TAYLOR VISION

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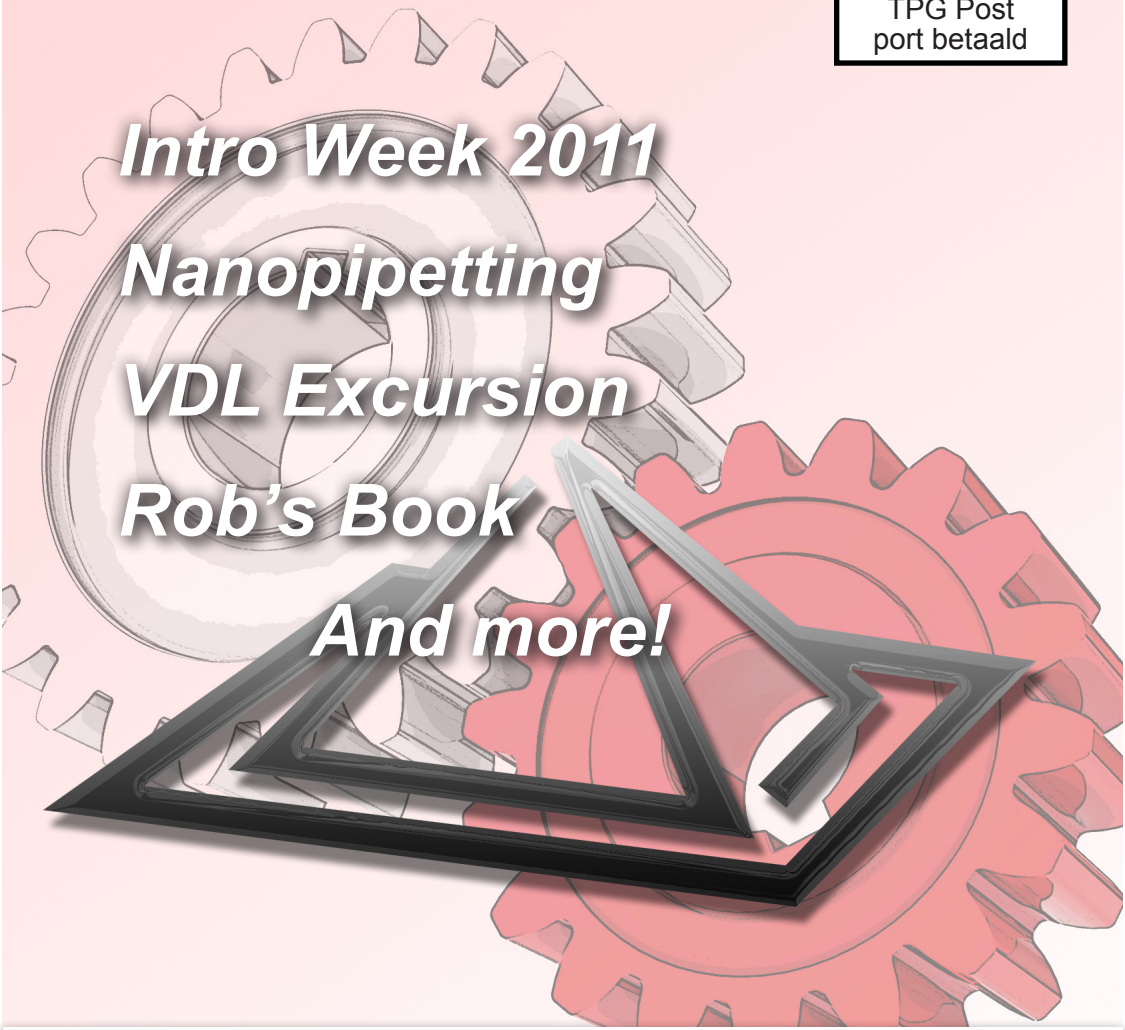

Intro Week 2011

Nanopipetting

VDL Excursion

Rob's Book

And more!

TU Delft Delft University of Technology
Section Precision and Microsystems Engineering

Issue November 2011

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Preface

Dear reader,

Here it is - the November 2011 issue of the Taylor Vision, hopefully still in time before Sinterklaas.

In this issue we've got some very interesting articles. Amongst other, we've got a piece by Hugo Perez who wrote about his PhD research on a nanopipet. Eric Kievit sent us some words about his new company Delmes and Rob Botter shared his view on the introweek.

Also, Rob Munnig Schmidt apparently got hooked on writing, because he wrote about the process of making his book "High Performance Mechatronics". His tips on using Latex may be useful for everybody who still has to write his/her thesis.

On another note, everybody who's up for an interesting and entertaining week, keep your schedule open between the 16th and 20th of January because Taylor is very busy right now organizing the yearly Taylor Trip then. More information on this trip will come soon, but I can already give away that we'll be visiting some very interesting companies. You can keep yourself up-to-date via our new website, dispuuttaylor.nl.

