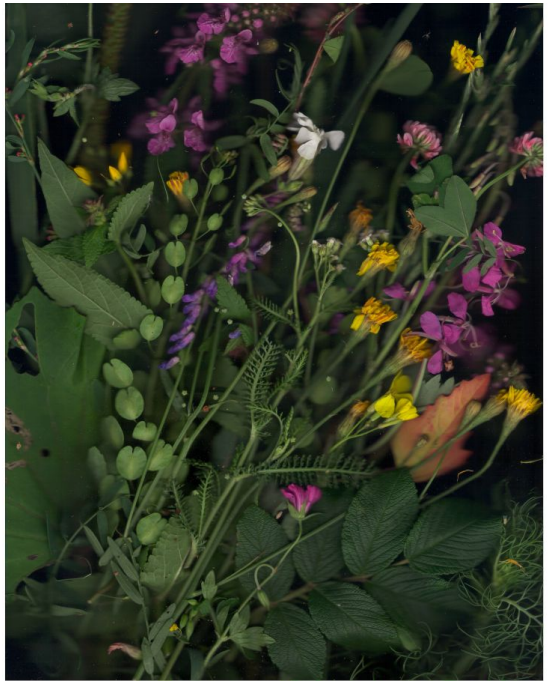
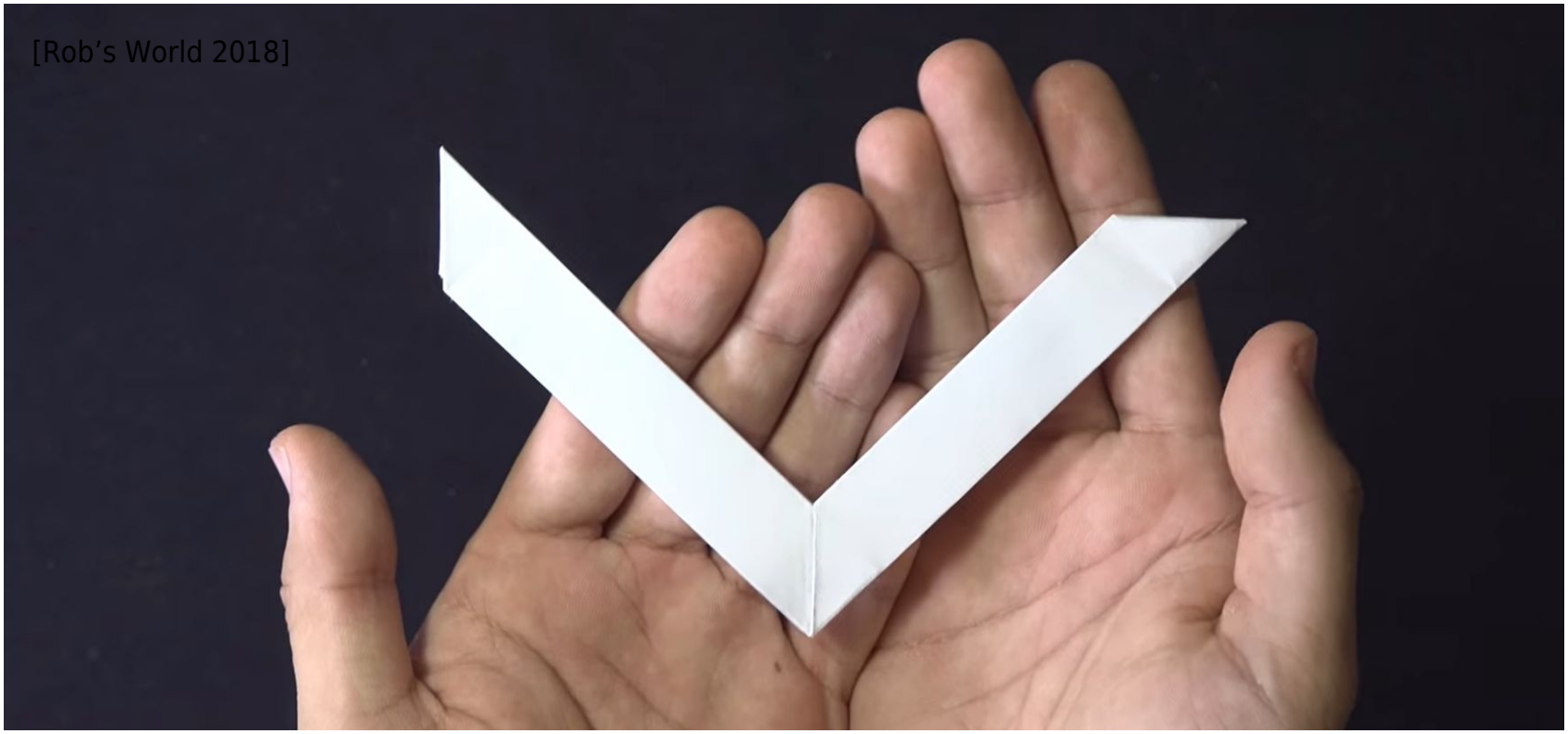


Preparation to the Young Physicists' Tournaments' 2025

Ilya Martchenko,[1]* Nikita Chernikov,[2] Aleksandr Zinkevich,[2] and Anastasiya Litvinova[3]

[1] Foundation for Youth Tournaments; [2] Novosibirsk State University; [3] Digital School


Is the novel research limited and discouraged by the existing common knowledge and the ongoing work of competing groups? :-)



Problem No. 1 "Invent Yourself: Paper boomerang"

Make a returning boomerang from a sheet of paper by folding and/or cutting. Investigate how its motion depends on relevant parameters.

