Short-list for IPT 2026

To stimulate creativity and interesting discussions, all the problems have been formulated as open physics questions with a statement that is not too stringent. Therefore, there is no uniquely favored understanding of the problem conditions and it is up to each team to interpret the conditions in a way that is both interesting from a physical perspective and coherent with the problem statement. It is assumed that every phenomenon will be studied theoretically and, whenever possible, experimentally, to propose and validate a model that explains the phenomenon and its dependence on the most relevant parameters. Teams are encouraged to carefully consider their time budgets, to strike a balance between the number of problems that are studied and the depth with which each problem is investigated.

All experiments should comply with local safety regulations and care should be exercised when dealing with dangerous equipment and substances. Teams are solely responsible for any damage or injuries incurred while working (or thinking) on the problems.

Everyone is allowed to vote! Please use the following form https://forms.gle/xkHFmDXTtFa9M6Kr7
To vote, distribute 100 points among the problems you prefer, but try not to spread it between too many problems as in that case it will be lost in the noise of the other votes.
The vote is open until August 31st 2025.

Acoustics

1. Singing Water
Several cultures use water as a musical instrument, creating a variety of sounds depending on how the surface of the water is stroked. Explain how the sound is formed and investigate how the properties of the sound depend on the stroke technique. https://youtu.be/i5ECtJvKd94

2. Blowing Horn
Ancient societies used to blow horns for calling people. How far a person can hear it? Imposing the physical constraint that the whole design should fit within a cube with a 30cm side, propose a design that maximizes this distance. If one wants to blow toward the wind, does the design change?

3. Squeaky Shoes
When you walk in the rain and then go inside, on some surfaces there is an effect, that the shoes make a squeaking sound. What are the relevant parameters for squeaking and how can one maximize/minimize the squeaking sound?

Electromagnetism

4. Treasure Cooks
Investigate the possibility of making an underground water detector of maximal penetration depth from a simple microwave oven. The detector should be capable of measuring the distance to the water. Please avoid boiling any human brains during experiments!

5. Costless Energy
Suggest, in your opinion, the most effective way to accumulate energy and energy use from the electromagnetic fields that surround us (excluding the >10 THz range). Make the appropriate experiments. Estimate the conversion efficiency.

6. Eddy Current Engine
Make an eddy current engine, with an AC voltage source and aluminum discs as in the video. Explain the phenomena, maximize the angular velocity of the discs and maximize the efficiency of this engine.
https://www.youtube.com/shorts/TVdB5-UKN8s

7. Electrostatic Cyclotron
With a DC voltage source, and a plastic ball covered in aluminum foil, you can make a setup as in the video. Determine the conditions for the ball to start rotating and maximize its speed. Investigate the relation between the speed of the ball and the relevant parameters of the setup.
https://www.youtube.com/shorts/t6uECHfaxgs

8. Laser Kaleidoscope
A kaleidoscope is an interesting device that uses a set of mirrors to construct fascinating geometric patterns. Try to input a coherent interference pattern in a kaleidoscope and describe the physics of such a system. If you add some sort of shape to mask out some of the input light, can you reconstruct the original shape based on the output? What if the mirrors inside are curved?

9. Van Der Graaf's Cat
Petting a cat may result in static electricity being generated on its fur. What are the ultimate energetic parameters of a possible discharge spark under normal conditions? What fur properties and petting techniques improve generation? Can one start a fire with such a spark? Please take the necessary precautions while performing the experiments. (No actual cats allowed!)
https://youtu.be/Th3GY5wgouA

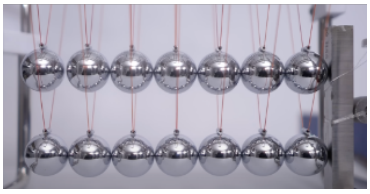
10. Paper on the Wall
If you blow against a small piece of paper placed on the wall, you can observe that the paper does not fall down. Explain the phenomenon and investigate the important parameters as the critical size, the material and the shape of the paper as well as the conditions of the air that is blown against the paper

11. Dust Collector
Devise a homemade setup to attract the dust in a room using electrostatic principles. Define and optimize its collection efficiency. What is the maximal room size that may be cleaned by such a device?

Engineering

12. Card master
A skilled person can throw a playing card and pop a balloon or cut some small fruits. Construct a machine to make this experiment repeatable in order to achieve stable destructive power and a bull's-eye-shot.
https://youtu.be/GYCI58pMGuQ

13. Double Decker Newton's Cradle
Make a double decker newton's cradle as in the video and optimize the transmission of the kinetic energy between the different levels. What is the maximum number of layers you can experimentally achieve?
https://youtu.be/kY2YeM5fNDw



14. Kinetic Voltmeter
A DIY method of testing the charge of battery is making it fall on a hard surface and seeing if it bounces or not (https://www.youtube.com/watch?v=suH32X91sQE). Explain the phenomenon and design, using materials accessible in every home, a device capable of measuring the charge of a battery using this effect, to the highest precision possible. What's the highest precision you can obtain? What are the important parameters? Optimize the device for precision and time/easiness of building it. Additionally, you can build a more complicated device with other materials. Are you able to obtain a much better precision?

