

Preparation to the Young Physicists' Tournaments' 2023

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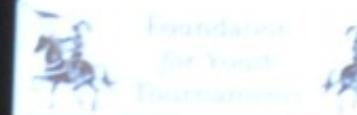
¹ Foundation for Youth Tournaments; ² Novosibirsk State University

Happy 80th birthday!



Let's all toast to the IYPT Founder as he celebrates his 80th birthday!

Born in 1943, Dr h.c. Evgeny Yunosov designed the Young Physicists' Tournament in 1979 and created the annual IYPT in 1988.





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!



[Myriam's Nature 2017]

Problem No. 1 “Fractal fingers”

The effect of fractal fingering can be observed if a droplet of an ink-alcohol mixture is deposited onto diluted acrylic paint. How are the geometry and dynamics of the fingers influenced by relevant parameters?

Background reading

- IYPT 2023 Problem 1 Fractal Fingers Demonstration (youtube, CAJCS FSA, 28.10.2022),
<https://youtu.be/6GUFSQRVxSM>
- Acrylic paint fractals (youtube, APS Physics, 19.11.2021), <https://youtu.be/DguNgm9tDFU>
- Fast Fractal Fingering in Fructose Fluids (youtube, APS Physics, 19.11.2021),
<https://youtu.be/zf1gR-tNzUs>
- FRACTAL ART - HIGH FLOW GOLD ACRYLIC - How to make DIRTY DENDRITES - Fluid Art (youtube, Dirty Artist - Acrylic Pouring, 21.06.2019), <https://youtu.be/92BOqGwzTxI>
- FRACTAL ART - How Big? "DIRTY DENDRITES" Acrylic Pouring / Fluid Art (youtube, Dirty Artist - Acrylic Pouring, 26.05.2019), <https://youtu.be/lHJL6sSzjVg>
- FRACTAL ART - BIGGER DENDRITES Secret Weapon!!! Easy for beginners! (youtube, Dirty Artist - Acrylic Pouring, 18.05.2019), <https://youtu.be/IFGw1aXvN4A>
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Background reading

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<https://math.nyu.edu/~shelley/papers/LDS2005.pdf>
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- G. Daccord, J. Nittmann, and H. Eugene Stanley. Radial viscous fingers and diffusion-limited aggregation: Fractal dimension and growth sites. *Phys. Rev. Lett.* 56, 4, 336-339 (1986)
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[曾賢德 2022]

Problem No. 2 “Oscillating sphere”

A light sphere with a conducting surface is suspended from a thin wire. When the sphere is rotated about its vertical axis (thereby twisting the wire) and then released, it starts to oscillate. Investigate how the presence of a magnetic field affects the motion.

Background reading

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- Torque on a rotating sphere in a uniform magnetic field (physics.stackexchange.com, Dec 24, 2019), <https://physics.stackexchange.com/questions/521105/torque-on-a-rotating-sphere-in-a-uniform-magnetic-field>
- Torsional pendulum: Definition, Derivation, Formula [with Pdf] (mechcontent.com),
<https://mechcontent.com/torsional-pendulum/>



Problem No. 3 “Siren”

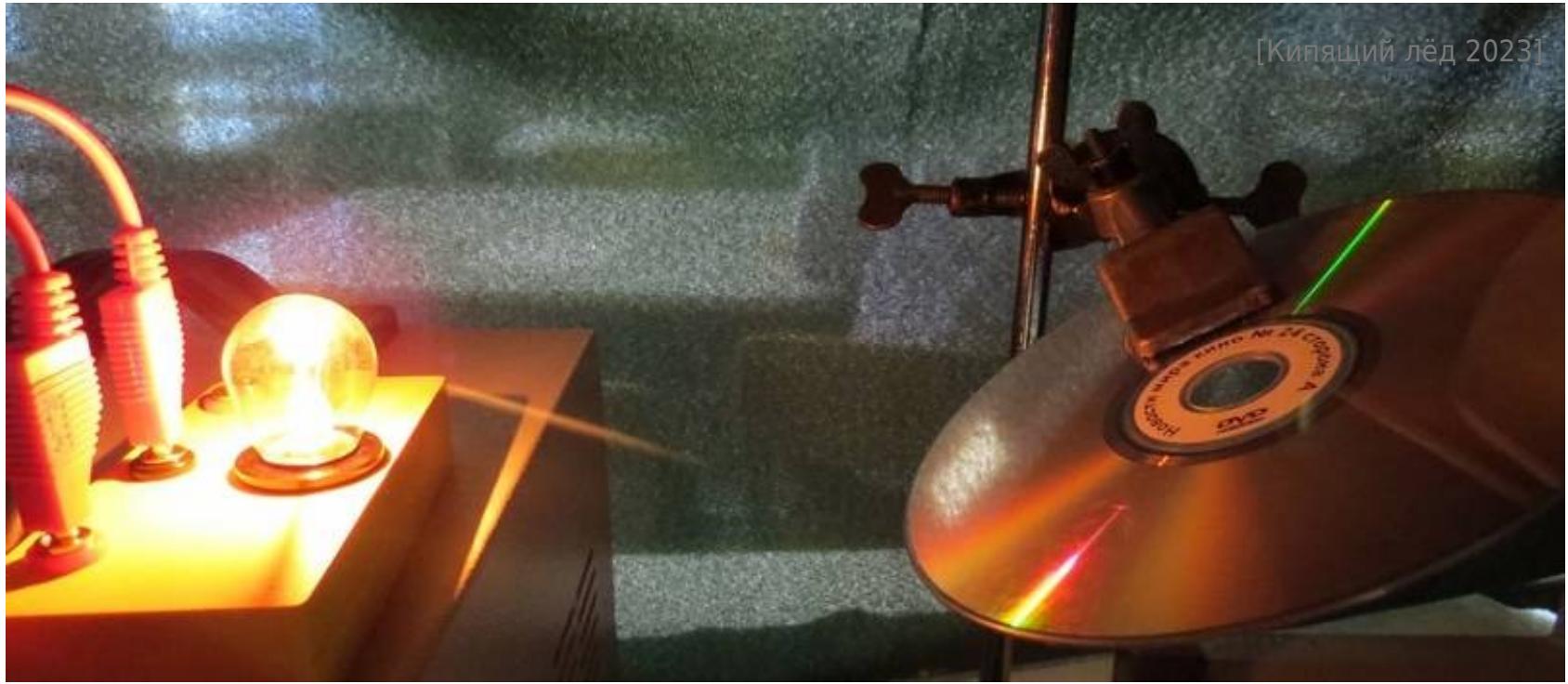
If you direct an air flow onto a rotating disk with holes, a sound may be heard. Explain this phenomenon and investigate how the sound characteristics depend on the relevant parameters.

