Problem Solving Block B: Iceberg Challenge

Task B3.1

You are walking by a river flowing at 1.67 m/s and decide to step into it to cool off.

(a) Estimate the force exerted on you as a function of the depth of the river.

(b) What is the force on you if you lie in a swimming position, but remain stationary?

(c) How does the force vary with the speed of the river?

Hints: Treat your body as a cylinder, and take the density of the water to be 1000 kg/m^3.

Task B3.2

A swimmer completes 100m in 1 minute.

(a) Estimate the average force the swimmer exerted on the water during the swim. How does this force compare with pushing up a dumbbell weight against gravity, and does the value you find seem reasonable?

(b) How does the power developed by the swimmer for the 100m swim vary with the swimmer's speed if they go at a constant speed, and what does it tell you about the challenges of going faster?

(c) How many kilo-calories did the swimmer use in the swim (1 kcal ~ 4220 J), and how much chocolate can the swimmer eat as a reward?

Task B3.3

The swimmer aims to complete the 100m in 1 minute in the most energy-efficient way to minimise the demands on the physiological energy releasing pathways. Decide whether the swimmer should complete the swim at a constant speed, or by varying speed over time, in the following ways:

(a) Consider that the swimmer completes the course at a constant speed except for one spell of duration dt where the speed is increased by dv, followed by a compensating spell where it is decreased by dv, so that the total swim duration remains 1 minute. Show that the energy expended increases with dt and dv.

(b) The swimmer decides to start slowly, and steadily increase speed v(t) over time in the following schedule:

$$v(t) = \frac{L}{T_0} + \alpha\left(t - \frac{T_0}{2}\right)$$

Here L=100m and the target time is T_0=100s; α is a suitable constant. What is the total time of the swim with this schedule, and what is the optimal choice for α that minimizes the expended energy?

(c) Develop a Matlab script that allows you to enter the swimmer's speed as a function of time, from which you can calculate the energy expended. Explore the conclusion that the constant speed swim is optimal in terms of energy expenditure.