**Scribent**
Would a crocodile be able to fly?

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# Francken Vrij

## Equilibrium


26.3 Equilibrium

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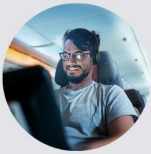

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Former Trainee

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## Editorial
**The Francken vrij** reaches equilibrium once there exists a healthy balance between interesting and fun. In this edition we're looking back at 60 years engineering physics, the role of equilibrium in potential energy-shaping stabilization of mechanical systems, and exploring if crocodiles can fly.

Unfortunately this will be the last '*Editorial*' I'll be writing. Next year, Hester Braaksma will take over as the editor in chief of our beautiful magazine. I wish her the best of luck, and want to thank everyone for the lovely years.
Enjoy reading!


## Address:
T.F.V. 'Professor Francken'
o/c Francken Vrij
Nijenborgh 4
9747 AG Groningen
The Netherlands
Telephone number: 050 363 4978
E-mail: franckenvrij@professorfrancken.nl



## General:
**Advertisers**
Thales$_{2}$, Braumeister$_{21}$, Schut$_{36}$
**ISSN:**
2213-4840 (print)
2213-4859 (online)
**Edition and circulation:**
Februari 2022, 100

## Special thanks to:
Jelle Bor, Maaike Groeneveld, Prof. dr. Jeff Th. M. De Hosson, Arjen Kramer, Rodolfo Reyes Báez PhD, Ids Schiere, Bradley Spronk

# Edition 26.3

# Chair's preface

By Ian Soede

I'll **have to** admit, writing a chair's preface has never been my specialty. Usually I start by scrolling through other volumes of the Francken Vrij to hope for a sparck of inspiration. The difficult truth is, eventually it simply comes down to making a good '*kakverhaal*'. It doesn't matter much what you write about, as long as you mention the theme of the edition, praise Francken, and the appropiate cliches and wisdoms of a true chair.

But isn't Francken a great association that is in a beautiful equilibrium with all of its diverse members? All kidding aside, looking through the photo albums to find the right picture for this piece, has made me a bit nostalgic. The past year has been one of trying to find an equilibrium in work and life, of beer, and well, beer. I'll miss the fond

days where I can call 'having a beer with friends' *work*. An experience I recommend to anyone walking around at Francken.

I hope you also enjoyed the past year, past editions of the Francken Vrij, and mostly, I hope you enjoyed one my last Chair's preface kakverhalen (about kakverhalen).

Cheers!

# News of the association

By Sjoukje de Jong

I **cannot believe** this is already the last piece I am writing for the Francken Vrij as a (demissioned) secretary. I think we can safely say that these last few months have been pretty busy, as there was no Covid, and there was a lot to catch up on! I think everyone is glad that there is a nice summer holiday after this packed period with also an exam week. There have been fun and serious activities including borrels, a foreign excursion, and a symposium.

**Greek Olympic borrel**

Borrelcie was in a creative mood and decided that we should go back to the very old days when there were still Greek philosophers deciding on whether the earth is flat or not. Including the ancient Greek clothing, this was a very successful borrel where some sjaarzen were also thaught the amazing Francken traditions and games.

**Craft beers and Burgers**

Fraccie got to show off their grilling skills by making burgers for around 35 people. It was great weather and an even better activity to fill your stomach and have fun at the same time. I think Fraccie did a great job making delicious burgers and picking craft beers, although it was a bit of your own responsibility whether you would actually get a burger or not.

**Buixie**

This year's destination for the excursion was France! The bus and train were used as a sustainable mode of transport which we first went to Paris with. We got to see some amazing things there, interesting museums along with the castle of Versailles and of course the other standard tourist attractions. Everyone that made it to Marseille also got to see ITER, the largest nuclear fusion experiment in the world! Along with the research institute of the University of Marseille, this was a very interesting trip with of course a good dose of fun activities and good food.

### AP dinner

It was time to have dinner exclusively for Applied Physics students, professors, and staff. It was amazing Italian food with many options for vegan and vegetarian food as well. I think the Gebouw 13 craft beers blew everyone's mind, not only because of the flavour. It was a great dinner where nice conversations could take place between everyone present.

### Karting with YER

YER wanted to have a fun activity with us, so what we came up with was a great afternoon of karting. We all got to drive around like a maniac twice, where some of us got to drive for the first time, and others tried to overtake these people. It was great to see which Formula 1 fanatics knew the best strategy and who was just trying not to run into anything. Some of us even got pretty high up the daily leaderboard of the track!

### Symposium: Go With The Flow

This year's theme of the symposium was Go With The Flow! It was a packed day with all kinds of lectures that have something to do with fluids. Of course some fluid dynamics, but also about how climate change will affect see level rise and how gas pipes could be used to transport hydrogen in the future. Personally, I thought the talk about physical and medical acoustics with bubbles, drops and microparticles was the most interesting. But of course, the other talks were very interesting too. The day ended with some delicious beers from Baxbier, a nice application of fluid dynamics.

### Tour de Francken

After a postponed tour in December, it was finally time to have a real one in the member's room again. All teams fought very hard to earn the beloved title but the team that was the fastest was Team 1 with Sibren Wobben, Joris Doting, Janco van der

Molen, en Roman Bell! They will be added to the plank of fame together with the other honorable winners.

### Sjaarcie dinner

One of the two events that the Sjaarcie has to organise is the Sjaarcie dinner. This year different things were cooked for us. Which we could taste outside of the beautiful building 13. It was a great night with a delicious polish starter, Indian curry, and Mexican dessert. After we all filled out tummies some stayed for a borrel in the room and the committee also took the sjaarscie committee picture before Ian demonstrated a waterfall. Overall a very successful event.

### Gala with Nuts

This was another one of the earlier postponed events, we could finally have a gala together with Nuts, the study association for English Language and Culture. The celebration was held at Het Pakhuis where everyone could enjoy unlimited drinks and great music. The camera guys were also pretty busy but and they did a great job capturing this amazing party.

### Member's weekend

The Wiecksie had organised a nice weekend away again. This time the theme was a birthday party, as it was at the same time as the birthday of our honorary member; Jeff de Hosson! On the first day the weather was great, in the evening there was geen cantus and it nice and gezellig. The day after there was a nice cake decorating activity like you used to do at every children's birthday party when you were 8. A few people went for a nice long walk after that, the others enjoyed the small pool. The dinner of the night was a bbq which was nice. On Sunday there was some cleaning up to do before everyone went home.

### End of the year BBQ

The first official activity as organised by the new board: Fusion. It was sponsored by ASML which we are of course very grateful for. There were good meat and meat replacers, as well as salads and drinks. There were also some interesting vehicles to entertain the people present, as well as some frisbees and footballs to play games with. I think this was a great activity to end the year with, and I hope to see you at more activities again next year.

# Meet board 'Fusion'

**Csilla Tijssen**

Dearest reader, thank you for taking the time to read through these pieces to get to know me and the rest of my newly installed board a bit better. I am Csilla Tijssen, the new president of T.F.V. 'Professor Francken'. Let me try and introduce myself with

some random facts about my life which might show you exactly who I am or might just turn out to be some random facts in a row.

I am a third year Astronomy student, realizing that becoming a board member and finishing your Bachelor project is not as compatible as I had thought before. I grew up in two countries, Hungary and the Netherlands, I am one of triplets (imagine: as a parent you want to have a second child and you're getting a third and fourth for free too, it's like some amazing Bonus deal). I really like being outdoors, doing activities like rock climbing, running and mountaineering. I also love riding my motorcycle and going on road trips (especially if I'm driving).

I hope this gives you a little insight in my life. I'm looking forward to seeing you around the room or at activities!

**Filippo Carretta**

Well, here I am the new kandi Secretary and Commissioner of Education of T.F.V. 'Professor Francken'. You probably don't know me all too well as I was not really active at the association before I was announced as a candidate board member. Although as a brief introduction I am an Italian third-year Applied Physics student, which makes me the one fully international candidate board member of the new board of Francken. What made me want to become one of the new board members though? Well, student associations always intrigued me although I never started to become active in one throughout my first couple of years of university. However, what is the best way to get into an association than becoming one of its next board members, right? I hope to get to know both Francken and all the Francken members next year in order to justify my not being in the association in my first couple of years of university.