Simon van Veen
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Location

TU Delft

Faculty of Mechanical, Maritime and Materials Engineering (3ME)

Section Precision and Microsystems Engineering

Mekelweg 2
2628 CD Delft
Block 4B room 1-47

Contact

015-278650

taylor-3me@tudelft.nl

www.dispuuttaylor.nl

Intro Week 2011

This year the section organized another introduction week for the new students. In this article Rob Botter describes how he experienced this week.

Day 1

The summer holiday had ended and the very first lecture of the year was a fact. After a brief explanation about PME en it's specializations everyone got a few seconds to introduce themselves. A very useful lecture by Urs Staufer followed in which we discovered what type of learners we are and how one can take notes in the most efficient way. A series of introductory lectures into different specializations followed.

Rob Munnig Schmidt gave us insight into the subwoofer and the concept of bass reflex as an introduction to Mechatronic System Design. Daniel Rixen gave an introduction into the field of Engineering Mechanics by teaching about the subject of thermo-mechanical coupling and the oral exam, a new concept to many of us. Two brave fellow students were asked to take on the task of preparing an oral exam for the next day. The last lecture in the field of Structural Optimization and Computational Mechanics was about thin walled structures by Fred van Keulen. We ended that lecture by making our own thin walled structures in groups. The only resources were a couple of sheets of paper, staples and some tape. Some structures could hold over 10 kg. The group with highest load to weight ration won a prize. After a "hard day of work" we were rewarded with (alcoholic) beverages.

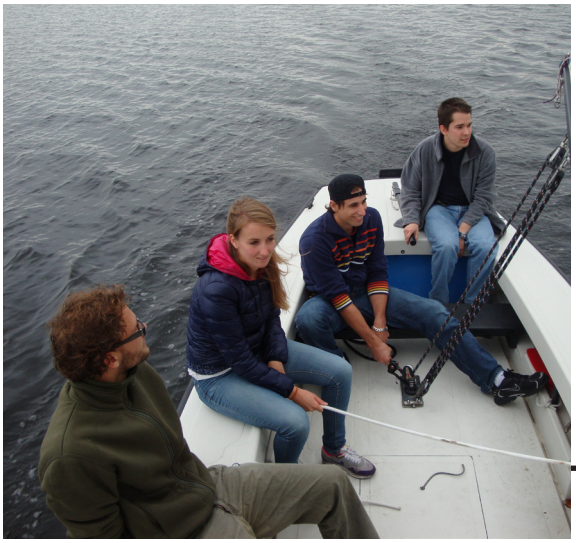
Day 2
The second day started of with a physics experiment an introductory lecture of Physics for Mechanical Engineers by Urs Staufer. Can water run up a slope? We doubted it, because the experiment unfortunately failed during the lecture. In the seconds hour we got the chance to see how an oral examination works thanks to the two volunteers. The rest of the day was divided into three experiments. We got to see how two subwoofer loudspeakers work in an enclosure when one is driven and the other one is passive. In another experiment were able to play with a thin plate actuated with two small loudspeakers and see nodal patterns in the sand on the plate form at different frequencies and tensions. In the last experiment we were able to prove ourselves water can actually run up a slope. We ended the day with a barbeque for the entire PME community, the perfect opportunity to mingle.

Day 3
Fred van Keulen started off with an introduction to LaTeX and told us in a very sarcastic way what to do when using such a text editor to write a report. After that, Paulo Tiso took over and talked about the content of a good report after which we had to judge some reports ourselves. After the lunch we got a grand tour through the laboratory and saw all facilities it has to offer, including the cleanroom, which was a drag to get into with so many people having to dress up. After Jan Neve told us about the Introlab course two graduates of PME told their story. The first speaker was COO at Advanced Lightweight Engineering. He told us about his career and the development of his main product, fiber reinforced pressure vessels. The second and last speaker was an heir to the Heerema Groep and now finally works at family company Allseas after working for Philips first and even getting an MBA degree.

Day 4
At the last day we all drove to picturesque village called Kaag (for which you have to take a 10 second ferry ride, ridiculous). We got divided into groups and got some drinks and snacks to take with us on the boat. We sailed across the lake, had some lunch and sailed back. Overall it was a very relaxing day with just enough wind to sail, no rain, good weather, perfect conditions to relax and end the week.

- Rob Botter

On the next page you can see some photos of the intro week. On our website we posted some more!

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Micro-molded soft lids with integrated thermal pump for microfluidics, dispensing and nanopipetting

By Hector Hugo Perez Garza - Delft University of Technology - PME

Controlling and handling small amounts of liquids is an essential competence for manipulations at the nanometer scale, leading to radical advancements in chemistry, biology and other fields. An instrument particularly suited for this purpose is the nanopipette, which stimulated original experiments at submicron scale due to its accuracy and versatility. Here we present a thermal pump and its assembly into a nanopipette cartridge.

