The Ramblings and Tribulations of a Teacher

Perio Interview: Diererik Roest

Periodiek

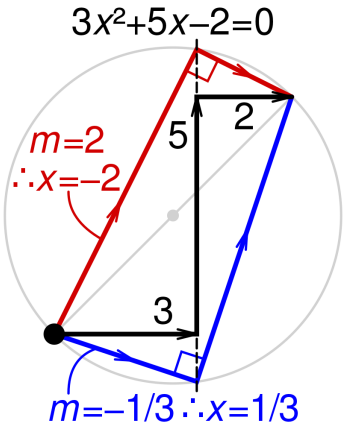
Recurring Magazine | Issue 2021-2

Asymetry in budgets: A short explaner on Modern Monetary Theory

FMF

Lill's Theorem

The roots of a given polynomial obviously depend on its coefficients, but only in some convoluted, unintuitive, and definitely algebraic way -- right? Lill's theorem illustrates a wholly geometric interpretation of a polynomial's real roots, in the most literal way. In this article, you'll be treated to a simple proof of this marvelous result, and be given some food for (mathematical) thought applying it.



Perio Interview; Diederik Roest

In this Periodiek, you will be met with an interview with a physics professor of our university you will most definitely have interacted with if you're a physicist or an astronomer.
Windsurfing, listening to Bob Dylan music, all whilst in his professional life upholding a superposition of research and teaching with an efficient overlap, we're talking about (and have talked with) no one less than Diederik Roest.

The Ramblings and Tribulations of a Teacher

Catherine Rigollet is well-known and loved by anyone who has ever taken one of her courses, such as Nuclear Energy. In this edition of the Periodiek she shines some light on her end of teaching, showing that even experienced teahcers still get nerveous on the first day of a course - and how she deals with it.

In this Periodiek

From the Editor in Chief

Hello there. With the summer break around the corner, we are excited to bring you the last issue of the Periodiek of this academic year.

In this issue, we have interviewed a physics professor about impulsively buying sailing boats, organized a writing competition, and, for something new, brought you an opinion piece. I am personally very excited about the comeback of *In the News*, and with that, the comeback of its author to the board of editors.

The past year has been an incredibly hectic year and I would like the thank everybody who has edited, written for, and read the Perio in the past year and hope to see you next year.

Robert Mol.

Editors
Robert Modderman,
Vedang Sumbre,
Tesse Tiemens,
Robert Mol

Authors
G. Hora de Carvalho
R. Modderman,
R. Scholtens,
C. Rigollet,
T. Tiemens,
V. Sumbre,
S. Chulei,
F. Drent,
R. Mol

Advertisers
ASML (p.15)
Schut (p.28)

Advertise? Contact us at bestuur@fmf.nl.

Print run 912 pieces

Press BladNL.nl

ISSN 1875-4546

The Periodiek
is a magazine from the Fysisch-Mathematische Faculteitsvereniging and appears three times per year. Previous issues can be found at perio.fmf.nl. The board of editors can be reached at perio@fmf.nl.

In the News

The return of your triannual dose of latest news in the world of science and engineering

AUTHOR: **R. MODDERMAN**

Yes, that's right: *In the News* is back! After an absence of two years, the editors of the Periodiek decided to give this column a comeback. To our current knowledge, *In the News* has been in existence from the start of Periodiek in 1996 until the summer of 2019. A lot has happened in two years. Some things you might still have fresh in your mind, others you might have forgotten. And so, here a collection of news items in the world of science and engineering of the past two years, compiled together in the form of a timeline.

July 2019 - *Last "In the News"*

In this month, the most recent Perio with an *In the News* (thus not counting the current Perio) was issued. This is the point at which we dive into the most important, intriguing and notorious scientific news items of the past two years.

April 11, 2020 - *"John Conway, 1937-2020"*

On this date, British mathematician John Conway passes away. By many mathematicians he is considered one of the best post-WW2 mathematicians, having been active in all four main areas that are often being agreed on to constitute modern pure mathematics: number theory, algebra, geometry, and analysis. Conway however never shied away from setting foot on other less "pure" areas as well, such as game theory. Within a broader public, Conway was especially known for the invention of the zero-player cellular automaton game *Game of Life*, in modern times often brought to life in the form of arcade-like animations[1]. In 2017, Conway was granted honorary membership of the infamous British *Mathematical Association*. John reached the age of 82. Rest in peace, John.

FIGURE 1: John Conway (photograph from CNN)

October 6, 2020 - *"Black Hole Themed Nobel Prizes in Physics"*

The 2020 Nobel Prize in Physics was decided by the Royal Swedish Academy of Sciences to be awarded in two halves. On half went to Roger Penrose (University of Oxford, UK) "for the discovery that black hole formation is a robust prediction of the general theory of relativity", the other half jointly to Reinhard Genzel (MPIfEP, Germany; University of California, Berkely, USA) and Andrea Ghez (University of California, Los Angeles, USA) "for the discovery of a supermassive compact object at the centre of our galaxy"[2]. The research for which the Nobel Prizes were awarded brings humanity to a closer understanding of the weirdest objects in existence in the universe.

February 18, 2021 - *"7 Minutes of Terror"*

On this date, having not been sending missions to Mars in a while, NASA's Mars rover Perseverance lands on Mars. Its main purpose is to collect samples from the soil of Jezero, a 30 mile crater on the surface of Mars. According to NASA[3], Perseverance's goal is four-fold: to look for indicators whether microbial life would have been possible on Mars, look for indicators of past microbial

1 https://www.youtube.com/watch?v=C2vgICfQawE

2 https://www.nobelprize.org/prizes/physics/2020/press-release/

3 https://mars.nasa.gov/mars2020/mission/overview/

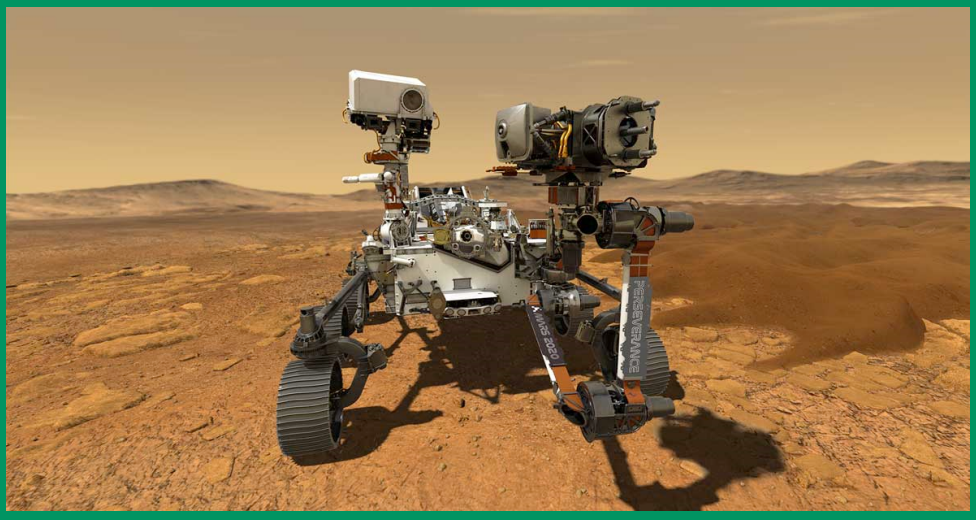


FIGURE 2: A CGI of the Mars rover

life in those regions, collect further soil and rock samples, and test if (and if yes, how much) oxygen is produced on Mars (and is present in its atmosphere). When landing the capsule, the last seven minutes will be automated by the capsule itself as communication between earth and the capsule will have a lag in the order of minutes. Since humans don't control the landing process, such a landing goes under the nickname of "7 Minutes of Terror". Breathtaking moments. But the landing succeeded. That the rover may persevere!

June 23, 2021 - *"John McAfee, 1945-2021"*

John McAfee committed suicide in a detention cell in Barcelona[4], where he was kept for having allegedly evaded taxes in the US in an illegal manner. John McAfee was known for his infamous anti-malware software, which he brought on the market under the name of "McAfee". In the old days, computers were mainly used in companies, universities, institutes, and governments, and in the early 80s, computer viruses arose and with that anti-malware software was developed as well. John however was the first (1987) to find a model to commercialize antivirus software and to distribute it on the world market, not only for professionals but also for private use. John McAfee was known for his eccentric lifestyle. He parted from his company in 1994, and after that he even said that he hated the software he created himself, claiming that he never used antivirus software at all! John even gave instructions on how to remove the software (we won't give a link, one can find this on their own on the internet). Nevertheless, John will be remembered for having a sharp insight on both the area of computers and the area of the computer market. John reached the age of 75. Rest in peace, John.

4 https://www.reuters.com/legal/government/john-mcafee-found-dead-prison-after-spanish-court-allows-extradition-2021-06-23/

FIGURE 3: A 1995 floppy disk with McAfee's

Summer 2021 - *"Today"*

…and this is where our trip through (popular) scientific news ends! But we're not done yet with you, dearest readers! For the next *In the News*, it is possible to send us tips for news items for us to write about! You can send them to perio@fmf.nl. If your tip is selected, and given your permission, we will publish your name alongside the particular news item. Goodbye for now, and take care.

From the Board

Treasurer

AUTHOR: **R. MOL**

Hi everyone,

Looks like it is my turn to write something for the Perio. Now that the academic year has ended and our board year is nearing its end, I look back on a remarkable year. Needless to say, there was a fair share of obstacles and learning opportunities. When I got glimpses of our bookkeeping program, Exact Online, before my board year, it always had a certain intimidating effect on me. Fortunately, this has been replaced by a deeper understanding of both it, and bookkeeping in a general sense. As well as a healthy bit of frustration when it won't save you taxes settings for the *n*-th time.

Why did you apply for board?

I started studying at the RuG in 2016, when the faculty was still called the Faculty of Mathematics and Natural Sciences (a way better name if you ask me), and have been an active member ever since. I remember the first committee I joined, the A-Team, having quickly falling in love with organising events and making posters. As time went on and the FMF became a more integral part of my student life, it felt only right to apply, and last year, with only some bachelor courses left, seemed like the best moment.

FIGURE 1: Robert Mol, the Treasurer of the FMF, wielding the treasurer axe.

What is the best part of being on the board?

Definitely the closer involvement with the association. As a board member, and also as treasurer you are involved with almost all aspects of the association in one way or another. Aside from giving you a bigger perspective and a deeper understanding of what we, the FMF, really are about, it broadens your network both inside and outside of association.

And the worst?