### Christian Berg

Dear readers, by the time you are reading this, I am the 38th treasurer of T.F.V. 'Professor Francken'. As the membersroom is now open again as usual, I hope I have already seen you in the membersroom before. Luckily, if this is not the case (shame on you, come more to the room), I can give you an idea of who I am by this wonderpiece of text. One thing which I really like to do is sports, to be honest, I must be careful to spend not too much time on sports.

Fortunately, I will be doing a board year such that this will be fine. Last year I went rowing about five to six times a week. That has cost a lot of time, but I am looking forward to exchange the boat with the Francken room! In my spare time, I also like to play some music on my piano, although I like listening to music more. In the next year, I hope to give Francken a financially healthy year and I hope to see you buying a lot of snacks or drinks in the membersroom!

### Annabelle van Berlo

Dear members, my name is Annabelle. I am a first year Astronomy student and after passing Mechanics and Relativity I thought, '**f*ck** it, I am going to sign up for a board position'. At the moment I am only a candidate but when this is published hopefully you will all know me as the new Intern of Francken. I discovered that I genuinely enjoy meeting and talking to new people. This is why I think the upcoming year is going to be amazing. I will be spending most of my days in the members' room while socializing, what better way to spend your time? Well, I also like to spend it on dancing and reading. I have been dancing for over 10 years, I have tried jazz, ballet, contemporary, hip hop and started pole dancing two years ago. When I read I mostly enjoy novels and other fiction, however I am often more busy with going to activities and parties. And then I also have to find a few hours to study... Anyhow, I am very excited for the upcoming months and I hope you are as well. See you soon!

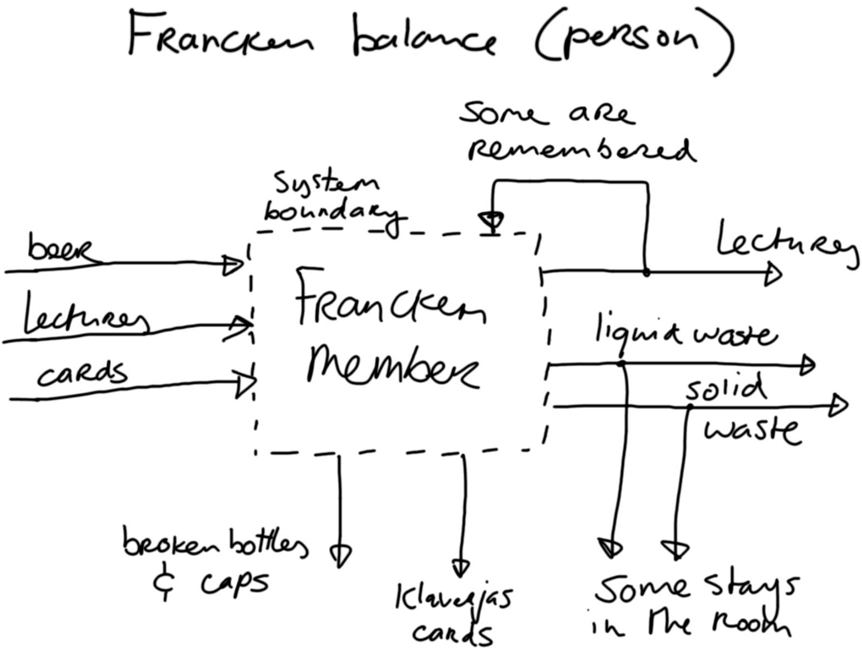
**Sjoerd Buitjes**

Hey everyone, my name is Sjoerd and I am a third year Applied Physics student. Due to the pandemic, most of my studies have been at home and online. Since I was way too close to graduating I thought let's extend my student life with a board year! For the people that already knew me, it wasn't really a secret that I was on the candidate board and neither was my function. But for the people that don't know me, I am the candidate Commissioner of External Relations. By the time you are reading this I will (hopefully) be board already. In my free time I like to play guitar and drums, the latter is a bit harder to play in the city. I am also a goalkeeper for hockey, so basically I don't do anything. I am very much looking forward to seeing everyone in the Francken room and at the activities in the coming year!

*'Fusion', the thirty-eighth board of T.F.V. 'Professor Francken'*

# Comic

By Bradley Spronk



# Balance

By Maaike Groeneveld

**Equilibrium or balance** is a situation where no changes will happen if there are no disturbances. This was the first description I found on the internet when I started looking for interesting topics to write about. There are many different kinds of equilibrium, for example the thermodynamic equilibrium, chemical equilibrium, economic equilibrium, physical balance, psychological balance, and so on.

From my background as a student in chemistry it would obvious to tell you something about the chemical balance, it is pretty hard to write a piece that can be compared to a lesson of chemistry from Havo 4. Because the chemical balance comes down to an equilibrium constant, you can use it for calculations to find out whether the balance of the reaction is to the left or to the right. If I would continue on this topic I think many of you would stop reading, so I will not!

That is why I chose the next topic, the equilibrium between human and nature. The disturbance of this equilibrium is one of the causes that we had to do with in the last three years with COVID-19. The main cause is the deforestation. Millions of bacteria and viruses that can cause disease live in forests. They are, however, kept in control by ecosystems, because of which outbreaks can be prevented. When forests and ecosystems disappear or get affected, the control disappears and risk of outbreaks increases. If wildlife loses their habitat they come into contact with humans more, which makes the transfer of pathogens easier. Lots of viruses have transferred from animals to humans this way, think of SARS, MERS, HIV, Ebola and now COVID-19 as well.

Deforestation is an enormous disturbance of the ecological equilibrium and if you look at it like that, it is our own stupid fault. Of course there will be a new equilibrium af-

ter a disturbance. But if the humans keep chopping down the trees you can wonder how that new equilibrium will look like.

Maybe there will be five new virus outbreaks before a new equilibrium will be set, how would our life look like then is something I rather not think about. What we can think about is how we will prevent further deforestation to not disturb the equilibrium any more. Unfortunately, I do not know the answer to this, but who knows, maybe one of you knows.

## References


*1. NatureToday.com. (2020, 2 mei). Evenwicht tussen natuur en mens helpt virusuitbraken voorkomen. Geraadpleegd op 10 september 2022, van https://www.naturetoday.com/intl/nl/nature-reports/message/?msg=26113*