Fluid Dynamics

15. Periodic Gurgles
Turn an open bottle of water, juice, lemonade, ketchup, or shampoo upside down. The liquid spills out not continuously, but with periodic gurgles. Investigate the phenomenon. How do results change if the bottle is tilted?

16. Whirly Jellyfish
In saltwater, jellyfish can wrap themselves around a bubble ring. Can this physics phenomenon be used to make jellyfish-like objects much denser than water rise to the surface? How big of an impact does water's salinity have? What are the other key parameters for such an occurrence?
https://www.youtube.com/watch?v=JXkWSgU-CL0

17. Inflatable air dancer

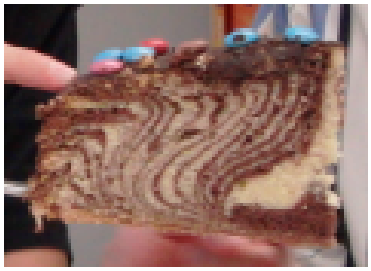
Inflatable air dancers are advertising tools used worldwide. Explain the physical mechanism of the device. Identify relevant parameters and how they affect the resulting movement of the system. Is it possible to identify distinct operation regimes? Many air dancers have branches ("arms" and "legs"). How these branches can be used to control the movement of the system? Can one establish a regular oscillatory movement with arbitrary frequency, or even a combination of frequencies? https://youtu.be/moa2KKC7Fr8

18. Windy Room Tomography
When shutting a door, we observe that sometimes it slams, sometimes it slows down and comes to a halt, depending on whether a window is closed or open. When multiple windows are open, air currents can shut the door by themselves. How much information about the room behind and in front of the door (number and location of open windows, their degree of openness, volume of the room, presence of obstacles…) can you infer just from the dynamics of the door (resistance of door to shutting, spontaneous closing due to air currents, …)? What door design is particularly suited to gain as much knowledge as possible on the rooms around?

19. The Life of Beer Foam
Investigate the dynamics of beer foam after pouring. How does the foam evolve over time? What are the key physical mechanisms that govern its stability, collapse, or growth? How does the behavior change with the shape of the glass?

Food Physics

20. Egg Fractals
While frying egg whites in a frying pan, characteristic structures form. Try to build a model of the pattern formation and investigate the number of branchings.

21. Zebra Cake

Bake a zebra cake: Beat the egg yellow with vanilla sugar/Vanilla essence until the mixture is creamy. Add oil and water, mix again, and add flour and baking powder. Subsequently fold in the beaten egg whites. Separate the batter into two equal parts, add cocoa powder to one part (dark batter) and keep the other part plain (bright batter). Then deposit in the middle of a round baking pan the amount of one spoon of each type of batter on top of each other in an alternating sequence. Bake for about 50-60 minutes at 175°C. Investigate and explain the resulting pattern inside the cake (see figure). What happens if you deposit batter like this at several equally spaced spots (e.g. 4 positions) inside the circular area of the baking pan?

22. Rice Holes

If you do the rice cooking without ever stirring it, in the end you will find out that your well-cooked and tasty rice shows a pattern of holes like the one in the picture. If you repeat the experiment in the same pot but using different types of rice, the pattern slightly depends on the aspect ratio and the dimension of the grains of rice. Can you suggest a physical explanation for the phenomenon? Can you identify the relevant tunable parameters governing its occurrence?

Hydrodynamics

23. Floating Log

It is known that a log floats down the river at a velocity different from the average velocity of the river's flow. Reproduce a scaled down version of this experiment in a laboratory. Investigate the dependence of velocity on depth and width of the "river", the flow velocity and the size of the log. Can you infer the behavior of a real-size log from the scaled down version?

24. Fountain in a Pot

On the video you may observe a drop periodically flying high over the water level in the pot. How does the drop's size, altitude and its period of formation depend on relevant parameters? Which jet, pot and fluid parameters can be determined by observing just these drops? https://youtu.be/2q1EPAacsUA

25. Vortex Rings Collision

When two vortices collide perfectly head-on, they expand and disappear. However, one can observe that smaller vortices formed where the original ones disappeared. Explain how the small vortices are formed after the collision and the direction of their spin. Can you find other cases where the same phenomenon occurs? https://youtu.be/EVbdbVhzcM4

26. Water Laser

A shallow water tank mechanically excited by a motor features the basic ingredients of a laser (i.e. a cavity and an amplifier). To what extend can this simple analogy capture more complex aspects of laser physics, such as laser class, Q switching or cavity design?

