LPR V Cup

9.s05.e03

The world is a machine.
Imperfect details together form a perfect whole.
Steampunk!

Underground aqueduct

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 a complex hydrodynamic system of cylindrical pipes stretching far down the tunnel. It's possible that this system was once used for heating. In any case, it was connected to a pump that indicated it created a pressure difference Δp_0. Tapping one of the rusty pipes, you realize they are still filled with liquid and ready for operation.

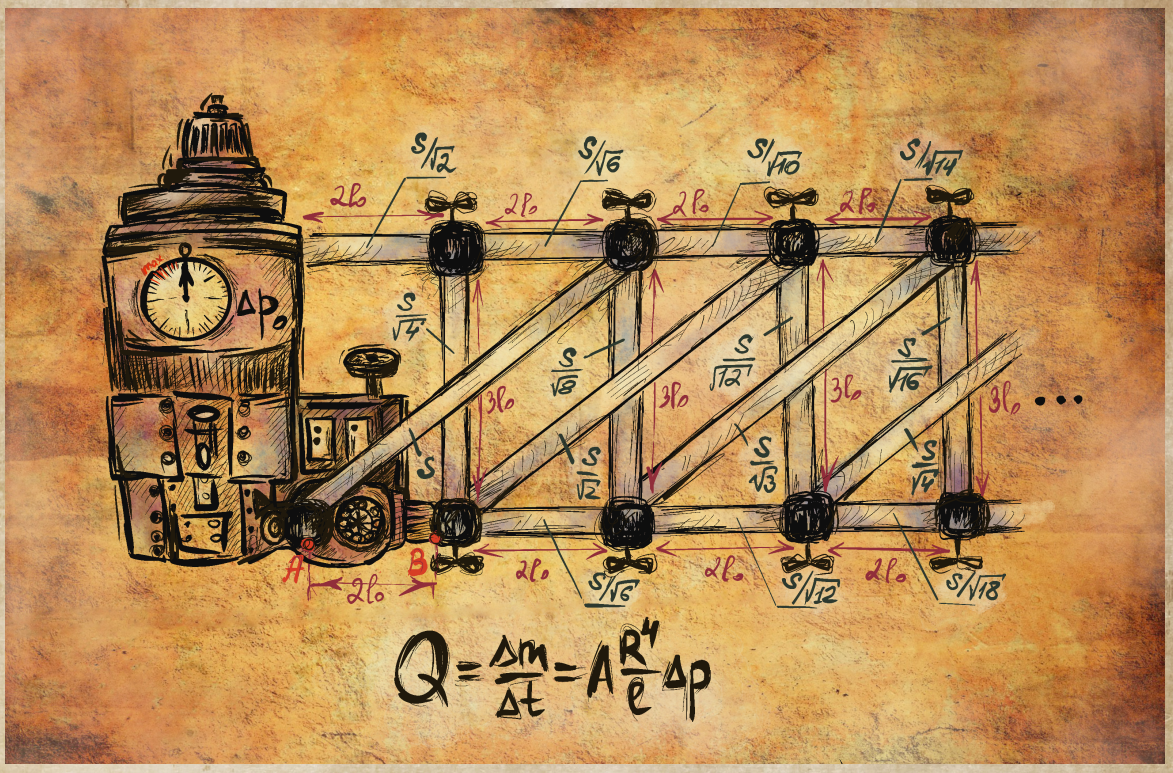
Turned around, you see a faded and mold-covered detailed drawing of the hydrodynamic system on the wall. From it, you learn that it consists of two parallel main lines, connected by transverse and diagonal pipes (see fig.), as well as all the characteristic dimensions.

You also have found a note on it, written in uneven and nervous handwriting: with a pressure difference Δp between the ends of a pipe with length l and radius R, the mass flow rate of the liquid is

$$Q = \frac{\Delta m}{\Delta t} = A\frac{R^4}{l}\Delta p,$$

where A is a dimensional constant, and Δm is the mass of the unknown liquid passing through the cross-section of the pipe in time Δt.

After waiting for some time, you eventually pull the old, worn lever, and the system starts working. Gears, pistons, and cranks, which you thought should have been worn out long ago, shift from their place with creak, and the pump starts working.



1. Determine the mass flow rate of the unknown liquid Q, which will show the flow meter arrow on the pump.

It is known that pressure in the connecting nodes A and B are the same, all pipes are straight cylinders, and the sizes of the connecting nodes can be neglected. The compressibility ratio and density of the liquid are such that the speed of sound propagation in it can be considered infinitely large. The pressure of any column of liquid in the system can be neglected compared to the pressure created by the pump. Express the answer in terms of l_0, S, Δp_0, A.

First hint — 13.05.2024 20:00 (Moscow time)
Second hint — 15.05.2024 12:00 (Moscow time)

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