Background reading

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- Аэроакустика: сирена и скакалка (youtube, GetAClass - Физика в опытах и экспериментах, 12.02.2015), <https://youtu.be/ljYa5U8MfrI>
- Helmholtz double-siren (youtube, Rene Bakker, 25.07.2008), <https://youtu.be/xaBoC7tbAE0>
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Background reading

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<http://berkeleyphysicsdemos.net/node/193>
- Siren Discs (Harvard Natural Sciences Lecture Demonstrations),
<https://sciencedemonstrations.fas.harvard.edu/presentations/siren-discs>
- Siren Disk ([exploratorium.edu](https://www.exploratorium.edu)), <https://www.exploratorium.edu/snacks/siren-disk>
- Build a Disk Siren ([sciencebuddies.org](https://www.sciencebuddies.org)), <https://www.sciencebuddies.org/stem-activities/build-disk-siren>
- Frequency and pitch: How do we know? (pressbooks.pub),
<https://pressbooks.pub/sound/chapter/sirens-and-singing-roads/>
- Building a Disk Siren: A noisy science activity from Science Buddies ([scientificamerican.com](https://www.scientificamerican.com)),
<https://www.scientificamerican.com/article/building-a-disk-siren/>



[Кипящий лёд 2023]

Problem No. 4 “Coloured line”

When a compact disc or DVD is illuminated with light coming from a filament lamp in such a way that only rays with large angles of incidence are selected, a clear green line can be observed. The colour varies upon slightly changing the angle of the disc. Explain and investigate this phenomenon.

Background reading

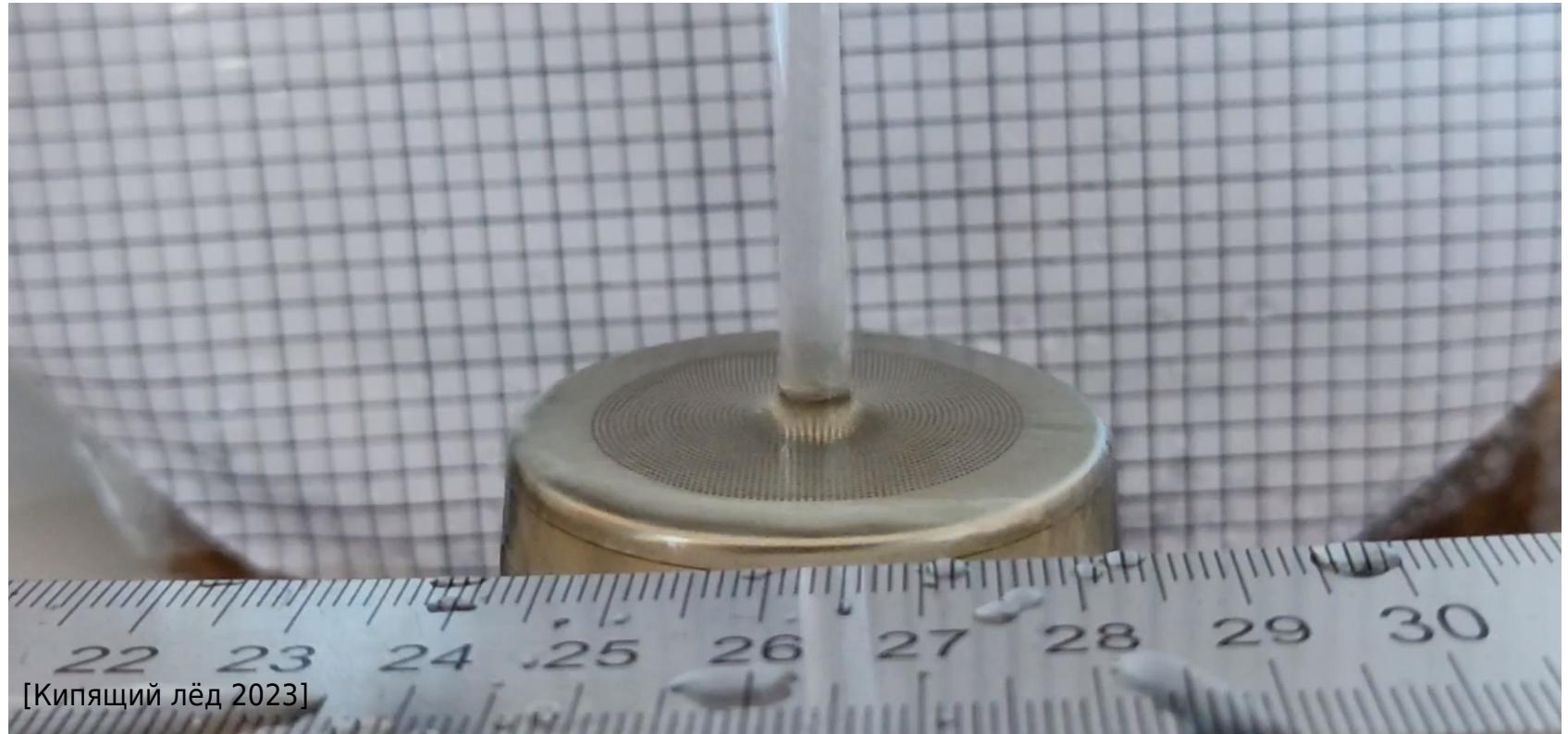
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<https://youtu.be/XP1tvZkECO4>
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<https://www.thenakedscientists.com/get-naked/experiments/colours-cds>
- Why do we see a rainbow of colors reflected off a CD or DVD? (physics.stackexchange.com, Mar 6, 2019), <https://physics.stackexchange.com/questions/464911/why-do-we-see-a-rainbow-of-colors-reflected-off-a-cd-or-dvd>
- Diffraction Grating (hyperphysics.phy-astr.gsu.edu), <http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/grating.html>, <http://hyperphysics.phy-astr.gsu.edu/hbase/phyopt/gratcal.html>
- 10.3. The diffraction grating. In: Applications of the Wave Nature of Light, pp. 520-525, http://panchbhaya.weebly.com/uploads/1/3/7/0/13701351/phys12_c10_10_3.pdf
- Why does a CD reflect a rainbow and a mirror does not? Can someone answer it to me in simple ways? (Brad Moffat, quora.com), <https://www.quora.com/Why-does-a-CD-reflect-rainbow-colors/answer/Brad-Moffat-1>