Background reading

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- Как сделать круглый бумеранг из бумаги. Оригами. How to make a round paper boomerang. Origami (youtube, Друг Оригами, 02.04.2022), https://youtu.be/hSKSLAFVMAU
- Fly back! This is the really fun origami boomerang 【 123 Paper Airplane 】 (youtube, 123 paper airplane, 20.11.2021), https://youtu.be/SGDzDWpvwOY
- How to Make a Mini Origami Boomerang- Rob's World (youtube, Rob's World, 13.10.2018), https://youtu.be/Mq3Vo-qW52g
- Easy Origami Boomerang (Paper Toys) (youtube, Red Ted Art, 26.05.2016), https://youtu.be/p0A_Lwr7a9s
- How To Make a Paper Boomerang - Origami (youtube, PPO, 15.11.2015), https://youtu.be/OufubGg-FVQ
- The Physics of a Boomerang (youtube, MIT BLOSSOMS, 04.09.2015), https://youtu.be/b2odUBvFzYA
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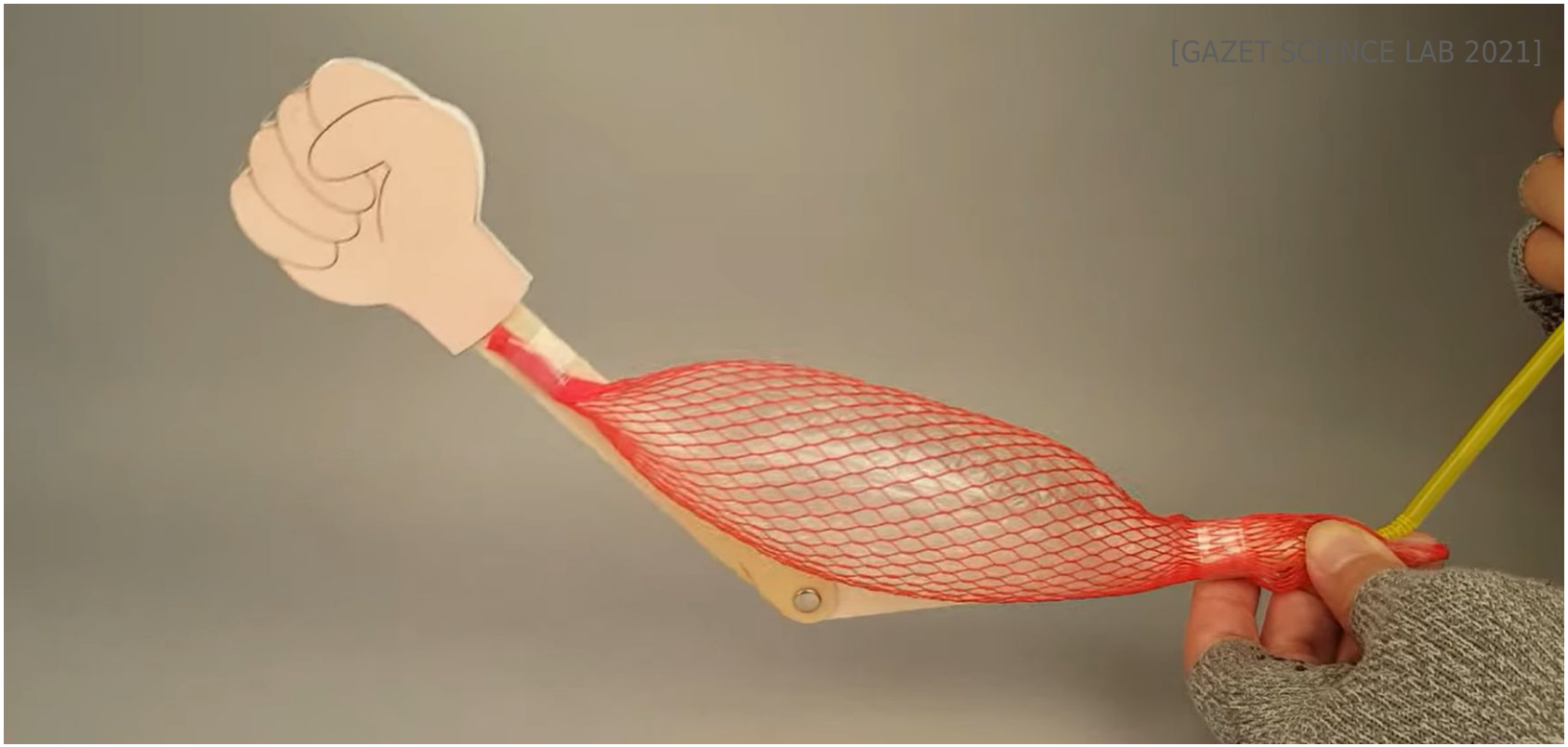
- How to Make a Paper Boomerang (Natalie Kay Smith and Kyle Hall, wikihow.com, 13.03.2024), https://www.wikihow.com/Make-a-Paper-Boomerang



Problem No. 2 “Air muscle”

Place a balloon inside a cylindrical net (as is sometimes used to wrap garlic) and inflate it. The net will expand and shorten. Investigate the properties of such a "muscle".

Background reading

- ИСКУССТВЕННЫЕ МЫШЦЫ для РОБОТА или Экзоскелета? (как сделать и куда применить) / Мягкий Схват (youtube, TrashRobotics, 28.03.2024), https://youtu.be/xJ9LUFiSsuA
- MAKE! arm muscle model (youtube, GAZET SCIENCE LAB, 04.01.2021), https://youtu.be/pBKBAaW3ydE
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- J. Stevenson. Mercator Projection Balloon (josmfs.net, 5 March 2017), https://josmfs.net/wordpress/wp-content/uploads/2018/12/Mercator-Balloon-170306.pdf
- Fluidic Muscle: The innovative principle (festo.com), https://festo.com//net/SupportPortal/Files/340809/Muskel
- Pneumatic Artificial Muscles (softroboticstoolkit.com), https://softroboticstoolkit.com/book/pneumatic-artificial-muscles
- How to Make Air Muscles! (Honus, instructables.com), https://www.instructables.com/How-to-make-air-muscles!/
- Making a Simple Air Muscle (William Gurstelle, makezine.com, May 21st, 2015), https://makezine.com/projects/joseph-mckibben-and-the-air-muscle//

Problem No. 3 “Lato Lato”

Attach a ball to each end of a string and connect the center of the string to a pivot. When the pivot oscillates along the vertical direction, the balls start to collide and oscillate with increasing amplitude. Investigate the phenomenon.

Background reading

- Lato-Lato Problem EXPLAINED by Board Topnotcher DJ Molina (youtube, Kippap Education, 06.06.2023), https://youtu.be/la93MRndo08
- Paano maglaro ng lato lato. Complete guide for beginner. How to play lato lato complete tutorial. (youtube, DaddyniEli, 02.06.2023), https://youtu.be/AFuXjZxQRKE
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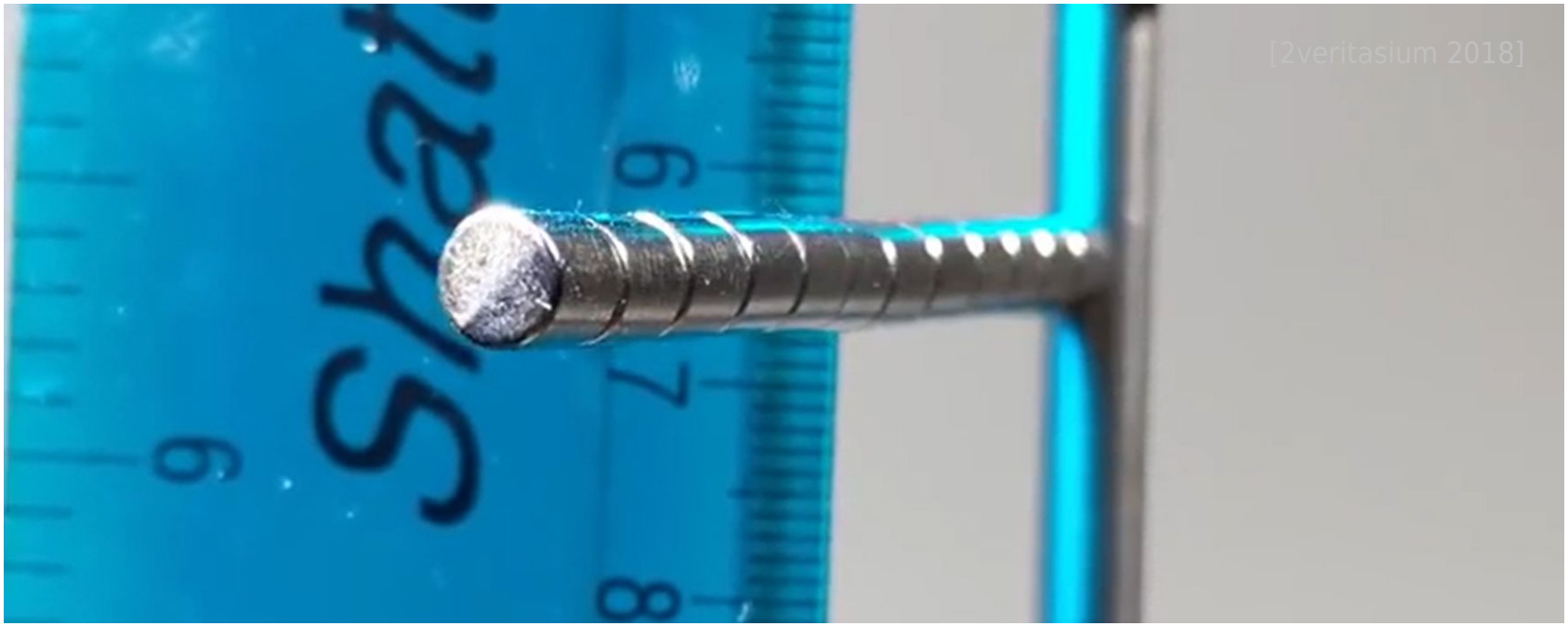
- 1N30.05 - Ball Clackers (umich.edu), https://sharepoint.umich.edu/lsa/physics/demolab/SitePages/1N30.05%20-%20Ball%20Clackers.aspx



