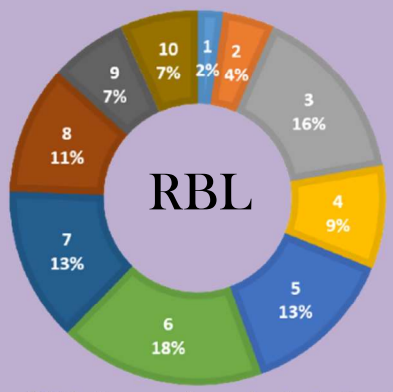
HERIOT WATT UNIVERSITY

The Maths Newsletter

Join our team!

Department News and Events

Volunteers Needed



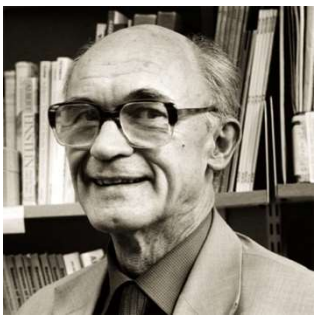
With Support from the Jack Carr Fund

From Heriot-Watt to the British Antarctic Survey

An Interview with Jakub Stocek

Department News and Events

Emeritus Professor Oliver Penrose received an honorary degree on Wednesday, December 8 for recognition of his long service to the University and to his subject, and of his worldwide renown as a versatile, original, and creative mathematical scientist.



He was a Professor of Mathematics at Heriot-Watt University from 1986 until his retirement in 1994 and is still active in research now. In his work he made key contributions to statistical mechanics and related topics such as the kinetics of phase transitions in metals and the physical chemistry of surfactants.

We have not had the opportunity to interview Oliver ourselves yet but you can check out his interview with Sir John Ball here: www.hw.ac.uk/uk/schools/mathematical-computer-sciences/departments/maths/oliver-penrose-in-conversation-with-john-ball.htm

Maths Café Talks

The Maths Café and the Maths Gym are very happy to introduce short talks on different mathematical topics aimed at an undergraduate audience. Recordings of previous talks can be found here https://mathsgym.hw.ac.uk/past-maths-cafe-talks/. Some talks to come:

- Lotte Hollands – 16th February
- Pamela Docherty – 23rd February

Maths Society

- Board Games – 12th January 13:00 at the Maths Gym
- Maths Bee – 19th January 9:30

Are you interested in problem solving and stretching your maths skills? Then listen here, in week 2 on 19th January, Student Maths Society will be running a fun problem-solving challenge called Maths Bee. You will be given one timed maths problem to solve individually. There will be around 20 problems and the event will last approximately 2 hours. Refreshments will be provided through the event.

This challenge is supposed to be fun and welcomes people of all mathematical abilities. For registration send your name(s) by 15/01 to the following email address: dah8@hw.ac.uk

ICMS Workshop - Mathematics: Inclusive or Exclusive? Putting colour, culture and context into the curriculum - https://www.icms.org.uk/events/workshops/MIE22

Scottish University Maths Olympiad (SUMO)

Probably happening around Saturday 5th March this year! Look out for more information, get in touch with: sums@st-andrews.ac.uk or directly join the Olympiad mailing list at https://forms.office.com/r/DZgKuqvteQ

Some Career Related things

For those considering MSc studies, applications are now open!

If you are interested in doing a PhD, then applications for many PhD training centres (CDTs) are now open until around early February. Check out our own Maxwell Institute Graduate School: https://www.maxwell.ac.uk/graduate-school/. You can find more PhD opportunities for many other universities advertised through pages such as jobs.ac.uk or findaphd.com.

