South Wales

- Norman Wildeberger and Chris Tisdell have been promoted to Professor.
- Mike Hirschhorn has been promoted to Honorary Associate Professor.

University of New South Wales Canberra

- Duncan Sutherland has joined UNSW Canberra from Victoria University as Level B Lecturer.

University of Newcastle

- A/Professor James McCoy and Professor Natalie Thamwattana have moved from the University of Wollongong to the University of Newcastle.

University of Sydney

- Samuel Mueller and Laurentiu Paunescu have been promoted to Professor.

- Fabian Held has been promoted to Lecturer.
- Michael Stewart has been promoted to Senior Lecturer.

University of Wollongong

- A/Professor James McCoy and Professor Natalie Thamwattana have moved to the University of Newcastle.
- Dr Chayne Planiden has begun a contract position.
- Dr Kai Du has left, at the end of his contract.

Victoria University

- Duncan Sutherland has left Victoria University to join UNSW Canberra as a Level B Lecturer.

New Books

Central Queensland University

Guo, W.W. (2018). *Essentials and Examples of Applied Mathematics*, 1st edn. Pearson Australia. ISBN: 1488623821.

University of South Australia

Van der Hoek, J. and Elliott, R.J. (2018). *Introduction to Hidden Semi-Markov Models*. London Mathematical Society, Lecture Notes Series 445. ISBN: 978-1108441988.

Conferences and Courses

Conferences and courses are listed in order of the first day.

*For information about MATRIX programs,
see the report by Jan de Gier in this issue.*

Topology in Australia and South Korea 2018

Dates: 23–27 April 2018

Venue: POSTECH, South Korea

Web: https://cgp.ibs.re.kr/conferences/Topology_in_Australia_and_South_Korea/

Contact: workshop@ibs.re.kr

Organisers:

- Gabriel C. Drummond-Cole (IBS Center for Geometry and Physics)
- Philip Hackney (Macquarie University)
- Marcy Robertson (The University of Melbourne)

Mini-course Lecturers

- Kathryn Hess (EPFL)
- Dominic Verity (Macquarie University)

Confirmed Speakers

- Youngjin Bae (RIMS)
- Benjamin Burton (University of Queensland)
- Jae Choon Cha (POSTECH)
- Chang-Yeon Chough (IBS Center for Geometry and Physics)
- Pierre-Louis Curien (CNRS)
- Xing Gu (University of Melbourne)
- Hee Jung Kim (Seoul National University)
- Sang-hyun Kim (Seoul National University)
- Joan E. Licata (Australian National University)
- Aaron Mazel-Gee (University of Southern California)
- Byungdo Park (KIAS)
- Jessica S. Purcell (Monash University)
- David Roberts (University of Adelaide)
- Dominik Wrazidlo (Kyushu University)

Contact organisers for program details.

Index Theory and Applications to Positive Scalar Curvature and Related Areas

Dates: 4–8 June 2018

Venue: Level 7, Ingkarni Wardli Building, Adelaide

Web: <http://www.iga.adelaide.edu.au/workshops/IndexTheory2018/>

Species Distribution Models Using R

Dates: 12–15 June 2018

Venue: Myuna Bay Sport and Recreation Centre, NSW 2264

Web: <https://www.prstatistics.com/course/species-distribution-models-using-r-sdmr01/>

The aim of this four-day course is to work towards an understanding of, and practical ability to fit, species distribution models (SDMs). It will be useful if you plan to use SDMs, or if you just want to understand them better. We will focus on statistical models of species distributions—those that combine observed species records with environmental data.

Structural Equation Modelling for Ecologists and Evolutionary Biologists

Dates: 18–22 June 2018

Venue: Myuna Bay Sport and Recreation Centre, NSW 2264

Web: <https://www.prstatistics.com/course/structural-equation-modelling-for-ecologists-and-evolutionary-biologists-semr02/>

This course is a primer on structural equation modelling (SEM) and confirmatory path analysis, with an emphasis on practical skills and applications to real-world data.