Problem No. 4 “Climbing magnets”

Attach a rod assembled from cylindrical neodymium magnets horizontally to a vertical ferromagnetic rod. Limit the motion of the magnets to the vertical direction. When the ferromagnetic rod is spun around its axis of symmetry, the magnetic rod begins to climb up. Explain this phenomenon and investigate how the rate of climbing depends on relevant parameters.

Background reading

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- Магнитный шарик и его необычное движение (youtube, GetAClass - Physics in experiments, 11.02.2023), https://youtu.be/KTSpaCdK14U
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Problem No. 5 “Dancing slinky”

Twist a slinky several times and keep its bottom fixed. After releasing the top, the slinky starts to "dance" – wave-like phenomenon can be observed from the side-view. Explain the phenomenon and investigate the parameters affecting the slinky's motion.

Background reading

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- W. J. Cunningham. The physics of the tumbling spring. Am. J. Phys. 15, 4, 348-352 (1947)

Problem No. 6 “Dripping faucet”

A leaky faucet develops interesting dripping patterns, where the time between drops depends on the water flowrate. Investigate this phenomenon and study how it depends on relevant parameters.

Background reading

- This equation will change how you see the world (the logistic map) (youtube, Veritasium, 29.01.2020), https://youtu.be/ovJcsL7vyrk
- 19.4 Dripping Faucet 8 14 2019 (youtube, UCLA modeling class, 17.08.2019), https://youtu.be/m_Z-SIxqYcI
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Background reading

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- R. M. May. Simple mathematical models with very complicated dynamics. Nature 261, 459-467 (1976)
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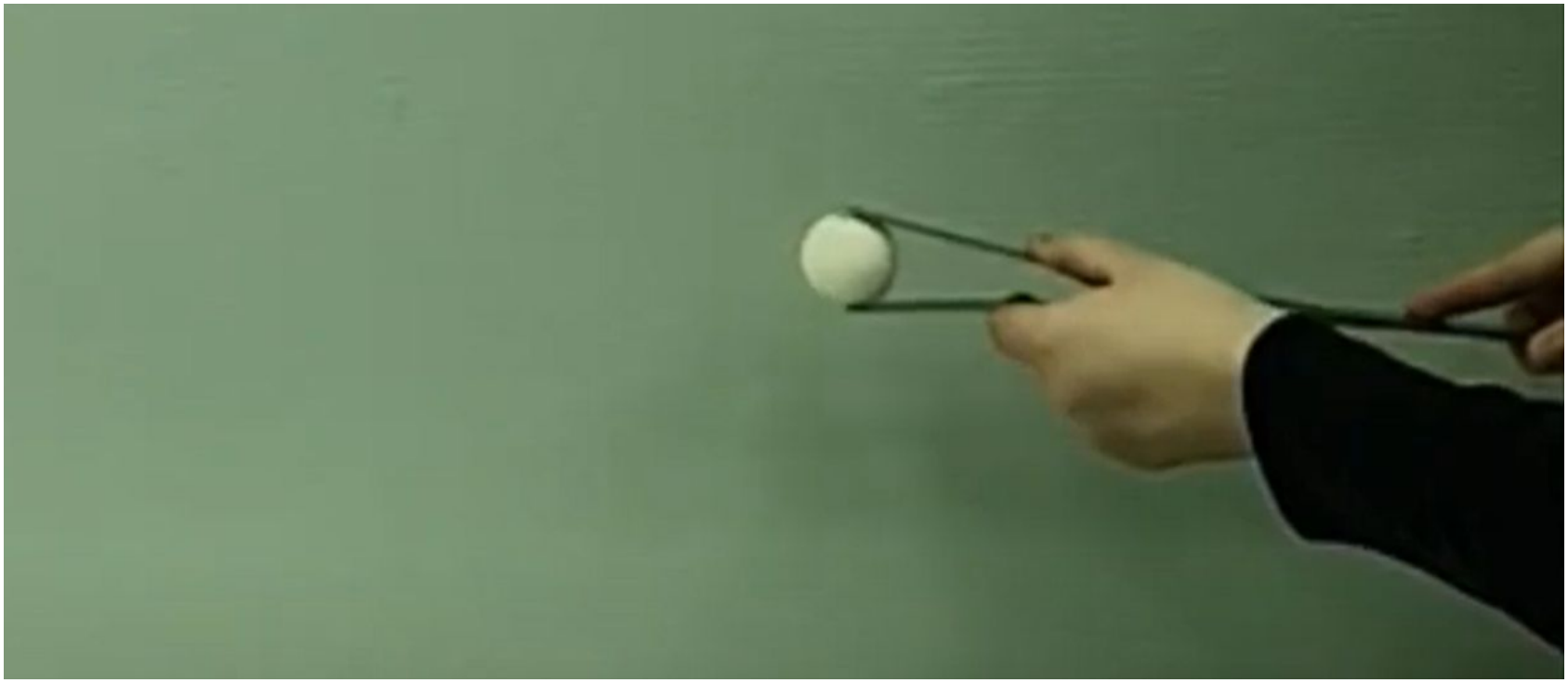

Problem No. 7 “Ruler cannon”

Two rulers are tightly held against each other. A round projectile (e.g. a plastic bottle cap or a ball) is inserted between them close to one of their ends. When extra force is exerted on the surface of the rulers, the projectile is ejected at a high speed. Investigate this effect and the parameters that affect ejection speed.