For anyone with an interest in robotics, the Edinburgh Centre for Robotics are offering 14 fully funded places available in September 2022. Closing date for applications is Friday 28th January 2022. www.edinburgh-robotics.org/apply

Financial Support

Applications to The Annual Fund and the Mary Burton Fund are now open for student-led projects that have an impact on the student experience or widen Heriot-Watt's global impact. www.hw.ac.uk/study/fees/financial-support.htm

School Officer

Lucy Welford

Hello and welcome back! I hope you had a good winter break and are refreshed ahead of the new semester. As always, I'll be working closely with staff in the department and our team of dedicated class reps to make this semester the best that it possibly can be for all maths students. In particular, I'm working to combat isolation and loneliness that some students have experienced when learning during RBL and making sure that students are best supported ahead of the change to 4 hour exams in Semester 2. As always, any problems or issues relating to your studies, please don't hesitate to contact myself at so.maths@hw.ac.uk or do reach out to the class reps in your year group.

Piscopia Initiative

Gemma Crowe

The Piscopia Society is a UK-wide initiative which aims to encourage women and non-binary students to pursue a PhD in Mathematics.

Upcoming Events:

- Tuesday 25 January, 1-2pm PiWORKS seminar talk by **Professor Mihaela van der Schaar** (University of Cambridge).
- Tuesday 15 February, 1-2pm, **Non-traditional Career Paths into Academia** – panel discussion with women and non-binary Mathematics researchers.
- Tuesday 29 March, PiWORKS seminar talk by **Dr Maria Bruna** (University of Cambridge)
- March, "What to expect from a PhD" (more soon)

To find out more about the society and other events please visit https://piscopia.co.uk/ or contact your Heriot-Watt representative Gemma: ggc2000@hw.ac.uk

Heads of Years

Year 1 (Mark Lawson)

I hope you all had a good holiday. The marks for your first semester courses will not now be released until 18th February. This is much later than usual and is, I am afraid, down to the pandemic. This does not affect your second semester courses since you are allowed to take those irrespective of how you did in semester 1. The decision about resits will not be made until June; I will contact you then. If you want to change your programme then you should contact me ASAP; changes within maths are usually easy but if you want to change to a programme outside of maths then this is much harder and not automatic. In any event, the sooner you talk to me the better. It remains to be seen how semester 2 shapes up, but I would encourage you to take advantage of any face-to-face teaching that is offered if you are able to.

Finally, the shortest day is over and so the days are gradually getting longer; this cheers us all up.

Good luck for semester 2. Mark

Year 2 (Thomas Wong)

Happy holidays! Semester 2 is almost upon us. :) With RBL still in effect, be sure to check each course (especially optional courses) to see what is expected of you and if any face-to-face options are offered. To help stay motivated during the semester, try to create a regular schedule to engage with the content and create study groups where appropriate. As always, your personal tutor and myself are available should you have any questions or concerns.

Year 3 (Alexandre Martin)

Dear students, First of all, I wish you all a happy and successful new year! I hope you enjoyed the holiday and had some well-deserved rest. As you are about to embark on a new term full of beautiful and interesting mathematics, remember that you can sample the various optional courses by asking the lecturer to be made an observer on Canvas. This will allow you to get a better idea of what is covered. Now is also a good time to reflect on how semester 1 went for you, and to use this knowledge to adapt the way you organise your studies this semester. Finally, remember that your lecturers want you to succeed, so don't hesitate to get in touch with us throughout the term. All the best for the term ahead! Alexandre

Year 4/5 (Laura Ciobanu)

This is your final semester! The COVID uncertainty stays with us, unfortunately, but there are many things about being a student that you will miss, so take the time to cherish them.

The only novel component this semester is your dissertation. It is daunting for most students to write a 20-30 page document. My advice is to write a bit of text from early on, even if it is not polished, so that you're not faced with writing everything before the deadline. Think of the dissertation as preparation for the many reports you will have to write in your life no matter what line of work you will go into. It's not just the maths, it's how you present a topic, how you explain complex ideas, and how you connect to your audience.

Finally, enjoy the thought that you will never have to take exams again after this summer!

