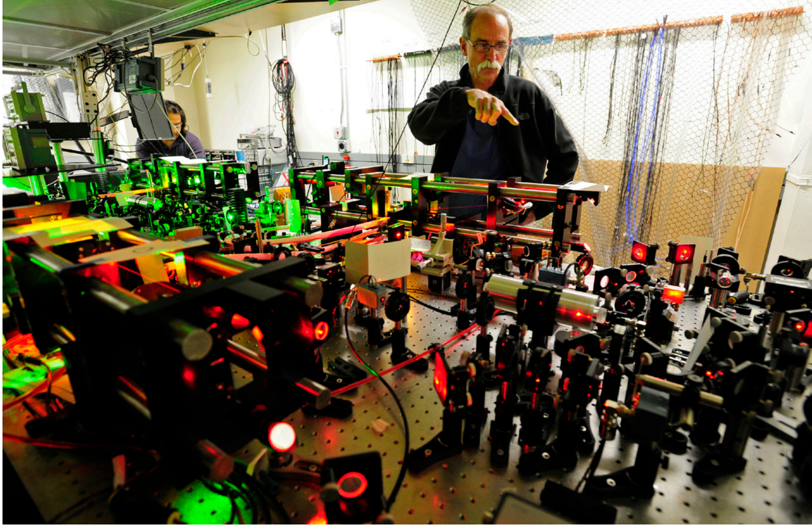
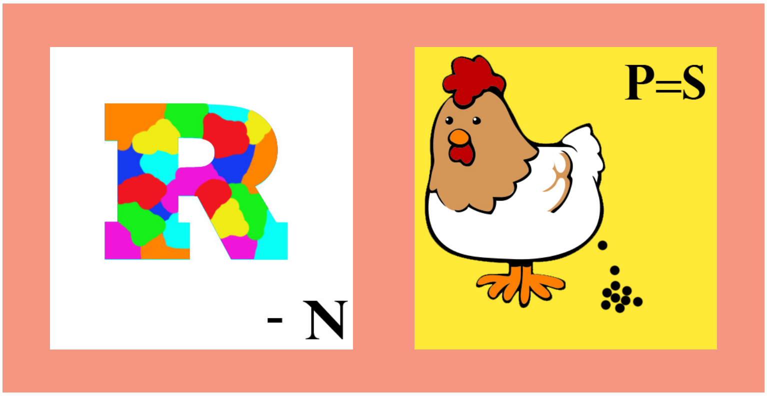
perio*diek

recurring at regular intervals volume 2016 number 1

6 - Quantum Computing

In 2012, the Nobel prize of physics in 2012 was awarded for research towards Quantum Computers. Now, Douwe Visser explains what the hype is all about, and how Quantum Computing actually works.



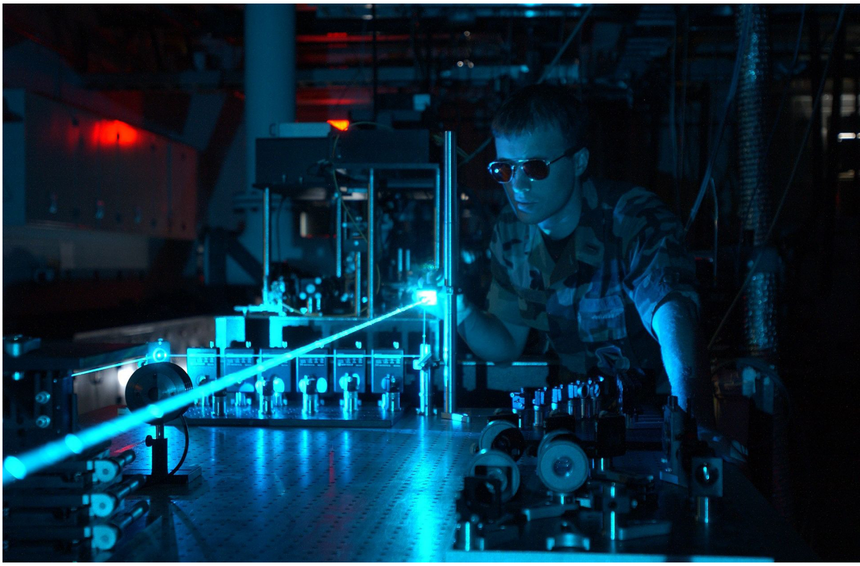


20 - Breinwerk

After the many positive responses to the previous rebus by Corine Meinema, she has kindly offered to make another one. This time, the theme is about cooking and we hope you'll enjoy this puzzle as much as the last one!

16 - Applied Physics

Always wondered the difference between Physics and Applied Physics is? In this article, prof. Van der Giessen goes over several definitions and reaches a nice conclusion.



In this Periodiek

From the editor in chief

Only a few more weeks and the holidays will be upon us. We only have to carry on for a few more days, finishing the last items and then there will be time to relax. Personally, I find these days to be one of the hardest. Not only because most of the work has to be done at the last moment, even more so because the end is within sight. Seeing the end so close, you start dreaming about the vacation, making it hard to focus on the job at hand. However, you can also put the soon to be vacation into something positive. Make a good schedule for the coming days with the vacation as your reward for finishing all your jobs. This way you are actively working on your job and enjoying the coming vacation.

This is also why we want to present to you this new Perio*diek, packed with all sorts interesting stories, which allows you to get new inspiration. This will help you get motivated for the last few days. In case you can't find time in your schedule for reading the Perio*diek, save it for the vacation. Then you will have even more motivation for finishing your jobs and you will have an awesome vacation.

— Douwe Visser

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In the news

Planets orbit surprisingly synchronous around star

A surprising ballet has been found around the star Keppler-223. It has four planets, all orbiting synchronously. In the time the innermost planet orbits 8 times, the second planet 6, the third 4 and the outermost 3 times.

American researchers have found this orbital pattern and published their results in Nature. Such patterns are not unusual, it even has a name: tidal lock. Pluto and Neptune are two examples in our own solar system: in the time Pluto orbits twice, Neptune has 3 orbits. Jupiter and Saturn have a similar tidal lock, but four planets locked together is considered exceptional.

