

# TAYLOR VISION



TNT Post  
Post betaald  
Post Payé  
Payo-Bus

## The New Board

### PME: ultimate of mechanical engineering

### Haptic Microgripper for Microassembly Operation

 **TU Delft**

Section Precision and Microsystems Engineering



February 2010

Dispuut Taylor - Mekelweg 2 - 2628 CD Delft

# Preface

It has been a while since the last TaylorVision, but now that the exam period has passed it is time for a new start! In the meanwhile some things have changed in the PME department. Prof. Urs Stauer has been inaugurated, Fred van Keulen has passed his hat of PME department chairman on to Prof. Munnig Schmidt and the monthly PME meetings are now held on Thursdays. Last but not least a new Taylor board has been installed. One second year and four first-year PME students including myself have volunteered to organize a year of great activities, a Taylor study trip abroad and the occasional drinks now and then.

In this TaylorVision the new Taylor board will introduce themselves properly. Dr. Shahzad Khan wrote a story on his Haptic micro gripper for micro assembly operation. There will also be an article from the new department chairman and his visions on the education within the PME department. Furthermore there is a new brand puzzle deviously devised by Hans van Gorp and a report on the visit of the Precision Fair.

The Taylor board is organizing an excursion in March to NXP in Nijmegen so keep an eye on the website and the announcement boards! In the long run we are making all the necessary arrangements for an interesting Taylor Trip of which the destination is still very classified.

Kenneth Kamp  
Chairman Taylor 2009-2010

## **Student Association Taylor**

Faculty of Mechanical, Maritime and Materials Engineering (3ME)  
Section Precision and Microsystems Engineering  
Mekelweg 2  
2628 CD Delft  
Block 4B room 1-47  
Tel/Fax: 015-278650/015-2783910  
Email: [taylor-3me@tudelft.nl](mailto:taylor-3me@tudelft.nl)  
[www.taylor.3me.tudelft.nl](http://www.taylor.3me.tudelft.nl)

## **Board**

Kenneth Kamp  
Peter de Lange  
Ferry Bastiaansen  
Maarten van der Kooij  
Finn van Rij



# Contents

The New Board	4
PME: ultimate of mechanical engineering	10
Haptic Microgripper for MicroassemblyOperation	13
Precision fair 2009	18
Interview Jordi Kerkum	21
The Hans Puzzling Experience	24



# The New Board

## Chairman - Kenneth Kamp

Last year I followed the mechatronics & control minor which made me enthusiastic about mechatronics and precision engineering so for me PME, specialization MSD was the logical thing to do. I had never really heard of the “Dispuut Taylor” until the kick-off drinks at the start of this year, which I attended with my now fellow board members Ferry (Treasurer) and Finn (External Commissioner). We arrived a bit late and jokes were already made by the old Taylor board that the three of us should form the next Taylor board since no other first year PME students showed up. This seed for joining the Taylor board was then planted in my mind and steadily grew. But why form a board with three if you can do it with five? After some meetings and really tough negotiations in the Locus Publicus and adding Peter and Maarten we came to the conclusion that we were the right guys for the job. As the new Taylor chairman my job is to keep an eye on the other members of the board and make sure they don’t fall asleep during those long nights in which we keep Taylor running. I’m also responsible for the Taylor Trip, of which the destination is still very secret but I can say that the starting direction will be eastwards. Furthermore I try to be involved in all the things going on at Taylor such as the excursions, fun activities, making the TaylorVision, contacting PME oriented companies etc. etc. I also hope that the my fellow PME students from the “new” batch will become very enthusiastic about all the activities Taylor has to offer. It will be a busy but fun-filled and above-all Taylor-tastic year!