Background reading

- the grating equation (Vik Dhillon),
http://www.vikdhillon.staff.shef.ac.uk/teaching/phy217/instruments/phy217_inst_grating.html
- CDs and DVDs as Diffraction Gratings (nnci.net), <https://nnci.net/node/5375>



Problem No. 5 “Whistling mesh”

When a stream of water hits a rigid metal mesh within a range of angles, a whistling tone may be heard. Investigate how the properties of the mesh, stream and angle affect the characteristics of the sound produced.

Background reading

- mesh whistle (youtube, Nicholas Wong, 16.02.2022), <https://youtu.be/OXLb40Ab5Jo>
- Why does the tea strainer sing? (youtube, odess4sd4d, 07.10.2019),
<https://youtu.be/ouZBN4WM5MU>
- Tea strainer weird sound (youtube, cheesemunche, 26.06.2018),
https://youtu.be/AMbkU_UDDIO
- The humming tea filter (youtube, altsmoosh, 31.07.2017), https://youtu.be/-t_sQ5PrRdk
- Odd sound from tea infuser (youtube, Anthony White, 27.05.2017),
<https://youtu.be/mz0jTEFrIKA>
- The Amazing Singing Tea Strainer (youtube, samgentle, 01.05.2015),
<https://youtu.be/eIWctlgvTMo>
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<https://www.spektrum.de/wissen/das-singende-teesieb/1918327>
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Background reading

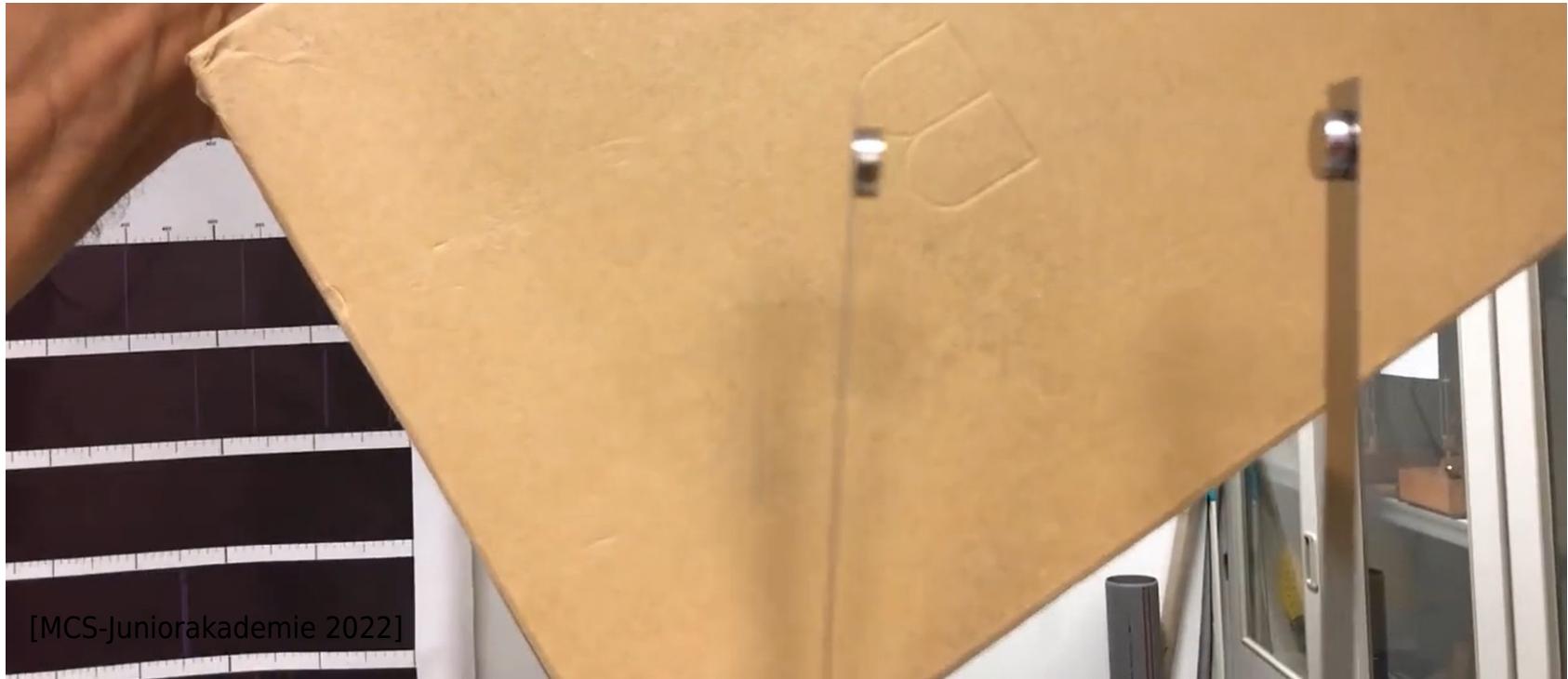
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- M. J. Lighthill. On sound generated aerodynamically. I. General theory. *Proc. R. Soc. Lond. A* 211, 1107, 564-587 (1952)
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<http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA098556>
- U. Backhaus und H. J. Schlichting. Regular and chaotic oscillations of a rotating pendulum. In: G. Marx (Ed.): Chaos in Education II. Vesprem (Hungary, 1987), pp. 312-317, http://www.uni-muenster.de/imperia/md/content/fachbereich_physik/didaktik_physik/publikationen/regula_rchaotik.pdf



