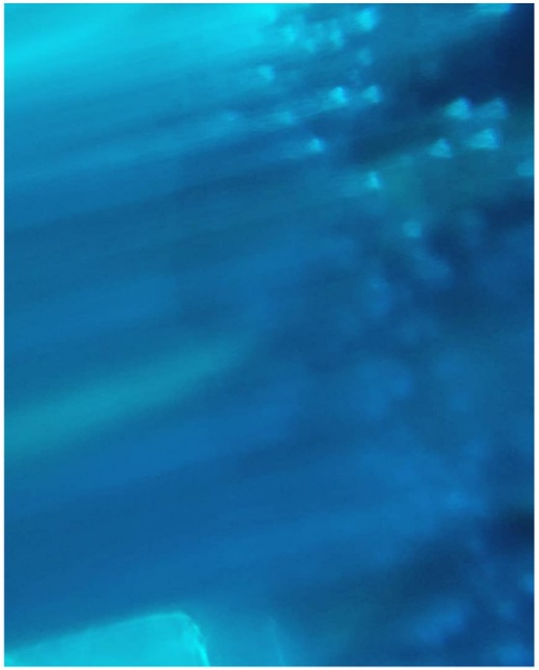
Enhanced edition // December 27, 2023



Preparation to the Young Physicists' Tournaments' 2022

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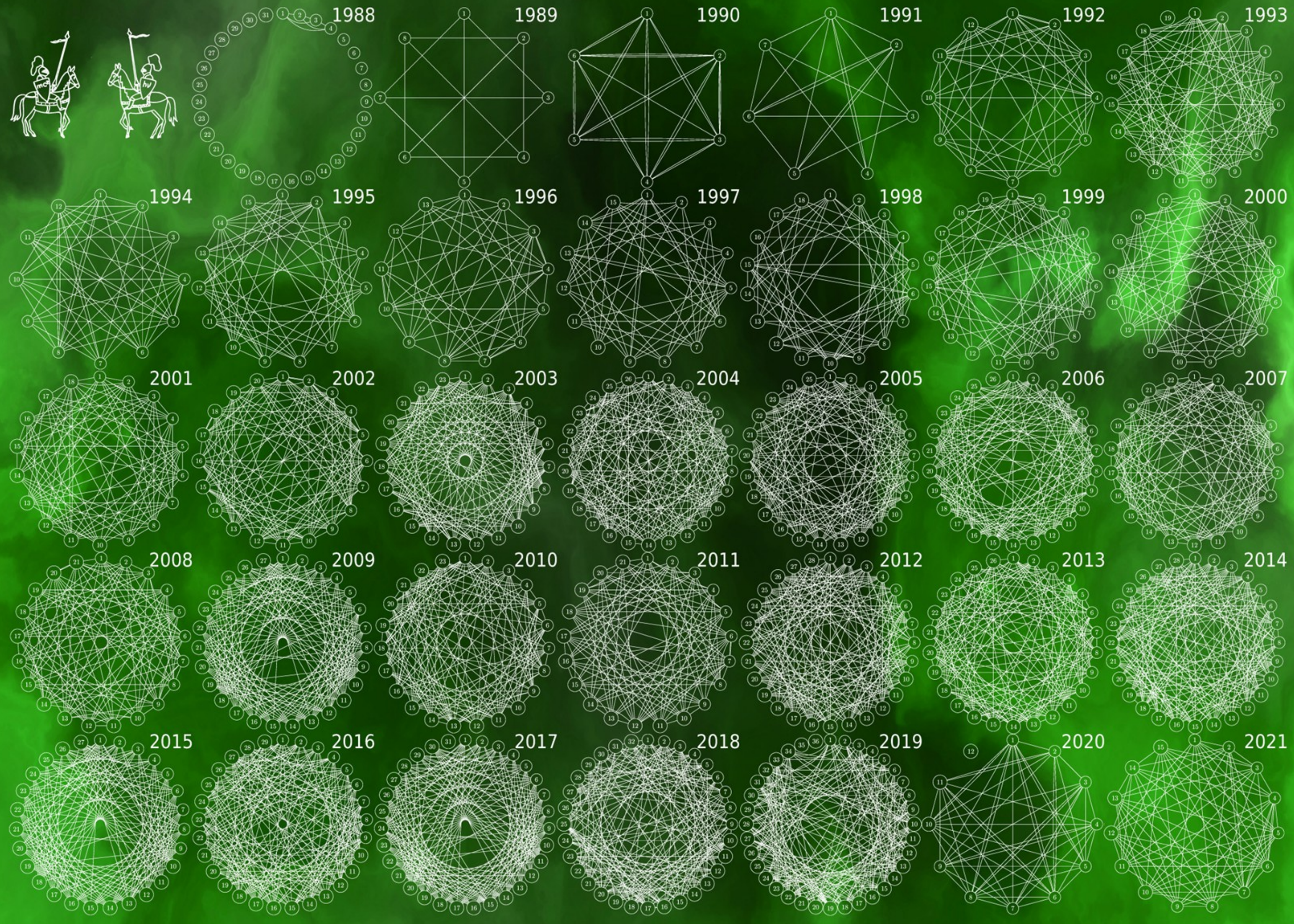

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Is the novel research limited and
discouraged by the existing common
knowledge and the ongoing work of
competing groups? :-)

How to tackle the IYPT problems?

- How to structure a report?
- What level is competitive?
- How to set the goals, fix the priorities, and set the direction of the work?
- How were people resolving particular issues in the past?

- Look through the historical solutions in the Archive
  - an opportunity for goal-oriented critical learning
  - examples, not guidelines
  - those solutions were good, but yours should be better!

iypt archive mc^2 hv

Problem No. 1 “Invent yourself”

Create a non-invasive device that determines the direction of fluid flow inside an opaque pipe. Optimise your device so that you can measure the smallest flow possible.

Background reading

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- Flow Meters for Liquid Flow in Pipes (rshydro.co.uk), https://www.rshydro.co.uk/liquid-pipe-flowmeters/

