1. Invent Yourself

František Kundracik

Department of Experimental Physics

Faculty of Mathematics, Physics and Informatics

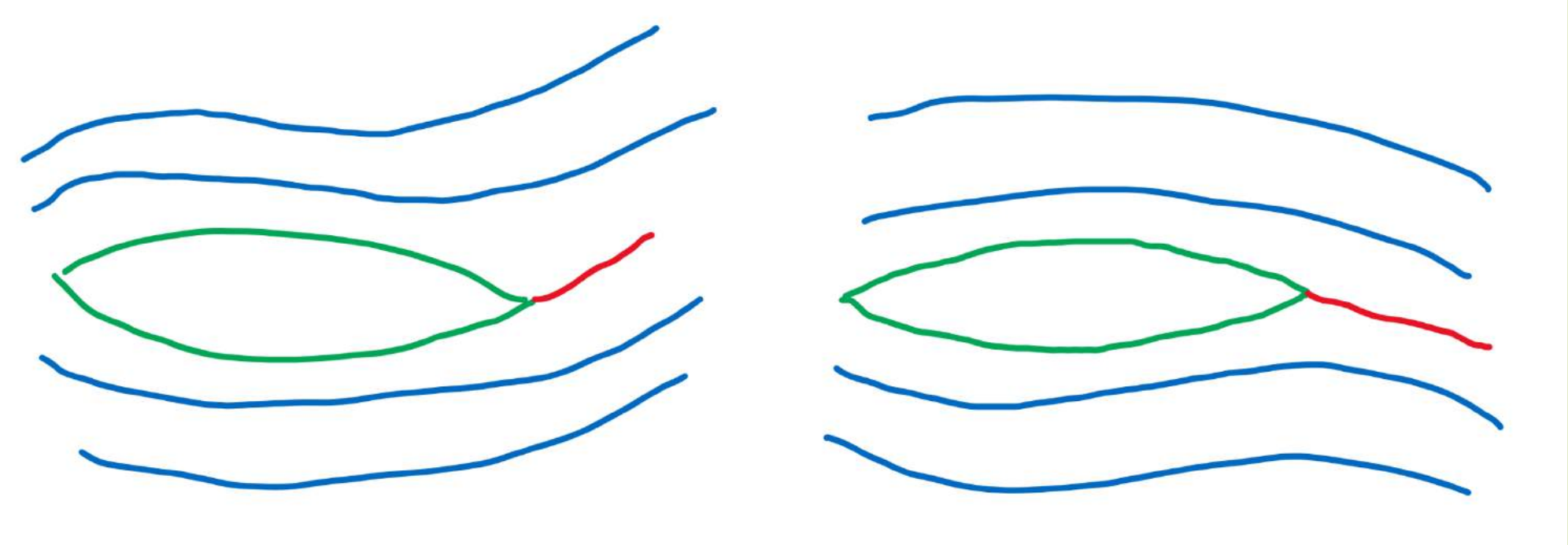
Comenius University, Bratislava, Slovakia

1. Invent Yourself

Design a boat that moves only due to the periodical mechanical movements of its internal parts and which only interacts with the environment (air, water) through its stiff hull. Optimise the parameters of your boat for maximum speed.