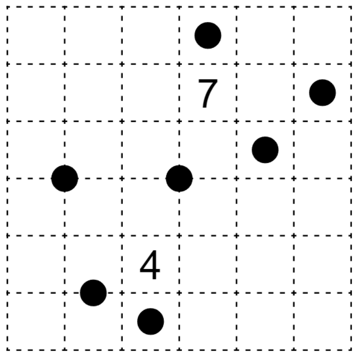
# Puzzle

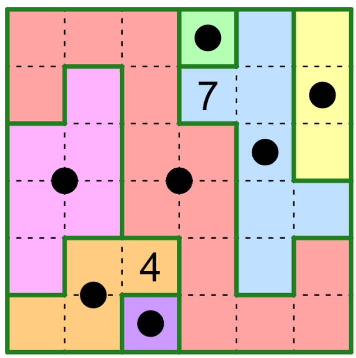
By Arjen Kramer

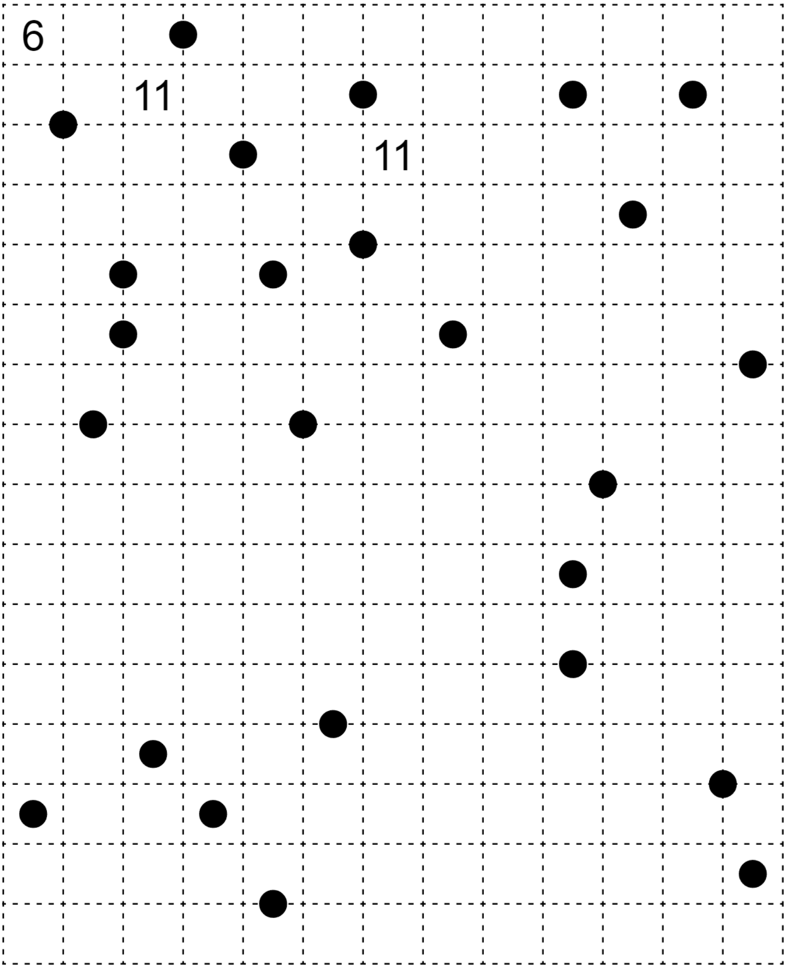
**The universe is** in chaos, through some kind of galactic accident all regions of space have forgotten which galaxy they belong to. As we all know, when the universe is in equilibrium, it is completely and fairly divided into galaxies of varying sizes, without any empty space left over. And all galaxies are of course perfectly symmetric under a rotation of 180° and have a big black hole exactly in the middle. Please restore order in this puzzle and divide the grid into correct galaxies. All big black holes have been given, and a number indicates that the galaxy that it belongs to covers exactly that many regions of space. To help you get started there is a small example with its solution.

The first to send in a correct solution will win a cool dance move, taught by the editor of the FranckenVrij.

If you liked this puzzle, more can be found if you google "puzzle Spiral Galaxies". Also check out wcpn.nl for daily handcrafted puzzles.



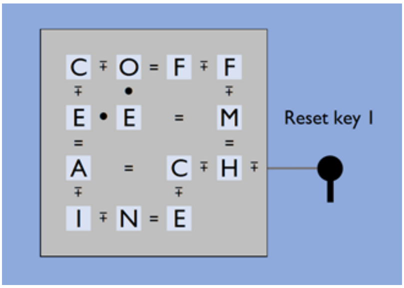



*The chaotic universe that needs organizing*

# Solutions to 26.2

## Fixing the coffee machine:

**1. Rotate the paper and put it on the logo:**
Note that when you rotate the first piece half a turn and place it on the logo of the coffee machine, the white squares will overlap the letters of the logo.




Now, the following 8 equations appear:

$$C \pm O = F \pm F \qquad C \pm E = A \pm I$$
$$E \cdot E = M \qquad O \cdot E = N$$
$$A = C \pm H \pm \ldots \qquad F = C \pm E$$
$$I \pm N = E \qquad F \pm M = H$$

To proceed, we need to understand the relation between these equations and the components. Note that there are 9 types of components given, indicated with letters. The second piece of paper hints that every letter should have a unique value from 1 to 9. With this information, the equations can be solved.

**2. Solve the equations:**
We start with the second equation E · E = M. The only two possibilities for this equation are {E, M} = {2, 4} or {3, 9} since every letter has a unique value.

Next, we evaluate O · E = N. If E = 2, O needs to have a value from 1 to 4 for N to have a value from 1 to 9. O = 1 is not possible, because that results in E = N and O = 4 is not possible, because that will create contradictions when we combine the first and seventh equation.

Hence O = 2 or 3. Note that it is already not possible for any other letter to be 2 or 3 since O and E occupy these numbers. Also note that N = 6 is the only option for N.

From the equation I ± N = E we know that I = 4 or 8 when E = 2 and I = 9 when E = 3. To avoid that M = I (eq. two), we cannot have that E = 3 or {E, I} = {2, 4}. Thus, the only possibility is {E, I} = {2, 8}. After this, we know that {E, I, O, M, N} = {2, 8, 3, 4, 6}.

The equation C ± O = F ± F can be simplified to C ± O = 2F. Combining this result with the seventh equation gives us F ± O = 2F ± E → ±O = F ± E. Since {E, O} = {2, 3}, we have that F = 1 or 5. When F = 1 and E = 2, equation seven F = C ± E has no valid value for C. Hence, we need to have that F = 5 and then C = 7 (eq. seven).

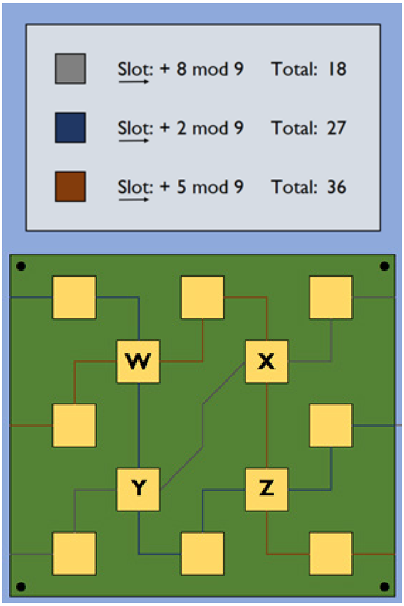
Only the numbers 1 and 9 are left for A and H. The equation F ± M = H, which is equivalent to 5 ± 4 = H, won't help us with this. Therefore, we evaluate C ± E = A ± I, which is equivalent to 7 ± 2 = A ± 8. This equation can be solved with A = 1. We now know the value of every letter: {A, C, E, F, H, I, M, N, O = {1, 7, 2, 5, 9, 8, 4, 6, 3}.

**3. The first reset key:**

The third equation is an unfinished equation and when we look at the picture of the coffee machine, that side of the equation points to the hole of the first reset key. The equation A = C ± H ± …, which is equivalent to 1 = 7 ± 9 ± …, can only be solved by the reset key with the value 3.

**4. The backside of the panel of the coffee machine:**

The backside of the panel shows the colours grey, blue, and brown. These colours have a value marked as 'Total' which is equal to 18, 27, and 36 respectively. These totals are the total value of the components that are connected along the wires with the corresponding colour.




Note that if we add the add the values of all the components together, we get 1+7+7+2+5+5+9+8+6+4+3+3=60. When we add the total values of the three wire colours, we get 18+27+36=81. The difference between these totals is 21. Note that 4 components (W, X, Y and Z on the picture) are connected to 2 types of wires. Hence the total value of these 'crossed components' is equal to the difference of 21.

Also note that every colour has a 'slot' value with an arrow to the right. This means that the component in the slot to the right of previous one has a certain value difference, depending on the colour of the connected wire. For example, using the picture above, when slot Y has a component with a value of 6, the next component in slot X, which is connected with a grey wire, needs to have a value of 6 + 8 mod 9 = 14 mod 9 = 5.

**5. Put the components back on the circuit board:**
For crossed components, we will use the letters W, X, Y and Z as given on the picture. Note that W and Z are connected to the blue and brown wires, X is connected to the grey and brown wires, and Y is connected to the blue and grey wires.

When we follow the slots on the grey wires, we see that after slot Y comes slot X. Therefore, the component values on these slots correspond to X = Y + 8 mod 9.

The distance between Y and Z is 2 steps on the blue wire. Hence Y = Z + 4 mod 9. And with the brown wires, we have that W = X + 10 mod 9 = X + 1 mod 9.

Working these differences out, we get the following table with all possible component values for each slot of a crossed component.

From this, we deduce that {W, X, Y, Z} = {3, 4, 5, 9} since that combination gives the

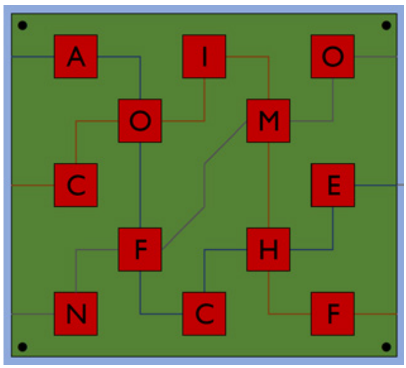
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| W | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| X | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 |
| Y | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 1 | 2 |
| Z | 7 | 8 | 9 | 1 | 2 | 3 | 4 | 5 | 6 |
| Sum | 13 | 17 | 21 | 16 | 20 | 24 | 28 | 23 | 18 |

*Table 1: all possible component values for each slot of a crossed component.*

needed total value of the crossed components. After this, we can fill the components in the right slots.