Background reading

- Ruler Cannon 1 (youtube, Никита Черников, 23.07.2024), https://youtu.be/ArXxTvDPPnM
- Ruler Cannon 2 (youtube, Никита Черников, 23.07.2024), https://youtu.be/6AVvGrh7fb4
- Ruler Cannon 3 (youtube, Никита Черников, 23.07.2024), https://youtu.be/6CQ1zwJaaxw
- Ruler Cannon 4 (youtube, Никита Черников, 23.07.2024), https://youtu.be/GdM-nUX6QDQ
- Friction gun (youtube, Никита Черников, 16.11.2022), https://youtu.be/vggznP9if6w
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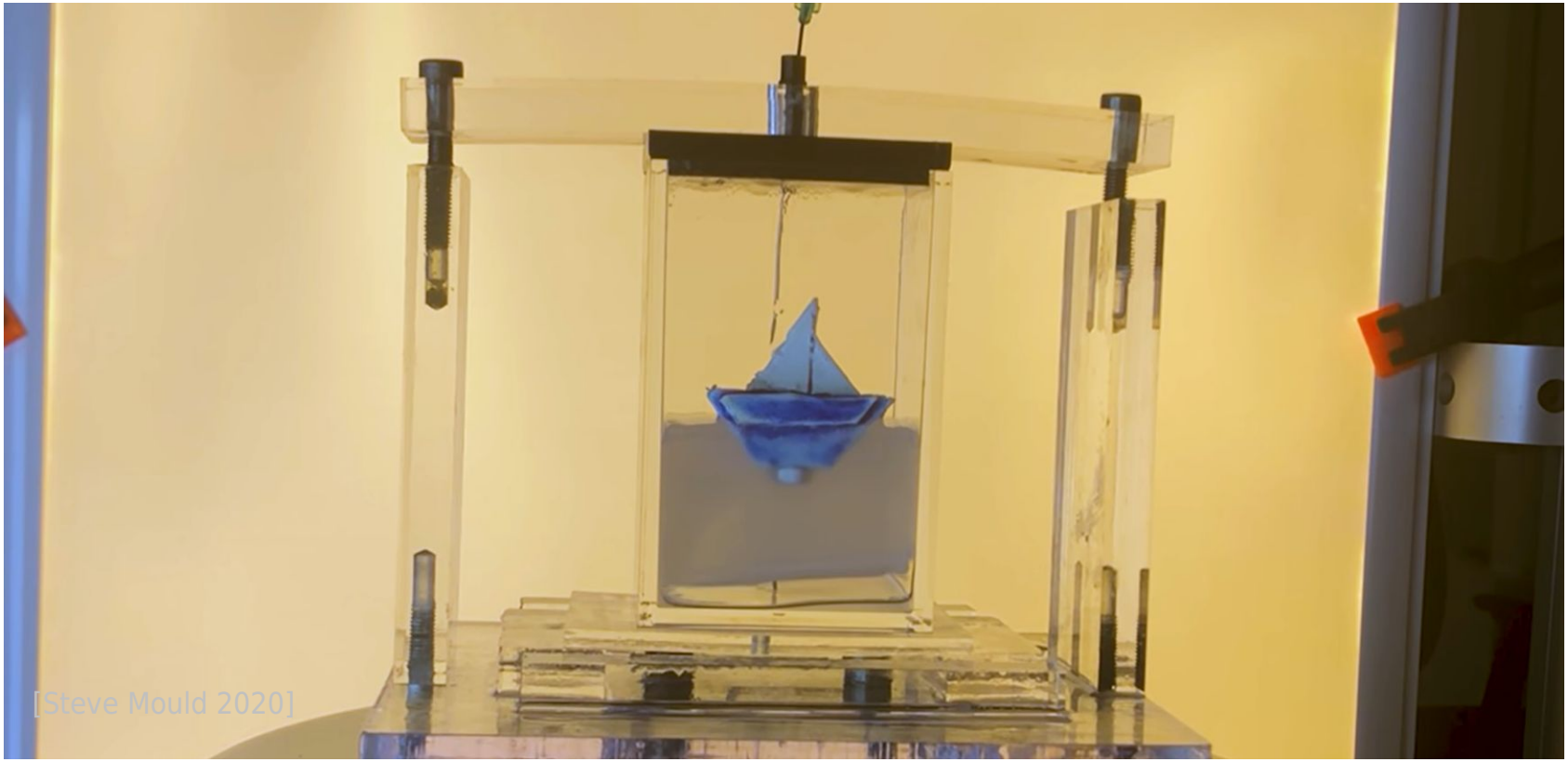

Problem No. 8 “Levitating fluid”

When a container partially filled with liquid is oscillated vertically and air is injected at the bottom of the container, the fluid can "levitate". Investigate the phenomenon.

Background reading

- The Levitating Liquid Pendulum (youtube, Steve Mould, 08.10.2020), https://youtu.be/gMAKamGIiMc
- Creation of a levitating liquid layers (youtube, Emmanuel Fort, 22.10.2020), https://youtube.com/shorts/3eGt3fClJAM
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- B. Apffel, F. Novkoski, A. Eddi, and E. Fort. Floating under a levitating liquid. Nature 585, 48-52 (2020), arXiv:2003.04777v1 [physics.flu-dyn]
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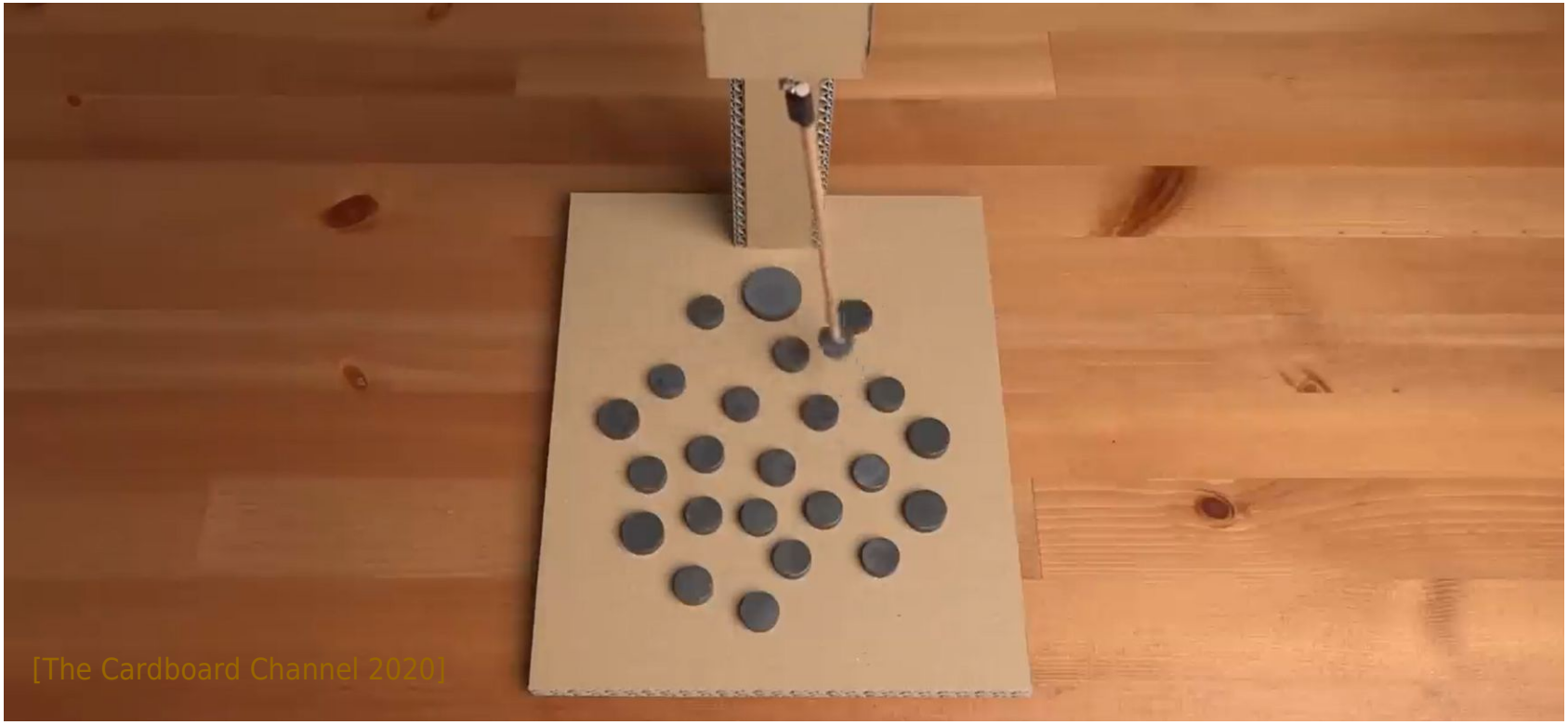

Problem No. 9 “Magnetic assist”

Attach one or two magnets to a non-magnetic and non-conductive base such that they attract a magnet suspended from a string. Investigate how the motion of the moving magnet depends on relevant parameters.

