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GIREP-ICPE-EPEC 2017



The Virtual Sandbox

An approach to introduce principles of granular flow physics in the
classroom

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University College of Teacher Education Styria
Dublin, 6.7.2017

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Der Wissenschaftsfonds.

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the idea

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idea of the project – science communication



Institute of Process and Particle Engineering
Technical University of Graz

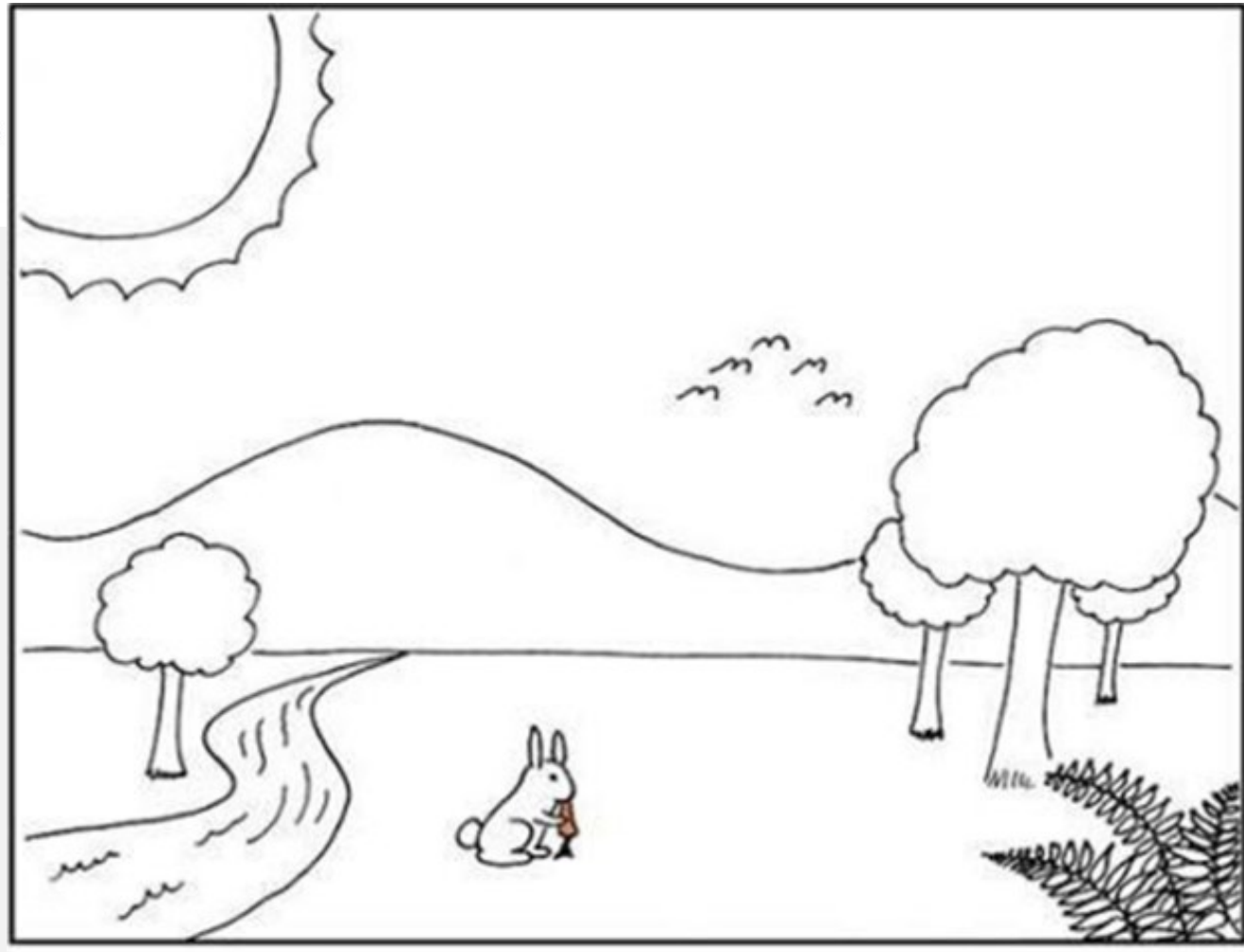


University College of teacher education of Styria





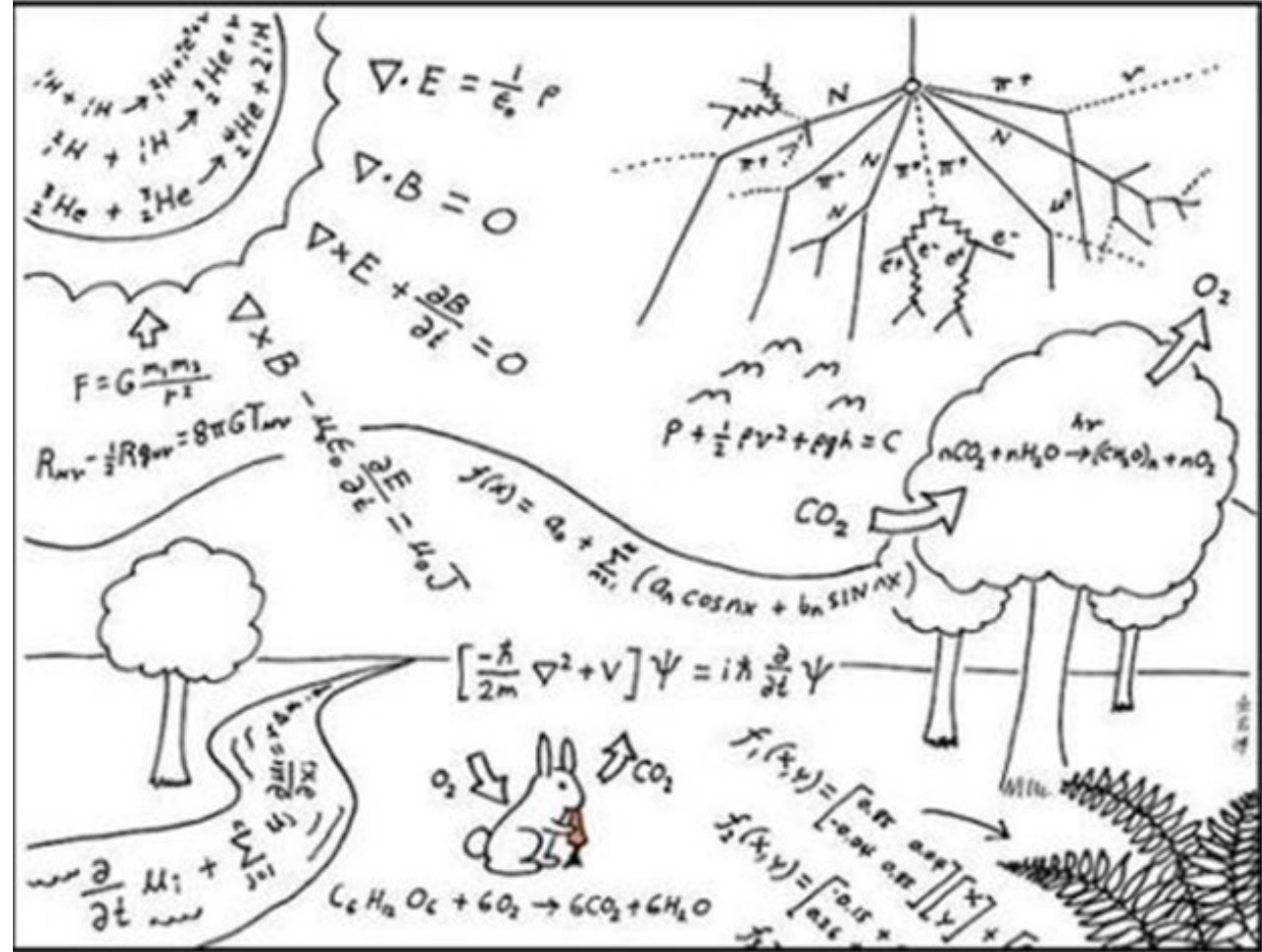
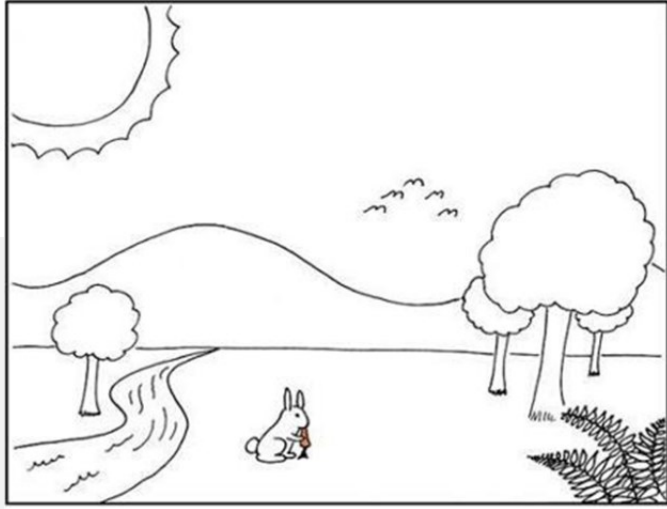
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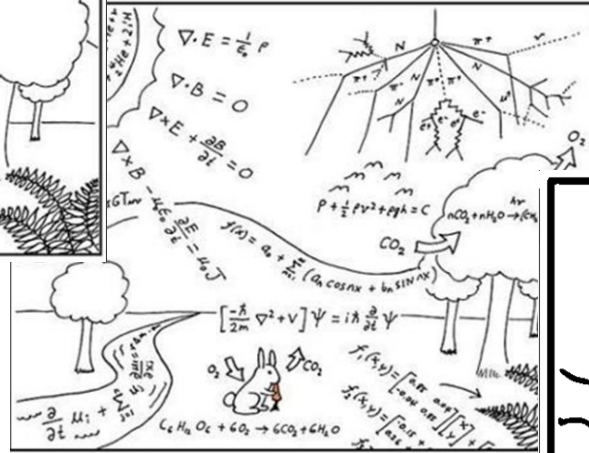
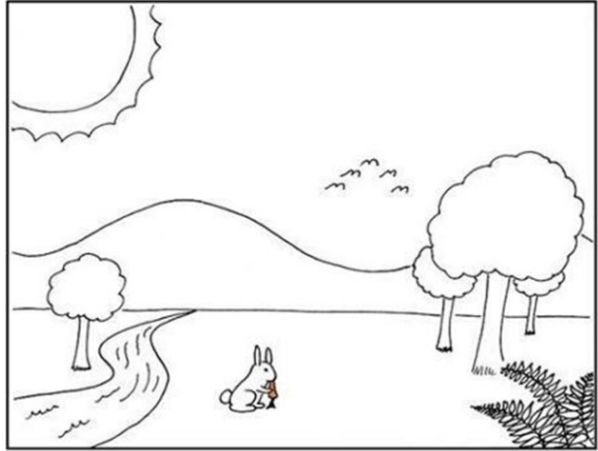
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This is how scientists see the world.



This is how scientists see the world.





Aims

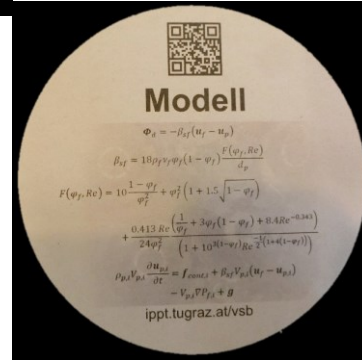
- Introducing up-to-date contexts for teaching the basics of physics and develop a general understanding of technology and engineering.
- Bridging the gap between fundamentals and application to understand the importance of learning fundamentals
- Understanding the importance of performing experiments and simulations during the research process
- Recognizing how modern applications in industry exploit simulations for process design and optimization



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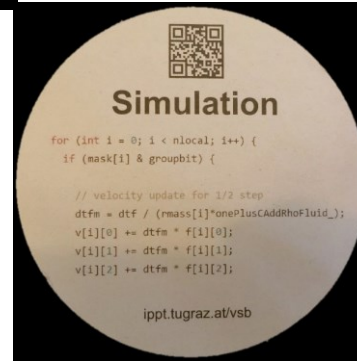
experiment



modeling



simulation



prediction





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Graz, Styria



<http://www.assistenten-tagung.de/2014/wp-content/uploads/2013/06/Dächer-Schiffer-281.jpg>

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Schlichting, H. J. (2014). Das Geheimnis der Sandburgen. Spektrum der Wissenschaft., S. 44-45.



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learning sequence

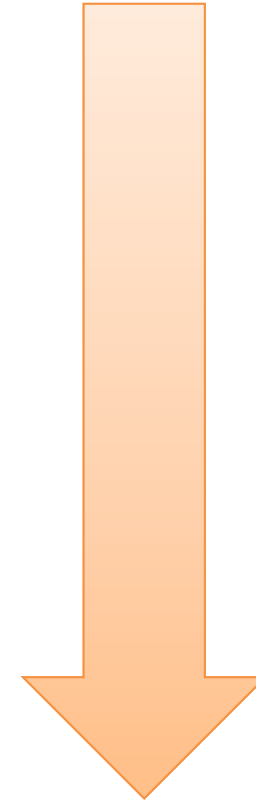
reality

- properties of particular matter
 - density
 - stability
- explanation of its behaviour
 - capillarity
 - surface tension

virtuality (augmented reality)

- basics for technology
 - modelling – „Keksperiment“
 - simulation
- interaction with the virtual world

can be adopted to
primary level



upper secondary level



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experiment

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Strategy

Inquiry- based learning





What has the higher density?

Dry or wet sand?