I would probably say the stress. While it is great to work for this association, it can take quite a bit of your time (which I am admittedly quite poor at managing). Sometimes you need take a step back, take a day off, and return to work. In the end, I can never sit still for long.

Closing

With that said, it is almost time for us to pass the torch to our succesors. The candidate board in in full swing to take over our tasks and learn how to become a fully realized board themselves. For me, I will retreat to the background and join the audit committee so I can keep an eye on my successor and enjoy some well-deserved croissants.

Lill's Theorem

A cute Solution to an obtuse problem

AUTHOR: **R. SCHOLTENS**

I've always been a person that can enjoy a visual proof of a statement, or otherwise just a visual accompaniment to an algebraic one. So, when I came across the demonstration of Lill's theorem in a math textbook I was perusing, it naturally caught my attention. Lill's theorem concerns real roots of general n-th degree polynomials,

$$x \in \mathbb{R} : a_n x^n + a_{n-1} x^{n-1} + \ldots + a_1 x + a_0 = 0, \qquad (1)$$

with arbitrary coefficients $a_i, i = 0 \ldots n$, but in a *strictly geometric setting!* Let me elaborate.

The trailing turtle

From our arbitrary polynomial (1), we first make the following construction. We start a turtle off at the origin, facing towards positive x, and set it off walking a distance of a_n (if $a_n < 0$, the turtle will move in the negative x-direction). Then, it turns counterclockwise 90^0, and walks a distance of a_{n-1} (again, in the opposite direction if $a_{n-1} < 0$). The turtle will follow this procedure all the way down to a_0, and it will end at a point somewhere in the plane - dub this point T. What our turtle has thus done is connect the points

$$\begin{aligned} &(0,0), (a_n, 0), (a_n, a_{n-1}), \\ &\quad (a_n - a_{n-2}, a_{n-1}), \\ &(a_n - a_{n-2}, a_{n-1} - a_{n-3}), \\ &\quad \ldots, T, \end{aligned} \qquad (2)$$

defining its *first* path. For convenience, denote the points along its path as O (for origin), $P_n, P_{n-1}, \ldots, P_1, T$.

We then transport the turtle back to the origin, and set it walking once more - but now, with a particular initial angle of θ . Once it reaches a line segment it has drawn previously, or an elongation thereof, it makes a ± 90^0 turn, depending on which turn is relevant, and repeats the process. The tireless turtle then trudges through till it reaches the final destination, T, completing its *second* path - dub the points it visits on this second path as O (for origin), $Q_{n-1}, Q_{n-2}, \ldots, Q_1, T$. The angle θ mentioned earlier is selected *so that* the point T will be reached in the end. Such an angle may or may not exist, but let us assume for now that it does.

These two paths are probably a bit much to draw mentally, so please consult figure 1 for two very helpful examples. Then, we can state the theorem.

Theorem (Lill, 1867). *Let θ be as in the above construction. Then, $x = -\tan(\theta)$ is a solution of the equation*

$$a_n x^n + a_{n-1} x^{n-1} + \ldots + a_1 x + a_0 = 0. \qquad (3)$$

How can it be that the *geometric* quantity θ is even related to the solution of the *algebraic* equation above?! The secret lies in similar triangles, and the proof is surprisingly concise.

The proof

We first aim to find $|\overline{P_n Q_{n-1}}|$, for which end we consider the triangle $\triangle O P_n Q_{n-1}$ - check figure 2 for a sketch of the quintic case. Since $\angle O P_n Q_{n-1} = 90°$, we can use trigonometry to conclude that

$$\begin{aligned} |\overline{P_n Q_{n-1}}| &= |\overline{OP_n}| \cdot \tan(\angle P_n O Q_{n-1}) \\ &= a_n \tan(\theta) = -a_n x. \end{aligned} \qquad (4)$$

Next, let us find $|\overline{P_{n-1} Q_{n-2}}|$. In this case, consider the triangle $\triangle Q_{n-1} P_{n-1} Q_{n-2}$, notice that $\angle Q_{n-1} P_{n-1} Q_{n-2} = 90°$, and so use trigonometry:

$$\begin{aligned} |\overline{P_{n-1} Q_{n-2}}| &= (a_{n-1} - |\overline{P_n Q_{n-1}}|) \cdot \tan(\angle P_{n-1} Q_{n-1} Q_{n-2}) \\ &= (a_{n-1} + a_n x) \cdot \tan(\theta) \\ &= -x(a_{n-1} + a_n x), \end{aligned}$$

where we crucially used that

$$\begin{aligned} \angle P_{n-1} Q_{n-1} Q_{n-2} &= 90° - \angle O Q_{n-1} P_n \\ &= 90° - (90° - \theta) = \theta. \end{aligned} \qquad (5)$$

Let's do one more step: by the same reasoning as earlier, we have that

$$\begin{aligned}&|\overline{P_{n-2}Q_{n-3}}|\\&= (a_{n-2} - |\overline{P_{n-1}Q_{n-2}}|) \cdot \tan(\angle P_{n-2}Q_{n-2}Q_{n-3})\\&= -x(a_{n-2} + x(a_{n-1} + a_n x))\end{aligned}$$

We then continue going all the way down, ultimately ending up with considering the length $|\overline{P_1T}|$ (recall that T is the final point of the turtle's second path) and resulting in

$$\begin{aligned}|\overline{P_1T}| &= -x(a_1 + x(a_2 + \cdots + x(a_{n-1} + a_n x)\dots))\\&= -a_n x^n - a_{n-1}x^{n-1} - \cdots - a_1 x.\end{aligned}$$

But, now, for the apotheosis, by definition we have that $|\overline{P_1T}| = a_0$. As such, we have that x satisfies the equation

$$a_0 = -a_n x^n - a_{n-1}x^{n-1} - \cdots - a_1 x, \quad (6)$$

which means that x solves (3). □

On the angle θ

However, it would be disingenuous of me not to mention the obvious downside: we *assumed* that an angle θ existed, but how do we know this - and more importantly, how could we find it? There's no general way to find the angle θ that works; in fact, it's probably harder than using an established numerical root-finding algorithm. Nevertheless, there are a select few cases in which the angle θ can be *constructed*, and for the remainder of this article I want to highlight two of these: applying Thales' theorem, and Beloch's construction.

Utilize Thales

Thales's theorem states that if you have two antipodal points on a circle, then if you create a triangle featuring these two points and another one on the circle, you are guaranteed a right-angled triangle. How does it relate to Lill's theorem, though? Consider a quadratic polynomial, where $c/a < 0$ (i.e., one of a, c is negative and the other positive) - see figure 3. Draw the circle on which O and T are antipodal, and extend the middle segment's length so that it intersects with the circle - call the intersection points A and B. Then, by Thales, $\angle OAT = \angle OBT = 90°$, so the paths from O to T via these intersections will form valid second turtle paths! Once you draw these paths, then, two angles $\theta_{1,2}$ will appear which negative tangents are solutions to the quadratic. Beautiful!

Beloch's construction (or: solve cubics with origami)

To me, this corollary/"application" touches the most base with how I originally found out about Lill's theorem, being through the context of origami. First found by Margharita Beloch in the 30's, the main idea is that if you draw the first turtle path of some given cubic equation on a piece of paper, you then construct two additional lines and subsequently *fold your paper* in a particular way: to make the origin O and T land on these two newly constructed lines simultaneously (or well, O on one of the lines and T on the other). This fold will serve as the middle segment of the second turtle path, from which that entire path can be reconstructed - see figure 4. The second turtle path has been found!

For full details of the construction of the two auxiliary lines and a proof that this method works, I refer you sources [1] & [2]. Suffice it to say though, what made this method work is precisely that we could "match" two distinct points with two distinct lines to create another line (or fold/crease). This move is impossible in the standard compass/straightedge geometry of the Greeks, and so allows "origami geometry" to construct things classically impossible, such as trisecting an angle or constructing $\sqrt[3]{2}$.

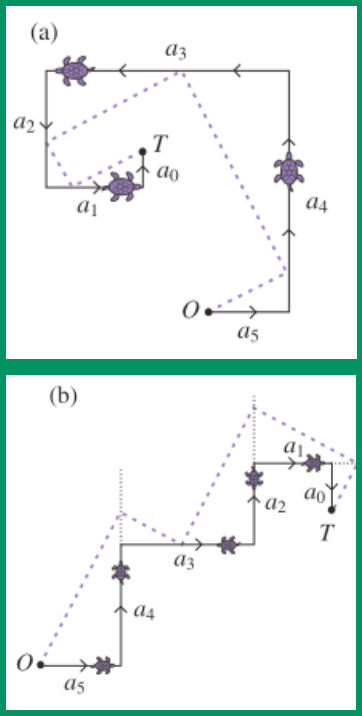


FIGURE 1: Examples of the two turtle paths (first solid, second dotted). Figure from [1]

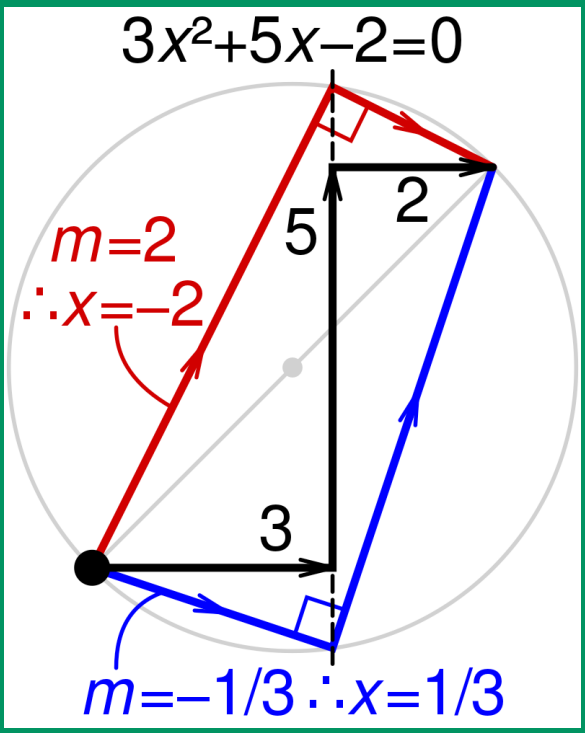


FIGURE 3: An example of how Thales' theorem is combined with Lill's theorem to solve quadratic polynomials. If only the ancient Greeks knew! Figure from [4].