Background reading

- What is a Thermal Mass Flow Meter? (omega.com), https://www.omega.com/en-us/resources/thermal-mass-flow-working-principle-theory-and-design
- Clamp On Heat Meters (rshydro.co.uk), https://www.rshydro.co.uk/flow-meters/heat-meters/
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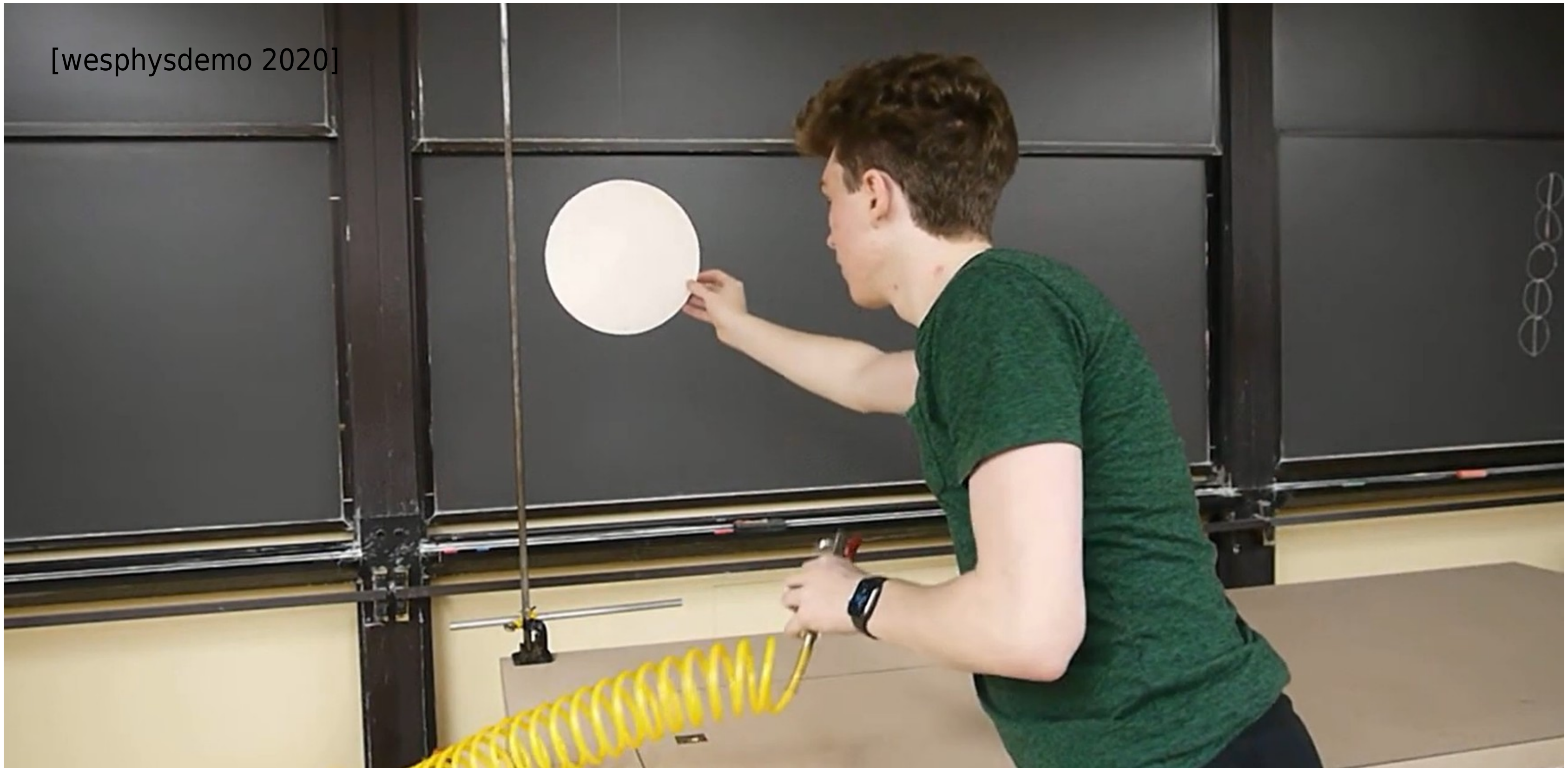

Problem No. 2 “Rayleigh disk”

A disk suspended vertically by a thin thread is placed in an acoustic field. This device can be used to measure the intensity of sound by turning about the axis of the thread. Investigate the accuracy of such a device.

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Problem No. 3 “Ring on the rod”

A washer on a vertical steel rod may start spinning instead of simply sliding down. Study the motion of the washer and investigate what determines the terminal velocity.

Background reading

- Ring on the rod has blown my mind! 🤯 (youtube, Runqiu Ye, 24.04.2022), https://youtu.be/VOA27D4O92o
- Кольцо на стержне ● 2 (youtube, GetAClass - Физика в опытах и экспериментах, 13.11.2021), https://youtu.be/m_eyPr3yOhw
- Кольцо на стержне ● 1 (youtube, GetAClass - Физика в опытах и экспериментах, 11.11.2021), https://youtu.be/p3naBTGr1Pc
- IYPT Ring on the Rod Demonstration - Single Point Contact (youtube, Aradhya Jain, 06.09.2021), https://youtu.be/qIGe3ycTujI
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- Gyro Ring in slow motion (the fidget spinner of the 90's) (youtube, ExpertGeneralist, 23.07.2017), https://youtu.be/eYEZ39oXDzI
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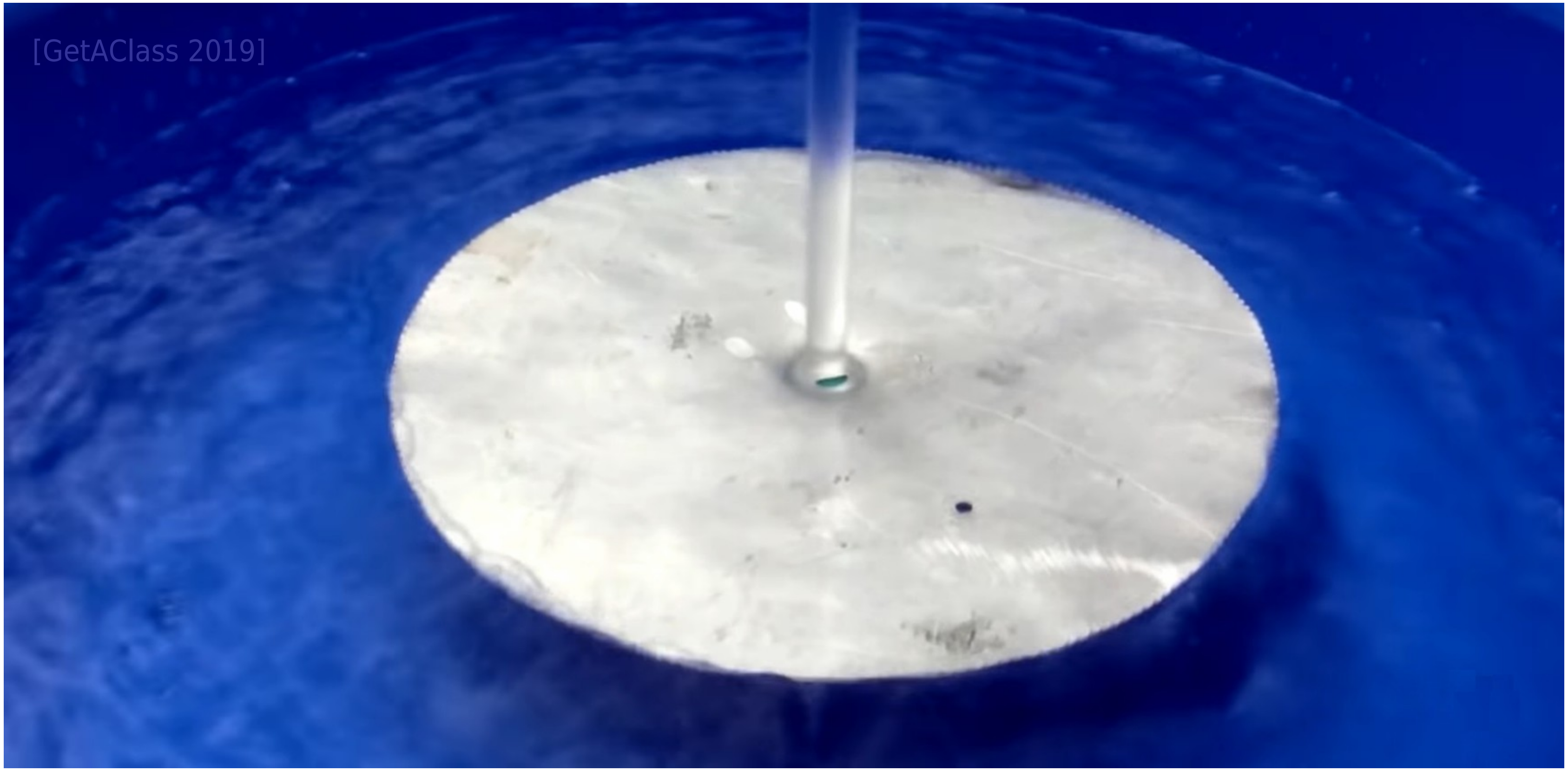

Problem No. 4 “Unsinkable disk”

A metal disk with a hole at its centre sinks in a container filled with water. When a vertical water jet hits the centre of the disc, it may float on the water surface. Explain this phenomenon and investigate the relevant parameters.