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paranut - effect

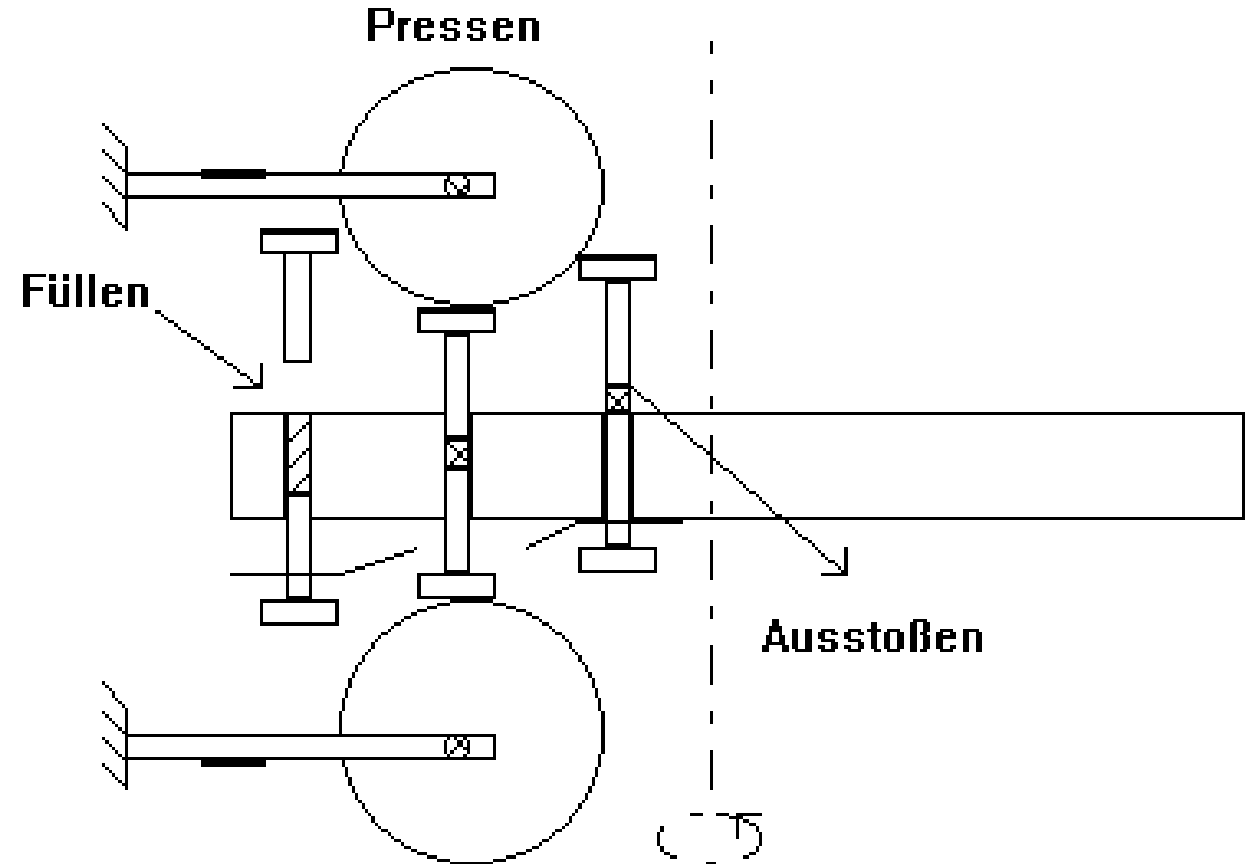




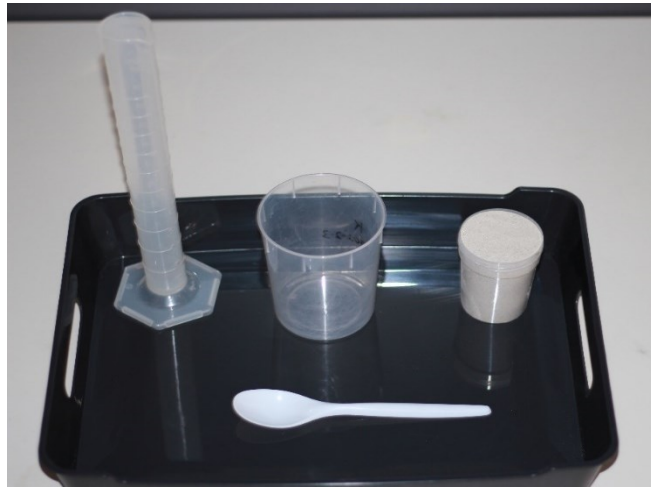
Why is the density so important?



<https://www.welt.de>



<http://www.fuzzytech.com>



measuring the bulk density (engineering standards)



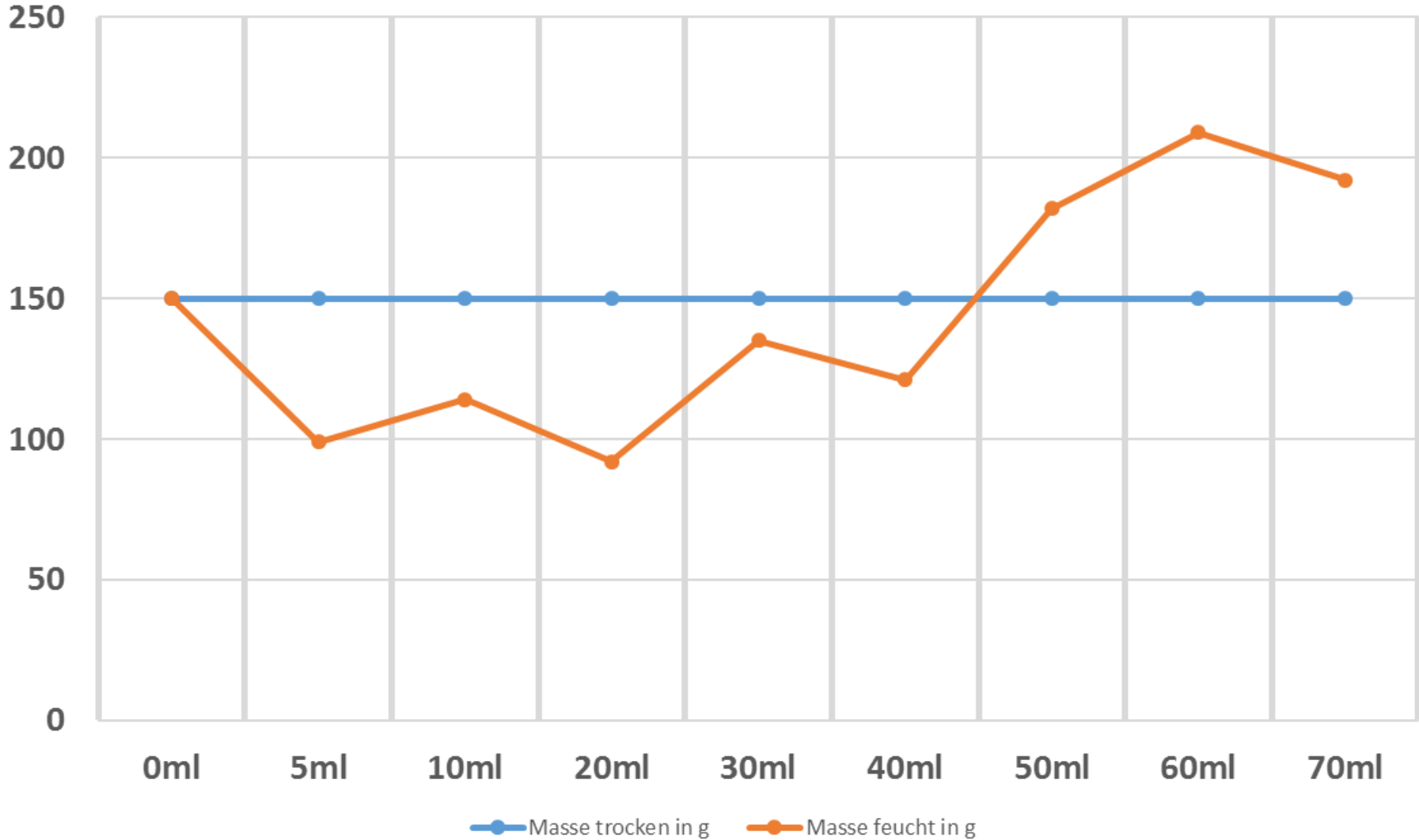
①	trocken 154,7g	+ 5ml 98,6g
②	150,7g	+ 10 ml 113,8g
③	153,7g	+ 20 ml 92,0g
④	150,5g	+ 30 ml 134,7g
⑤	149,5g	+ 40ml 121,1g

⑥	trocken 147,0 g	+ 50ml 182g
⑦	157,4g	+ 60ml 208,7g
⑧	154,0g	+ 70 ml 192,0g
⑨	154,7g	+ 10 ml 114,9g
⑩	158,3g	+ 20ml 99,6g

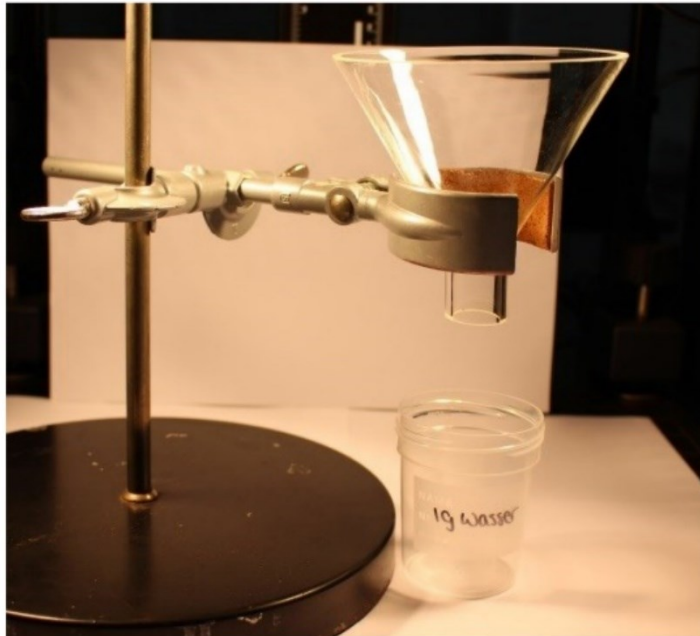


dry and wet sand

Masse in g



volume = const.