Pr. No. 6 “Magnetic-mechanical oscillator”

Secure the lower ends of two identical leaf springs to a non-magnetic base and attach magnets to the upper ends such that they repel and are free to move. Investigate how the movement of the springs depends on relevant parameters.

Background reading

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<https://youtu.be/cUIpTVGQQEI>
- Magnetic-Mechanical Oscillator (youtube, MWU, 20.06.2023),
<https://www.youtube.com/shorts/ZaxRxZtesew>
- Биения связанных маятников (youtube, GetAClass - Физика в опытах и экспериментах, 18.02.2023), https://youtu.be/e7GmpqLyl_w
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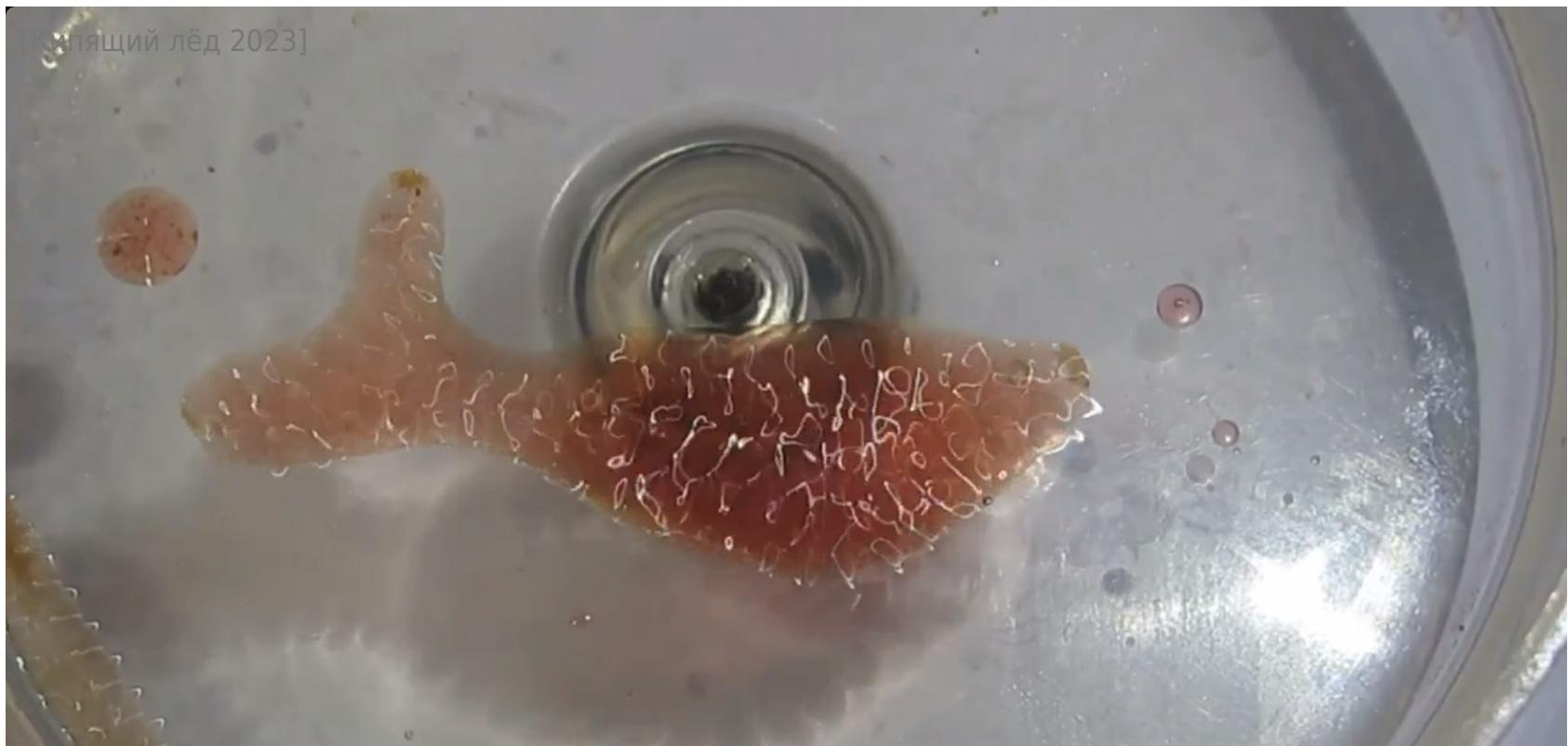
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[Кипящий лёд 2023]



Problem No. 7 “Faraday waves”

A droplet of less viscous liquid floating in a bath of a more viscous liquid develops surprising wave-like patterns when the entire system is set into vertical oscillation. Investigate this phenomenon and the parameters relevant to the production of stable patterns.

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[Fenix Science Club 2022]



Problem No. 8 “Euler's pendulum”

Take a thick plate of non-magnetic material and fix a neodymium magnet on top of it. Suspend a magnetic rod (which can be assembled from cylindrical neodymium magnets) underneath it. Deflect the rod so that it touches the plate only with highest edge and release it. Study the motion of such a pendulum under various conditions.