AMSI Optimise 2018

Dates: 18–22 June 2018

Venue: The University of Melbourne, Parkville Campus

Web: <https://optimise.amsi.org.au/>

For further details, please see the website.

AMSI Winter School 2018

Dates: 2–13 July 2018

Venue: University of Queensland

Website and details coming soon!

2018 Annual Meeting of the Society for Mathematical Biology & the Japanese Society for Mathematical Biology

Dates: 8–12 July 2018

Venue: University of Sydney

Web: <http://conferences.science.unsw.edu.au/SMB2018/>

A conference on connections between mathematics and the medical and life sciences.

Targeted minisymposia; broad range of contributed papers; poster and discussion evening; prize talks; women in mathematics lunch; mentoring lunch; conference banquet at the edge of Sydney Harbour.

ATSIMA Conference 2018

Date: 10–13 July 2018

Venue: RMIT, Melbourne

Web: <https://atsimanational.ning.com/conf2018>

ATSIMA, together with the Wurundjeri people of the Kulin Nation, is excited to announce its 3rd Aboriginal and Torres Strait Islander Mathematics Alliance conference.

The conference will bring together a collaboration of leaders, educators and stakeholders from Community, education, research, and business sectors around Australia.

International Congress of Mathematicians

Dates: 1–9 August, 2018

Venue: Riocentro, Av. Salvador Allende, 6555 - Barra da Tijuca,
Rio de Janeiro, Brasil

Web: <http://www.icm2018.org/portal/en/>

The International Congress of Mathematicians (ICM) is the largest international congress in the mathematics community. It is held once every four years under the auspices of the International Mathematical Union (IMU). The Fields Medals, the Nevanlinna Prize, the Gauss Prize, and the Chern Medal are awarded during the opening ceremony on the first day of the congress. Each congress is memorialized by printed Proceedings recording academic papers based on invited talks intended to reflect the current state of the science.

As the first edition of the ICM in Latin America, as well as in the Southern Hemisphere, the ICM in Rio de Janeiro will give us an opportunity to reflect on the great progress of the region in terms of research and public awareness of mathematics.

See the website for an extensive listing of Satellite conferences.

Early Career Researchers' Day (International Society for Clinical Biostatistics and Australian Statistical Conference)

Dates: 30 August 2018

Venue: Melbourne

Web: <http://iscbasc2018.com/early-career-researchers-day/>

We welcome all students and researchers new to the field to join the Early Career Researchers' (ECR) Day during next years' joint International Society for Clinical Biostatistics and Australian Statistical Conference.

The aim of the day is to encourage discussion on how to be a good researcher and how to come up with statistical research projects of ongoing or future interest. This day should be used to share our personal experiences relating to statistical research and discuss how to deal with the potential pitfalls of the research process. Whether you are just about to graduate or have already gained some experience from working as a researcher or statistical consultant, you will benefit from meeting your peers, exchanging your thoughts and ideas, and getting to know more about how to shape a career in statistics. As such, the day will complement the main Conference which mainly concentrates on research results.

Sixty-second Annual Meeting of the Australian Mathematical Society

Dates: 4–7 December 2018

Venue: The University of Adelaide

Director: Dr T. Leistner

STEM Education Conference

Dates: Between November 2018 and February 2019

Venue: Central Queensland University

Contact: William Guo (w.guo@cqu.edu.au)

Discussion with international partners is ongoing on hosting a STEM education conference in Australia in November–December 2018 or January–February 2019. The conference aims at publishing high quality peer-reviewed papers in special

issues of ERA eligible journals or Scopus-indexed proceedings. Potential Australian partners are welcome to join the discussion and/or organising team.

Please contact William Guo for further information.

Vale

Leon Poladian

It is our sad duty to inform members that Leon Poladian of the University of Sydney passed away on Tuesday 13 February. Jacqui Ramagge writes ‘He was free of pain and surrounded by friends. We will feel his loss dearly. We can derive some small consolation from the fact that he had a very good year last year doing everything he wanted to do and that he had outstanding care from Lifehouse during his final weeks. The staff at Lifehouse commented on the amazing support Leon received from his friends and colleagues, and I want to thank everyone for the care they have shown. Our actions speak so much louder than our words ever could.’