## The New Board

# Secretary - Peter de Lange

Hi all! My name is Peter the Lange and I'm the secretary of the 2009-2010 Taylor board. Before I started my study in Delft, I studied in Den Haag at the Haagse Hogeschool, where I did a bachelor called Movement Technology. After that I started with the Mechanical Engineering premaster program, followed by a master in Biomechanical Engineering Design. But after following some interesting PME related courses I decided to switch master to PME! My job as a secretary is to keep the website up to date, publishing numerous Taylor visions and help organizing all kinds of things for the students. Now some personal stuff... I live in Den Haag in a cool pink student flat. I enjoy visiting rock concerts and festivals. This inspired me to start playing some music myself to. Two years ago I started playing the guitar, and more recently I joined a band, which is even more fun to do. Next to that, I like doing sports, especially endurance sports such as running and cycling. Feel free to come by to me with questions, ideas, complaints of any kind.



## The New Board

# Treasurer - Ferry Bastiaansen

Hello everyone! My name is Ferry Bastiaansen and I will act as treasurer for the Taylor board this year. Before I started with PME this year I did a number of courses at the Offshore department, apart from finishing my BsC. Gradually I noticed this was not meant for me, and I decided to look for a masterstudy in which I was more interested, which turned out to be PME. As Kenneth already was a friend he soon approached me to do the Taylor board with him. My main goal as Treasurer is to manage the finances and to keep them as organized as my predecessor delivered them to me. Furthermore I hope to attract a lot of sponsors so there are sufficient funds for educative and recreative activities. This is going to be an interesting and exciting year!



## The New Board

# Commissioner - Maarten van der Kooij

Being the commissioner of activities of the Taylor board my responsibilities include the organization of excursions and the monthly drinks with the department. Of course these are not the only things that keep me busy at the so called 'Taylor-hok'; the organization of the Taylor-trip, making phone calls to potential sponsors and 'manusje-van-alles'-tasks take quite some time too. Being part of one of the largest Taylor boards ever is a lot of fun and the cooperation among the five board members goes smoothly. And not to forget, when drinking beers it's more fun with more people. My PME career started in January 2009, so technically I'm not a real 1st year's student at the department. Within PME I am an automotive student, which also matches with what I'd like to do in my free time: cowboy-engineering at my BMW E30.



## The New Board

# Commissioner - Finn van Rij

My name is Finn van Rij and I'm 25 years old. I'm born and raised in Amsterdam and recently moved to Delft. I'm participating in the master PME with "Mechatronic system design" as specialization. Before this I did the Minor "Mechatronica en Regeltechniek". I really liked doing this minor, which made me choose it as my specialization.

I joined the Taylor board, because it seemed like a nice experience, but also to become more involved with the organization and their activities within the department. The current chairman has contributed a great deal in my final decision to participate in the Taylor board.

My personal objective for this year is to improve the link between students and interesting branches of the industry. An improvement of this simplifies finding the right master thesis or internship and furthermore finding a nice job in which students have the possibility to develop themselves and build a career. I hope this personal objective will be achieved and that it will be a very good board year!



# nieuwsgierig?



Binnen DEMCON wordt jouw nieuwsgierigheid beloond. En niet alleen jouw nieuwsgierigheid, maar ook jouw passie voor techniek en jouw drive om voor complexe vraagstukken, binnen een uiterst gedreven team, tot de beste oplossing te komen.

DEMCON realiseert - door onderzoek, ontwikkeling en productie - high-tech mechatronische systemen en producten. Met zijn mechatronische ontwerpbenadering genereert DEMCON hoogwaardige oplossingen voor complexe vraagstukken in uiteenlopende markten, van semicon en defense tot medical en life sciences. De aanpak van DEMCON kenmerkt zich door sterk analytisch vermogen, creatief denken en pragmatisch handelen.

analyze. create. achieve.

Kijk voor actuele vacatures op:  
[www.demcon.nl](http://www.demcon.nl)



Rob Munnig Schmidt

## Precision and Microsystems Engineering track, the ultimate of mechanical engineering.

When Taylor asked me to write a column for our students as the new chairman of PME I decided neither to talk about typical departmental issues with funding, administration and personnel matter nor to spend time introducing myself as you all know me from my lectures and the PME meetings. Instead I'd rather focus on the role PME plays in education especially in the master phase.

