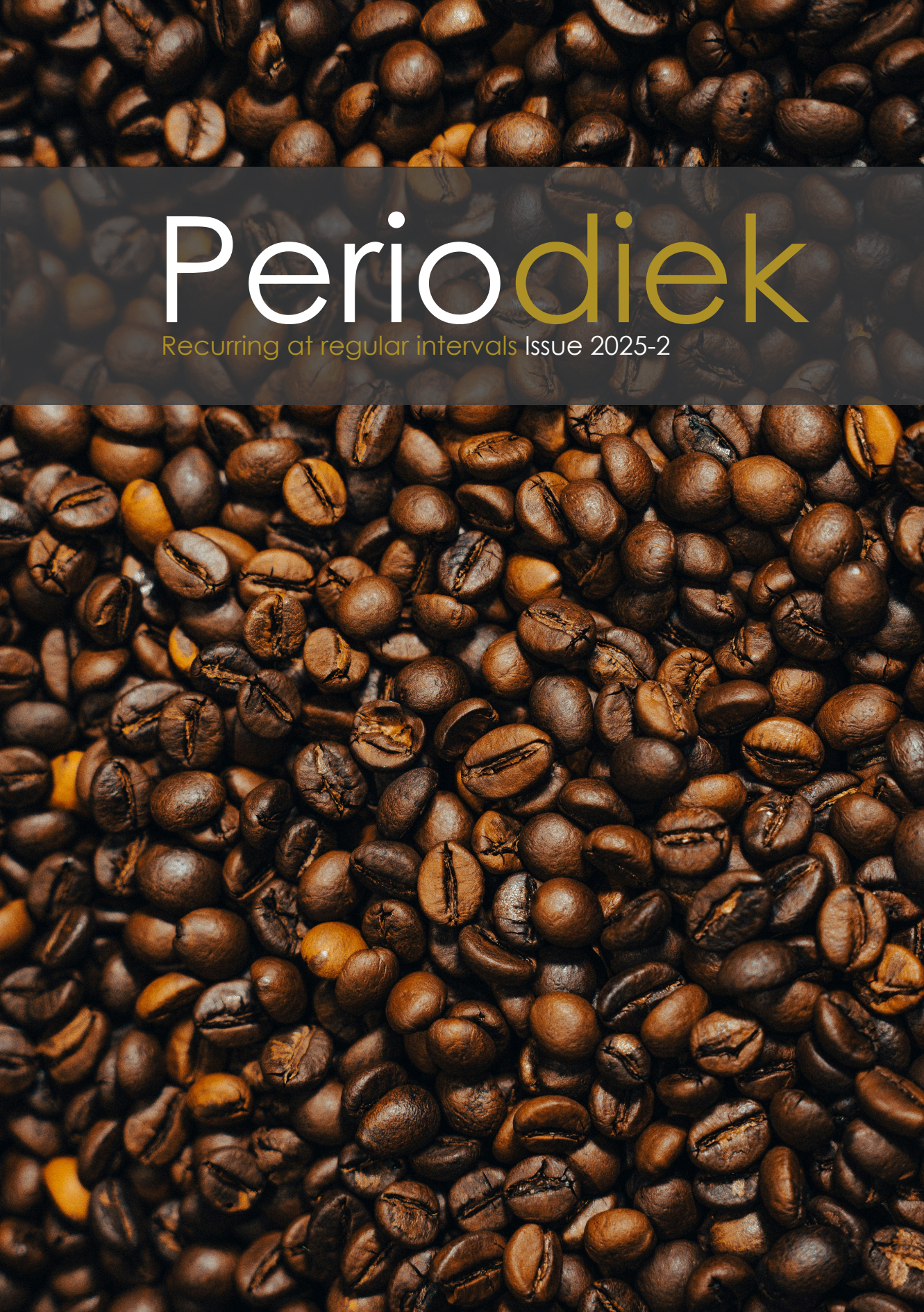


Periodiek

Recurring at regular intervals

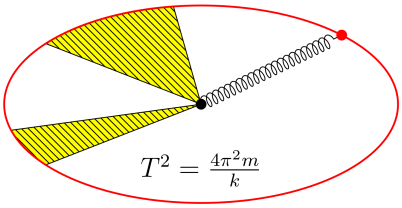
Issue 2025-2

Perio Interview: Manuela Vecchi - 8

Having lived in many parts of the world, Manuela Vecchi, with a fascinating background story, is an astronomy professor and a Rosalind Franklin Fellow. In this issue, we interviewed Manuela and got answers to important questions about working in academia, her fascinating career, and her favourite book.

Planets $\sim$ Springs - 19

Springs, oscillations, and planets have nothing in common, right? That is why they are taught in different courses. But is that true? In this article, Tamás Görbe reveals the connection between springs and everything else in physics.



24 - Book Reviews

Find out what your next read is going to be with the book reviews of some of the members of the Perio*diek*. Maybe you want to read more about the history of mathematics or join Gulliver on his adventures? Or maybe gay vampires or historical fiction about heartbreaks are more your thing? Stick around and read our opinions to find out.

In this Periodiek

Editors
Yoana Savova,
Qianyi Huang,
Annisa Nijlant,
Luci Addams,
Ioana Balint,
David Rosa,
Robert Mol,

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From the Editor in Chief

Recently, I celebrated my fantastically shaped birthday. Not only were the day and the month of my birthday a cube and a square number, the year is also a cube. On top of that, I also celebrated an age which is a cube number and I will let you figure out how much that is.

Unfortuantely, Stefi has recently left the committee. We thanks her for all her creative ideas and hard work. In her place, two new people have joined the Perio*diek*, David and Annisa are our two new editors. The days of having 3 Robert's in the Perio*diek* are now well and truly behind us.

This issue, we also have a higher-than-usual focus on food statistics and reading. You can read about an experiment surrounding potato chips and find out what the new FMF coffee machine has been dispensing. And I don't even like coffee...

Robert Mol

From the Board
Treasurer

AUTHOR: **J. PRUIM**

Hello everyone, my name is Jorian and today I will be the author of one of my favourite sections: From the Board.

This year I had the honour of being the one in charge of the financial administration of our beloved association. Of course, as goes for every board member, if you told me this factoid a couple of years ago, I would not have believed you. However, in hindsight, I should not be so surprised. I come from a family of financial minds, as my father is an accountant (whom I got a lot of advice from in my bookyear), my sister is a fresh graduate from the Faculty of Economics and Business, and my grandpa is a retired bookkeeper for a construction company. Thus, even with my choice to become a mathematician, this dabble in the language of money was bound to happen.

If there is one thing I can take away from this year, it is the following: "Bookkeeping is easy, treasuring is hard". The former is a deceptively well-kept secret in the world of business and accounting, as (mathematically speaking) you are only bound to two equations. The first one demands that your balance is, well, in balance. Alternatively, it asserts that your equity is the difference between your assets and liabilities. The second equation states that the change in equity over your year (your result), is the difference between income and expenses. Sounds easy, no?

Figure 1: Jorian Pruim

However, I also claim that treasuring is hard. This difficulty does not stem from the repetitive tasks like processing declarations or importing ticket sales from events with a sign-up cost, as there is rather something therapeutic for that. No, the most annoying part of treasuring is unfortunately talking to other people. Debts tend to pile up, and you are the one to tell those students who did not have the best of luck with our governments financial and education policy. Also, direct debits tend to get reversed if someone thinks they are not eligible for a cost that you informed them about beforehand. Still, this is also the part of treasuring where I learned the most, and I am forever grateful to my fellow board members who helped me with these tasks.

"Bookkeeping is easy, treasuring is hard."

In conclusion, I look back on a great year. It was a blast going to all those consti's, national meetings, and FMF events, and I look fondly onto the memories I made with my fellow board members. I am proud of the steps we have taken behind the scenes, and look forward to give a cleaner administration to my successor. If it weren't for my pursuit of a masters degree, I would definitely do it again.

Cheers,
Jorian Pruim

Bridging the gap between science & the public

A creative career choice

AUTHOR: **C. BRUIL**

"What do you want to be when you grow up?", the teacher asked playfully when Fardou Haagsma was in the fourth grade of primary school. "A teacher", she confidently replied.

Most of us have been asked what we want to become many times in our lives already, especially when we were very young. And most of us replied that we wanted to become teachers. "It was the only job I really knew existed," Fardou, a Biology bachelor graduate, says, "so it was a logical answer at the time".

Yet, while growing up, our passions change. You get to know the world is larger than your primary school where you grew up, and you learn there are more jobs out there. The opportunities seem infinite, and so your imagination will run wild. "When I was a bit older I wanted to be an archaeologist. It seemed so cool to be digging up treasure chests around the pyramids of Egypt," Fardou recalls, "but when I learned they mostly spend time studying books and rarely find treasures, that desire faded."

"For a long time, I did not know what I wanted to become. I knew I still liked educating people, and that I had a broad interest in science, but I wanted to discover more about science and the world before immediately going to a classroom," Fardou says. "I did, however, look up the education master in Groningen during my bachelor in Biology there and, to my surprise, it also featured a science communication track".

The master Science Education and Communication at the University of Groningen allows you to become a teacher or explore other types of communicating science. For example, you can use your biology background as a communication consultant at a scientific institute, or become a science journalist for magazines, newspapers, TV, or podcasts. But also museums, science centres, the government, and hospitals have a need for people who bridge the gap between science and the general public. "When I learned there was a field in which I could dive into the most exciting parts of science to explain what I found to others, I knew I had to apply for this master track," says Fardou.

"If you'd ask me now what I want to become, I would say a medical communicator at a patient association." She starts laughing, "There is no way little me even knew this job existed and now I'm trying my best to get an internship there."

"If you love being creative and have a broad interest in science, this master might be really up your alley. The teachers push you out of your comfort zone, and make you study up on different disciplines," Fardou says. "I learned so much from the journalism course about writing and interviewing, I really developed new skills." She continues to explain how different courses highlight different aspects of science communication: "During the course Science and the Public I got to use my directing skills from my theatre background in making a video about sleepwalking, which was really fun." She continues: "For a different project I dove into AI, wrote an article and made an exhibit about the topic, even though I was not too familiar with AI as I have a background in neurobiology."

Besides direct skills, Fardou mentions there are also indirect skills you develop during this programme. "You will become better at time management quickly, as there are so many deadlines, you have no choice but to plan well." Additionally, you also build up your CV as you follow the courses. "As you have the opportunity to publish end products, for example in Ukrant or on Bridgingscience.org, work with real companies, and get guest lectures from people from the science communication field, you gain valuable experiences."

"It's a shame so few people know about this master, it's the perfect match for creative scientists who don't want to spend their life in the lab," Fardou says. "When you are in doubt about which master to pick, this is a good choice!"

If you want to see what students make during this master you can check their works on www.bridgingscience.org.

Statistics of the New FMF Coffee Machine

AUTHOR: **M. ERIKS**

Coffee, also known as the black liquid you drink at 1am while studying, is made from the well-known coffee bean. There are many interesting facts about coffee, though today I will not entertain you with my list of 10 reasons **not** to make coffee stamppot. Rather, you will be enlightened about the wonderful world of the FMF coffee machine statistics. Using these statistics and the history of prices we have paid for coffee, we will discover whether the investment into the new coffee machine was financially beneficial or not.

Before diving into these statistics, we have to retrieve them from the coffee machine first. Luckily, it keeps track of the total consumption of every kind of coffee, regular, with milk, espresso and cappuccino. By keeping track of this number, you can find the amount of cups drunk in a delta time span.

For this experiment, we have taken the arbitrary 25th day of every month. This way, we can determine the amount of cups drunk for every month since September 2024. See figure 1 below.

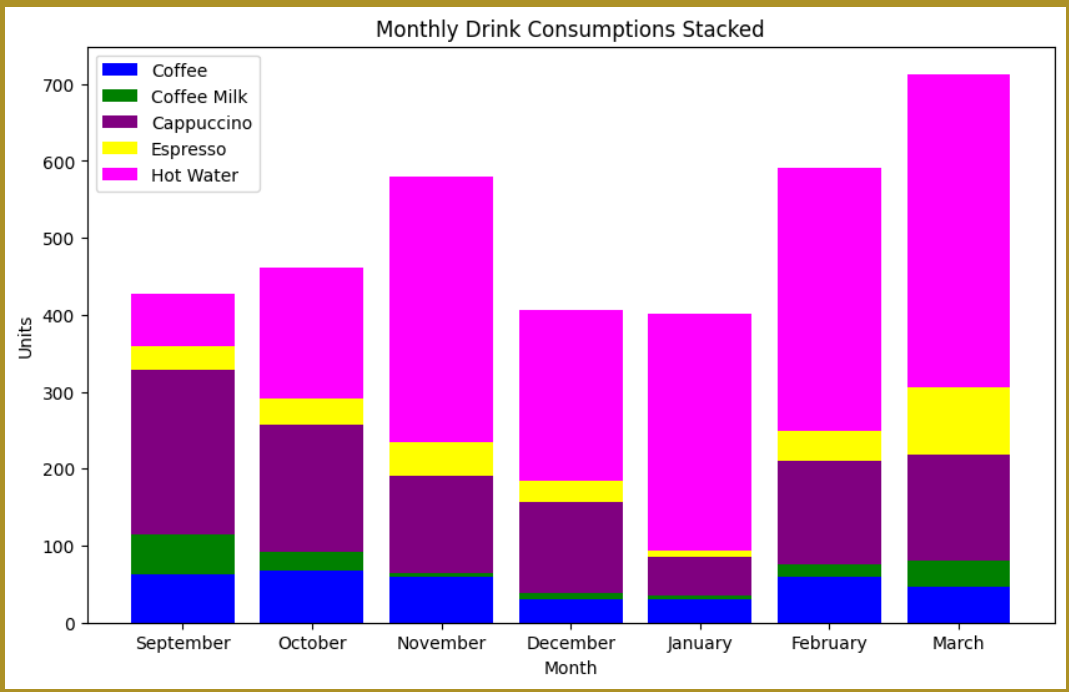

Figure 2: Overview of the coffee statistics since September 25th of 2025 until March 25th of 2025

Thus far we have had a few different types of coffee: gold coffee from Hanos, gold coffee from Albert Heijn, and red coffee from Albert Heijn. For those unaware, gold coffee is 100% arabica beans, while red is 70% arabica and 30% robusta. After we received feedback, we decided that in general our members prefer the stronger taste of red coffee.