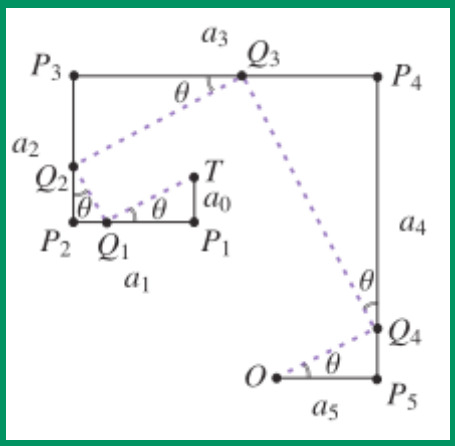


FIGURE 2: Sketch of proof of Lill's theorem for quintic case; general case follows similarly. Figure from [1].

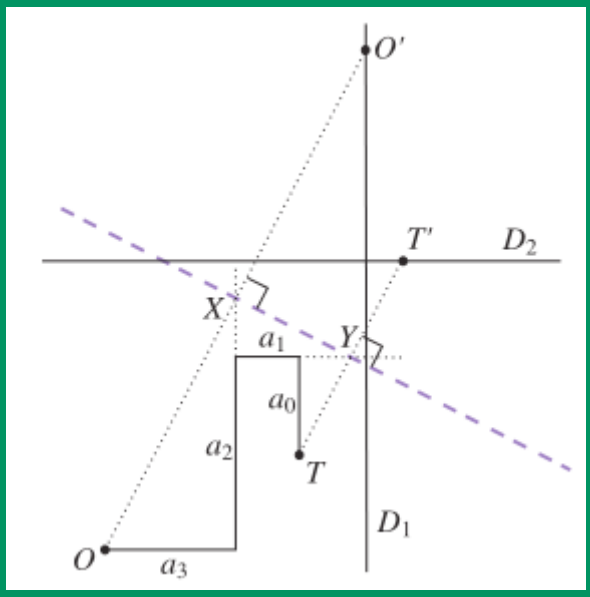


FIGURE 4: Beloch's (origami) construction to solve a cubic polynomial, based on Lill's theorem. Figure from [1].

References

[1] Thomas C. Hull, *Origametry,* Cambridge University Press (2021). ISBN 978-1-108-47872-4.

[2] Thomas C. Hull, *Solving Cubics With Creases,* American Mathematical Monthly 118 (2011) 307-315. doi: 10.4169/amer.math.monthly.118.04.307.

[3] Mathologer, *Why don't they teach this simple visual solution?* (Lill's method), YouTube, 2019. https://www.youtube.com/watch?v=IUC-8P0zXe8&ab channel=Mathologer (accessed 7-7-2021).

[4] https://en.wikipedia.org/wiki/Lill%27s method.

Perio Interview: Diederik Roest

and questions about the universe

AUTHORS: **V. SUMBRE, T. TIEMENS**

Diederik Roest is a staple of the Physics programme, giving Quantum Physics 1 in his own iconic style, and has a passion for teaching. Besides that, he is also a theoretical physicist and cosmologist at the Van Swinderen Institute for Particle Physics and Gravity. In this edition of the Perio Interview we get to know him a bit better.

Hi, I'm Diederik, Diederik Roest. I am a theoretical physicist and cosmologist at the Van Swinderen Institute for Particle Physics and Gravity. We try to study the smaller structure of nature, so we zoom in, but I'm also a cosmologist and who studies the universe, so we zoom out. And of course the big question is, "Why on Earth is that a useful thing to do?", because normally things on different length scales are unrelated right? In order to play basketball, you don't need to understand quantum physics. But that's not true for the universe! Because even though now of course the universe is massive, in the good old days it was really really tiny, and we think it was actually governed by quantum physics. And there's a lot of strong evidence that suggests that everything that we see in the universe actually originated from quantum fluctuations in the fraction of a second following the big bang. So that's why it makes sense actually to both zoom in and zoom out, because by studying the very largest, what the universe looks like today, all the different structures, their statistical properties, you can learn something about the laws of quantum physics that governed the universe back in the days, 13.8 billion years ago.

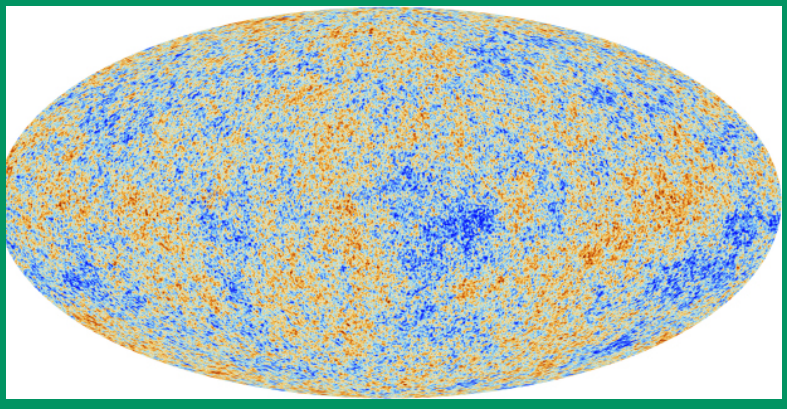


FIGURE 1: The termperature fluctuations in the Cosmic Microwave Background, a remnant of the primordial universe

How did you end up in this field?

So I did my PhD in Groningen actually, I'm sort of home-bred. I did my bachelor, master and PhD in Groningen, with Eric Bergshoeff, and that was more in the direction of string theory, so really trying to unify special relativity, gravity, on one hand, and on the other hand quantum physics, Quantum Field Theory (QFT) for instance. That's notoriously hard of course, quantum gravity is really difficult, both theoretically, and even more so experimentally, and so my PhD was on different aspects of string theory, if you like. And it was only afterwards that I got sort of interested in the universe, a bit out of frustration about the difficulty to test these ideas. At some point I realized, and many people with me - there was a movement in the field - that we should think about the universe as maybe a possible laboratory to test those ideas of quantum gravity. And again that's related to the big bang. So in a sense I started off studying the really small, and then at some point I realised that you have to include the very large, and the origin of the very large, to be able to test those ideas.

Do you continuously work on this or is it in projects?

I think there's a relatively short time cycle, which means it's always in projects, and every project is around half a year. Of course,

different projects are connected and build onto each other. So we always have a few research lines, one of them is more formal, as in theoretical or mathematical physics, the other one is more related to cosmology and understanding the big bang, with a number of topics that sort of follow up on each other. I kind of like the fact that there's this relatively short time scale, like within a few months or maybe half a year, because then it means you get to publish a paper again, and you get a little pat on the shoulder, either from yourself or from your colleagues, and you can start afresh.

"In order to play basketball, you do not need to know quantum physics"

How did you spend your off-time during the pandemic? Were there any projects that you picked up or were you just with the family?

A part of that, yea sure. I realised I started doing more sports, like running for instance. And I bought a sailing boat, nearly the best decision of my life. We bought the smallest possible, so it's like 4 metres and it fits like 3 people or maybe 4. We chucked our youngest kid in the smallest part in the front. But the fun thing is, we just paid like 300 euros for the boat, and we're going to learn to sail sort of on the fly. We can't sail, but we thought we could just, well, buy it and sort of see how it goes. So far it's going really well, we're going faster every time and it's really nice. Of course this is one sort of big escapist thing right? There's so many things you can't do so indeed you start looking for alternatives, and this was something which was possible.

Do you have any hidden talents? Do you have the talent for sailing?

Well I'll tell you one thing, where I don't have a hidden talent, which is windsurfing! I did windsurfing like five years ago, but I think windsurfing is something you really have to learn when you're young. Either that or I'm sort of singularly unsuitable for it, because I tried it for like three years and I really, well maybe it's exaggerating a bit to say that I got nowhere, but it didn't take off very fast. Of course, the first weekend I basically just dropped off, only, and I didnt make a single run, and of course it slowly started to improve, but I thought the learning curve was super slow. At some point maybe I got a bit frustrated, so maybe the sailing boat is much easier right? Whatever mistake you make, you're not directly penalised by falling off. So I think that's part of the reason why we bought this sailing boat, just out of frustration with windsurfing.

Is there anything you think you are talented in?

Yea hidden talents, what can I say? Um, I'm good at running. I don't train much, but I always outrun my friends who train way more, and they're always pissed off about it. So, I did half a marathon and even a marathon once, and then of course you have to train a bit right? I trained way too little, and of course I suffered because of it, because it's super painful, but I still made it in a very decent time. None of my friends did.

What was your most interesting project?

I'm very proud or happy with a particular theory or model that we cooked up, that I cooked up, together with two colleagues from Stanford University, which is a description of what could've happened during the big bang, and it turns out that these predictions are in perfect agreement with what the data is telling us. So the data is in this case the cosmic microwave background, that you may have heard about, or not, I don't know. But it's a sort of afterglow. It's the remnant radiation from the big bang. So it's stuff that's still out there, and we send satellites into space to capture that radiation. If you analyse what the radiation looked like, you can reconstruct what the universe looked like at a very early stage, right? Like really, very very early universe, the primordial universe. And then of course different models for the big bang predict different properties of those specific aspects of the microwave background. There was a very famous satellite, the Planck satellite, that was launched in 2008 or 2009, and published the first data in 2013, and then in 2015 and 2017. Our results were a very good fit to the data. We were the only model that was added after the data came in. So that's something that I think is very cool.

Do you have a lot of these collaborations with other universities?

I'm a very interactive person, I don't like sitting by myself, so that's why the last year has been, well, not so stimulating for me. I like to collaborate a lot. I think I have like 100 papers or so, and I think only two of them are single author, just by myself, and all the other ones are collaborations. I like to collaborate with PhD students, postdocs, but also with other staff members because it's just, it's both more fun in my opinion, and also it brings you to a higher level. Because by myself I can only sort of convince myself,

and critically question myself, so often, and then at some point you really start believing what you're telling yourself, and of course it's good if somebody else says "Yeah but, why do you say that? Is that really true? What if it's related to this?". So there's always some sort of cross-fertilisation going on, I think, when

FIGURE 2: Diederik Roest, out sailing

you're talking to other people. I think brainstorming, sparring with people, is probably what I like best about doing science. Just standing in front of the blackboard, and going "This is how I understand it" and you start drawing on the blackboard, and the other person then butts in and says "No no that can't be right, it has to be different because of this", and then sort of talking and trying to figure out things, and of course afterwards you still have to go home and do the calculation or write the code, and check whether everything that you sort of conjectured at the blackboard is true. That's in some sense the way that we do it right? So we talk a lot, we think a lot, and then you calculate. And especially the first part is very nice to do, and that's of course where colleagues are crucial.

Are you currently working on a project?