The Importance of Career Planning

Lindsay Wilson (MACS Careers Consultant)

Lindsay has very valuable advice and we had to summarise the key points below for brevity reasons, you can find the full article here:

It's never too early to consider and plan for your next steps after university. Creating a career development plan early on will help you to identify and achieve your goals not just after your studies but throughout your working life. It involves four key steps:

1. Self-Awareness: identify your skills and interests.

Think about: your technical, specialist and transferable skills, qualifications and interests. Also consider the wider environment you could thrive within (consider the type of industry/sector/company, culture, size, team etc).

2. Opportunity Awareness: research the job market.

Review graduate/industry job boards, professional associations, employer directories, websites of companies you would like to work for and search on LinkedIn to identify where previous graduates of your course have moved on to; attend employer events and careers fairs.

Speak to those working in the industry/company/role you are interested in to develop further understanding of your options. Undertake work experience (internships, volunteering, job shadowing etc) to gain greater insight into areas you are interested in.

3. Decision Making: make realistic choices.

Do you meet the job requirements? Where do the gaps exist? Does the job meet your priorities? What are the pros and cons of different opportunities?

Speak to and bounce your ideas off of others, then reinforce any decisions by undertaking further work experience and allow time to reflect on decisions.

4. Taking Action: put your decisions into effect.

What does the recruitment process involve? What are the different interview question types? What is involved in an assessment centre? Prepare a tailored CV for *each and every* position. Book in for mock interviews and mock assessment centres.

Around 70% of opportunities are not advertised by employers. Be proactive and develop speculative applications for roles and companies you are interested in.

Discover your career options and build your experience from second year by taking part in Insight Days, Spring Weeks/Insight Weeks, Summer Internships/Vacation Schemes, Industrial Placements/Year in Industry, Networking Events, Mentorship Programmes, and Graduate Schemes.

Graduate employers are already advertising their 2022 opportunities now!

Your Careers and Graduate Futures Service is here to support you throughout your university journey and beyond.

From Heriot-Watt to the British Antarctic Survey

Recently we sat down with Jakub Stocek of the British Antarctic Survey (www.bas.ac.uk/profile/user_3357-2/). See the full interview on YouTube (or using the QR code): https://youtu.be/dju77-KkA2k. If you are interested in project opportunities and funding check out here: https://www.bas.ac.uk/science/science-and-students/

Could you tell us about your current job, and how you got there since graduating?

I currently work for the British Antarctic Survey as an ice structure modeller, trying to understand the processes in the Antarctic and Greenland ice sheets that contribute to the sea level rise. I finished my Bachelor's in Mathematics at Heriot-Watt University in 2016, before starting my PhD at the Maxwell Institute Graduate School for Analysis and Applications, which is a joint venture between Heriot-Watt University and the University of Edinburgh. I defended my thesis in 2020 and from September that year I have been a part of British Antarctic Survey.

As part of this big consortium of researchers at Project Sea Level Rise (https://protect-slr.eu/) we are working to narrow down the uncertainty margins on different climate change scenarios that come from melting ice. The IPCC has recently published its new report and there are different scenarios for how much CO_2 emissions we allow for, but the crucial part is that we don't actually understand what's happening to this big chunk of ice that's all around the globe somewhere.

In Retrospect, what was the most useful thing you learned during your degree?

It's important to develop your own routine that suits you and others around you. Obviously, you have other commitments, but everyone has a wonderful chance of trying what works for them and what doesn't. Experimenting with this is certainly rather useful during an undergraduate degree.

The second thing that I've definitely learned is that if you need help then ask for it, there are people that will help.

Otherwise, more maths related: if you are looking for a job, the job title will very rarely say "mathematician". You should look around quite widely and check out any company you are interested in. They are just hiding in plain sight! There is a really broad range of things that you can do with maths. You are told some of them in primary and secondary school, then in university they tell you something more, and eventually you realise more and more what you can actually do.

What kind of maths enters into the work you do now, and how does it enter?