These three types of coffee, of course, have different prices. Taking the average of them and combining this with the total amounts of coffee, a price of around 20.2 euro cents per cup is achieved; note that this also includes the creamer used for cappuccino and coffee milk. In the scenario that we would have only bought red coffee from Albert Heijn, this number changes quite a bit; it would reach 10.6 euro cents per cup. This would cut the cost per cup of coffee in half, while also having a more appealing taste to caffeine-loving students.

Figure 3: The coffee machine in the FMF room

While the 10.6 cents is a fun fact, it is not that insightful on its own. This is why we decided to guesstimate the costs per cup using the old coffee machine. For this, we need to know a few things: the amount of coffee used per cup of coffee, the price of a package of coffee, and the price per coffee filter. The prices were easy to find by looking on the Albert Heijn website. We picked Caffè Gondoliere Classic filter coffee since it would be the equivalent to the red coffee we buy for the current machine. At the time of writing, a package costs 5.29 euros. By measuring the volume of the package, the density of coffee can be determined. It turns out that ground coffee has a density of about 0.5 kg per litre. By remembering the instructions used for the coffee back in the day, a ratio of 2 scoops per 10 cups was used. After extremely precise measuring, the volume of a scoop was found to be around 100 ml. Combining these values, we find around 10.3 grams of ground coffee per cup. By returning to the prices, we determine that a cup of coffee from the old coffee machine costs 11.0 euro cents.

"For the sake of good coffee, we used the more expensive option."

Now, before we celebrate, we have to take into account some potential sources of errors in these calculations. While I have kept the error analysis as an exercise for the reader, please take into account the following: measuring the volume of the coffee scoop was done with utter lack of proper equipment leading to a high uncertainty, and the coffee picked for the old machine was not the cheapest coffee available. The cheapest one costs 2.69 euros per package, but for the sake of good coffee, we used the more expensive option.

As a quick overview, I would like to summarize our findings: there is a price difference of 0.4 euro cents in favour of our new coffee machine. This is a small difference, and due to the uncertainty in our measurements, we cannot conclude which coffee is truly cheaper. Further research is required to determine the true winner; for this we are setting up a new committee, Kofcie. In case you are interested in helping, please get in contact with the board of FMF.

Perio Interview: Manuela Vecchi

Professor, Book Lover, Mother

AUTHORS: **I. BALINT, L. ADDAMS**

Manuela Vecchi is an Italian professor known for her thoughtfulness and intellectual rigour. Throughout her career, grounded in experimental astroparticle physics, she developed a deep intercultural perspective by working in the context of several large, international scientific collaborations. Having lived and worked in various countries, she became fluent in multiple languages. In this issue of the Periodiek, we get to know her a little better.

What motivated you to become a professor?
Despite having an uninteresting physics teacher in high school, I decided to study physics at university. I always had a passion for reading, studying, and understanding, and I think that was what drove me towards following this path to a career in academia. Additionally, I did not envision myself doing a conventional job. I have always been a creative person, constantly looking for new challenges.

Figure 4: Manuela Vecchi

What did you have for breakfast?
I had coffee and yoghurt with honey.

Did you consider other job prospects or workplaces before settling for research and teaching?
At the conclusion of my master's, I had a bit of time to think, and I started considering working in consultancy. This is what we would call nowadays data science, but in 2006 there was no data science. So, as a person who has a Master's in physics, the possible outcomes were either to work in academia, to teach at high school or middle school level, or you work as a consultant. I didn't see myself as a teacher at high school, so I considered the option of data science. I even actually had an interview for a job. It was a small firm in Rome, and I was offered the position, but then I decided to decline because I realised that I wanted to at least try to get a PhD. I had to study for a few months to prepare for the PhD exam.

You worked as a postdoc at CERN for 3 years. How was your experience working in such a wonderful environment?
CERN is certainly a unique place to work. The level of the environment is exceptionally high. I was working as a postdoc in the frame of the AMS experiment. The headquarters of AMS is at CERN, so you have people from all over the world. AMS is led by a Nobel Prize winner, so I was working with people working for MIT, Taiwan, Italy. It was an incredible experience. The workload is possibly infinite. Here in the Netherlands, at 5 P.M., you will see no one in the corridors. At CERN, 5 P.M. is like snack time, people stay around until 7 or 8 P.M. It's a completely different vibe. But it is certainly a terrific, really impressive place for working.

What are the differences between Italy and the Netherlands in terms of student-professor communication?

In the year 2000, the Italian academic atmosphere was extremely formal, and there was a lot of hierarchy. We didn't have student TAs, so there was a huge gap between the teacher, who was a big professor, 99% of cases men, and the students. The teaching assistants were also professors but younger. There was no connection, no one who could make the gentle transition like you have here, a teaching assistant who is a Master's student or a PhD student, so they are more approachable. It was very different.

Can you tell us more about your experience as a Rosalind Franklin fellow?

There was an open position in 2018 for a joint assistant professor and Rosalind Franklin Fellow, because essentially these fellowships mean being hired with funding which is related to this programme. The Rosalind Franklin Fellowships target and are meant to increase the number of female academic staff in the University of Groningen. And, of course, they were meant to hire excellent, beautiful, fantastic, [laughs] smart female researchers and professors. I thought it was an amazing opportunity for me so I decided to apply, and then I was selected. At that time, I already had a permanent position as an Assistant Professor at the University of São Paulo in Brazil. That was an incredible experience, but in the long-term, I wanted to return to Europe.

How is your experience as a female professor at the university?

Research shows that women are evaluated more harshly than men at all stages of their careers, both inside and outside of academia. This bias also extends to student evaluations of courses. Personally, I've found students to be generally kind and constructive, both during courses and in their evaluations. However, the broader issue remains. For instance, I once received a harsh and unfounded comment like, "She cannot answer any single question"—a statistically implausible claim, to say the least! There are a lot of sociological aspects, you know. If a woman is assertive, she's mean. If a man is assertive, he's strong.

What is the most exciting and inspiring aspect of your own research?

My research is about cosmic rays and gamma rays; the high energy particles and radiation produced in outer space. I like studying how the particles can be accelerated. They can reach energies which are much higher than what we can produce on Earth. I like understanding what the sources of these particles can be, and developing methods that can help us to identify these particles. It's a very broad set of things that I do, from developing algorithms that enable the identification of particles, to trying to understand where these particles can come from.

It is a field that is moving forward and there is space to come up with new ideas, really the creative work that I always wanted to do. My journey towards studying Cosmic Rays started before, when I was doing my Master's and my PhD theses. I was working on Neutrino Astronomy and this was also extremely fascinating. Neutrinos are very interesting particles because they are very peculiar. They are neutral, yet ultra-relativistic, and they have a very tiny mass; so tiny that it's very difficult to measure accurately.

"If a woman is assertive, she's mean. If a man is assertive, he's strong."

How can they reach such tremendous energies to be produced outside Earth? It's rather challenging to detect them because they interact very little. When I was working in that field, I decided to become acquainted with Cosmic Rays because they can also produce neutrinos, meaning they can provide information on the sources of Cosmic Rays. Working in gamma-ray detection has always been my scientific dream, since I was an MSc student. This became true about 10 years ago. I recently became Science Coordinator of the Cherenkov Telescope Array Observatory, which includes 1500 scientists from all around the world. That's a big honour and a huge step forward for my career.

How do you balance being a professor at the University with being an academic and working on so many projects? How is the workload?

The workload is high. As an associate professor, my workload is 40% dedicated to, at least on paper, teaching, which means the actual lectures plus supervising Bachelor's and Master's students. The rest is research and management. During my lecturing periods, the time goes in vast majority to the actual lecture preparation, lecturing, grading, etc.

What is your favourite course to teach?
I am teaching three courses: Astroparticle Physics, Dark Matter Detection, and Quantum Universe Student Seminar. I think the one that I prefer is Astroparticle Physics. But Dark Matter Detection was fun. It's a bit different because dark matter detection is an elective, and it's a very small course of three ECTs, so it's a small group. There is a different interaction with the students because you can have a very nice interaction with everyone. And apparently the students like it too.

I'm hesitant between the two because Astroparticle Physics is a longer course. It used to be in the Bachelor's, now it's in the Master's, so it is much more work to prepare. I like it because it's my field, but Dark Matter Detection is broader. I'm hesitant to say, I wouldn't know.

What is your go-to assessment method?
I think varying between questions and essays. Having a diverse assessment is enriching. Not every student performs well with every type of assessment. Some students perform well in presentations, less well in written exams, or the opposite. Nowadays, in the ChatGPT era, an essay is something that I unfortunately have to consider not a priority, because it's a little bit difficult to be sure that an essay was written by the students.

What languages do you speak?
A few of them. I speak Italian, French, English, Portuguese, and an intermediate level of Dutch.

If you had not chosen to study Physics, what would you have picked?
When I was in high school, and this is quite fun, I had to do the pre-registration at the university. So I actually did my pre-registration to what was called Lingua Orientali (Oriental Languages) in Italian, so a collection of Asian Languages. I wanted to study Japanese. I was interested in the philosophy, and I was seriously in doubt whether to choose philosophy or physics. My 18 year-old self decided to study Physics instead of Philosophy because I thought that there were more options for a job outside the university.

Do you ever regret not choosing Philosophy?
No, as I said, I think I always had the will to think and reflect about things that happen in life, even though I wasn't like a super geek. That was weird for me when I arrived at the university, because I mean, you can imagine the type of diversity in characters that were there. I was absolutely not the stereotype of a Big-Bang-Theory-like person and I remember that there were quite some of them in my cohort. There was a colleague there who on the first day of lectures arrived with a specific type of broccoli because it was an example of a fractal, and I felt like totally non-belonging there, you know. Besides a few peculiar characters, there were a lot of people who were like me, just people who like to think, and they were very bright and had a lot of interests besides Physics. We're still in contact now, 25 years since I started university. I started in 2000.

Anything you want to add about the academic experience?
Nowadays, working in academia is very different from what it used to be in the past. This is a very difficult job, but it's also very exciting and stimulating. If you are a university professor, you are a scientist, you are a manager, a lecturer; a project manager; a group leader, and you are sort of a psychologist. Science became a lot more complex than it used to be. You have to spend an enormous amount of time writing funding proposals to get funding for PhD students, postdocs, travel expenses, and equipment.

This is an art that you have to develop with time. Then you have to supervise students. This requires a bit of organisation because the students have to be guided, depending on their level. The students are people, first of all. That's why I say psychologist, of course it's a joke, but interacting with people requires a lot of skill. There are a lot of things that we do everyday that have a lot to do with science, but also with making decisions and assigning priorities to things. People will be late, people will disappear, in the sense of not responding to emails, people will not do what they have been asked to do. So it's not like sharing tasks and playing and having fun together. It's just being ready for the complete collapse of the system, which often happens, and making quick decisions, to put things back into shape.

What can you tell us about your experience in Brazil?
I was a faculty member there for four years. I enjoyed it. Teaching there was very different. First of all, the teaching load here is less than half of what I was teaching there. It was very high in Brazil, and the lack of organisation added pressure. Another difference is here in the Netherlands, everything is a lot more organised and structured. Research-wise, in Brazil, I was more free. In the Netherlands, the research is done according to strategic plans. That means we decide beforehand what the research line will be for the next decade, for physics or for astronomy. You cannot just wake up one day and say oh, look, I found this fantastic thing, I want to do that, because of the strategic plan. But in Brazil, it works like that. You decide one thing and you just go for it.

What did you do for research in Brazil?
I arrived in Brazil while I was working with AMS. Nobody in Brazil was working with them. I asked for funding to create the first South American group of AMS. They approved it, and were happy that I was doing that. If I wanted to invent something else, come up with another group, if I was able to secure funding, that would be absolutely possible. So, as a scientist, you have more freedom. At the same time, you have to pay for this freedom, because you have to continuously prove that what you are doing is good. So you have a lot of bureaucratic work because you have constant reports to write, because you are *free,* but people have to check. You are constantly being asked to prove that what you are doing is worth funding, even for the tiniest amount of money. This creates an enormous workload.

At the level which I was working in Brazil, the Bachelor's students got scholarships to do their research, because they got paid to do it. It counts like a paid internship. The students work for a group for one year and get paid enough to pay their rent, the equivalent of 500 euros per month. So, it's not a sizeable amount of money, but even for a small amount like that, I was requested to write reports.

But for the students, they have these grants, which is incredible because they have the opportunity to work in research groups since they are in the second year of the Bachelor's. They can work for the full Bachelor's and Master's in research groups and get paid for it. It's an amazing opportunity.