We previously reported the fabrication process for the nanopipette [1] (see also Vision feb. 2009, ed), in our implementation an AFM cantilever with integrated microchannels and hollow tip as shown in Figure 1. Controlled dispensing of the reagents stored in the reservoir of such a device remains challenging and to our knowledge has only been shown by external means o far, which hinders e.g. parallel, high throughput operations.

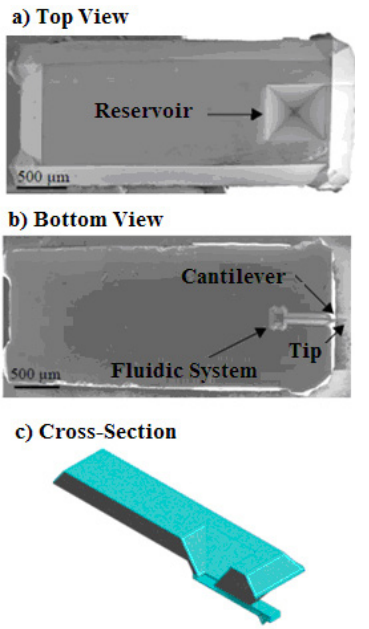


Figure 1

Methods previously developed for manipulating liquids inside other microfluidic systems comprise mechanical micropumps, directed gas injection into the liquid, electroosmotic pumps and thermal bubble actuation Of these concepts not all are suited for operating a nanopipette, either due to their size, complex fabrication process or risk of forming obstructing gas bubbles. An evaporation-based micropump has been integrated into a nanopipette, but in applications involving a local deposition of minute volumes the evaporation of liquid represents a threat before the dispensing is fully achieved.

Continued on page 8.

We addressed these issues by implementing a thermal pump, comparable to the bubble actuation, and which can be separately fabricated and integrated within a soft-lid. The latter can then be bonded to a prefabricated and fluid-loaded nanopipette. This forms a well-sealed microcartridge, which helps avoiding sample contamination and evaporation while decreasing reagent use at the same time. The core of the pump is a thin wire, which when heated causes thermal expansion and evaporation of the fluid inside the closed reservoir, generating over-pressure and pushing the liquid into the microchannel, leading to the nanopipette-tip.

We selected micro-molding of polydimethylsiloxane[PDMS], a low-cost technique, accounting for the disposable character of the cartridge concept. First, a wire loop was inserted into the reservoir of a nanopipette-chip, acting as the master-mold. This wire was embedded through a polymer called Cyanoacrylate which keeps the position of the wire fixed (Figure 2c). The PDMS is poured, covering everything except the space of the Cyanoacrylate (Figure 2d). The stamp is removed from the mold and the Cyanoacrylate is eliminated with acetone, which doesn't attack the PDMS. The demolded replica is activated in oxygen-plasma and bonded to the nanopipette such that the wire loop was entrapped inside the reservoir (Figure 2f-g). The cartridge could be mounted in an AFM.

Operation of the device was tested and analyzed under optical-microscope using water as fluid. To clearly see the pumping effect, we selected a nanopipette with a hydrophobic channel, showing a contact angle of 145 degree. We found this to be a typical value for our SiO2 nanopipettes, which were stored for several weeks under ambient conditions. These channels were hydrophobic enough to prevent self-filling by the capillary effect (Figure 3).

We first checked the tightness of the seal. While the water from an open nanopipette was evaporated within 18 minutes, the soft-lid maintained it filled for more than 40 hours. Using a current of 0.1 to 1 A flowing through the device was sufficient to evaporate the liquid inside the reservoir, causing a high enough pressure to overcome the resistance of the capillary pressure estimated from the contact angle to be of 0.75 bar. The transparent cantilever allowed the real-time visualization of the advancing meniscus (Figure 4). First experiments revealed a pumping velocity of up to ~2.43μm/s.

[1] Hug, T. S., et al. The 13th International Conference on Solid-State Sensors, Actuators and MicrosystemsTransducers05, 2: p. 1191 - 1194, 2005.