**6. The second reset key:**
The component slot next to the hole for the second reset key needs has an E component. One step further is the value 4 which is the value of the second reset key that is needed.

**7. The solution:**
The components should be installed as given in the picture underneath. The first reset key is key number 3 and the second reset key is key number 4.



GEBOUW 13

# THIS BRAUMEISTER IS LOOKING FOR A HOME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- YEAST
- BERT
- OTHER STUFF

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*Only on the condition of your mandatory membership of and full dedication to the Brouwcie: the brewing committee of T.F.V. 'Professor Francken'. Your room, shed, garage, stable, cubicle, student house's common room, laboratory, grandma's bedroom, church, palace, dungeon, or wherever you decide to put this brewing kit will become the Brouwcie's headquarters where you will malt, mill, mash, lauter, boil, ferment, condition, filter and bottle the next batch of Gebouw 13.

# Diamond Jubilee of Engineering Physics Groningen: only rock 'n' roll

By prof. dr. Jeff Th. M. De Hosson (MK)

**Sorry, sorry, sorry** - fashionable 'Hague' weasel wording ('*vaagtaal*') - we forgot almost our *Diamond Jubilee*, the 60th anniversary of Engineering Physics Groningen. The appointment by the Crown of the very first professor of engineering physics in Groningen, dr. ir. J. C. Francken (1919-2007), was published in the Government Gazette of the Netherlands (*Staatscourant*) on July 3 1962, followed by his start in Groningen on August 1 1962. Many congrats to all of you.

### Diamonds forever

As the Zernike complex did not exist in 1962 you may ask: where was our nucleation site located? Space is a prerequisite for education and research, and the situation was quite similar in 1962 to the present state of affairs in 2022, i.e. free space for education & research was, is and will be only barely available. Just two experimental rooms and office space were offered to professor Francken in a tiny building (at present near Westersingel #32-34, Fig.1). In order to accommodate the engineering physics students additional rooms were assigned to the '*techies*' on the top floor of the main building in the Westersingelcomplex, the so-called 'A-zolder' (attic A-floor), which spanned an area of about 70 meter-squared (Fig.1).

Problems associated with the lack of space were truly remedied in June 1968 when the new *Technisch-Fysische Laboratoria* (TFL) of building 13 became available in the Paddepoel district, the current Zernike Campus; at present also housing the impregnable bastion of '*Francken*' in rooms 13.02-13.06. For the real diehards and soul mates of TFL: please remember for specific reasons the plural form in the wording *Laboratoria*.

The course length of a Bachelor degree (called '*Kandidaatsexamen*') was three

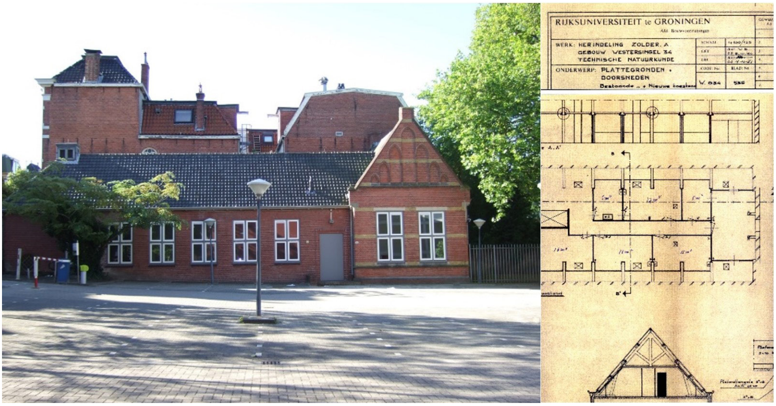



*Figure 1: nucleation venue of Engineering Physics at RuG and attic A (Westersingelcomplex).*

years in 1962, whilst five years being more a rule than an exception. For the Master phase of 'Engineering Physics' (*Technische Natuurkunde*), the same study period of three years was assigned, meaning a total of 6 years being expected for getting an MSc academic degree. However, in practice the average study duration for students in Engineering Physics took a bit longer – likewise for those reading Experimental and Theoretical Physics – i.e. more than 9 years! Groningen was second 'best', or worst, in the country. Undisputedly the School of Physics of the Free University of Amsterdam became the champion in Holland, with a duration of 11 years (on average !) for an MSc Physics degree in the sixties and early seventies.

**Only rock 'n' roll**

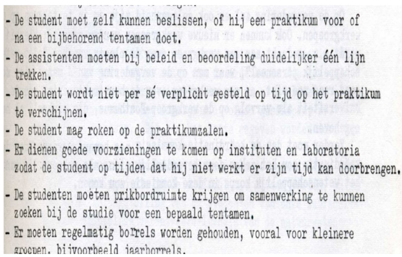
As customary in academia, we should position our sparkling Diamond Jubilee in international context. First, we have to compete with the *Rolling Stones* group, one of the most enduring rock bands ever, which also started in 1962 and likewise has reached the Diamond status as well. So, that is all quite appealing and exciting but it is fair to acknowledge that our unique position in history is convincingly beaten by *Her Majesty Queen Elisabeth II* of the UK and on a very different level we are painfully overhauled by, take it or leave it, ......*Donald Duck*; both hitting a Platinum Jubilee this year.

To stay then, rather out of necessity, together with the *Stones* in the same basket, and singing '*I said I know it's only rock 'n' roll*', you may ask yourself are those 60 years of Engineering Physics also characterized by 'only rock 'n' roll'?

As far as R&D are concerned: funny enough electron *beam-rocking* methods were developed since the sixties in my own field of electron microscopy research, both in scanning and in transmission electron microscopy. To overcome spatial resolution limitations a special methodology of selected-area-electron channeling-pattern was developed, reducing the area from which the patterns are collected by rocking the electron beam at a singular point.

Arrangements of our beloved dislocation patterns in cellular like structures could be clearly revealed using these beam-rocking techniques, which was really exceptional compared to classical scanning electron microscopy. In transmission electron microscopy beam-rocking turns also helpful to collect integrated intensities suitable for the structure determination by (convergent beam) electron diffraction. So far so good for *rock 'n' roll* in electron microscopy.

Indeed, in addition to developments in research, the sixties were turbulent times in university education and, even when I started university studies myself in 1968, a wait was still ahead. Interesting observations, invariant and sustainable over decades, are the continuous requests by students such as '*get-togethers should be held on a regular base*' (*with a pint of beer, please*). This seems to be a universal law of physics on a global scale. Fig.2 displays other pressing demands of yearning physics students, 60 years ago. Tacitly we should ignore some of the requests listed in Fig.2, like '*the student is not necessarily obliged to appear on time for the practical*', neither we should pay too much attention to the specific demand of '*the student is allowed to smoke inside the practical rooms*'!



- De student moet zelf kunnen beslissen, of hij een praktikum voor of na een bijbehorend tentamen doet.
- De assistenten moeten bij beleid en beoordeling duidelijker één lijn trekken.
- De student wordt niet per sé verplicht gesteld op tijd op het praktikum te verschijnen.
- De student mag roken op de praktikumzalen.
- Er dienen goede voorzieningen te komen op instituten en laboratoria zodat de student op tijden dat hij niet werkt er zijn tijd kan doorbrengen.
- De studenten moeten prikbordruimte krijgen om samenwerking te kunnen zoeken bij de studie voor een bepaald tentamen.
- Er moeten regelmatig borrels worden gehouden, vooral voor kleinere groepen, bijvoorbeeld jaarborrels.

*Figure 2: Pressing demands of yearning physics students in the sixties.*

It goes without saying that by all means Engineering Physics at RuG in 2022 is not the same as 60 years ago. Scope and aims have transformed in quite a number of very different '*basiseenheden*'. The nomenclature in Dutch of '*de basiseenheid*' in our faculty of *FS&E* - i.e. not FSE please! - sounds to me a left-over *verbatim* of the former ***Советских Республик***. Immutably, the missions for excellence in research and education are still top priority in 2022, but

*Figure 3: endless loop of Johann Bernoulli (1696) on the Zernike Campus (artist: Henk Oving) illustrating so incredibly aptly the 'endless control by the endless number of controllers' in 2022.*

the means to achieve this goal, have altered dramatically since1962.

