

# Problems for the 36<sup>th</sup> IYPT 2023

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*Thinking is more interesting than knowing, but less interesting than looking.* – Johann Wolfgang von Goethe

## 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?

## 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.

## 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.

## 4. Coloured Line

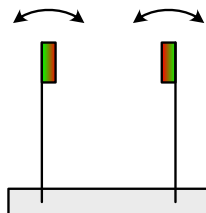
When a compact disc or DVD is illuminated with light coming from a filament lamp in such a way that only rays with large angles of incidence are selected, a clear green line can be observed. The colour varies upon slightly changing the angle of the disc. Explain and investigate this phenomenon.

## 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.

## 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.

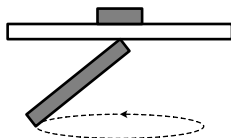


## 7. Faraday Waves

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.

## 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.



## 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.

## 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.

## 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.

## 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.

## 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.

## 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.

## 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.

## 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.

## 17. Arrestor Bed

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

**Authors:** Samuel Byland, Nikita Chernikov, Leszek Gladczuk, Artyom Golomolzin, Teck Seng Koh, Paul Lee, Ilya Martchenko, Luc Mazereeuw, Florian Ostermaier, Kerry Parker, Oksana Pshenichko, Andrey Shchetnikov, Nicholas Wong, Kathryn Zealand

**Problem selection committee:** John Balcombe, Samuel Byland, Ilya Martchenko