The pattern may tell something about the history of the solar system around Keppler-223. It would appear that the four planets originated further from their star. Over time, they were pulled further inwards. Now their gravity keeps them locked in this rhythm.

There is a theory that the Jupiter, Saturn, Neptune and Uranus used to be tidally locked together, but that there was a disturbance. According to the reasearchers, ``such a resonance is extremely unstable and vulnerable. Objects flying around and striking the planets, could push them out of their pattern.''

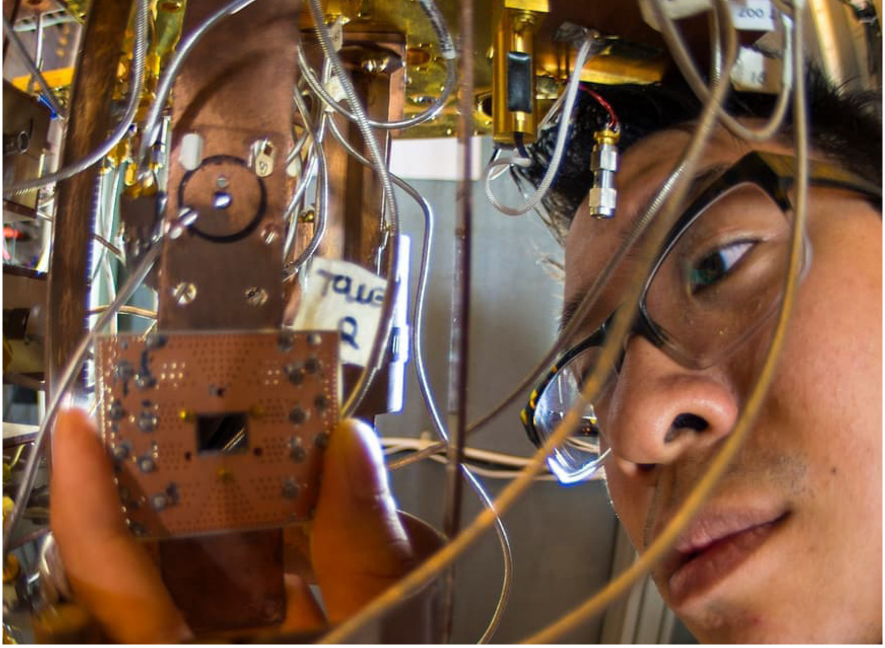
Nu

First test with hyperloop shows promising results

The electric engine of the Hyperloop was tested in the dessert of Nevada, and achieved a velocity of 483 km/h. The test has been conducted by Hyperloop one. The company called the test a "mile stone", but recognizes that there is still a lot of work to do.

The Hyperloop is an idea from Elon Musk. It is a new form of passenger transport that could reduce travel time between Groningen and Paris to 30 minutes. This means a cruise velocity of 1220 km/h. To make this possible, Musk proposes to build a type with a very low air pressure, and thus a low air resistance. Capsules with passengers travel through this tube, not on rails, but on cushions of air. Musk himself admitted that he does not have the ambition to realize this dream, but a lot of companies are now busy designing and testing a version of the Hyperloop.

Scientas

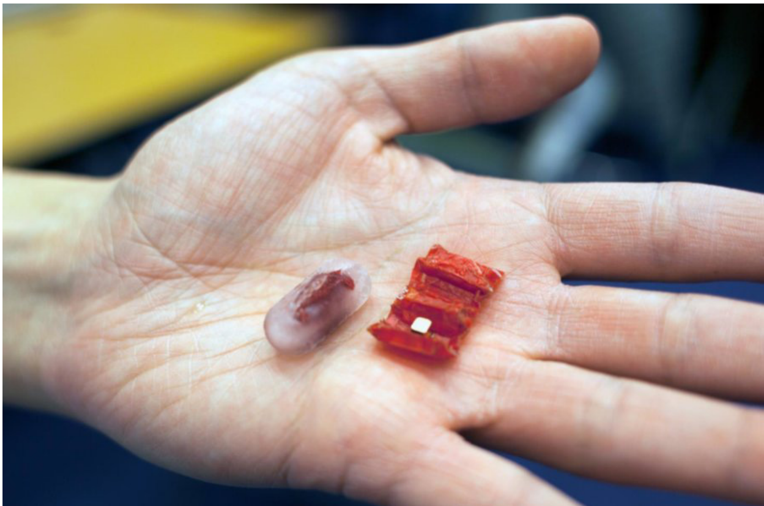


IBM brings quantum computing to the masses

For the first time, IBM Research has allowed public access to its new quantum processor via the IBM Cloud. Dubbed IBM Quantum Experience, this will provide users with the ability to experiment with individual quantum bits (qubits), process their own experiments, and run some of their own algorithms directly on IBM's quantum processor.

Though not a full-blown quantum computer (the IBM processor comprises just five superconducting qubits) it does represent the latest advances in IBM's quantum architecture that the company claims may one day scale up to create much larger, more complex quantum processors and eventually lead to the development of a universal quantum computer. Which could solve some of the problems that simply can't be solved using classical computers.