In my view the key distinguishing factor of the PME track in respect to other tracks is the presence of all technological aspects needed to bring mechanical engineering to the highest level of perfection. Mechanical engineering is the ultimate goal of applying physics or as one former colleague of mine formulated it: As soon as physics becomes useful it is called mechanical engineering.

So it all starts at the PME track with the basics and we are convinced that for instance knowing material properties starting at the atomic level gives us better insight in the behavior of the matter at far larger scales such that we can reliably predict that behavior. For this reason we introduced a new lecture in the curriculum on "Physics for mechanical engineers".



While mechanical engineers by definition are trained to ultimately realize products in a team, the design aspect is of paramount importance. This means not only attention should be given to the analysis of a problem but also to the integration of all applied technologies into one functionality which is all that “Mechatronic System Design” is about. At the same time several gaps in the knowledge on electromechanics, optics and electronics are filled, necessary to complete the basic education of a good mechanical engineer. From a manufacturing point of view attention is given in the curriculum to assembly processes and precision manufacturing methods as they are applied in any machine design. Because modern mechanical designs are complex and often very expensive to manufacture, it is crucial that their behavior is modeled and predicted up to extreme levels of accuracy. This is the field of expertise of our Mechanics and Dynamics group which knowledge is transferred in lectures on optimization of structures, on dynamic modeling and analysis, and on mechanical properties of different materials including statistical analysis on the functionality of different parts in a complete mechanical system.



I personally think this all represents a very exciting combination of expertise that is not easily found anywhere else and which is applicable in any mechanical design. It offers a wide scope of learning opportunities to anyone working and studying at PME. Certainly different research topics appear to be so diverse that it is impossible to master all aspects of everything up to the full academic level. In practice this means that our students have a wide choice of subjects to work on, and no MSc. thesis is alike.

I have only one worry and that is that still too few students choose for this exciting track. When talking with different students the above message appears less clearly perceived because the name of the track seems to imply something different namely rather a “niche” kind of specialization for only those who like to work in clean rooms with lab-suits and microscopes, or who like to drown themselves in FEM calculations. I will emphasize the above message stronger in the MSc. information sessions and on our website in order to correct this erroneous perception.

It is also often heard that our track is difficult. This, I will not deny and not change as I am proud of it! In my view, and based on my experience from industry, those students who are not afraid for the ultimate challenge are the ones that achieve the highest positions later on in their career. And indeed as I observed in the present crisis the unemployment rate of our students is extremely low. With this positive view in mind I wish all our students a very prosperous stay in our department.

- Rob Munnig Schmidt -



# Haptic Microgripper for Microassembly Operation

## Introduction

With the advancement of recent technologies, there is a strong trend towards the miniaturization of many products and their components, down to the micrometer and sub-micrometer range. One big challenge on the production of these products lies on the assembly of micro-parts coming from different processes or technologies: in the assembly of products consisting of micro parts, the assembly process can add up to 80% of the production costs. The traditional ways of macroassembly processes, by automated positioning robots, are not always applicable, due to the requirements of high precision motion, high tolerances, and the predominance of surface forces on gravity that makes it very difficult to release the parts that tend to stick to the end-effector.

Micro-assembly is often performed manually by hand (with the support of tools) or by expensive, (semi-) automated machinery. Unfortunately, the manual approach often fails in the force and precision requirements. Moreover, the process leads to non-consistent products and causes excessive strain to the eyes and may cause a long term health problems to the human operator. This leads to high costs and often low yield of the assembly process. Automated assembly systems are more reliable in terms of yield, but are not always economically profitable, especially in case of low batch production. Thus, a semi-automatic scheme is favorable and is achieved by the inclusion of the human operator in the loop to perform microassembly through tele-operated systems. The approach is an interesting alternative to both the pure manual and the automated assembly, but the lack of force feedback increases the risk of damaging the micro components and decreases the operator efficiency to perform the task.