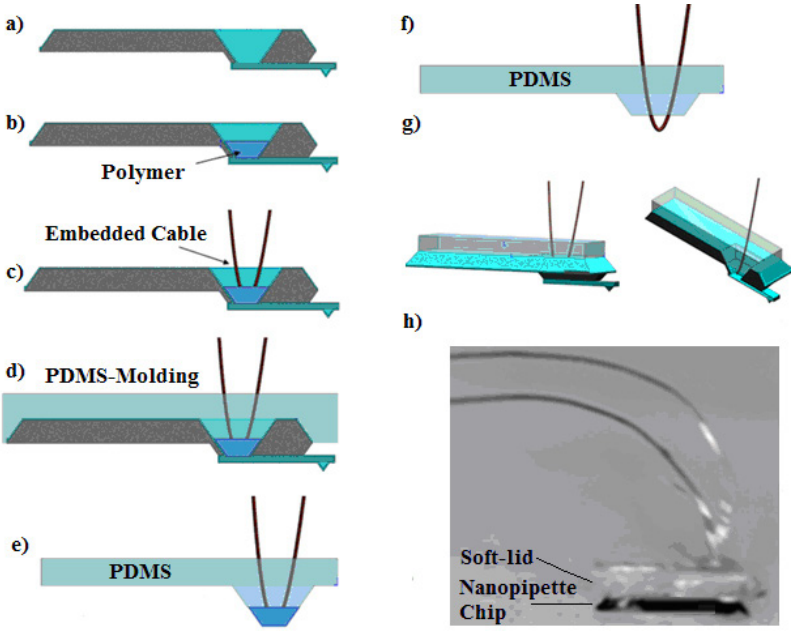


Figure 2

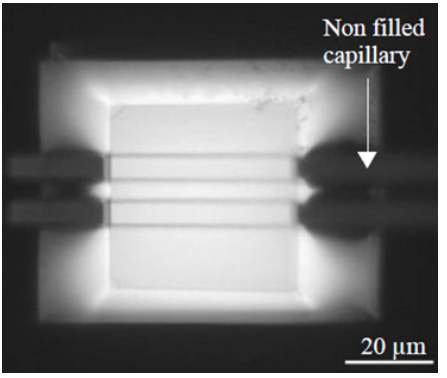


Figure 3

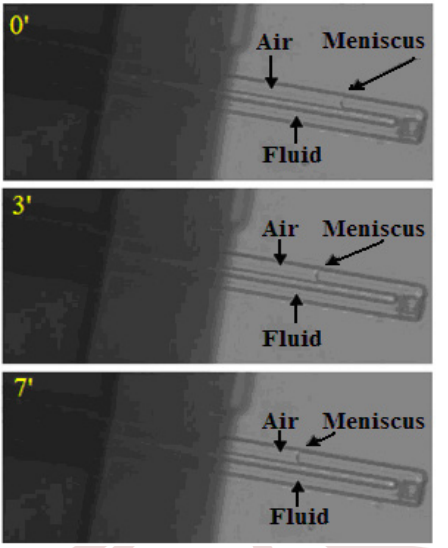
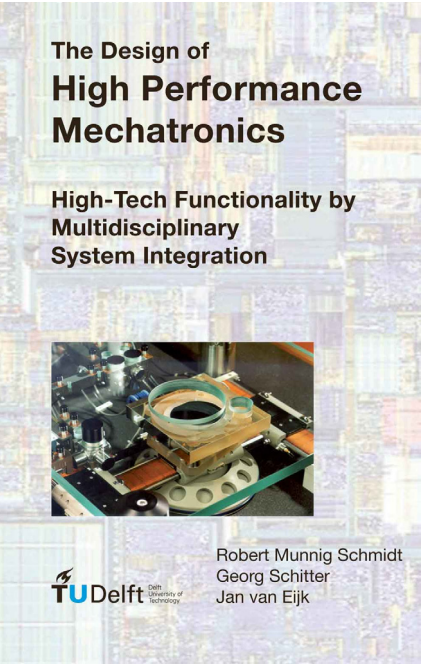


Figure 4

Taylor has a new website

The writing of "The Book"

(Confessions of an industrial professor)



Like many of you may have noticed the arrival of my most intensive personal "delivery" since long has recently become reality. Nine hundred samples of "The Design of High performance Mechatronics" were delivered on Monday, September 19th on a few pallets in the 3mE hall and until that moment I had no idea that it had become so nice. With offset-printing it is rather costly to get an advance pre-print sample so we went directly for the final result, trusting the quality of the LaTeX-created pdf file.

This mega-project started around 4 years ago when I took over the responsibility for the lectures on "Advanced Mechatronics" of Jan van Eijk and Piet Teerhuis and it was clear that the transparencies of Piet and the Philips-based sheets of Jan needed a revision with better connection of the material and some new stuff on electronics and electromechanics. At that time most of the evaluation remarks from students were pointing to the need of lecture notes and in the 2008/2009 course WB2414 (then renamed to "Mechatronic System Design") I asked Ton de Boer, a master student from our group, to work for me as student assistant and make notes from my lectures.

This appeared to be quite cumbersome especially while we were too stubborn to follow the advice of Fred van Keulen to work in LaTeX. At the end of the course period we had a 160 page document, written in "Word" that I still keep in my files just to show the disastrous effects on Figures, captions and lay-out when not working in LaTeX.

So we decided after all to transfer the notes to LaTeX and immediately made our second mistake of LaTeX laymen. We used pdf-LaTeX which is a more direct pdf compiler of LaTeX but for some reason it can only handle pdf and jpeg images. Regular LaTeX first compiles the document into a postscript file using .eps (postscript) images and this is more compatible with the methods used by

publishers which forced me to do the entire lay-out of the book myself. Directly related to this mistake was the choice to start with jpg images leading to cloudy artefacts around the embedded text. The last mistake we made was to use the drawings from Powerpoint and convert these to .jpg or .pdf. For some reason Adobe Acrobat divides pdfs in rectangular strips where the sharp transitions between the strips just cross text and other details which makes it impossible to change the text later in the pdf. Only during the last year I learned to work with Adobe Illustrator and copy/paste the already made drawings directly in AI giving vectorial drawings. After all it appeared that most of the figures are made at least two or three times, not counting the conversion from RGB into CMYK for the full-colour offset.