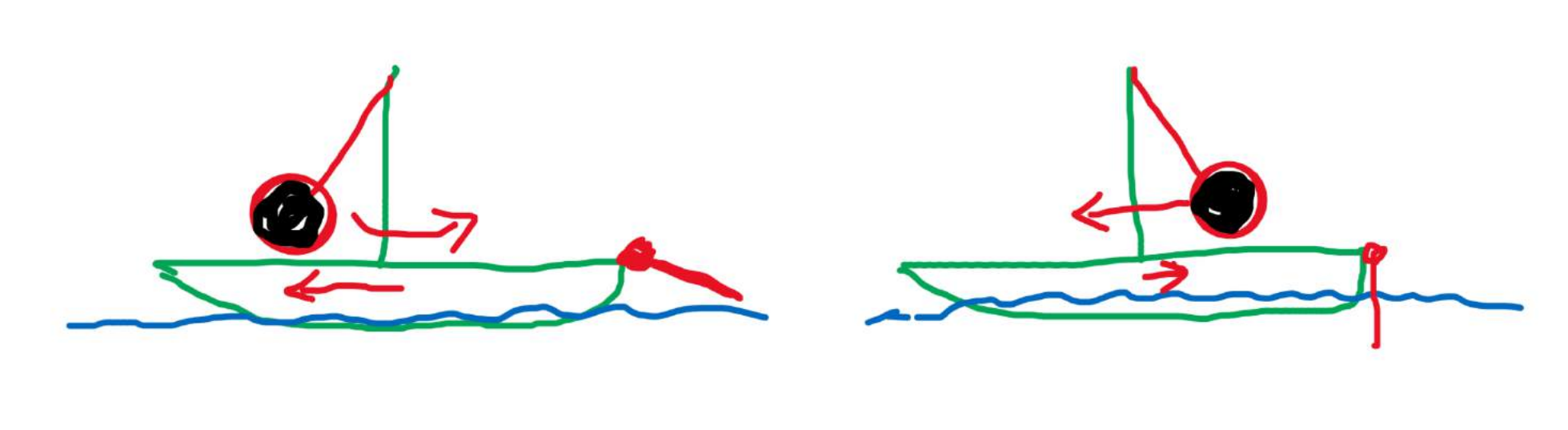
Stiff hull only – no rudder

Fish-like motion



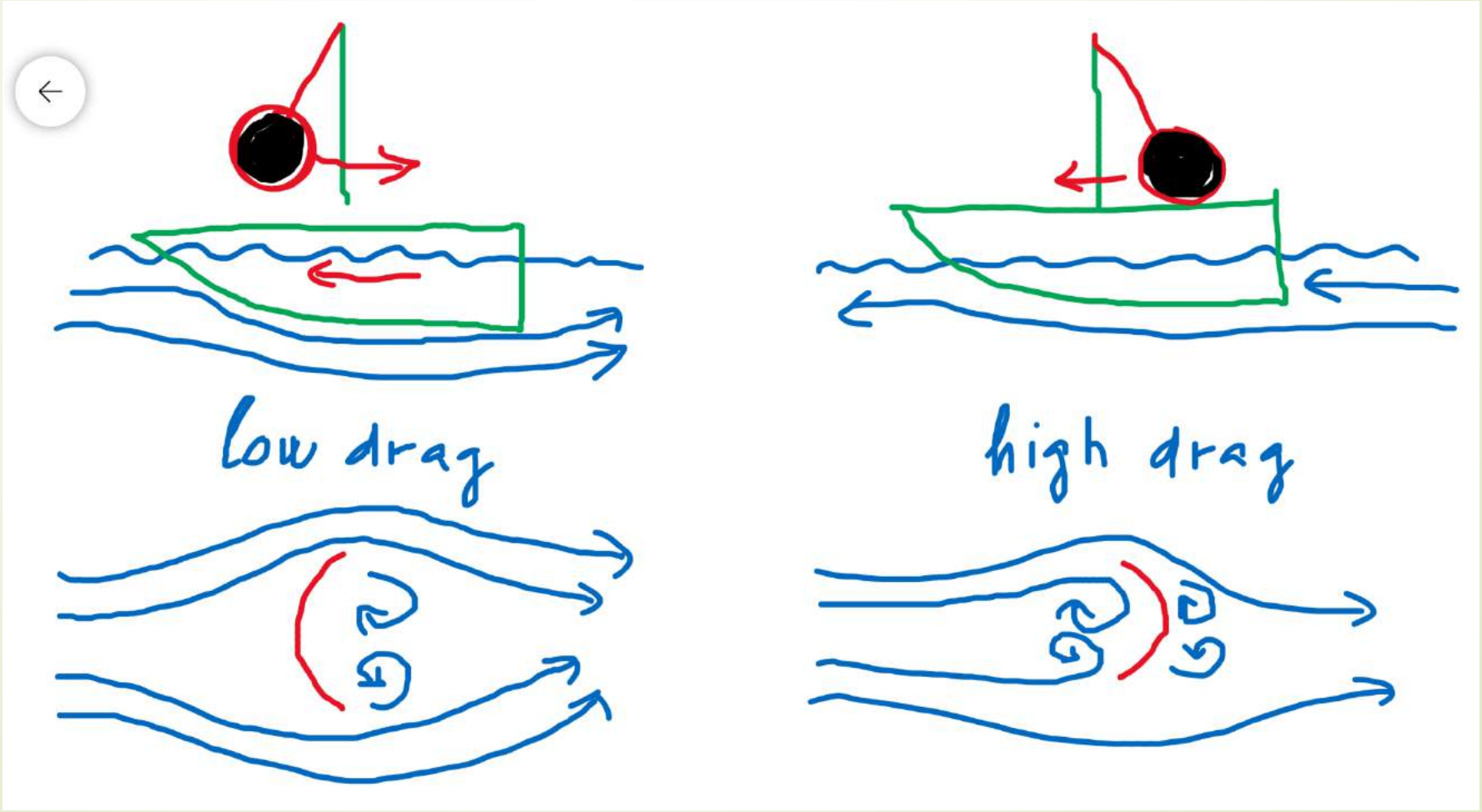
Stiff hull only – no flaps

Backward motion is supressed