I use maths on a daily basis. I develop mathematical models that help us understand if we will have Antarctica in the shape that we know it at all, in one or two hundred years. The crucial question is: why do we need a big complicated model to understand a giant block of ice? The answer is kind of convoluted.

At the big scales ice is an extremely thick fluid. In certain places, near the centre of the ice sheet, it moves really slowly at maybe 10 metres per year. Along the coast it moves more like thousands of metres per year. The interior of the ice is thicker and the surface is higher, therefore you have cooler weather, and at the coast the temperature is warmer and there the ice also comes into contact with relatively warm ocean water. The question is how much will melt or break off, and so you need to know how quickly it moves and how it breaks, and for this you need a fairly big computer with fairly big simulations. However, there are a lot of uncertainties. You don't know what happens at the coast, how exactly it interacts with the seawater, what happens if it hits some obstacle or where the ice will actually go.

My job is to understand what happens and how it happens. I use a simpler version of the Navier-Stokes equations (which you can see in the applied courses at Heriot-Watt). I then modify these and include some other things while still making sure the problem makes sense. Then I write a lot of computer code and simulations, and make sure that these simulations converge to a correct solution.

Did you always know that you wanted to go into this area?

No. I learnt about the British Antarctic Survey maybe ten or twelve years ago, and I knew at some point I wanted to do something with maths. So I went and did my undergrad, after which it made sense to go into a PhD. Then last year I was looking for a job, and the British Antarctic Survey was always kind of in the back of my mind and I found a job with them. So no, I didn't know that I wanted to do precisely this, but something with mathematics was always an option for a long time.

Are there any challenges you personally faced since leaving university?

Going into a new research area is certainly a challenge, but in some respects because you are new in that area you have a certain excuse to ask silly questions for a while. Everybody probably has the worry of not wanting to ask silly questions, and then people tell you there is no such thing. And while that is probably true when entering a new research area you can ask the silliest possible questions, like what is that acronym that I don't know and should probably know if I have been working on something for half a year!

Do you have any words of wisdom for us?

Find a thing that makes you happy and gives you fulfilment. If you think that something is interesting or sounds interesting then try it, go for it. Maths crops up in a lot of unexpected places so if you want to do mathematics it's everywhere. It's all around us in all possible different jobs, in all possible different places so go for what makes you happy.

Year 4/5 Courses

Here are some unofficial course descriptions from our lecturers to help you choose your year 4/5 courses.

Maths Biology B/Maths Medicine (Cathal Cummins)

If you have ever wondered how tigers get their stripes or how strong the immune response must be to prevent cancer invasion, then this course is right up your street.

In this course, we will model physiological processes such as tumour growth and the action of enzymes in the body. My favourite part of the course is travelling waves; in particular, I like the part of the course where we use travelling waves to model the healing of epidermal wounds.

We use similar mathematical methods (phase plane analysis etc.) as in Maths Bio A in Semester 1, so it would be helpful to you if you are familiar with these techniques.

Geometry (Alessandro Sisto)

Come along, we will draw lots of pictures and we will discover the mathematically correct way to eat pizza! :)

The course is about 1- and 2-dimensional objects, that is, curves and surfaces. We all have an intuitive idea that a curve, well, curves around in space, but how do we measure this? A surface can be flat or not flat, but how do we capture this mathematically? We'll find out!

Pure Maths D/F (Anastasia Doikou)

(*This course is only taught every other year and alternates with Lie groups and algebras)*

This course is divided in two parts. In the first part we introduce the main mathematical set up of discrete quantum mechanics. We introduce basic quantum mechanical concepts such as quantum states, observables and time evolution of quantum systems. We discuss the time dependent and time independent Schrödinger's equation and we use this as a background to study non-linear PDEs that display soliton (particle-like) solutions in the second part of the course.