Stativ, Trichter, und 150 ml Messbecher



Wasser-Sand Mischung

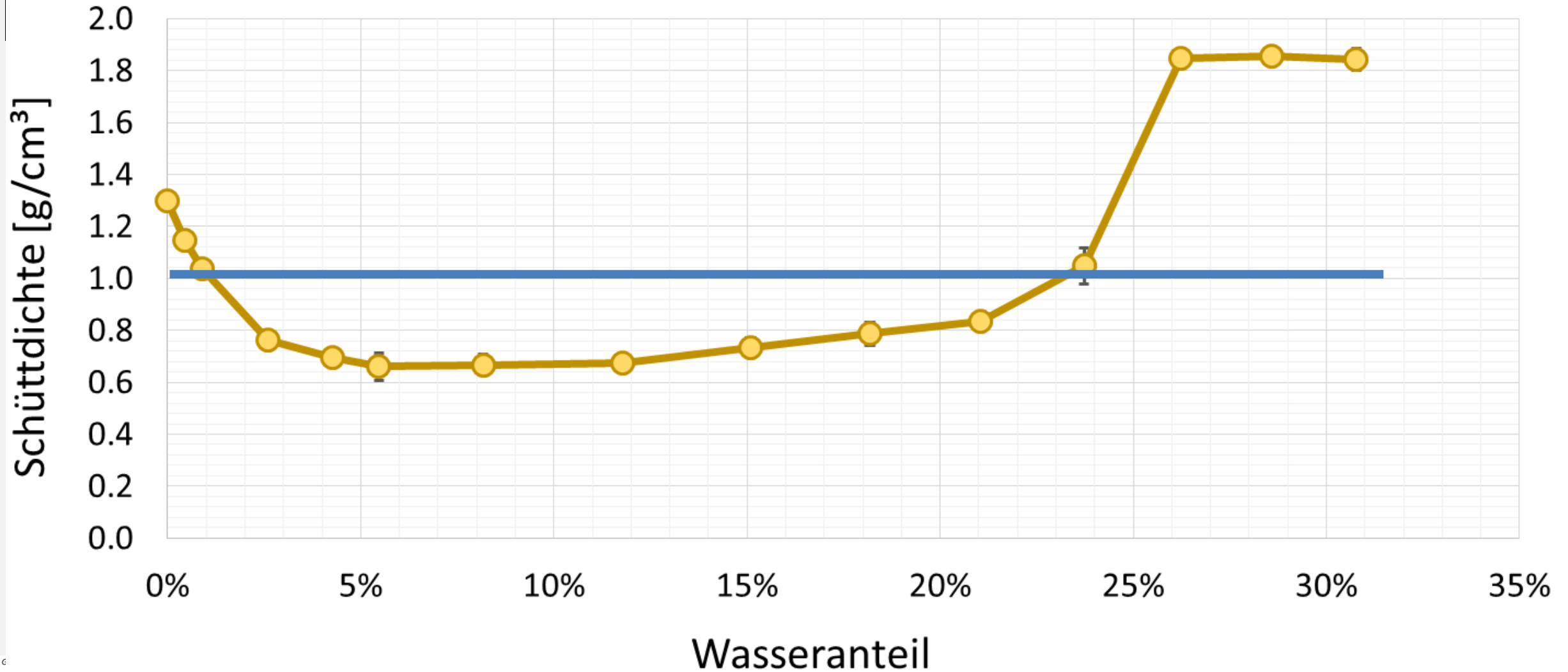


Spatel zum Abstreichen

standard method



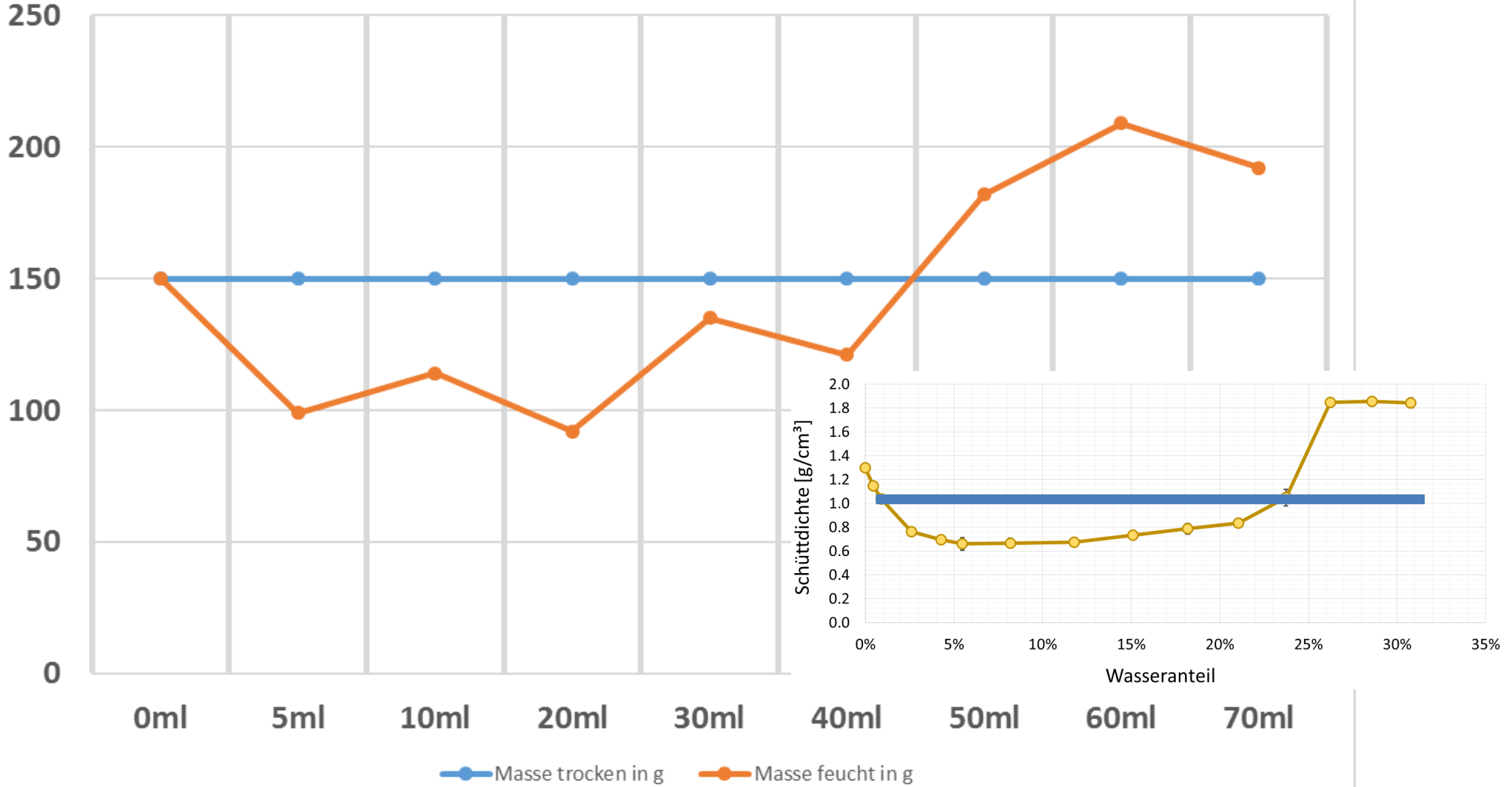
bulk density vs. water content





Trockener und feuchter Sand

Masse in g





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stability



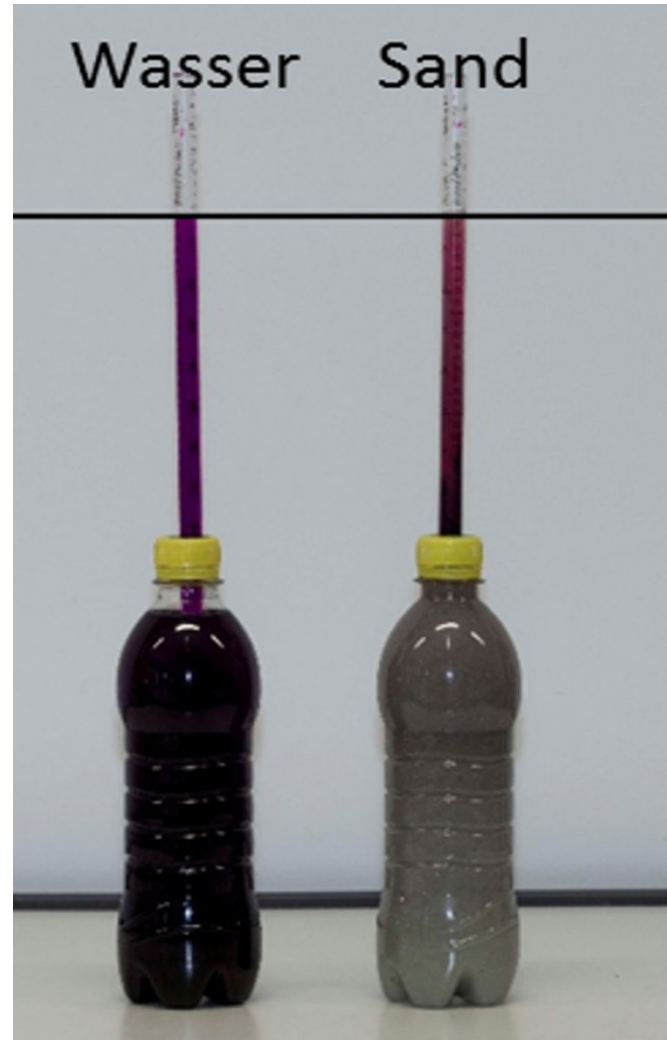
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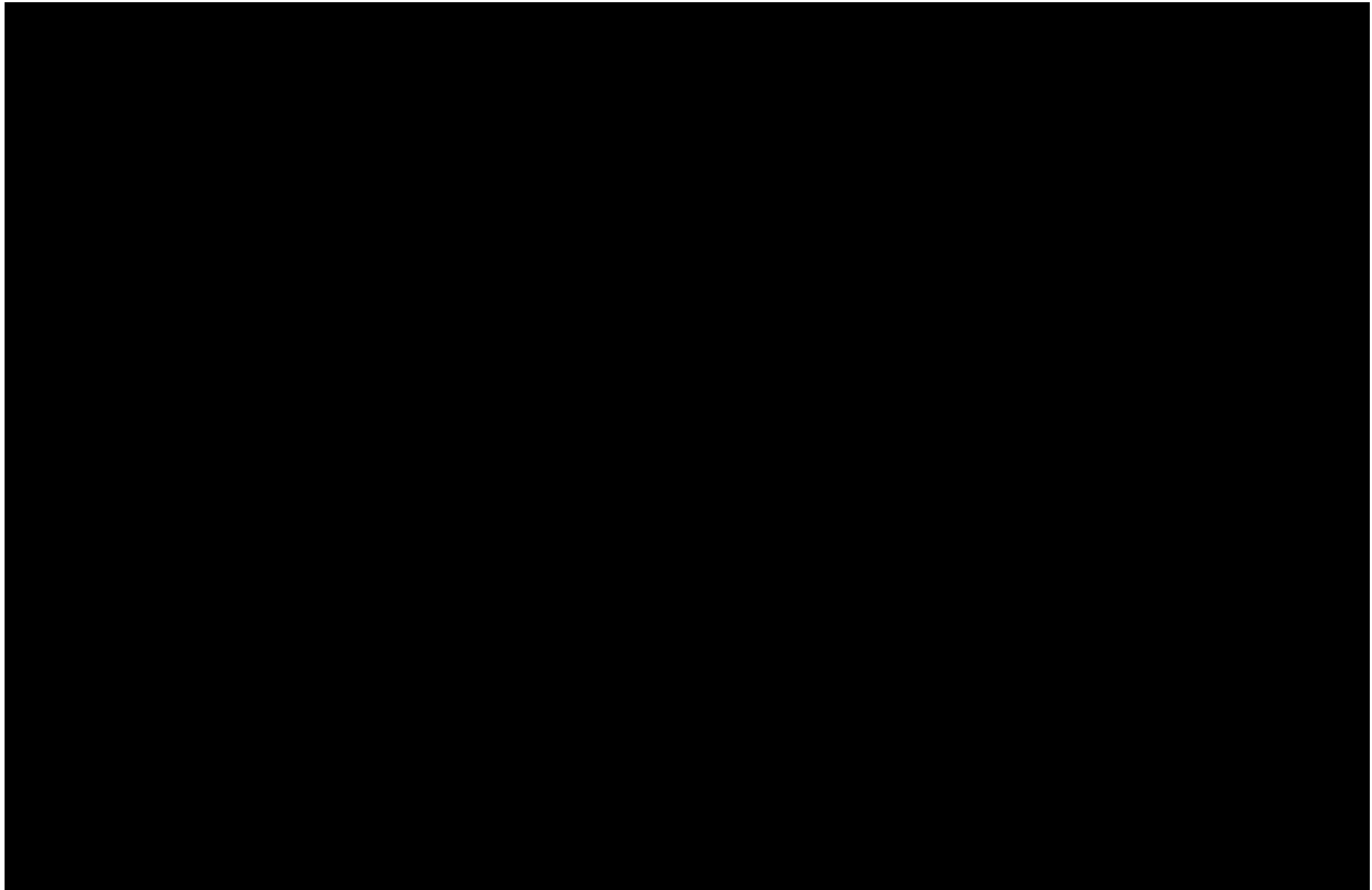


Reynold's dilatancy





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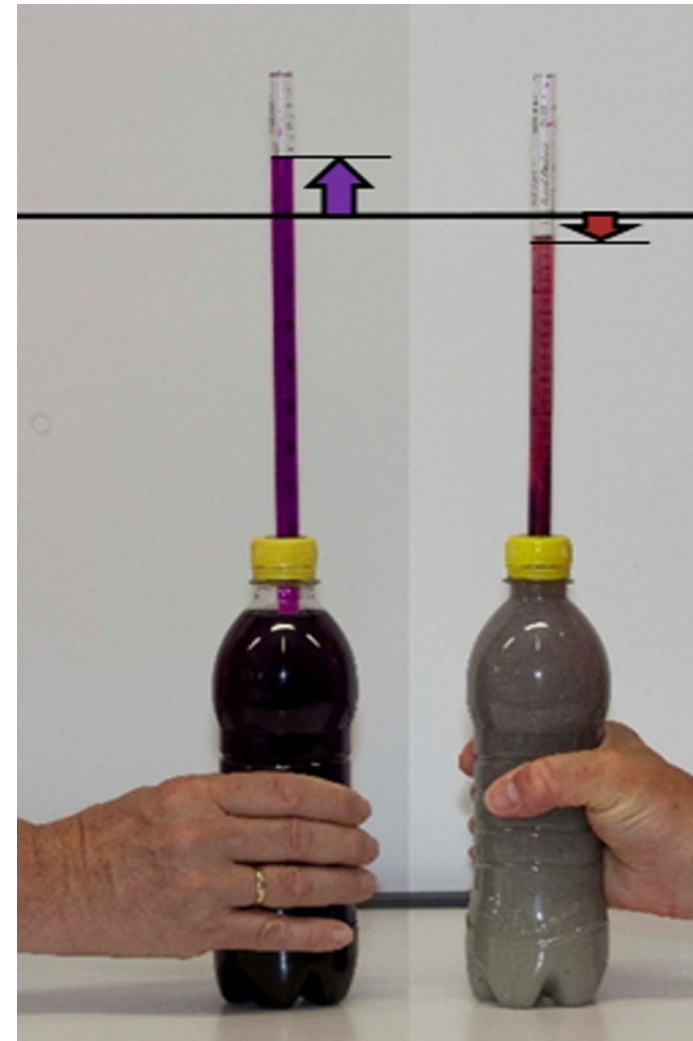
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Reynold's dilatancy