What about an eye-catching turn in all those 60 years behind us? The biggest n-th order phase transition in academia life I have experienced during the past *rock 'n' roll* of 60 years, was the introduction by the government of a business model for universities, the so-called earning & revenue programs. That particular switch in the nineties provided an impetus to the top-down development of highly refined complex protocols for benchmarking, controlling and managing of *science policy*. The latter I consider in essence a contradiction-in-terms, see also J.Th.M. De Hosson, '*A breakthrough is something you don't see coming*', Progress in Materials Science 56, 573 (2011). Fair to say that this flipflop in the circuitry of science policy, nearly identical to rock 'n' roll, was not our own invention in Holland. In fact it was largely a shameless and impudent copy-paste operation by our politicians and bigwigs, adapted from other European countries, especially from the UK (following the Margaret Thatcher period).

Nonetheless, there are still politicians in The Hague and to date some, but luckily not all, university managers, deans & faculty boards in the country dreaming that academic education & research will generate immediately cash-flow. Even our reputedly modest and frugal Groningen is targeting nowadays the deepest pockets and wants to attract *older and richer* non-EU students (see ukrant, June 22, 2022). Recently I understood from the *FS & E* faculty board that grant applications are becoming so complex that emeriti professors (*on pension but not retired !*) are approached to team with young researchers so as to get *xyz* tons of money, money, money from external funding agencies allocated to Groningen (see UK Newspaper e-Bulletin, May 31, 2022: https://ukrant.nl/retired-professors-to-help-young-researchers-with-complex-grant-applications/?lang=en ). Certainly this might be an interesting idea for a pilot testing but it seems to me far more efficient for a leading young Groningen researcher, and definitely not for a leading emeritus professor, to jump as soon as possible into the 'driver seats' of the funding agencies and subsequently making those grant applications less complex.

As a consequence of all of these measures, 'control' of education & research has increased to frightening levels. Please note that due to the non-linearity in these merry-go-rounds of endless controls, the probability is quite high that due to one tiny perturbation the whole process becomes chaotic; for the professionals among us I recommend to study first the sign of the *Lyapunov exponent*.

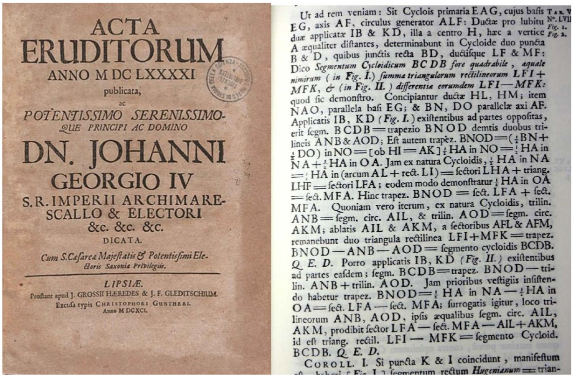
**We're rocking it**

To our comfort and consolation: the impressive Johann Bernoulli (1667-1748) thought about these endless loops already when he and his extremely talented family were stationed in Groningen. He provided us a beautiful mathematical expression, see Figs.3 and 4, i.e. the solution of the so-called brachistochrone curve.

Here, brachistochrone means the 'shortest time' path of swiftest descent that an object under gravity will follow from one given point to another point, the latter of which does not lie directly below the former along the same vertical. For sure, it was a(n arc) geometrical approach (Fig.4), not so much an engineering physics description whereas friction was fully ignored. In fact the mathematical problem was posed by his brother Jakob Bernoulli as a public contest published in the prestigious *Acta Eruditorum* (June 1696), the very first scientific journal ever of German speaking countries in Europe (published in Latin though). Solutions to the swiftest descent problem were provided by Johann Bernoulli, Jakob Bernoulli and subsequently by Gottfried Leibniz, Guillaume de l'Hôspital and by the 'headmaster' himself ……..Isaac Newton.

The gossip goes that Newton solved the brachistochrone contest in just one single day but that is very questionable and only claimed by himself. In contrast, without much doubt Newton's reputed arrogance was attested, no less than by himself, via a rather blunt response to Bernoulli: '*I do not love to be dunned and teased by foreigners about mathematical things...*'. My own interpretation of this rudeness inclines to the reason that Newton was just too bitter of *Acta Eruditorum* (created by his opponent Leibniz) becoming such an excellent and strong competitor to the *Philosophical Transactions of the Royal Society London*. *Acta Eruditorum* was also one of the favorite, as we call these days, 'high-profile journals' and 'high-impact' journals of Christiaan Huygens.

In summary, as regard Engineering Physics Groningen in the past 60 years , yes we should simply copycat the Stones: *It's only rock 'n' roll but I like it, yeah*, being always very non-linear, far from thermodynamic equilibrium, and never in any ground-state. Subsequently, the mathematics provided by Johann Bernoulli turns out to be helpful in describing the non-linearities in the endless control of the endless number of


ACTA
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LIPSIÆ.
Proſtant apud J. GROSSII HÆREDES & J. F. GLEDITSCHIUM.
Excuſa typis CHRISTOPHORI GUNTHERI.
Anno M DCXCI.

Ut ad rem veniam: Sit Cyclois primaria EAG, cujus baſis
EG, axis AF, circulus generator ALF: Ductæ pro lubitu
duæ applicatæ IB & KD, illa a centro H, hæc a vertice
A æqualiter diſtantes, determinabunt in Cycloide duo puncta
B & D, quibus junctis recta BD, ductiſque LF & MF:
Dico *Segmentum Cycloidicum BCDB fore quadrabile, æquale*
*nimirum (in Fig. I.) ſummæ triangulorum rectilineorum LFI+*
*MFK, & (in Fig. II.) differentiæ eorumdem LFI—MFK:*
quod ſic demonſtro. Concipiantur ductæ HL, HM; item
NAO, parallela baſi EG; & BN, DO parallelæ axi AF.
Applicatis IB, KD (*Fig. I.*) exiſtentibus ad partes oppoſitas,
erit ſegm. BCDB = trapezio BNOD demtis duobus tri-
lineis ANB & AOD; Eſt autem trapez. BNOD = (½BN+
½DO) in NO = [ob HI = AK] ½HA in NO = ½HA in
NA + ½HA in OA. Jam ex natura Cycloidis, ½HA in NA
= ½HA in (arcum AL + rect. LI) = ſectori LHA + triang.
LHF = ſectori LFA; eodem modo demonſtratur ½HA in OA
= ſect. MFA. Hinc trapez. BNOD = ſect. LFA + ſect.
MFA. Quoniam vero iterum, ex natura Cycloidis, trilin.
ANB = ſegm. circ. AIL, & trilin. AOD = ſegm. circ.
AKM; ablatis AIL & AKM, a ſectoribus AFL & AFM,
remanebunt duo triangula rectilinea LFI+MFK = trapez.
BNOD—ANB—AOD = ſegmento cycloidis BCDB.
*Q. E. D.* Porro applicatis IB, KD (*Fig. II.*) exiſtentibus
ad partes eaſdem; ſegm. BCDB = trapez. BNOD — tri-
lin. ANB + trilin. AOD. Jam prioribus veſtigiis inſiſten-
do habetur trapez. BNOD = ½HA in NA — ½HA in
OA = ſect. LFA — ſect. MFA; ſurrogatis igitur, loco tri-
lineorum ANB, AOD, ipſis æqualibus ſegm. circ. AIL,
AKM, prodibit ſector LFA — ſect. MFA — AIL + AKM,
id eſt triang. rectil. LFI — MFK = ſegmento Cycloid.
BCDB. *Q. E. D.*
COROLL. I. Si puncta K & I coincidunt, manifeſtum

*Figure 4: Acta Eruditorum title page and part of Johann Bernoulli proof of the brachistochrone curve.*

controllers over six decades.

Invariant and steady in this *rock 'n' roll* atmosphere over the years are the student-get-togethers (Fig.2). But, there are also important differences since the start in 1962, e.g. www internet, the extremely popular new student verb, e.g. *I google - you google - we google*, et cetera. At present the TFV activities offer mighty convincing evidence that the association is amazingly vibrant. Student members are often deadly tired and fatigued, even approaching fracture (in contrast to faculty staff), not just due to courses in engineering physics but also because of camaraderie, just to say by the virtue of $(D\&I)^{2+n}$ with $n>>0$, i.e. diversity & divergence and inclusion & inclusiveness, et cetera.