In order to overcome these difficulties, a tele-haptic assembly system approach is adopted in which the operator receives different kinds of feed back (e.g. visual, force reaction, etc.), assisting the operator to succeed in the assembly tasks. The use of force feedback to the human operator could lead to an improved execution of human based assembly operations, in terms of time, efficiency and reliability. Moreover it would avoid damage of the fragile parts or the micro gripper and would allow for dexterous manipulation of micro-objects. The presence of the human, opposite to the more rigid approach of automatic micro-assembly, improves the flexibility of the system due to its capability to plan, adapt, and react to unexpected situations during the assembly process.

One of the bottlenecks to perform complex haptic microassembly tasks is the necessity to develop a microgripper capable of performing pick-and-place of micro-objects with diverse sizes and to sense the grasping force. This research is focused on the development of a mechanical microgripper capable of sensing the grasping force and transferring this force to the human operator using a 1-DOF master device.

### **Haptic Microgripper**

The mechanical design of the custom built sensorized micro-gripper is shown in figure 1(a). A base part is holding two aluminum fingers of 5mm x 1mm x 0.5mm, actuated by DC micromotors (Faulhaber BLDC 0206). The gripper arms are directly mounted on the shaft of the motor to reduce backlash and friction in the system. By using the BLDC-motor as a direct drive, the force estimation by means of a current measurement is more direct. A photo-interrupter device is utilized as position sensor to sense the displacement of the gripper arms and is mounted on the rear-ends of the arms.



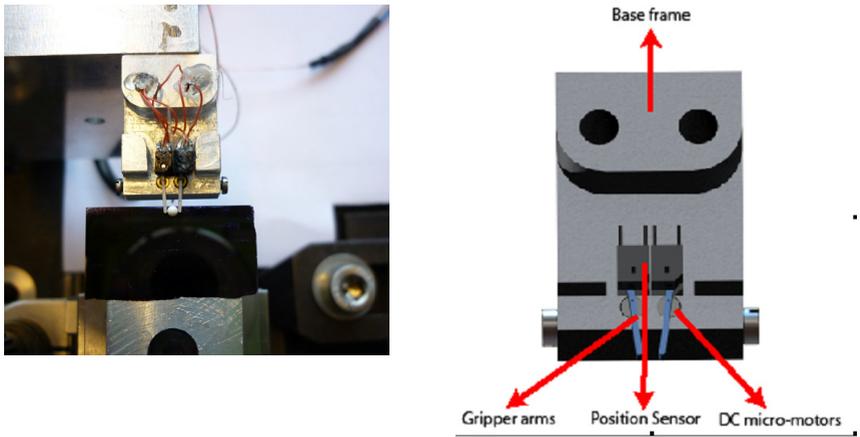
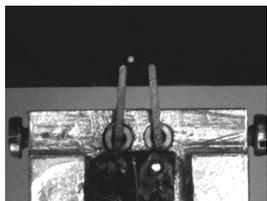


Fig. 1 (a) Mechanical design of the gripper module. (b) Haptic Microgripper

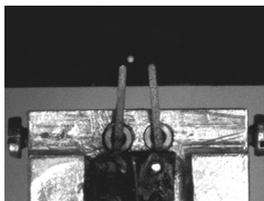
Two brushless DC micro-motors have been utilized to drive the two arms of the micro-gripper. The dc micro-motors consist of permanent magnets and coils, configured as Lorentz actuators. Due to the linearity between the current flowing through the coils and the delivered torque, a current measurement is used to estimate the grasping force between the arms and the micro-objects. Two optical sensors measure the absolute position of the respective gripper arms. The output of the optical sensors depends on the amount of light blocked by the gripper arms, providing a measurement of their displacement. The complete assembly is shown in figure 1(b).