It is worthwhile to mention that writing a book is mainly a learning exercise. Next to learning to work with LaTeX and MATLAB (Yes I never used that software before!) I think that almost 90% of the material in the book was hidden in the background noise of my brain, forgotten after I finalised my studies. When applying technology one often uses tricks of which the real reason is forgotten but teaching technology requires full comprehension and it made me study a lot on Wikipedia.

In the years after the first writing, the material was continuously refined and extended. Georg Schitter, then working in our group, wrote the control and piezoelectric chapter as that was not my main area of expertise. Jan van Eijk contributed especially in the dynamics chapter while that part is fully based on his lectures in “Advanced Mechatronics” and “Predictive Modelling”.

In 2009/2010 the students kept complaining about the large amount of errors in the notes and I decided to execute one complete correction before sending it to a publisher at the start of the 2010/2011 class. I started this work in the summer vacation of 2010 and finalised only the frequency and dynamics chapters at the start of the course, leading again to complaints of the students who were confronted with improved versions all along the lectures. This made me decide to really finalise the book before the new lectures of 2011/2012 and I had to pay that urge dearly on private time, working several weeks for more than 10 hours per day on 7 days per week. I think the amount of corrections was at least 10 per page and still it is not perfect.

But now it is ready, in time for the lectures, and I have a momentary abundance of private time. I hope it stays that way but I am afraid that new work will fill the gap. As a training, though, it is much advised to write a book in case one has problems with time management.

- Rob Munnig Schmidt

An enterpreneur introduces himself

My interest in technology, and engineering in particular, started at a young age. Like many budding engineers, I started out with a curious but destructive nature. I would take something apart to see how it works and never put it back together again. At the age of 16 I took a part-time job at a major consumer electronics store and quickly developed a knack in communicating my enthusiasm for the latest gadgets. During the remainder of high school I worked in various sales positions until moving to Delft in 2005. During my bachelors in Mechanical Engineering I combined my engineering studies with a wide variety of entrepreneurial courses and commercially oriented jobs to learn more about this intriguing career.

Over the last couple of years I have been active in the start-up of various organizations and companies (YES!Delft Students, IcySolutions B.V., LeQuest B.V., 3Derde V.O.F.) where I learned the ins and outs of the 'real' business world. When I decided on which Masters I would pursue I wanted something challenging, unique, intriguing and offering an enormous commercial potential, obviously the decision was PME. In 2010 I joined the Micro & Nano Engineering department with the long term dream of starting up a company in the exciting field of micro & nano Engineering.

Believing that if you are truly dedicated and have a clear drive you can achieve whatever you want, I discussed my ambitions with Prof. Dr.Urs Staufer. During an inspiring discussion the concept of a start-up took shape. So, in August 2011 the first spin-off company from PME was officially founded. DELMES (DELft Mechanical Engineering Solutions) is a micro & nano engineering start-up which has been set up to bridge the gap between (high-tech) fundamental research and industry. DELMES develops simple, practical and value-adding solutions to complex scientific and technological challenges in the micro & nano engineering industry. Our solutions are aimed at delivering an advantage over traditional approaches on the following five counts: Cost, Energy, Scale, Speed and Ease.

DELMES
Delivering the future

DELMES is currently developing two parallel product portfolios which will be divided into different business units to expand its market and to spread risk.
The first business unit revolves around cantilever calibration solutions for the Atomic Force Microscope (AFM) market and its scope of commercial exploitation is relatively short term (<2 years). We aim to set up a complementary portfolio of calibration techniques to help the industry produce better calibrated

cantilevers at a lower cost.

The second business unit is focused on nano mechanical separation technologies. Here we are creating ground-breaking base technology with extensive market applications (e.g. process industry, energy transport, water purification) but will take at least another 5 years of development time. To achieve this DELMES and TU Delft have joined forces and initiated a research project which is supported by NanoNextNL, a consortium of more than one hundred companies, universities, knowledge institutes and university medical centers.

DELMES has three revenue models for the creation of business.

1. University knowledge valorization (TU Delft).

DELMES and the TU Delft determine if a proprietary technology has a significant market potential. DELMES will then invest, develop and commercialize this value adding knowledge.

2. Contract research.

We will bring value to our partners by means of selling our expertise.

3. Production.

In the long term DELMES will create its own base technology which will be developed into a product. This method is the most scalable but does require larger investments and long development times.