There's one project which I can try to explain; we talked very briefly about quantum gravity right? How there's general relativity on one hand and QFT on the other, and that they're very difficult to somehow combine, but separately these two theories are perfect? So we have of course QFT, there's many examples, one of which is the standard model, and within the entire standard model we have theories that work really well and explain perfectly what we see in the LHC for instance. Maybe there's a few cracks, but it's doing really really well. The way we calculate with that theory is using Feynman diagrams; there's a process and you have to calculate all the contributions to that process using different Feynman diagrams. We always used to think of that kind of QFT and general relativity as wildly different, they're just completely different beasts right? Different theories. But now there's a particular notion which is not well understood, and of course that makes it interesting, which suggests that there's a sort of hidden relation between the two theories, and that if you know one theory, QCD for instance (Quantum Chromo-Dynamics) - the nuclear strong force - then there's a way to construct gravity out of it. And in a sense, you can think of it as gravity in some sense being the square of QCD. And one very very simple way of understanding why it should be a square is that QCD involves things like gluons, and those are spin 1 particles, and gravity is a different field, or a different theory, and that involves spin 2 fields or particles. So in some very simplistic sense, you can think of the graviton as being composed out of two gluons, and that's just the very simplest relation, but it turns out you can make this very precise. And there are very specific calculations which you can do on the QCD side, and which you can do on the general relativity side, and it turns out there's a sort of magic dictionary between them. We don't understand that dictionary at all, why it should be there, because we used to think of those two theories being completely different. So in my research group we're studying aspects of this. What does this relation mean exactly, and how can we use it? Is it real? What does it teach us about those two theories that we thought we knew and which are super useful for the world right? I mean, general relativity governs the entire universe, and has been around for 100 years. Similarly, QFT governs the microscopic world, has been around for 50 years, and all of a sudden over the last 5 years people are finding hidden relations between the two. That's really cool.

Do you like cookies? This is a very important question.

Do I like cookies? Yea sure, definitely. Maybe more so pie.

What is your favourite pie?
I think I'll go for carrot, carrot cake. You can wake me up for it any day of the week.

What do you prefer? Do you prefer teaching or do you prefer doing research?
I really prefer the combination, sorry, I don't wanna choose. I think it's great fun to do both, because it also sort of helps you in both ways right? Stuff that I talk about in Quantum Physics 1 for instance, from which there are all kinds of things that I recognise later when I research, because it's all theoretical physics in a sense, and vice versa as well of course. The things that I learn in research also help you to explain things and stay motivated for teaching. So it's really the combination which I like. Every now and then I spend a few months at CERN, which is wonderful, and it's super stimulating, and I love to be there for a few months and it's very... I mean you're just fully energised. There's so many people coming in and you just talk to everybody the entire day, and there are seminars, so it's really like a hub of activity and of brainstorming, the stuff that I talked about before, but I always think that I wouldn't want to work here full time. I think that at some point doing only research, and only talking to other researchers wouldn't be satisfying for me, it wouldn't be fulfilling. There has to be, well, input from you guys right? From the young people that are super motivated, and eager to understand and learn physics, and that's for me very important, and very fulfilling in a sense. Yeah so I don't think I'd want to work at a research institute. Many colleagues of mine would, but I like the teaching part.

What do you like most about teaching?
Again, I'm a sort of interactive person, so I like to discuss and explain, and that's part of it which is nice. It's nice to sort of be in a lecture room to have a feeling that things are clicking, right? That people are understanding. So I must say that's something I missed tremendously over the last year, because I didn't know whether things were clicking, you just can't tell, right? I hope they were, but you just can't tell in an online ... **[the interviewers switch off their cameras and microphones]**, yea exactly, once you start switching off your camera, you have no idea what's happening on the other side. [**the interviewers turn their cameras back on**]. Point taken, it's a good joke. It's horrible! Of course it's been a tough year for all of us right? I'm sure that you know all about this from the student end, and I can easily imagine that in terms of quality of education, in terms of motivation, in terms of feeling like a community, etc, social aspects, but also for lecturers, it's been super boring right? And of course many people felt they could both give better lectures on-site, like real life, but also it's draining to talk for two hours to a black screen, and everybody's got their mics off, their cameras off. So I started in a rant complaining, etc, but the question is what I like about it, so that's what I like about it.

"I really like the combination of teaching and research"

What kind of music do you listen to?
Right so I think it varies. I think, well part of my things are more like folk music, but then slightly more modern. So maybe starting at Bob Dylan, through to Bruce Springsteen, but also more modern things like Mumford and Sons, or The Tallest Man on Earth.

You're also the Programme Director, what is that like?
So I signed up for it because I think it's a lot of fun, and very worthwhile, and, of course, I care about the programme, I care about the students. I think it's wonderful, I think we have super motivated and eager students, maybe that's what I should've added to the previous question as well. I really like just seeing that every year there's a whole bunch of new and very motivated and very curious students, and of course really clever, and also intrinsically motivated. You really just want to understand things, most of you. That's something I really like, I think it's great to work with, so from that respect I care about the students, I care about the programme. I must say last year was pretty tough though, as programme director, because of, again, what we mentioned, the C-word. So just in terms of the number of meetings, all of them online, at some point, you get, we got... well there's just a lot of things to arrange. It was very important that we had to do this, because otherwise it would be even more chaos. Of course we've had our chaotic moments, but I think what my intrinsic drive as the programme director is more, sort of content related and long term. Think about how we can change the curriculum, slightly improve it, which parts of physics we're not sufficiently addressing, how we can improve this, how we can prepare students better for their research projects, for their master projects, for the job that they'll eventually have, those kinds of questions.

Do you have a favourite particle?

Can I also do a particle that's hypothetical? It hasn't been discovered yet, but I don't know. So, let me go for the graviton, because the graviton is the particle that you would get if you quantise gravity. So we haven't seen it yet, you probably know, right? We've seen gravitational waves, but that's a different cookie, that's not gravitons, you're observing collective excitations of the gravitational field. Yea, but gravity is wonderful in so many ways, because of the way that it works. I mean it's sort of the most mundane force, right? Which we know from childhood, from babyhood, the hard way probably, but then there's this beautiful description by Einstein; general relativity, and it's conceptually very rich and stimulating, with beautiful math, and like curved geometry, and then it makes these predictions! Which by themselves are puzzling and weird, like gravitational waves and black holes, and then they're even verified! So we now routinely observe gravitational waves emitted by black holes merging. I mean that's a sentence which contains many things that are sort of out of the world right? People would think "wow!". So I think that's really cool about gravity, and then of course there's the fact that we don't really understand it yet, right? So we don't know quantum gravity, and also the universe at large is doing funny stuff. Gravity of course should be attractive, but then the universe as a whole is not only expanding, but it's expanding in an accelerated fashion, so it's not just pulling, but something is also pushing, right? Such that things are expanding in an accelerated fashion. So that's related to the cosmological constant, if that means anything to you. That's again a big puzzle in gravity, we just don't understand it! Why is it there, why does it have that value? Yea, so that's something that I really like, the fact that it ranges over all these scales, right? You can drop your apple, and you can observe the universe, and that should be governed by the same force, and there's one description, which is both beautiful and puzzling. So there you have it, the graviton.

What are you looking forward to the most when regulations relax?

So one thing which I've already started a bit is discussions at the blackboard, and that's really really great. Also I must say that lecturing in front of a big lecture hall is something which I'll be very happy to be able to do again, I think it's great, it's a lot of fun, I also believe in it, I think it's useful, and that's some part of my job which I realise I really miss. All the contact with students, just the lecturing in front of, either a big or small audience, and then coffee time, a little chit chat, yeah, that. Even if you can do the sort of factual information transfer also online, the contact is lacking. So that's one thing I learnt, that is really the part of my job that I really like.

Would you rather only be allowed to teach and not do research, or do research but not be able to teach anyone about it?

Research. With pain in my heart. What I like about research is the freedom, just the fact that you can sort of follow your nose, follow your instinct. I think if I would only have to teach, I would be a bit worried about it sort of becoming a chore at some point, because you have to teach the same course a number of times. I think now that it's a combination it's perfect, you can sneak in your new inspiration from research into teaching and the other way round. So that's why I really care about research, just the fact that it's always new, it's always challenging and fresh, and you can sort of follow your gut instinct. Academic freedom.

Would you rather be a tree, or have to live in a tree for the rest of your life?

Be a tree or live in one? Well I think I'd live in one. What does that tell you about my personality?

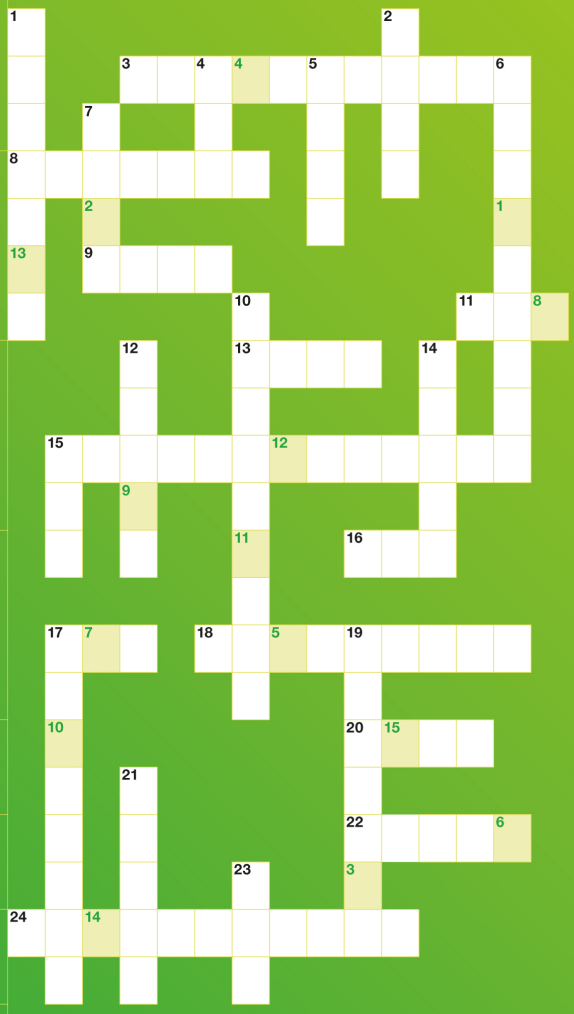
Why?

To me I think autonomy is sort of important, the fact that you can sort of change things or craft things differently if you don't like them, and that seems to be very hard when you're a tree right? You're just stuck!

Is there anything you want to ask us?

No, maybe just mention a massive compliment to all the study associations over the last year, for all the wonderful work that you've done. Of course in general you do wonderful work, but especially last year it was great to see how, well, the large contributions that you've also made to keeping the programme studyable etc.