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- Unsinkable Disk 19.80mm (youtube, Unsinkable Disk 2021, 25.12.2021), https://youtu.be/IIF6OzOb1RQ
- Unsinkable Disk 9.35mm (youtube, Unsinkable Disk 2021, 25.12.2021), https://youtu.be/gNKrhalCMmA
- Unsinkable Disk 6.55mm (youtube, Unsinkable Disk 2021, 25.12.2021), https://youtu.be/xpEGTOes0jM
- Unsinkable Disk 1.25mm (youtube, Unsinkable Disk 2021, 25.12.2021), https://youtu.be/4lI9tNIrMbs
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- Непотопляемый диск (youtube, GetAClass - Физика в опытах и экспериментах, 10.05.2019), https://youtu.be/eP5_9eUjfkI
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- R. P. Godwin. The hydraulic jump (‘shocks’ and viscous flow in the kitchen sink). Am. J. Phys. 61, 9, 829-832 (1993)
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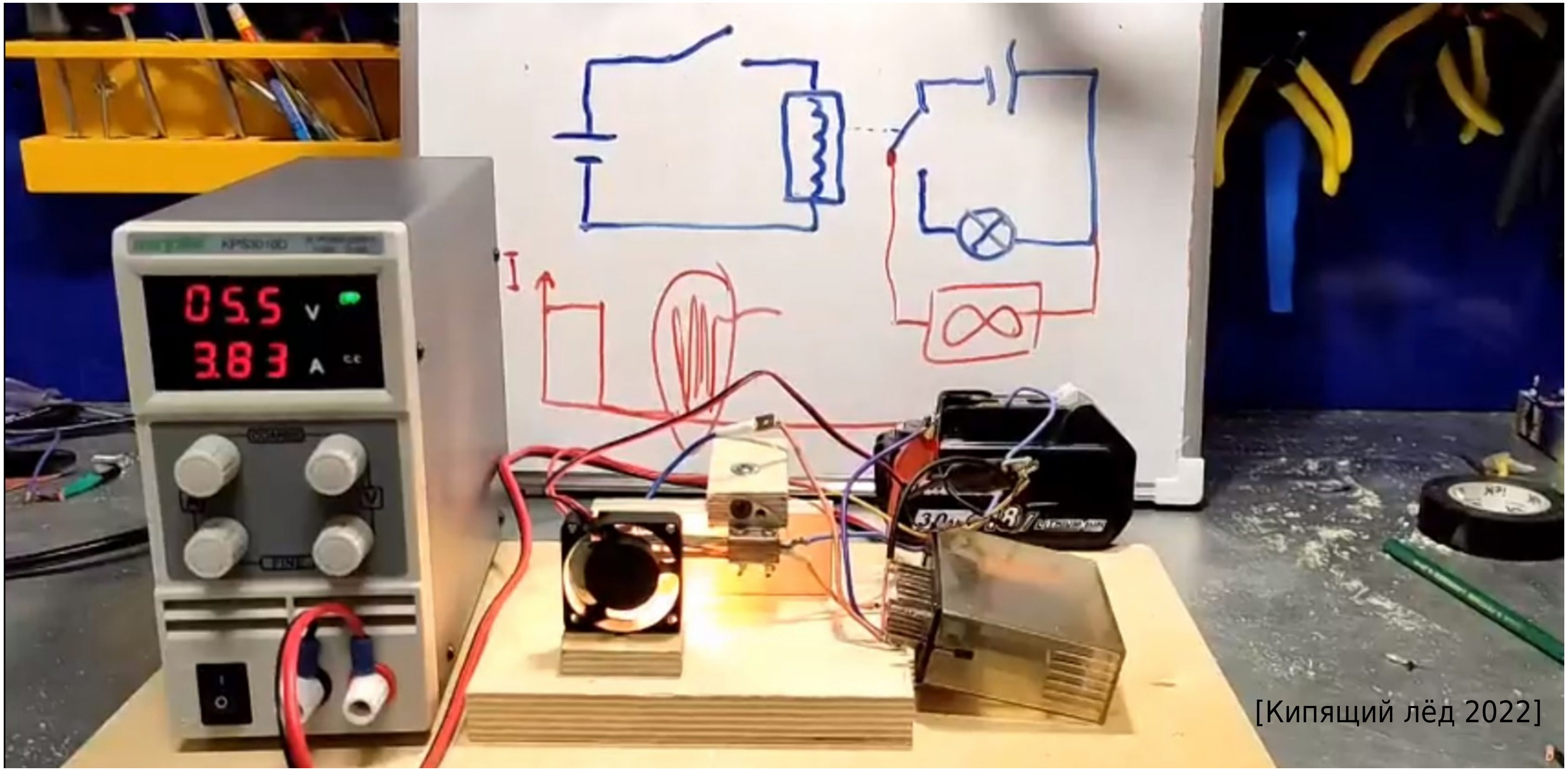

Problem No. 5 “Bimetallic oscillator”

A simple electric oscillator can be made using a bimetallic contact-breaker. Investigate the relevant parameters that affect the frequency of such an oscillator.

Background reading

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Problem No. 6 “Tennis ball tower”

Build a tower by stacking tennis balls using three balls per layer and a single ball on top. Investigate the structural limits and the stability of such a tower. How does the situation change when more than three balls per each layer and a suitable number of balls on the top layer are used?