The fact that Engineering Physics has been flourishing in Groningen over six decades is for a significant portion owing to the numerous generations of active members of '*Francken*'. The association has not only become a professional study organization but something very special indeed because every student from Groningen reading Engineering Physics generates beautiful memories, develops every respect for each other's talents & limits, gets inspiration for new concepts and discovers oneself. That is something for the *FS&E* and university to be proud of and also to enjoy.

Warm congrats again on the success of the Diamond Engineering Physics. *We're doing just great* and propelling the same appraisal in vernacular usage would simply read.......................**we're rocking it!**

# The role of the equilibrium in potential energy-shaping stabilization of mechanical systems

By Rodolfo Reyes-Báez, PhD

**Equilibrium in mechanical systems without damping and external forces**

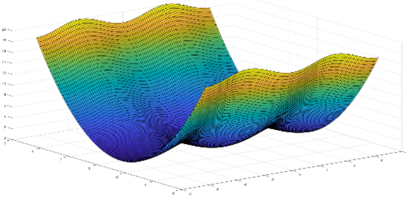
The concept of equilibrium in mechanical systems without damping and external forces (or inputs) relies on the idea that no variation of the energy function $E(q,\dot{q})$ occurs as time evolves, where $q$ and $\dot{q}$ are the position and velocity, respectively. In this case, we say that the system is in (physical) equilibrium. This in turn implies that $E(q,\dot{q})$ satisfies the ordinary differential equation (ODE) $E(q,\dot{q})=0$ at $(q,\dot{q})=(q_e,\dot{q}_e)$. Clearly, the equilibrium state $(q_e,\dot{q}_e)$ is a critical point of $E(q,\dot{q})$. The first conclusion that we can get from this short analysis is that a mechanical system is in equilibrium when the state $(q_e,\dot{q}_e)$ lies in the level sets of the energy function $E(q,\dot{q})$. For instance, consider the normalized equations of motion of the simple pendulum without dissipation (friction) and external forces, that is,

$$\ddot{q} + \sin q = 0. \tag{1}$$

The corresponding total energy, $E(q,\dot{q})$, of the pendulum is given as the sum of the kinetic energy $K(q,\dot{q})=0.5q^2$ and potential energy $V(q)=(1\text{-}\cos\ q)$, i.e.

$$E(q,\dot{q}) = 0.5q^2 + (1-\cos q). \tag{2}$$

The derivative of this function along the ODE (1) is given by is $\dot{E}(q,\dot{q})=\ \dot{q}\ddot{q}+\ \dot{q}\sin q\ =\ 0$. This means that the pendulum has an equilibrium state for constant energy levels. Moreover, the expression $\dot{E}(q,\dot{q})=0$ is a mathematical manifestation that the simple pendulum without damping and external forces satisfies the energy conservation principle. This suggests that there is a relation between the existence of equilibrium states and the energy conservation.


(a)

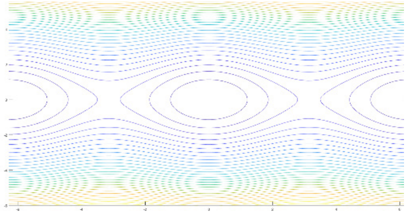

(b)

*Figure 1: On the left, (a), the plot of the total energy function $E(q,\dot{q})$. On the right, the plot of the level sets or contours defined by the equation $E(q,\dot{q})=c$, with $c$ any real number.*

We can conclude that having a constant energy level does not imply a constant state that the configuration $(q_e,\dot{q}_e)$ is constant. In Fig.1(b), we observe that the algebraic equation $E(q_e,\dot{q}_e)=c$ defines a family of closed geometric curves of ellipsoid type in the $(q_e,\dot{q}_e)$–plane for different values of the constant $c$. As the intuition suggests, the pendulum without damping or external forces would oscillate perpetually in the downwards position, which explains the closeness of the curves in Fig.1 (b).

In Fig.1 (b) the ellipsoid-type curves are centered at some specific points $(q,\dot{q})$, for example, at the point $(q,\dot{q})=(0,0)$ which is the *downwards* position of the pendulum. On the other hand, at points like $(q,\dot{q})=(3.1416,\ 0)$ that corresponds to the upwards pendulum position, a hyperbolic-type curve is centered instead of an ellipsoid-type one. Notice that these phenomena occurs in a periodic manner, and that the energy evaluated at the points, which are the centers of the ellipsoid or hyperbolic type curves, is zero.

In order to further understand this phenomenon, let us analyze the level contours on the phase portrait on the $(q,\dot{q})$–plane in Fig. 2.

In this plot, we can see the flow associated to the solution of the equations the ODE in (1), which is represented by the arrows in blue. Note that for the point $(q,\dot{q})=(0,0)$, the arrows "living" in the ellipsoid-type curve *remain* there as time evolves. This is not the case for the arrows on the hyperbolic-type curve centered at the point $(q,\dot{q})=(3.1416,\ 0)$, we can appreciate that the arrows go away from the curve. Keep in mind that despite of the mathematical model of the pendulum has an infinite number of equilibrium states (with periodicity of $2\pi$) that make the energy $E(q,\dot{q})$ zero, there are only two *physical equilibrium points* that do that, namely, the upwards and

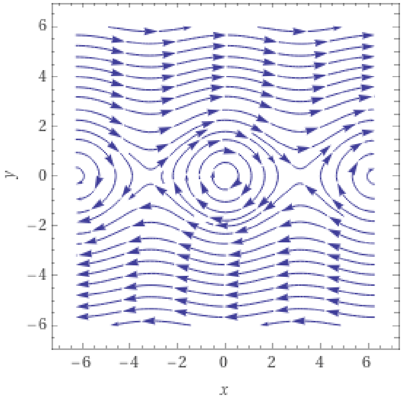



*Figure 2: Phase portrait of the simple pendulum equation of motion[2].*

downwards positions. In this sense, we say that the upwards position of the pendulum is an unstable equilibrium point, whereas the downwards position is an stable equilibrium point.

Hence, a stable equilibrium state remains stable under the action of some disturbances. Indeed, in the left plot of Fig. 3, we observe that in a stable equilibrium point the perturbations does not change the stability property. However, as it is shown in the right plot of the same figure, a rather small disturbance moves away the state from the equilibrium point.

**Equilibrium in mechanical systems with damping and without external forces**

Let us now consider linear damping in the equations of motion of the pendulum, but still without external forces. With this, the ODE in (1) becomes in the following one:

$$\ddot{q} + \dot{q} + \sin q = 0. \tag{3}$$

The energy function $E(q,\dot{q})$ in (2) remains the same. Then, the derivative of $E(q,\dot{q})$ along the solutions of the ODE in (3) is given by

$$\dot{E}(q,\dot{q}) = -\dot{q}^2 \leq 0. \tag{4}$$

This implies that the energy is not conserved anymore! The linear damping is dissipating some of the energy in the system. Is this a bad or good situation? To give an answer, let us see the phase portrait for (3). In Fig. 4, there are two main differences with respect to the phase portrait of Fig. 2. The first one is that the ellipsoid and hyperbolic type curves around the equilibrium points are not symmetric anymore. Second, the arrows around the stable equilibrium points point towards them instead of lying on closed curves as in Fig.2, but the for the unstable equilibrium points the phenomena remains similar.

Thus, the addition of linear damping caused that the flow of the solutions of (3) converge towards the equilibrium points. When this happens, we say that the stable equilibrium points is *asymptotically stable*. In this case, the equilibrium point has a constant position and a zero velocity, and it is a (local) minimum of the energy function, see Fig 1 (a).

A similar phenomenon occurs in the 2D pendulum next to the entrance of the Bernoulliborgh. How many equilibrium points does this mechanical system have?

**Equilibrium in mechanical systems with external forces: a control perspective**

Suppose that we have the pendulum system without damping, but with external forces that enter through the input u, that is, the ODE given by

$$\ddot{q} + \sin q = u. \tag{5}$$

Just like in Section 2, the energy function $E(q,\dot{q})$ in (2) remains the same. Then, the derivative of $E(q,\dot{q})$ along the solutions of the ODE in (5) is given by

$$\dot{E}(q,\dot{q}) = \dot{q}u. \tag{6}$$

If the external input $u=0$, then we recover the same conclusions of Section 1. However, that is not that interesting from an engineering point of view. The input $u$ can be designed in such a way that after substituting it, the system has desirable stability properties.