27. Knife Jet Streaks

When water impinges on a serrated knife, or similar structures, a steady pattern of lines appears in the reflected water screen. Investigate this phenomenon.

28. Vortex in a Square Mug

When stirring a liquid in a square mug one may observe a strange vortex shape composed of four rays. What determines this shape and what conditions are necessary for its observation? What other shapes can be obtained with different types of mugs? What information about the mug geometry may be obtained by examining the vortex shape? https://youtu.be/9f9E2AAoXuU

29. Best Teapot

The quality of a teapot is determined by the fact how transparent and long jets can be poured from the spout of a teapot. As it could be easily found out, the more laminar is the jet, the better is the teapot. Devise the best teapot with the length of the spout limited to 1 cm and the volume of the teapot limited to 300 ml. How will it work for the water of different temperature? https://youtu.be/4R6t4qozgVU

30. The Washer Jet

When a washer hits a container with water and soap, a central jet can be observed, study the phenomenon and determine the relevant parameters for the bubble to form. How can you maximize the jet height? What happens when one uses a shape different from that of the washer?
https://www.facebook.com/reel/538241128009387?fs=e&s=cl

31. Bartender Trick
When one walks with some beverage in a glass that has (initially) multiple phases in such a way that it doesn't spill from the cup, typically the phases will start mixing. Study the phenomena. What happens when one of the phases is foam? https://www.youtube.com/watch?v=4OJd_phsa5w https://www.youtube.com/watch?v=GFJXRg7nQVY

32. Dancing Soapy Vortices
When exposed to sound, a soap film shows beautiful dancing color patterns. Under certain conditions, vortices appear. Investigate these vortices. Why do vortices appear? What are the best experimental conditions to make them appear (sound frequency, orientation of the soap film with regards to the sound wave, size of the film, etc.)? https://www.youtube.com/shorts/j9Y3ansvt0U https://iopscience.iop.org/article/10.1088/1361-6404/aa7147

Ice Physics

33. Seracs
Under what conditions can ice columns form in highlands? What limits their size and lifetime?

34. Ice Lighthouse
At the times of winter storms, huge ice formations can grow on the walls of lighthouses. Estimate the maximal weight of such formation. How does it depend on the weather conditions during the formation? Make a mini-replica in the lab.

Material Physics

35. Straw Hat
Shirakawago, in Japan, is famous for its tradition of thick straw roof. What thickness of straw is required to keep the house dry? How will the answer change for a different climate zone?

36. Sticky Fingers
Take a grain of silica gel with dry and wet hands. When fingers are wet the grain sticks to your skin as if it is glued. Explain the phenomenon. What are the conditions for strongest adhesion? How long would this "glue" last when applied to different surfaces?
Warning: don't eat silica gel!

37. Cracking Fingers
We all have experienced the very satisfying (or annoying, depends on the person) cracking sound fingers can produce. This sound is thought to be originated by the creation of a cavity filling itself with gas in the synovial liquid. Investigate the phenomenon and reproduce it in the lab (don't experiment with your own fingers, the goal of this problem is non-human reproduction of the phenomenon). Maximize the volume of the sound produced. https://youtu.be/wf-B_jHRl1g?si=Lv1qcqlZxRH6ljWA

Mechanics

38. The Crazy Cylinder
Fill the space between two parallel panels with liquid, then attach two threads to the ends of a heavy circular cylinder and submerge it into the liquid. The cylinder diameter should be slightly smaller than the inter-panel distance. Next, pull the cylinder up, and under some circumstances the cylinder will begin to hit the walls periodically. Explain this phenomenon and estimate the oscillation frequency.

39. Dangerous Straw

After hurricanes one can find trees pierced by wooden. The photo shows a one-inch thick pine-plank piercing a tree. Under what circumstances can one expect to observe a tree pierced like this after a hurricane?

40. Ping-Pong Balls Cannon

Construct a mechanical cannon (no explosives and compressed gas) that is capable of firing a ping pong ball a considerable distance. Optimize your design and determine what thickness of Aluminum sheet the ping pong ball is capable of penetrating. Compare this value to the theoretical maximum thickness that can be penetrated by a typical ping pong ball. Take extreme care when performing these experiments.

41. Two-Wheel Skateboard

Derive the conditions of stability for the two-wheel skateboard and test them experimentally. Additionally, explore the typical trajectories of the wheel traces.

Particle Physics

42. Low-Cost Particle Accelerator

Build a low-cost particle accelerator. Try to maximize the particle current density and energy of the particles.

