École polytechnique fédérale de Lausanne
School of Architecture, Civil and Environmental Engineering
Civil Engineering & Environmental Science and Engineering Sections
CIVIL-312: Hydraulic Engineering and Infrastructures

Homework 1

Instructor: Prof. Mirko Musa
Due date: November 7, 2025

General Instructions

- This is an individual and mandatory assignment. Copying will result in a null grade (NA: *non acquis*) and a formal reprimand according to EPFL regulations.
- The assignment should ideally be **typed on a computer** and submitted as a **PDF file** through the corresponding Moodle submission form. This helps ensure clarity and readability. For **Problems 1 and 2**, you may alternatively submit a **neatly handwritten** solution, provided it is well organized and fully legible. Submissions that are poorly formatted or difficult to read will receive a **maximum grade of 5.0**. **Problem 3 must be completed on a computer** without exception.
- Figures and graphs may be included either in-line with your solution or attached as appendix. These must be neat and, if applicable, created using tools such as Excel, Matlab, or Python.
- Your work must be supported by a clear, logically structured solution process. You are expected to organize your responses effectively. A classic problem-solving approach is recommended:
  - **Conceptualize:** Identify all relevant data and draw a clear sketch showing applied forces, boundary conditions, and interactions.
  - **Categorize:** Define the unknowns, make justified assumptions to simplify the problem, and determine the path to a solution.
  - **Analyze:** Apply the appropriate physical laws, set up equations, and carry out calculations to find the unknowns.
  - **Finalize:** Evaluate your results. Check units, physical consistency, and whether the solution is reasonable by comparing it to similar cases or known benchmarks.
- For any questions related to this assignment, please use the dedicated **Moodle forum** so that everyone can benefit from the discussion and clarifications.

Problem 1

A vertical wall separates two tanks. The wall has a circular orifice of diameter d whose center is located at a height a above the bottom. The left tank contains a liquid with density ρ_1 and the right tank contains another liquid with density ρ_2. The orifice is sealed with a plug (ρ_p) shaped as a sphere of diameter D with $D > d$, placed as shown in Figure 1.

(a) Estimate the pressure difference at the bottoms of the two tanks. (1 pt)

(b) Find the magnitude and point of application of the horizontal component of the hydrostatic force exerted by the liquid in the right tank on the plug. (1 pt)

(c) Find the magnitude and point of application of the horizontal component of the hydrostatic force exerted by the liquid in the left tank on the plug. (1 pt)

(d) Compute the magnitude of the vertical hydrostatic force exerted by the liquid in the right tank on the plug[1]. (1 pt)

(e) Suppose the free surfaces in both tanks are at the same height and coincide with a (i.e., $H_1 = H_2 = a$). State the physical conditions (qualitative, not quantitative) that must be satisfied for the plug to remain in equilibrium, without moving laterally or vertically. (1 pt)

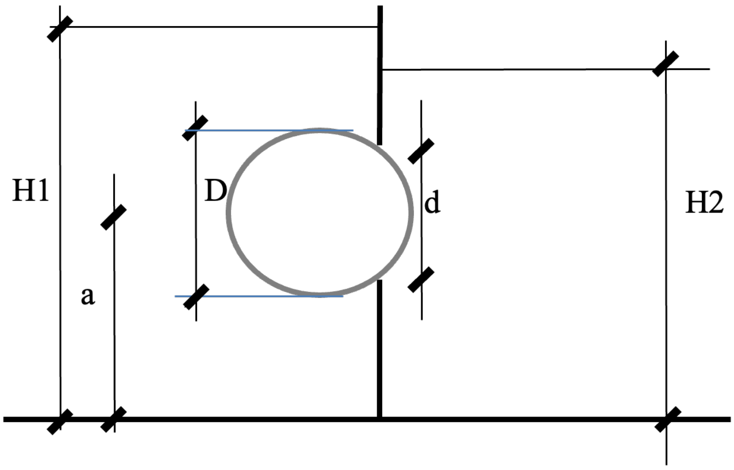

Figure 1: Geometry of the tank and orifice

[1] You may find **this link** useful

Problem 2

The system shown in Figure 2 consists of two tanks connected by pipes with known lengths and diameters.