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<https://www.nagwa.com/en/videos/860137075132/>



[Jiří Zůna 2011]

Problem No. 9 “Oscillating screw”

When placed on its side on a ramp and released, a screw may experience growing oscillations as it travels down the ramp. Investigate how the motion of the screw, as well as the growth of these oscillations depend on the relevant parameters.

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[Кипящий лёд 2023]



Problem No. 10 “Upstream flow”

Sprinkle light particles on a water surface. Then allow a water stream to be incident on the surface from a small height. Under certain conditions, the particles may begin to move up the stream. Investigate and explain this phenomenon.

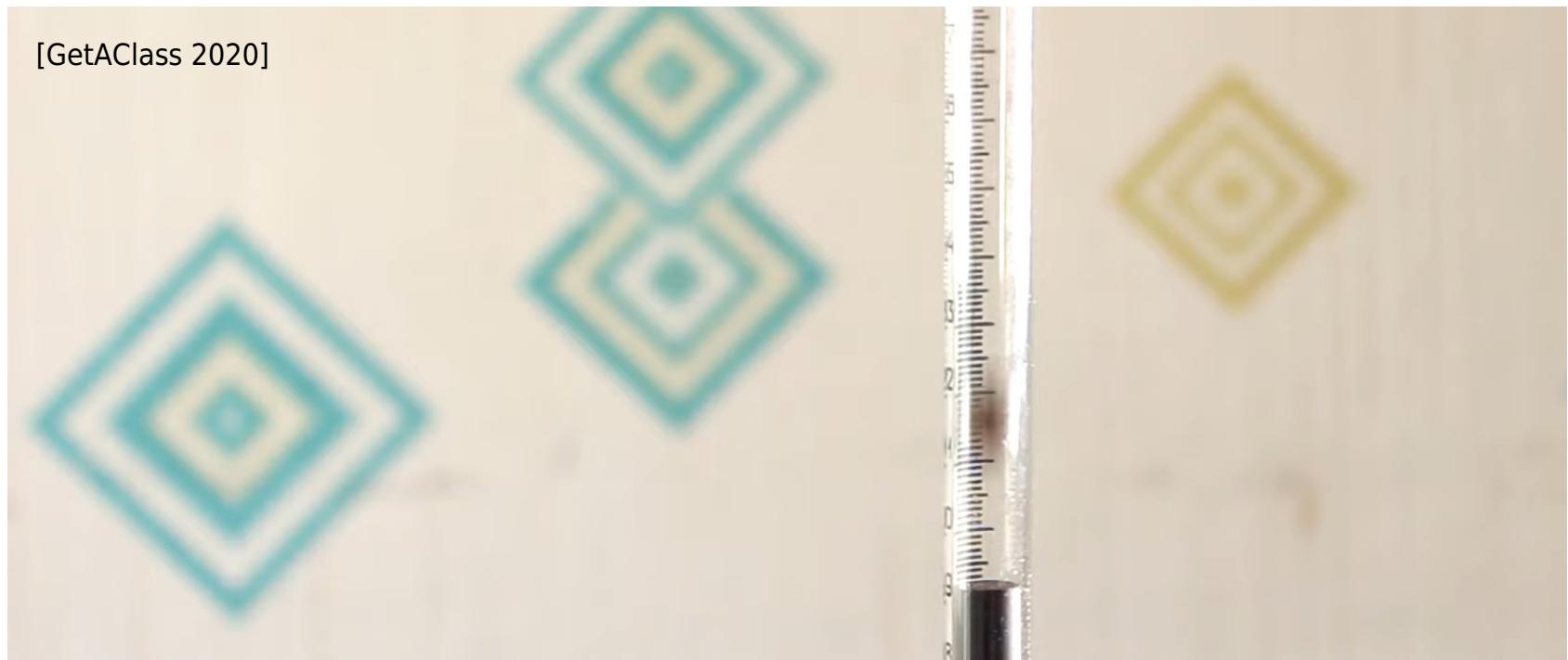
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[GetAClass 2020]



Problem No. 11 “Ball on ferrite rod”

A ferrite rod is placed at the bottom end of a vertical tube. Apply an ac voltage, of a frequency of the same order as the natural frequency of the rod, to a fine wire coil wrapped around its lower end. When a ball is placed on top of the rod, it will start to bounce. Explain and investigate this phenomenon.

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Problem No. 12 “Rice kettlebells”

Take a vessel and pour some granular material into it, for example rice. If you dip e.g. a spoon into it, then at a certain depth of immersion, you can lift the vessel and contents by holding the spoon. Explain this phenomenon and explore the relevant parameters of the system.