### **Pick-and-place of Micro-objects using Haptic Microgripper**

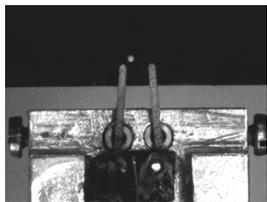
To validate the experimental setup, snapshot of single pick-and-place operation of micro-sphere (SiLibead of type 9405) of diameter 0.5 mm using haptic interface is demonstrated in figure 2(a) till 2(h).



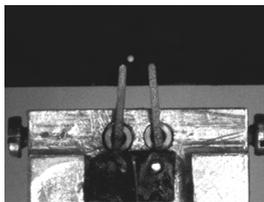
(a)  $t = 0$  s



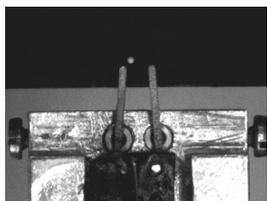
(a)  $t = 5$  s



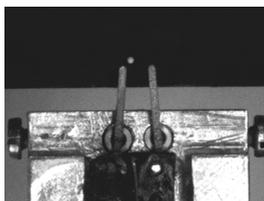
(a)  $t = 16$  s



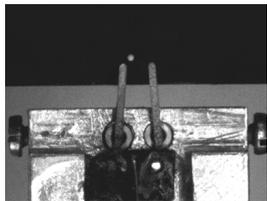
(a)  $t = 26.3$  s



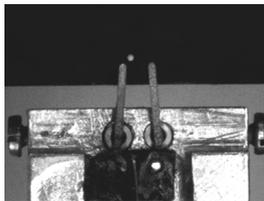
(a)  $t = 30.5$  s



(a)  $t = 40$  s



(a)  $t = 57.5$  s



(a)  $t = 59$  s

Fig. 2: Snapshots of single pick-and-place operation of micro-sphere.

## Future work

In this research work, a developmental effort to realize a micro-gripper with force feedback mechanism has been demonstrated. Some preliminary experimental results concerning pick-and-place of micro-objects have been demonstrated.

Methods for measuring the interaction forces in the microenvironment are not readily available, and gripping, releasing and positioning mechanisms are currently being studied. The design of a master device specially tailored to the application has also produced interesting results. It is also necessary to understand the effect of certain mechanical design decisions on the operator experience. Preliminary studies in virtual environments have analyzed the effect of different operation and assistance modes, mechanical architectures and specifications on the user. In order to extend and verify these studies, an off-the-shelf 4DOF assembly station is being set up by joining micropositioners, microgrippers and a master device.

If you are interested in the project then please contact Dr. Shahzad Khan ([s.khan@tudelft.nl](mailto:s.khan@tudelft.nl)) or Ir. Pablo Estevez ([P.EstevezCastillo@tudelft.nl](mailto:P.EstevezCastillo@tudelft.nl)) or Dr.ir. Hans Langen ([H.H.Langens@tudelft.nl](mailto:H.H.Langens@tudelft.nl)).

# Visit at the Precisionfare 2009

This years Precisionfare took place Wednesday 2nd and Thursday 3th of December, at the NH conference centre Koningshof, Veldhoven. With over 3000 visitors, 193 stands and 218 companies (exposanten) this is the largest precision-event of the Benelux.

As it seems to be a tradition to visit the Precisionfare in Veldhoven, this year the board of Taylor went to Veldhoven as well. Several people had made their vehicles available for both the Board and Students, and together we met up at the faculty of mechanical engineering to carpool to Veldhoven.

At arrival at the fare we first enjoyed a cup of coffee to boost the spirit as it had been a somewhat long drive. After this the group swarmed out to the interesting products and companies.