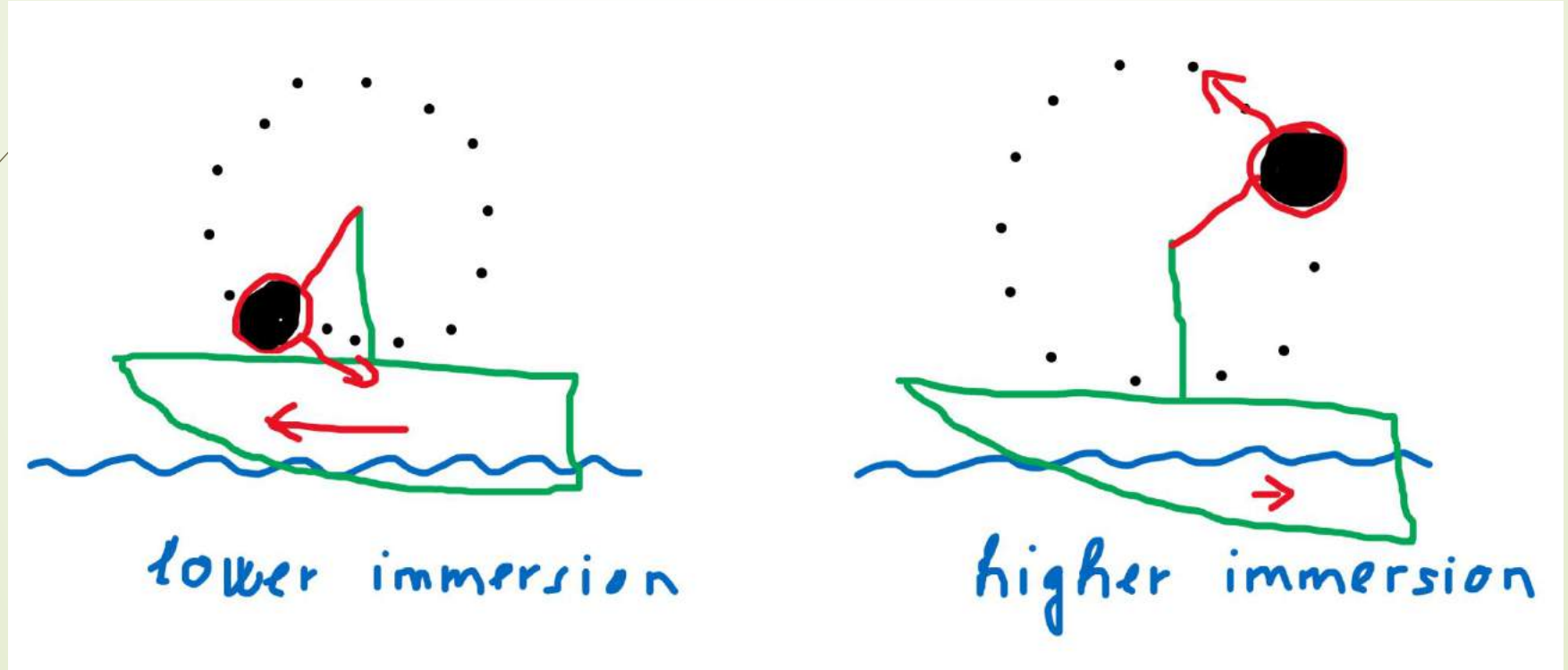
Stiff hull only – asymmetry is allowed

Backward motion is supressed



Stiff hull only – asymmetry is allowed

Even better – **circular motion** – immersion depth is changing