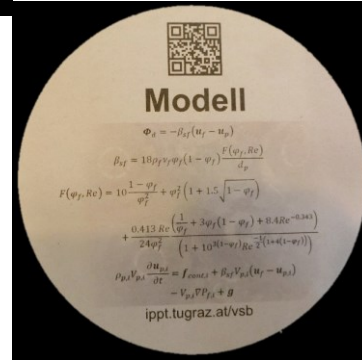




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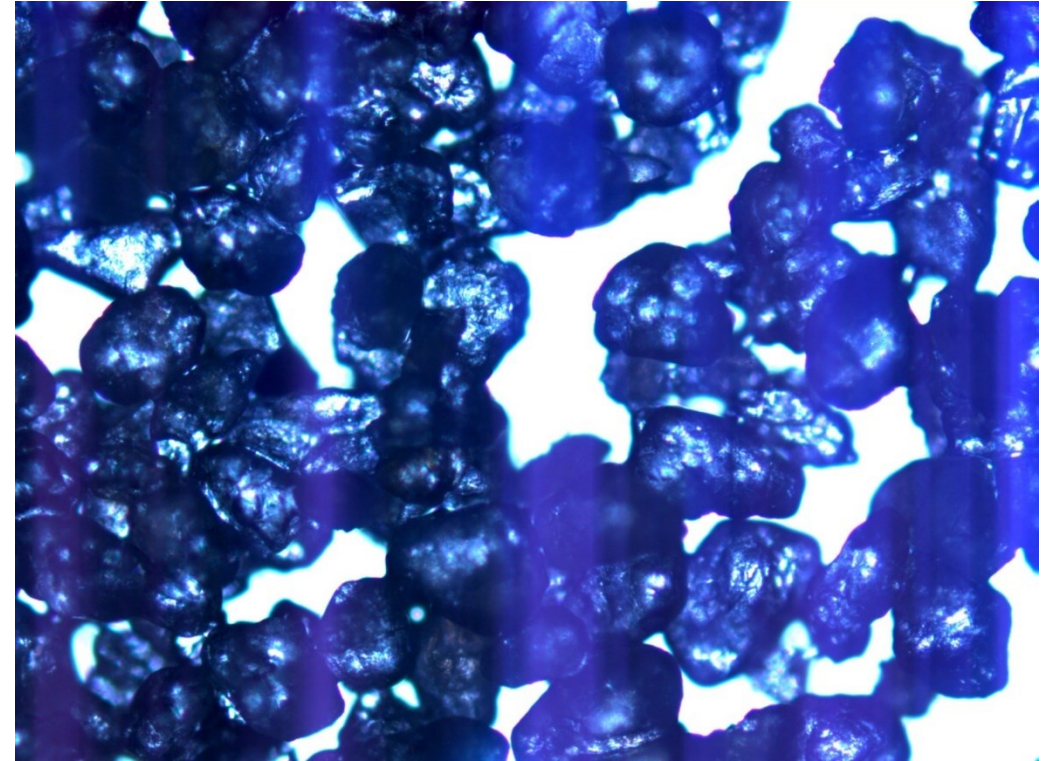
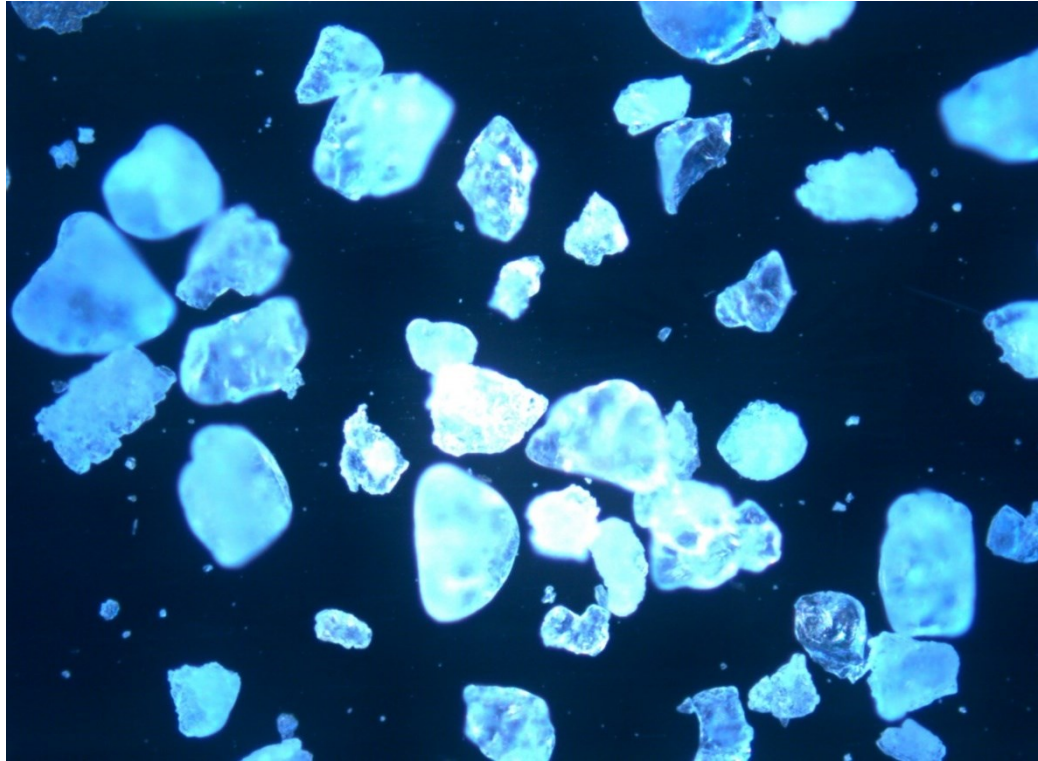


experiment



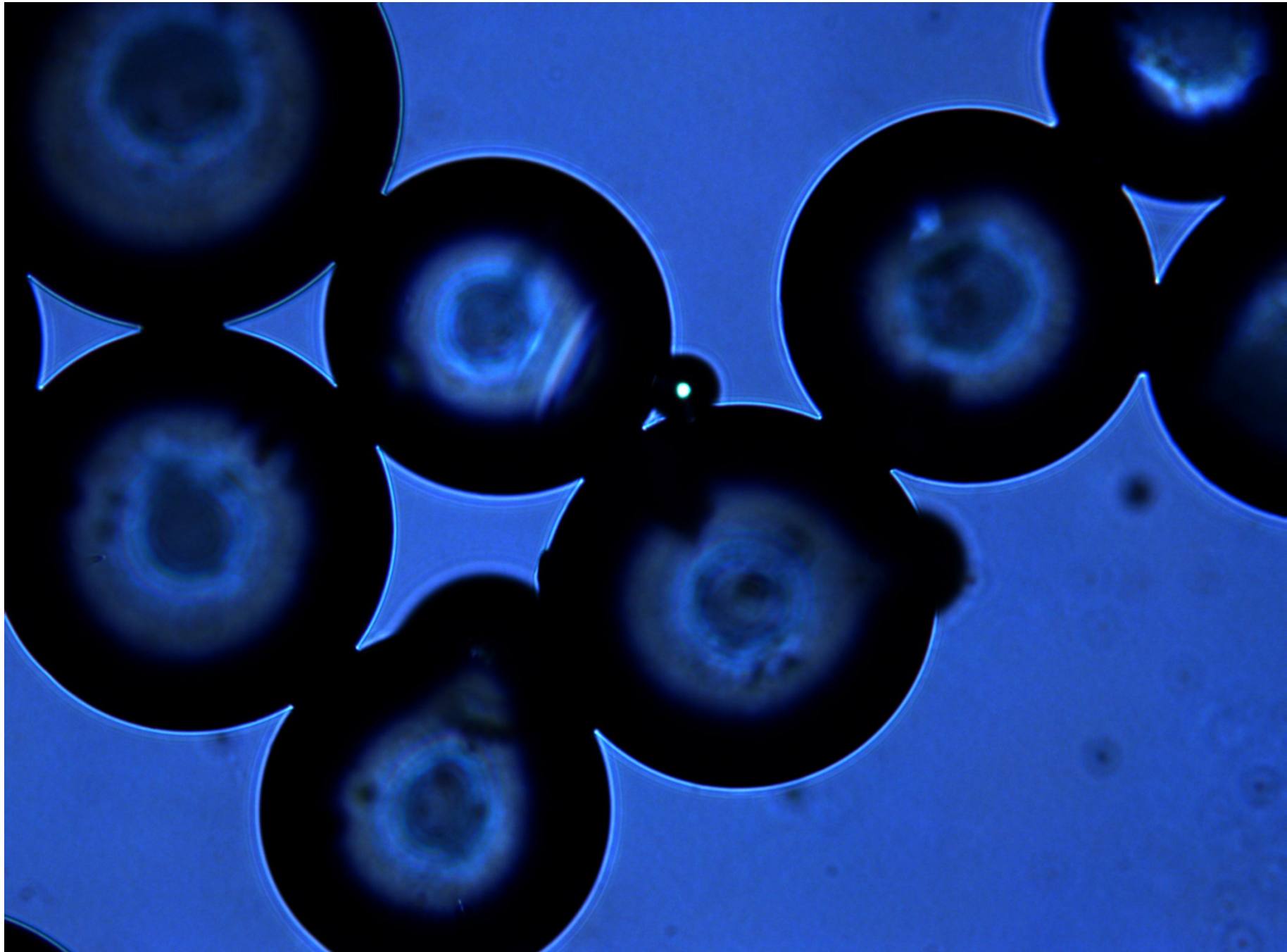
modeling







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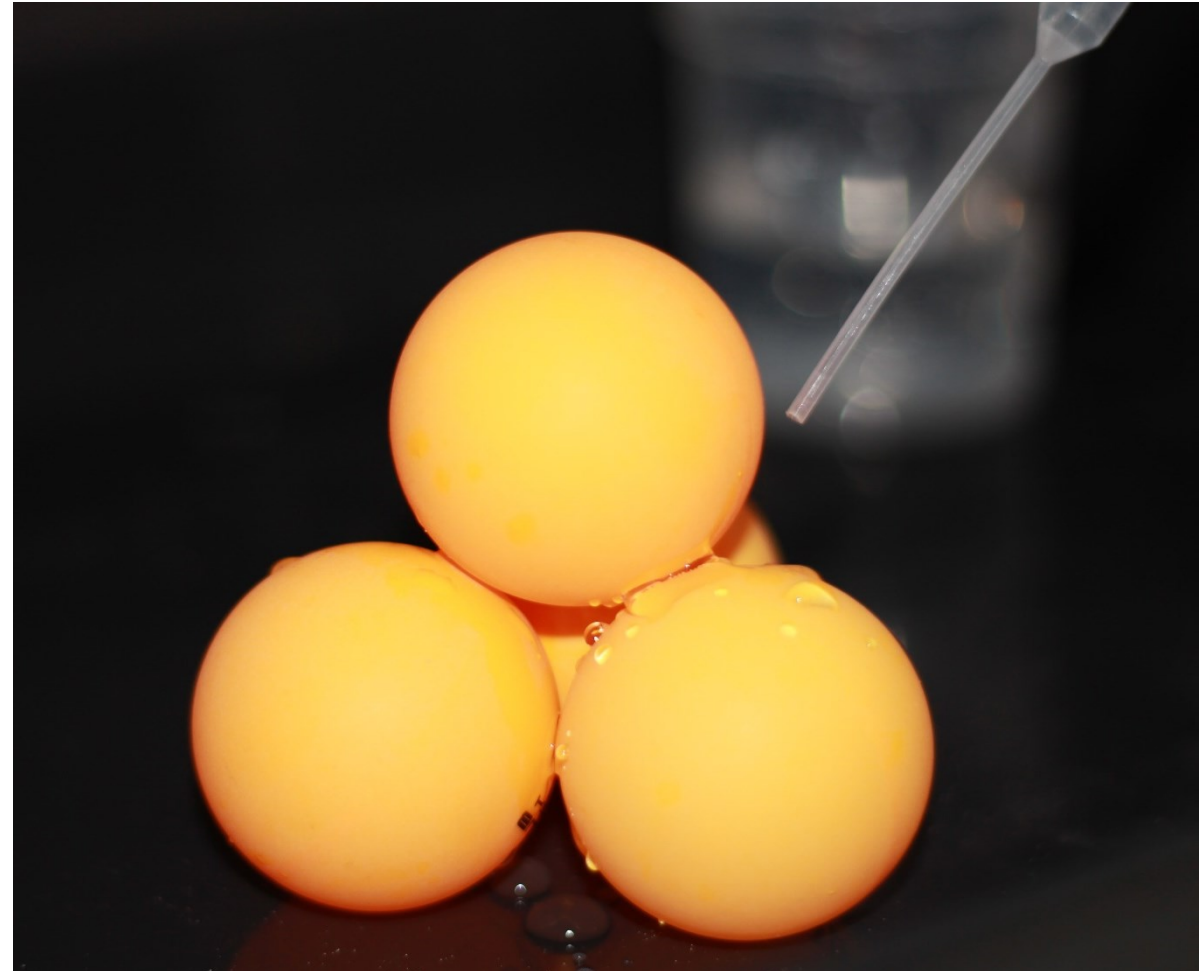
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ping pong ball pyramide



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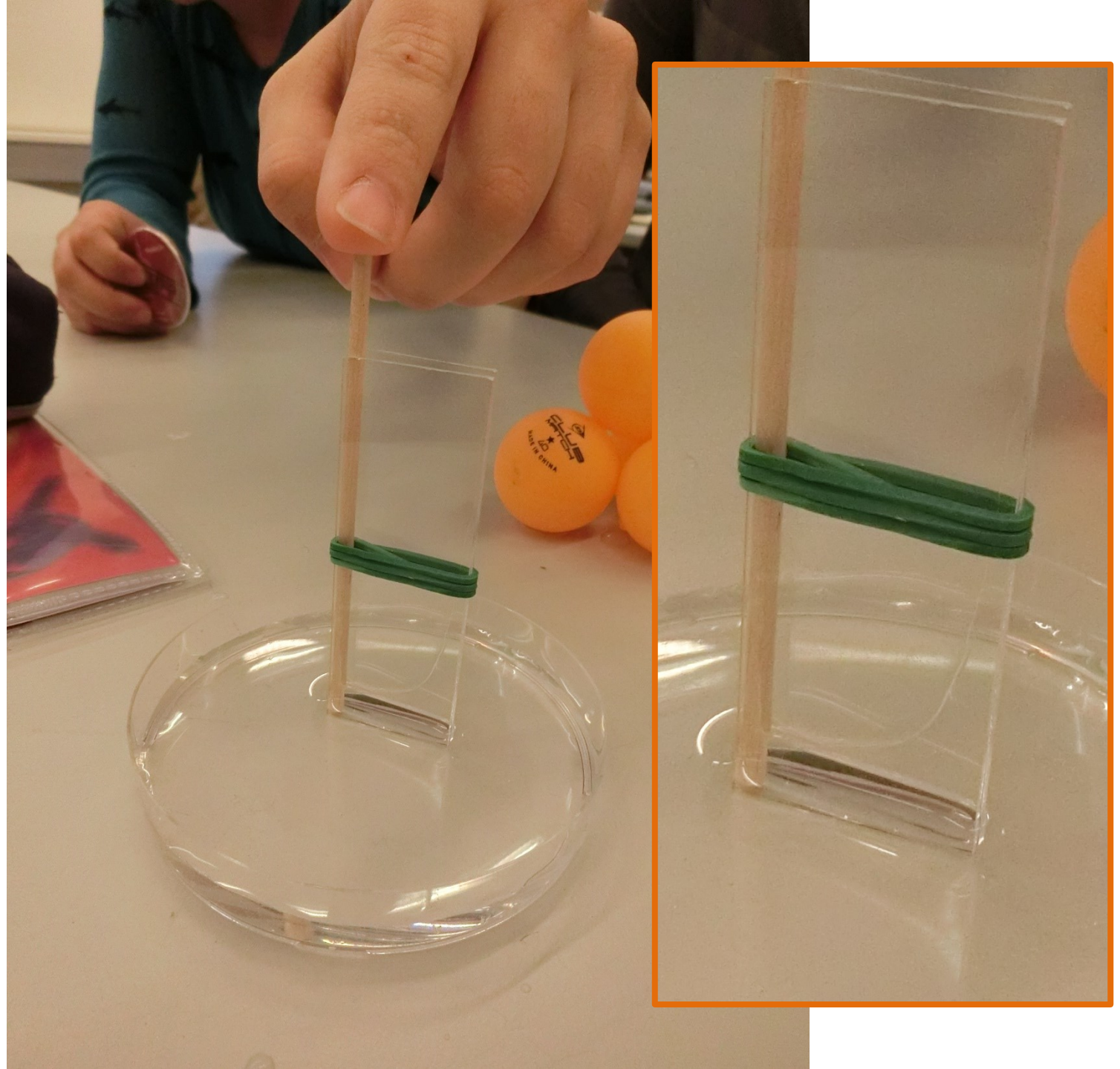
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capillarity