1. **Flow with given valve loss** (2 pts)
   Suppose the valve is partially open with a loss coefficient of $K_{\text{VALVE}} = 100$.
   - Compute the flow rates through each of the pipes.
   - Discuss whether such flow conditions are physically feasible under the given operating conditions, considering aspects such as pressure distribution and the limits imposed by the vapor pressure and cavitation. Justify your reasoning.
2. **Maximum flow conditions** (3 pts)
   Determine the maximum flow rate that can circulate through the pipes without having cavitation problems, and the corresponding value of K_{VALVE} associated with this situation.

Notes:
(1) masl = meters above sea level.
(2) The vapor pressure of the liquid is -10 m of water column (relative to atmospheric pressure).

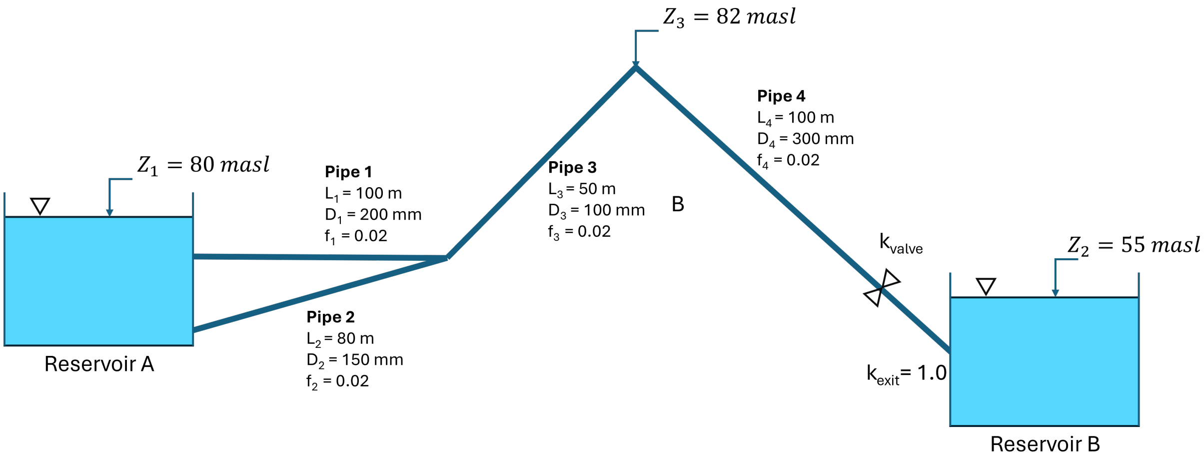

Figure 2: Schematic of the hydraulic system.

Problem 3

The following figure shows a drinking water network of a rural community that demands a total average water flow of 182 L/s.