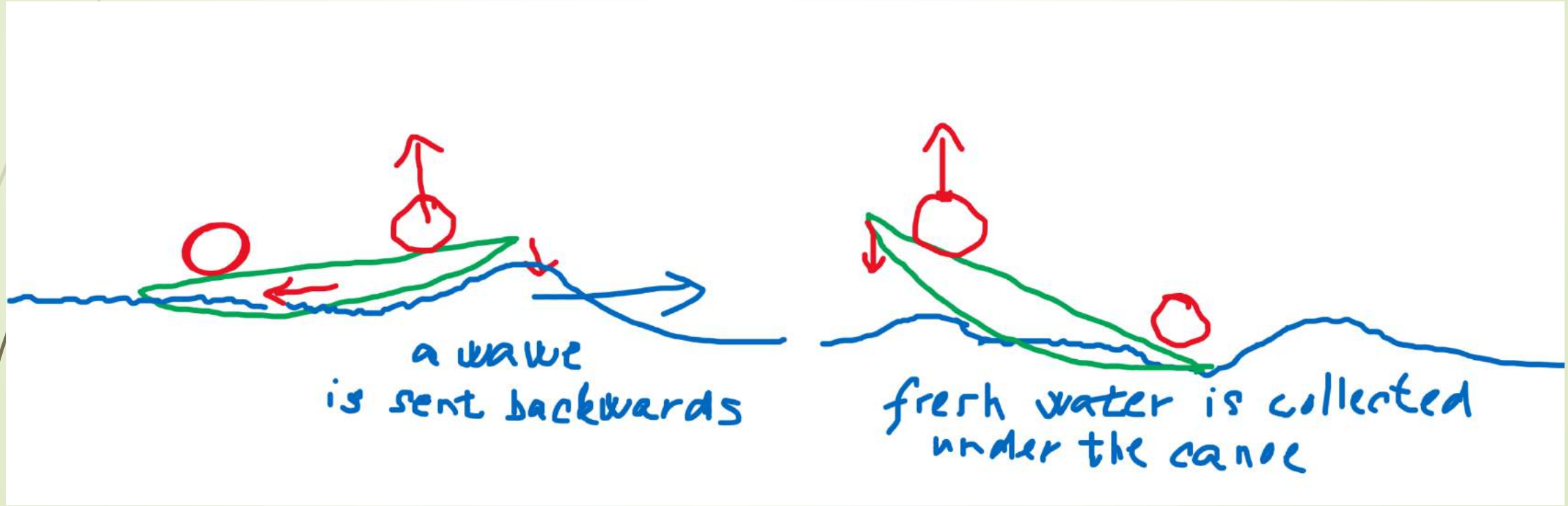
Motivation

Video of a moving canoe without paddles

https://www.youtube.com/watch?v=jlvmQzoossI&feature=youtu.be

Motivation

Two main phases:

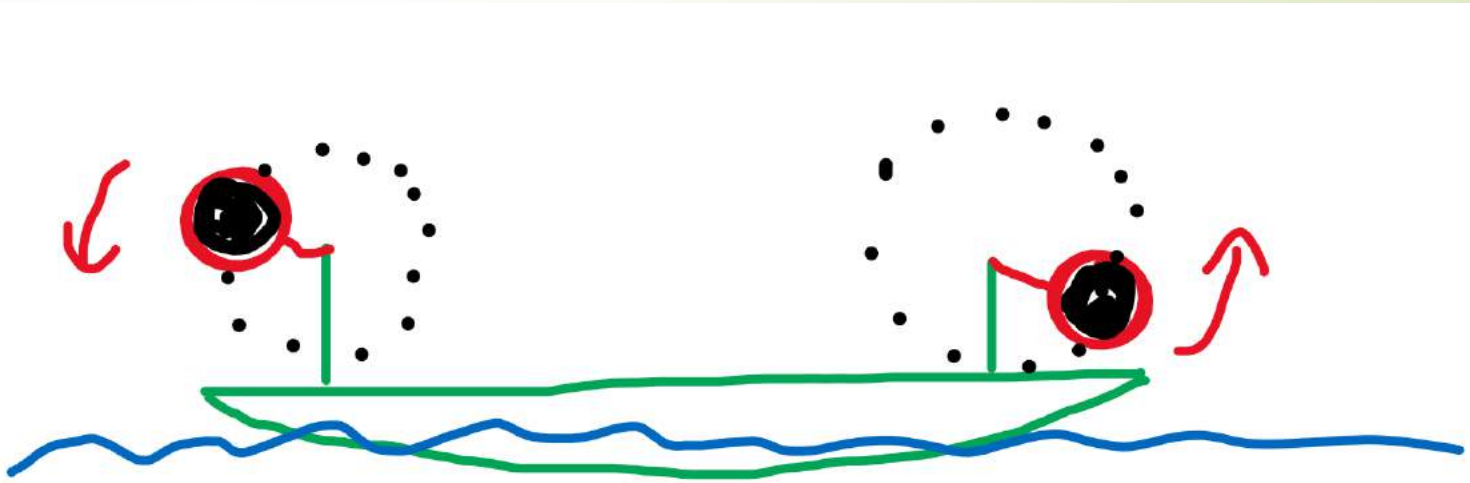


What to do with the task

- Build and optimize scaled-down model based on the motivation video
- Try to invent your own design (another principle)

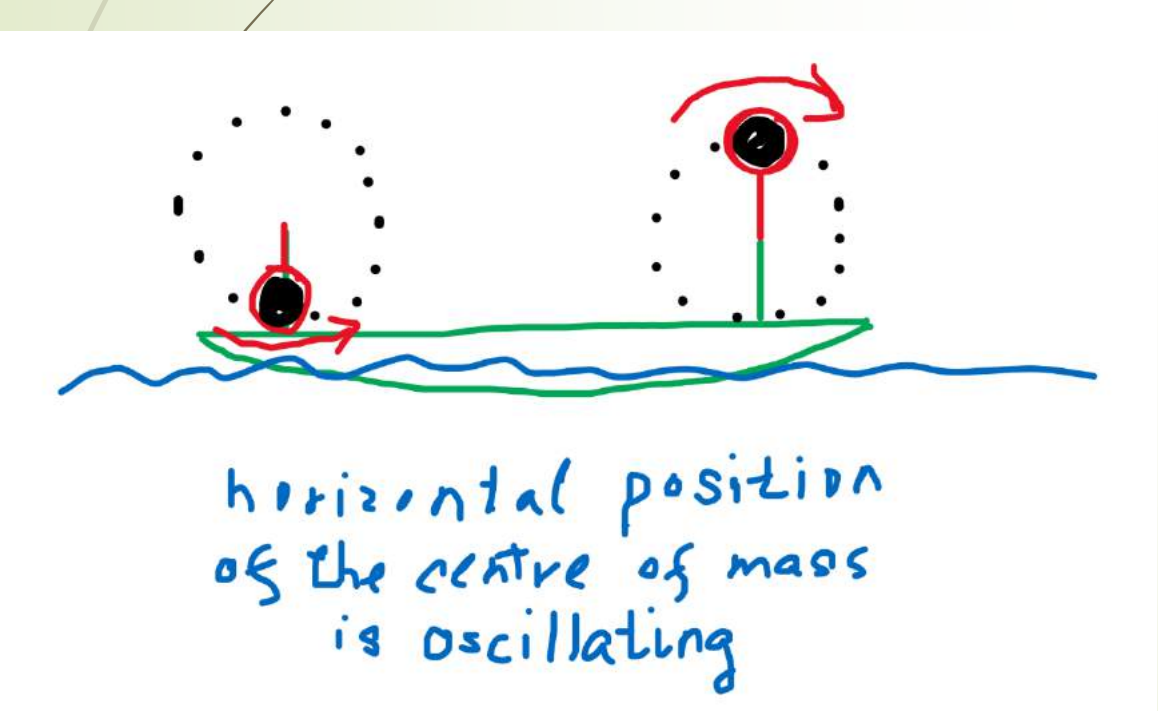
Optimizing the model based on the motivation video