Background reading

- Chaotic magnet pendulum...entertaining and easy to build (youtube, Homemade Science with Bruce Yeany, 23.03.2024), https://youtu.be/axiL50LAFg0
- Chaotic Dynamics of a Magnetic Pendulum (youtube, Richters Finger, 18.12.2022), https://youtu.be/WPqxmEajCO0
- Chaos in the Pendulum (youtube, Zenzicubic, 19.11.2022), https://youtu.be/oVNr5wPHuTs
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- The Chaotic Pendulum (youtube, The Cardboard Channel, 05.02.2020), https://youtu.be/yQeQwwXXa7A
- Demonstration: Chaotic pendulum (youtube, Dmitri Kartofelev, 29.06.2018), https://youtu.be/TYXVgJdcX_Q
- magnetic decision maker (youtube, funlearners, 12.11.2016), https://youtu.be/55J-ZjTTiBc
- Magnetic Pendulum: An example of a chaotic system (youtube, Lutfi Al-Sharif, 25.11.2012), https://youtu.be/vFdZ9t4Y5hQ
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- K. W. Yung, P. B. Landecker, and D. D. Villani. An analytical solution for the force between two magnetic dipoles. Mag. Elec. Sep. 9, 39-52 (1998)
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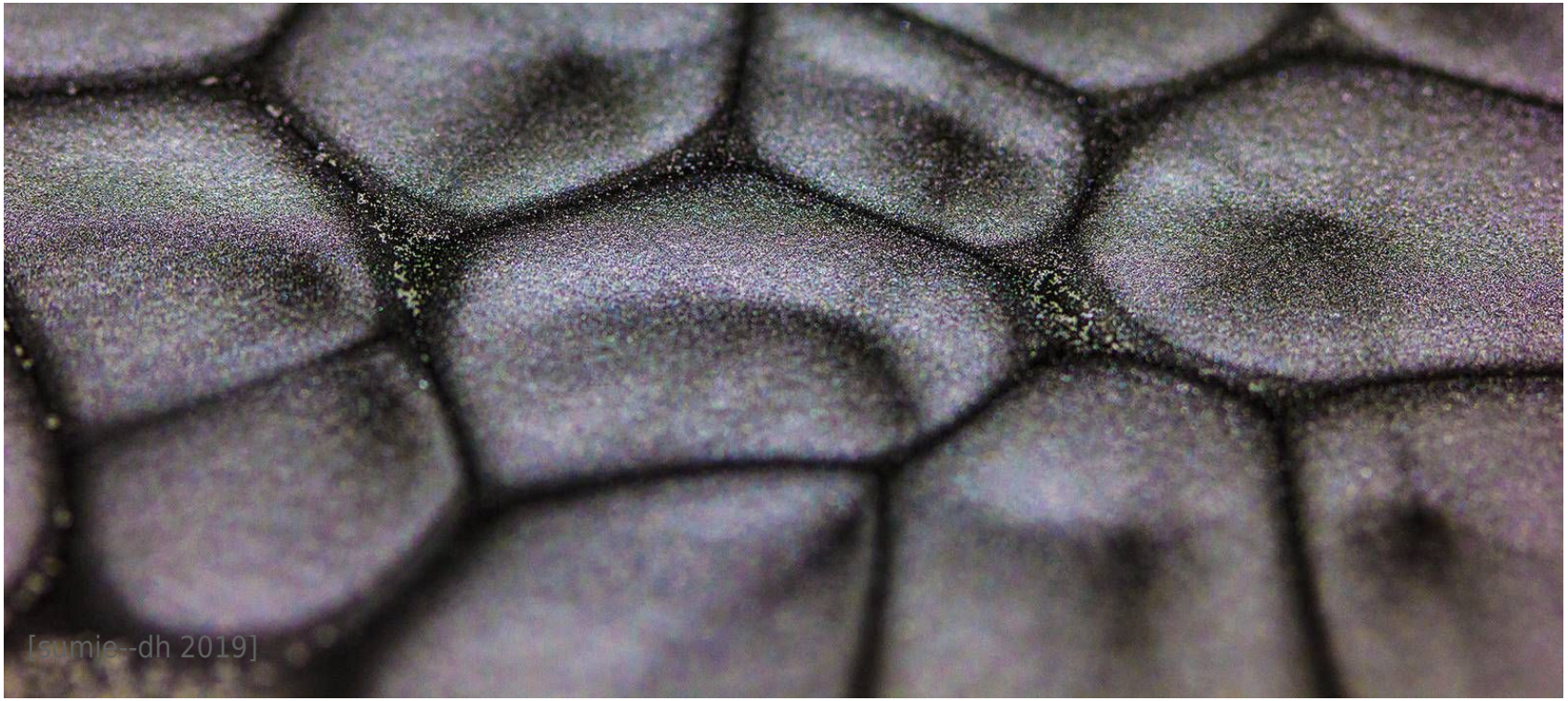

Prob. No. 10 “Rayleigh-Bénard convection”

Uniformly and gently heat the bottom of a container containing a suspension of powder in oil (e.g. mica powder in silicon oil), cell-like structures may form. Explain and investigate this phenomenon.

Background reading

- Rayleigh–Bénard Convection in Silicone Oil + Mica Powder, Ra = 9894, Pr = 10023, Aspect Ratio 8:8:1 (youtube, Martin Petry, 29.04.2024), https://youtu.be/Rna6QR7pNwg
- Experiments on Rayleigh–Bénard Convection in Silicone Oil (youtube, Martin Petry, 18.08.2023), https://youtu.be/mvl3P4Vh9as
- Rayleigh-Benard convection at Ra=10^11 (youtube, Alessandro De Rosis, 25.05.2023), https://youtu.be/V-mp8jcMJaE
- Ячейки Бенара ● 3 (youtube, GetAClass - Physics in experiments, 25.04.2020), https://youtu.be/yXLGYaXgQ2g
- Ячейки Бенара ● 2 (youtube, GetAClass - Physics in experiments, 24.04.2020), https://youtu.be/PqgzWGX_wa8
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- Benard-Marangoni instability (youtube, Fluid Dynamics, 11.12.2016), https://youtu.be/v2vMXmuC818
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- Rayleigh Benard Thermal Convection 3D Simulation with LBM -- Simulations in Process Engineering (youtube, openlb, 17.09.2015), https://youtu.be/buskqZlPdvI
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Background reading

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- Wikipedia: Rayleigh-Bénard convection, https://en.wikipedia.org/wiki/Rayleigh%E2%80%93B%C3%A9nard_convection
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Problem No. 11 “Spring hysteresis”

Connect two identical linear springs symmetrically to a mass in a "V" shape, and apply an adjustable force to the mass. When this force is varied, the resulting motion of the mass depends on the history of changes in the applied force under certain conditions. Investigate this phenomenon.