Feedback

Letters and comments that appear here may have been edited.
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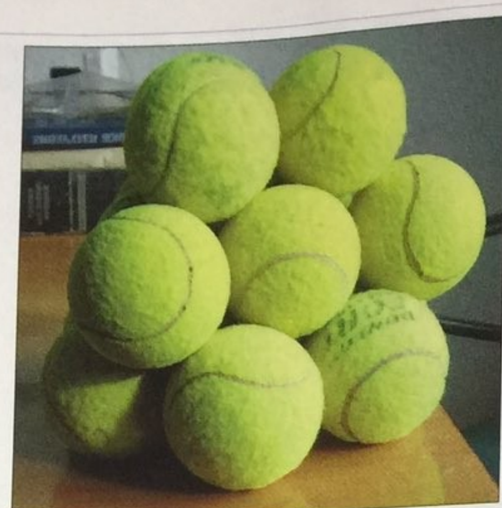
Web physicsworld.com
Twitter @PhysicsWorld
Facebook facebook.com/physicsworld

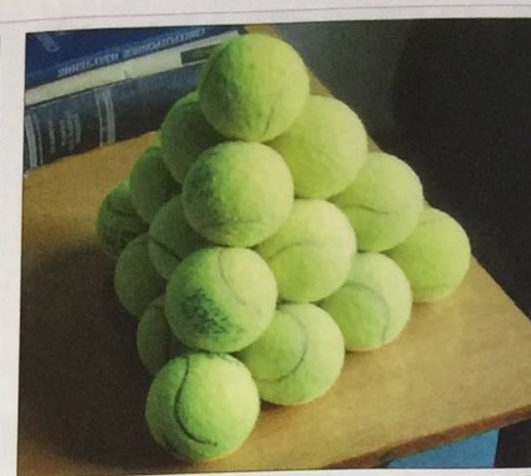
Tennis-ball towers

As a physicist and keen tennis player, I would like to share an amusing "discovery" I recently made. In my office, I have about 20 used tennis balls and so decided to try building some tennis-ball "pyramids".

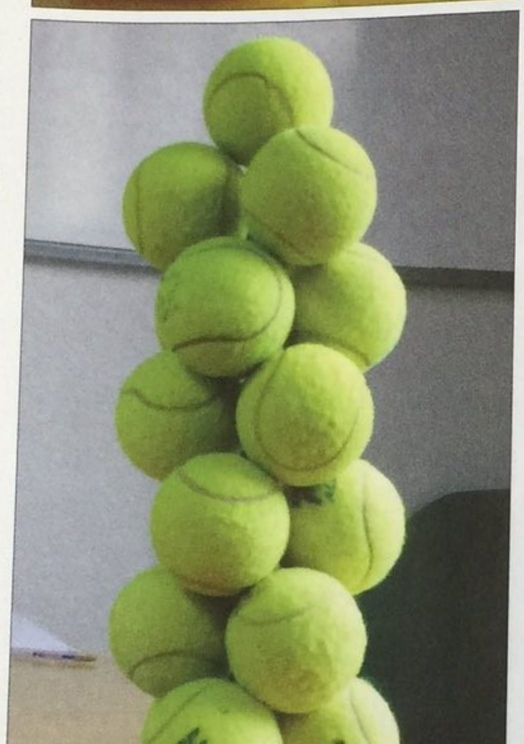
As you might expect, a four-level pyramid has a triangular cross-section, with 10 balls at the bottom, followed by six in the next layer, then three and finally one ball on top (image top right). When I carefully removed the three corner balls from the bottom layer plus the upper-most ball, I ended up a with a beautiful, symmetric structure of 16 balls with three hexagonal and three triangular sides (image top left).

Interestingly, the corner balls in the second-bottom layer are kept in equilibrium, hanging over the layer below. These "exposed" balls are held in place because the balls directly above press down on them and into the two adjacent





All images: Andria Rogava



Background reading

- Record high 3n+1 tennis ball tower with n=11 again (Theessink, Evans & Cooder - Build Myself A Home) (youtube, Andria Rogava, 19.04.2023), https://youtu.be/9UVNfNqFQ7g
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- 3n+1 tower with n=11 (Ace Cannon - Blues Stay Away from Me) (youtube, Andria Rogava, 16.04.2022), https://youtu.be/CYCKYeLfxnI
- Olivier Vernet - Dietrich Buxtehude's Nun komm der heiden heiland (BuxWV 211) (youtube, Andria Rogava, 22.01.2022), https://youtu.be/rTvlk8KE6XY
- Loose 7 Ball Tower (youtube, Andria Rogava, 30.11.2021), https://youtu.be/4spa34zH8kE
- Dietrich Buxtehude - Chorale prélude BuxWV 206, (Bernard Foccroulle) [Pyramidal frustum, 16 balls] (youtube, Andria Rogava, 06.10.2020), https://youtu.be/-EsrbXkx0lo
- Herbie Mann & Stéphane Grappelli - Mellow Yellow (Tennis Ball Towers) (youtube, Andria Rogava, 20.04.2020), https://youtu.be/JoS8vdo1ZTk
- Art Hodes - Make Me a Pallet On The Floor (Three tennis ball towers: 13, 16 and 19 balls) (youtube, Andria Rogava, 06.12.2019), https://youtu.be/r-d3m8fXu2Y
- Ten-storey high 3N+1 tennis ball tower (youtube, Andria Rogava, 13.11.2019), https://youtu.be/Dz31_-gzk7c
- Ten-storey tennis ball tower, 28 balls - falls down (youtube, Andria Rogava, 09.11.2019), https://youtu.be/cvLK6Jd2xJU

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- Six-storey tennis ball tower, 16 balls (youtube, Andria Rogava, 22.05.2019), https://youtu.be/cdnQTMX0W3U
- Nine storey tower, made of 25 balls (youtube, Andria Rogava, 22.05.2019), https://youtu.be/ZIzGfmrcVOw
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Problem No. 7 “Three-sided dice”

To land a coin on its side is often associated with the idea of a rare occurrence. What should be the physical and geometrical characteristics of a cylindrical dice so that it has the same probability to land on its side and one of its faces?

Background reading

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- Does a Fair 3 Sided Coin Exist? (youtube, sirrandalot, 15.09.2020), https://youtu.be/cE12ri79FUQ
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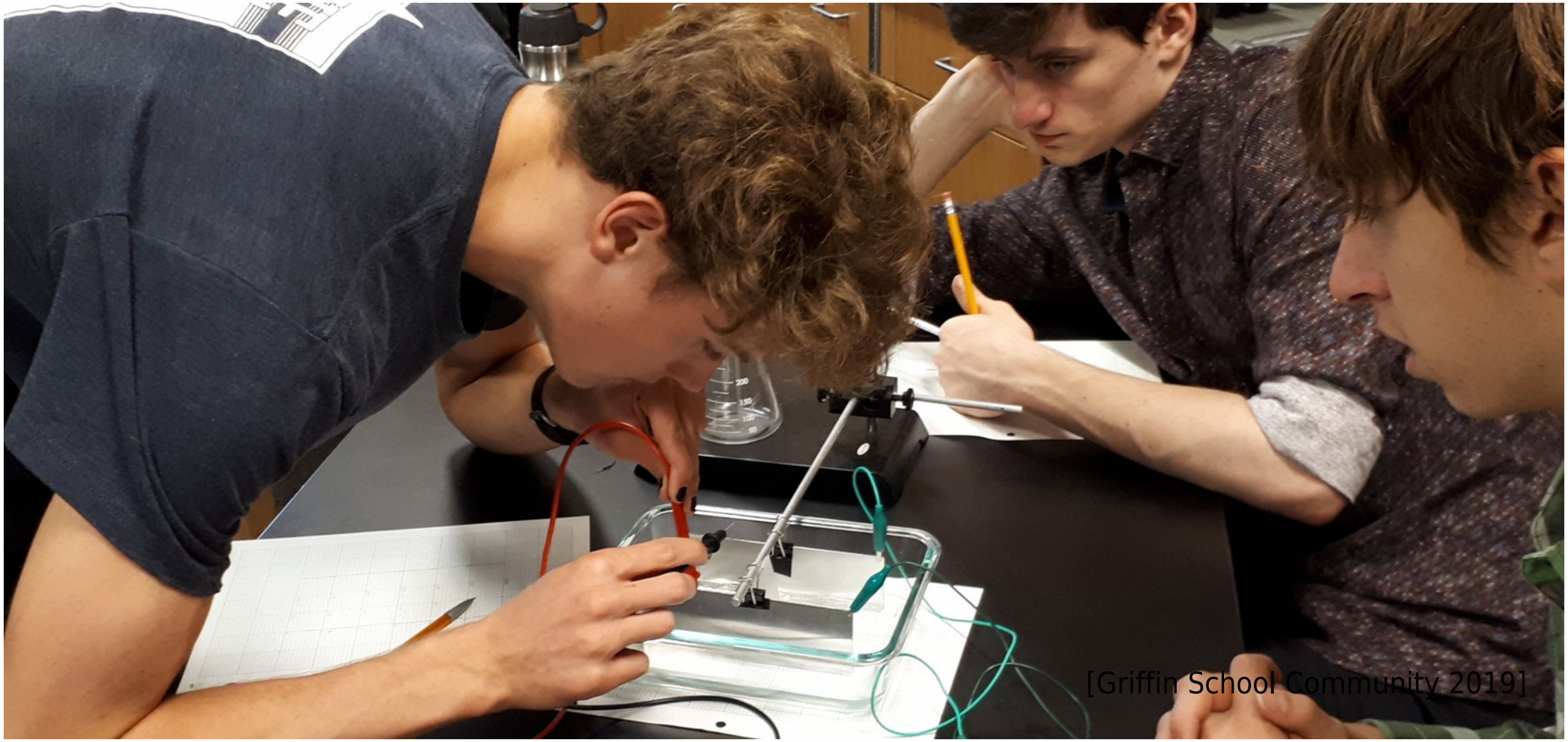

