Computer Science 2 – Test

Time: 75min

15.04.2025

A ship begins its voyage from port. Its crew are navigating it in such a way that the velocity of the ship in the reference frame of the land is constant. Along the path of the ship, buoys have been placed, which measure the velocity of the sea current. Given the mass of the ship's available fuel at the start of its journey, compute the maximum distance that the ship can travel. For simplicity, assume that the water current always flows parallel to the ships path.

Quantities

- C_d – hydrodynamic drag coefficient
- ρ – water density
- A – cross-section area of the submerged hull
- v_s – ship velocity in the land reference frame (constant)
- v_w – water current velocity in the land reference frame (measured at buoys)
- n – number of buoys
- Δx – distance between consecutive buoys
- M – starting mass of the fuel
- W – fuel energy density
- η – engine efficiency

Correlations

Hydrodynamic drag:

$$F_d = \frac{1}{2}\rho C_d A \left(v_s - v_w\right)^2$$

Work needed to overcome hydrodynamic drag over distance d:

$$W_h(d) = \int_0^d F_d(x)\,\mathrm{d}x$$

Total energy generated by the engine using the available fuel:

$$W_e = MW\eta$$

Your task is to find d such that $W_h(d) = W_e$.