Background reading

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- J. J. Bissell. Bifurcation, stability, and critical slowing down in a simple mass–spring system. Mech. Res. Commun. 125, 103967 (2022)
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Problem No. 12 "Sound versus fire"

A small flame can be put out by sound. Investigate the parameters of the flame and characteristics of the sound that determine whether the flame will be extinguished.

Background reading

- МЫ ПОГАСИЛИ ОГОНЬ ЗВУКОМ ! (youtube, GoldenBurst, 29.05.2024), https://youtu.be/OtMB6_KngYY
- Можно ли потушить свечу с помощью звука? #shorts #разрушителимифов (youtube, Мифы и Факты, 13.10.2023), https://youtube.com/shorts/7fgPbHs16P8
- Sound To Blow Out Candle (youtube, n Beats, 29.03.2023), https://youtu.be/Yo4KswfwYzo
- How Does This App Blow Out Candles? (youtube, The Action Lab, 13.12.2021), https://youtu.be/tX6XSs2T5Go
- How to see sound blowing out candles (youtube, Homeschool Fridays, 04.02.2019), https://youtube.com/shorts/PhDI_qXagwQ
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- IMAX Subwoofer Blows Out Candles Using Interstellar Soundtrack (youtube, Timothy J. Alguire, 27.04.2015), https://youtu.be/sPWPvT9au7U
- Pump Up the Bass to Douse a Blaze: Mason Students' Invention Fights Fires (youtube, George Mason University, 05.02.2015), https://youtu.be/uPVQMZ4ikvM
- C. Xiong, Z. Wang, and X. Huang. Acoustic flame extinction by the sound wave or speaker-induced wind? Fire Saf. J. 126, 103479 (2021)
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- P. Niegodajew, K. Łukasiak, H. Radomiak, D. Musiał, M. Zajemska, A. Poskart, and K. Gruszka. Application of acoustic oscillations in quenching of gas burner flame. Combust. Flame 194, 245-249 (2018)
- A. N. Friedman and S. I. Stoliarov. Acoustic extinction of laminar line-flames. Fire Saf. J. 93, 102-113 (2017)
- A. A. Alexander. Study of sound wave as a flame extinguisher (PhD thesis, Universiti Teknologi PETRONAS, 2015), https://utpedia.utp.edu.my/id/eprint/15706/1/Dissertation%20-%20Alan%20A.%20A.%20-%2016036.pdf
- How Does a Candle Flame Respond to a Sound Wave? - Question of the Week 2014 Summer Girls Special Part 1 (physics.umd.edu, 2014), https://lecdem.physics.umd.edu/question-of-the-week-archive/154-qotw-020-with-answer.html
- Dousing flames with low-frequency sound waves (physicsworld.com, 02 Apr 2015), https://physicsworld.com/a/dousing-flames-with-low-frequency-sound-waves/
- Charlie K. Thrift. Using Sound Waves to Extinguish Flames (CALIFORNIA STATE SCIENCE FAIR, 2016), https://csef.usc.edu/History/2016/Projects/J1724.pdf

Problem No. 13 “Spaghetti accelerator”

When a piece of spaghetti is pushed into a bent tube, small debris of spaghetti may be ejected from the other end of the tube at a surprisingly high speed. Investigate this phenomenon.

Background reading

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- spaghetti snapped at 420 fps with Casio EX-FH20 High Speed Camera (youtube, Iainp1211, 02.01.2009), https://youtu.be/kuofWlxfUSE
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- R. W. D. Nickalls. The dynamics of linear spaghetti structures — how one thing just leads to another :-) (nickalls.org, June 14, 2006), http://www.nickalls.org/dick/papers/spaghetti/spaghetti.pdf
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Problem No. 14 “Water bottle rocket”

Pump air into a plastic water bottle partially filled with water. Under certain conditions, the bottle is launched and flies into the air. Investigate how the acceleration during lift-off depends on relevant parameters.

Background reading

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- Галилео. Эксперимент. Водяная ракета (youtube, GalileoRU, 24.02.2014), https://youtu.be/Y-hvDuw-5wQ
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Background reading

- C. J. Gommes. A more thorough analysis of water rockets: Moist adiabats, transient flows, and inertial forces in a soda bottle. Am. J. Phys. 78, 3, 236-243 (2010)
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Problem No. 15 “Wailing bowl”

When you strike the side of a metal bowl containing some water, you can hear a characteristic sound. The sound changes when the water in the bowl is moving. Explain and investigate the phenomenon.

Background reading

- IYPT 2025 - пустая миска (youtube, Никита Черников, 31.07.2024), https://youtu.be/def1MOypBpU
- IYPT 2025 - миска с водой (youtube, Никита Черников, 31.07.2024), https://youtu.be/f-kjTzymD88
- IYPT 2025 - миска с подвижной водой (youtube, Никита Черников, 31.07.2024), https://youtu.be/Z4iMfXT-QY8
- Weird noise made using a metal bowl filled with water (youtube, Wynolan, 15.11.2023), https://youtu.be/N255WPwvT7M
- D. Terwagne and J. W. M. Bush. Tibetan singing bowls. Nonlinearity 24, R51–R66 (2011), arXiv:1106.6348v1 [physics.flu-dyn]
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- How does the sound changes when we strike a empty bowl and a water filled bowl (byjus.com), https://byjus.com/question-answer/how-does-the-sound-changes-when-we-strike-a-empty-bowl-and-a-water-filled/
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- N. H. Fletcher and T. D. Rossing. The physics of musical instruments (New York, SpringerVerlag, 1991)
- Lord Rayleigh. The Theory of Sound (London, Macmillan, 1877, Courier Dover Publications, 1945), http://books.google.com/books?id=v4NSAlsTwnQC, http://books.google.com/books?id=Frvgu1wSFfU

Problem No. 16 “Wirtz pump”

A Wirtz Pump is a hollow spiral, mounted vertically. It is arranged such that one end dips below water once per revolution, while the other end (at the center of the spiral) is connected to a vertical tube. When rotated, it can be used to pump water to a great height. Explain this phenomenon and investigate how relevant parameters affect the pumping height.