Problem No. 8 “Equipotential lines”

Place two electrodes into water, supply a safe voltage and use a voltmeter to determine electric potential at various locations. Investigate how the measured equipotential lines deviate from your expectations for different conditions and liquids.

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Problem No. 9 “Water spiral”

If a stream of liquid is launched through a small hole, then under certain conditions it twists into a spiral. Explain this phenomenon and investigate the conditions under which the spiral will twist.

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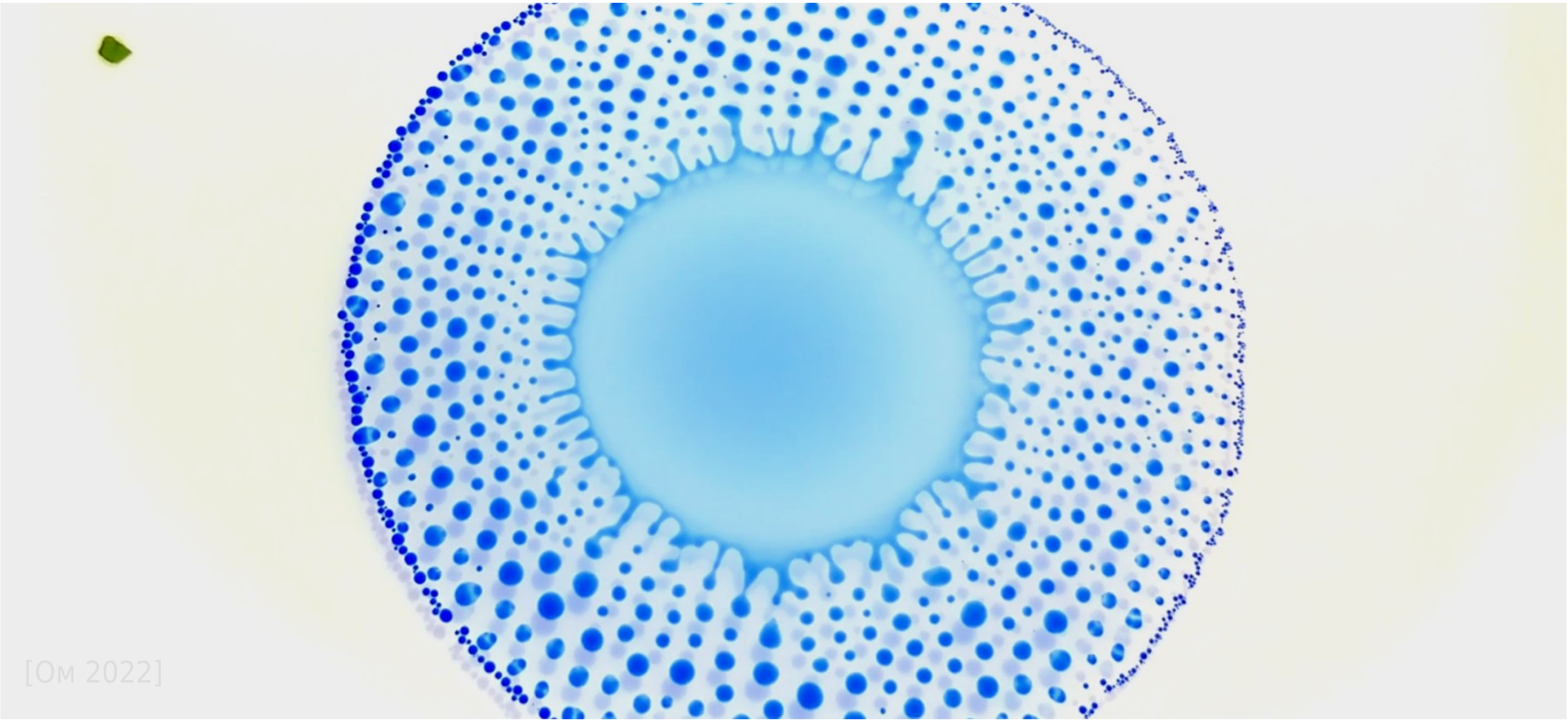

Problem No. 10 “Droplet explosion”

When a drop of a water mixture (e.g. water-alcohol) is deposited on the surface of a hydrophobic liquid (e.g. vegetable oil), the resulting drop may sometimes fragment into smaller droplets. Investigate the parameters that affect the fragmentation and the size of the final droplets.