Leon’s funeral was held at Camelia Chapel Macquarie Park Cemetery & Crematorium on Tuesday 20 February.

Visiting mathematicians

Visitors are listed in alphabetical order and details of each visitor are presented in the following format: name of visitor; home institution; dates of visit; principal field of interest; principal host institution; contact for enquiries.

- Professor Ramiz Aliquliyev; Azerbaijan National Academy of Sciences, Baku; November 2018; optimisation; FedUni; Adil Bagirov
- A.A. Ambily; Cochin University, India; January 2018 to January 2019; path algebras; WSU; Roozbeh Hazrat (r.hazrat@westernsydney.edu.au)
- Pere Ara; Autonomous University of Barcelona, Spain; May 2018; path algebras; WSU; Roozbeh Hazrat (r.hazrat@westernsydney.edu.au)
- Ms Li Deng; Central Southern University, China; 21 November 2016 to 20 November 2018; CUT
- Prof Steve Doty; Loyola University Chicago; 1 February to 30 April 2018; pure; USN; Andrew Mathas
- Prof Juan Enrique Martinez Legaz; Universitat de Autònoma Barcelona; November 2018; optimisation; FedUni; Adil Bagirov
- Bo Friis Nielsen; Technical University of Denmark; 31 January to 24 February 2018; stochastic processes; UAD; Nigel Bean
- A/Prof Ricardo Parreira da Silva; University of Brasil; 1 April 2017 to 31 March 2018; pure; USN; Daniel Daners
- Prof Dmitry Pelinovsky; McMasters University; 1 January to 30 June 2018; applied; USN; Nalini Joshi

Oscar Peralta Gutierrez; Technical University of Denmark; 29 September 2017 to 31 March 2018; stochastic processes; UAD; Giang Nguyen

Dr Krzysztof Przesławski; University of Zielona Gora; August 2018; FedUni; convex and discrete geometry; David Yost

Prof Keisuke Shiromoto; Kumamoto University, Japan; 1 September 2017 to 31 March 2018; coding theory and combinatorics; MNU; Graham Farr

Tim Stokes; University of Waikato, New Zealand; March/April 2018; semigroups; WSU; James East (j.east@westernsydney.edu.au)

Dr Jinxue Sui; Shandong Technology and Business University, China; 26 December 2017 to 25 December 2018; CUT

Ms Pei Wang; Central South University, China; July 2016 to June 2018; CUT; stochastic optimisation; Ph: 92663534

Mr Frederic Weber; University of Ulm; 15 March to 15 June 2018; pure; USN; Daniel Daners

A/Prof Junyan Xu; Fuzhou University, China; 1 March 2018 to 29 February 2019; mathematical biology; SUT; Tonghua Zhang

Dr Li Yang; Shandong Technology and Business University, China; 26 December 2017 to 25 December 2018; CUT

Zhengqiang Zhang; Lanzhou University; 1 October 2017 to 30 September 2018; ANU; Qinian Jin



Nominations sought for the 2018 Australian Mathematical Society Medal

The Medal Committee for the 2018 Australian Mathematical Society Medal is now seeking nominations and recommendations for possible candidates for this Medal, which will be awarded to a member of the Society, normally under the age of forty, for distinguished research in the Mathematical Sciences.

Nominations close on **25 May 2018**, should comply with rule 9 below and should be sent to <http://journal.austms.org.au/ojs/index.php/AMPA/login>. Nominators should receive an acknowledgement of the nomination: if this is not received, please contact the Committee Chair.

Nominations will not be automatically rolled over from previous years.

For further information, please contact the Chair of the 2018 AustMS Medal Committee, Dr C.M. O’Keefe (Christine.O’Keefe@csiro.au). The other members of the 2018 Medal Committee are Professor P.J. Forrester (Outgoing Chair), Professor A.W. Hassell (Incoming Chair) and Professor S.G. Lack (one year).