Background reading

- Wirtz pumps are really clever (youtube, Steve Mould, 10.10.2023), https://youtu.be/wCxRHueX6jQ
- Water wheel pump (youtube, Milan Vitéz, 20.03.2011), https://youtu.be/mN9iLNHGOYI
- R. Matz, R. Błażejewski, T. Nawrot, and M. Pawlak. Hydraulic capacity and efficiency of a low-speed nonpressurized coil pump. Water 11, 8, 1659 (2019)
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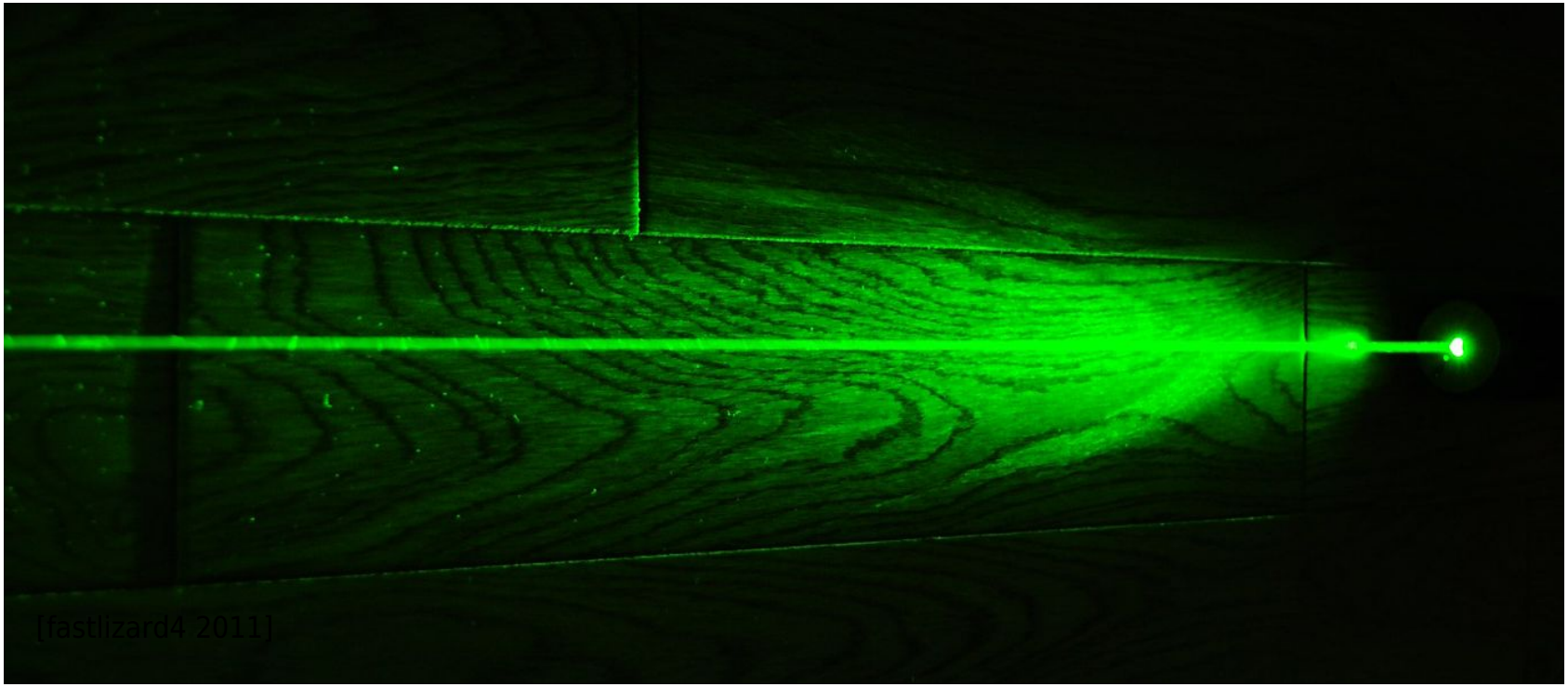

Problem No. 17 “Quantum fingerprint”

Shine laser light onto an organic polymer (e.g. styrofoam). The scattered light may have a higher or lower wavelength than the incident light. Explain the phenomenon and determine what can be concluded about the molecular structure of the material from the wavelength shift.

Background reading

- Homemade Raman Spectroscopy (youtube, Chemistry 4all, 16.08.2017), https://youtu.be/Rjk55FZBPKk
- Intro to DIY Raman Spectroscopy (youtube, Applied Science, 27.05.2013), https://youtu.be/tRrOdKW06sk
- Wikipedia: Raman spectroscopy, https://en.wikipedia.org/wiki/Raman_spectroscopy
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- Understanding Raman Spectroscopy: Principles and Theory (T. Adamo, utsc.utoronto.ca, 2021), https://www.utsc.utoronto.ca/~traceslab/PDFs/raman_understanding.pdf
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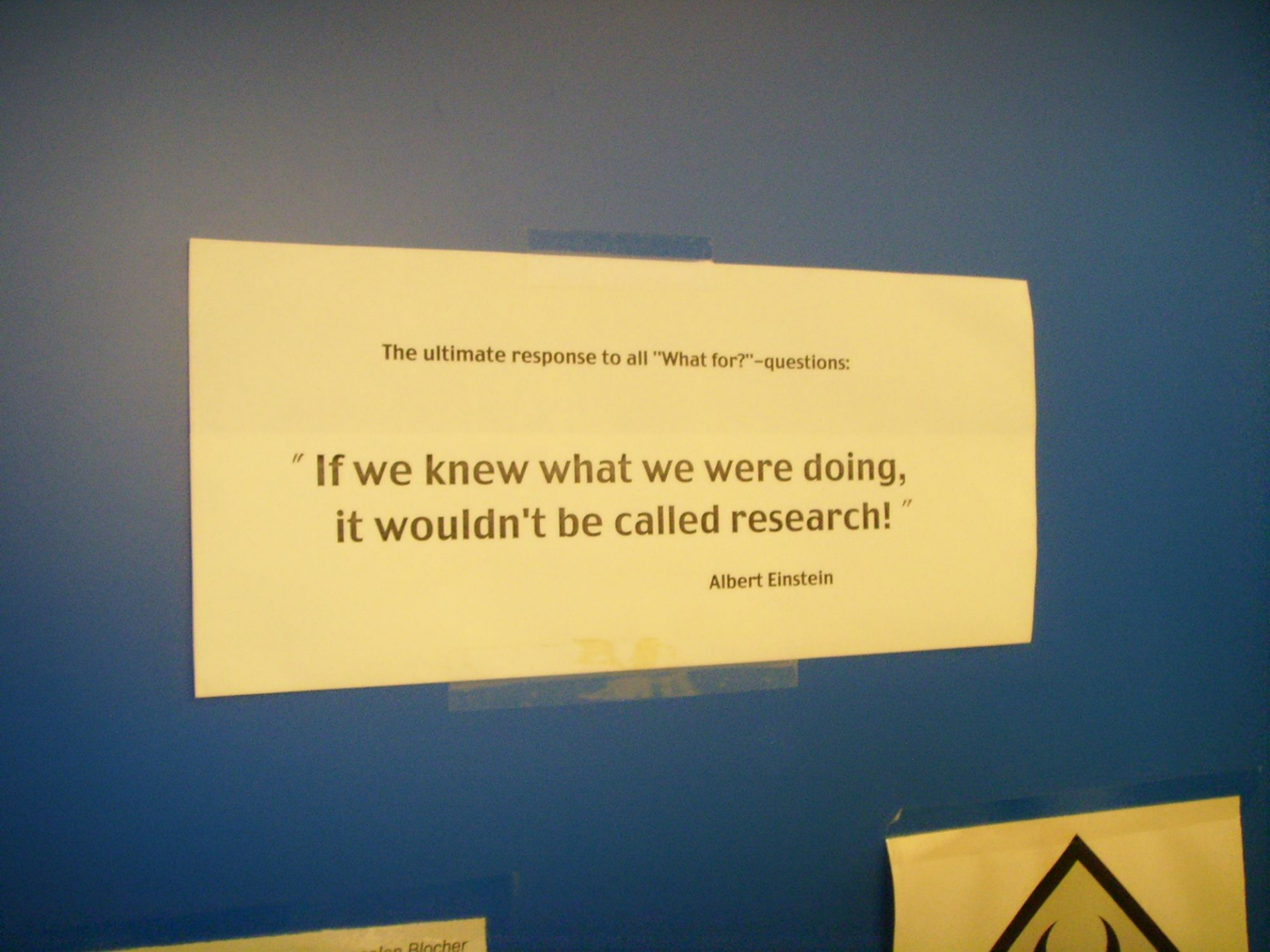