What are your hobbies?
The time I have for hobbies has decreased as a function of my age and my career stage. Nowadays, the time for hobbies is very limited. The thing I still do, that I never gave up on, is reading. I enjoy reading novels very much. I also like going to the movies, museums, or exhibitions. My New Year's resolution, I am telling you because if I tell many people, I hope that I will stick to it, is that at least once per month, I want to go to the movies or to a museum. Kids' movies and museums are not included. Because I have a son who is almost five, sometimes I bring him to the movies, sometimes to a museum, but they are not counted in my New Year's resolution.

What is your favourite book?
One of the best books I have read in years is called The Eighth Life. It's fantastic. It's by a writer who's originally from Georgia, but now she's living in Berlin. It has maybe a thousand pages. I don't know how long it took me to read it, probably just a few weeks, but this is something that you cannot just put down.

What's your favourite cuisine?
I'm Italian. So, Italian.

Do you have any colleagues that you admire or like working with?
Since I work as an experimentalist and I work in data science, my research is carried out mostly in the frame of large international collaborations, so I've always been working in groups. I think the way I operate is not like an individual, but as working in groups, so there are a lot of people with whom I have enjoyed working. For example, next week, I will have a guest with whom I have been working for many years.

"The time I have for hobbies has decreased as a function of my age."

One thing that I am happy to see here is a lot of female colleagues, because astroparticle physics has generally been, historically, a male-dominated environment. In the projects I have been working on, factually, I am most likely the only female group member. But things are changing, so this is very nice. There are also a lot of colleagues that are very good inspirations. I must say that one name of someone that I don't really work with, but I find to be a role model, at the university, is Beatriz Noheda. She is a person that I consider to be extremely talented, extremely smart, but at the same time, she has a lot of empathy. She has two kids and she's really someone that I admire a lot for the level of extreme excellence in research. She is, above of all, smart and excellent in her work, while balancing healthy relationships with her students and her group, and having the enormous effort of also balancing personal life with the kids. She keeps being a person that I really admire.

Interview with intern Ben van Zon
Advertisement

How to take your internship to the next level

Internships can be pivotal for a student's both personal and professional development, especially when it comes to fields such as high-tech research engineering. Choosing a good internship program will impact your future in the best possible way. However, making a choice can be difficult, and with so many companies and internship programs around it's easy to feel overwhelmed.

This was the case with Ben van Zon, an Applied Physics undergraduate who felt indecisive and frustrated about his internship options. After much thought, he decided to join ASML – a leader in semiconductor manufacturing technology – where his work impressed his mentors and coworkers.

But how did he do all this? In this article, Ben and his ASML mentors, Richard van Lent, Richard Engeln and Alexander Puth, reflect on his time at ASML, providing insights into the company's culture, the challenges and breakthroughs of working on complex technology, and advice for those considering a similar path.

How to get started

Ben found out about ASML through one of the multiple career events that the company organizes for students and fresh graduates. He met one of his future mentors at this event and after connecting over plasma and spectroscopy topics, they reconnected online to explore whether Ben would be a good match to the ASML intern culture. Spoiler alert: He was!

"My main goal was to deepen my knowledge and gain hands-on experience in a corporate setting. In hindsight, it turned out even better than I had imagined," Ben notes.

"Ben stood out even during our initial conversation. He was curious, driven and communicative, knowing precisely what he wanted to achieve. Although he came from a different academic background than we typically see in our interns, he quickly proved himself, exceeding even our usual standards," Engeln remarks.

A day in the life

According to Ben, his day would start with a coffee at ASML's plaza and a quick check of his emails. "After that, I'd set up the lab for measurements, which involved a lot of meticulous preparations, from stabilizing the laser's temperature to adjusting pressure levels in the measurement chamber." Around lunchtime, it's again time to take a break and enjoy some time with your colleagues. ASML's plazas are a hot spot for events, meetings and other activities, beyond being cafeterias. ASMLers also enjoy a wide range of campus benefits, from a fully equipped gym to an on-campus supermarket.

"ASML's culture is very welcoming. Its international environment means there's always an opportunity to learn from people with diverse backgrounds. I felt very comfortable, and I appreciated the collaborative, respectful atmosphere," Ben says. The culture is focused both on boosting soft skills and technical work experience. "ASML is unique in the hands-on experience we provide. Interns here aren't just observing; they're making real contributions, notes Puth.

Ben himself admits that at first, it was intimidating to work with such advanced technology. "But my supervisors were patient, explaining every component and process, which helped me feel confident. My motivation came from wanting to understand the complexities of extreme ultraviolet (EUV) gas plasma. The more I learned, the more curious I became, which led to many valuable discussions with my mentors."

Supported in Excelling

Ben's main task was to calibrate the wave meter in ASML's Cavity Ring-Down Spectroscopy (CRDS) setup. This required precise measurements of water's absorption spectrum under different pressure conditions.

According to Engeln, Ben's work was quite demanding, but he approached it with discipline. He mapped the spatial distribution of H3+ molecules and matched his data with pre-existing experimental data.

"His findings added real value, and his internship report was appreciated by both ASML and his academic supervisors. It was above what we usually see at the bachelor's degree level," Engeln notes. However, Ben was not alone through all this. His mentors were there every step of the way, to support him without interrupting the "discovery" process that an internship entails.

"My supervisors were always available for questions and discussions. What I appreciated most was their friendly, often humorous approach, which made even complex discussions enjoyable. Initially, I was nervous about presenting my work, especially among colleagues with Ph.Ds., but they offered practice sessions and constructive feedback, helping me improve my presentation and scientific writing skills," Ben says.

Looking ahead and internships advice

Ben says his experience at ASML helped him gain the confidence he needed to pursue a career in research, while focusing on continuous learning. "My next step is a graduation internship in Finland, where I'll study phonon tunneling phenomena at the University of Jyväskylä. After earning my bachelor's degree in applied physics, I hope to return to ASML in a more permanent role and eventually pursue a part-time master's degree."

When it comes to advice for choosing internships, he notes that the biggest lesson was not to let fear hold you back. "Even if something seems daunting or above your experience level, go for it. I almost didn't apply because I thought I lacked the right credentials. Internships are a learning experience, and with the right mindset, you can gain invaluable skills and knowledge."

"ASML values its interns and the fresh perspectives they bring. Our internships are hands-on and involve real projects. Interns here should come with curiosity and a willingness to engage deeply with their work," Puth adds.

The Potato Chips Experiment

AUTHORS: **I. BALINT, J. BRINK, K. DE VALK, F. DOBOS, S. ILIUTA, S. KHONG, A. MATVEICIUC, M. PASERE, I. STANCA, AND M. GRZEGORCZYK**

As part of the Honours College course "Practical Statistical Hypothesis Testing" during the 2024/2025 academic year, we conducted a sensory experiment in the form of a blind taste test, comparing Lay's potato chips with two low-budget store brands. This article presents the results of that experiment.

Introduction

Crispy, salty, and undeniably addictive, potato chips have established themselves as a universally popular snack, enjoyed across cultures and age groups. In 2024, the global potato chips market reached an estimated value of nearly USD 39.6 billion. Lay's maintained its position as the top-selling potato chip brand in the United States, with sales reaching USD 4.27 billion. In contrast, store-brand alternatives are marketed as budget-friendly options, often costing less than half as much. Despite this substantial price difference, the core ingredients—potatoes, oil, and salt—remain largely unchanged. This raises the question of whether the higher price reflects a genuine difference in quality and taste or is primarily driven by brand recognition and marketing. To investigate this, we organized and conducted a blind taste experiment comparing three different brands of natural-flavored potato chips:

- **Lay's** – one of the most popular potato chip brands, originally founded in the US in the 1930s, and now owned by the PepsiCo corporation
- **Albert Heijn** and **Jumbo** – budget-friendly alternatives from two major Dutch supermarket chains.

The nutritional values of the three chip brands are presented in Figure 5. We compared these values in advance to identify potential reasons—other than taste or branding—for a preference for Lay's. As shown in Figure 5, the only notable difference is in salt content (0.85 g vs. 1.2 g per 100 g). The label on a bag of Lay's chips states that a portion is 30 g. Accordingly, one portion contains approximately 0.255 g of salt, while a portion of Albert Heijn or Jumbo chips contains about 0.36 g. In light of the WHO recommendation that daily salt intake should not exceed 5 g, we consider the 0.105 g reduction in salt content in Lay's to offer only a very limited health benefit and certainly no justification for the significantly higher price.

Nutritional value (per 100g)			
Energy	512 kcal	526 kcal	536 kcal
Fats	29.0 g	30.6 g	31.0 g
Carbohydrates	55.0 g	54.5 g	56.0 g
Salt	0.85 g	1.2 g	1.2 g

Figure 5: Nutritional comparison of three potato chip brands. Lay's (premium) and two store brands (Jumbo and Albert Heijn). The protein content per 100 g is 6.1 g for Albert Heijn and Jumbo, and 6.2 g for Lay's. All chip bags were purchased in February 2025 in supermarkets in Groningen, NL.

The Experiment

To investigate whether the three potato chip brands differ significantly in taste, we conducted a blind taste test. The study took place in February 2025 in the Bernoulliborg building at the University of Groningen (NL) and focused on three brands of natural-flavored potato chips:

- **Lay's** – the premium brand (€2.49 per 300 g)
- **Albert Heijn** – the 1st store-brand option (€0.99 per 250 g)
- **Jumbo** – the 2nd store-brand option, (€0.99 per 250 g)

Students enrolled in the course invited fellow BSc students to participate in the experiment, and a few PhD students also joined. In total, $n = 44$ participants from the Faculty of Science and Engineering (FSE) at the University of Groningen took part and provided ratings for the chips.[1] For the study, we created a questionnaire

using Google Forms to collect some general background information before inviting participants to taste the chips. First, we asked the participants to indicate which chip they liked most, capturing their spontaneous preference. They were then given more time to rate each brand on four specific attributes: **taste**, **aftertaste**, **texture**, and **appearance**. Each attribute was assessed using a five-point scale: bad (−2), below average (−1), average (0), above average (+1), and good (+2). Finally, participants were asked to provide an overall numerical rating from 1 to 10 for each sample.
To prevent brand-related bias, chips from the three brands were served in neutral cups, and the presentation order was randomized for each participant. Participants were also instructed not to discuss their impressions with one another during the tasting.

The Student's t-test

The Student's t-test is arguably the most widely applied statistical hypothesis test.[2] It is used to determine whether there is a significant difference between the means of two groups. The test assesses whether the observed mean differences are likely due to random variation or reflect a true underlying effect.

In the context of our potato chip experiment, the t-test can be used to evaluate whether participants rated one brand of chips significantly higher or lower than another. In our study, we focus on the paired-sample t-test (also known as the coupled t-test), which is appropriate when the same participants provide ratings for multiple conditions—in this case, different brands of chips. Since each participant tasted and evaluated all three brands, their ratings form naturally paired observations, allowing us to account for individual differences in taste preferences.

More generally, a statistical hypothesis test is used to assess whether the observed data provide sufficient evidence to reject a stated assumption, known as the null hypothesis (H_0). In our context, H_0 states that there is no difference in the mean ratings between two chip brands, while the alternative hypothesis (H_1) posits that a difference does exist.

A central concept in hypothesis testing is the p-value. It represents the probability of obtaining a result at least as extreme as the one observed, assuming that the null hypothesis (H_0) is true. A small p-value indicates that such extreme results are unlikely under H_0, and therefore provide empirical evidence against hypothesis H_0.

In practice, if the p-value falls below a conventional significance threshold (typically $\alpha = 0.05$), we reject the null hypothesis H_0 in favour of the alternative hypothesis H_1. In that case, H_1 is considered statistically supported. In our application, this implies that the observed mean difference in chip ratings is statistically significant and unlikely to be due to random variation alone.