Visit <http://www.austms.org.au/AMSInfo/medal.html> to see a list of past AustMS Medal winners.

Rules for the Australian Mathematical Society Medal

1. There shall be a Medal known as “The Australian Mathematical Society Medal”.
2. (ii) This will be awarded annually to a Member of the Society, under the age of 40 on 1st January of the year in which the Medal is awarded, for distinguished research in the Mathematical Sciences.

The AustMS Medal Committee may, in cases where there have been significant interruptions to a mathematical career, waive this age limit by normally up to five years.

- (ii) A significant proportion of the research work should have been carried out in Australia.
- (iii) In order to be eligible, a nominee for the Medal has to have been a member of the Society for the calendar year preceding the year of the award; back dating of membership to the previous year is not acceptable.
3. The award will be approved by the President on behalf of the Council of the Society on the recommendation of a Selection Committee appointed by the Council.
4. The Selection Committee shall consist of 3 persons each appointed for a period of 3 years and known as “Incoming Chair”, “Chair” and “Outgoing

Chair” respectively, together with a fourth person appointed each year for one year only.

5. The Selection Committee will consult with appropriate assessors.
6. The award of the Medal shall be recorded in one of the Society’s Journals along with the citation and photograph.
7. The Selection Committee shall also prepare an additional citation in a form suitable for newspaper publication. This is to be embargoed until the Medal winner has been announced to the Society.
8. One Medal shall be awarded each year, unless either no one of sufficient merit is found, in which case no Medal shall be awarded; or there is more than one candidate of equal (and sufficient) merit, in which case the committee can recommend the award of at most two Medals.
9. Nominations for the Australian Mathematical Society Medal should include: (a) an extended citation, not more than two pages in length, arguing the case for awarding the Medal to the nominee; (b) a full list of publications of the candidate, with the most significant marked by an asterisk; (c) a curriculum vitae of the candidate’s professional career, highlighting any achievements which add support to the nomination; and (d) the names of three suitable referees, along with a brief statement as to their appropriateness.

Nominations sought for the 2018 George Szekeres Medal

The Medal Committee for the 2018 George Szekeres Medal is now seeking nominations and recommendations for possible candidates for this Medal. The George Szekeres Medal is awarded for outstanding research achievement for work done substantially in Australia. It is awarded only in even numbered years.

Nominations close on **25 May 2018**, should comply with rule 6 below and should be sent to <http://journal.austms.org.au/ojs/index.php/AMPA/login>. Nominators should receive an acknowledgement of the nomination: if this is not received, please contact the Committee Chair.

For further information, please contact the Chair of the 2018 George Szekeres Medal Committee, Professor C.E. Praeger (cheryl.praeger@uwa.edu.au). The other members of the 2018 George Szekeres Medal Committee are Professor R.H. Street (Incoming Chair), Dr R.S. Anderssen and Professor K.A. Landman.

Visit <http://www.austms.org.au/The+George+Szekeres+Medal> to see a list of past winners of the medal.

Rules for the George Szekeres Medal of the AustMS

- Rule 1.** The award is for a mathematical scientist who is a member of the Australian Mathematical Society and normally resident in Australia.
- Rule 2.** The medal may, in exceptional circumstances, be shared by at most two candidates.
- Rule 3.** The Medal is awarded every two years.