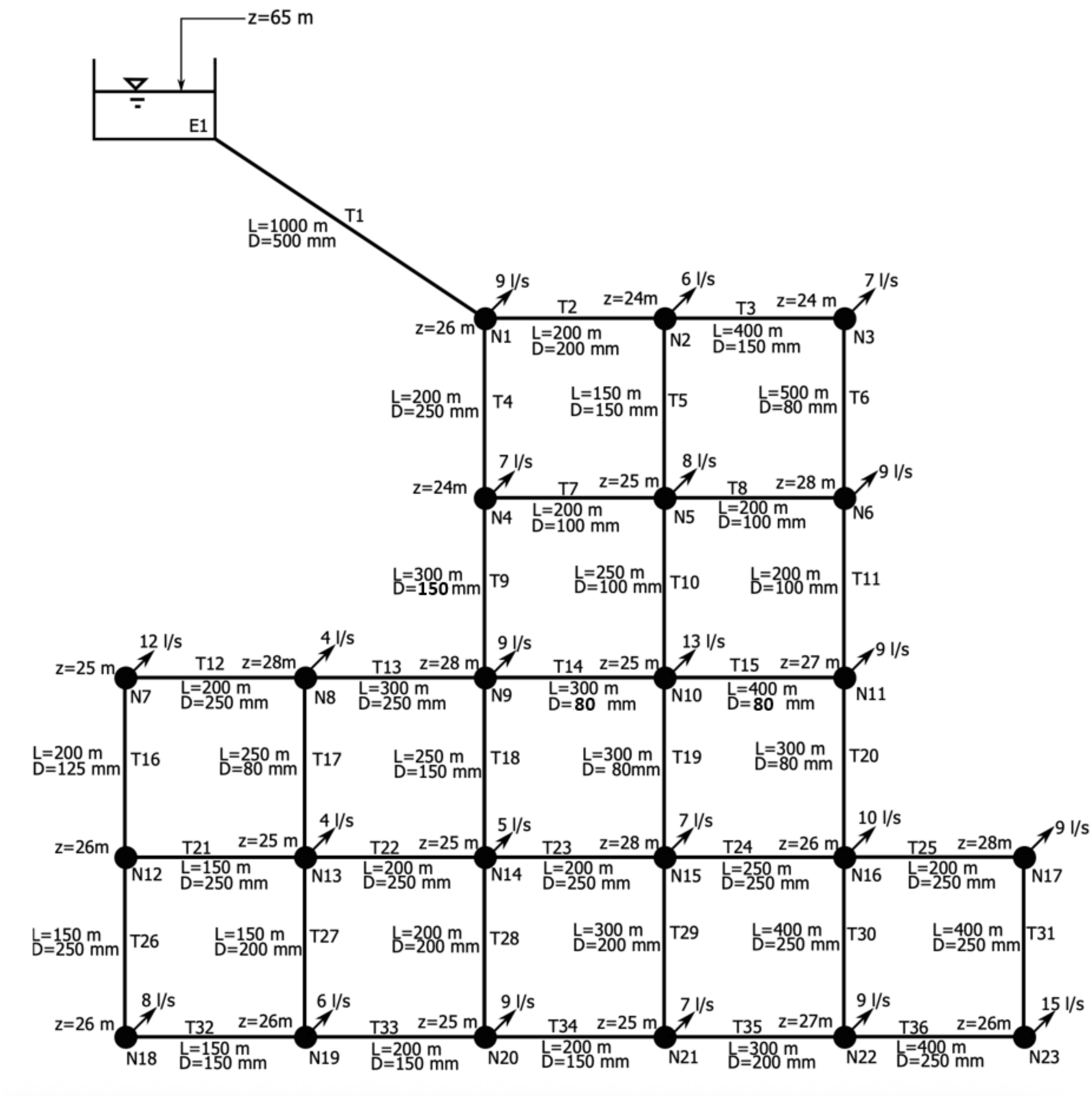

Figure 3: Water distribution network

The characteristics of the nodes and pipes are shown in Figure 3. For head losses in the pipes, use the Darcy-Weisbach model. Consider a roughness of $\varepsilon = 0.01$ mm. The pump curve is as follows:

Table 1: Pump curve points

Flow [L/s]	Head [m]
0	45
20	43
30	40

In this problem, the objective is to calculate the network and modify it so that it meets certain design parameters, both under normal operation and under special water demand conditions.

The design requirements are:

- Pressure at the nodes must not drop below 20 m of water column (m.w.c.) and must not exceed 50 m.w.c.
- Velocity in the pipes must remain between 0.1 m/s and 2.9 m/s.
- The available pipe diameters are 80, 100, 125, 150, 200, 250, 500 mm.

i) Compute the network shown in the figure using the EPANET software. Build the network in the program exactly as it appears in the figure (i.e., with the same numbering of nodes and pipes). For clarity and later corrections, always draw the pipes from the node with the smaller number toward the node with the larger number (for example, if T_k connects nodes N_i and N_j, it must satisfy $j > i$). Verify that the design requirements are not met and explain why. (1 pt)

ii) Since the pressures at the nodes and the velocities in the pipes do not meet the design requirements, it is decided to inject the network directly at node 12 through a pump connected to a reservoir of same height as node 12. Recalculate the network and verify the design conditions. (2 pts)

iii) Suppose that due to being a fire-risk area, a hydrant is to be installed between node 3 and node 6 at an elevation of $z = 25$ m. Modify the needed pipe diameters so that the design conditions are met and also ensure a minimum pressure of 28 m.w.c. and a discharge of 15 L/s at the hydrant. (2 pts)

For all three items, configure EPANET display options to show the labels of all network elements. Use the notation employed in the tutorial for each element and configure it under the Defaults options.

For all three items, present tables with the pressure at the nodes and the velocity in the pipes. Also attach a screenshot of the computed network showing the pressure values at the nodes and the velocities in the pipes. Present your network with an appropriate color map.