Background reading

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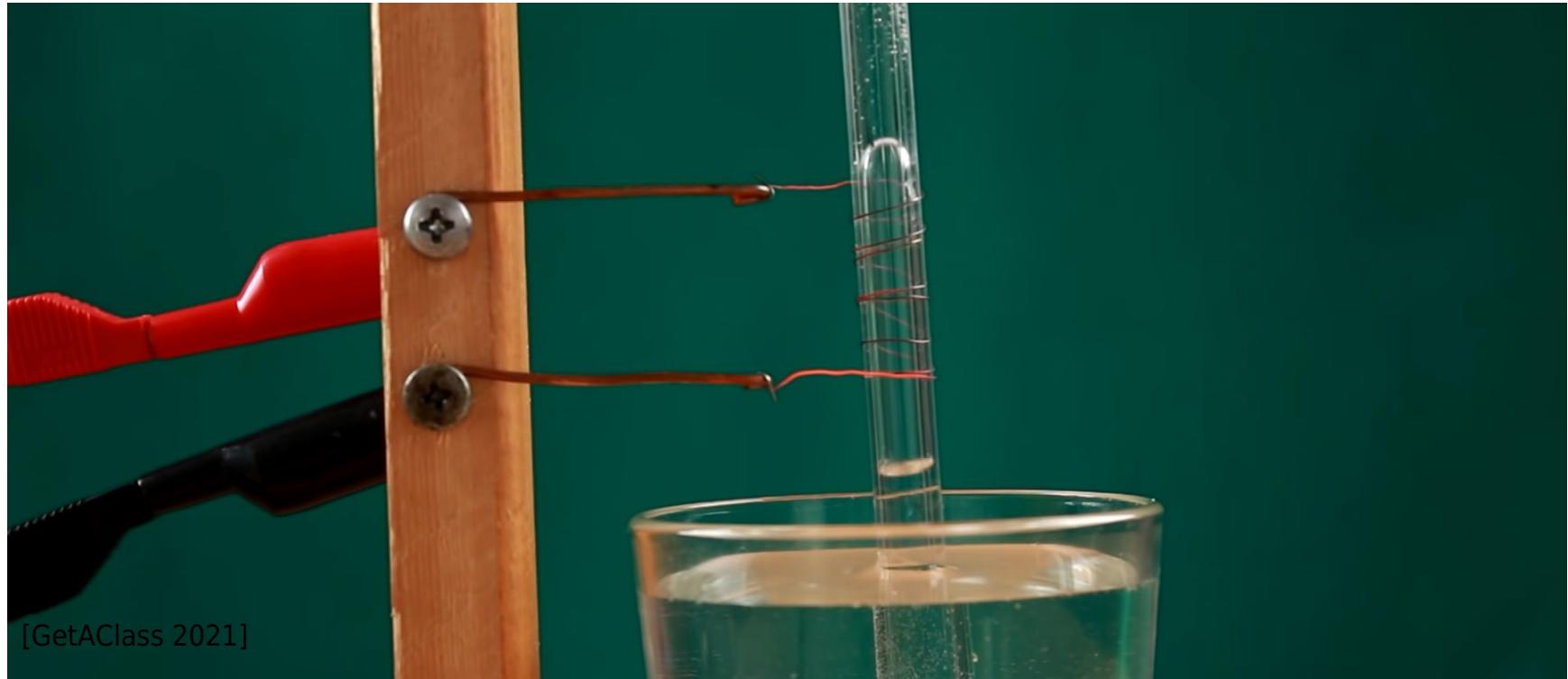
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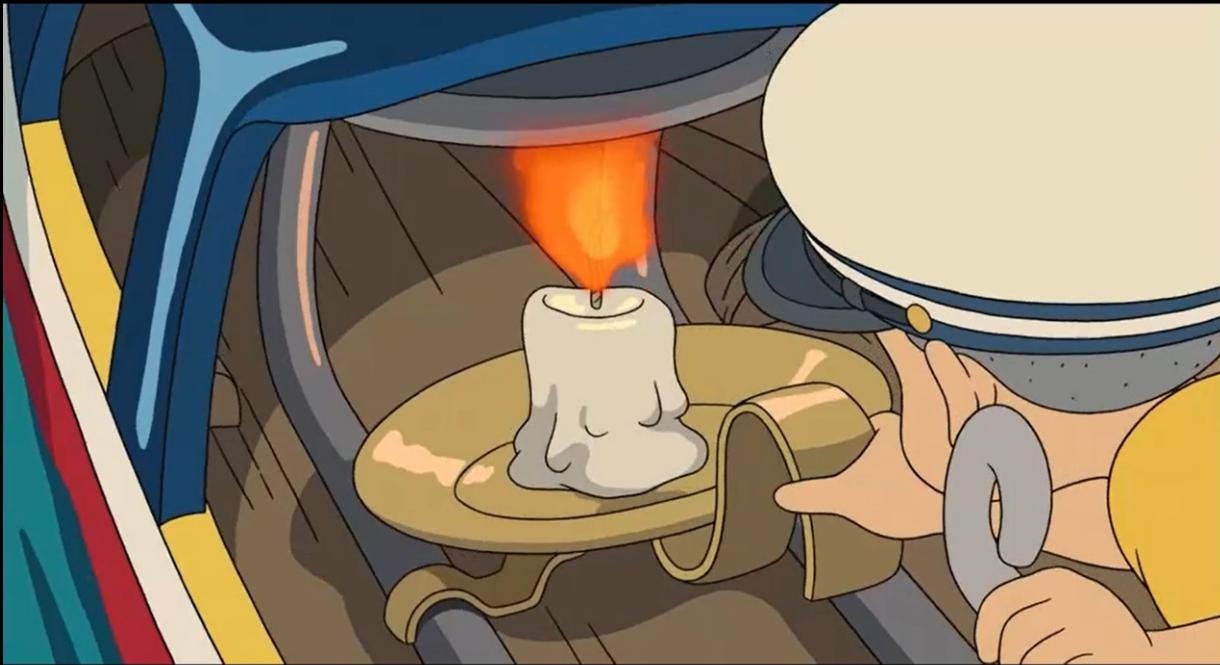
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[GetAClass 2021]

Problem No. 13 “Ponyo's heat tube”

A glass tube with a sealed top is filled with water and mounted vertically. The bottom end of the tube is immersed in a beaker of water and a short segment of the tube is heated. Investigate and explain the periodic motion of the water and any vapour bubbles observed.



Physics in a Toy Boat

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A method of propulsion commonly used in toy boats consists of a shallow chamber, covered by a thin diaphragm, which is connected to the water astern of the boat by pipes. Filling the chamber with water and then heating its base leads to vigorous self-induced vibration of the diaphragm and water column in the pipes with resulting forward motion of the boat. The paper describes the mechanisms of self-induced vibration and of propulsion. It is shown that this inexpensive toy demonstrates a number of physical principles and provides opportunities for further research.

