LPR Cup

11.s05.e03

Name the greatest of all inventors. Accident
Mark Twain

Strange membrane

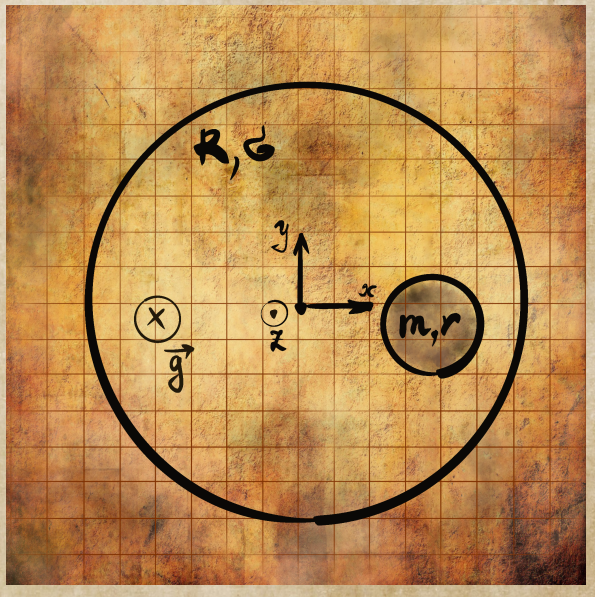
Splash... and the furious roar of the unwinding chain sends the anchor down, deep into the water. Something inside you follows it along a thread of fear down your spine. The cold sea wind creeps through the cloak and wraps around its folds.

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.

The light from the gas discharge lamp is reflected from the horizontal, uniformly stretched, light and disturbingly familiar leather surface in the form of a circle with a radius of R, fixed along its edges. The surface can be considered as an elastic film with a surface tension coefficient σ. Something irresistible prompts you to place a small washer with a mass of m and a radius of $r \ll R$ at the center of the film (see the diagram visible on the wall).



1. *(2 points)* Find the dependence $z(x, y)$, where z is the vertical displacement of a certain portion of the film.

The same mysterious force prompts you to move the washer to the point $(x_0, 0)$ and hold it with an external horizontal force F_0. You choose the position of the washer such that $R - x_0 \gg r$.

2. *(4 points)* Find $z(x, y)$ in this case.
3. *(3 points)* Find the force F_0.
4. *(1 point)* The washer is released. What speed v will the washer have at the center of the circle?

The friction of the washer on the film is absent. Consider that $mg \ll \sigma r$.

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)