List of problems for the XII edition of the International Physicists' Tournament

All the problems, to stimulate a good discussion, have been formulated as open physics questions. That's why the statement is never too stringent and it is assumed that every phenomenon will be studied both theoretically and experimentally (when possible) with dependence on all the most relevant parameters. More than that, there is not any general understanding of the task condition. If your interpretation of a certain problem condition corresponds to the written one and is interesting enough and your investigation is challenging and broad – the jury members will most likely award you with the nice marks. Surely, your team is not expected to spend years on every problem. So you should carefully consider your time budget and choose the most important and interesting parameters to study together with doing your best on both the theoretical model and experimental confirmation.

1. Cumulative cannon
How high may a ping-pong ball jump using the setup on the video? What is the maximal fraction of the total kinetic energy that can be transferred to the ball?
https://youtu.be/mPOcFSHyd9o?t=478

2. Precious energy
Shaking a bottle of carbonated liquid (soda, beer, champagne etc.) before opening it will lead to a fountain of liquid coming out. Design and optimize a setup to extract electrical energy from opening such a bottle.

3. Paper tube
Roll a long paper strip into a tight tube and put it vertically on a table. Why does it often unwind in jerks? What determines the period of the jerks? https://youtu.be/G3yzSMLMRds

4. Electrostatic copier
If you rub against each other two sheets of paper, one of which contains text, they become electrified. The electrical pattern that is formed on the clear sheet may be analyzed later to restore the text, depending on the way the text was created. Propose and build a setup to recover an image of the original text with the highest possible resolution.

5. Whirlpool in a bottle
When an open bottle of water is turned upside down and slightly rotated, a whirlpool is formed. What are its characteristics? How fast can the bottle be emptied that way? What will change if the bottle is filled with sand instead? https://youtu.be/J207s0zk6Kg

6. Planetary clock
Propose the most accurate clock that measures time with a temporal resolution of a minute or less using the rotation of the Earth. The clock design should allow calibrating the clock to work even on a different planet. With what certainty will your clock show the correct time after one year?

7. Wavy pages
After extensive use of a book, wavy bends may form in the stacked paper. Investigate the shape and distribution of bends.

8. Rippled water columns
When a vertical water jet hits a surface, ripples may appear. If certain conditions are met, the ripple structure is pronounced, steady and very reproducible. Describe the phenomenon. What properties of the fluid and the flow can be deduced from the observations?
https://youtu.be/266bwu9CuyA

9. Optical compass
Bees locate themselves in space using their eyes' sensitivity to light polarization. Design an inexpensive optical compass using polarization effects to obtain the best accuracy. How would the presence of clouds in the sky change this accuracy?

10. Hail
Extract as much information as possible about the shape and dimensions of a metal container from the sound produced when dropping small objects (such as peas) into it.

11. Flat fog
After pouring liquid nitrogen into a mug, you will notice that the mug starts to cast a mist. The mist's border is a clearly marked thin plane at a certain height from the mug. Investigate the phenomenon.

12. Resonating glasses
When you take two glasses between your fingers, they sometimes emit a particular sound containing a frequency sweep. Investigate the phenomenon. https://youtu.be/AIZkIfoQhIU

13. Pickle night light
If you pass current from a conventional household wall socket through a pickle it will glow. Investigate this effect, including the effect of alternating current, and the use of multiple pickles in a chain. What is the mechanism (and time) for a pickle to die out?
Be very careful not to confuse the pickles with your fingers!
https://youtu.be/aab8VjzuXyM?t=39, https://youtu.be/axbAvYK9Hcw

14. Jumping bean
A simple toy called a "jumping bean" can be constructed by putting a metal ball inside of a pill capsule. Placed on an inclined surface at a certain inclination, the jumping bean will tumble down in a rather surprising way, seemingly standing up-right, flipping end to end, instead of rolling. Investigate its motion. Find the dimensions of the fastest and slowest beans for a given inclination. https://youtu.be/Azb9bDktZVc

15. Wobbly vortex rings
It is known that a vortex cannon with a non-circular aperture may produce oscillating smoke rings. Investigate the ring shape dynamics. https://youtu.be/N7d_RWyOv20?t=190

16. Little soldiers
Investigate and explain the phenomenon whereby metal chips, initially resting on a flat surface, suddenly arrange vertically as the support begins to vibrate intensively.

17. Quantum gram
As of 2019, the International System of Units (SI) defines the kilogram from the Planck constant, which is now defined exactly as 6.62607015×10^{-34} J·s. Propose and make a room-temperature experiment to calibrate a weight of one gram with maximal precision using the new definition (you may freely measure the other primary units with your equipment considering them calibrated at the room temperature too).

The Organizing Committee is grateful to all people who took part in the problems proposition and selection!

3rd August 2019 **_____Vladimir Vanovskiy, IPT IOC Secretary**