Some readers might be skeptical and think that at the age of 25 I do not have enough engineering experience to build a company like this and, of course, this is a risk. But, luckily, DELMES gets a lot of support from the department and its staff. Especially the dedicated contributions of Prof.Dr. Urs Staufer and Prof.Dr. Fred van Keulen will help ensure success. In addition, we have been able to bring together many well-connected and experienced people behind the screens who truly believe in what we want to achieve and assist in the development. However, **real success also depends on you.**

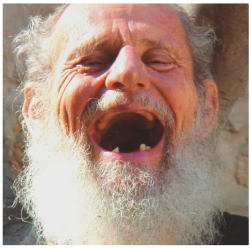
DELMES can only succeed if it can attract bright, ambitious and creative young engineers who are eager to put what they have studied into practice and join an ambitious team dedicated at developing game-changing solutions. If you are an MSc student looking for an internship or graduation thesis or an MSc/PhD graduate looking for a challenging career working with cutting edge technology in an industrial setting please pay a visit to DELMES (next to Jan Neve's office) to see what the possibilities are.

Eric Kievit, DELMES – Your Partner in Micro & Nano Engineering

Joke Box

Ain't broke
Normal people believe that if it ain't broke, don't fix it.
Engineers believe that if it ain't broke, it doesn't have enough features yet.

Real Engineers
- Real engineers consider themselves well dressed if their socks match.
- Real engineers have a non-technical vocabulary of 800 words.
- Real engineers know the second law of thermodynamics, but not their own shirt size.
- Real Engineers will make four sets of drawings (with seven revisions) before making a bird house.
- Real Engineers don't find the above at all funny.



Birth Control
Q - What do engineers use for birth control?
A - Their looks.

Infinity
After explaining to a student that:

$$\lim_{x \to 8} \frac{1}{x-8} = \infty$$

a professor checked if he really understood this by a different example.
This was the result:

$$\lim_{x \to 8} \frac{1}{x-5} = 5$$

Report VDL Excursion

A couple of months ago, I received an email asking me if it wouldn't be nice to organize a trip to VDL ETG in Eindhoven. Truth be told, the name VDL ETG did not immediately ring a bell… So some research was needed to figure out what sort of company VDL ETG actually is. It turned out that VDL ETG is a supplier for mechatronic systems to the semiconductor industry as well as the medical- and defense industry. This all sounded very interesting and the arrangement was made to visit VDL ETG together with the women's study association L'Attaque Attique from the TU Eindhoven.

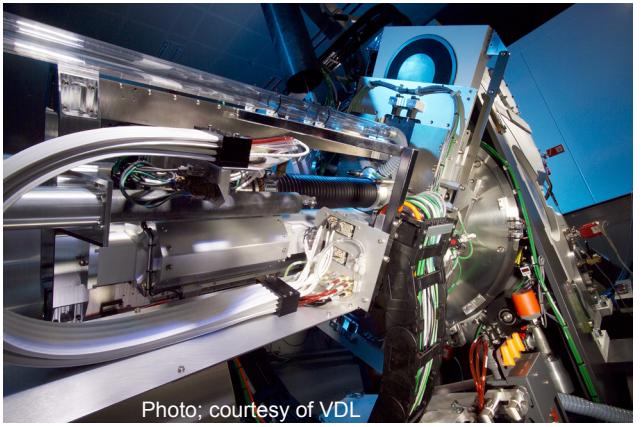
So on the cold and early morning of October 14th, a group of 14 PME students met at the 3mE parking to head off to Eindhoven. The day would be filled with presentations, a factory tour and a technical case we needed to crack.

When we arrived at VDL ETG, a well-earned coffee was poured and a 'gevulde koek' (or two) were ate. Jadranko Dovic, the research managing director, gave us an overview of the company and its history. After this, Marije Linden from ORMIT (a management development company) told us about doing traineeships for example within VDL ETG. Now it was time for us to have a tour through the factory. We were actually allowed to enter the cleanroom so a small outfit change was needed. We could see the assembly of a wafer handler unit in different stages from up close! The function of the wafer handler is to load the wafer into the wafer stage. Not only does this need to be done very precise this also needs to be done relatively quickly and of course without damaging the precious wafer. To see how this part was assembled was a very impressive sight. But the best bit of this tour was just around the corner. Quite literally, because in a corner of the factory hall a unit was being through its paces. To see the whole sequence of aligning the wafer, picking it up and moving it around was awesome.

After a lunch with 'kroketten' in abundance, it was time to split into groups and solve a case VDL ETG had come up with. The case was about a so-called docking module within the wafer handler. This docking module ensures that the arm handling the wafer always stops in the exact same spot each and every time. We were asked to improve the current design. Since the design of the whole wafer handler is rather complex, it took some time before we even understood the current design let alone improve it. However after some hard thinking all three groups came up with a solution. After a healthy discussion, the judges picked a winner and awarded them with the official company tie. Of course no excursion is complete without a drink afterwards. And so we joined the ladies from L'Attaque Attique to help them empty the cases of Bavaria and bottles of wine. The end of a great day.