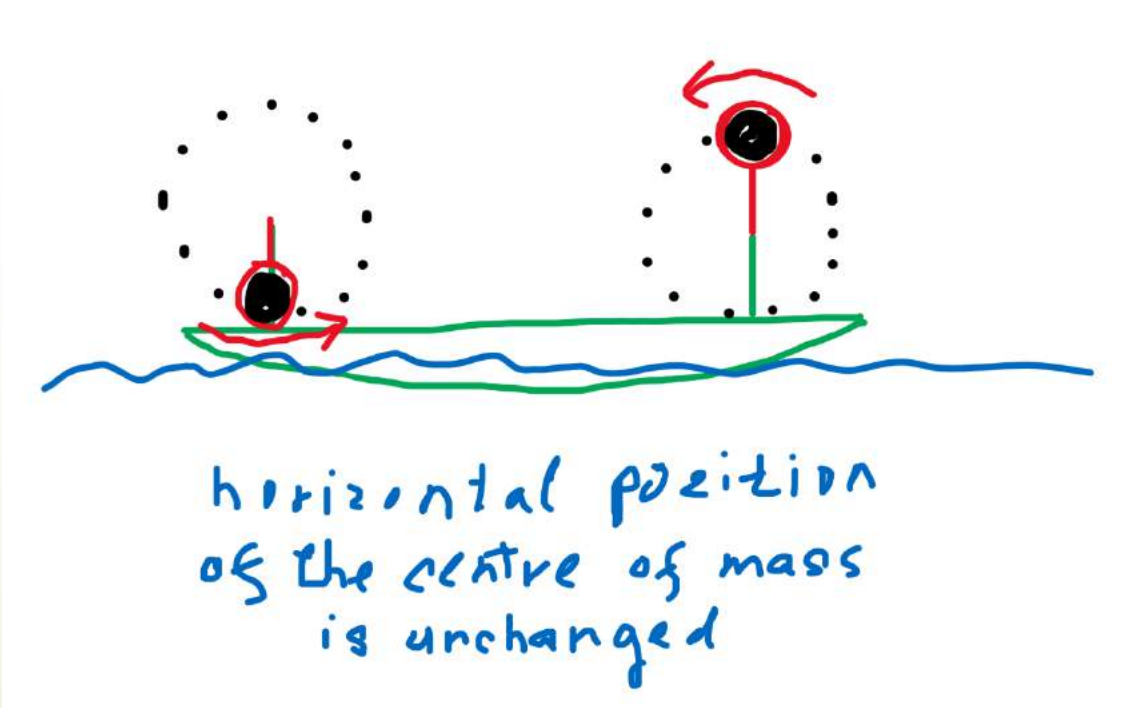
- Vertical oscillations can be changed to synchronized circular motion of weights
- Parameters: mass, radius, frequency, they can change
  - Depth of immersion
  - Frequency of wobbling