Background reading

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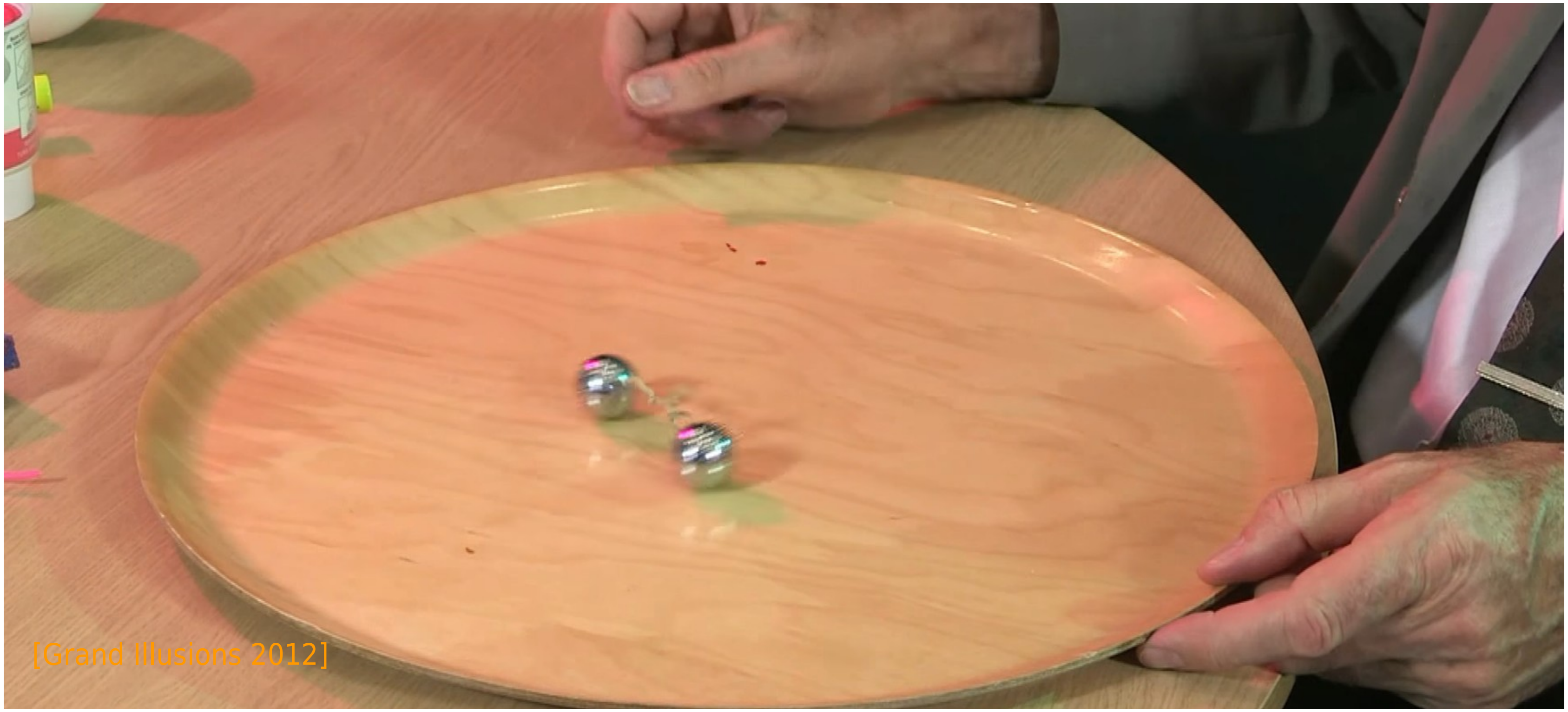

Problem No. 11 “Balls on an elastic band ”

Connect two metal balls with an elastic band, then twist the elastic band and put the balls on a table. The balls will begin to spin in one direction, then in the other. Explain this phenomenon and investigate how the behaviour of such a "pendulum" depends on the relevant parameters.

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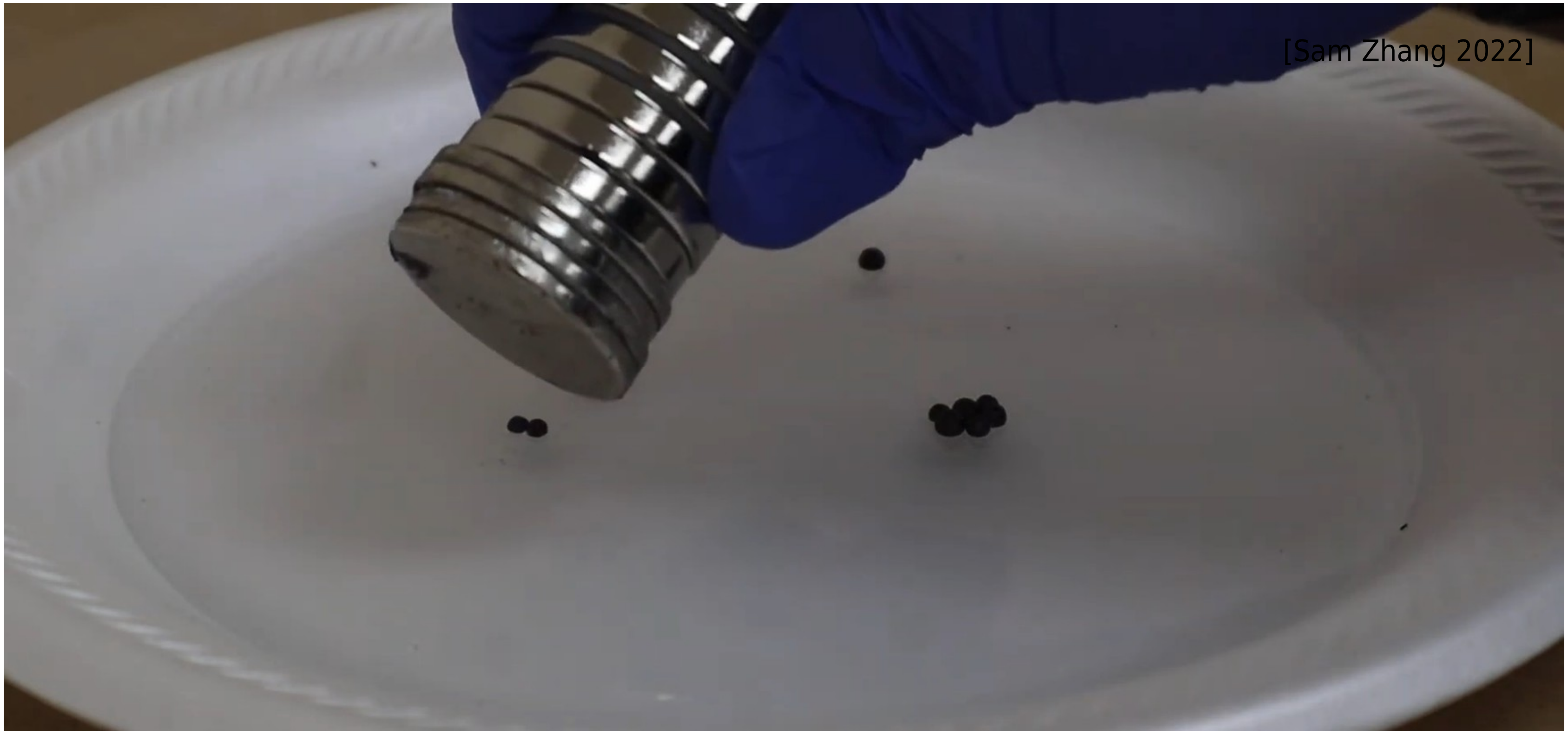

Problem No. 12 “Strange motion”

Sprinkle small floating particles on the surface of water in a bowl. Bring a strong magnet above and near to the water surface. Explain any observed motion of the particles.