The ultimate response to all "What for?"-questions:
" If we knew what we were doing,
it wouldn't be called research! "
Albert Einstein

Important information

- The basic goal of this Kit is not in providing students with a start-to-finish manual or in limiting their creativity, but in encouraging them to
  - regard their work critically,
  - look deeper,
  - have a better background knowledge,
  - be skeptical in embedding their projects into the standards of professional research,
  - and, as of a first priority, be attentive in not “re-inventing the wheel”
- An early exposure to the culture of scientific citations, and developing a responsible attitude toward making own work truly novel and original, is assumed to be a helpful learning experience in developing necessary standards and attitudes
- Good examples are known when the Kit has been used as a concise supporting material for jurors and the external community; the benefits were in having the common knowledge structured and better visible
- Even if linked from iypt.org, this file is not an official, binding release of the IYPT, and should under no circumstances be considered as a collection of authoritative “musts” or “instructions” for whatever competition
- All suggestions, feedback, and criticism about the Kit are warmly appreciated

Habits and customs

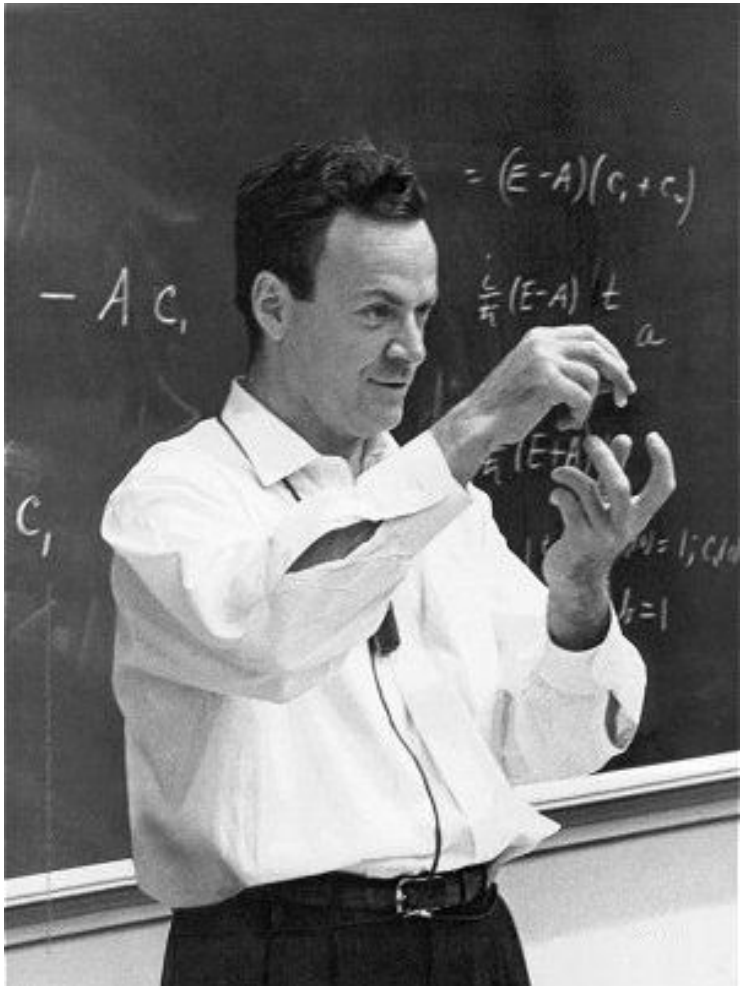
- Originality and independence of your work is always considered as of a first priority
- There is no “correct answer” to any of the IYPT problems
- Having a deep background knowledge about earlier work is a must
- Taking ideas without citing is a serious misconduct
- Critically distinguishing between personal contribution and common knowledge is likely to be appreciated
- Reading more in a non-native language may be very helpful
- Local libraries and institutions can always help in getting access to paid articles in journals, books, and databases
- The IYPT is not about reinventing the wheel, or innovating, creating, discovering, and being able to contrast own work with earlier knowledge and the achievements of others?
- Is IYPT all about competing, or about developing professional personal standards?

Requirements for a successful IYPT report

- Novel research, not a survey or a compilation of known facts
- Balance between experimental investigation and theoretical analysis
- Comprehensible, logical and interesting presentation, not a detailed description of everything-you-have-performed-and-thought-about
- Clear understanding of the validity of your experiments, and how exactly you analyzed the obtained data
- Clear understanding of what physical model is used, and why it is considered appropriate
- Clear understanding of what your theory relies upon, and in what limits it may be applied
- Comparison of your theory with your experiments
- Clear conclusions and clear answers to the raised questions, especially those in the task
- Clear understanding of what is your novel contribution, in comparison to previous studies
- Solid knowledge of relevant physics
- Proofread nice-looking slides
- An unexpected trick, such as a demonstration *in situ*, will always be a plus

Feynman: to be self-confident?

- “I’ve very often made mistakes in my physics by thinking the theory isn’t as good as it really is, thinking that there are lots of complications that are going to spoil it
- — an attitude that anything can happen, in spite of what you’re pretty sure should happen.”



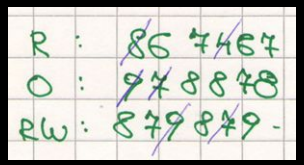
R.P. Feynman. Surely You’re Joking, Mr. Feynman (Norton, New York, NY, 1985)

Call for cooperation

- If you are interested in the idea behind the Kit — to structure the existing knowledge about the physics behind the problems and to encourage students to contrast their personal contribution from the existing knowledge — your cooperation is welcome
- If more contributors join the work on the Kit for 2025, or plan bringing together the Kit for 2026, good editions may be completed earlier
- It would be of benefit for everybody,
  - students and team leaders, who would have an early reference (providing a first impetus to the work) and a strong warning that IYPT is all about appropriate, novel research, and not about “re-inventing the wheel”
  - jurors, who would have a brief, informal supporting material, possibly making them more objective about the presentations
  - the audience outside the IYPT, who benefits from the structured references in e.g. physics popularization activities and physics teaching
  - the IYPT, as a community and a center of competence, that may generate original, state-of-the-art research problems, widely used in other activities and at other events
  - and also the authors of the Kit, who could rapidly acquire a competence for the future activities and have a great learning experience

In search for missing results

- Have you attended an IYPT marked in **red** and preserved Physics Fight results, e.g. by keeping printed rankings?
- Have you attended an IYPT marked in **orange** or **red**, and recorded grades from a Fight, e.g. by writing them down?



iypt archive

Green: each and every Juror's grade has been preserved
Orange: all Sums of Points (SP) are known, but some Juror's grades are not
Red: some Sums of Points (SP) are missing

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2020	2021	2022	2023	2024					

Thank you for helping us locate the missing results of past IYPTs

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Preparation to 38th IYPT' 2025: references, questions and advices

Ilya Martchenko, [1] * Nikita Chernikov, [2]
Aleksandr Zinkevich, [2] and Anastasiya Litvinova [3]

[1] Foundation for Youth Tournaments
[2] Novosibirsk State University
[3] Digital School

August 2, 2024

* http://kit.ilyam.org