LPR V Cup

10.s05.e03

What if our feelings are also a malfunction, just a glitch in a mechanism that can be fixed?
And then everything will be fine for everyone?...
Kikoriki

Heatextractor

Splash... and the furious roar of the unwinding chain sends the anchor down, deep into the water. Something inside you follows it along a thread of fear down your spine. The cold sea wind creeps through the cloak and wraps around its folds.

Two weeks of travel are already behind you, and now you're finally there. There have been many rumors about this place. But those who spoke of it, usually in hushed tones, had never been here before. And those who told them about it had never been there either. Thus, if anyone had been there, they had never spoken about it. Some say, it's because they couldn't.

You have no desire to go there, but a sense of duty doesn't allow you to retreat. When the thick fog descends over the water, you order a small boat to be lowered after it, and half an hour later, you find yourself on the shore of the island.

Seemingly aimless wandering for a long time yields no results, but, at one moment, the compass needle starts to go crazy, and you realize you are close. Taking another step, you hear something beneath your feet reverberate with a deep metallic echo. With a prolonged and hoarse creak, the heavy hatch finally gives way, and you see the descending steps.

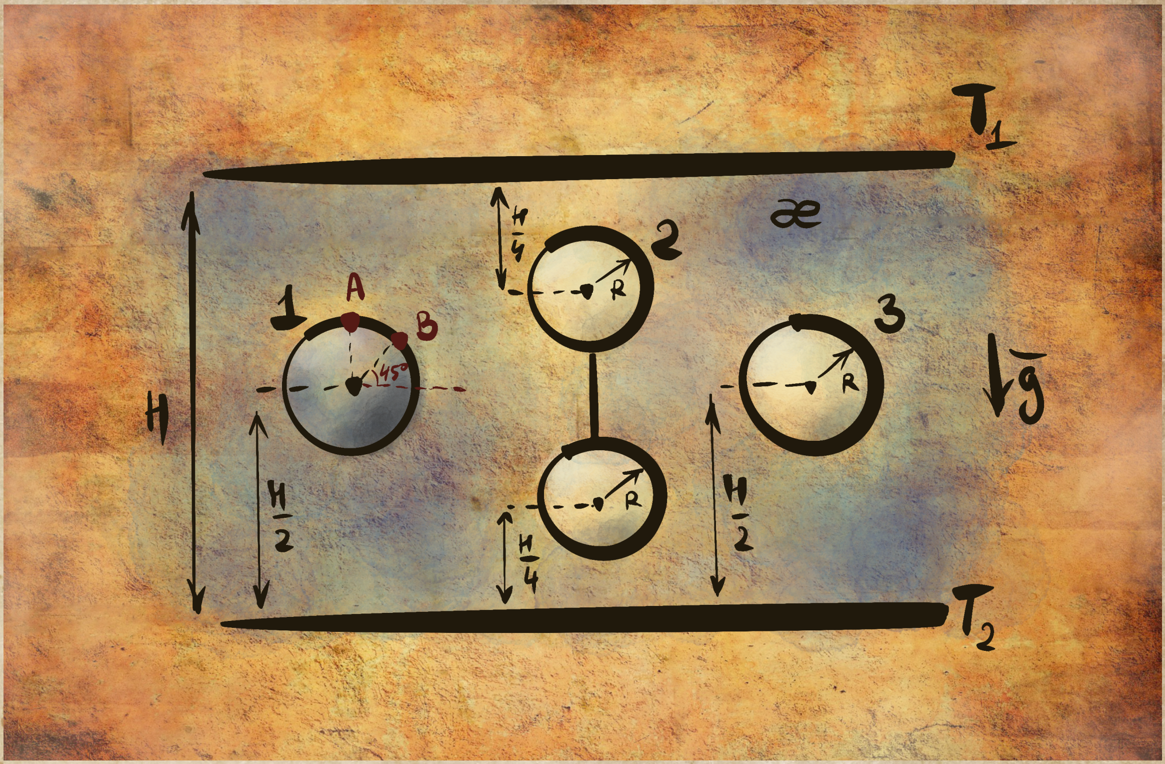
In the light of the gas discharge lamp, you see scattered diagrams and a transparent heat sink with a thickness of H and thermal conductivity of $\varkappa$, similar to glass, clamped between two planes. Whoever left this substantial part of the massive heat center did not obstruct the water in the serpentine tubes, which maintain constant temperatures of the planes T_1 and T_2 (see fig.).

Upon closer inspection, you notice several defects inside the heat sink material.

1. *(3 points)* One of these defects turns out to be a metallic ball bearing with a radius $R \ll H$, solidified at a distance of $H/2$ from both planes. Find the ratio of the heat flux densities q_A/q_B at points A and B (see fig.). Assume that the thermal conductivity of the ball bearing is infinitely large.

2. *(2 points)* The other defect consists of two small spherical cavities with radii $R \ll H$, connected by a very thin heat-insulated tube and filled with air. The bubbles are located at a distance of $H/2$ from each other, and the upper one has solidified at a distance of $H/4$ from the upper plane (see fig.). Find the ratio of the air pressures in the cavities after a long period of time.

3. *(5 points)* The last type of defect is an air bubble with a radius $R \ll H$ and a thermal conductivity coefficient $\varkappa_a$. Determine at what temperature difference $T_1 - T_2$ the equilibrium of the air inside the cavity will be disrupted by the onset of convective processes. The molar mass of air is μ, its specific heat at constant volume is C_V, and the acceleration due to gravity is g.



Consider that all the defects are located at a significant distance from each other.

Zero hint — 12.05.2024 15:00 (Moscow time)
First hint — 14.05.2024 12:00 (Moscow time)
Second hint — 15.05.2024 12:00 (Moscow time)

Final of the third round — 17.05.2024 20:00 (Moscow time)