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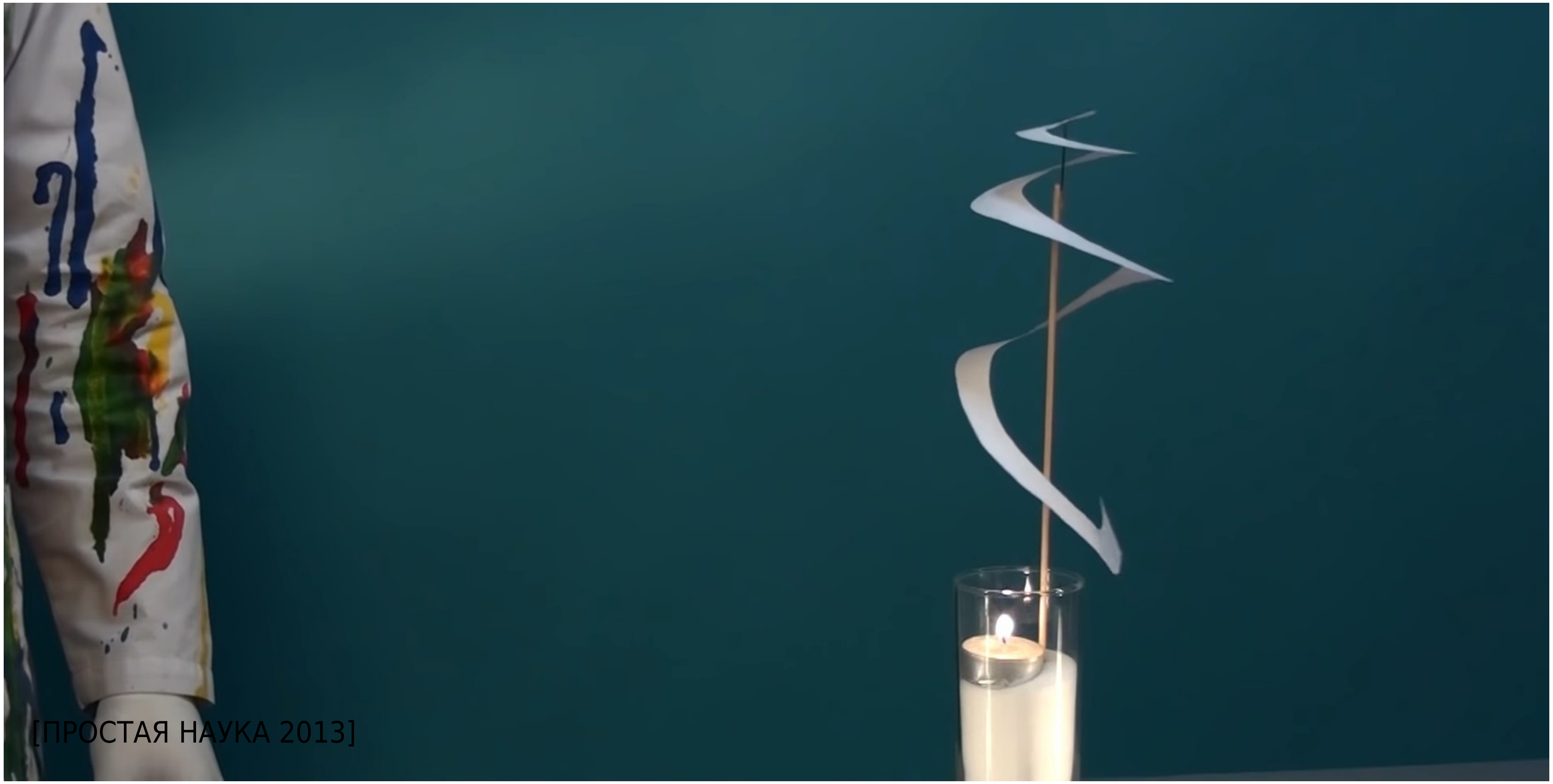

Problem No. 13 “Candle powered turbine”

A paper spiral suspended above a candle starts to rotate. Optimise the setup for maximum torque.

Background reading

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- Spinning spiral snake (youtube, The Experiment Archive, 03.03.2022), https://youtu.be/rRgfWw8BLv0
- Science At Play: Heat Engine (youtube, Connecticut Science Center, 09.09.2021), https://youtu.be/BFuVGWXlZxk
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- Candle Turbine | 7th Grade Next Generation Science Standards Activity for Teachers | PS3-5 & PS2-33 (youtube, STEM Scholar Library, 05.05.2021), https://youtu.be/pTOD2_F08nw
- Make your own heat-powered turbine with Scott and Cosmo (youtube, Brimbank Libraries, 18.09.2020), https://youtu.be/a72rCAfqBkU
- Convection Pinwheel - STEAM Puffs (youtube, The Awty International School, 30.06.2020), https://youtu.be/K6CmaSawBlA
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- The Spinning Tree (esplora.org.mt), https://esplora.org.mt/the-spinning-tree/
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- When a candle is kept under a spiral that is in the form of a snake, what will we observe? (byjus.com), https://byjus.com/question-answer/when-a-candle-is-kept-under-a-spiral-that-is-in-the-form-of-a/
- Air Movement (scienceprojects.org), https://www.scienceprojects.org/air-movement/

Problem No. 14 “Ball on membrane”

When dropping a metal ball on a rubber membrane stretched over a plastic cup, a sound can be heard. Explain the origin of this sound and explore how its characteristics depend on relevant parameters.

Background reading

- Ball on membrane demonstration (youtube, PhasePrimal, 03.04.2022), https://www.youtube.com/shorts/64ldYKJzVkk
- Шарик на мембране (youtube, GetAClass - Физика в опытах и экспериментах, 21.12.2021), https://youtu.be/ZKUaNQZKrUc
- CBC IYPT 2021 Ball on a Membrane Vid (youtube, Ball on a Membrane CBC 2021, 06.12.2021), https://youtu.be/aeM8ywpnXM8
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- BALL TRAMPOLINE - KANNADA - 13MB (youtube, Arvind Gupta, 08.09.2013), https://youtu.be/NQJEt1VZK_E
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Problem No. 15 “Boycott effect”

If particles are suspended in a liquid that has a lower density than the particles, the particles will settle to the bottom of the container. The rate of settling can be affected by tilting the container that holds the liquid. Explain this phenomenon and investigate the effect of relevant parameters.

Background reading

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Problem No. 16 "Saving honey"

When rotating a rod coated with a viscous liquid (e.g. honey), under certain conditions the liquid will stop draining. Investigate this phenomenon.

Background reading

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- Honey Dipper / Honey spoon (youtube, ALLT OM BIODLING, 17.01.2020), https://youtu.be/qN_PMjuZ5vI
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- Question: You may have observed that when you a spoon into honey, withdraw it, and hold the spoon horizontal, the honey can be kept from draining by (chegg.com), https://www.chegg.com/homework-help/questions-and-answers/may-observed-spoon-honey-withdraw-hold-spoon-horizontal-honey-kept-draining-rotating-spoon-q42054752

Problem No. 17 “Invisibility”

Lenticular lenses can be used to distort light and make objects disappear. Investigate how changing the properties of the lens and the geometry of the object affect the extent to which the object can be detected.