Mathematical description:
Let the paired data consist of n observations, represented as

$$(X_1, Y_1), (X_2, Y_2), \ldots, (X_n, Y_n)$$

where X_i and Y_i denote the scores given by participant i to two different chip brands. For each pair we compute the difference as

$$Z_1 := X_1 - Y_1, \ldots, Z_n := X_n - Y_n$$

This reduces the paired comparison to a one-sample problem involving the mean of the differences $Z_1, \ldots, Z_n$. From the n data points we compute the sample mean and sample variance:

$$\bar{Z} := \frac{1}{n}\sum_{i=1}^{n} Z_i \quad \text{and} \quad S^2 := \frac{1}{n-1}\sum_{i=1}^{n}(Z_i - \bar{Z})^2$$

Furthermore, we assume that the differences Z_i are independent and identically distributed, following a Gaussian distribution with known variance σ^2:

$$Z_1, \ldots, Z_n \sim \mathcal{N}(\mu, \sigma^2).$$

We want to test the hypothesis that the mean of the differences is zero (H_0), against the alternative hypothesis (H_1) that the mean difference is non-zero. Symbolically:

$$H_0\colon \mu = 0 \quad \textbf{vs.} \quad H_1\colon \mu \neq 0$$

Under the null hypothesis H_0, the sample mean follows a Gaussian distribution, $\bar{Z} \sim \mathcal{N}(0, \sigma^2/n)$. By standardising with the square root of the variance, $\sqrt{\sigma^2/n}$, we obtain a standard Gaussian distribution. That is, under H_0: $\mu = 0$, we have

$$\sqrt{n} \cdot \frac{\bar{Z}}{\sigma} \sim \mathcal{N}(0, 1)$$

We use this statistic, which depends on $Z_1, \ldots, Z_n$ and σ^2 as test-statistic

$$W = W(Z_1, \ldots, Z_n, \sigma^2) := \sqrt{n} \cdot \frac{\bar{Z}}{\sigma}$$

For the observed data, the test statistic W takes on a specific value, which we denote by w. The p-value is

the probability that a standard Gaussian distribution $\mathcal{N}(0,1)$ yields a value whose deviation from the expected value 0 is at least w, as illustrated in the left panel of Figure 6. We have:

$$\begin{aligned} \text{p-value} &= P_{H_0}(W \leq -|w|) + P_{H_0}(W \geq |w|) \\ &= 2 \cdot P_{H_0}(W \leq -|w|) \\ &= 2 \cdot \phi(-|w|) \end{aligned}$$

where $\phi(.)$ denotes the cumulative distribution function (CDF) of the standard Gaussian distribution, which can be evaluated using standard statistical software such as **R**. One may wonder whether the differences are truly Gaussian distributed and, consequently, whether W follows a $\mathcal{N}(0,1)$ distribution. However, for sufficiently large sample sizes n, the Central Limit Theorem ensures that W is at least approximately $\mathcal{N}(0,1)$-distributed, so any resulting bias is likely to be small. For small n, however, it may be advisable to consider non-parametric or randomization tests as alternatives to the t-test.

which no longer depends on σ^2 and can be computed directly from the values $Z_1, \ldots, Z_n$. However, this statistic no longer follows a standard Gaussian distribution $\mathcal{N}(0,1)$. Replacing the true variance with the sample variance introduces additional uncertainty into the value of the test statistic. It can be shown that under the null hypothesis H_0, the distribution of the modified W follows a t-distribution with $n-1$ degrees of freedom, denoted by t_{n-1}. The t-distribution, like the Gaussian distribution, is bell-shaped and centered at zero, but it has heavier tails to account for the additional uncertainty introduced by estimating the variance. To illustrate the difference, the right panel of Figure 6 shows the density of the t-distribution with $n-1=10$ degrees of freedom. As the sample size increases ($n \to \infty$), the t-distribution t_{n-1} converges to the standard Gaussian distribution $\mathcal{N}(0,1)$.[3]

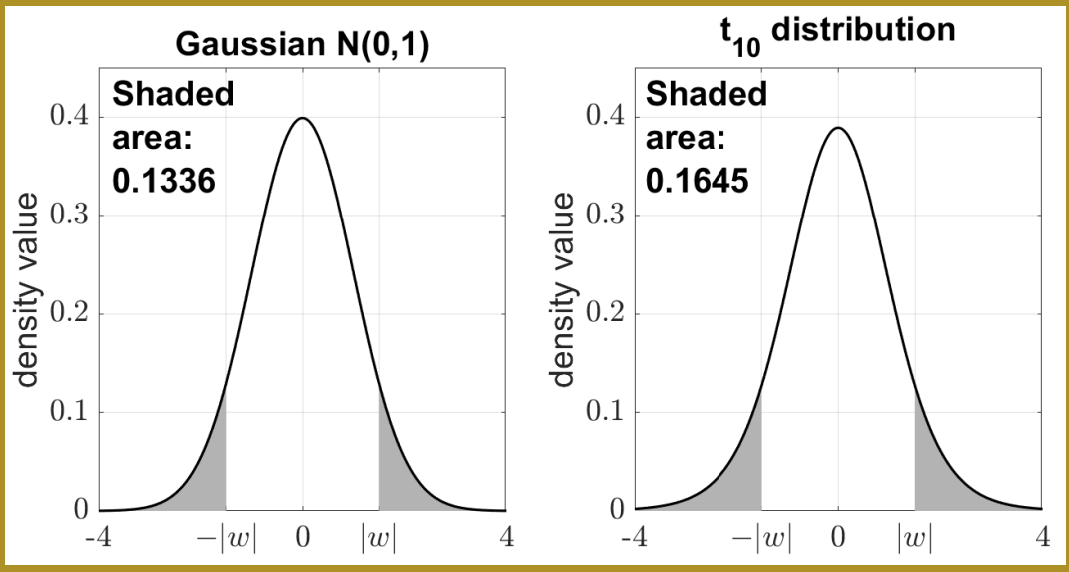

Figure 6: Illustration: Difference in density and implication for the p-value (shaded area) for the example test statistic values $w = \pm 1$; i.e., $|w| = 1$.

In practice, the true variance σ^2 is unknown, so the value w of W cannot be computed. Instead, we estimate σ^2 from the sample $Z_1, \ldots, Z_n$ using the sample variance S^2. Substituting this estimate into the statistic W yields the modified version

$$W = W(Z_1, \ldots, Z_n) := \sqrt{n} \cdot \frac{\bar{Z}}{\sqrt{S^2}}$$

In the p-value computation, we therefore replace the CDF $\phi(.)$ with the CDF $\phi_t(.)$ of the t-distribution with $n-1$ degrees of freedom

$$\text{p-value} \quad = \quad 2 \cdot \phi_t(-|w|)$$

Again, statistical software such as **R** can be used to compute the CDF $\phi_t(.)$.

X_i	Y_i	$\bar{z}$	s^2	w	p-value
Lay's	A.Heijn	-1.13	2.76	-4.54	0.00005
Lay's	Jumbo	-1.41	6.20	-3.75	0.00052
A.Heijn	Jumbo	-0.27	2.63	-1.11	0.2710

Table 1: Paired t-test results for three pairwise comparisons: For each comparison, we computed the differences $Z_i = X_i - Y_i$. The table reports the sample mean $\bar{z}$, the sample variance s^2, the value of the test statistic value w, and the corresponding t-test p-value.

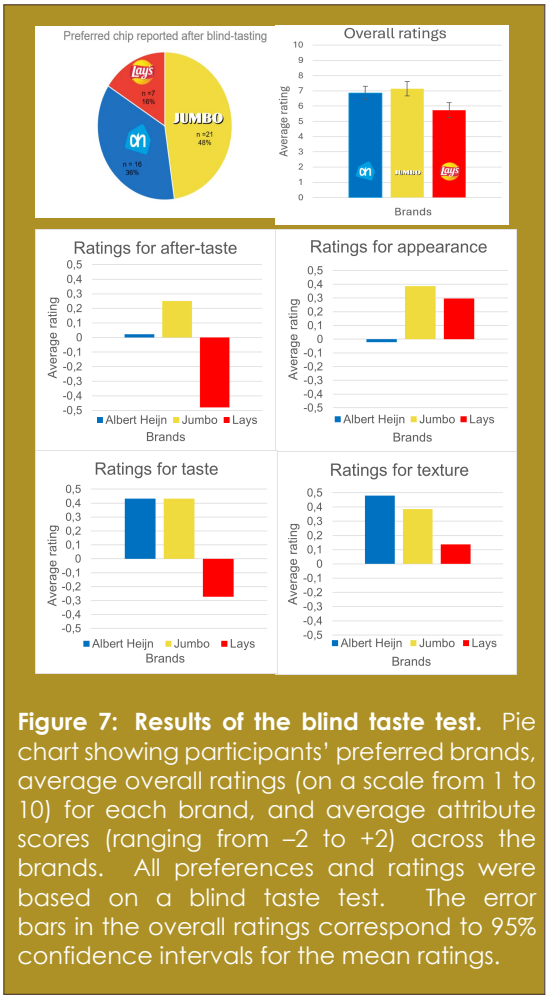

Figure 7: Results of the blind taste test. Pie chart showing participants' preferred brands, average overall ratings (on a scale from 1 to 10) for each brand, and average attribute scores (ranging from –2 to +2) across the brands. All preferences and ratings were based on a blind taste test. The error bars in the overall ratings correspond to 95% confidence intervals for the mean ratings.

Results

Figure 7 presents the surprising results of our potato chip blind taste experiment. Unexpectedly, only 7 out of 44 participants (16%) preferred Lay's over the two budget-friendly alternatives, and Lay's also received the lowest average overall rating (5.73). The two budget brands performed similarly. With 16 (36%) and 21 (48%) participants preferring them and average ratings of 6.86 and 7.14, the Jumbo chips achieved the best results. In all four attributes, Lay's is outperformed by Jumbo, while Albert Heijn surpasses Lay's in three categories. Only in appearance is Lay's rated higher than Albert Heijn. Finally, to assess whether the differences in ratings are statistically significant rather than due to random variation in the data, we performed three paired t-tests. The results of these tests are presented in Table 1. Based on the very low p-values, we conclude that participants rated the taste of Lay's chips significantly lower than that of the two store brands. The small difference between Albert Heijn and Jumbo is not statistically significant. As we tested three hypotheses, we needed to correct for multiple testing. The Bonferroni correction divides the significance threshold $\alpha = 0.05$ by the number of tests. The resulting corrected threshold, 0.017, ensures that the probability of wrongly rejecting one or more null hypotheses remains bounded by $\alpha = 0.05$.

Conclusion and Discussion

Surprisingly, in our blind taste experiment, the premium brand Lay's received a significantly lower rating (5.7/10) than the two budget-friendly store brands. The two store brands scored similarly in our experiment (6.9/10 and 7.1/10). A possible explanation for Lay's poor performance is its reduced salt content (0.26 g instead of 0.36 g per portion). However, as the health benefit of reducing salt intake by 0.1 g appears negligible, we not only doubt Lay's slogan "*Great Taste – Less Salt*" but also question whether it was a wise decision to reduce the salt content. For the next student party, we strongly recommend considering one of the store brands; particularly if the chips are served in a neutral bowl rather than in the original packaging.

Your text could be here!

Are you a student or staff member and do you have an interesting or fun contribution to the Perio*diek*?

Get in contact!

at perio@fmf.nl

Also for questions.

Planets ∼ Springs

The Newton-Hooke Duality and Beyond

AUTHOR: **T. GÖRBE** (T.F.GORBE@RUG.NL)

Everything's a spring!? When I'm in a cheeky mood, I like to tease first-year physics students by telling them that for physicists everything is a spring[4] or a (potentially infinite) collection of springs, and that their degree programme for the most part consists of solving the harmonic oscillator in different contexts.[5] Some students, with enough courage and wit, push back and say *"What about Planets? The inverse-square law of Newtonian gravity obviously doesn't correspond to any spring."* So I ask them "Do you mean the Kepler problem?" to which they respond, somewhat victoriously, *"Yes, Kepler isn't related to springs..."*, but upon seeing my smirk they hesitate and add *"...or is it?"* This is when I make the astonishing revelation, "Oh yes, Kepler, too! And you can prove it using complex numbers." Sadly, I seldom get to tell them the full story; instead, I simply refer to some good books [1,2]. This article is to explain, as best I can, this surprising connection between planets and springs. As a bonus, we derive Kepler's laws of planetary motion.

Before we go any further, let's agree on notation! In this article, vector quantities and their magnitudes will be denoted by the same letter. For example, the position vector $\vec{r}$ has magnitude r (distance), i.e. $r = |\vec{r}|$. Unit vectors will appear with hats, e.g. $\hat{r} = \frac{\vec{r}}{r}$. Differentiation is indicated by dot or prime based on the independent variable (time), e.g. $\dot{z} = \frac{dz}{dt}$, $\ddot{z} = \frac{d^2z}{dt^2}$, $w' = \frac{dw}{d\tau}$.

Central forces and conservation laws

If a particle of constant mass m is moving through space[6] in a *central* force field[7] given by $\vec{F} = f(\vec{r})\,\hat{r}$ at position $\vec{r}$, then Newton's second law reads $m\ddot{\vec{r}} = f(\vec{r})\,\hat{r}$. Consequently, the angular momentum $\vec{L} = \vec{r} \times m\dot{\vec{r}}$ is conserved, thereby restricting the particle's motion to the plane spanned[8] by the initial position $\vec{r}_0$ and initial velocity $\dot{\vec{r}}_0$. Indeed, since the cross product of parallel vectors is zero, the product rule yields

$$\dot{\vec{L}} = \dot{\vec{r}} \times m\dot{\vec{r}} + \vec{r} \times m\ddot{\vec{r}} = \vec{r} \times f(\vec{r})\,\hat{r} = \vec{0}$$

proving that $\vec{L}$ is a constant vector and the particle's orbit lies in the plane $\vec{L} \cdot \vec{r} = 0$. The position vector sweeps out equal areas in equal time intervals at a rate proportional to the constant magnitude L. More precisely, the areal speed is $\dot{A} = \frac{1}{2}|\vec{r} \times \dot{\vec{r}}| = \frac{L}{2m}$. This is the *law of equal areas*, which governs the particle's speed. The particle must move faster as it gets closer to the centre and become slower as it moves away from the origin.

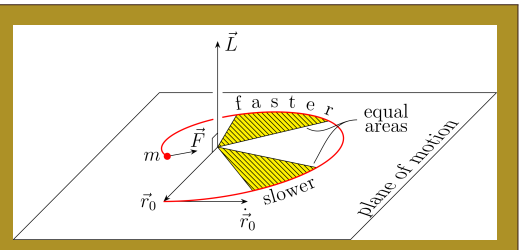

Figure 8: A particle in a central force field.

In *spherically symmetric* central force fields $\vec{F} = f(r)\,\hat{r}$ the magnitude depends only on the radial distance from the centre. Such forces are conservative[9] meaning that $\vec{F}$ is the negative gradient[10] of some scalar potential U. Indeed, we have $-\nabla U = \vec{F}$ for any $U = -\int f(r)\,dr$. As a result, the particle's total[11] energy $E = \frac{1}{2}m(\dot{\vec{r}} \cdot \dot{\vec{r}}) + U$ is conserved, which can be shown by employing the product rule and the chain rule

$$\dot{E} = m(\ddot{\vec{r}} \cdot \dot{\vec{r}}) + \nabla U \cdot \dot{\vec{r}} = \vec{F} \cdot \dot{\vec{r}} - \vec{F} \cdot \dot{\vec{r}} = 0.$$

We shall focus on *attractive power laws* $f(r) = -kr^n$ (with constants $k > 0$ and $n \neq -1$) since they include our main characters, Hooke's linear spring law ($n = 1$) and Newton's inverse-square gravity law ($n = -2$).