Puzzle to win a wireless powerbank



DOWN

1 The museum that became a long-term partner with ASML.
2 A wafer is made of this material.
4 ASML's supply chain has this many tiers.
5 Name of the event where ASML created the "You Gave Me Wings' project.
6 The family of optical metrology systems produced by ASML.
7 First name of ASML's CEO before Peter Wennink.
10 One billionth of a meter.
12 ASML bought this company to develop light sources for EUV machines.
14 Name of our largest customer in the United States.
15 Abbreviation of Supply Chain Management.
17 Thin membrane which is used to keep out particles.
19 An ASML-organized event for those who love music performance, called 'ASML ...'.
21 Last name of the co-founder of Intel, which is now the name of semiconductor scaling.
23 One of the 3TG minerals that ASML uses in manufacturing.

ACROSS

3 A projection technology used during the chip fabrication process.
8 The country where an acquisition by ASML took place in July 2020.
9 One of ASML core values.
11 Name of the football club that is sponsored by ASML.
13 Most of ASML's customers are in this continent.
15 ASML operates in this industry.
16 This Dutch company makes both cars and parts of ASML systems.
17 Name of the first machine launched by ASML.
18 The solution to measuring imaging performance on wafers.
20 ASML was founded in this type of building.
22 A program by ASML that aims to prevent unnecessary waste by remanufacturing used system parts.
24 ASML is the world's only manufacturer of lithography machines that use extreme ... light.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Send an email with the correct answer in the subject line to campuspromotion@asml.com by December 2021. Each month until then, we'll randomly select one correct answer from those we receive. Winners will be notified via email. You can only participate once in the draw. The results are not open for discussion.

Curious to learn about our opportunities for students? Visit www.asml.com/students

Asymetry in budgets: a short explaner on Modern Monetary Theory

Writing Competition

AUTHOR: **F. DRENT**

Recently, I have read 'The Deficit Myth' by Stephanie Kelton where the author gives an introduction to Modern Monetary Theory(MMT). I would like to give you a summary of MMT, as its metaphysics, its way of thinking, regarding money is completely different to what we are used to. The physicists among us are drilled with conservation laws, where the conservation of energy is the big one. We can think of money as having the same properties, after all the size of our wallets is sadly enough a conserved quantity. Naturally we assume that this is also the case for Governments[1].

We are taught that a Government has taxation as income and spends that money for stuff, good or bad. If the Government spends more than it obtains through tax income, then it has to borrow money, increasing public debt. Since for us, having debt is bad, we assume that this is also the case for Governments. Whenever you look at some public debt counter, you can find a very large number for every country which is naturally frightening. MMT counters this view and tells a different story about money if a Government has sovereignty of its own currency[2].

So let us start with what money actually is. The overruling dogma is that money evolved from making barter easier. Carrying 200 eggs to buy a cow seems incredibly inconvenient, so why not use small shiny metal disks to replace that? However, there is no historical evidence that money emerged from barter[3].

MMT uses the historical evidence that money as we know it emerged from Government taxation. It works like this. The Government makes money; coins, little papers with a number on it, a digital number on a bank account, and spends it in order to get stuff done. This makes the Government not a currency user like us, but a currency issuer. It can make money appear out of nowhere, making it a non-conserved quantity. This gives the Government an infinite wallet, unlike currency users like you. Now why would you use this magic hat money as your currency? And if the Government has infinite money, why would I have to pay taxes? The answers to both questions are related. The Government not only has the power to print money, it also demands that same type of currency through taxation. Everyone in the society of the Government has to pay taxation to the Government, so everyone has an actual need to obtain said currency.

[1] In such economics books, the word 'Government' is often written with a capital letter.

[2] There are many countries which do not have sovereignty over their own currency. For example every Eurozone member cannot print euros on their own. Many other countries also have their currencies pegged to more dominant currencies. Examples of countries with a sovereign currency are the US, Japan, UK, Canada and Australia.

[3] David Graeber, Debt: the first 5000 years, (2011)

You may go to a store and pay with FMF-stickers if the shopkeeper agrees, but the VAT over the products has to be paid in Government currency. The Government does not accept FMF-stickers, only its own currency. This forces everyone to use the Government currency as the currency on the market.

Now comes the next dogma regarding Government taxation and spending. We instinctively think the Government budget works like ours. The dogma is that if a Government wants to do something, they first have to Tax And Borrow money to Spend it. This is the (TAB)S-model. However, a Government can print its own currency. If it has to spend a million on building a school, it can just go to a computer keyboard, enter a figure with six zeroes and suddenly a million currency units exist to be spent. This is first Spending and then Taxing And Borrowing, S(TAB). This does mean that a number goes up on the expenditure side on the Government budget without compensation in taxation. This therefore creates a Government budget deficit. However, in MMT, a Government deficit is not a bad thing on its own. It can even be a good thing! Through the lens of MMT, a budget deficit means that a Government has pumped more money into a society than has taken out of it. It does not mean that the Government is going bankrupt like a person or company would in a similar situation. Since a Government is a currency issuer and not just a currency user, it will never go broke. Just like in Monopoly: "The bank never goes broke."[4]

"If the Government has infinite money, why would I have to pay taxes?"

Now we arrive at the last two issues. One: if the Government has basically infinite money, then why are we not partying right now[5]? Two: will the Government creating money out of nothing not create (hyper)inflation? Also these two questions are related.

When it comes to printing money, people who have paid attention in history class are instantly reminded by the hyperinflation in Weimar Germany right after World War 1[6][7]. Although money for a Government is unlimited, real resources like goods and services are not. This scarcity of goods and services can cause a so-called demand-pull inflation. This is not a problem if the market is not going very well, but when a market is doing well, inflation can occur. To illustrate, let's create an example. Imagine the Government is hosting a huge party and needs a lot of Ketel1[8]. Normally the brewery is fine with meeting the Government demand, but imagine now that the FMF also suddenly needs a lot of Ketel1. The production of the brewery cannot meet such high demand. Due to supply-and-demand mechanics, the Government and the FMF have to outbid each other, meaning the price of Ketel1 rises. Since the Government has infinite money in the MMT-scenario, the Government will outbid the FMF with a high Ketel1 price as a consequence. Here we see the real limiting factor in Government spending, the real goods and services available, represented by inflation, and not its budget. Through the MMT-lens, one of the major reasons behind taxation is the prevention of harmful inflation. Preventing that the FMF never has the money to start outbidding the Government in the first place, roughly said.

Now I am omitting a lot of details, especially regarding interest rates and borrowing. Also I am in no position of authority to state that this is an excellent theory. However, MMT provides an unusual way of thinking regarding money that contradicts our intuition about money being a conserved quantity like energy. That on its own makes an interesting theory.

[4] "The Bank collects all taxes, fines, loans and interest, and the price of all properties which it sells and auctions. The Bank "never goes broke." If the Bank runs out of money, the Banker may issue as much as needed by writing on any ordinary paper.', https://www.officialgamerules.org/monopoly

[5] Disregarding the pandemic of course...

[6] For example, an egg in Germany costed 0,08 Mark in 1913. Ten years later, iIn 1923, an egg costed 80.000.000.000 Mark, https://www.johndclare.net/Weimar_hyperinflation.htm

[7] Such extreme inflations often have more complicated causes regarding the use of foreign currencies.

[8] Ambachtelijk graanjenever.

Playing with 2-factor authentication is easy and fun

Exploring standards of the Internet

AUTHOR: **T. TIEMENS**

Recently, the RuG introduced 2-Factor Authentication for everyone. Besides just knowing your password, one now also needs something they own, in the form of an app on their phone. This app, for which seemingly the only option is Google Authenticator, generates a code which you can then use to log into your account. So far so good. But what if you don't have a phone? What if you don't want to carry it around while studying so it doesn't distract you? Is this Google app the only option?

Short answer: no. Turns out there's nothing special about the Google Authenticator, and you can definitely subsitute it by desktop apps. For the long answer we have to start where all good investigations start: the problem.

The problem

Simply said: I don't want to be dependent on my phone. I want to be able to stop using it without too much issues, and being forced to have Google Authenticator goes against that. So I started looking around for solutions. The first thing I thought of was to try and find some form of portable android emulator, which I could have on a USB stick and carry around with me. This would allow me to just run Google Authenticator on any PC I happen to be working on without having to install anything, solving my problem. Sadly it does not seem that at this time there is such a tool that also works with all the systems I'll be working on (both Windows and Linux).

The first solution

After this first defeat, my second line of enquiry was whether I could use my personal webserver to somehow generate codes and display them on a webpage (and yes I do realize this defeats the purpose of 2-FA), and after some searching, I came across an Arch wiki[1] page describing how to use a piece of software called oath-tool (keep that name in mind, we will look into it some more later) to generate the 2-FA codes from the "databases" file in which Google Authenticator saves its data[2]. To access this file however I needed more access to my phone than it gave me; I needed to have a rooted phone[3].

After rooting an old phone I had laying around and installing the authenticator on it, I got my file. I used it with the script from the Arch wiki and voilà, I got my code! But this was not a very satisfying solution; either I had to somehow expose my login codes to the entire world, or I could only use this on Linux computers. Besides, I didn't understand *why* this worked, which is arguably the most interesting thing of any such a project.

OATH and the databases file

So what is this oath-tool anyway? Basically, it's a piece of software that can generate a One Time Password (OTP) from a special "secret key". The oath in the name refers to OATH, the Initiative for Open Authentication, who, according to themselves, are an "industry-wide collaboration to develop an open reference architechture by leveraging existing

[1] The Arch wiki (https://wiki.archlinux.org/) is the wiki for Arch linux, but generally a good source of information about tools for Linux

[2] *Google Authenticator - ArchWiki*. url:https://wiki.archlinux.org/title/Google_Authenticator.

[3] The process of rooting an android phone uses special versions of android to give the user access to all the files and software of the phone, think of it as gaining "administrator access" on a Windows machine. It's interesting and useful for certain people, but not without risk.

open standards for the universal adoption of strong authentication"[4]. In normal people terms: they create and maintain standards for 2- or multi factor authentication.

So what is in the "databases file"? Well, turns out this is an SQLite database (SQLite databases are a way of saving and structuring databases) that contains 3 things for each account: The name, in my case "RUG:WORKSPACE\S3652327", the "secret", "PVNCP2A2UBJH3EGX", and an issuer, "RUG". This "secret" is the secret key the oath-tool uses, and the other stuff is just some extra information to find out what account the key belongs to. But where does this info come from?