In the second part we study basic ideas in the theory of solitons. Solitons are solutions of certain non-linear PDEs and are localized travelling wave packets that maintain their shapes as they travel, and emerge unaltered after interacting with each other. Due to their unique properties solitons have a plethora of applications including optical fibers, water wave and tsunami formation, Bose-Einstein condensates among others. The soliton is part of Heriot-Watt history being discovered by J. S. Russell who noticed a solitary "wave of transition" that travelled for great distance on the Union canal just 1 mile from campus.

Numerical Analysis D (PDEs) (David Bourne)

Why you should take this course: The finite element method is used to design Dyson vacuum cleaners!

In this course we will analyse and implement numerical methods for solving PDEs, namely finite difference and finite element methods. The moral of this course is 'think before you compute'; we will see that even the most reasonable looking methods can fail. Counterintuitively, using a more accurate approximation of the 2nd-order derivatives in the heat equation can lead to a (catastrophically) worse approximation! For me, the highlight of the course is proving (half of) the Lax Equivalence Theorem, which is one of the most important theorems in numerical analysis.

Data Assimilation (Simon Malham)

Shout it: "Sharpie-gate!", whisper it: "Covid!"

We assemble the skill set necessary to tackle, e.g. weather forecasting. Here we have a mathematical model with uncertainty, we have partial weather data from satellites and stations which also contain uncertainty, and our goal is to produce a forecast from these two combined, that minimises the uncertainty.

Stochastic Simulation (Lehel Banjai)

Take this course if you would like to understand how randomness affects physical processes and how to model this on a computer.

The course introduces the concept of a stochastic process (family of random variables), stochastic differential equations, and their numerical modelling. Throughout, applications stemming from physical processes and finance are used as a guide and motivation. Two Python assignments illustrate the use of the numerical methods developed in the course.

You can find the official course descriptions here:

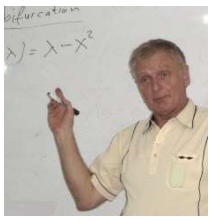
Year 4: http://www.macs.hw.ac.uk/students/wp-content/uploads/4thyear2021-2022.pdf

Year 5: http://www.macs.hw.ac.uk/students/wp-content/uploads/5thyear2021-2022.pdf

Jack Carr Fund Grants Scheme

Robin Knops

Applications under the above scheme are invited at any time for grants not exceeding £500 and should be submitted by email to June Maxwell *j.maxwell@hw.ac.uk*. The Departmental webpage provides further particulars and also an Application Form for use if preferred. Alternatively, applicants should send an email stating name, degree course and year, brief description of intended use of the grant, and estimated cost. The scheme is open to Heriot-Watt University students currently registered in Edinburgh for an undergraduate or postgraduate degree normally in the mathematical sciences.



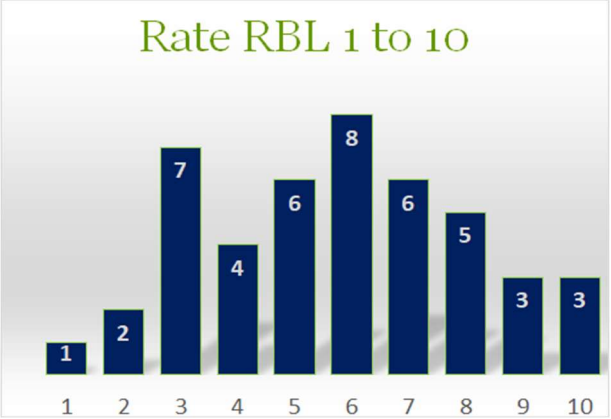
For informal advice, please consult Professor Robin Knops *r.j.knops@hw.ac.uk*

Responsive Blended Learning: Your response

We recently asked all of you (Years 1-5) for your opinions on the RBL scheme. We received a total of 45 out of (approximately) 300 responses on our questions;

- On Scale of 1-10 rate RBL
- Describe RBL in three words.
- Positive/Negative side of RBL.

On average your rating of RBL was 5.4/10. Perhaps quite unexpectedly, there were very few extremes!