Gizmag

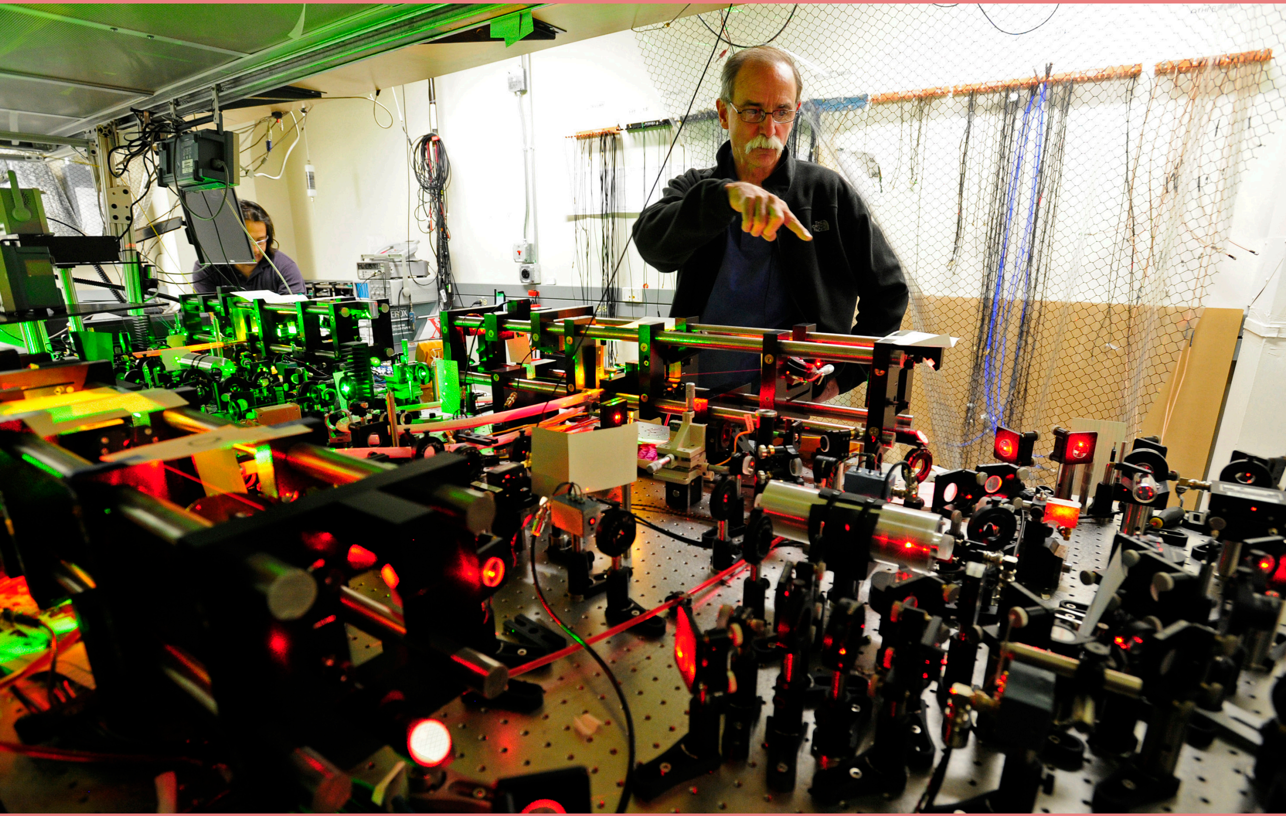


Ingestible robot operates in simulated stomach

In experiments involving a simulation of the human esophagus and stomach, researchers at MIT, the University of Sheffield, and the Tokyo Institute of Technology have demonstrated a tiny origami robot that can unfold itself from a swallowed capsule and, steered by external magnetic fields, crawl across the stomach wall to remove a swallowed button battery or patch a wound.

The small robot has large potentials in health care. Indegestible robots have the potential of doing surgery without opening a person. For application inside the body doctors want to have a small, controllable, robot system. If reasearchers are able to design and build such a machine this could revolutionize heathcare.

Sciencedaily



AUTHOR: **DOUWE VISSER**

Quantum computing

The Nobel prize of physics in 2012 was awarded to Serge Haroche and David J. Wineland for their "ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems". Hence the progress on the development of quantum computing was made known to the public. But what is this new type of computer? Modern day computers have transistors so small that all kinds of quantum mechanical effects come into play. What is the difference between the current day computers and these quantum computers?

In this article we will tell you how and why a quantum computer is fundamentally different from the computers we use today. Furthermore we will discuss the basic principles of this new type of computing as well as the main difficulties of designing such a machine. Along the way we touch on their potential and try to explain why "the quantum computer will change our everyday lives in this century in the same radical way as the classical computer did in the last century." [1]

Quantum spins

Let us begin at a very simple point. Suppose we build a computer where the bits are represented by the state of a single $s = 1/2$ spin state. An obvious way to represent the data is by choosing the spin up |↑> to be the 1 and the spin down state |↓> the 0. Now we can use a multiple spin state |↑↓↑↓↓↑↑ … > to represent the data 1010011… You might wonder why this form of data representation is different from the conventional ways to represent data and how to get the spins aligned in such a particular fashion.

Let us first take a look at the last point and then on the way we will also try to explain the other point. To be able to align spins we need to have that all of the individual spin need to have an own resonance. What one typically does is to put all the spins in a high magnetic field and then cool the entire system down. Then all spins will be aligned and we will choose this to be the ground state |↓↓↓↓ … > corresponding to 0000… After that one can apply half a Rabi oscillation to flip, for example, the first spin. When each of the individual spins has their own resonance, we can flip each spin individually, and thus we can build our desired multi-spin state. Nothing strange has happened so far.

Rabi Oscillations

Consider a two level system with an energy gap of ΔE. When the system is in the ground state and you apply a light pulse of photons with the energy of ΔE, the system will oscillate between the ground state and the excited state, with the period of τ. Thus when you would send a light pulse with the duration of τ the system will again be in the ground state. This corresponds to a full Rabi oscillation. A light pulse with duration of half a τ, corresponding to half a Rabi oscillation, will put the system in the excited state. Any other duration, which is not a multiple of half a τ, will give a super position of the ground and excited state.

However we don't necessarily have to apply half a Rabi oscillation to the first spin. we could also apply a quarter Rabi oscillation such that the multi-spin state becomes: 1/√2|↓↓↓↓ … > + 1/√2|↑↓↓↓ … >. Thus when we apply a general Rabi oscillation to the first spin, we get a multi spin state, a super position of 2 states. When we now also apply a general Rabi oscillation to the second spin we gain a super position of 4 states. So when we have a multi-spin state consisting of n spins, we can get it into a super position of 2n states. Obviously, the memory of an ordinary bit cannot be put into a super position, we remind ourselves of this by referring to the multi spin state as a qubit. It is this property which divides standard computing from quantum computing. All these super imposed states can all be manipulated in a single computation, making quantum computers extremely suitable for parallel computing. This makes certain problems, like prime factorization, able to be solved in totally new and faster ways.