Several examples of what we have seen there, among many many others:

Demcom with their high-tech mechatronic systems. VSL, the dutch metrology institute which is located in Delft. SKF with many types of bearings, seals, etc. Etchform BV with etched and electroformed metal precision parts. Heidenhain with for example its encoders.

A walk along Piezoboulevard took us to a large number of compa-nyies with their piezotechnology. A visit to the Technologie hotspot took us to several Universities with precision technology and re-search, including our own TU Delft with research of the Dynamics of a riding bicycle.



After an inspiring day at the fare several people enjoyed a snack-on-the-way in the Volkswagen Van that was made available by Paul, depicted below.



For those who are interested to go to the next precision event: it will take place on the 1st and 2nd of December, 2010, at NH conference centre Koningshof, Veldhoven.



**HEIDENHAIN**

## Hoeveel miljoen functies passen er morgen op een microprocessor?

Waar functionaliteit en kosten tellen, mag geen plekje onbenut blijven. Dat geldt ook voor wafers. Steeds kleinere structuren op steeds grotere formaten: Deze schijnbare paradoxale eisen zorgen voor een optimaal gebruik. De eisen die gesteld worden aan lengte- en hoekmeetsystemen luiden daarom als volgt: De hoogste nauwkeurigheid en de kleinste resoluties bij steeds grotere meetbereiken. Een voorwaarde waaraan voldaan wordt door de meettechniek van HEIDENHAIN, want door voortdurend onderzoek en permanente ontwikkeling zijn wij vandaag al gereed om de schijnbare tegenstellingen van morgen op te lossen. HEIDENHAIN NEDERLAND B.V., Postbus 92, 6710 BB Ede, Tel.: (0318) 581800, Fax: (0318) 581870, [www.heidenhain.nl](http://www.heidenhain.nl), E-Mail: [verkoop@heidenhain.nl](mailto:verkoop@heidenhain.nl)

Hoekmeetsystemen + Lengtmeetsystemen + Contourbesturingen + Digitale uitlezingen + Meettasters + Impulsgevers



Interview with Jordi Kerkum

**“A real student will go PhD!”**

**Could you introduce yourself for everyone that doesn't know you, and could you tell us about your function within PME.**

As Department Secretary I am the right hand man of the Chairman and the Management Team. I monitor the finances and personnel of the department and prepare policy decisions. In consultation with the chairman I prepare the budget and assist project leaders in applying and managing their projects. Within the department I am the main contact for the various support services and for scientists with questions on support.

**Last time we had an interesting conversation concerning the PHD program. What makes this interesting for students?**

In contrast to a job at a company you will get a lot of freedom to focus on subjects of your interest. So if you enjoy doing research; the freedom granted within a PhD program is incomparable with a regular job. The PhD program also gives you a nice opportunity to explore the academic world and find out if it suits you. The PhD program is foremost a learning trajectory; you will learn many skills that a scientist needs such as research methodology, writing, publishing and presenting. PhD students are in a comfortable position in the Netherlands, compared to other countries; you even get paid a nice salary. After 4 years you will be a specialist, and you will have built up a network through colleagues, conferences and connections in industry. At the end you will be an independent researcher.

## **What will you be doing as a PhD student?**

In the first place you will be mainly concerned with doing your own research, literature review, calculations, drawings, simulations, manufacturing, experimenting and reporting and publishing your work. Next to that, you will spend up to 25% of your time on organizational tasks, teaching and supporting graduate students for example.

From the beginning, you will have a supervisor and a promoter to guide you in your research, but at some point in those four years you will (hopefully) surpass them on your field of research.

It's good to remember that during these four years you will be focusing on one subject within a certain field of research. If you see a PhD as a chance to extend your studies, or to delay a choice, you should not go for it. As a department we only want the best, and you really have to be motivated, as a top-level achievement is expected of you.