THERE is a child's toy known as the putt-putt boat, which demonstrates a remarkable number of physical principles. For the benefit of those who have not experimented with such a boat, its operation may be described with respect to Fig. 1. A thin diaphragm E covers a shallow chamber A. From the base of the chamber, a pipe, or usually two pipes, lead to the rear of the boat at C. If the chamber and pipes

are heated from below by a heat source B, such

As a starting point, it is best to refer to an

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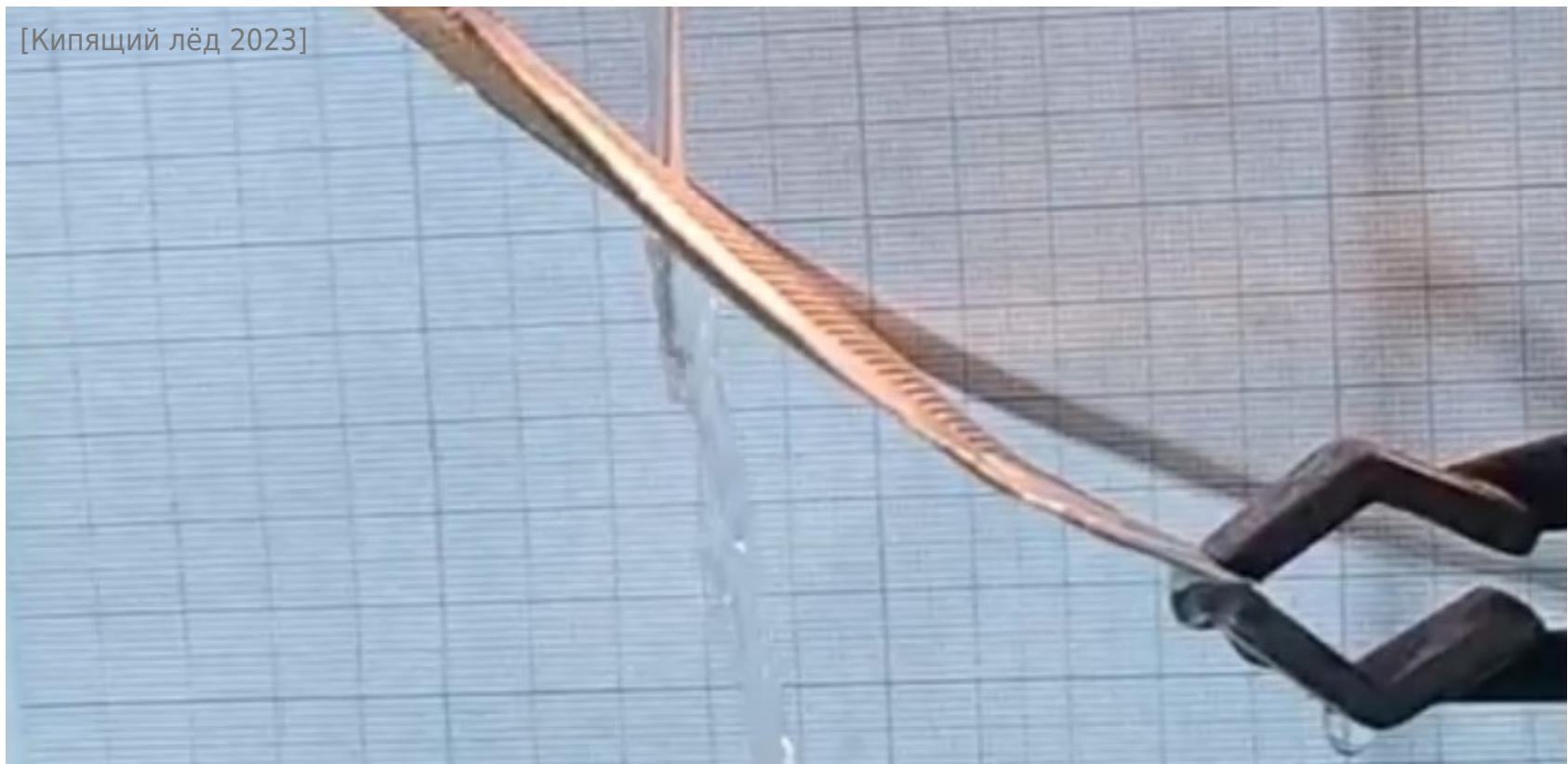
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[Кипящий лёд 2023]



Problem No. 14 “Jet refraction”

A vertical jet can be refracted when passing through an inclined sieve with a fine mesh. Propose a law for such refraction and investigate relevant parameters.

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Problem No. 15 “Pancake rotation”

Place a few balls in a round container. If you move the container around a vertical axis, the balls can move co-directionally with the movement of the container, or they can move in the opposite direction. Explain this phenomenon and investigate how the direction of movement depends on relevant parameters.

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[Бобры 2023]



Problem No. 16 “Thermoacoustic engine”

A piston placed in the open end of a horizontal test tube which has its other end partially filled with steel wool may oscillate when the closed end is heated up. Investigate the phenomenon and determine the efficiency of this engine.

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[Jordi Escuer 2011]

Problem No. 17 “Arrester bed”

A sand-filled lane results in the dissipation of the kinetic energy of a moving vehicle. What length is necessary for such an arrester bed to entirely stop a passively moving object (e.g. a ball)? What parameters does the length depend on?