The QR-Code

At this point I was starting to suspect that it would be quite easy to adapt the 2-FA the RUG uses to other software. Heck, I'd even managed to do so by taking the secret key from the databases file to the Microsoft OTP manager and was able to log in using that. But not everyone has a rooted android, and so I turned my attention to the way you set up the Authenticator: the QR code.

If this QR code was something specifically linked to Google Authenticator, it would be an issue. Luckily, there was very little special about it. The QR code you see in Figure 1 reads "otpauth://totp/RUG:WORKSPACE\S3652327?secret=PVNCP2A2UBJH3EGX&issuer=RUG", which, conveniently, is the exact info we also find in the databases file. In fact, when I scanned the QR I originally used to set up my authenticators with the Windows OTP manager, it just worked; these QR codes are also standardized!

TOTP and HOTP

So what's the underlying tech here? The link generated from the QR code gives it away: TOTP, which stands for Time-Based One Time Password, which is indeed one of the standards created by OATH. Taking a look at RFC6238, the standard defining TOTP, we find that it is an extension of HOTP, which in turn is based on HMAC[6].

To make sense of this, we start by taking a look at HMAC. HMAC, Hash-based Message Authentication

FIGURE 1: One of the QR-codes generated by the 2-FA system (don't worry, this is not one I actually used to set up any authenticators)

Codes, takes in a key and some text, and generates a "message authentication code" by doing some fun bitwise-XORs and running it through a hashing algorithm a few times[7].

HOTP takes this, but replaces the text with a counter which is upped every time the button on some device is pushed, and truncates the rather long output of HMAC to something human-readable. TOTP then builds on this by replacing this counter by the floor of the current Unix time (a time-system used by almost all computers) divided by some time-step. By default this time-step is 30s, hence why your code changes twice a minute. The standard also outlines a lot of other reccomendations, for instance regarding time-drift, and is surprisingly readable, so if you're interested it's definitely worth a read.

Conclusion

The 2-FA system employed by the University is based on very broadly accepted and open standards, and any One Time Password app will accept the QR code. Besides, any QR code scanner can tell you anything you need to key into your manager to set it up manually. So to circle back to the beginning, Google Authenticator is indeed in no way special.

[4] The OATH website, https://openauthentication.org/

[5] D. M'Raihi et al. *rfc6238*. url:https://datatracker.ietf.org/doc/html/rfc6238

[6] D. M'Raihi et al. *rfc4226*. url:https://datatracker.ietf.org/doc/html/rfc4226

[7] Krawczyk et al. *rfc2104*. url:https://datatracker.ietf.org/doc/html/rfc2104

The Ramblings and Tribulations of a Teacher

AUTHOR: **C RIGOLLET**

The year is almost over, the exams are done and dusted, the grades have been sent to the ESC, and I don't know what to do with myself. I guess now is an ideal time to take a break, relax and sleep past 5:00. Though this time is ruled by the felines in my life and depends largely on how successful they were in their nocturnal hunt and whether or not they choose to share their spoils with me (they usually do).

I am actually looking forward to the next couple of months. This is my time to read old and new textbooks, time to think of new assignments, time to reshuffle my lecture slides, time to reflect on what went well and what could have been better.

While my desk resembles the skyline of a metropolis with piles of books and numerous notepads like skyscrapers, my Nestor sites are well organised and tidy. At least that's what I like to think. I have adopted the weekly template put in place by ESI, and have grown to like it a lot. My favourite weekly section, which I call "additional information", is the place where I add scientific publications, links to websites and YouTube videos. Most of the time, these videos are informative and illustrate concepts from the lectures, but sometimes, I enjoy adding something a bit less conventional.

Allow me to digress for a moment. I've raised my sons on Guns N' Roses, Green Day (the early years), The Clash, Stone Temple Pilots and the likes. After a brief foray into rap and country music, the oldest found his groove and introduced me to deathcore and hardcore punk (the latter being quite ironic since I had a punk period in my youth with bright pink and green hair and dodgy acquaintances). My schooling began with bands such as Slaughter to Prevail, Lorna Shore and Emmure. I will not lie and say that I loved that genre straight away. The guttural voices coming out of the speakers could be a bit creepy at first. Soon after my introduction into deathcore, I was getting ready to teach the course Nuclear Energy. I like to start this course with a historical background and tell stories about the main protagonists, the discovery of radioactivity, fission and of course the bomb. In the early 1940s, Los Alamos was the epicentre of research into the atomic bomb and where the first bomb test (code name Trinity) took place. At the time, Robert Oppenheimer was the director of the laboratory (did you know he was the first one to predict the existence of black holes?). Years later, he shared his recollection of the explosion and how he then remembered the line from the Hindu scripture, the Bhagavad Gita, "Now I am become Death, the destroyer of worlds". I have always found his words very poignant in view of the monstrosity the scientists had created. So, imagine my surprise when one Saturday morning, on our way to do some grocery shopping, my son plays me a song from Slaughter to Prevail, Hell, and I hear the recorded voice of Oppenheimer. It seemed fitting to add the video links to Oppenheimer's interview and to the song Hell in the "additional information" section.

"The twist of your wrist to align your fingers along the magnetic field and the velocity of a particle is like a gangster sign showing your affiliation to the physics world."

At the start of the academic year, in full blown lockdown, I was a bit anxious about teaching 90 students online. Would my voice carry the important concepts of nuclear energy, would my attempts at humour be well received or fall flat? Let's face it, I am a lot more entertaining in person than online. How could I judge the students' interest and reactions without seeing faces and body language?

On the first day of the course, I have butterflies in my stomach. Will the students like me? Should I care whether they do or not? Is my self-esteem so low that I need the adulation of students to believe in my abilities as a teacher? If I were to share my qualms with my husband, he would simply say "drink a cup of cement and harden the f*** up!". A sensitive man, my husband. Yet, I can't help wondering if the students will be chatty or silent and if they are indeed quiet,

are they actually listening to me or doing something else entirely?

But at the same time, it is always exciting to welcome a new cohort of students into the course. Once you enrol, you are mine for eight weeks. I will know your names, your interests, the names of your pets. Do not take this as a threat, think of it as a promise. I will follow your progress, email you when I feel you are falling behind, try to motivate you and alleviate your doubts. I decided long ago that I would never leave a student behind, like the Marines in movies. I hope this is also true in real life as my son (the deathcore one) is about to join the army. I'm rambling now, but that should not come a surprise given the title of this piece.

On reflection, I think the course went well. Here, I must thank my TAs who did a wonderful job manning the tutorials online, grading assignments and organising the debate at the end of the course. I am also particularly grateful to one of them (he knows who he is) as we discussed and finalised the assignments during the summer prior to the course.

An important goal this year was to try and build our own community bubble, where we could share a little bit about ourselves and get to know each other. The use of short introductory videos certainly helped (who can forget M and his cat?).

My main purpose in teaching the Nuclear Energy course is to show you the inner workings of nuclear fission reactors, what makes them safe and how beneficial they are in the fight against global warming and harmful CO_2 emissions. Renewable options, like wind and sunlight, are becoming increasingly popular but nobody ever talks (or chooses to hear) about the hidden costs. Both solar and wind have their own carbon footprint stemming from the mining of metals required to build the power plants. The manufacture of photovoltaic cells necessitates a large amount of aluminium (just think of the panel frames) and wind turbines require a lot of nickel. These two metals score the highest (apart from iron) on the global greenhouse gas emission from metal production scale, while uranium is at the lower end. In addition, every part of a solar farm or wind park is produced using fossil fuels to generate the required electric power. Of course, and I have to be honest, this is also the case for the elements making up nuclear power plants. In an ideal world, one would want to replace the toxic fossil fuel plants by nuclear ones to produce clean electricity to use in the manufacture of renewables options. Only large investments and strong political will can make this possible. While I have strong opinions on the subject, I want to hear what you think, what your ideas are to get us out this mess, the more outlandish the better! Like moving to Mars to let the earth heal itself, or simply not using heating in winter and wearing an extra jumper. Surprisingly, no one came up with the simple idea of culling the population by half (yes, I am well versed in the art of sarcasm).

There are obvious downsides to nuclear power and you and the public at large are well aware of them. However, all the nuclear accidents, except Fukushima, can be traced back to faulty equipment and poor operator's training. As for nuclear waste, it is a common misconception that radioactive waste takes up a lot of space. Only about 3% of the nuclear waste is long-lived and highly radioactive and needs to be converted into a stable form suitable for geological disposal.

In hindsight, the part of the course about fusion energy should have been a bit more extensive. I should have taken you on a journey into the plasma world. After all, more than 99% of the universe is made of plasma. Three fingers suffice to find the direction of the Lorentz force. The twist of your wrist to align your fingers along the magnetic field and the velocity of a particle is like a gangster sign showing your affiliation to the physics world.

The concepts of plasma containment are as complex as they are ingenious. The idea of mini suns on earth, as fusion reactors are advertised, is somehow poetic, yet completely unrealistic. The sun fuses four protons (in steps) to create helium and producing energy. It takes about 10 billion years for two protons to react with each other. Ain't nobody got time for that! Instead, man-made plasma is created with the two isotopes of hydrogen. The sheer size of the magnets used to contain the plasma is breath-taking and a feat of engineering. While the construction of ITER is advancing at great pace, it is only an experiment to prove the feasibility of fusion energy. Will I use electricity produced by a fusion reactor in my life time? Probably not. Is it worth trying to make fusion work? Definitely!

Come the first day of the new academic year, I will listen to some deathcore music while I (with trepidations and butterflies) wait for you to enter the classroom.

Opinion: Ethics of AI is Dumb and Ignorant

Exchange Article

AUTHOR: G. HORA DE CARVALHO

As per usual, the Perio collaborated with another association to bring you an Exchange article. This edtion was brought to you by Cover, but since they don't have a regular magazine, we asked Gonçalo, who created their DisCover magazine last year.

We begin, as per Wittgenstein's de facto sentence with which he finishes his first treaty in philosophy, Tractatus Logico-Philosophicus: "Whereof one cannot speak thereofone must remain silent"[1].

Ethicists are not AI scientists. But AI scientists... Regardless, the two fields should not be confused - something that I see academia attempting to change, quickly. The methods by which the two arrive at their conclusions are astronomically different. While AI, an empirical science, attempts to explain natural phenomena through experimentation, ethics, like the rest of philosophical inquiry, happens in the head. And regardless of logical consistency, its claims are not self-evident. In fact, most, if not all, remain unproven or unrelated to objective reality. And the ones that have been verified to be the case have had most of the work done by other fields. Other fields like AI, which require substantiating concepts like reproducibility

"Ethicists are trying to own the definitions of correct and incorrect"

(i.e. an experiment that is able to be repeated in the same way) and replicability (i.e. a method that produces the same results every time it is reproduced) as well as the capacity to output general natural laws that systematically yield predictive results above that of chance.