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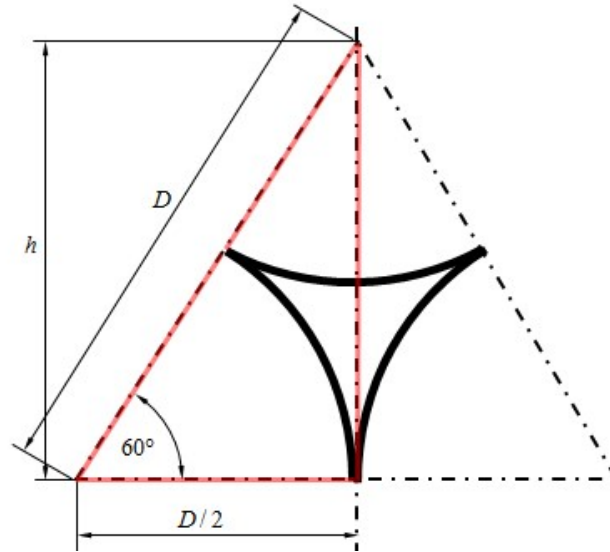
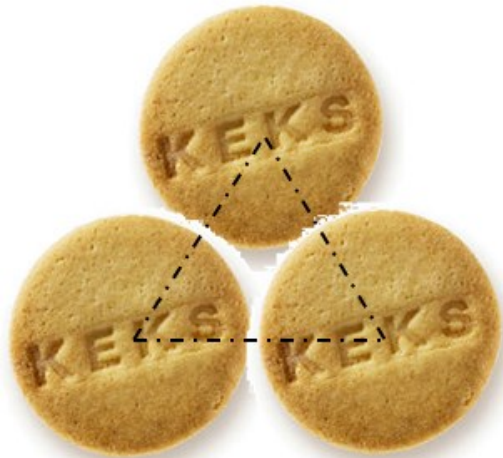
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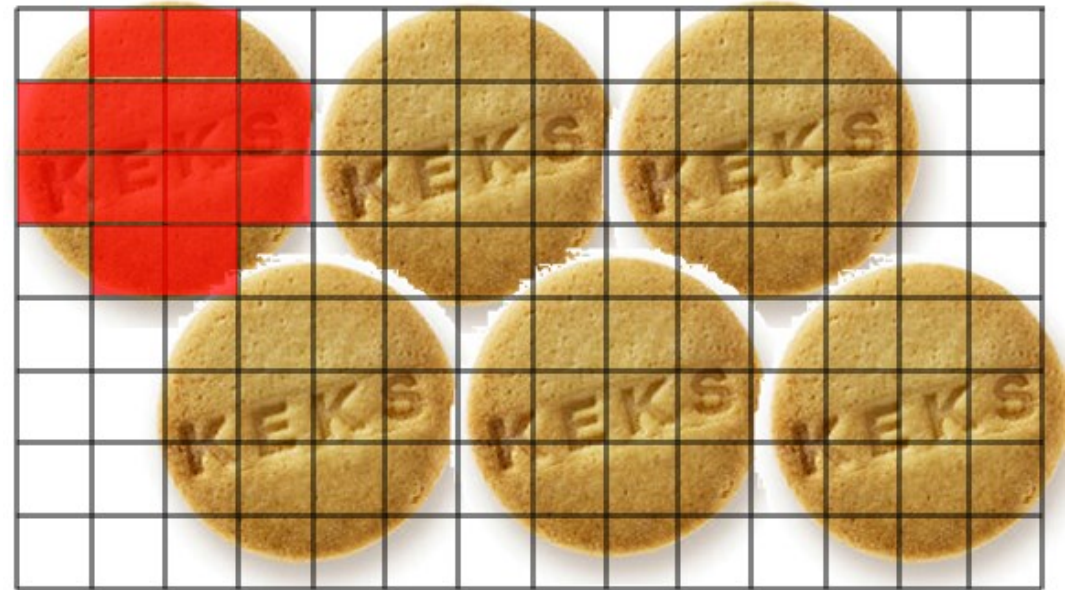


Keksperimente

geometry

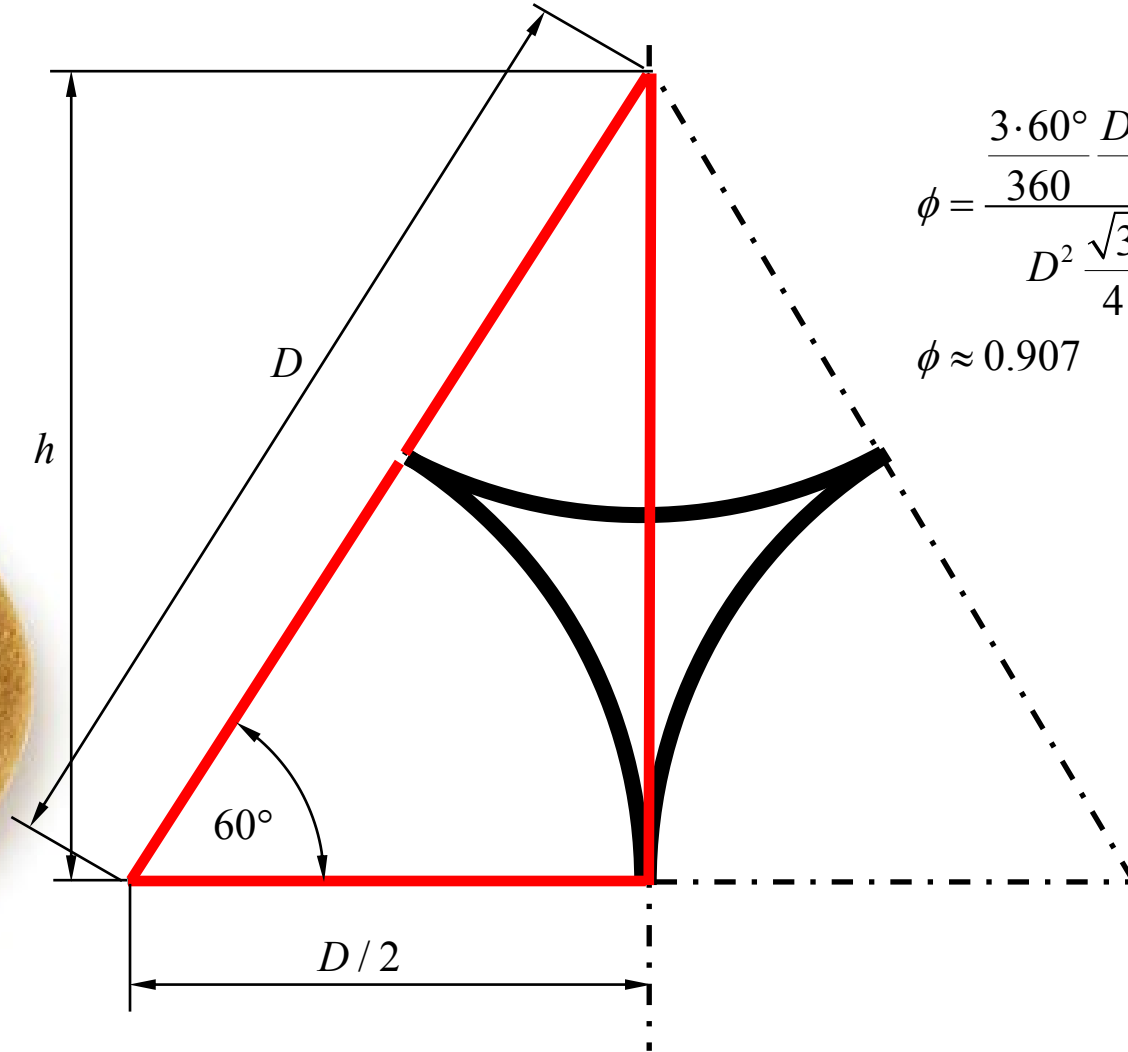
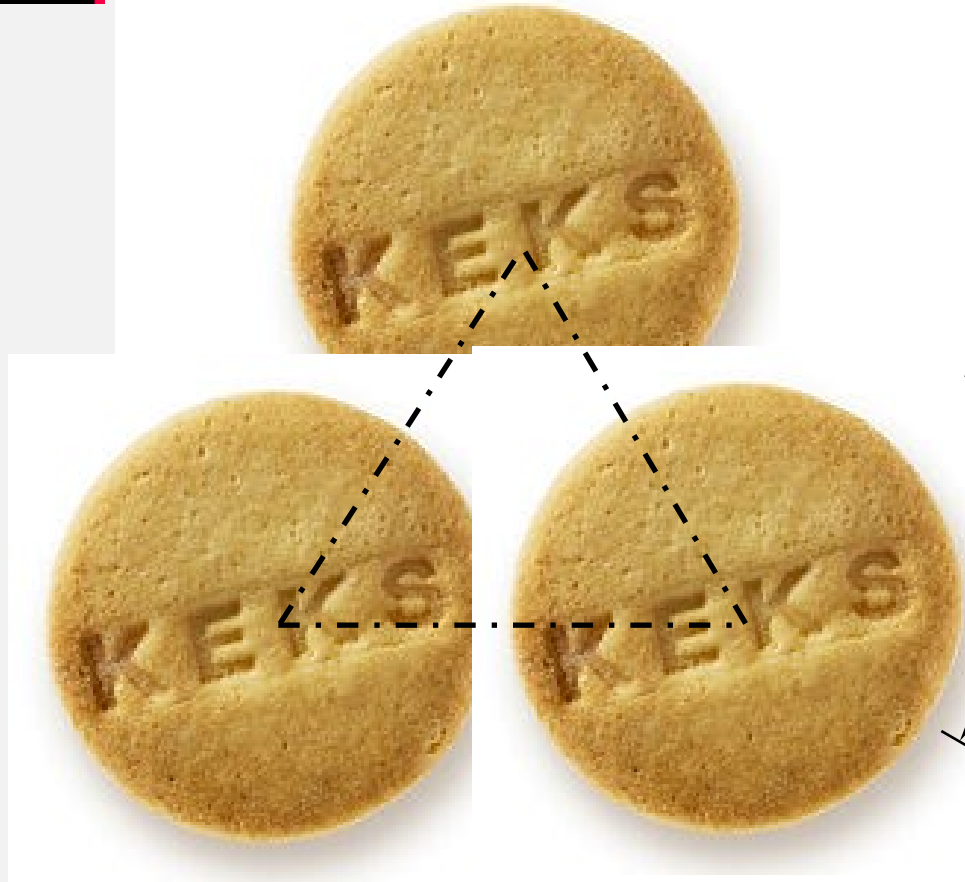


Monte-Carlo-iteration





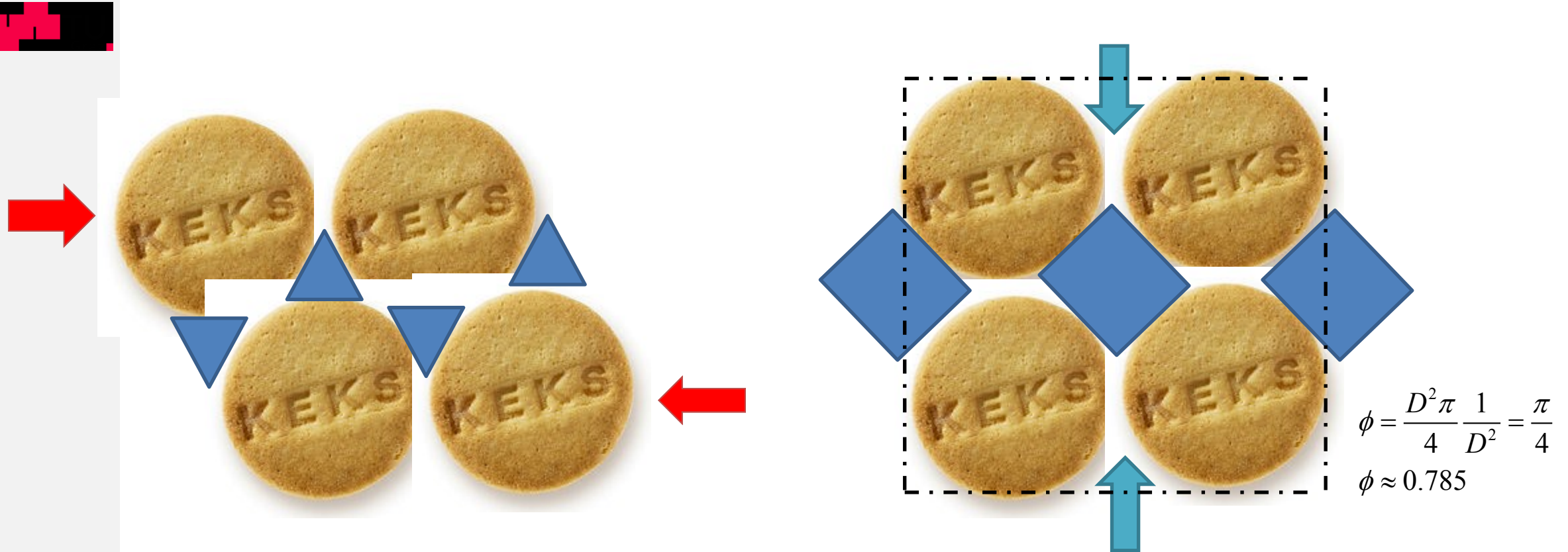
Keksperiment: „Keksmodell“



$$\phi = \frac{3 \cdot 60^\circ \frac{D^2 \pi}{4}}{D^2 \frac{\sqrt{3}}{4}} = \frac{\pi}{2\sqrt{3}}$$
$$\phi \approx 0.907$$



Keksperiment: „Keksmodell“



Calculation of the space between
the „particles“



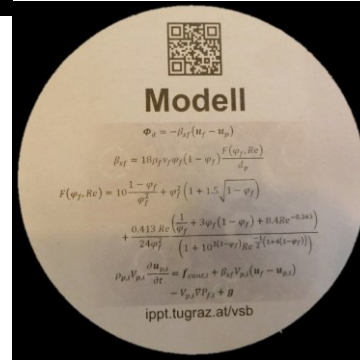
Golden rule of Keksexperiments: Never use chocolate cookies!