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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 **iyp.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

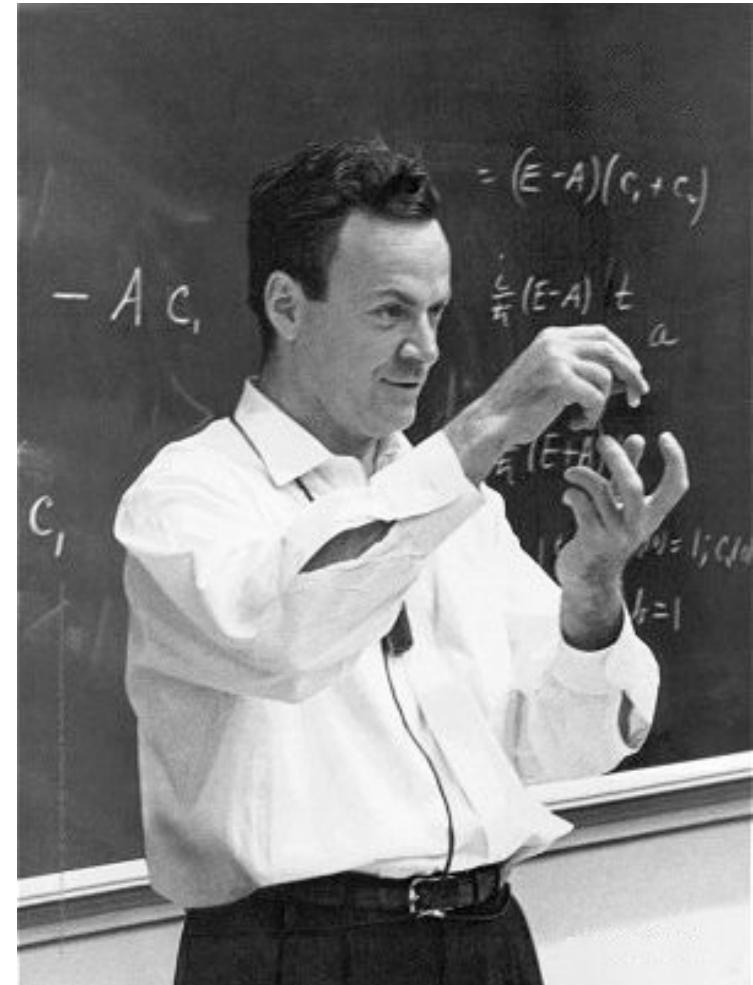
- Originality and independence of your work is always considered as of a first priority
- There is no “correct answer” to any of the IYPT problems
- Having a deep background knowledge about earlier work is a must
- Taking ideas without citing is a serious misconduct
- Critically distinguishing between 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.”

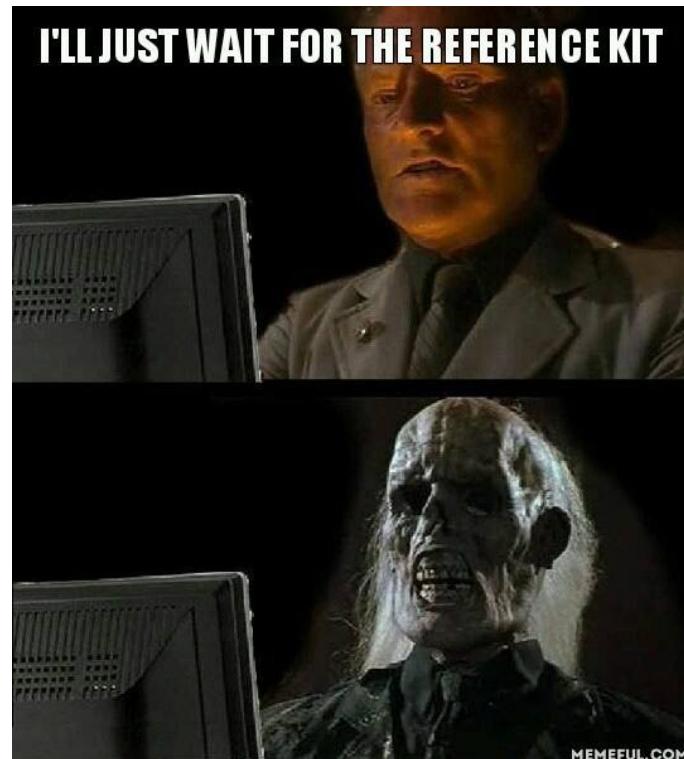
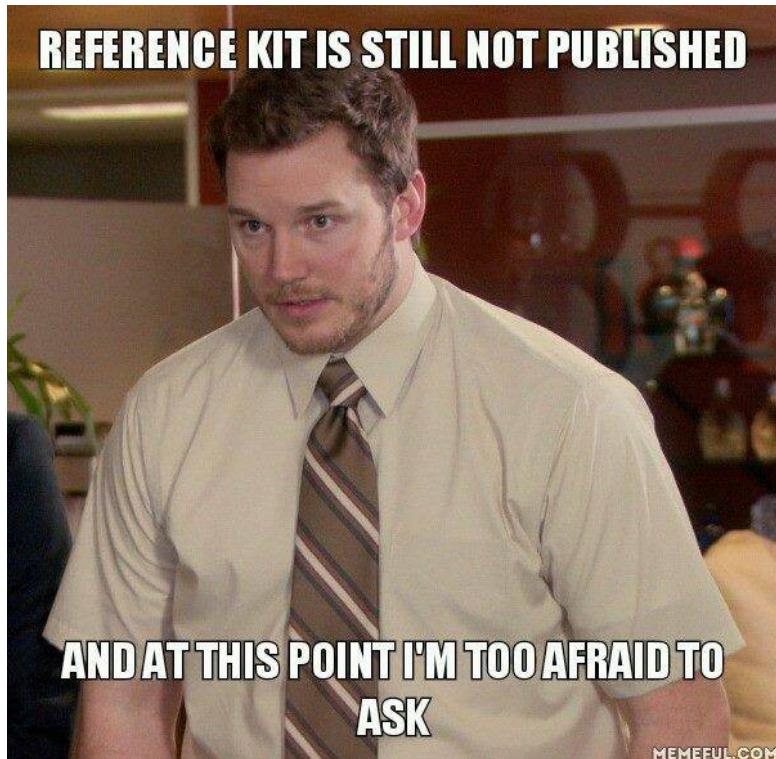


R.P. Feynman. *Surely You're Joking, Mr. Feynman* (Norton, New York, NY, 1985)

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 2023, or plan bringing together the Kit for 2024, **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

Cheers to IYPT Memes!





Preparation to 36th IYPT' 2023: references, questions and advices

Photos by Alexey Cheremisin used
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* <http://kit.ilyam.org>