Logic

A logical next question would be: How would you perform logic on quantum computer? Until now we only discussed the possibility of storing data in possible super positions. And because we want quantum computing to be parallel, we need to figure out which operations we need to be able to do to make a logical machine out of the quantum computer. We want to design a set of operations which allow us to shift every state into every other state. Such a set of operations is called a universal set.

It turns out that only two operations are needed to form a universal set. The first one is one bit flip operations, which can be achieved by Rabi oscillations as discussed before. The second operation that we need is the so called controlled NOT gate, or the quantum XOR gate. The controlled NOT has a completely classical description, with 2 input variables: the control and target bit. If the control bit is 0 the controlled NOT gate will not flip the target bit and if the control bit is 1 it will flip the target bit. If we choose the first bit to be the control bit and the last bit to be the target bit we have the following scheme: 00→00, 01→01, 10→11, 11→10.

The description of the controlled NOT gate may be classical, however it can quickly be transferred to the quantum case by demanding $|\varphi\rangle = a|\downarrow\downarrow\rangle + b|\downarrow\uparrow\rangle + c|\uparrow\downarrow\rangle + d|\uparrow\uparrow\rangle \rightarrow a|\downarrow\downarrow\rangle + b|\downarrow\uparrow\rangle + c|\uparrow\uparrow\rangle + d|\uparrow\downarrow\rangle$. These two operations form a universal set. These two operations are not the only universal sets of operators and depending on the environment for the quantum computer it may be easier to use a different set of universal operators.

Quantum errors

With all the ingredients above, we have the basic understanding of what is needed for a quantum computer. But probably the most limiting factor for the construction of the quantum computer are the errors. This is the field of "quantum error correction". The first error one can make in the computations is by miss-rotating. When, for example, we want to switch a qubit in the zero state to the first state, one can do this using of half a Rabi-oscillation. However if you apply a little bit more or less, you will get a new final state which is mostly, but not completely, in the first state.

The other type of error which occurs is called "decoherence". Decoherence is the phenomenon where the qubit interacts with the environment. The result is a loss of initial information. This can for instance be in the case of a spin due to an electromagnetic wave. Decoherence can also be caused by an unwanted measurement upon which the qubit collapses into some unknown state.

Now comes the question how do we deal with these types of errors, and how imprecise can the operations be performed such that quantum computation is still useful? First note that we cannot completely deal with the computational errors as we would do in a classical way. That is because there exists no unitary transformation for the following mapping

$$U(|\varphi\rangle \times |\psi\rangle) \rightarrow |\varphi\rangle \times |\varphi\rangle,$$

for all qubits |phi>. This means that in general we cannot clone a qubit, which means that we cannot simply store multiple copies to increase the recoverability of the data. Instead the general idea is to use a highly entangled state. Suppose that we want to store a general qubit of the form

$$|\varphi\rangle = a|\uparrow\rangle + b|\downarrow\rangle,$$

where a and b satisfy the normalization condition. If the environment has interacted with this qubit, there is no way of telling what the initial qubit was. However, suppose we use the following highly entangled state

$$|\varphi\rangle = a\,|\uparrow\uparrow\uparrow\rangle + b|\downarrow\downarrow\downarrow\rangle.$$

In this case, if the interaction with the environment is small enough such, we can assume that at most one of the spins has interacted and thus flipped. This could result, for example, into the following state:

$$|\varphi\rangle = a\,|\downarrow\uparrow\uparrow\rangle + b|\downarrow\downarrow\downarrow\rangle$$

Since the majority of the states is still in the correct state, the initial state can almost be recovered by the use of ingeniously placed CNOT gates. Thus we can reduce the errors made during a quantum computation. However we do require a certain precision on the pure quantum computations such that the error correction still works. Therefore we require a specific tolerance before quantum computation is a reliable way of doing computations, a so called error tolerance threshold. Simulations show that the error tolerance threshold is around 1%, provided that there are many qubits. Due to new developments on the quantum error correction schemes, this error tolerance threshold keeps increasing. In parallel to this research, engineers keep improving their designs of the quantum computer. All in all, quantum computing becomes ever closer to reality •

References

[1] The Royal Swedish Academy of Sciences, Nobel prize in physics 2012, press release, http://www.nobelprize.org/nobel_prizes/physics/laureates/2012/press.html

AUTHOR: **ROOS WESTERBEEK**

Cake and Groups

Let's combine two good things of the mathematical life: cake and groups! The next time you have to struggle through your algebra homework, bake a nice Battenberg cake and Group theory never tasted so sweet.

Ingredients for 1 cake:

- 200 gram soft butter
- 200 gram sugar
- 4 eggs
- 200 gram self-rising flour
- A pinch of salt
- 6 spoons of jam (apricot jam for neutral color)
- 400 gram marzipan
- A little bit of icing sugar
- Half a teaspoon vanilla extract
- Food coloring (I took "dr.oetker kleurstoffen" from Albert Heijn) and/or cocoa powder.

Preparation

Although there are specialized Battenberg cake tins available, you don't need one. This cake can be baked in a square baking tin and the two batters can be separated with a piece of cardboard. Do not forget to butter the sides of your tin. Preheat the oven to 160°C.

Put the sugar and butter in a bowl and beat it with a whisk until the mix is smooth. Beat in the eggs, one at a time, and then **carefully** mix in the flour, salt and vanilla extract. If the batter is a little thick, add a drop of milk. Beat until light and fluffy.

Separate the mix into two equal parts, add the coloring and scrape into the tin. Bake for 35 to 40 minutes. When you poke with a skewer, it should come out clean. Let the cake cool down.

Once at room temperature, trim the cakes to make them match. Then cut each sponge in half lengthways so you have four long rectangles. Dust a work surface with icing sugar. Roll the marzipan wide enough to wrap around the cake. Heat the jam in a small pan. Brush the surface of your rectangles with the warm jam. Place on the marzipan and roll up gently. Trim any excess marzipan.