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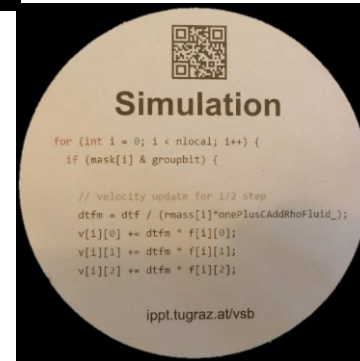
experiment



modeling



simulation





Is computer-based research necessary?

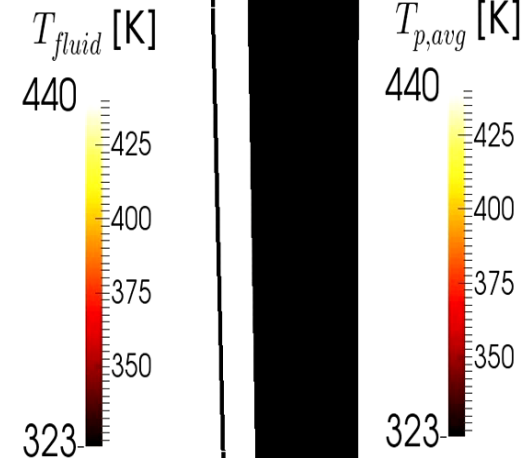
goal: **better products, more efficient** production



(TU Graz)

experiments

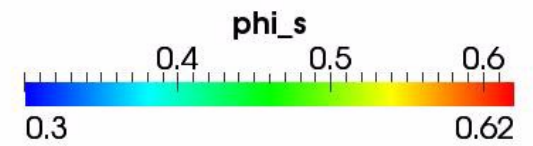
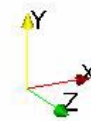
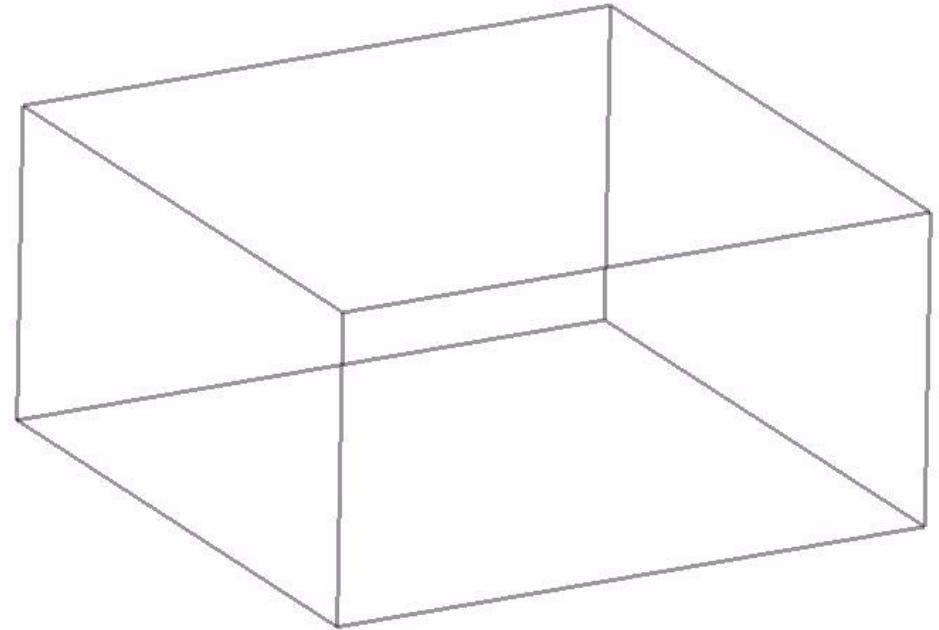
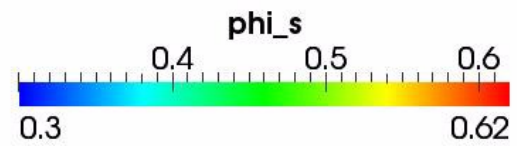
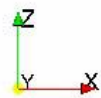
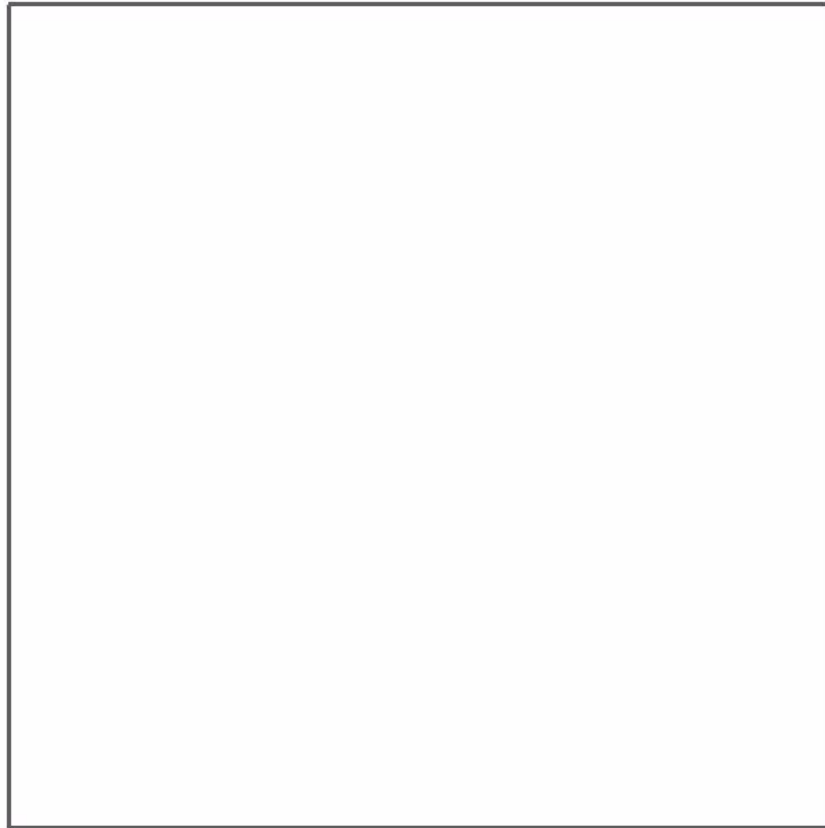
- mostly **expensive**
- allow only **restricted insight**
- sometime do not succeed
- **safety**



Time: 0.00 sec

simulations

- allow **deeper insight**, especially when using opaque materials
- allow **extreme variations** of parameters

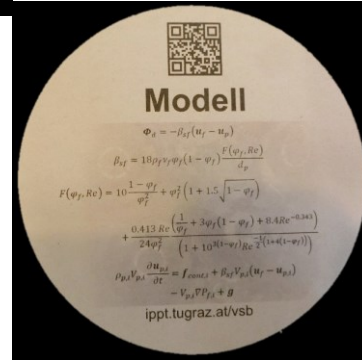




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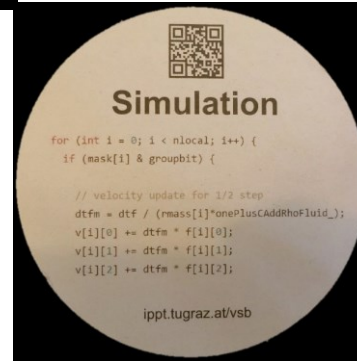
experiment



modeling



simulation



prediction



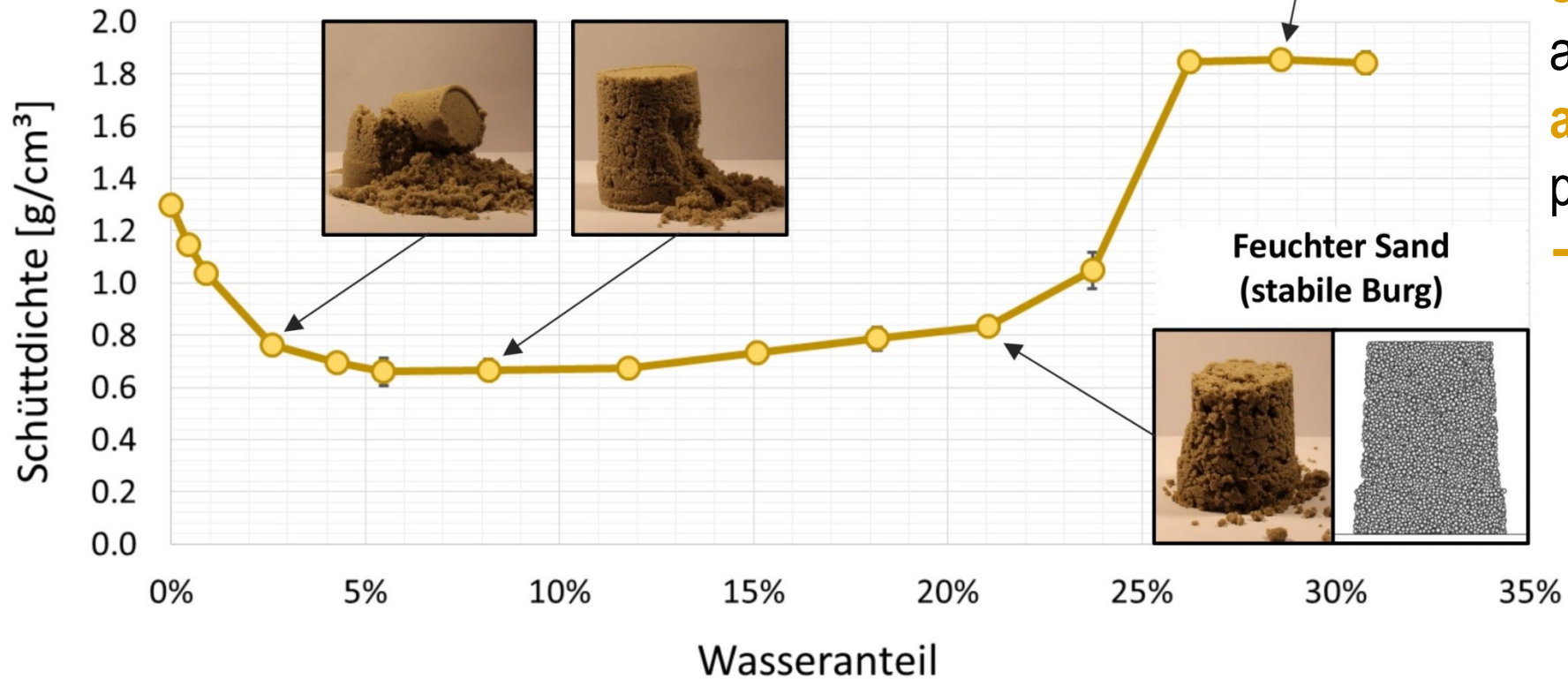
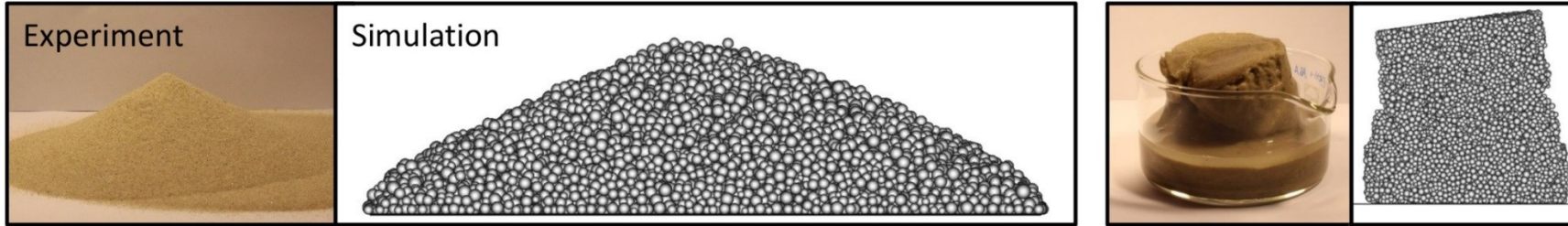


Is computer-based research necessary?