By choosing the constant of integration in U in such a way that the potential vanishes where the force does, we obtain $U = \frac{k}{n+1} r^{n+1}$. For energies with $(n+1)E > 0$ we get bound orbits since the particle must stay in the disc $r \leq (\frac{(n+1)E}{k})^{\frac{1}{n+1}}$. All power laws have closed (circular) orbits, but only two potentials produce bound orbits that are *always closed*, Hooke ($n = 1$) and Newton ($n = -2$). This result, known as Bertrand's theorem [3], hints at a link between springs and planets[12]. Let's explore the connection!

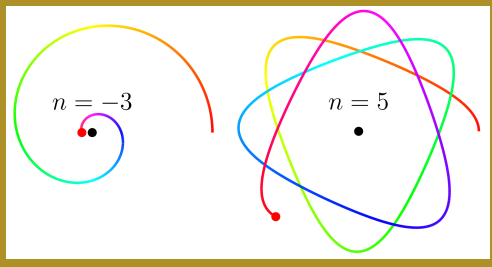

Figure 9: Orbits due to attractive power laws.

Kepler's laws of simple harmonic motion

We start by doing what physicists love doing the most, solving the harmonic oscillator. Recall Hooke's law $\vec{F} = -k\vec{r}$ and thus the equations of motion $m\ddot{\vec{r}} = -k\vec{r}$. Given an initial position $\vec{r}_0$ and initial velocity $\dot{\vec{r}}_0$, the solution can be written as follows

$$\vec{r} = \vec{r}_0 \cos \omega t + \tfrac{\dot{\vec{r}}_0}{\omega} \sin \omega t,$$

where $\omega = \sqrt{\frac{k}{m}}$. The particle's orbit is an ellipse centred at the origin[5]. The orbital period is $T = \frac{2\pi}{\omega}$. Without loss of generality, we may assume that the initial position is a point furthest from the origin along the particle's orbit[13]. This means that r has a maximum at r_0, which in turn implies $\vec{r}_0 \cdot \dot{\vec{r}}_0 = 0$. Let's introduce a Cartesian coordinate system in which the plane of motion is spanned by the orthonormal vectors $\hat{x} = \hat{r}_0$ and $\hat{y} = \hat{L} \times \hat{r}_0$. The position vector can therefore be expressed as

$$\vec{r} = x\,\hat{x} + y\,\hat{y},$$

where $x = r_0 \cos \omega t$ and $y = \frac{\dot{r}_0}{\omega} \sin \omega t$.
N.B. The coordinates are given by $x = \hat{x} \cdot \vec{r}$ and $y = \hat{y} \cdot \vec{r}$. This clashes with our notation as $x \neq |\vec{x}|$, but this won't be an issue since we will avoid using the symbols $\vec{x}, \vec{y}$.

The orbit $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ has semi-axes $a = r_0$ and $b = \frac{\dot{r}_0}{\omega}$ with $a \geq b$ due to our assumption. Note that the foci are located at $\pm\sqrt{a^2 - b^2}\,\hat{x}$ and the particle's angular momentum and energy can be expressed as $L = m\omega ab$ and $E = \frac{k}{2}(a^2 + b^2)$.

We collect these results in the form of three 'spring laws': (S1) The orbit of a particle is an ellipse with its *centre* at the origin. (S2) A particle's position vector sweeps out equal areas during equal intervals of time. (S3) The square of a particle's orbital period is $T^2 = \frac{4\pi^2 m}{k}$.

For comparison, recall Kepler's laws of planetary motion: (P1) The orbit of a planet is an ellipse with one of its *foci* at the origin (Sun). (P2) A planet's position vector sweeps out equal areas during equal intervals of time. (P3) The square of a planet's orbital period is $\widetilde{T}^2 = \frac{4\pi^2 \widetilde{m}}{\widetilde{k}} \widetilde{a}^3$ (with semi-major axis $\widetilde{a}$).

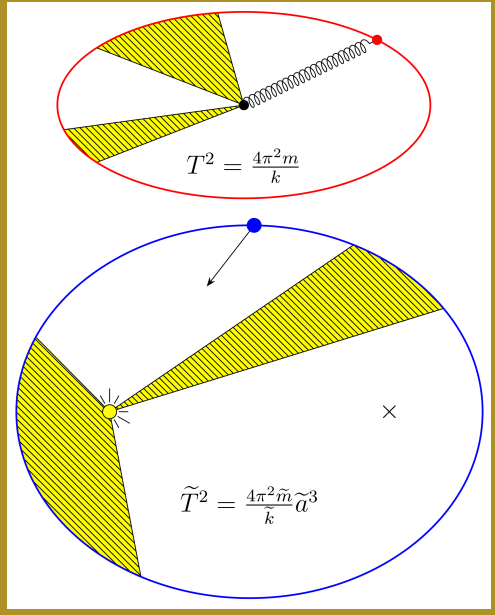

Figure 10: Kepler's laws of springs and planets.

The resemblance is so striking that we are tempted to call the former three *Kepler's laws of simple harmonic motion*. Our suspicion that springs and planets are related grows even stronger; it becomes the following

Conjecture! There is a way to turn the equations of motion of the harmonic oscillator into those of the Kepler problem.

$$m\ddot{\vec{r}} = -k\vec{r} \quad \overset{?}{\rightsquigarrow} \quad \widetilde{m}\vec{\rho}\,'' = -\widetilde{k}\frac{\vec{\rho}}{\rho^3}.$$

(oscillator) (Kepler)

N.B. To avoid any confusion, we employ new symbols for the constants and variables on the Kepler side, most notably the position vector $\vec{\rho} = u\,\hat{u} + v\,\hat{v}$ is a function of time τ.

Newton-Hooke duality using complex geometry

Now that we have the dynamics in the xy- and uv-planes, we may use complex variables instead of position vectors, i.e. replace $\vec{r} = x\,\hat{x} + y\,\hat{y}$ and $\vec{\rho} = u\,\hat{u} + v\,\hat{v}$ with $z = x + i\,y$ and $w = u + i\,v$, respectively. Therefore the equations of motion take the following form

$$\underset{\text{(oscillator)}}{m\ddot{z} = -kz,} \qquad \underset{\text{(Kepler)}}{\widetilde{m}w'' = -\widetilde{k}\frac{w}{|w|^3}.}$$

Both forces vary with the modulus, so it makes sense to introduce polar coordinates[14] and write $z = r\,e^{i\,\theta}$ and $w = \rho\,e^{i\,\phi}$. We've arrived at the main question:

Is there a complex mapping $z \mapsto w$ from springs to planets?

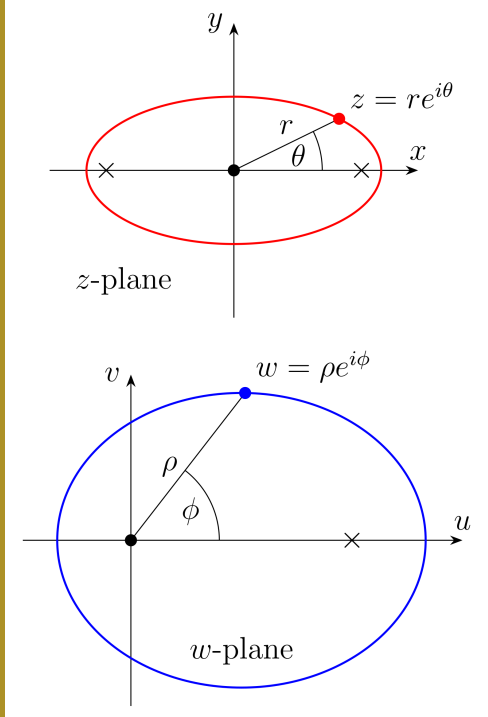

Figure 11: The orbits in their respective (complex) planes.

If you haven't played a lot with complex functions, seeing what magic they can do, it might be difficult to decide where to even begin the search for the mysterious function. But surely we can make an educated guess – after all, the forces are given by *power* laws!

Let's be bold and test power functions, i.e. $w = z^\alpha$ with an undetermined exponent α. Having $w = z^\alpha$ means $\rho = r^\alpha$ and $\phi = \alpha\,\theta$. How are the time variables τ and t related? The key is the law of equal areas (conservation of angular momentum). Indeed, you may recall, or quickly verify, that $\dot{A} = \frac{L}{2m} = \frac{1}{2}(x\dot{y} - \dot{x}y) = \frac{1}{2}r^2\dot{\theta}$ and similarly $\widetilde{A}' = \frac{\widetilde{L}}{2\widetilde{m}} = \frac{1}{2}\rho^2\phi'$. If we require equal areal speeds[15], that is $\dot{A} = \widetilde{A}'$, then their ratio can be written as

$$1 = \alpha\, r^{2\alpha-2}\frac{\theta'}{\dot{\theta}} = \alpha\,(z\overline{z})^{\alpha-1}\frac{dt}{d\tau}.$$

Above we used the relations between moduli ($\rho = r^\alpha$) and arguments ($\phi = \alpha\,\theta$) as well as the identity $r^2 = z\overline{z}$ and the chain rule ($\frac{d\theta}{d\tau} = \frac{d\theta}{dt}\frac{dt}{d\tau}$). We obtained the following

$$\frac{dt}{d\tau} = \frac{1}{\alpha}(z\overline{z})^{1-\alpha}.$$

We can employ this relation to express w' in terms of z and $\dot{z}$, viz.

$$w' = \frac{dw}{d\tau} = \frac{dw}{dt}\frac{dt}{d\tau} = \frac{1}{\alpha}(z\overline{z})^{1-\alpha}\frac{d}{dt}(z^\alpha) = \overline{z}^{1-\alpha}\dot{z}.$$

By differentiating both sides with respect to τ we see that w'' takes the following form

$$w'' = \frac{1}{\alpha}(z\overline{z})^{1-2\alpha}z^\alpha\big((1-\alpha)\dot{\overline{z}}\dot{z} + \overline{z}\ddot{z}\big).$$

We made use of the identity $\overline{z}^{-\alpha} = z^\alpha(z\overline{z})^{-\alpha}$ in the last step. Note the appearance of the velocity squared, that is $\dot{\overline{z}}\dot{z} = |\dot{z}|^2$. This term can be replaced with the expression we get by rearranging $E = \frac{1}{2}m|\dot{z}|^2 + \frac{1}{2}k|z|^2$ (the oscillator's energy). Also the term $\ddot{z}$ lets us utilize the oscillator's equation of motion $m\ddot{z} = -kz$. Upon these substitutions, we find

$$mw'' = (z\overline{z})^{1-2\alpha}z^\alpha\left(\tfrac{(1-\alpha)2E}{\alpha} - \tfrac{(2-\alpha)k}{\alpha}|z|^2\right).$$

Using $w = z^\alpha$ to convert the right-hand side into an expression with the variable w yields

$$mw'' = \tfrac{(1-\alpha)2E}{\alpha}\frac{w}{|w|^{4-\frac{2}{\alpha}}} - \tfrac{(2-\alpha)k}{\alpha}\frac{w}{|w|^{4-\frac{4}{\alpha}}}.$$

This equation tells us that under the mapping $w = z^\alpha$ the harmonic oscillator becomes a central force problem in which the force is given by the sum of two power laws. Naturally, if one of the coefficients vanishes, we get a single power law. This happens exactly when $\alpha = 1$ or $\alpha = 2$. The exponent $\alpha = 1$ yields nothing new, as expected, because it produces the identity function $w = z$, and indeed, we map the harmonic oscillator into itself

$$m\ddot{z} = -kz \quad \xrightarrow[(\tau=t)]{w=z} \quad mw'' = -kw.$$

However, the exponent $\alpha = 2$ leads us to an inverse-square force law (success!)

$$m\ddot{z} = -kz \quad \xrightarrow{w=z^2} \quad mw'' = -\widetilde{k}\frac{w}{|w|^3},$$

where $\widetilde{k} = E$. We proved our conjecture by showing that the squaring function $w = z^2$ transforms the harmonic oscillator into the Kepler problem. This connection is called the *Newton-Hooke duality*.

Notice that our derivation can be generalised to arbitrary power laws $f(r) = -kr^n$. The equation of motion $m\ddot{z} = -k|z|^{n-1}z$ is transformed by the complex mapping $w = z^\alpha$ into

$$mw'' = \tfrac{(1-\alpha)2E}{\alpha}|w|^{\frac{2}{\alpha}-4}w - \tfrac{n+3-2\alpha}{n+1}k|w|^{\frac{n+3}{\alpha}-4}w.$$

Again, we have the trivial case of $\alpha = 1$ (the identity transformation) when the first term on the right-hand side vanishes leaving us with $mw'' = -k|w|^{n-1}w$. On the other hand, if $\alpha = \frac{n+3}{2}$, the second term vanishes resulting in a power law with exponent $\widetilde{n} = \frac{4}{n+3} - 3$,

$$m\ddot{z} = -k|z|^{n-1}z \quad \xrightarrow{w=z^\alpha} \quad mw'' = -\widetilde{k}|w|^{\widetilde{n}-1}w,$$

where $\widetilde{k} = \frac{2(n+1)}{n+3}E$. We established the *generalised Newton-Hooke duality* also known as the Kasner-Arnol'd theorem.