Model based on the motivation video

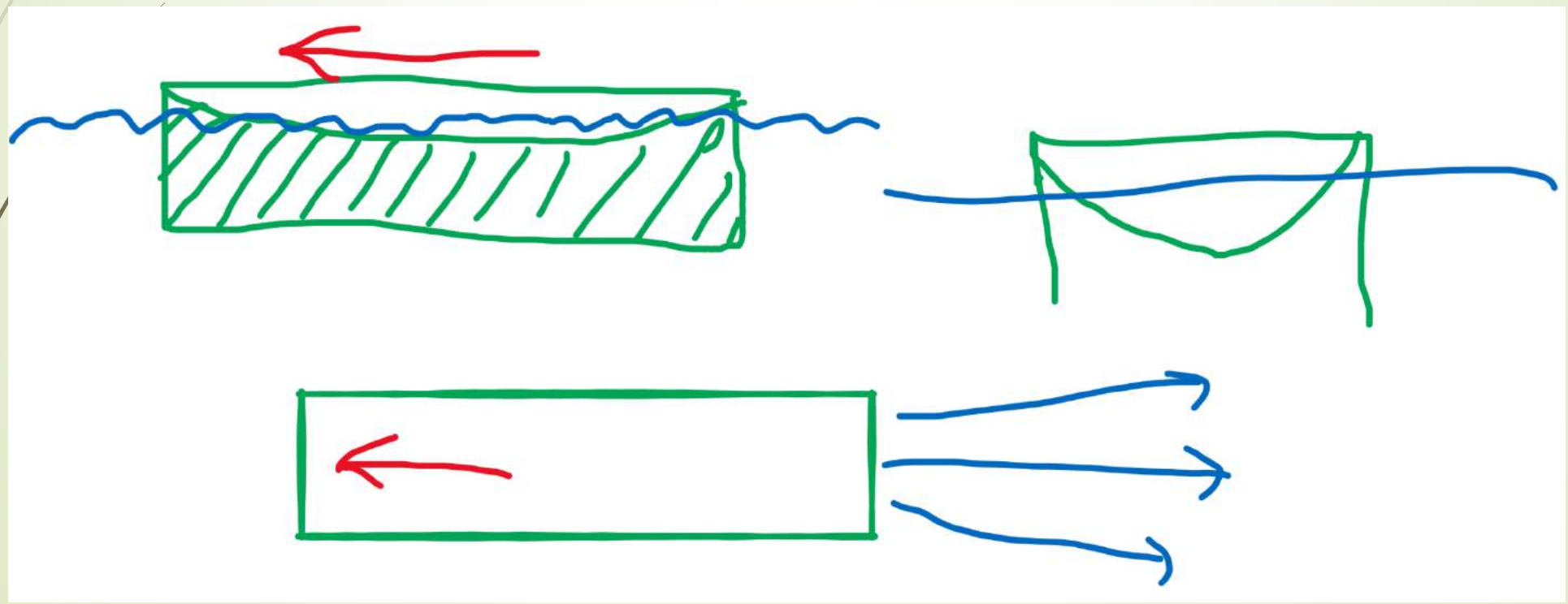
- Parameter: the same/opposite direction of rotation
  - Horizontal oscillations are canceled/amplified
- Parameter: phase shift between the weights
  - Water flow can be influenced





Model based on the motivation video

- Optimizing the shape of the boat
  - Side-stops can prevent the off-axis flow of the water



Model based on the motivation video

- Optimizing the frequency
  - Interaction boat-waves is influenced
- Gravity waves on the water
  - The main force returning the water level to equilibrium is gravity
  - Consult Wikipedia and references therein for more information