- Rule 4.** (i) The award is for a sustained outstanding contribution to research in the mathematical sciences. The candidate should have been resident in Australia when the bulk of the work was completed.
- (ii) The successful candidate will have an excellent record of promoting and supporting the discipline, through activities such as extensive graduate student supervision, outstanding contributions to leadership in the Australian Mathematical Society, or other activities which have materially promoted the mathematical sciences discipline within Australia.
- Rule 5.** (i) The George Szekeres Medal can be awarded to a recipient of the Australian Mathematical Society Medal, provided that the sustained outstanding contribution to research in Rule 4(i) is subsequent to the work for which the Australian Mathematical Society Medal was awarded.
- (ii) The George Szekeres Medal cannot be awarded to the same person on more than one occasion.
- Rule 6.** Nominations should include: (a) an extended citation, not more than two pages in length, arguing the case for awarding the Medal to the nominee; (b) a shorter citation, of not more than 100 words, which may be used to report the candidate's achievements in the event that the nomination is successful; (c) a full list of publications of the candidate, with the most significant (up to a maximum of 20) marked by an asterisk; (d) a curriculum vitae of the candidate's professional career, highlighting any achievements which add support to the nomination; and (e) the names of between three and six suitable referees, along with a brief statement as to their appropriateness

Nominations sought for the 2018 Gavin Brown Prize

The 2018 Gavin Brown Prize Selection Committee is now seeking nominations and recommendations for possible candidates for this prize, to be awarded for an outstanding and innovative piece of research in the mathematical sciences published by a Member or Members of the Society. The award will be for a single article, monograph or book consisting of original research, and published in the nine calendar years 2008–2016.

Nominators should provide a brief (1–2 pages) summary of what makes the nominated publication important and original, with appropriate references to prior or subsequent work in the field. They should also suggest the names of three assessors.

Nominations close on **25 May 2018** and should be sent to <http://journal.austms.org.au/ojs/index.php/AMPA/login>.

Nominators should receive an acknowledgement of the nomination: if this is not received, please contact the Committee Chair.

For further information, please contact the Chair of the 2018 Gavin Brown Prize Selection Committee, Professor S.O. Warnaar (o.warnaar@maths.uq.edu.au). The

other members of the 2018 Gavin Brown Prize Selection Committee are Professor J. Ramagge (Outgoing Chair), Professor N.F. Smyth (Incoming Chair) and Professor A.H. Welsh (one year).

Visit <http://www.austms.org.au/Gavin+Brown+Prize+winners> to see a list of past Gavin Brown Prize winners.

Rules for the Gavin Brown Prize

1. The Gavin Brown Prize will be awarded annually for an outstanding and innovative piece of research in the mathematical sciences published by a Member or Members of the Society.
2. Each award will be for a single article, monograph, or book, consisting of original research, and published in the 9 calendar years $Y - 10$ to $Y - 2$, where Y is the year of the award.
3. To be eligible for the award of the Gavin Brown Prize, a publication must have at least one author who must
 - (i) be a member of the Society, and have been a member of the Society for the calendar year at the time of publication of the paper (back-dating of membership is not allowed);
 - (ii) normally be resident in Australia, and have been normally resident in Australia at the time when the research was carried out.
4. In the case of publications with multiple authors, the prize will be shared by all authors. The existence of authors who do not meet the conditions in Rule 3 will not preclude this award, although the Selection Committee may take it into account in assessing the achievement of the author(s) who do meet those conditions.
5. The Selection Committee may deem a publication ineligible if an author has previously received an award from the Australian Mathematical Society for a body of research which included the publication in question.
6. Nominations for the Gavin Brown Prize will be called for in the first half of each year. A publication may be nominated for the award by anyone who is not an author of that publication.
7. The award will be decided by a Selection Committee appointed by the Council.
8. The Selection Committee will consist of 4 persons:
 - (i) 3 persons each appointed for a period of 3 years, namely a Chair, an Incoming Chair who will become the Chair in the following year, and an Outgoing Chair who has been the Chair in the preceding year;
 - (ii) 1 person appointed for one year only.
9. The Selection Committee may consult with appropriate external assessors. Nominators are requested to suggest names of three assessors.

News from the annual conference

The Society's 61st Annual Meeting was held in December at Macquarie University. The Directors, Professor Paul Smith and Professor Xuan Duong, their team of local organisers and the Program Committee, led by the Vice-President (Annual Conferences), were responsible for a very successful conference.

The following matters from the meeting are provided here for the information of those who could not attend.