Many thanks to Crispijn Jansen and Erik Alferink from ORMIT for organizing this day and Hans Steijaert and his colleagues for guiding the case study!

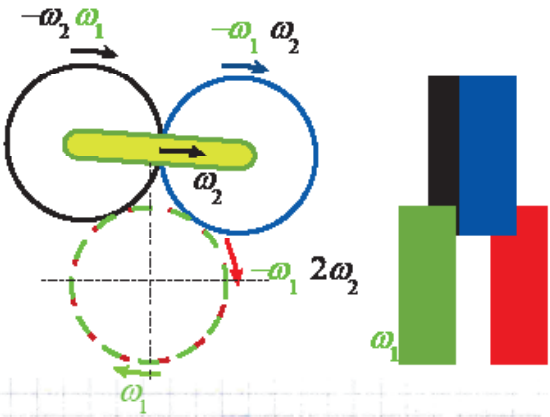
- Koen Holwerda

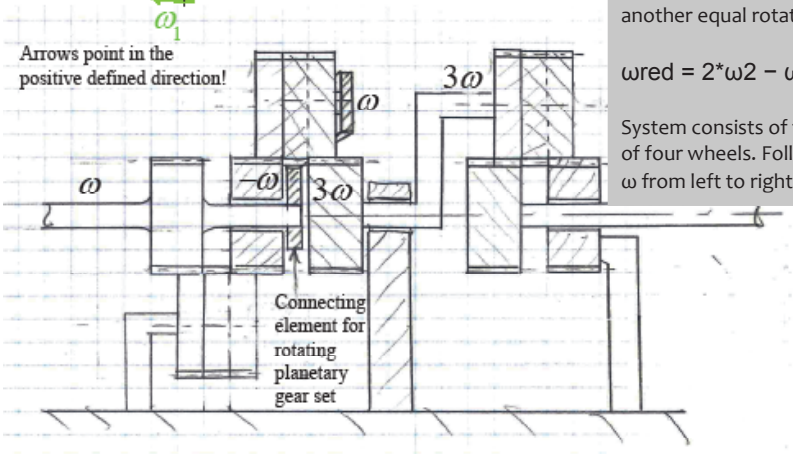

Photo; courtesy of VDL

Mindbreaker Solution

Sadly, last issue's mindbreaker (sent to us by Rob Munnig Schmidt) was not solved by anyone. Here is the question again, this time with the solution Rob gave us.

A mechanical engineer needs to quickly deliver a transmission with a ratio of 6:1 (six revolutions of the ingoing shaft gives 1 revolution of the outgoing shaft). He finds in his garage only 12 equal standard gear wheels as shown in the picture and an ample assortment of ball bearings and steel rods, but he has no time to buy other gearwheels. After clever thinking he succeeded. Now the question is how has he realised the required transmission by using all of the gear wheels?





Planetary transmission with 4 gearwheels

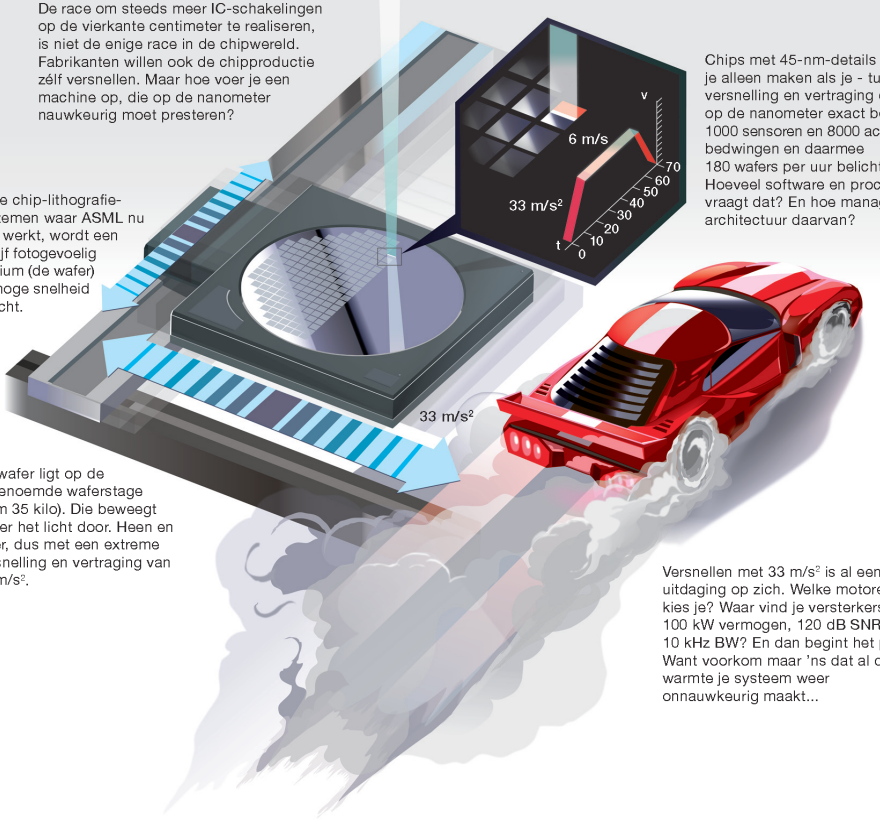
The rotation of the output shaft (red) is the summation of the separate effect from driven shaft 1 (green) and driven shaft 2 (set of planetary gears/ yellow), each calculated when keeping the other shaft stationary. Shaft 1 results in an inverted negative rotation speed of the output shaft via the two planetary wheels.