The pattern

The pattern of the battenberg cake is an example of a mathmatical structure that pops up all over the place in different guises. Let's start by thinking about addition on a two-hour clock, or, to use the technical term, 'addition modulo 2'. We can draw an addition table for this, i.e. a Cayley table.

+	0	1
0	0	1
1	1	0

Rotation	0°	180°
0°	0°	180°
180°	180°	0°

In fact, this is the second smallest possible *group*. Now here's another way that this pattern appears. We can

think about the rotational symmetry of a rectangle. A rectangle only has two forms of rotational symmetry: the rotation by 0° and the rotation by 180°. We can put these in a Cayley table as well. The same you can do for instance with multiplying 1 and -1. In fact, all the interior parts of these Cayley tables have the same pattern as a Battenberg cake.

Here's a challenge: can you draw a picture of a Battenberg cake, each of whose squares is itself a Battenberg cake, such that we get an iterated Battenberg cake? This means you have to start with two types of Battenberg cake, in different colours. So there are four colours altogether and they need to fit together in a 4x4 grid. This pattern comes up if we look at the rotations and reflections of a rectangle, instead of just the rotations. Another place this comes up is if we draw a multiplication table for the odd numbers, modulo 8 •

*	1	3	5	7
1	1	3	5	7
3	3	1	7	5
5	5	7	1	3
7	7	5	3	1

References

[1] E. Cheng, 2015, Cakes, Custard and Category Theory: Easy recipes for understanding complex math. Profile Books, ISBN 9781782830825.

[2] Heel Holland bakt, Battenberg cake: heelhollandbakt.omroepmax.nl/recepten/details/battenberg-cake

ASML

Nowadays, you can find 16 GB USB sticks on supermarket shelves for as little as €10. This probably isn't something you think about much, but it actually represents quite a significant milestone.

Let's revisit the world of *Moore's Law* for just one moment. It's a highly complex world in which companies everywhere are doubling the capacity of their chips on an annual basis, but not without a high degree of effort. It's a world in which major breakthroughs measure only a few nanometres in size. It's a world in which one of the leading players is located in the Netherlands, or to be more precise, Veldhoven.

Crucial Step

Welcome to ASML, a manufacturer of lithography systems for producing computer chips. ASML supplies equipment to all the world's major chip manufacturers including Samsung, Intel and TSMC.

There are dozens of steps along the path to producing a chip. ASML helps manufacturers take just one of these steps, but it's a very crucial step. Lithography involves exposing and chemically etching the wafers used to 'print' a chip's components. The degree of miniaturization achievable is fully dependent on the accuracy of the lithography process.

With ASML's latest generation of machines, it's possible to print lines on chips measuring only about 20 nm in thickness. To put this into perspective... that's like printing the contents of a 500-page novel onto a centimetre-long strand of human hair!

High-Tech Hotbed

You probably think ASML's machines are incredibly complex. You'd be right. Every day, thousands of engineers and researchers dedicate themselves to refining its machines still further.

Moore's Law is relentless. Driven by cut-throat competition in the high-tech marketplace, the maxim is *smaller, faster, cheaper*. This perpetual race against the clock makes ASML a highly demanding, yet fascinating place to work. It's a high-tech hotbed where state-of-the-art dynamics, precision mechanics, optics, electronics and information technology converge – fully focused on supplying systems that are faster, more accurate and more reliable than their predecessors.

Driving Force

The driving force behind ASML's technological breakthroughs is its forward-thinking engineers. ASML's employees are some of the most creative thinkers in the world of physics, mathematics, chemistry, mechatronics, optics and informatics. And because ASML invests over €800 million annually into research & development, these experts have all the resources at their disposal to push the envelope to an extreme. It's the only way ASML can maintain its edge – worldwide.

Learning Environment

ASML is an ideal environment for professional growth and development. Do you have an unbridled passion for technology? Do you dream of playing on a team that experiments with new ideas every day, that pushes the edge of the envelope and that's driven by the goal of *smaller, faster, cheaper?!* If so, look no further, visit our website at www.asml.com/careers •

AUTHOR: **EMILY MOOK**

From the Commissioner of Education

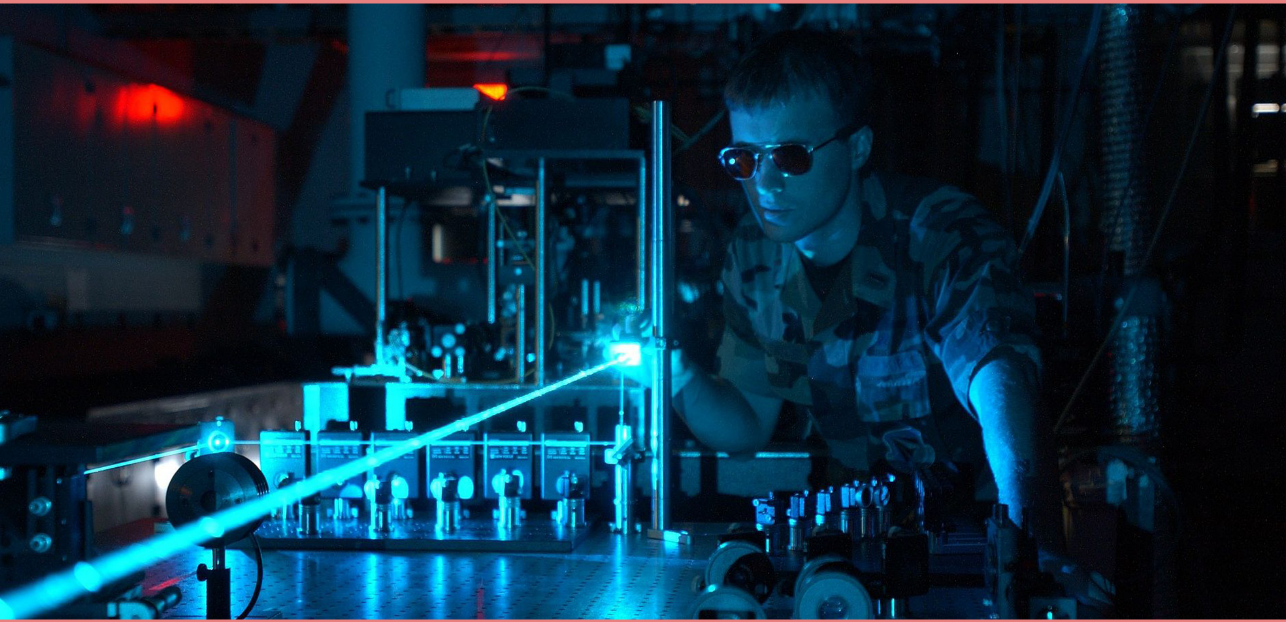
Let me introduce myself. My name is Emily Mook and I'm the Vice Chairman and Commissioner of Education of the FMF. Most people wonder what these titles actually mean or what the purpose is of my function. Luckily I get to fill this space with some hopefully inspiring words and try to shed some light on these difficult questions.