Theorem (Kasner [4], Arnol'd [1])**.** *The central force given by a power law $F \propto r^n$ can be transformed, via the complex mapping $z \mapsto z^\alpha$, into a dual central force given by $\widetilde{F} \propto \widetilde{r}^{\,\widetilde{n}}$ with the exponents subject to*

$$(n+3)(\widetilde{n}+3) = 4, \qquad \alpha = \frac{n+3}{2}.$$

On a related note, we mention that among the central forces given by power laws, only a handful is soluble by trigonometric or elliptic functions [5]. The list of relevant exponents consists of the integers

$$5,\ 3,\ 1,\ 0,\ -2,\ -3,\ -4,\ -5,\ -7$$

and the fractions $-\frac{3}{2}, -\frac{5}{2}, -\frac{1}{3}, -\frac{5}{3}, -\frac{7}{3}$.

They form dual pairs $(n, \widetilde{n})$ as follows $(5, -\frac{5}{2})$,$(3, -\frac{7}{3})$, $(1, -2)$, $(0, -\frac{5}{3})$, $(-4, -7)$, $(-5, -5)$, $(-\frac{3}{2}, -\frac{1}{3})$. The exception $(n = -3)$ is a very interesting power law in its own right, but that's a story for another time.

Now we return to the Newton-Hooke case $(n, \widetilde{n}) = (1, -2)$ to see how the duality can be used to derive Kepler's laws of planetary motion (P1-P3) from those of harmonic motion (S1-S3) we obtained previously.

Kepler's laws of planetary motion

As we saw earlier, Kepler's second law, the law of equal areas, follows from the conservation of angular momentum which holds true in every central force field. Therefore we have (P2). Next, let's see what oscillator orbits become under the complex mapping $w = z^2$. To this end, we consider the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$ in the z-plane and its image in the w-plane. Since $w = z^2 = (x+iy)^2 = (x^2 - y^2) + i(2xy)$, we have $u = \operatorname{Re} w = x^2 - y^2$ and $v = \operatorname{Im} w = 2xy$.

With this setup, it's a matter of simple algebraic manipulation to prove the following

Lemma. *The complex function $w = z^2$ maps ellipses centred at the origin to ellipses with one focus point at the origin. More precisely, if $z = x+iy$ is a point on the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$, then its image $w = u+iv$ lies on the ellipse*

$$\frac{(u-\widetilde{c})^2}{\widetilde{a}^2} + \frac{v^2}{\widetilde{b}^2} = 1$$

with the semi-axes, centre, and foci given by

$$\widetilde{a} = \frac{a^2+b^2}{2}, \quad \widetilde{b} = ab, \quad \widetilde{c} = \frac{a^2-b^2}{2},$$
$$\widetilde{f}_1 = 0, \quad \widetilde{f}_2 = a^2 - b^2.$$

The proof is left as an exercise for the reader. Once the proof is complete, we have Kepler's first law (P1) also established.

Finally, the position vector $\vec{\rho}$ sweeps out the entire area $\pi\,\widetilde{a}\,\widetilde{b}$ of the ellipse during the orbital period $\widetilde{T}$. Since the areal speed is constant $\frac{\widetilde{L}}{2\widetilde{m}}$, we have

$$\frac{\widetilde{L}}{2\widetilde{m}}\widetilde{T} = \pi\,\widetilde{a}\,\widetilde{b}.$$

or equivalently

$$\widetilde{T} = 2\pi\widetilde{m}\,\frac{\widetilde{a}\,\widetilde{b}}{\widetilde{L}}.$$

Recall that we defined the time variable τ so that areal speeds are equal, i.e. $\frac{\widetilde{L}}{2\widetilde{m}} = \frac{L}{2m}$. As for the oscillator's angular momentum and energy, we have $L = m\omega ab = m\omega\widetilde{b}$ and $E = \frac{k}{2}(a^2+b^2) = k\widetilde{a}$ (cf. the lemma). Also remember the notation $\widetilde{k} = E$. Therefore the square of the orbital period can be written as

$$\widetilde{T}^2 = \frac{4\pi^2 m}{\widetilde{k}}\widetilde{a}^3.$$

Thus we have obtained Kepler's third law (P3) as well.

A brief history of the Newton-Hooke duality

The link between springs and planets has been known for a long time. Newton himself showed [6] that a body describes the same elliptical orbit if attracted by linear force toward the centre or pulled by an inverse-square force toward a focus point[16]. The complex-geometric proof we gave dates back to the early 1900's (see Bohlin [7] and Kasner [4]). The generalised duality was rediscovered and popularised by Arnol'd [1]. Needham [2] also has a nice complex-geometric proof in which curvature plays a central role.

The beginning of a beautiful friendship

What we've described in this article gives us a small glimpse of the fruitful connection between planets and springs. In fact, we've barely scratched the surface. The Newton-Hooke duality can be used to obtain other Keplerian orbits [1] and to regularise collision orbits. We can use the duality to gain insight into the hidden symmetry of the Kepler problem. What's more, it persists at the level of quantum mechanics, where it lets us calculate the energy levels of the hydrogen atom from those of the harmonic oscillator [8]. And so you're left to wonder...is everything a spring?

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Notes

[1] We thank all participants for taking part in the experiment.

[2] The test is named after the pseudonym "Student", used by W. S. Gosset, a statistician working for the Guinness Brewery. He published his work under this name to comply with company policy that prohibited employees from publishing under their real names.

[3] For our sample size $n = 44$, the difference is nearly indistinguishable.

[4] This occurs in Calculus class when we Taylor expand potential energy functions around minima.

[5] Most physicists are of course aware of and happy about this fact so here I just quote two of them: "The career of a young theoretical physicist consists of treating the harmonic oscillator in ever-increasing levels of abstraction." – Sidney Coleman, "Physics is that subset of human experience which can be reduced to coupled harmonic oscillators." – Michael Peskin

[6] We assume a 3-dimensional Euclidean space for simplicity's sake, but, in fact, everything nicely generalises to higher dimensions (with the cross product replaced by the wedge product).

[7] For us, a central force has the sole requirement that force vectors are pointing towards or away from the origin. Some authors set spherical symmetry (i.e. $\vec{F} = f(r)\,\hat{r}$) as an extra condition.

[8] We ignore the special case of zero angular momentum when the particle is confined to a straight line through the origin.

[9] In fact, a central force field is conservative if and only if it is spherically symmetric.

[10] Recall that the negative gradient yields the direction of steepest descent.

[11] Kinetic plus potential energy.

[12] Crucially, there exist additional conserved quantities in both systems: the Jauch-Hill-Fradkin tensor $S = m\dot{\vec{r}}\dot{\vec{r}} + k\vec{r}\vec{r}$ for the oscillator, and the Laplace-Runge-Lenz vector $\vec{A} = m\dot{\vec{r}} \times \vec{L} - mk\hat{r}$ for Kepler.

[13] The equations of motion are invariant under time-translation (conservation of energy).

[14] Recall the relations $x = r\cos\theta$, $y = r\sin\theta$, and Euler's formula $e^{i\theta} = \cos\theta + i\sin\theta$.

[15] This is a purely aesthetic requirement. Unequal areal speeds produce an overall constant factor.

[16] With appropriately chosen constants $k, \widetilde{k}$.

Book Reviews

Infinitesimal

AUTHOR: **D. ROSA**

This book not only presents the origins of a revolutionary mathematical idea, but also tells a tale about the clash of two visions of the world, in a time of uncertainty and social volatility.

The story starts with the founding of the Society of Jesus (the Jesuits) in the wake of the Protestant Reformation. Its aim was to safeguard the Catholic Church and the "old world order" in the face of an uncertain future. One of the three pillars of Jesuit education, besides theology and philosophy, was mathematics; at its core stood Euclidean geometry, with its proofs based purely on a handful of unchanging axioms and on the laws of logic. However, a new school of thought was on the rise among some mathematicians of the day. The translation of Archimedes' works into Latin made his tentative ideas about infinitesimal quantities accessible to Western scholars. Starting with Kepler, many scholars went on to develop the idea of an "infinitely small" quantity and use it to prove novel results in geometry, which had previously been unattainable.

The first place where infinitesimals really took off was Italy in the first half of the 17th century. During this time, Galilei, Cavalieri, Torricelli, and others used this new theory not only to tackle unsolved problems, but also to find new proofs of old results. However, the elusive nature of the infinitesimal incurred the ire of the Jesuits. Mathematics had been valuable to them because it could describe the world around us in a clear and unambiguous language, revealing, therefore, the perfection of God's design. However, affirmations like "a geometrical figure is made up of an infinite number of infinitesimally thin lines" seemed ambiguous and thus undermined the clarity of mathematics. The Jesuits were determined to defend the "old view" of the world by any means necessary. The clash between them and the "infinitesimalists" was not just a mathematical debate; it had deep philosophical and theological ramifications. Eventually, the Jesuits decided to forbid anything related to infinitesimals in their schools; given the reach and popularity they had achieved across the Catholic world, this practically suppressed any research on infinitesimals in Italy and many other places by 1660.

Despite being shunned by the Catholic establishment of the time, the concept of infinitesimals found fertile ground elsewhere. In England, there was also a fierce battle between their proponents and detractors, which is best represented by the rivalry between John Wallis and Thomas Hobbes. The latter (also) relied on the classical Euclidean geometry proof as a scientific basis for his idea of a perfect authoritarian state, laid out in the *Leviathan*; he thought everything can be divided into building blocks like lines or points, and that nothing can be infinitely small. In the end, Wallis won the battle of ideas and went on to be among the founding members of the Royal Society. From there, other mathematicians like Newton and Leibniz used infinitesimals to lay out the foundations of calculus. Later, limits and continuity were rigorously defined... and the rest is history.

What I like about this book is the way in which it not only gives plenty of examples of infinitesimals at work, from the works of Cavalieri, Wallis, and others, but also delves into the political machinations and philosophical dilemmas that they triggered. Most of all, I was amazed to see how deeply the outcome of these debates has shaped not only the history of mathematics, but that of our modern world in general.

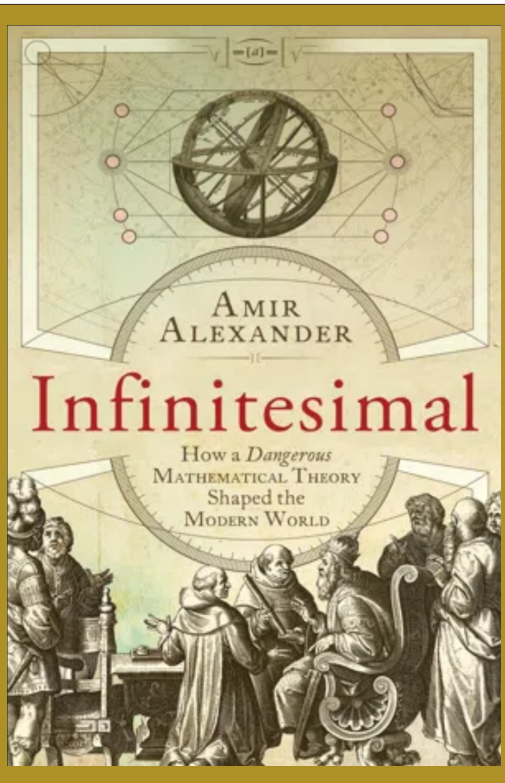

Figure 12: Infinitesimal

Gulliver's Travels

AUTHOR: **A. NIJLANT**

The book, written by Jonathan Swift, is called *Gulliver's Travels* or its official title, *Travels into Several Remote Nations of the World. In Four Parts. By Lemuel Gulliver, First a Surgeon, and then a Captain of Several Ships*, but who has time to say that? This is a book about the adventures of Lemuel Gulliver, divided into four parts. Before he started on his voyages, Lemuel Gulliver was an ordinary man who was interested in medicine, navigation and mathematics.

Part I: A Voyage to Lilliput

After a shipwreck, Gulliver was washed ashore of an island called *Lilliput*. The inhabitants, not taller than fifteen centimeters, took him in and even made him part of their politics there. The island of Lilliput was at war with the neighbouring country of Blefuscu. This is a reference to the political situation between England and France in the 1700's. Gulliver helped the Lilliputians to steal the marine fleet of Blefuscu.

Part II: A Voyage to Brobdingnag

Not long after getting back to England, Gulliver was yet again travelling by boat. This time, due to a storm, they diverted from their original path. Gulliver was abandoned by his companions on *Brobdingnag*. This race of people is the opposite of the Lilliputians: Brobdingnagians are giants. When Gulliver saw them for the first time, he hid in some wheat field and was found by a farmer who took him in. The farmer's daughter took care of Gulliver and not long after, Gulliver got his own "house". In Brobdingnag, Gulliver talked to the king and queen about politics in Europe.

Part III: A Voyage to Laputa, Balnibarbi, Luggnagg, Glubbdubdrib and Japan

This time, Gulliver's ship was attacked by pirates and the people of the floating island *Laputa* rescued him and welcomed him in their country. This is by far my favourite part, because the people of Laputa, the Laputians, were musicians, mathematicians, astronomers, and they were also very good at visual arts. However, their politics was a mess and they did not have an army either. After a couple side quests, Gulliver returned to England.

Part IV: A Voyage to the Land of the Houyhnhnms

After swearing he did not want to set foot on a ship ever again, Gulliver returned on a ship as the captain, however, his crew hated him and abandoned him again at the first possible island. The inhabitants of this island were peculiar, to say the least. The Houyhnhnms are talking horses and they are super strict, almost military-like. The Houyhnhnms called any human-like creature "Yahoo", but they saw Gulliver as a threat, and after some time, Gulliver was told to swim back to where he came from.