The word cloud demonstrates the most used words to describe RBL.

Below we have collected some representative responses of RBL, which show much stronger opinions.

We would just like to stress here that having and giving your opinion on what you are directly affected by and involved in is a good habit and often essential in life.

Make a Wish: https://forms.gle/tJmb8yFWqeFN4pT19

There is not as much support from professors as I would like. I doubt RBL is the definitive answer.

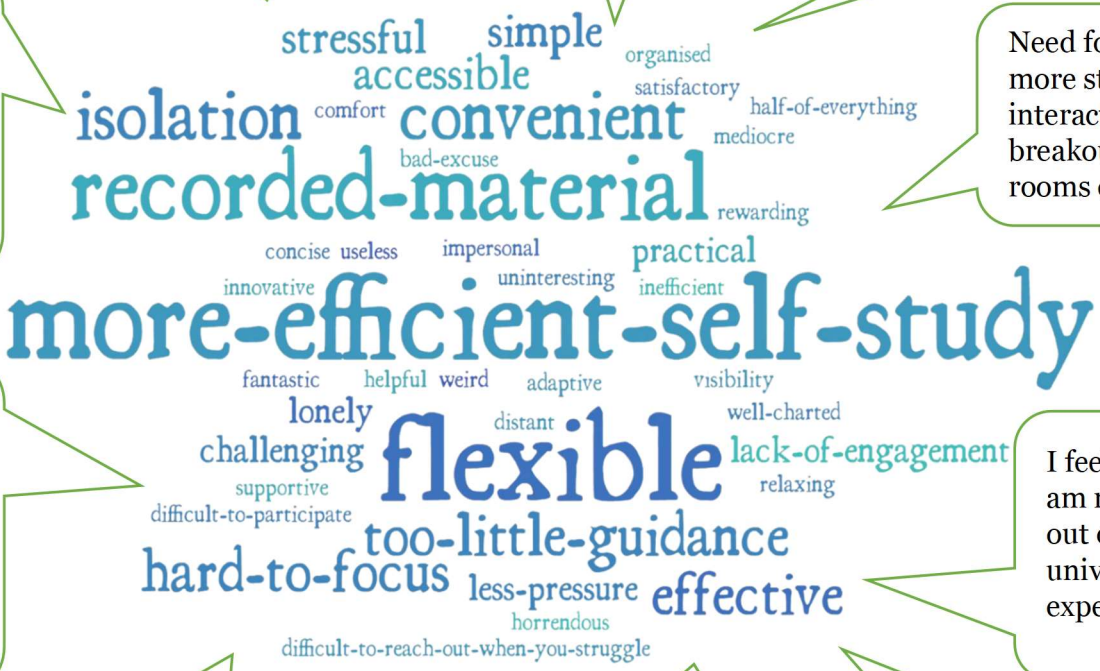
It is a good way to train self-discipline and realise my potential to be independent and learn on my own account.

My grades and interest in my subject is greatly declining because of RBL.

It allows me to focus on understanding the content rather than acing tests in a short amount of time. I think the future is this.

RBL itself just feels inferior to on-campus teaching. I was disappointed to see that not much changed about it since last year.

Need for more student interaction, breakout rooms etc.



Lecturers should make more videos in reaction to problems students are having as sometimes the current ones are not enough.

I feel like I am missing out on my university experience.

Everything is in one place, recorded, stored online and fairly simple to use. I can go back and forth between previous lectures, rewatch if they go too fast and learn when it suits me, which improved my learning experience.

Asking questions was a lot easier in person, I could ask many smaller questions throughout a lecture whereas now I have to ask one large question to cover one main problem.

It is impossible to concentrate from the same space where you sleep, and spend all your personal time, lectures used to be a space of constant focus and attention, which was made easier with your peers around you.