Shaft 2 (assuming shaft 1 stationary!) gives a positive rotation of the blue wheel around its centre and a negative rotation of the black wheel around its centre with a positive rotation of the output shaft but due to the fact that the entire set of planetary wheels rotates another equal rotation is added.

$\omega red = 2*\omega 2 - \omega 1$

System consists of three sets of four wheels. Follow the speed ω from left to right

Morgen kunnen we sneller chips maken. Vandaag mag jij ons vertellen hoe.



De race om steeds meer IC-schakelingen op de vierkante centimeter te realiseren, is niet de enige race in de chipwereld. Fabrikanten willen ook de chipproductie zélf versnellen. Maar hoe voer je een machine op, die op de nanometer nauwkeurig moet presteren?

Chips met 45-nm-details kun je alleen maken als je - tussen versnelling en vertraging door - op de nanometer exact belicht. 1000 sensoren en 8000 actuatoren bedwingen en daarmee 180 wafers per uur belichten. Hoeveel software en processoren vraagt dat? En hoe manage je de architectuur daarvan?

In de chip-lithografie-systemen waar ASML nu aan werkt, wordt een schijf fotogevoelig silicium (de wafer) op hoge snelheid belicht.

De wafer ligt op de zogenoemde waferstage (ruim 35 kilo). Die beweegt onder het licht door. Heen en weer, dus met een extreme versnelling en vertraging van 33 m/s².

Versnellen met 33 m/s² is al een uitdaging op zich. Welke motoren kies je? Waar vind je versterkers met 100 kW vermogen, 120 dB SNR en 10 kHz BW? En dan begint het pas. Want voorkom maar 'ns dat al die warmte je systeem weer onnauwkeurig maakt...

Voor engineers die vooruitdenken

Profiel: Wereldwijd marktleider in chip-lithografiesystemen | Marktaandeel: 65% | R&D-budget: 500 miljoen euro | Kansen voor: Fysici, Chemici, Software Engineers, Elektrotechnici, Mechatronici en Werktuigbouwkundigen | Ontdek: ASML.com/careers

ASML

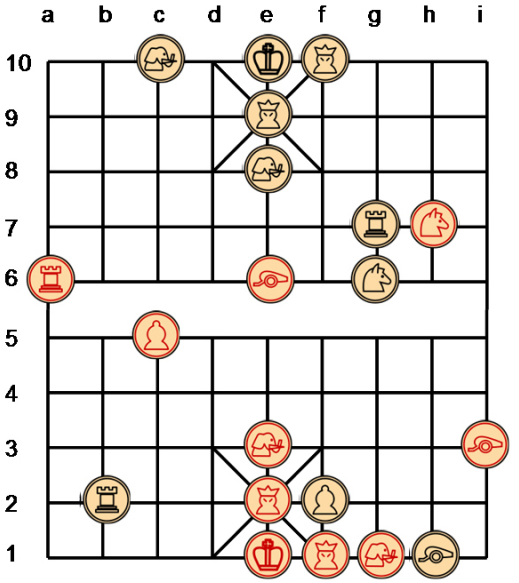
Hans' Horrible Puzzle Experience

It's back! Hans's Horrible Puzzle Experience.

This issue's mindbreaker is sent to us by Hans. The first one to send in the correct solution will win a bottle of wine and can call himself the proud owner of the "Taylor Wisselbeker".

Xiangqi is one of the most played games in the world. The name literally means "elephant boardgame", but in Europe this fascinating game is often called Chinese Chess. The rules of the game are broadly described on Wikipedia. Whoever wants to play a game with me is always welcome. To let you get a taste of the game, I made up the following situation. For comfort, it is displayed with the "western" symbols instead of Chinese.

The question for you is: How can red win in 4 moves?



Get involved!

If you have any comments, ideas or questions about Taylor and its activities, feel free to contact us.

Taylor also communicates with the PME staff, so if there is anything you'd like to share -about the curriculum for example-, but don't know who to contact, you can always contact us and we'll see what we can do.

Also we'd be very happy to recieve any comments or new content for the next issue of the Taylor Vision. For example: PhD work, thesis or internship reports or mindbreakers.

You can contact us at:
taylor-3me@tudelft.nl