I picked up this book when, in youth orchestra, I played a piccolo solo for a piece by Bert Appermont that was based on this book. The solo was at the very start of the piece and this is why the first part of the book really spoke to me. Even though this book is funny, it is meant as satire, to critique the politics in England. This is why most of the political debates in this book are silly and have nothing to do with ruling a country. Besides this book being funny, I feel like we can learn a lot from this as a society and even though it was written in 1726, it is still relevant. It is so interesting to read about Gulliver's adventures and to see how he integrates in all of these societies, even though he is so different from the inhabitants. He studies the language and learns to live like those people, or horses... But I like that in the end it is just a book about an unlucky guy who got abandoned by his crew mates a bit too often and it is amusing.

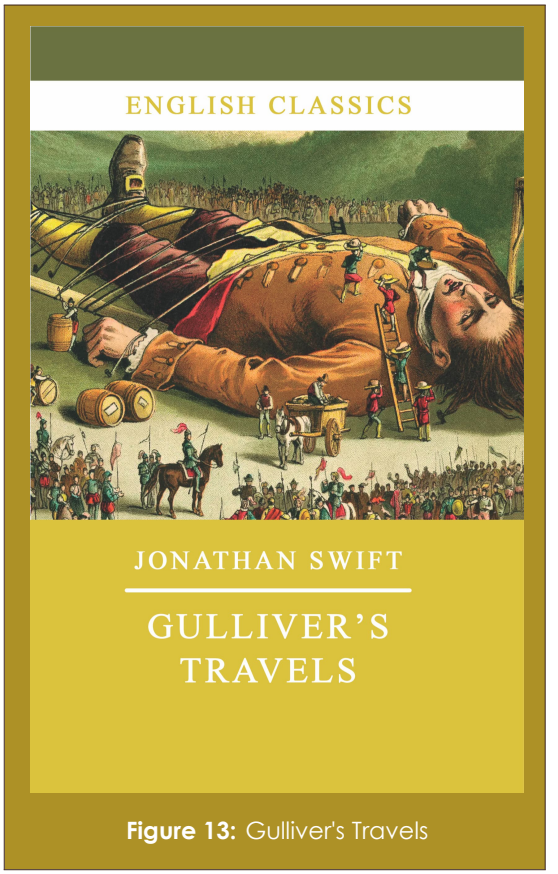

Figure 13: Gulliver's Travels

Lost Souls

AUTHOR: **L. ADDAMS**

If you like vampires; disturbing, unapologetic, 'in your face' issues; an amazing gay couple with a clearly dysfunctional yet loving relationship, this book is for you. From the very first sentence, you are immediately transported to New Orleans; a perfect setting for all kinds of Bohemian debauchery. This book quickly became one of my favourites, despite how utterly peculiar and just so *wrong* it is. Then again, the weirder, more unsettling or off-putting a book, the more I like it... in the right way. We are constantly surrounded by white-washed lies, so there's nothing better than a book that slaps you with the horrible things most people shy away from. The story, focusing on ±5 vampires and two possibly human men, is written in third person.

The author, Poppy Z. Brite, now a trans man known as Billy Martin, is a master of descriptive, vivid, visceral writing. All of your senses are needed when experiencing a piece by this author. It almost tastes like a more 'modern' (1993) Edgar Allan Poe, with a fascinating focus on alcohol, intimacy, and the numbed or dissociative states achievable through substance consumption (or abuse). Sometimes, it feels like you are drinking with the characters, especially when things get *weird*. If you have ever read anything by Joe Hill, Stephen King's son whom I find outshines his father, it has a similar effect.

The book has been placed under (gothic) horror, its dominant atmosphere, but it also easily falls under LGBTQ+ Fantasy and Gay Fiction. Before you consider picking up the book, be prepared to constantly feel like there is something *off* the whole time, and to feel uncomfortable and possibly outraged at some things that take place, like a psychological horror film done right (but with all the glorious bloodshed of a slasher). You also need a spoiler-free warning: there are rather disturbing topics and scenes that take place in this tale. It is definitely a deranged, demented expression of violent passion, and an utter disregard for morality. Something written by a tortured soul with no filter or any care for keeping things tolerable.

I have a funny story with this particular novel. You see, my uncle wanted to take me to buy a book, as he admired my obsession with reading and wanted to encourage me to keep doing it. I walked around the book store, looked around for a while, until I saw the mesmerising cover of this instantly tantalising tome. I have always been a fan of fantasy and horror, from a young age, so when I read the title, *Lost Souls*, I was immediately intrigued.

I mean, when 14 (or maybe younger) year-old Luci saw the word "*VAMPIRES*", plastered proudly on the front of the volume, she was going to read whatever was contained within. He happily bought it for me, and I got to exploring the story.

I was greeted with sex, drugs, and alcohol... and bloodsuckers. The infamous rock n' roll combination we were all exposed to when I was a teenager. Novels about vampires could easily be terrible drivel, as Twilight would go to prove, but not this. The pale handsome men with sharp teeth and the desire to kill you, who were growing quite popular at the time, accompanied by the aforementioned mixture, are vampires done right. This book *might* appear to be about those beautiful creatures of the night, but it tackles some fascinating topics. Rereading it now that I am 28, I find it amusing I was exposed to such a story at that age, but it entertained me beyond words nonetheless. I will be reading it again for sure, and I hope, after this review, you consider picking it up. It's available as an Ebook, too. Happy mind-twisting, gut-wrenching reading!

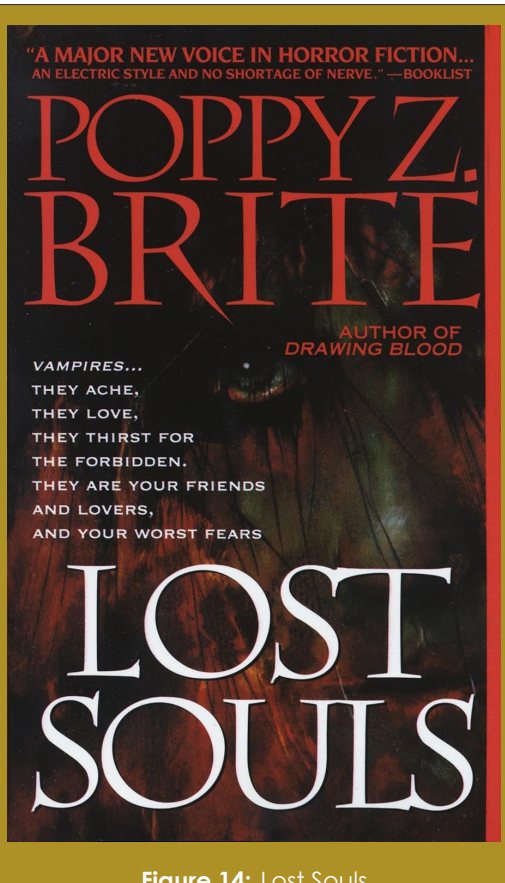

Figure 14: Lost Souls

The Nightingale

AUTHOR: **Y. SAVOVA**

Kristin Hannah's The Nightingale is a powerful and haunting work of historical fiction that follows the harrowing and heroic stories of two sisters in German-occupied France during World War II. Set against the backdrop of one of history's darkest periods, it is a moving tribute to the resilience, bravery, and quiet courage of women - sisters, mothers, wives, and widows - whose vital roles in times of war are so often overlooked or forgotten. These are the women who held families, communities, and nations together when everything around them was falling apart.

Vianne, the elder sister, begins the novel clinging to the hope that the Nazis will never invade France. She is a schoolteacher, a mother, and a wife trying to maintain a semblance of normalcy in a world inching toward chaos. But when her husband is drafted and sent to the front lines, and the German occupation of France begins, Vianne is forced to face the brutal reality of war. With a young daughter to protect and a Nazi officer assigned to live in her home, she finds herself making impossible choices in order to survive and keep her family safe.

In stark contrast, her eighteen-year-old sister Isabelle is fiery, rebellious, and unwilling to sit still as the world crumbles around her. Expelled from finishing school and thrust into a world on the brink of war, Isabelle longs to prove her worth and take action. She soon meets Gaëtan, a passionate young partisan who ignites in her a fierce desire to resist the Nazi regime. But when Gaëtan abruptly leaves her behind, Isabelle is left heartbroken and more determined than ever to fight back. She joins the French Resistance and begins a dangerous mission, risking her life over and over again to lead downed Allied airmen out of hostile territory and into safety.

The story unfolds through a compelling dual narrative structure: a present-day first-person account from an elderly woman interwoven with a third-person account of the sisters' experiences during the war. This layered storytelling approach lends the novel both intimacy and immediacy, as past and present slowly converge. Though Hannah avoids overly graphic depictions of violence, she doesn't shy away from portraying the cruelty, terror, and moral complexity of life under Nazi occupation. Instead of sensationalizing war, she emphasizes its psychological and emotional toll - the hunger, the silence, the fear, and the impossible decisions faced by ordinary people trying to survive.

"In love we find out who we want to be. In war we find out who we are."

What makes The Nightingale especially moving is its focus on women's contributions to the war effort - not just through grand acts of defiance, but also through the quiet, everyday acts of resilience that made survival possible. Hannah's characters are not flawless heroes, they are deeply human, shaped by their fears, their losses, their mistakes, and their love for one another.

The Nightingale is not an easy read, but it is a profoundly beautiful and necessary one. It celebrates the resilience of the human spirit and the enduring strength of women in the face of overwhelming adversity. Though I don't typically gravitate toward historical fiction or slower-paced narratives, this novel moved me deeply and has stayed with me long after I turned the final page. It's more than just a story of war - it's a story of love, sacrifice, identity, and what it means to stand up for what's right in a time when doing so could cost you everything.

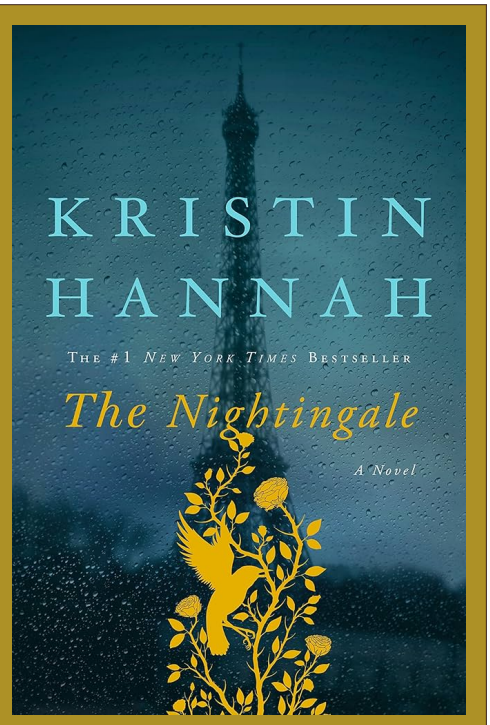

Figure 15: The Nightingale

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Social Reading
Exchange Article

AUTHOR: **H. GHATTAS**

Introduction

Reading, reading, reading. I think everyone who is pursuing a university degree has something in common: it is a lot of work and a lot of reading. I myself am a law student and have to read thick books with a lot of text. But when was the last time you read a book for pleasure? Was that still when you were in elementary school and read books like Percy Jackson, or was it in high school, before you were forced to read books for English or Dutch? It is well known that people read less than before. Some are struggling with a reading slump, while others cannot muster the concentration for it or simply do not enjoy it. Additionally, most people already read enough for their studies and see no added value in reading fictional books that offer nothing else for their career or studies.

I read many books when I was younger, but in high school I read less and less due to the amount of schoolwork I had to do. When I got to university, I became a member of the Literary Student Association Flanor: a cozy association with more than 30 book clubs in all sorts of different genres. The fun part about this association was that it made reading for me a social activity. Since I joined the association, I have read new books from different genres that I haven't tried before. It has made me realize that reading shouldn't be an individual hobby that people have but rather a social activity. We already know that reading books has many benefits, such as consuming knowledge and empathy. However, in this article, I want to share with you the added value of viewing reading as a social activity instead of a solo activity, by reading a book together with friends or joining a book club.

Socializing

At Flanor, we have reading groups that choose a new book together approximately every two months. Once most people have (almost) finished it, we discuss it at someone's home or in our regular pub. I really enjoyed the first book I read in one of Flanor's reading groups. I had already discussed with several people that we wanted to read it, and finally, the moment had come: it was chosen by a Flanor reading group. The best part was giving each other updates on how far you were, teasing each other with spoilers, sometimes reading together in a café or park, and building the suspense until the end of the book. During the discussion, you can immediately talk with each other about what you thought of the book, share your enthusiasm, good reviews, or, of course, your criticism, because, let's be honest, there is nothing more enjoyable than complaining together about a bad book. After the discussion, you can plan which books you want to read together next time.

This whole experience made reading no longer something you do alone on the train or in your room, but rather something you can experience together and everywhere. It adds so many more dimensions to reading and makes it an active activity with a lot of social interaction.

Figure 16: Reading at the park.

Motivation to get out of your reading slump

Reading together has also gotten me out of my reading slump. It is often thought that people stop reading for pleasure because they are no longer reading the right books. The combination of a not-so-interesting book and distractions like social media can make reading feel

less enjoyable. As a solution, people often recommend the perfect book to each other to get back into consuming literary works.

Although this is true for many people and a good book can certainly help, I think that social reading can also play an important role. Nowadays, many books go viral on social media and are read with great enthusiasm. I don't think these books are necessarily read so much because they are exceptionally good, but mainly because so many people are reading the same book together. It creates a shared sense of involvement: people can talk about it together, exchange opinions, and be part of a larger conversation.