- (1) The Australian Mathematical Society Medal for 2017 was awarded to Dr Richard Garner of Macquarie University and Associate Professor Anthony Licata of the Australian National University.
- (2) The Gavin Brown Prize was not awarded in 2017. The Selection Committee encourages members to nominate outstanding publications, published between 2008 and 2016, for consideration for the 2018 Prize.
- (3) The newly established Mahony-Neumann-Room Prize, for a publication in one on the Society's journals, was awarded for the first time.

The 2016 Prize, for an article in the Journal, was awarded to Mark V. Lawson for the paper 'A noncommutative generalization of Stone duality', *J. Aust. Math Soc.* 88 (2010), 385–404.

The 2017 Prize, for an article in the Bulletin, was awarded to Jason P. Bell, Michael Coons and Kevin G. Hare for the paper 'The minimal growth of a k -regular sequence', *Bull. Aust. Math Soc.* 90 (2014), 195–203.

The 2018 Prize will be for an article in the ANZIAM Journal and will be selected based on nominations by the Associate Editors.

- (4) The 2017 B.H. Neumann Prize was awarded to Michael Hallam (University of Adelaide) for his talk 'End-periodic K -homology and positive scalar curvature' and Adrienne Jenner (University of Sydney) for her talk 'Modelling heterogeneity in biology: How do cancer-killing viruses interact with tumour cells?'.

Honourable mentions were given to Becky Armstrong (University of Sydney) and Harry Crimmins (University of New South Wales).

- (5) There was a successful *Women in Mathematics Dinner* on the Monday preceding the conference.
- (6) The meeting contained a debate, chaired by Adam Spencer, on the topic 'The traditional mathematics blackboard lecture is dead'. The audience decided that the motion was defeated.
- (7) At the AGM the fee for Life Membership at Retirement for Members over 55 years was set at \$280, reduced from \$690 in 2017.
- (8) At the AGM, it was confirmed that the sixty-second Annual Meeting of the Society will be held at the University of Adelaide from Tuesday 4 December to Friday 8 December 2018 with Dr T. Leistner as Director.

It was provisionally determined that the sixty-third Annual Meeting of the Society will be held at Monash University from Tuesday 3 December to Friday 6 December 2019 with Professor I.M. Wanless as Director.

- (9) Council decided to establish an Equity, Diversity and Inclusion Committee.
- (10) Council decided to establish a new position of Vice-President (Learning and Teaching).
- (11) Council has established two annual Teaching Excellence Awards, each of \$1,000, one of which is to be restricted to early career teachers, including sessional teachers and PhD students. It is hoped that detailed guidelines for the nomination and selection process can be decided in time for awards to be made in 2018.

Applications for Special Interest Meetings

Applications are now considered twice a year. The next closing date is Monday 18 June 2018 and the following one is Sunday 18 November 2018. Applications are required at least three months in advance of the meeting.

If funding is being sought from both AustMS and AMSI, a single application should be made at <http://research.amsi.org.au/workshop-funding/>.

If funding is not being sought from AMSI, please use the application form available at <http://www.austms.org.au/Special+Interest+Meetings> and send it to the secretary, Peter Stacey ([hrefmailto:Secretary@austms.org.au](mailto:Secretary@austms.org.au)Secretary@austms.org.au).

To reflect recent funding allocations, caused by budgetary constraints, Council reduced the maximum grant for each meeting to \$3,500.

Peter Stacey
AustMS Secretary
Email: P.Stacey@latrobe.edu.au



Peter Stacey joined La Trobe as a lecturer in 1975 and retired as an associate professor at the end of 2008. Retirement has enabled him to spend more time with his family while continuing his interest in mathematics. He took over as secretary of the Society at the start of 2010.

The Australian Mathematical Society

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Membership and Correspondence

Applications for membership, notices of change of address or title or position, members' subscriptions, correspondence related to accounts, correspondence about the distribution of the Society's publications, and orders for back numbers, should be sent to the Treasurer. All other correspondence should be sent to the Secretary. Membership rates and other details can be found at the Society web site: www.austms.org.au.

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