Historically, ethics is an autocratic effort to claim ownership over what is good and what is bad. It was firstly procured and owned solely by religion. It doesn't offer solutions to problems, rather it limits the set of possible decisions regarding the solution of a problem, arbitrarily deeming some good and others bad. Allow me to advance to the technical difference between the two with a thought experiment which will hopefully elucidate better the contrasting nature of these fields: would the reader prefer to fly an aeroplane built by an expert in Aeronautical Engineering or an applied ethicist? The reader will be alleviated to know that the latter wouldn't pose much risk since it would never lift from the ground. What about an aeroplane that was built by an Aeronautical Engineering expert under the supervision of an ethicist that deemed landing wheels immoral?

If your answer is no, then you cannot support the idea of giving the same responsibility to an ethicist as the one AI scientists hold. It would be bad for most if healthcare fell in the hands of profit seeking capitalists, where money is valued above and beyond peoples health. Ethicists are trying to own the definitions of correct and incorrect, morally speaking, and universities are laying these down on top of technical definitions of correct and incorrect results under the nonsensical presumption that AI scientists are not capable of distinguishing right from wrong? Furthermore, these new definitions take priority over solutions to real world problems - someone's arbitrary abstract good looms over solutions that actually benefit people - the real objective good that requires empiricism, experiment and data. This is ironic - and what a strange decision - picking a fight with AI, of all other fields. AI is a (if not THE) science that studies knowledge, intelligence and how to make informed decisions. It does exactly what ethics pretends to do, but does it correctly through

[1] Ludwig Wittgenstein. *Tractatus Logico-Philosophicus*. London: Routledge & Kegan Paul, 1922.

hypothesis testing (the beginnings of ascientific epistemology). I see the attempt in absorbing AI as an impulse propelled by a rudimentary survival instinct, or even academic parasitism. Let's be frank though, this is part of a larger problem that has been looming over the hard sciences and academia for a while. The humanities are endangered. In the last 20 years or so the fields have been mutating into a mashup of "science" and classical humanities due to the obvious increase in scientific productivity, societal relevance and popularity among students. From their evolutionary strife results a soup that is fitting of the absurd, since these inbetween fields show none of the scientific integrity of the hard sciences nor do they hold the same standards of truth - I can't not mention Feynman's cargo science culture text and how diluted scientific notions are in these fields. Philosophy has a special place amongst the inbetween sciences though. As it stands today, unproductive and completely abstract, it has had the uncomfortable tendency to claim ownership over ideas, work and even complete fields. This is usually argued in favour of from an historical fallacy. Philosophy was the mother of science, not of the modern science, but of the ideas that birthed the naturals sciences and the methodology of thinking rationally into existence (of course, history is the story of people much more than of abstract concepts like 'science' and 'philosophy'). So it's only natural that it would feel that it deserves some recognition. And it does: I cannot remember a single popular science book that does not begin with some praise or even adoration for philosophers, specially the ones that walked ancient Greek marble floors.

But going back to more technical ground again. Take the more prolific and prevailing approach in AI to making decisions: that of acting rationally. The rational agent approach sees an agent as something that acts autonomously, perceives its environment, persists over a time period, adapts to change, and creates and pursues goals. A rational agent is also one that acts so as to achieve, under uncertainty, some best expected outcome. Making correct inferences is important in this context since deducing that a given action is best enables an agent to act on that conclusion. But there are ways of acting rationally that cannot be said to involve inference. For example, reflexive actions like moving away from an upcoming vehicle. Finally, the standard of rationality is mathematically well defined and completely general[2].

If one wants to build a robot - let's call it Johnny - that achieves a certain goal autonomously that is to be delineated by an engineer, an ethicist might come in handy when discussing the goal in the context of the alignment problem and the overall state of

"The deployment of ethics in its current form is not only unscientific, it castrates AI of its empirical basis and renders the field useless"

people. But then again, wouldn't a lawyer know more? Or an anthropologist - wouldn't they offer a better contextualised representation of the society in question and their morals and culture? The problem aggravates: while the engineer is vividly aware of the technical complexity, the ethicist is free to roam a landscape of virtues and utility calculations that are not grounded on reality or the intricacies of the problem.

One can shape an infinite amount of sets of arbitrary virtues, goal states, and preferable ways of doing things over others. If we dispose of empiricism then we cascade into a Wittgensteinian nightmare where anything can be said and done - the world of unicorns in our heads. This is the equivalent to having people make decisions with a real impact over others based on the space and content of their minds without needing proof - at least proof that is demonstrably true and falsifiable, since the shared physical space of reality has been lost and traded for the mind and its stories. Independently of opinions of the mind and outside of the mind, out there, a testable truth that can be arrived at by anyone at any moment using experiments and data. The space of the mind isn't shared except through flawed systems that are prone to error and that offer too many different interpretations to be considered optimal, like human language (e.g. this essay). More importantly, it isn't bounded by rules of nature that can be observed and measured: there are no 1-to-1 mappings between the mind and the real world. Science offers an in-direct way of testing hypothesis and showing how they may be wrong.

[2] P. Norvig & S. J. Russell. *Artificial intelligence: A modern approach*. Boston: Pearson, 2020.

The deployment of ethics in its current form is not only unscientific, it castrates AI of its empirical basis and renders the field useless. Ethics is important as a framework where normative assertions can occur regarding goals and the way to achieve them, even if only historically speaking. This discussion has its place in the space where politics and legal considerations exist. Particularly, it funds, and exists prior to, written law - which is the consensus achieved through a complex system of historically relevant institutions, appointed members, etc. Ethicists should not be the sole deciders of such rules. In fact, I'd wager they should be kept out of the AI loop entirely.

Take the relationship between the church and the state. This is an analogous relationship to that of AI and Ethics as they currently are taught in universities. Why were the former separated? Succinctly, this was done because public opinion shifted, fuelled by heated arguments among elites that were starting to think that maybe proof should be demanded of the ones who rule, particularly regarding their sovereign power and where it comes from. Soon enough definitions of good and evil were also being discussed. Fostered by certain Enlightenment philosophers like John Locke and Thomas Jefferson in their search for the secular state, the debate became widespread enough that a crack formed in Europeans' model of reality. They searched not only for religious freedom and the freedom to not be religious, but also for the freedom to foster views and ideas that detached themselves from the world of story and religion (i.e. faith-based and religious scripture supported view of the world). Instead, approximating them to a world based on reason, mathematics and proof (i.e. secular or scientific view of an empirically observable world instead of a faith based view). Ethics applied to AI marks a regression from these efforts within the field of AI. In fact, its inception in the form of "Ethics of X", where X is any scientific field, is dauntingly similar to the religious state poisoning our methods of inquiry. In the case of AI even more so, where a logically grounded science that relies heavily on complex computational methods that are sensible to mathematical manipulation yields to the ethics of the ignorant: the scriptures and descriptions of some ideal state that only exists in the head of an arbitrary philosopher elite. If the two sound disconnected that's because they are and they should be.

Religion has the necessity to make claims regarding the real world. In fact, it requires the power to do this, so as to support its normative rules against the wider populous. But it does this without the burden of proof, when evidence would contradict these very claims. There is then a competition for truth between the two. Since ethicists require the capacity to create their own view of the world (based on their arbitrary utility functions), allowing them to exist in the AI engineering pipeline as is the case currently, they compromise the scientific effort in the field of AI. In fact, it possibly corrupts the attempt at approximating our very limited knowledge to some truth, and in its place we're left with opinions imposed by a particular elite and their political agenda. In the end and in the extreme, we find ourselves with the too well known problem of totalitarianism and the tyrant. A living example of which is China. The super power outputs their students in mass to the USA and the EU mainly because their world view, state and government requires the use of heavy censorship (e.g. Chinese internet[3]) so as to not see their views opposed or undermined by scientific efforts, reason, scepticism or just critical thinking and simple disagreement among the people. In this space, education and science can't exist properly. Totalitarian countries like China, or very religious environments like Galileo Galilei's XVII century Europe don't allow for empiricism, and, unfortunately, in the name of some arbitrary good, atrocities are committed. Undermining AI as a scientific effort, albeit being quite different from China and religion's previous terrible atrocities, should not go unnoticed, less we give up the study of knowledge and intelligence altogether. The usefulness of ethics when deployed in it's original form: of consistent rational inquiry about what is good or bad, will always have a vital place in people's education - perhaps more importantly now than ever, we need to remember that the world is complex and nuanced and our best tool yet is to explicitly deploy empiricism, not to arbitrarily choose who decides right from wrong.

React to this article? Feel free to submit an article outlining your thoughts to perio@fmf.nl.

[3] Shiyang Wei. "A Pilot Study on the Chinese Internet Environment". In: *Education and Management*. Ed. by Mark Zhou. Berlin, Heidelberg: Springer Berlin Heidelberg, 2011, pp. 617–621. ISBN: 978-3-642-23065-3.

Recipe

Mushroom risotto

AUTHOR: **S. CHULEI**

Ingredients

- 800g vegetable stock (other option: 800ml water + 2 stock cubes)
- 160g risotto rice
- 2 tablespoons of olive oil
- 250g mushrooms, diced or sliced
- 1 middle-sized onion, finely diced
- 60g white wine (recommended but not mandatory)
- 1 pinch of salt (unless you are already using stock cubes)
- 1 pinch of black pepper
- 1 tablespoon of (vegan) cream or butter
- 15g (vegan) cheese, grated

Cooking

1. Dice the mushrooms and an onion, keep them separate for now.
2. Start cooking with the stock and salt (or water and stock cubes), pour it all in a sauce pan and bring to simmer. We will get back to it later, just keep in on the low heat until you are cooking the rest.
3. To toast the rice, heat a dry non-stick pan on a medium heat, add the rice, stir frequently for about 5 minutes. It should become pearly but not brown. Remove from the heat and put aside.
4. Heat the olive oil in a different/clean non-stick pan, add mushrooms, coot on medium to high heat for about 3 minutes.
5. Add diced onion to the pan, stir, and cook until the mushrooms are browned, about 2-3 more minutes.
6. Put the toasted rice to the pan and stir frequently. This is also the point when you add white wine if you are using it.
7. Add some stock to the rice mixture, just enough to cover all the rice. Keep the rice simmering. Stir frequently and keep adding the stock when the previous portion is fully absorbed. When rice stops absorbing water, just let the rest of the stock evaporate and do not let more, you then might have some stock left.
(Optional). Drink the rest of the wine. Consider leaving a glass for during dinner
8. To finish, turn off the heat, add the pepper, the cream, and the cheese, adjust salt to taste, cover with the lid, and let the risotto rest for 3-4 minutes before serving. Risotto is best if eaten then at once, as the rice can soften with time and become mushy.