Figure 17: Group Reading at Cat Café

You can also experience the same feeling when you read a book with a friend or in a small book club. Many people find it motivating to know that others are reading the same story, making reading enjoyable and meaningful again. In such a club, you often choose a book together: sometimes one you already wanted to read, but other times, also a surprisingly new genre you had not thought of before (and honestly never wanted to read). Yet, it turns out that those very books are often the key to getting back your reading motivation.

Furthermore, once you get started, you often find that you naturally start reading individually again, perhaps because that one book you wanted to read was not chosen by the group. But that does not have to be the goal, of course. Social reading is reading, and that is often enough to get out of your reading slump.

Activities for social reading

To prepare you for your social reading journey, I want to share a few fun tips that you can do together with your reading group to motivate each other to read (more) again.

Now that the weather is getting nicer, it is the perfect time to organize a silent reading party in the park with your book club or friends. Everyone brings their book and some snacks, and you all go read together for an hour outdoors. It feels a bit like studying in the university library; when you see others studying, you get motivated, too. The same goes for reading!

Figure 18: Flanor visiting the bookshop Van der Velde in Groningen

Chatting is, of course, not forbidden; it makes the reading session even better. It does not have to be your joint book at all. It is actually more fun if everyone brings a different book so you can tell each other what you are working on and get each other excited about new titles.

Another tip: go together to bookstores in Groningen! We have plenty of great options here, such as the two branches of Van der Velde, Walter's Bookshop, and of course Riemer (tip: Riemer also has a cute café!). These stores have a wide selection and are ideal for browsing together and discussing books. Just be careful not to

spend too much money on books you are not ready to read. Besides reading, you can also keep a book journal. You can do it individually, but is it not even more fun to work on it together? Schedule a time when you all work on your own journals and inspire each other with ideas. Chat away while you work, exchange creative goodies, and rediscover your enthusiasm for the book you just read or the one still on your list.

Flanor
Literaire Studentenvereniging

Conclusion

To conclude, I recommend everyone read socially. It has so many benefits: you get out of your reading slump more easily, it makes reading fun again, and it is a perfect hobby to share with your friends! Do you not have any friends around you who love reading or who read your favourite genres? Then definitely check out the Literary Student Association Flanor! We are a literary student association with around 220 members that you can join throughout the year. Members can join one (or more!) of our 30+ reading groups, with genres like literature, young adult, fantasy, science fiction, and much more. Check out our website: www.flanor.nl/en.

Figure 19: Typical Flanor activity

ART SECTION

Q.HUANG

Recipe

Grandma's Easy Chocolate Walnut Cake

AUTHOR: **Y.SAVOVA**

This cake has been the highlight of every family gathering since I was a kid. It wasn't until I got to university that I realized how simple it actually is to make. If I can pull it off in a tiny student kitchen with a microwave-sized oven, you definitely can too. I even made it twice for one of my favorite FMF events - the potluck, where everyone brings a homecooked dish to share. The feedback was positive so if you don't trust me, you sure trust your fellow FMF members.

Recipe

Preparation time: ~ 20 minutes
(+ a few hours for the cake to cool down)
Baking time: ~ 35-40 minutes
(more or less depending on your oven)
Portions: 12-16 servings
Allergen information: eggs, walnuts

Main Ingredients

- 6 eggs
- 250 g room-temperature unsalted butter
- 3 tbsp cocoa powder
- 300 g powdered sugar
- 300 g ground walnuts (about 1½ cups)
- Extra walnuts or sprinkles for decoration

Figure 21: Ingredients

Figure 20: The cake at the FMF potluck

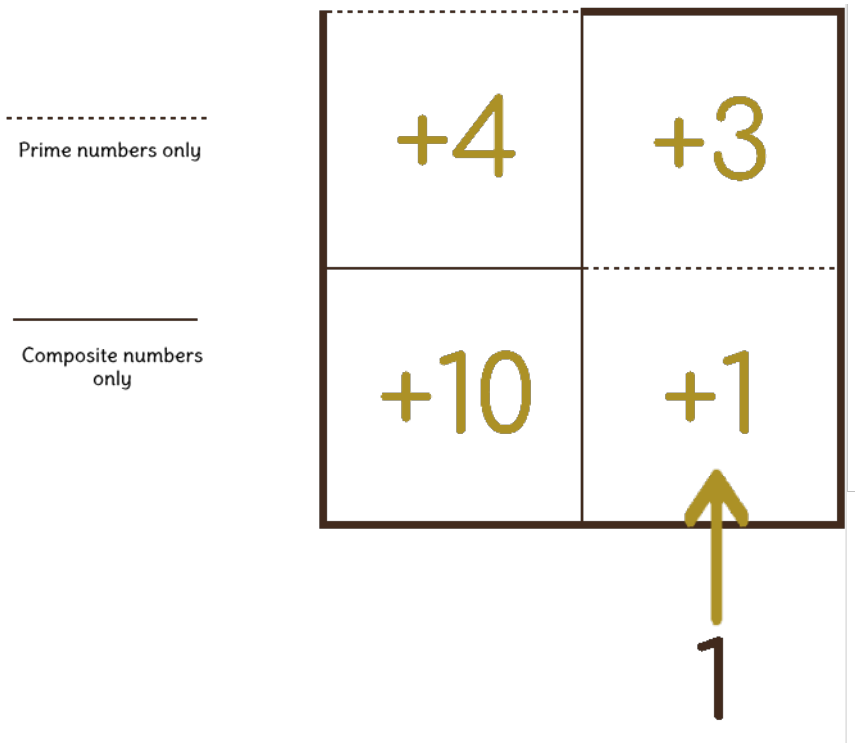
Cooking Instructions

1. Preheat your oven to 180°C.
2. Separate the egg yolks and whites in two bowls.
3. In the bowl with yolks, mix in the room-temperature (or melted if you didn't plan ahead) butter, cocoa powder, and powdered sugar. Set aside ¼ of this mixture for the frosting.
4. Beat the egg whites until stiff peaks form.
5. Gently fold the beaten egg whites and ground walnuts into the remaining ¾ of the yolk mixture.
6. Bake for 35–40 minutes, or until a toothpick inserted in the center comes out clean.
7. Let the cake cool completely. Spread the reserved mixture on top as frosting.
8. Decorate with chopped walnuts or sprinkles.

Brainwork

The smallest maze

AUTHOR: **R. MOL**



Welcome to the world's smallest maze. Every time you enter a room in this maze, your number increased by the amount indicated in that room. You enter at the bottom right as the number 1 (thereby becoming the number 2 immediately) and can only pass through a door if your number is of the right kind.

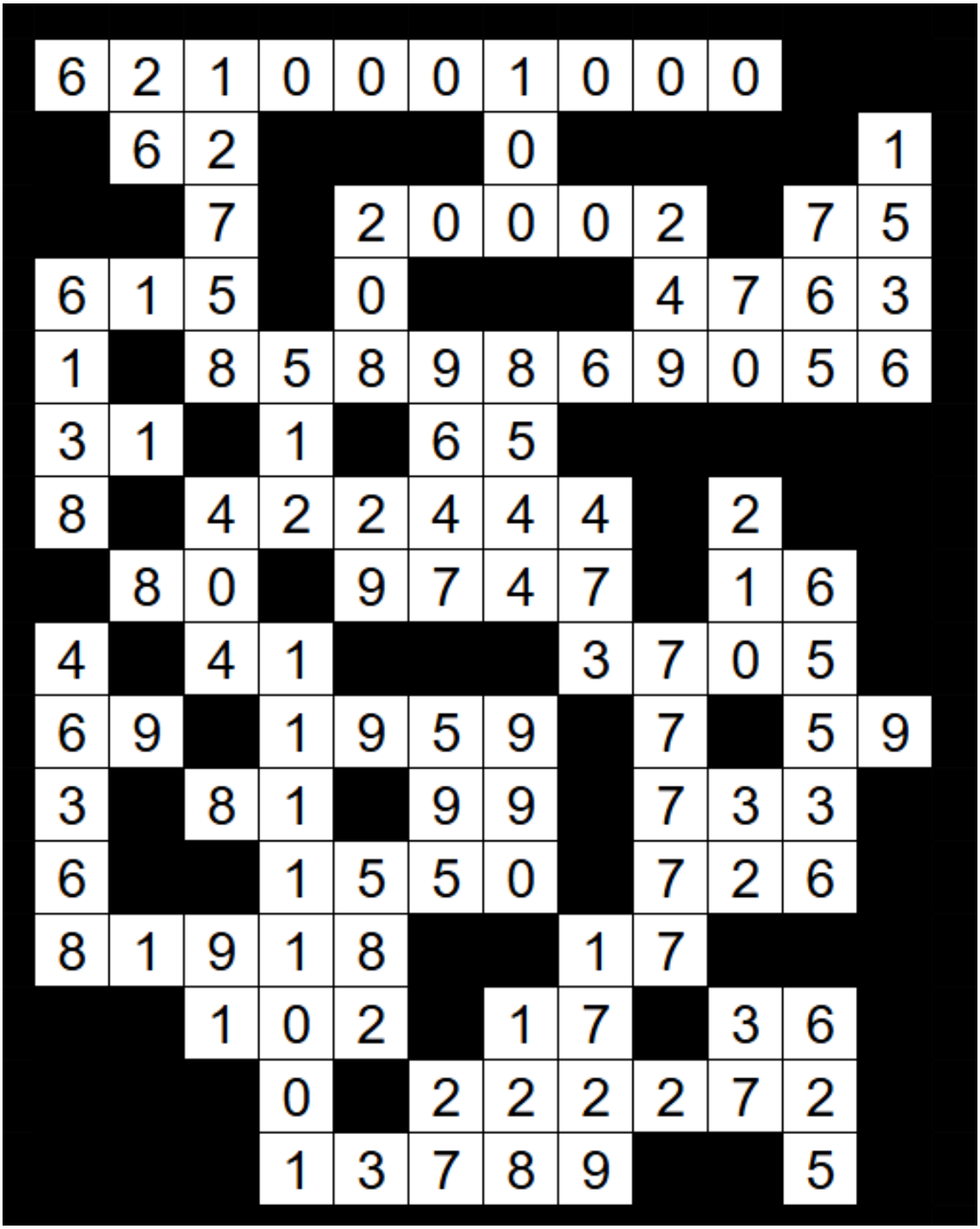
Only prime numbers can pass through dotted doors (between +1 and +3, as well as the exit in the top left).
Only composite numbers (non-primes) can pass through the thin solid doors (between +3 and +4, between +1 and +10, and between +4 and +10).

As you enter the maze and become 2, you can only pass through the dotted door, becoming 5. You can only leave the maze through the top left, there are many paths to leave the maze, what the smallest number you can leave the maze as?

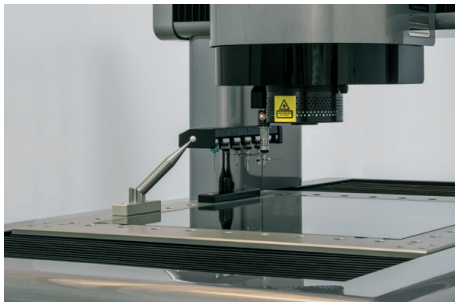
For an added challenge, can you find a way to get stuck in the maze?

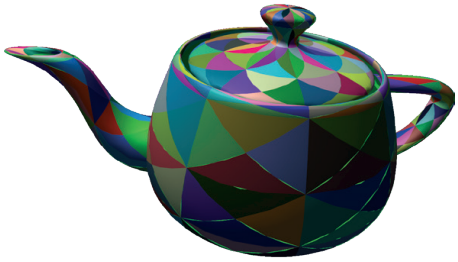
Send your solutions to perio@fmf.nl to be featured in the next issue!

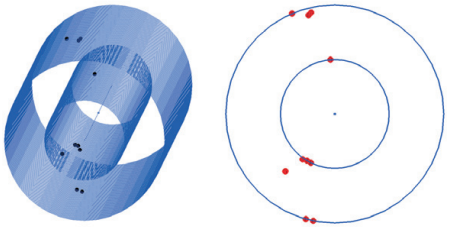
Solution to the previous Brainwork

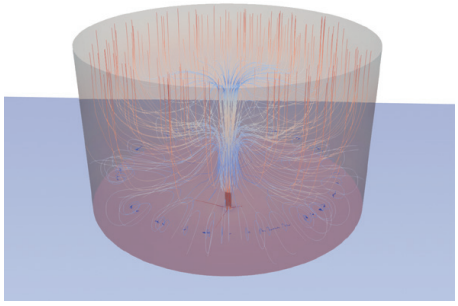


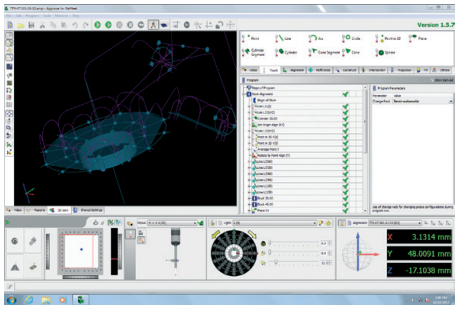
The previous puzzle was solved by Max-Friso Schaap, congratulations!











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We offer positions for careers, internships or graduation projects involving a wide variety of technical subjects. Previous projects include topics such as adaptive tessellation using Bézier patches, fit algorithms for geometrical shapes from point clouds, optical lens system design, computational fluid dynamic analysis for air bearing designs and Monte Carlo raytracing.

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