For instance, by defining the input as

$$u = -k_d\dot{q} + v, \tag{7}$$

with $k_d$ a constant gain and $v$ an auxiliary external input. Substitution of (7) in the ODE (5), one gets

$$\ddot{q} + k_d\dot{q} + \sin q = v. \tag{8}$$

This has a very similar structure as the

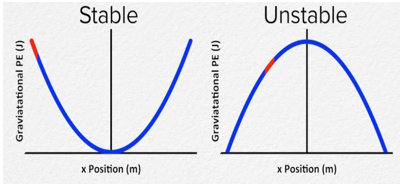



*Figure 3: Image taken from:* [3].

ODE in (3). Indeed, for $k_d=1$ and $v=0$, we recover the same ODE! Thus, designing the external input gives us the possibility to *control* the behaviour of the pendulum. Instead of having only stability of the equilibrium point, by designing the input $u$, we forced the equilibrium point to be asymptotically stable by *feeding back* the velocity of the system.

Modifying the stability property of the equilibrium point is already a quite remarkable feature of the external input force $u$. Nevertheless, what about if we are not interested in modifying the stability properties of the already stable equilibrium point, but of the unstable one.

Is this even possible? The answer is yes! We can stabilize the unstable equilibrium point by modifying the energy function. Before that, keep in mind the following observation about the potential energy

$$\frac{\partial V}{\partial q} = \sin q. \tag{9}$$

With this, we can rewrite the ODE in (5) as follows

$$\ddot{q} + \frac{\partial V}{\partial q} = u. \tag{10}$$

By choosing the external input as

$$u = -k_p \frac{\partial V_a}{\partial q} - k_d \dot{q} + v, \tag{11}$$

Where $k_p$ and $k_d$ are constant gains, and $V_a(q)$ is an artificial potential energy term. Then, combining (10) and (11) yields

$$\ddot{q} + k_d \dot{q} + \left( \frac{\partial V}{\partial q} + k_p \frac{\partial V}{\partial q} \right) = v. \tag{12}$$

We see that the resulting system has damping injection given by the term $k_d\dot{q}$ and *potential energy shaping* via the term $k_p(\partial V_a/\partial q(q)\ )$. The new potential energy is given by $V_d(q) = V(q) + V_a(q)$. The unstable equilibrium point of the pendulum can be stabilized by *ensuring that $V_d(q)$ has a minimum at it*. This suffices to ensure that the unstable equilibrium point becomes asymptotically stable.

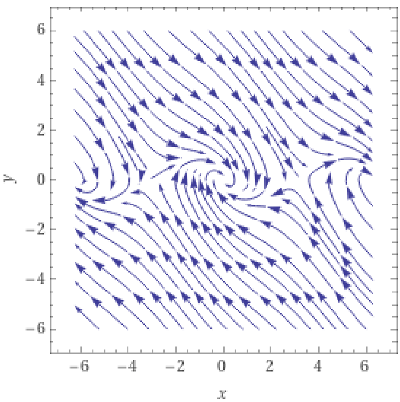



*Figure 4: Phase portrait of the simple pendulum equation of motion with linear damping[2].*

## Concluding remarks

In this brief article, I have discussed the concepts of stable and unstable equilibrium points, and the role of the damping in asymptotic stability. Moreover, in section three I briefly sketched how the external forces input u can be used to modify the stability properties of natural equilibrium points, or even how to stabilize other equilibriums by mean of potential energy shaping.

The scientific disciple that develops methods to modifying the behavior of a given system is called systems and control. The engineering discipline that deals with the application of this methods is called control engineering. Groningen has a long tradition in both. In fact, it started with the solution of the brachistochrone problem by Johann Bernoulli here in Groningen, which is the foundation for optimal control. If you are interested in knowing more about the research of systems and control in Groningen, visit the page of the Jan C. Willems Center for Systems and Control.

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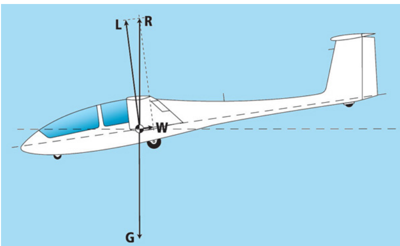
*3. https://wolframalpha.com/*
*4. https://www.youtube.com/watch?v=4rG9u478X1Q*

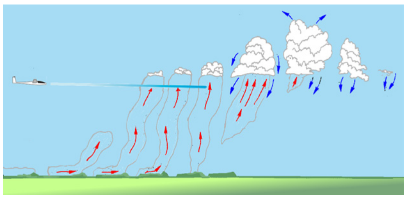
# Equilibrium in gliding

By Sjoukje de Jong

**There are many** things to gliding that have to be in equilibrium in order for it to go correctly. First of all, the most obvious one as a physicist: the forces must be in equilibrium in order to fly at a constant speed.




For a glider, this unfortunately means that this velocity is aimed towards the ground a little bit, but that is what makes gliding more challenging than flying in a powered aircraft! Gliders are able to stay in the air for up to about 11 hours if circumstances are good. This all has to do with the weather of the day. In order to stay in the air, you have to find columns of rising air, so-called thermals.



In the diagram, you can see how these thermals build up and form a cumulus cloud above them. This is usually an indicator for the pilot of where to look for them. However, it can also happen that the rising air does not reach the dew point. Then no cumulus clouds would be present and the pilot has to rely on its instruments.

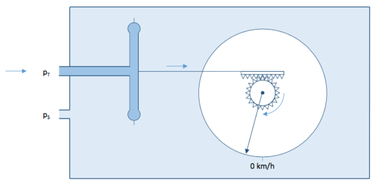
### Instruments

There are three very important instruments present in every cockpit. An altimeter, speed indicator, and vertical speed indicator. I think the reason for having an altimeter speaks for itself. The speed indicator is very important, as it is important to know what your airspeed is. If you are going too slow there is a chance of stalling, but if you are going too fast the aircraft structure might not hold all the forces acting on it. The vertical speed indicator is mostly used when flying in thermals, to see how fast the air is actually rising and if you are in the center of the thermal. This instrument is especially useful when there are no cumulus clouds. There are also other instruments to help you with navigation, but these are not always necessary.

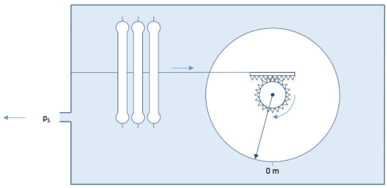
In the image, you can see from left to right the most important instruments: The speed indicator, vertical speed indicator, and altimeter. In this image the airspeed is 120 km/h, the vertical speed is about +1.4 m/s and the altitude is 1 km.

These instruments are analog and are based on differences in air pressure. On the aircraft, there are two different pressures measured. The total pressure (dynamic + static) is measured in a pitot tube. The static pressure is measured at different points on the aircraft where no turbulence is expected, static openings. They are holes that are perpendicular to the aircraft's surface. The airspeed can be derived from the dynamic pressure, which can be acquired by subtracting the static pressure from the total pressure. In practice this is done as follows:

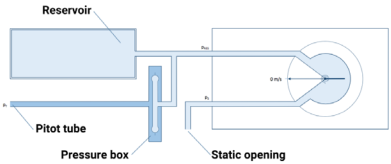
In the airspeed indicator, there is a differential pressure capsule. The inside of it is connected to the total pressure and the outside to the static pressure. When the airspeed increases the capsule increases in size, with a transfer mechanism this increase is then visible on the instrument.




For the altimeter, the instrument is connected to the static pressure. There are 3 vacuum chambers next to each other in the instrument that increase in size when the static pressure decreases (altitude increases). The vacuum chambers decrease in size when the static pressure increases (altitude decreases). These vacuum chambers are also connected by a transfer mechanism to the indicator in the instrument.