## **How is the current flow of PME graduate students entering the PhD program?**

Only the best will be accepted. High marks alone are not enough; you will also need the right personality to accomplish things. Gaining enough capable PhD students is hard; openings are advertised internationally, so you have global competition. The PME department strives to have a balanced international group of PhD students.



## **What is the job perspective after acquiring your PhD title?**

Sometimes PhD students are offered good positions even before they are finished. On the other hand, the title is sometimes undervalued by industry, depending on the country. In most foreign countries however, the PhD title (especially from Delft) is highly appreciated. The field that you work in is always international, as science is a global sport. A good PhD can find a job anywhere around the globe. But of course we try to keep the best of them in Delft!

## **So far so good, but what will you earn as a starting PhD student?**

Doing your PhD is the same as any other job in one respect: If you're only doing it for the money, it will never be your passion! The salary may not be as good as in some companies, but realize that education, guidance and freedom like this are unmatched by industry. Therefore your time spent as PhD student can be fantastic, and a great start of your career! Currently you will start with a gross salary of €2042,-, this will increase each year up to €2612,- in the 4th year. The package includes a holiday allowance and a bonus 13th month.

## **I think we can all agree on that. Thank you for you time!**

Extra information on the PhD program can be found here: [promoveren.tudelft.nl](http://promoveren.tudelft.nl) (for general information).

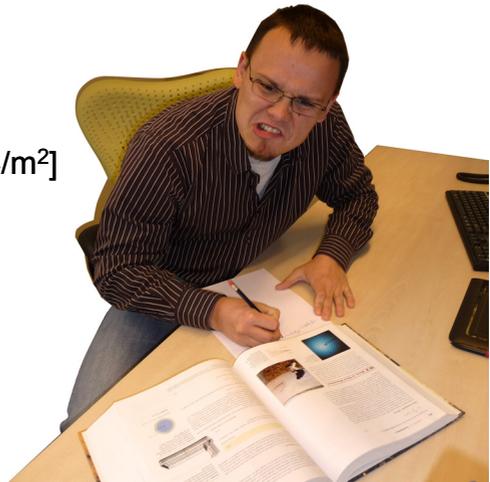
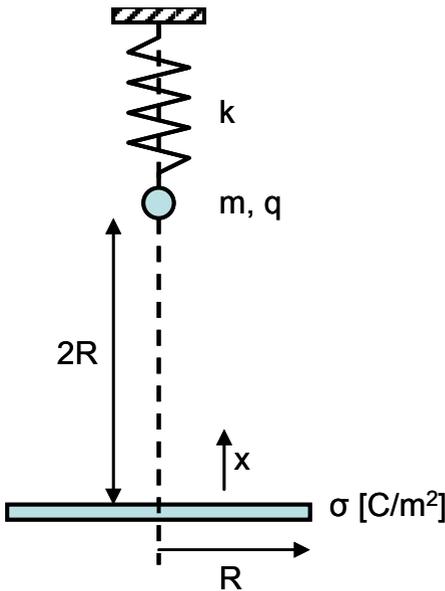
If you think this might be interesting to you, talk to your professors and teacher about it.

# Hans Horrible Puzzling Experience

Consider the setup below. A point mass with mass  $m$  and positive charge  $q$  is suspended by a mass-less spring with spring constant  $k$  [N/m]. Assume there is no gravity.

At a distance  $x = 2R$  below the suspended point mass, there is a negatively charged circular disc with radius  $R$  and area charge density  $\sigma$  [C/m<sup>2</sup>].

When  $x = 2R$ , the spring is at its rest-length.



In order to win the fabulous price handed out by the chairman of the Taylor board himself, you will have to complete the following tasks:

- a. Derive an analytical expression for electrostatic force and the spring force.

