

1. Tagged along

It is well known that in the race cyclists often break up into groups of two or three and tag along with each other in order to minimize air resistance. How much do they benefit from this strategy? Is it useful to marathon runners?

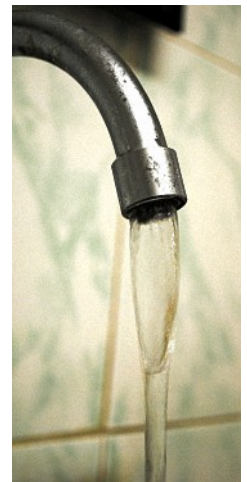
2. High-voltage clock

In the so-called Jacob's Ladder experiment a spark goes up between two V-shaped electrodes, fades out at the top and burns up again in the bottom http://www.youtube.com/results?search_query=jacob%27s+ladder+spark. Evaluate the period of this process given different parameters of the experimental setup. What error will a chronometer have if based on such a device as frequency standard?

Be very careful when working with high voltage!

3. Air Pocket

A stable volume of air can appear near the tap end. That volume increases with time until some moment. After this moment it abruptly decreases. This situation repeats periodically. Explain the phenomenon and find the conditions for it to occur. Find out how the speed of pocket growth and period of oscillations depend on jet parameters.



4. PowerBall

What is the maximum frequency at which a person can spin a [PowerBall](#)? In what way must one rotate the PowerBall so that the energy transfer is the most efficient?

5. Irreversibility

There is a famous experiment where a viscous liquid is placed between the walls of two coaxial cylinders. A drop of ink that is dropped into the viscous liquid can visually be spread apart and gathered back in a drop. Is it possible to carry out this experiment using water between the two cylinders instead and what parameters of the setup should be used?

http://youtu.be/_dbnH-BBSNo

6. Dry Ball

A ping-pong ball placed over a hair dryer can float in the air, even when the air stream is inclined. What is the biggest angle for which the ball can be in equilibrium?

<http://www.youtube.com/watch?v=WWHXTumy4RQ>

7. Dangerous flash

In many museums it is prohibited to take photos with a flash. Explain the mechanisms by which a flash can destroy materials. How many flashes does it take to spoil a) medieval icon, b) metal armor, c) papyrus from ancient Egypt? How does the effect depend on flash power?

8. Rubber band ball

How does the “bounciness” of a rubber band ball vary with its size? i.e. for a rubber band ball dropped from a height of 1m, how many rubber bands maximizes the rebound height? The ball must be composed entirely of rubber bands.



9. The incantation of levitation

It is possible to levitate small objects using standing waves of sound: <http://www.youtube.com/watch?v=G9SlyXhNoZ4>. How does the maximum particle size that can be levitated depend on the properties of the sound wave?

10. The water rocket

Water rockets are easily made using a simple plastic bottle: some water is poured in the bottle, the bottle is pumped to big pressure, the water starts pouring out of the bottle and the rocket flies up. What is the maximum height for a rocket with one PET bottle as the engine? (<http://www.youtube.com/user/gk123434534>)

11. The burning arrow

What is the maximal speed for a burning arrow not to die out during the flight? At what speed should one run with the burning candle in hands without wind to blow it out?

12. The sound energy

Is it possible to use city noises as an energy source? Make a setup to gather the biggest amount of energy from the sound of a train passing nearby.

13. Gears of chaos

Propose a simple clockwork mechanism that demonstrates chaotic dynamics with oscillations close to «white noise». Develop the theory of that mechanism's motion and study it experimentally.

14. Priceless vitrages

The vitrages (stained glass windows) in churches are often colored by the colloidal solution of gold particles. What size and form should these particles be in order to obtain the bright red color of a vitrage at minimum cost (minimal gold expenses)?



15. Wireless energy transmission

Make a setup to wirelessly transfer the maximum amount of power possible from a normal AA type battery. The energy transmission should be continuous and there should be at least one meter of air between the energy transmitter and receiver. The transmitter and receiver size should not exceed 20x20x20 cm.

16. Chelyabinsk meteor

Estimate the mass needed by a meteor on entering the Earth's atmosphere in order to break the glass in windows at a distance of one kilometer from the point of impact.

17. The hospitable scientist

Some guests of Sir Isaac Newton once complained that the gate to his garden was hard to open and suggested he replace it with a better one. Newton responded, "I don't know if a better one is possible. You see that gate is a pump. Every person who comes in draws at least a gallon of water from my well to my water tank!". Propose a schematic diagram of such a gate, that delivers water from a well at 10m depth to the surface with the maximum efficiency. Is it likely that a guest could lift a gallon of water easily?

The IPT IOC is grateful to all the authors of the problems!

In case of any questions do not hesitate to contact the IPT Secretary Vladimir Vanovsky
e-mail: ipt.inbox@gmail.com, phone: +7 916 724-40-52