However, first I'll tell you something about my personal life. I'm a bachelor Physics student, doing the track Energy and Environment. This doesn't make me a hippy or tree hugger (which I'm sure can be fun), but has made me aware of many different clever sustainable energy solutions. My greatest passion is dancing, last year I danced at least five times a week, various styles from ballroom dancing to bachata, salsa and zouk. This year I discovered an interest in photography, which I'll continue to pursue. Finally, like most students in Groningen, I like to hang out with friends, have a drink (or more) and enjoy life (oh yes, and study).

As the Commissioner of Education you get to know some important people within the faculty and how the faculty functions. The first thing I noticed is how little a regular student knows about what's going on within our faculty and educational system. This is where I come in. Whenever I hear sounds, suggestions, complaints or criticism from students, I can discuss that with the right people. Or when the faculty wants to start a new project and needs feedback from students on how to implement that in the system, I can also help.

An important aspect of our job as FMF-board is to organise events, anything from introduction events for high school students to a bachelor research project mini-symposium. We organize all these events with the faculty and help support the study. We're constantly listening to the needs of students and adjusting the events program accordingly. Furthermore, we connect with all the research institutes by organising activities as a gateway for students.

As the academic year comes to an end, we can all look back on great memories and be proud of all our achievements in the last year. I've personally enjoyed the success this past year, but (warning: this might sound a bit cheesy) I couldn't have done it without my amazing team of strong, smart and sometimes a bit silly board members •



AUTHOR: **ERIK VAN DER GIESSEN**

Applied Physics

Bridging Physics and Engineering?

When acting as Deputy Director of Teaching in Physics and Applied Physics, I was periodically approached by potential students and/or their parents with the question what the difference is between physics and applied physics.

A Very good question if you are considering to study at Groningen University (or Harvard University), where both programs are being offered. At the same time it is a bit confusing to some people that all other general universities in the Netherlands only have a physics program while the three technical universities (Delft, Eindhoven and Twente) only offer applied physics. The explanation of the latter is quite simple: the programs at the technical universities are called applied physics because they are technical universities; the applied physics curriculum at, for example, Delft University of Technology is closer to our physics program than to the applied physics program. The first question is more subtle, for what is applied physics?

> *"Applied physics is what people do who call themselves applied physicists."* [1]

Years ago, I asked this question to an American colleague and he give me the definition: "Applied physics is what people do who call themselves applied

> *"Physics is about understanding phenomena, Applied Physics deals with using this understanding in applications."* [2]

physicists." This answer puzzled me at that time, but there is some truth in it — I will return to that in a little while. Anyway, it was obvious that this sort of recursive definition would not be of much help to the prospective students or their parents.

While designing the 2010 physics curriculum (including interdisciplinary tracks), one of the challenges was to strengthen the distinction between physics and applied physics. Gradually, along the way, the simple mantra: "Physics is about understanding phenomena, Applied Physics deals with using this understanding in applications," evolved. This is admittedly not a tight distinction and is apt to debate, but this is why the notion of design, in the sense of utilizing physics rather than studying it, plays an important role in the Groningen applied physics program. Also, I have used it as the basis of my answer to the high school kids and their parents.

The list of examples to substantiate the statement is nearly endless, of course; let me just give a few. Newton laid the fundaments of mechanics (and with this, physics as we know it), a topic that is indispensable for the design of everything that moves and rotates. Giant magnetoresistance is a fascinating physical phenomenon discovered in 1988, without which modern smart phones would not exist. Figure 1 shows images of theoretical physicist Hendrik Lorentz and of Anton Philips to stress that the Lorentz force is key to almost all the electromagnetic applications developed over the years in the Philips company. Closer to home, in the Zernike Institute for Advanced Materials, there are scientists who work on intriguing physical concepts such as orbital ordering and Mott insulators, as well as those who develop, for example, new spintronic devices and new multifunctional materials.

With these examples, we should be reminded of Box 1, since the applications that can be covered in any institute is restricted by the expertise and the research interests of the scientific staff present. And it is this staff that is teaching the applied physics program. Thus, the statement in Box 1 not only holds true but is inevitable.

So, while it seems I have convinced myself, let me be self-critical and check the endless source of wisdom called Wikipedia. The main definition quoted in Box 3, does not falsify the above, nor does the statement "applied physics is rooted in the fundamental truths and basic concepts of the physical sciences but is concerned with the utilization of these scientific principles in practical devices and systems." It becomes more interesting when Wikipedia continues with "'Applied' is distinguished from 'pure' by a subtle combination of factors such as the motivation and attitude of researchers and the nature of the relationship to the technology or science that may be affected by the work. It usually differs from engineering in that an applied physicist may not be designing something in particular, but rather is using physics or conducting physics research with the aim of developing new technologies or solving an engineering problem."