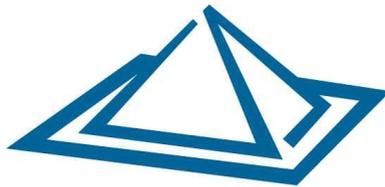
Now take the following values for the parameters:

$$\begin{aligned}\sigma &= 1 \cdot 10^{-4} \text{ C/m}^2 \\ q &= 5 \cdot 10^{-5} \text{ C} \\ k &= 120 \text{ N/m} \\ R &= 1 \text{ m} \\ m &= 2 \text{ kg}\end{aligned}$$

- b. Make a plot of the total force acting on the mass as a function of its position  $x$ .
- c. Find the numerical values for the equilibrium point(s) and indicate for every equilibrium point if it is stable or not.
- d. For the stable equilibrium point(s), compute numerically the eigenfrequency.

Mail your solution to: [taylor-3me@tudelft.nl](mailto:taylor-3me@tudelft.nl)





**Don't forget to check our website  
[www.taylor.3me.tudelft.nl](http://www.taylor.3me.tudelft.nl)  
for the agenda and more information  
about our activities!**





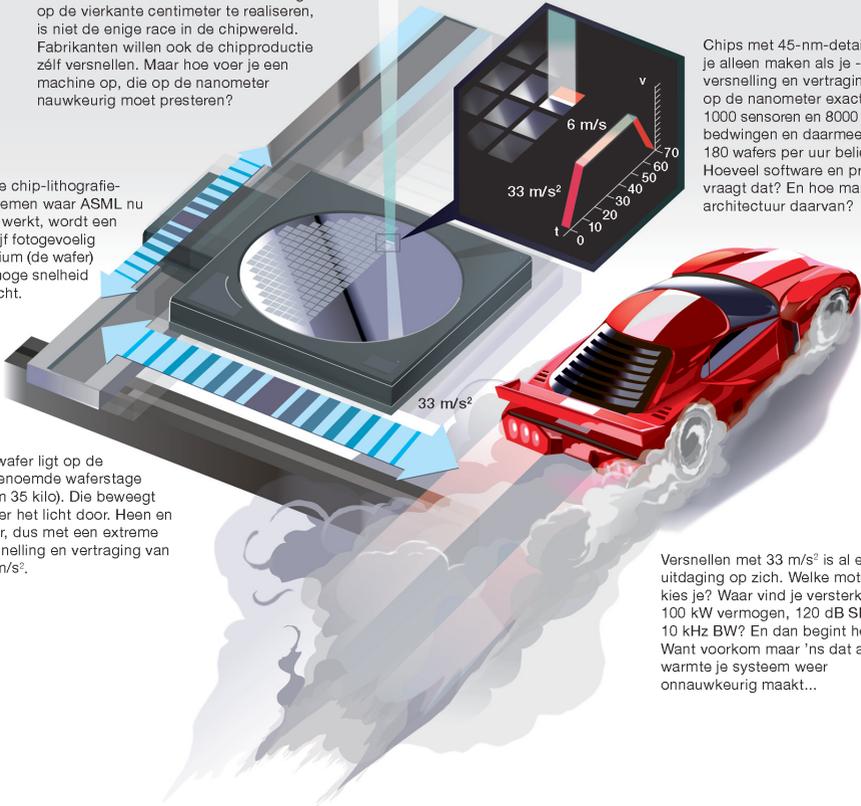
# Morgen kunnen we sneller chips maken. Vandaag mag jij ons vertellen hoe.

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 zelf versnellen. Maar hoe voer je een machine op, die op de nanometer nauwkeurig moet presteren?

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  $33 \text{ m/s}^2$ .

Deep UV-licht  
(193 nm)



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?

Versnellen met  $33 \text{ m/s}^2$  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-lithografie-systemen | Marktaandeel: 65% | R&D-budget: 500 miljoen euro | Kansen voor: Fysici, Chemici, Software Engineers, Elektrotechnici, Mechatronici en Werktuigbouwkundigen | Ontdek: [ASML.com/careers](http://ASML.com/careers)



**ASML**