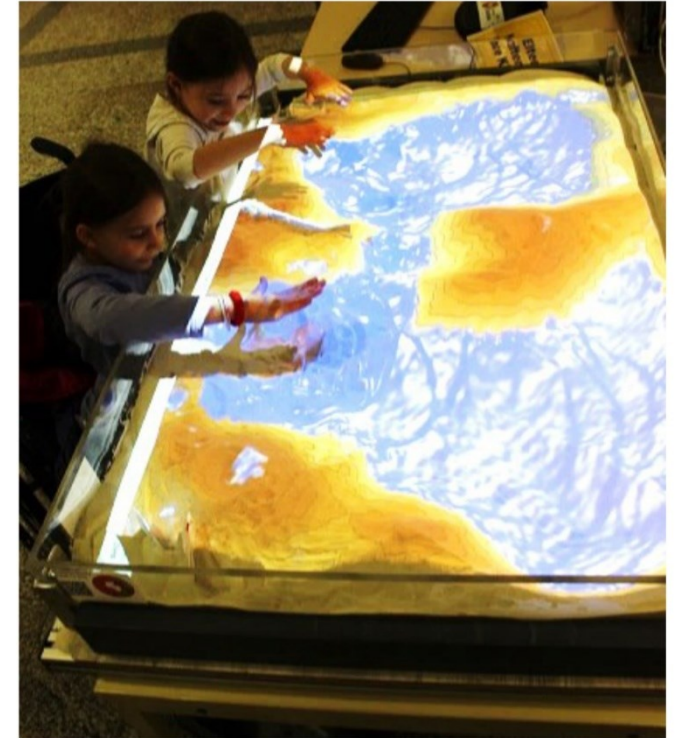
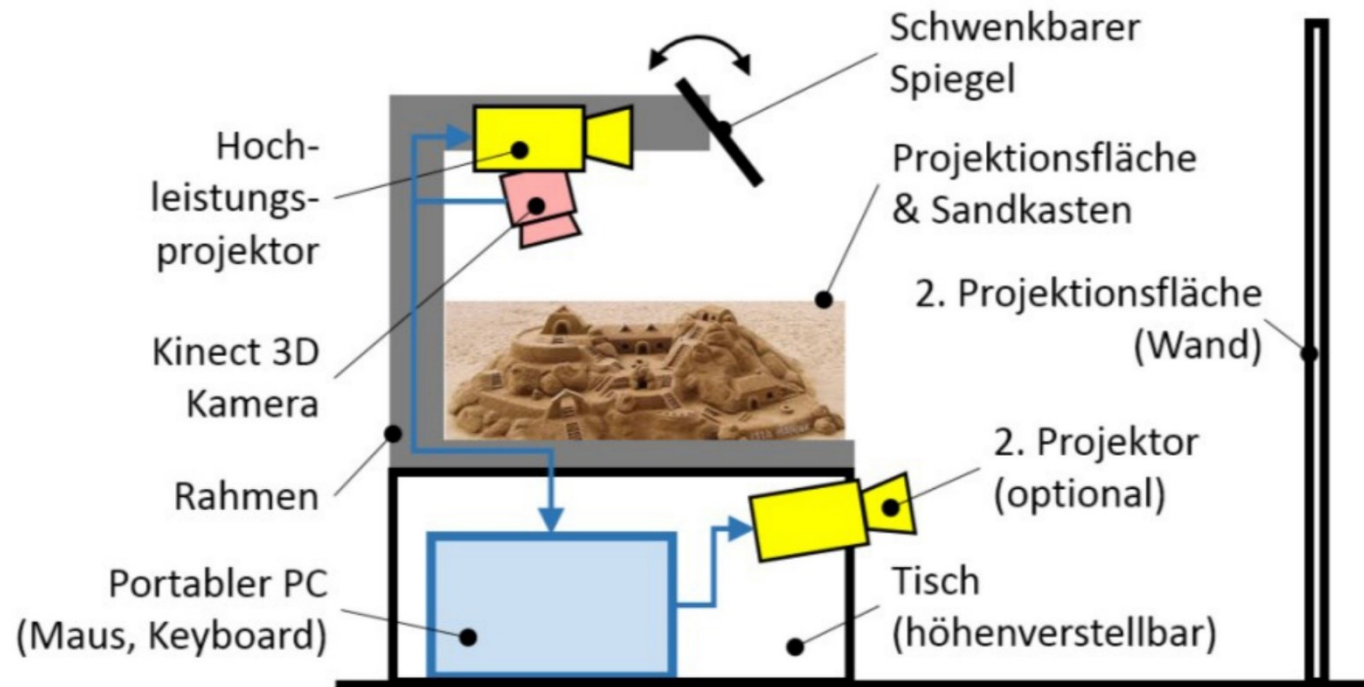
Trockener Sand

Zu feuchter Sand (Slurry)



simulations
allow predictions and
analysis of industrial
processes
→ planning reliability

finally, „The Virtual Sandbox“?

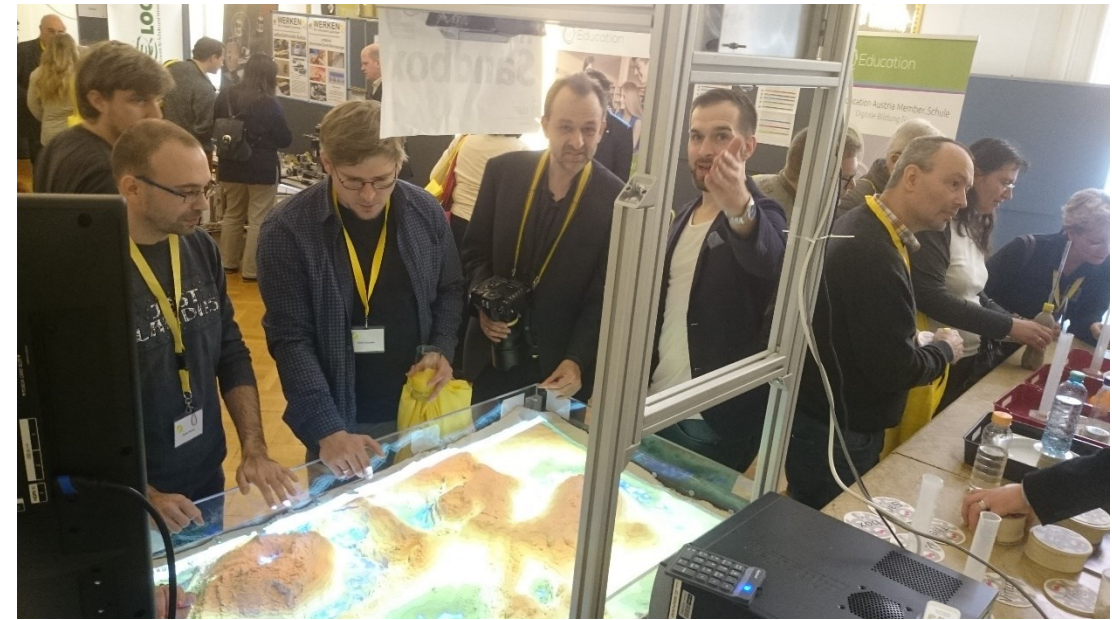
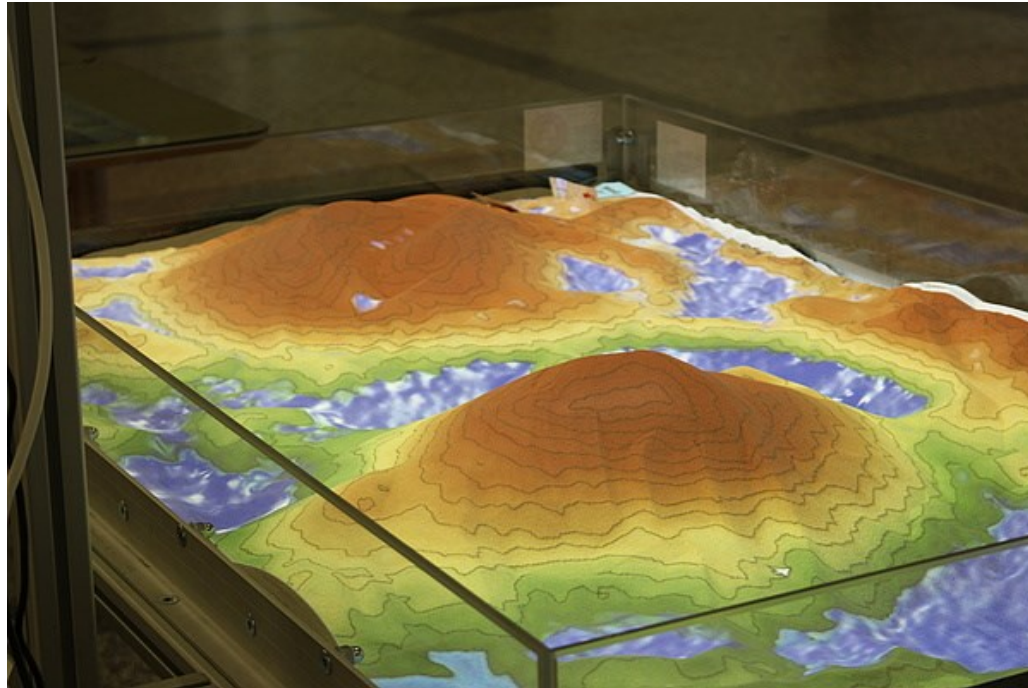


Reed, S.E., Kreylos, L., Hsi, S., Kellogg, L.H., Schladow, G., Yikilmaz M.B., Segale, H., Silverman, J., Yalowitz, S. & Sato, E. (2014). Shaping Watersheds Exhibit: An Interactive, Augmented Reality Sandbox for Advancing Earth Science Education. Americal Geophysical Union, Fall Meeting 2014.M

Kloss, C., Goniva, C., Hager, A., Amberger, S. & Pirker, S. (2012). Models, algorithms and validation for opensource DEM and CFD-DEM. Progress in Computational Fluid Dynamics 12, 140 – 152.



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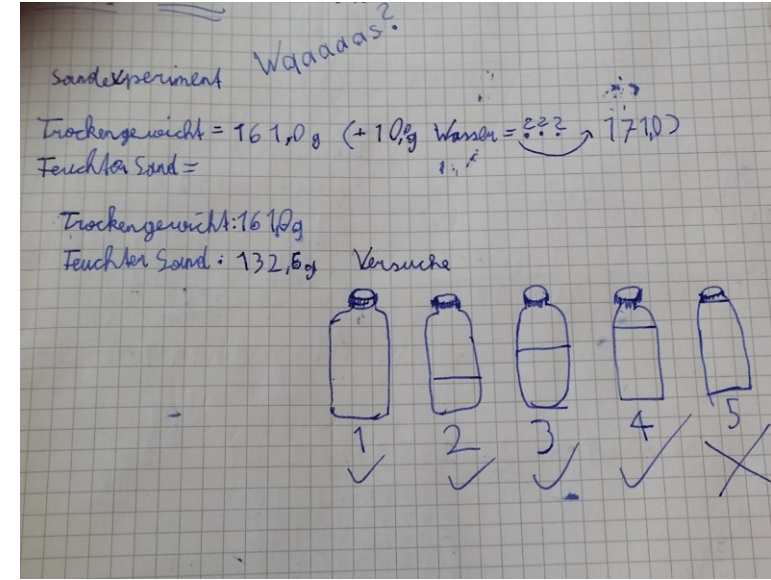


how do the learners
recognize the lectures?

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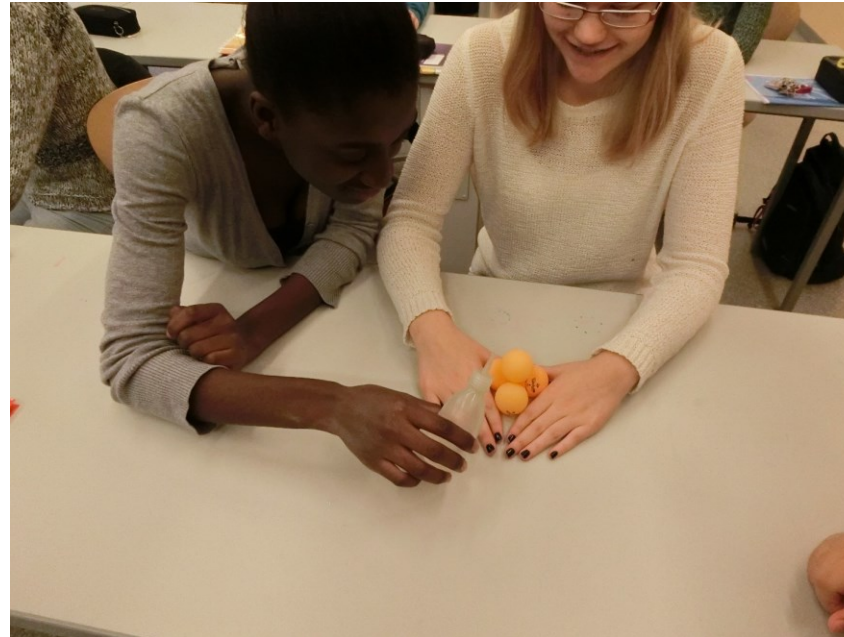
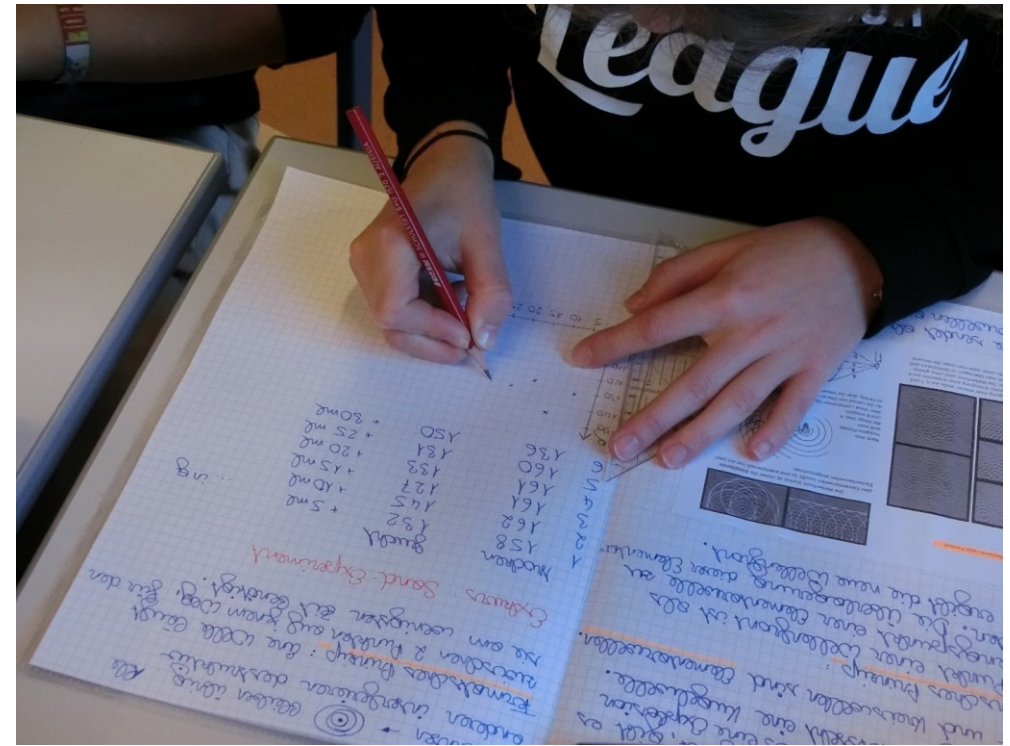
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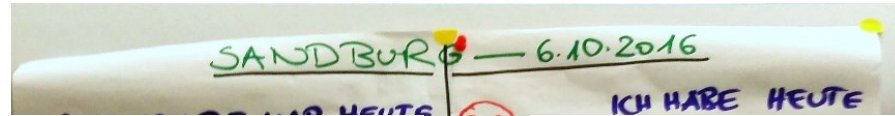
age \approx 16