Background reading

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- DIY Printed Holographic Display (Lenticular Optics Explained) (youtube, bitluni, 07.03.2021), https://youtu.be/ktgbtoCD58I
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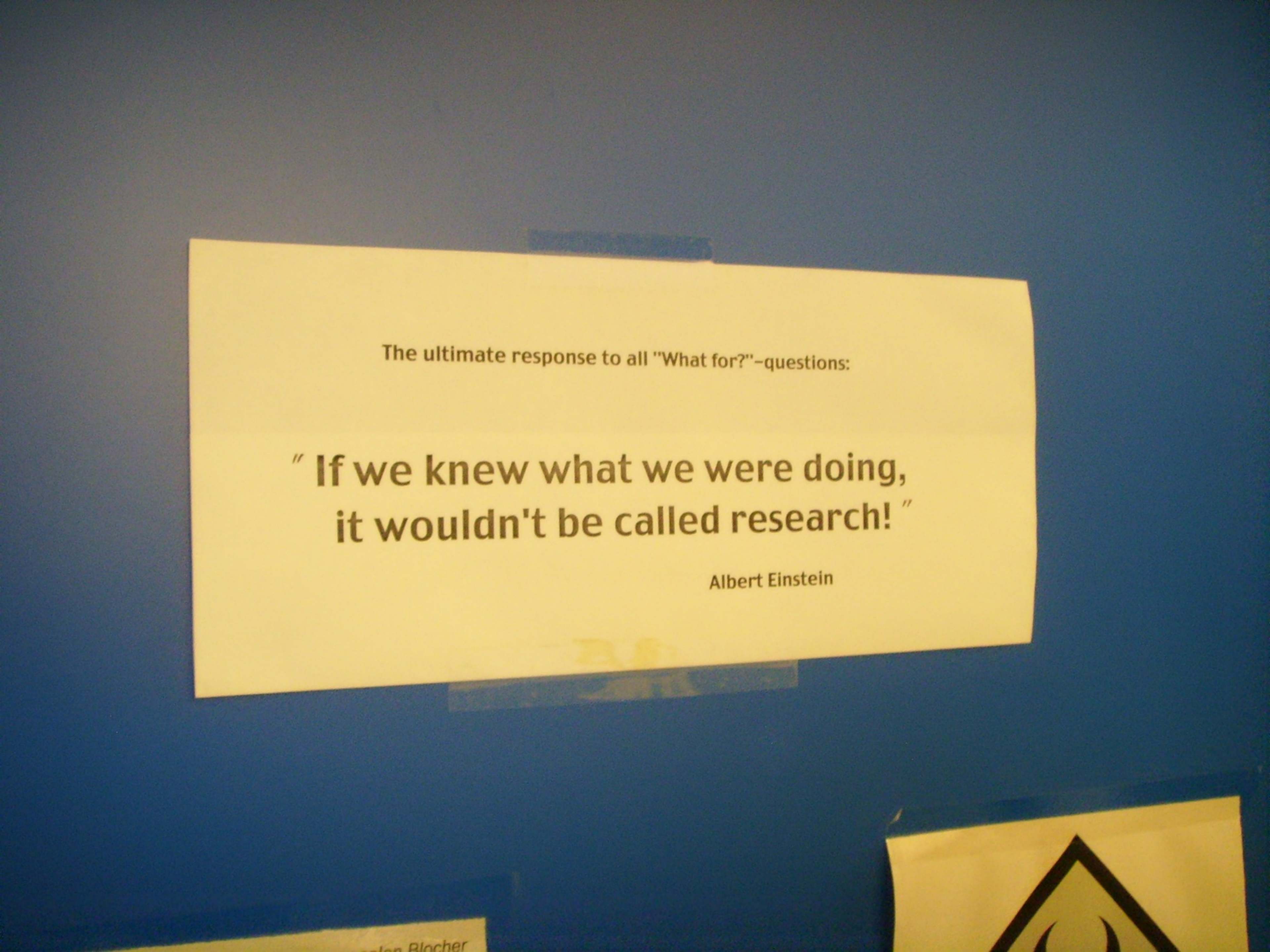
- 3D printed lenticular lens makes 3D display (Al Williams, hackaday.com, March 10, 2021), https://hackaday.com/2021/03/10/3d-printed-lenticular-lens-makes-3d-display/
- Lenticular lens makes things invisible (Al Williams, hackaday.com, January 25, 2021), https://hackaday.com/2021/01/25/lenticular-lens-makes-things-invisible/
- R. B. Johnson and G. A. Jacobsen. Advances in lenticular lens arrays for visual display. Proc. SPIE 5874, Current Developments in Lens Design and Optical Engineering VI, 587406 (2005)
- D. E. Roberts. History of lenticular and related autostereoscopic methods (Leap Tech., 2003), http://archiviostereoscopicoitaliano.it/documenti/history_of_lenticular.pdf
- The Discovery of a Material with a Negative Refractive Index leads to Invisibility (Guy Cramer, Hyperstealth Biotechnology Corp.), https://invisibility.ca/discovery.html


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?

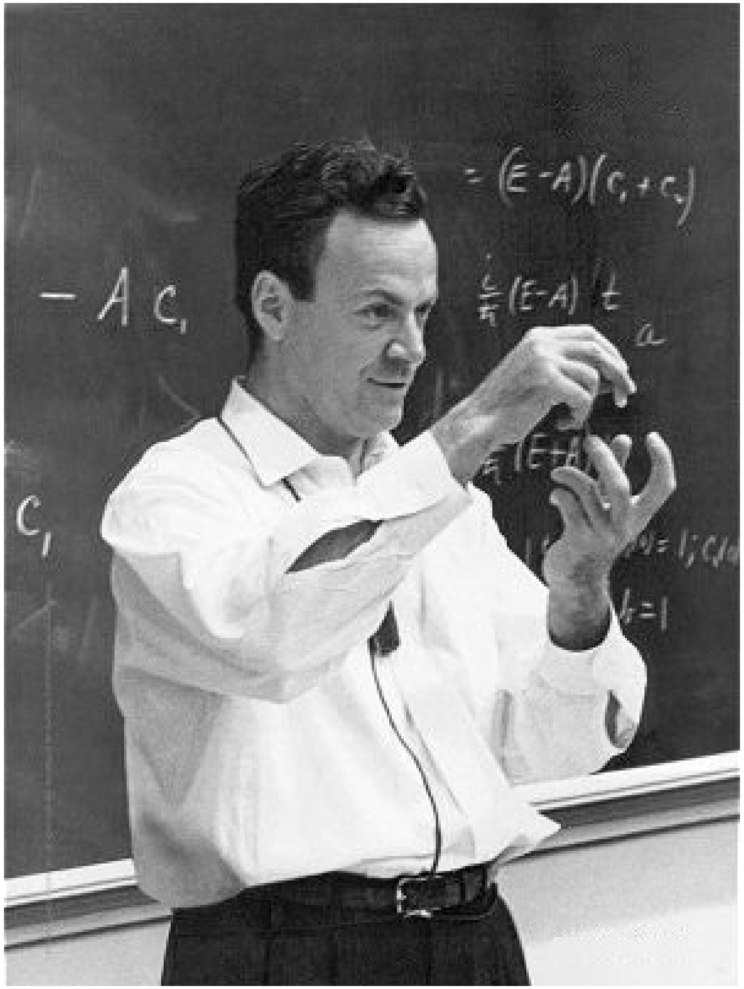
Requirements for a successful IYPT report

- 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 2022, or plan bringing together the Kit for 2023, 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 skeptical and 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 generates vibrant, state-of-the-art research problems, widely used in other activities and at other events
  - and also the author (-s) of the Kit, who could rapidly acquire a competence for the future activities and have a great learning experience

Enhanced edition // December 27, 2023

Preparation to 35th IYPT' 2022: references, questions and advices

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