What I find inspiring in this latter statement is the suggestion that one could see applied physics as bridging the gap between fascination about physical phenomena and an actual product. Just an idea: the Zernike Institute has physicists studying the photoelectric effect, applied physicists who develop (organic) materials in which this effect and photochemistry lead to efficient conversion from phonons to electrons — imagine if there would be engineers at this university who develop roll-to-roll organic solar films! Needless to say that this is just one of many examples, even for the current staff of pure and applied physicists.

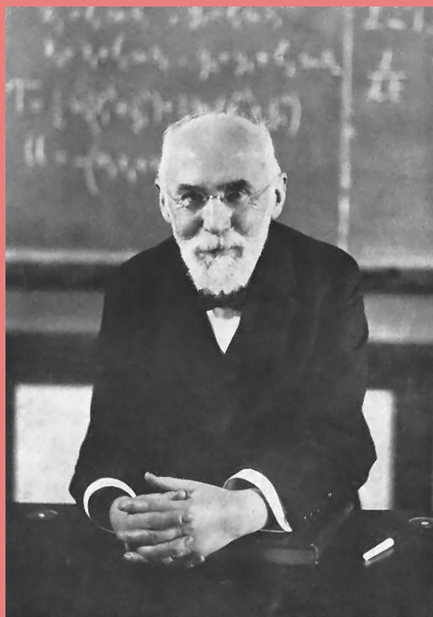
There is an opportunity for building such bridges. In December 2014 our university proudly instituted

> ***"Applied physics is physics which is intended for a particular technological or practical use."*** [3]

the *ENgineering and TEchnology institute Groningen* (ENTEG). While having germinated from the former Institute for Technology and Management (ITM), ENTEG is receiving extra funding in order to expand its research and teaching activities. Until now, applied physics as well as the other applied versions of the disciplines in the faculty of Mathematics and Natural Sciences have often been projected as being natural members of ENTEG. The applied physics staff has not always been so excited by this embedding in ENTEG, for various reasons some of which are mostly historical. Applied physics in Groningen has been very strong, on all metrics, since its inception in 1972 — no need to worry about the future. Perhaps it is more inspirational for all stakeholders to look at applied physics as the bridge between physics and engineering[1]. This is an open invitation to all readers to send me any suggestions they may have in this direction •

[1] And if this creates an organizational problem, it may be good (as often) to take a peek at Harvard University's School of Engineering and Applied Sciences.

Hendrik Antoon Lorentz (1853-1928)



Anton Philips (1874-1951): co-founder of the Philips company in Eindhoven.

FIGURE 1 The founder of the Lorentz force and the man who applied it.

AUTHOR: **THE EDITORS**

Previous Brainwork

A cross number puzzle

Many of you spend a lot of time on the previous brainwork. The lucky winner of this brainwork is Susan van der Woude! Congratulations for finding the correct solution and have fun with your "The Colossal Book of Mathematics". For those who want to check their own answer, the solution is given below •

The solution

■	(1) 2	6	(2) 5	3	7	(3) 9	5	2	2	(4) 5	■	■	■	■
■	8	■	0	■	■	8	■	■	■	1	■	(5) 6	0	(6) 6
■	(7) 7	1	5	5	(8) 2	7	2	2	2	5	■	1	■	2
■	■	■	0	■	9	■	■	■	■	(9) 1	0	5	0	1
(10) 9	9	(11) 2	6	(12) 4	■	(13) 3	(14) 2	0	8	5	■	4	■	0
9	■	8	■	2	■	(15) 1	6	■	■	■	(16) 3	8	■	0
9	■	4	■	8	■	■	8	■	(17) 4	(18) 5	■	(19) 7	0	0
9	■	4	■	(20) 5	(21) 2	2	6	0	2	1	■	3	■	1
(22) 9	4	7	■	(23) 7	9	■	3	■	■	5	■	2	■	0
9	■	(24) 2	3	■	■	■	(25) 2	(26) 5	■	1	■	0	■	0
9	■	7	■	(27) 9	8	0	0	0	■	(28) 5	(29) 9	9	2	0
(30) 9	1	7	8	1	■	■	■	■	(31) 9	■	1	■	■	■
6	■	4	■	(32) 2	0	8	1	(33) 1	2	7	1	3	(34) 7	■
(35) 7	4	2	■	0	■	■	■	4	■	■	9	■	2	■
■	■	■	■	(36) 1	9	9	9	9	9	9	9	9	9	■

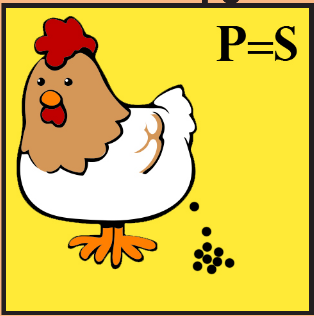
AUTHOR: CORINE MEINEMA AND THE EDITORS

New Brainwork

A cryptic rebus

After two similar puzzles we figured it would be time for a change, so we asked Corine to make a nice puzzle. What we forgot to mention is that we switched to English. So one last time a Dutch puzzle for you to enjoy. All answers are related to food. The solutions can be handed in before the 30th of June 2016 at perio@fmf.nl. Among the right solutions we will select the winner of the book *"Cakes, Custard and Category Theory: Easy Recipes for Understanding Complex Maths"* by lottery •