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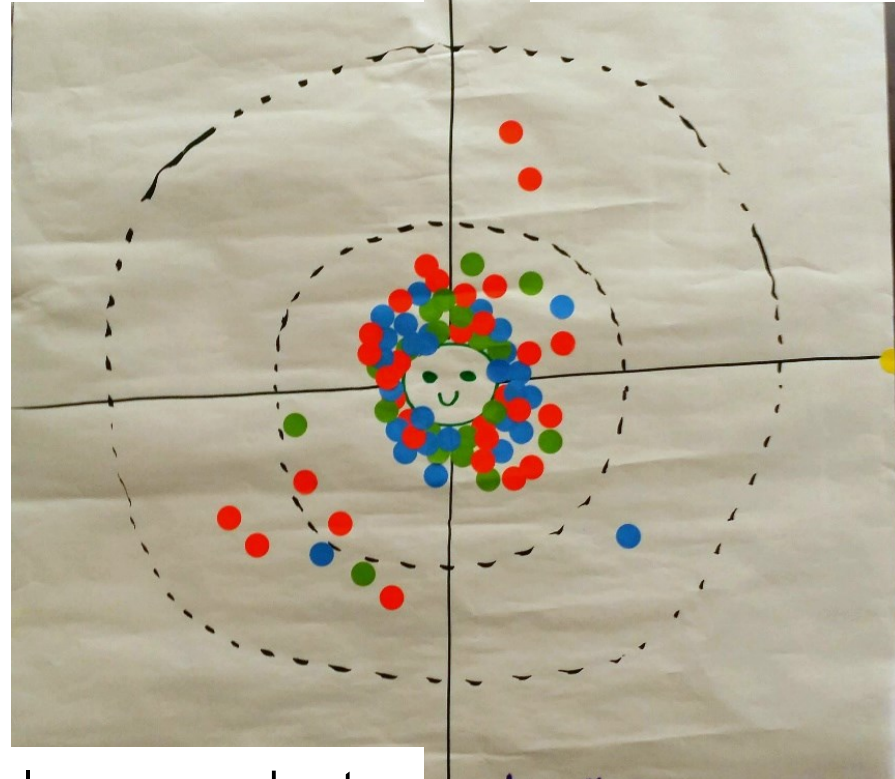
age > 16



This lecture was interesting



I learned something new today



I want to learn more about sand.

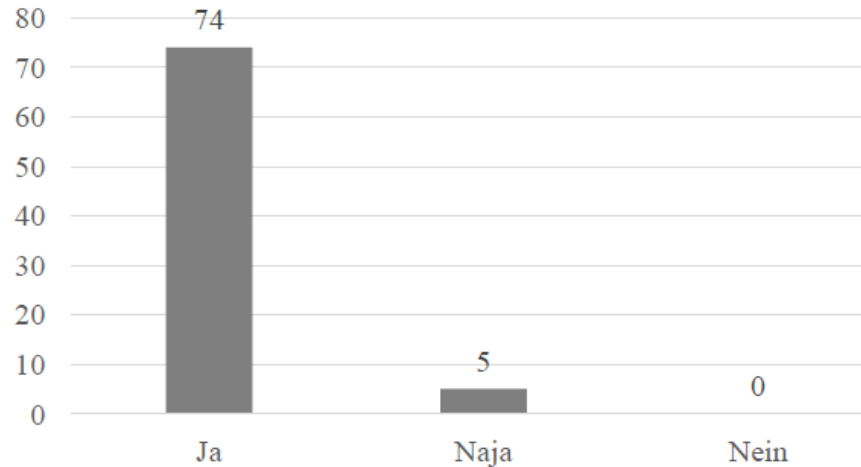
I want more lectures like this
DIESE.



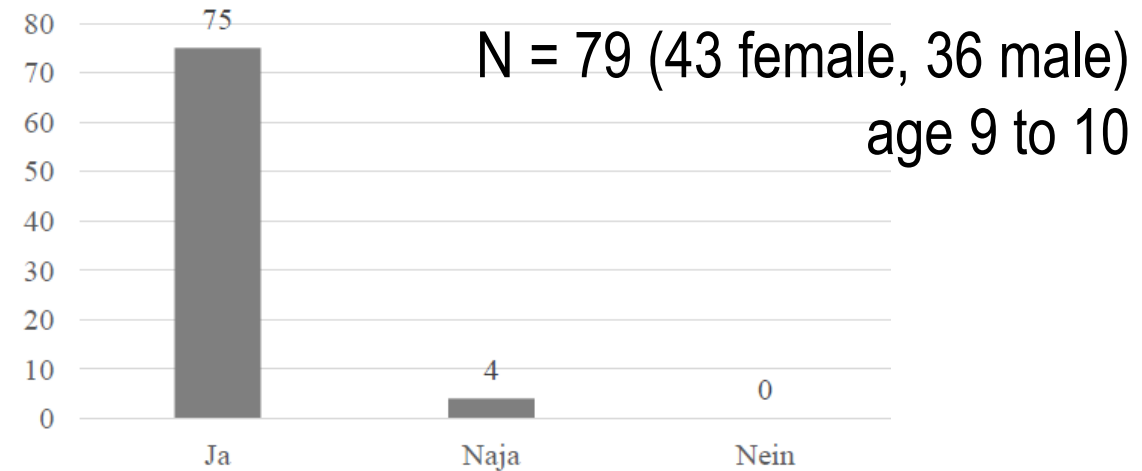


Some results for primary classes

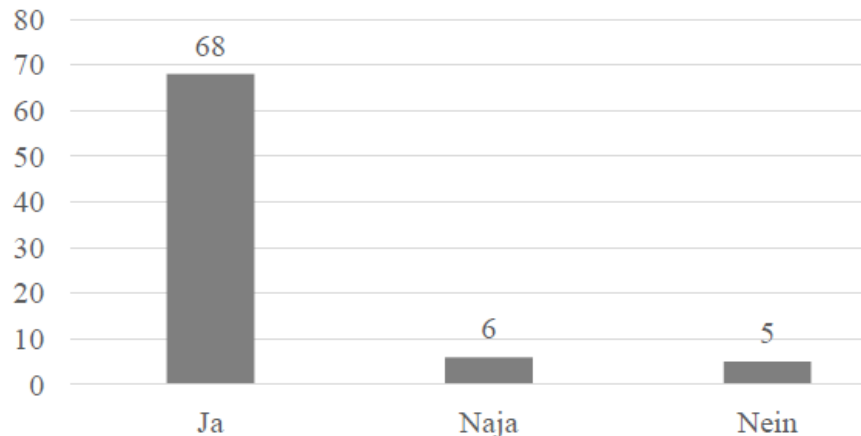
The workshop with sand was interesting.



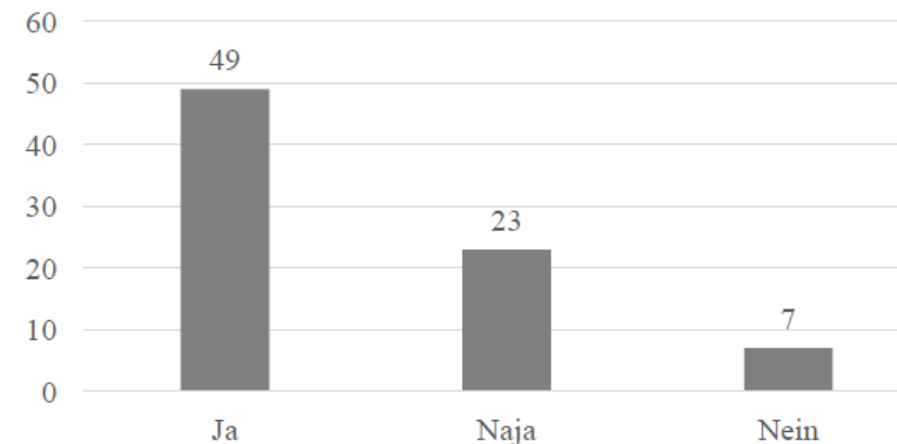
I liked the experiments with sand.



I can explain, how to build a stable sandcastle.



I can explain, why wet sand is sticky..





Linda

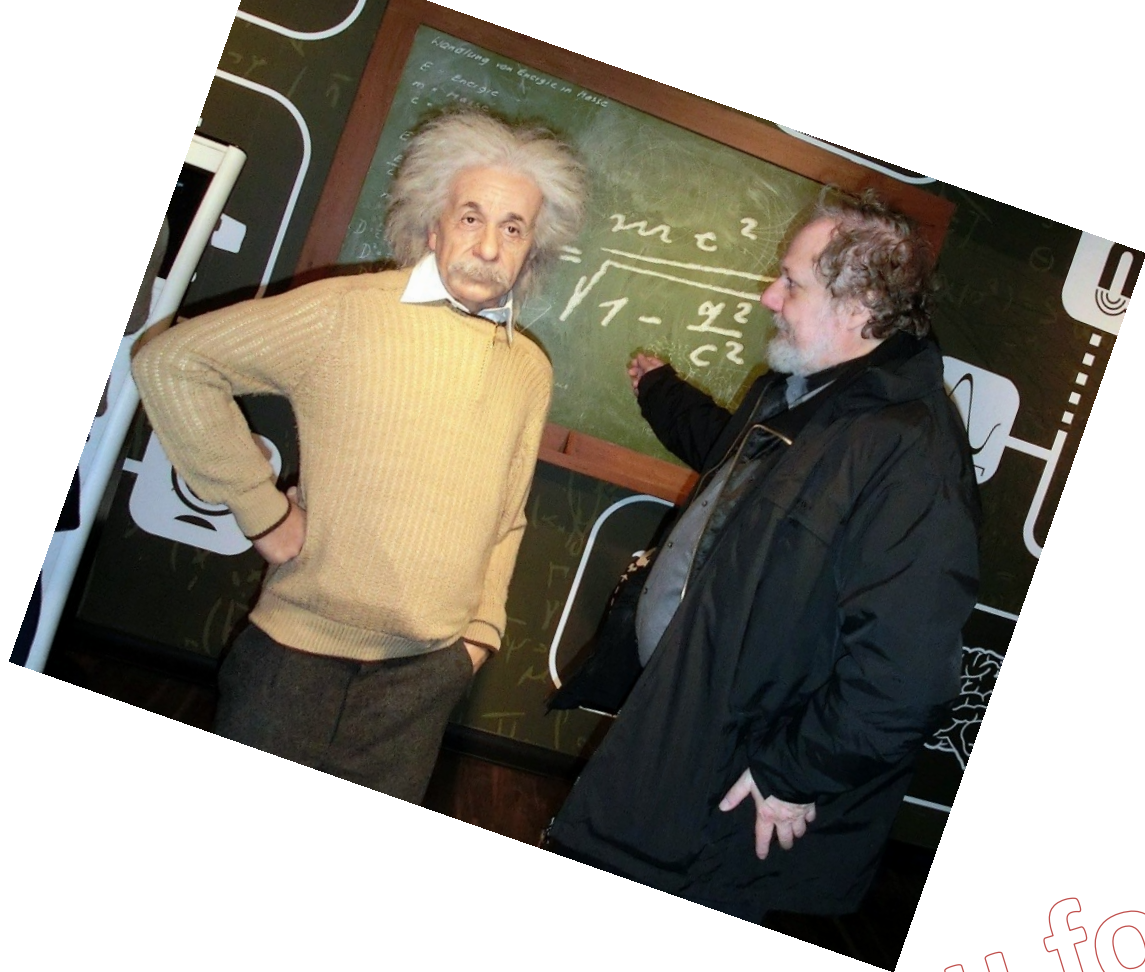
Ich fand den Sandkuchen cool, und
es war komisch, dass er eine drei-
viertel volle Flasche aushält. Auch die
kleine Waage war sehr praktisch. Das
Wasser die Tischtennisballer zusammen
halten wusste ich nicht. Das Team
war sehr sehr nett. Mir hat die
Zielscheibe gut gefallen, wo man ange-
zeichnet hat wie es einem gefallen hat.

Vielen Dank!





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Thank you for your attention!
More questions than answers?!

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Radl, Jakob Redlinger-Pohn, Hans Eck, Nora Wiesauer, Andrea Karner, Benjamin Bahar, Lukas Wachtler, Ma