How to Keep Squirrels in Line

(Puzzle Solution)

Recall from last time: *We had a (countably) infinite number of squirrels and two kinds of nut. The squirrels get into a line and given a nut; and they only know the type of nut the squirrels in front of them have (this does not include their own). The squirrels must guess simultaneously what kind of nut they have and can only leave the line if they guess correctly. Our goal was to come up with a strategy so that only a finite number of squirrels stay in the line.*

Let us assume that we are a squirrel. Our goal is that only finitely many of us guess wrong, but we all must guess at the same time. We can consider the infinite line of squirrels guessing one of the two types of nuts as a sequence of 1s and 0s (call them 1 and 0 for particularly tasty nut flavours). Once all of us have made a guess, this sequence of nuts might look something like

0 1 0 1 1 0 1 0 1 0 1 0 1 1 0 1 0 1 0 0 0 1 0 1 1 0 1 0 1 1 1 ....

The key is to divide all the possible sequences into equivalence classes. If you haven't heard of equivalence classes before, you may think of the 'classes' part as a collection of baskets. The 'equivalence' part tells us that if sequence A is in the same basket as B and B is in the same basket as C then A and C must also be in the same basket. (There is more to equivalence classes, but this will suffice for now).

We can specify the 'relation' by which we sort the sequences into the equivalence classes. We will say that sequences A and B are related if they only differ in finitely many terms.

*Now we call upon the axiom of choice!** Equivalence classes have representatives. You can think of this as a label on each basket. The one thing we must all agree on as our strategy is which representative to choose for each equivalence class. Once we have labelled our baskets, there is nothing more left to do than compare the sequence of nuts we see in front of us - when standing in line - to the label on each box. We must simply find the box with the correct label and declare the type of nut which appears in our spot.

(Note: we do not need to know the finitely many digits that came before our spot in the sequence for this as the full sequence will be equivalent to the representative.)

The equivalence classes will now take care of ensuring that only finitely many of us guess wrong. (This is subtle so I would encourage you to take out your pen and convince yourself of this using the properties of equivalence relations.)

Thank you, Stefanie Zbinden, for this puzzle!

***Aside on the axiom of choice:** The axiom of choice is an axiom of set theory. To demonstrate its use, let's imagine we have a collection of baskets with infinitely many presents in each basket. If we *assume the axiom of choice*, we are now able to select from each basket a particular present. Even if there were infinitely many and we could not possibly know how to make this choice in a "real life situation" of a never-ending collection of presents.

The axiom of choice was first formulated in 1904 to be used in the well-ordering theorem, which for example allows us to use ≤ on the natural numbers.

Although originally controversial, the axiom of choice is now used without reservation by most mathematicians, and it is included in the standard form of axiomatic set theory. One motivation for this use is that a number of generally accepted mathematical results, such as Tychonoff's theorem, require the axiom of choice for their proofs. Contemporary set theorists also study axioms that are not compatible with the axiom of choice, such as the axiom of determinacy.

Maths Newsletter

Thank you for reading this far and for continuing to support this project! We hope that everyone had a good festive season and is looking forward to the upcoming semester.

With this issue we would like to give a big thank you to some of our contributing members who are leaving or have recently left Heriot-Watt. Firstly, we would like to thank Heiko Gimperlein, who has been with us since the beginning and been a tremendous help in getting and keeping this project up and running. We would also like to thank both Michael Driscoll and Jay Sinclair for their help in making the first editions of the newsletter. We wish everyone leaving us the best in their future endeavours!

On a different note, we are excited to welcome our new members to the team, including Laura Ciobanu and Mahsa Manzari, both of whom have already contributed to both this and previous editions. We would like to give a huge thank you to everyone who made this project possible. A special mention to Jonas Lotter and all the people who took the time to contribute towards the Newsletter and the Jack Carr Fund for supporting us in this endeavour.

We hope you are as happy with the final product as we are.

The *Maths Newsletter* team

The Team

Clara Flegel

David Taylor

Mahsa Manzari

Heiko Gimperlein

(PREVIOUS ISSUES)

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