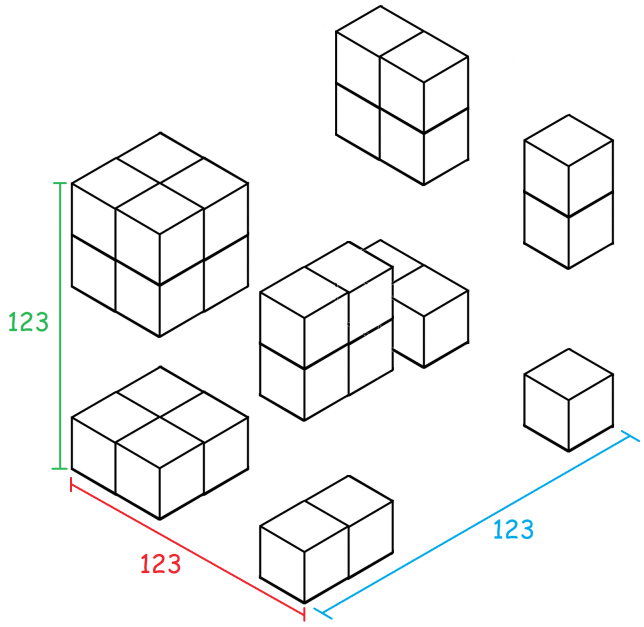
Notes

1. If you cannot find rice that claims to be for risotto, look for one of these types: arborio, carnaroli, vialone nano, bomba.
2. For cooking, it's fine to use rather cheap wine. Pick dry wine. You can also use a 1/2 tsp of vinegar in the end of cooking instead.

Brainwork
1, 2, 3, cube!

AUTHORS: **R. MOL, R. MODDERMAN**

We have a cube consisting of 123×123×123 identical cubes stacked together, as shown in the figure. Can you find a *nice* path from any of the eight corners to the exact middle cube of the entire construction, such that you have visited each of the 123^3 cubes exactly once? By symmetry, any corner block goes as starting point. If you can, describe exactly a path. If not, prove that there does not exist such a nice path from a corner cube to the exact middle cube.



The rules

A *nice* path of cubes is a path that is such that each two consecutive cubes travelled in the path share exactly one face. You cannot go diagonally. For example, a move from (1,1,1) to (1,1,2) is allowed, but from (1,1,1) to (1,2,2) or to (2,2,2) is not allowed.

You can send your solution to perio@fmf.nl before November 14th 2021. Correct solutions will be awarded with a nice prize!

Rectification solutions (2021-1) of Brainwork 2020-1:

In the previous edition of the Periodiek, we solved the Brainwork of two issues ago. However, we made a ~~mistake~~ typo. We said that Y = {00, 11} as a set of bitstrings corresponds to the only uniform 2-entangled state in which exactly half of the bitstrings contain a '1' in the second spot. This is incorrect, as there is precisely one more: {01, 10} is also valid. There are no more: if Y has size 3 then there is no integer half of bitstrings, if Y has size 4 then Y is the maximally mixed state hence not entangled, if Y has size 1 then Y is classical hence not entangled, and the four other bitstring sets of cardinality two ({00, 01}, {00, 10}, {01, 11}, {10, 11}) are obviously product states. Point is that Y = {00, 11} still can occur as a posibility, and since the zero bitstring is in this set this means that all yellow cats might be dead upon opening the box. Hence, our argument that yellow was not the answer was still correct.

Solution to the previous Brainwork

Genious Graphs Solution

AUTHOR: **R. MOL**

In the previous Brainwork we asked you to find χG_n as a function of n for a graph G_n in which two vertices a and b are connected iff a divides b or b divides a.

The solution.

For a final solution, you should have found

$$\chi G_n = \lfloor log_2(n) \rfloor + 1$$

or an equivalent expression.

Underlying theory/method.

We will use numbers for the colours, starting at 0. Clearly, we only need colour 0 for G_1, so then $G_1 = 1$.

Since 1 divides every number after that, each vertex will be connected to 1 so no other vertex will be coloured 0. Henceforth it will be a very uninteresting point so we will set it aside and just add it back later. This means we now start our vertices at 2 and our colours at 1.

When you add a prime, it will be disconnected from any vertices you've already drawn (except for 1, which we are excluding now) although it will be connected later. Since no 2 primes will be connected (on account of them being primes) they can all be given the same colour, which will be colour 1. This means that every time you add a prime, other than 2, G_n does not increase.

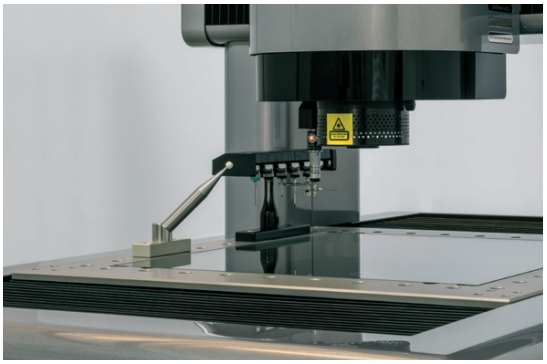
If you spent half an hour drawing on a blackboard drawing graphs and writing down G_n for the first 50 or so terms of n, as I might or might not have done, you'll notice that G_n increases each time you reach a different power of 2, but does that hold indefinitely, and if so, why? Let's list the numbers 1 through 16 and seperate them on their amount of primes divisors. For this, we will treat 1 as having no divisors, since 1 is not a prime number.

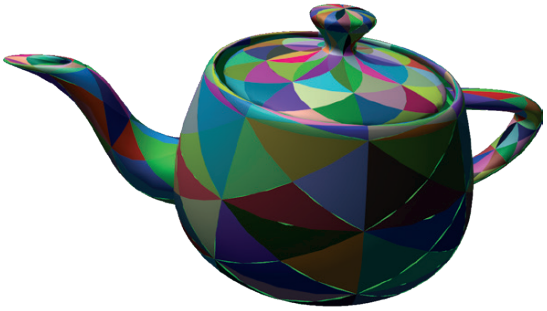
0: 1
1: 2, 3, 5, 7, 9, 11, 13
2: 4, 6, 10, 14, 15
3: 8, 12,
4: 16

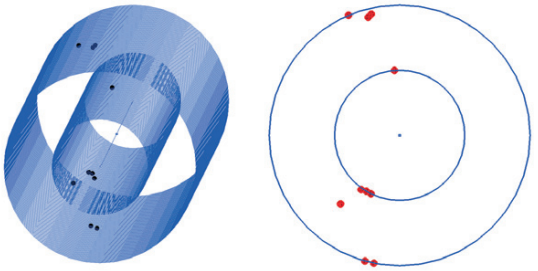
Here, we see that of course everything with 1 divisor is a prime but moreover the number of divisors is also the colour we assign to the corresponding vertex. To see this, remember that all primes have the same colour and consider that two numbers with the same number of divisors cannot divide each other and cannot be the same colour as their divisors. From this, it inductively follows that all numbers with 2 divisors must have the same colour, that all numbers with 3 divisors must have the same colour and so on. It helps to realize that a number with 3 divisors cannot be the same colour as a number with 2 divisors since a number with 3 divisors will be divisible by a number with 2 diviors (which all have the same colour).

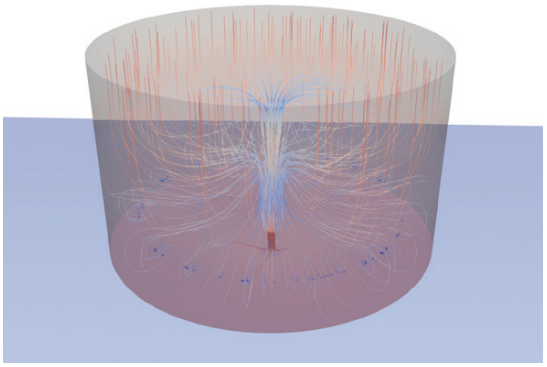
With this, the first number with k divisors will be 2^k, since 2 is the smallest prime. Consequently, the first time a new colour is needed is whenever $\log_2(n)$ increases. So we add a floor function around it. Then, at the very end, we add 1 to account for the vertex 1 which we excluded at the start.

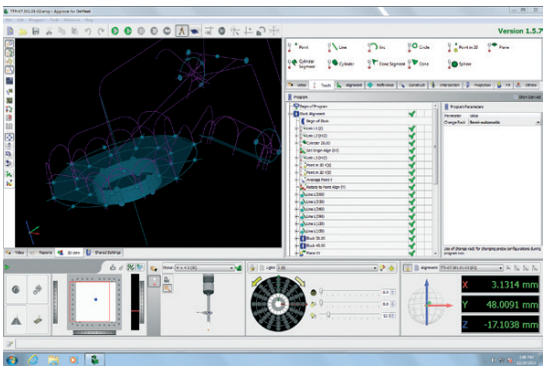
Q.E.D.











Schut Geometrical Metrology (Schut Geometrische Meettechniek bv) is an international organization, founded in 1949, with five offices throughout Europe, specialized in the development, production, sales and service of precision measuring instruments and systems.

Products developed and produced by Schut Geometrical Metrology are the 3D CNC coordinate measuring machines DeMeet in video as well as multi-sensor model. The DeMeet 3D CNC measuring machines provide automatic, user-independent quality control with measuring results traceable to the international length standard.

Technological advancements as well as the integration of new methods of measurement cause this development to be an ongoing process, with challenges for construction of mechanical and electronic components and the implementation of software.

For this reason we offer positions for internships, graduation projects and careers 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, computational fluid dynamic analysis for air bearing designs and Monte Carlo raytracing.

For various departments we are looking for enthusiastic colleagues with a flexible attitude. The job is an interesting mix of working with people and advanced technology.

We are interested to get in touch with:

- Software Developers (C++)
- Technical and Software Support Engineers
- Mechatronics Engineers
- Technical Sales Engineers
- Service Engineers

You are very welcome to contact us for an orientating discussion, for an open job application or for a possible internship or graduation project. We are always happy to come into contact with motivated and talented students.

For more information go to www.Schut.com and Jobs.Schut.com, or send an e-mail to Jobs@Schut.com.

APPROVE for DeMeet