43. Cosmic Skyscraper Tomography

Radiography is an imaging technique that uses X-rays, gamma rays, or similar ionizing radiation and non-ionizing radiation to view the shape of an object. There are many subatomic particles that are produced by solar radiation and propagate at the sea level called secondary cosmic rays. There are many methods of using cosmic rays in tomography of terrestrial objects, such as muography (https://en.wikipedia.org/wiki/Muon_tomography). Develop a method that will allow you to determine how many floors are above you in the building where you place the experiment.

Hint: simplest particle detector can be made from store bought x-ray films or with scintillators.

Plasma Physics

44. Roaring Flame

If you blow on the top of the flame from a lighter from the side so that it is not completely blown out, but tilted, you can hear a trembling sound. Explain the mechanism of sound formation and the relevant parameters that affect the sound. https://drive.google.com/file/d/1VlhwL9FqLjygj9OsXS3d_P1Evlr6opvD/view?usp=sharing

45. Singing Flame

It is now well known that flames can travel. However, did you know that they can sing too? They will emit sound if an alternating electrical current passes through them. Explore this interesting phenomenon. What are the upper bounds of it in terms of intensity and frequency? Can you make this work the other way around, i.e. record sound using a flame? What would be the limitations of such a recording? Here a video that demonstrates the phenomenon: https://www.youtube.com/watch?v=WoVQky1a53k

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Statistical Mechanics

46. Leaf Fall

Many trees shed leaves regularly or seasonally (for instance, in autumn). How is the carpet of leaves that forms around such trees affected by parameters like the shape of the tree, the leaf-shedding rate, and local climatic conditions? Investigate the spatial distribution of leaf concentration and the characteristic size of the carpet. Which trees produce the largest carpets?

Thermodynamics

47. Crowbar Distillery
According to Siberian tales, people would purify liquids containing alcohol, for instance, strong detergents, to obtain drinkable alcohol. The method is very simple: a crowbar is carried out in the frost and the liquid is poured on it. It is then allowed to run slowly along the full length of the crowbar. By iterating the process, one obtains purified and drinkable alcohol. Investigate the efficiency of this method.

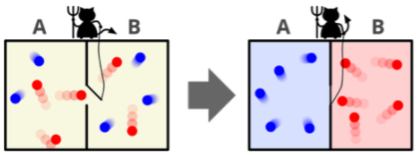
48. The Nervous Pot
One may observe the pot with water on the electric cooker begin trembling with high frequency. The water in the pot is still far from boiling. Investigate the phenomenon. How could one design a pot with the most violent trembling (possible applications might be the mass transfer enhancement)?
https://youtu.be/zfTwLiBJPLk https://youtu.be/UtnlIIku8KM

49. Air Conditioner
For having air conditioning in the house, the following setup is proposed. The cold water is poured into the bottles and the air from a ventilator is directed on them. How efficient is this setup? Propose your own equipment for air cooling with maximal efficiency based on this principle.

50. Molecular Rebounce
Propose a homemade equipment to measure the coefficient of molecular rebounce for some gas hitting the liquid surface of the same chemical substance.

51. Heat Pipes
When lava is flowing freely long caverns called 'Lava Tubes' can be formed. Reproduce and study the effect with less dangerous matter (like paraffin etc)?

52. Bubbly Plastic
Consider a plastic cup. If a flame is placed under it, the plastic melts. However, if water is placed inside the cup, the plastic will not melt. On the other hand, if carbonated water is added, small holes will appear on the side of the cup exposed to the flame. Based on these holes, estimate the average radius of the gas bubbles in the water and the roughness of the cup's surface. Explain how this phenomenon depends on the water, the gas, the plastic, and the flame.

53. Maxwell's Demon


The Maxwell's demon thought experiment (https://en.wikipedia.org/wiki/Maxwell%27s_demon) is a famous setup in which one is able to create a temperature differential in an initially thermalized gas by exploiting the information extracted from measurements on the gas particles. There are many versions of the setup that fundamentally show the same thing (e.g. creating a difference in number of particles instead of temperature).
By placing a shallow box with small balls inside on a vibrating table one can simulate a 2D gas in a box. Implement the Maxwell Demon setup in such a system (or one of its cousins) and optimize the speed and efficiency of the process by which you create the difference in temperature/number of particles. Furthermore, is it possible to turn your device into an engine and use perform work? If so, characterize its power and power fluctuations.
Hint: by using balls of different masses one can simulate a gas with different chemical species.

Wave Mechanics

54. Tin Can Telephone
Build a tin can telephone without any electronics and maximize the distance over which you can speak over this device.

Thanks for your time!

August 13, 2025 **Alberto Rolandi, IPT Secretary**