The vertical speed indicator is a bit more complicated. There is a disk in between the reservoir and the static openings, it moves when traveling air presses against it. So when the altitude increases, the static pressure drops, and air travels from the isolated reservoir to the static openings. This results in the disk going down and therefore the indicator of the instrument going up, indicating a positive vertical pressure. When the pressure in the reservoir and the static pressure are in equilibrium, the disk does not move and the vertical speed is thus zero. A pressure box connected to the pitot tube is added to account for the increase in altitude when the pilot decreases speed. This increase in altitude is not what you want to measure with the vertical speed indicator, as you want to find thermals with it, not see that you are going up when decreasing airspeed.




## Weight and balance

Another very important topic about gliding is weight and balance. The point of mass needs to be at the right place. Otherwise, you might increase the chance of stalling or make the aircraft fly very inefficiently. Gliders are designed a bit differently than passenger aircraft in this case, as gliders are usually designed to be more stable. When a disturbance occurs the aircraft will go back to its initial equilibrium situation. So when all the masses are placed in the correct position, disturbances sometimes don't even need correction, they will be resolved by themselves.

For instance, when an aircraft does stall, the elevator at the back of the aircraft will stall just a few seconds later due to its larger angle of attack. This results in the glider making a nose dive. This might not seem like something you want to happen, but in order to correct a stall the airspeed should be increased. A nose dive is one way to increase the airspeed. This is not something that is implemented when designing passenger aircraft, as a nose dive also might not be that nice for passengers.

# Would a crocodile be able to fly?

## Without growing wings and becoming a lame dragon that doesn't breathe fire.

By Ids Schiere

**Lately I've been** thinking about flying crocodiles a lot (no drugs involved, (sometimes) I'm just a crazy person). Usually this is just some weird imagination kind of epic story I have in mind that involves flying refrigerators, flying washing machines, flying washing machine gods, some challenges and perhaps a little romance (again I'm a crazy person). It always was intended to be just some random story but lately I've been thinking: would it actually be able for a crocodile to fly?

Firstly, crocodiles obviously are not able to fly but I did some research (read, I googled for 15 minutes) into the possibility of their possibility to fly. Interestingly enough, crocodiles and birds share a common ancestor. This common ancestry mostly shows in their raspatory system but otherwise evolution went a bit different somewhere and we are denied this incredibly scary flying crocodile. Now, in the most basic way it only counts as flying for the case where it is possible to obtain equilibrium while flying, in other words the lift force has to be equal to gravity. Since in physics we consider air and water both to be fluids,the forward thrust can be generated in a similar way as it does in water, that's by using its tail to create an undulating motion propelling itself forward. Depending on the orientation of the tail it also possible to create a force upward or downwards. This means liftoff and landing would be possible, however, this tail can really only work in one direction at a time so maintaining equilibrium by creating lift force equal to the gravitational force (4022 – 5101 N for average male crocodiles and 745 – 981 N for female croco-

diles) is a bit of a problem. If the crocodile would only move up it could be able to fully maintain equilibrium and just float, that is if it's able to whip its tail at the appropriate speed (which probably wouldn't be possible in air). Of course, there would be the option of using its arms but those arms are about as useless as T-Rex arms.

Unfortunately, due to the physiology of the crocodile it wouldn't be possible for it to fly unless it does in fact become a lame dragon that doesn't breathe fire. Maybe if it does complete the challenges of the flying washing machine gods it will be able to overcome this obstacle of maintaining some sort of equilibrium but in the real world it would be impossible unless we give it a jet engine.

# Out of Equilibrium

By Jelle Bor

**Equilibrium is a** well-known principle for physicists and it has been studied over centuries. A mechanical body is said to be in equilibrium if it experiences no acceleration, i.e. the sum of all forces is zero. In addition, the sum of all torques acting on the body equals zero, so that a state of rotational motion remains constant indefinitely. Besides, an equilibrium is said to be stable if small, externally induced, displacements produce forces that tend to oppose the displacement and return the body to the equilibrium state, such as a weight suspended by a spring. In thermodynamics the concept of equilibrium is extended to include possible changes in the internal state of a system, characterized by its temperature, pressure, density, and any other quantities to specify its state completely. At strict thermodynamic equilibrium, the temperature of the system is uniform, otherwise heat would flow. Any gradients in state functions such as pressure or density are balanced by external forces so that they remain constant. It is also useful to consider quasi-equilibrium processes where temperature gradients are allowed if the rate of heat flow is too slow to be significant. For example, in adiabatic expansion or cooling, the pressure in a gas decreases while its volume increases, resulting in a decrease in the temperature of the gas. However, equilibrium, and even worse stable equilibria, are a rather ideal situation, it is an exception rather than a rule in Nature. Instead, most physical systems are out of equilibrium. The understanding and theoretical description of far from equilibrium systems poses one of the major present challenges in theoretical physics.

In recent years, due to outstanding experimental advances in quantum devices and cold atomic physics, a new chapter in physics has been opened. These experimental advances have led to a new interest in fundamental questions of quantum statistical physics and classical statistical physics. Key questions in this context are: How does an

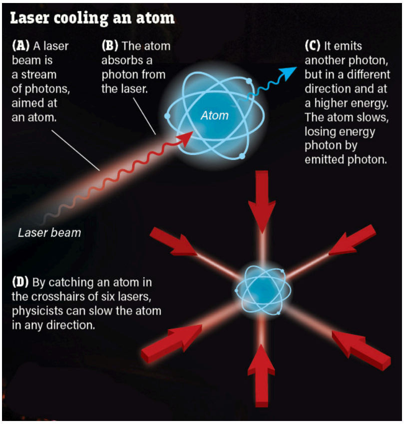
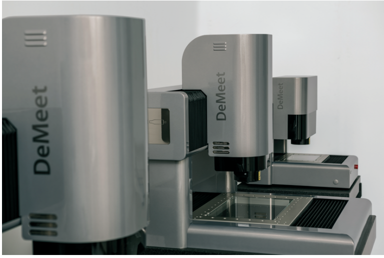


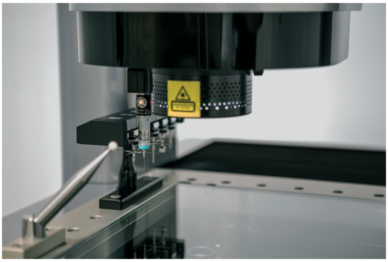

*Figure 1: Laser cooling for dummies.*

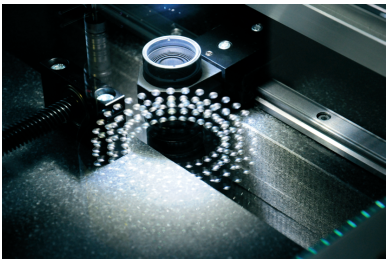
isolated many-body quantum system relax? Which physical principles underlie the relaxation and what are the associated timescales? What characterizes the steady states reached at late times?

A precise protocol is given by the so-called quantum quench: consider a quantum system initially prepared in the ground state $|B\rangle$ of a Hamiltonian $H(g_0)$. At the time $t = 0$, the coupling constant $g$ is abruptly changed from the initial value $g_0$ to the new value $g_1$. This process is a quantum quench, i.e. a swift kick to the system. The abrupt change of the Hamiltonian leads the system out of equilibrium but its subsequent time evolution is perfectly unitary and ruled by the new Hamiltonian $H(g_1)$. If the system has few degrees of freedom, the time evolution is very well understood and the expectation values of the various observables on the initial state $|B\rangle$ presents, in general, a (quasi) periodic behavior. This quantum recurrence simply comes from the decomposition of the initial state $|B\rangle$ in terms of the energy eigenvectors of the new Hamiltonian: for the new Hamiltonian, $|B\rangle$ is in fact an excited state and, since the energy is conserved, the system cannot relax to the new ground state. The previous scenario changes, however, if the quantum system has infinitely many degrees of freedom. In this case, one can imagine that, for any given sub-system, the rest of the sample acts as a thermal bath and therefore the situation is less clear.

Does an extended quantum system reach asymptotically a stationary state after a quench? If so, does it keep memory of the initial state $|B\rangle$ or does it assume a thermal form? For a long time, these were considered purely theoretical questions, because for any extended quantum systems coupling to the environment were considered unavoidable, with the subsequent thermalization due to decoherence and dissipation. But, in cold atom set-ups these effects can be largely minimized (the cooling of an atoms using lasers in schematiclally shown in Figure 1), even eliminated at all. Therefore, this topic has become an active and rapidly developing field of research.



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