10



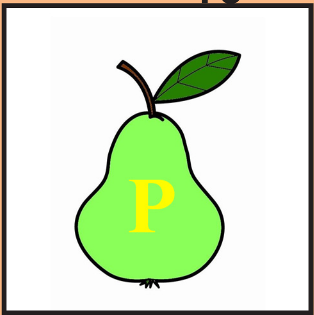
11

B B B B B
B B
-i
B B
B B
B B B B B

12

K = B

13



14

B

15

1. K ←
2. K
3. K

16

P=V

17

44

V = E

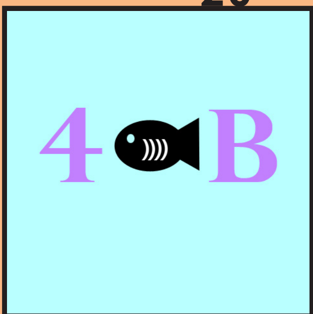
18

TE

19

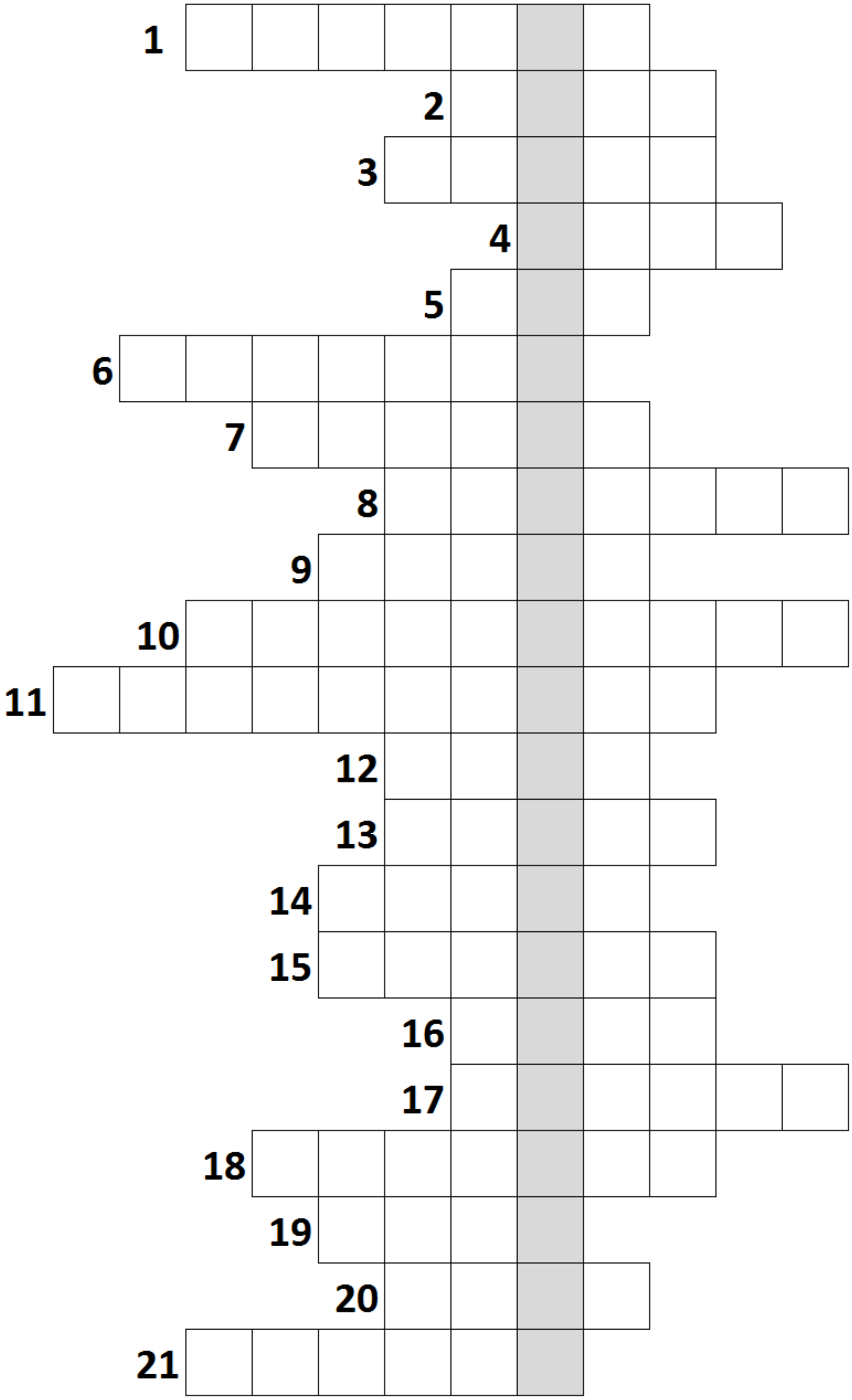
O=U O=U O=U O=U O=U O=U O=U O=U

20



21

B ?



Schut

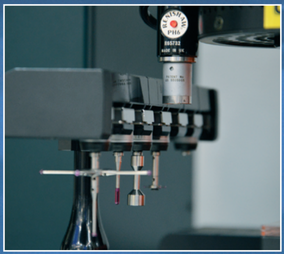
Schut Geometrische Meettechniek is een internationale organisatie met vijf vestigingen in Europa en de hoofdvestiging in Groningen. Het bedrijf is ISO 9001 gecertificeerd en gespecialiseerd in de ontwikkeling, productie en verkoop van precisie meetinstrumenten en -systemen.

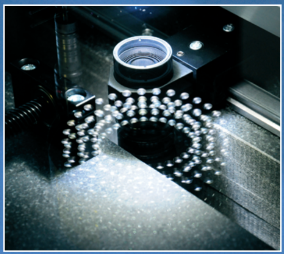
Aangezien we onze activiteiten uitbreiden, zijn we continu op zoek naar enthousiaste medewerkers om ons team te versterken. Als jij wilt werken in een bedrijf dat mensen met ideeën en initiatief waardeert, dan is Schut Geometrische Meettechniek de plaats. De bedrijfsstructuur is overzichtelijk en de sfeer is informeel met een “no nonsense” karakter.

Op onze afdelingen voor de technische verkoop, software support en ontwikkeling van onze 3D meetmachines werken mensen met een academische achtergrond. Hierbij gaat het om functies zoals ***Sales Engineer***, ***Software Support Engineer***, ***Software Developer (C++)***, ***Electronics Developer*** en ***Mechanical Engineer***.

Je bent bij ons van harte welkom voor een oriënterend gesprek of een open sollicitatiegesprek of overleg over de mogelijkheden van een **stage-** of **afstudeerproject**. Wij raken graag in contact met gemotiveerde en talentvolle studenten.

Voor meer informatie kijk op www.Schut.com en Vacatures.Schut.com, of stuur een e-mail naar Sollicitatie@Schut.com.





Approve for DeMeet