Gravity waves on water

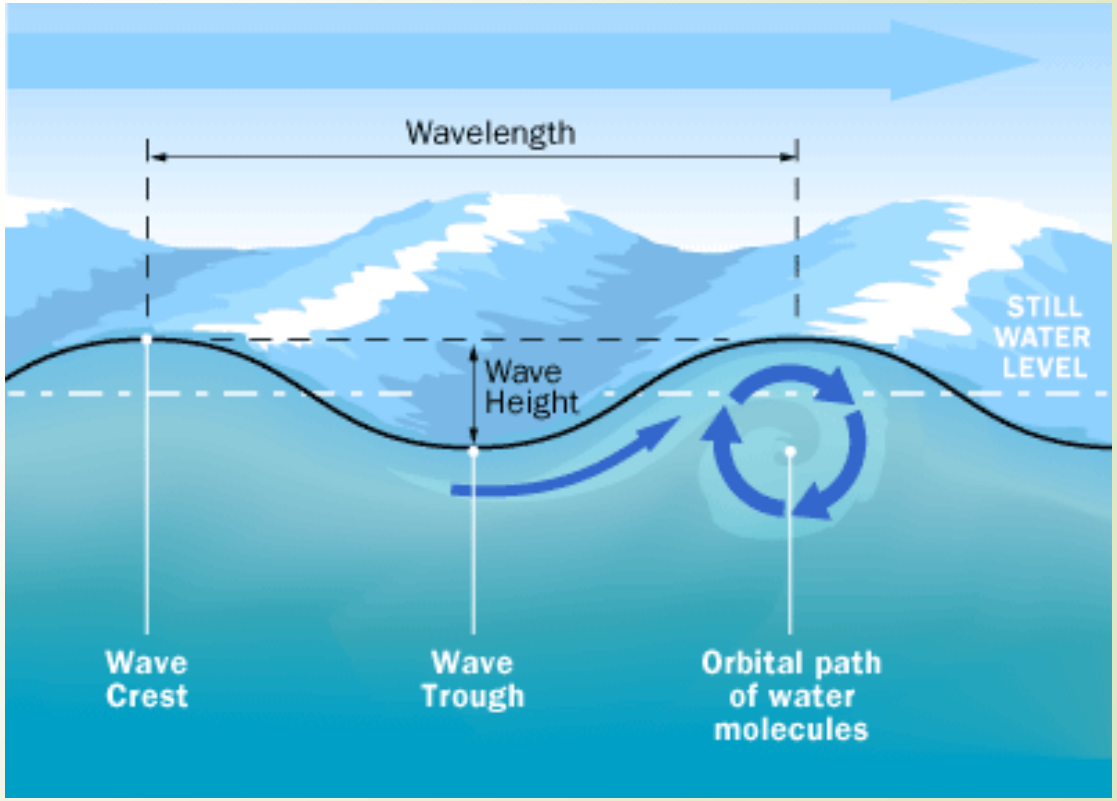
- Phase velocity:

$$c_{ph} = \sqrt{\frac{g}{k}} = \sqrt{\frac{g\lambda}{2\pi}}$$

- g – gravitational acceleration
- λ – wavelength, k=2π/λ
- Wavelength vs. Frequency

$$c_{ph} = \frac{\omega}{k}$$

$$\lambda = \frac{2\pi g}{\omega^2}$$

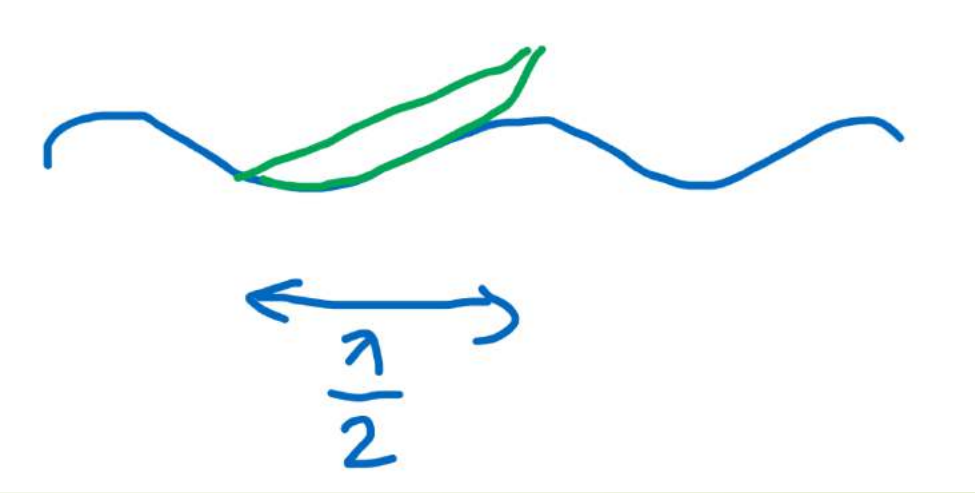


Optimizing the shape of the boat

- Wavelength of the waves produced by a boat oscillating with angular frequency ω is:

$$\lambda = \frac{2\pi g}{\omega^2}$$

- What happens if the wavelenth is comparable with the length of the boat?
  - Faster motion?
  - Slower motion?



Finding your own design

- Try to find another principles
- Don forget, that boat „interacts with the environment (air, water) through its stiff hull. “
- Whole mechanism should be hidden in the boat, otherwise the oponent can argue that the boat is moving due to interaction of your mechanism with the air

Thanks for your attention!