Faculty of matter Sciences and Computer Science
Department of Physics – L2_Physics
Exercise Series of Fluid Mechanics, 2024-2025
Exercise Series Number 3: Perfect Fluid Kinematics and Dynamics

Exercise 01:

In a pipe with a diameter of 30 cm, water with a density of ρ=103 Kg/m3 circulates at an average velocity of 1m/s.

1. Calculate Volume Flow rate and Mass Flow rate
2. Calculate the average flow velocity if the flow rate is 1800 liters/min
3. Calculate the new value of the average velocity if the diameter of the pipe is 15cm

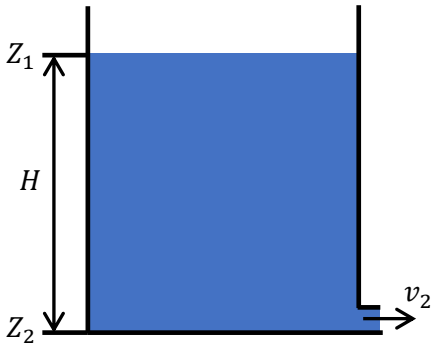
Exercise 02:

Let us have a venturi tube in a vertical position where water with a density ρ=103 Kg/m3 circulates

1. Write the continuity equation and express the relationship between the velocities V1 and V2 and the diameters D1 and D2.
2. Calculate the velocities V1 and V2, if Qv = 200 liters per second,
3. Calculate Pressure Difference Δp = (p1 - p2) if D1=300mm and D2= 150mm

Exercise 03:

We consider a tank filled with water at a height $H = 3\,m$ with a small orifice at its base with a diameter of $d = 10\,mm$.



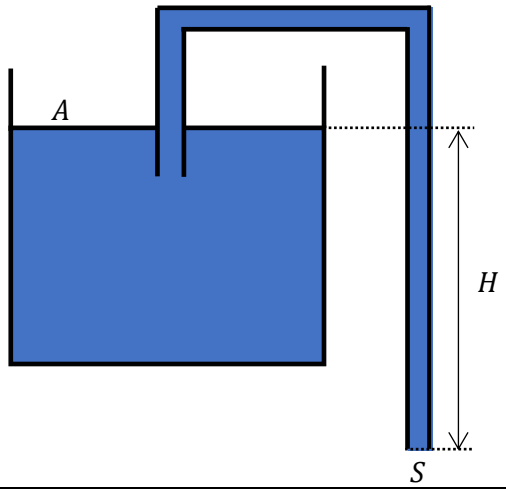
1. Specifying the assumptions taken into account, apply Bernoulli's theorem to calculate the velocity v_2 of water flow.
2. Deduct the volume flow rate qv in at the outlet of the orifice. We suppose that

Exercise 04:

We consider a siphon with a diameter of $d = 10\,mm$ fed by a gasoline tank of large dimensions in relation to d and open to the atmosphere. It is assumed that the fluid is perfect and the level of the fluid in the tank varies slowly. The acceleration of gravity g = 9,81 m.s-2, the density of the gasoline: ϖ = 6896 N /m3 and $H = Z_A - Z_S = 2{,}5\,m$

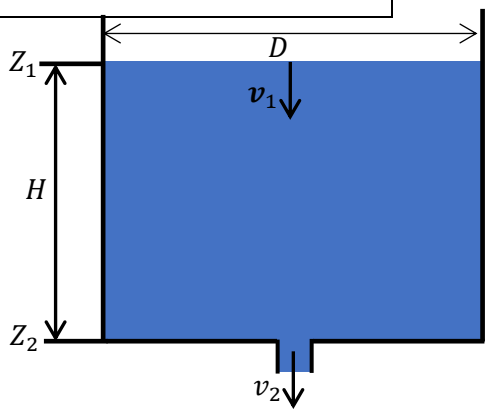
1. Applying Bernoulli's theorem between points A and S, calculate the flow velocity V_S in the siphon.

2. Deduct the volume flow rate q_V.



Exercise 05

We consider a cylindrical tank with an inside diameter D=2m filled with water to a height $H = 3m$. The bottom of the tank is equipped with a diameter orifice $d = 10mm$ to drain the water.

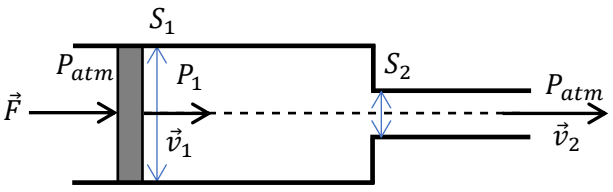


If we let a very small amount of time dt pass, the H level of the tank goes down by an amount. dH. We note $v_1 = dH/dt$ the velocity of descent of the water level, and v_2 the velocity of flow through the orifice. We give the acceleration of gravity .

1. Write the continuity equation. Derive the expression of v_1 as a function of v_2, D and d.
2. Write Bernoulli's equation. It is assumed that the fluid is perfect and incompressible.
3. From the answers to questions 1) and 2) establish the expression of the flow velocity v_2 as a function of g, H, D and d.
4. Calculate the velocity v_2. We assume that the diameter d is negligible in front of D. That is to say $d/D \ll 1$.
5. Deduct Volume Flow Rate q_V.

Exercise 06:

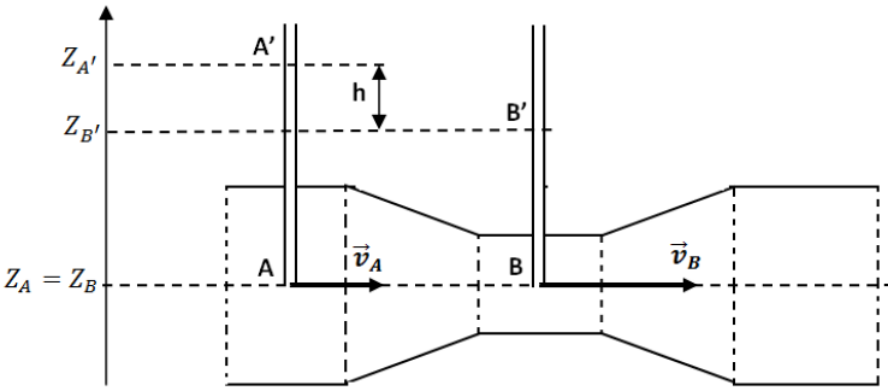
The figure below shows a piston that moves frictionlessly in a cylinder of cross-section S_1 and diameter $d_1 = 4cm$ filled with a perfect fluid of density $\rho = 1000\, kg/m^3$. The piston is pushed by a force F of intensity 62,84 N at velocity v_1 constant. The fluid can escape outwards through a cylinder of cross-sectional S_2 and diameter $d_2 = 1cm$ at a velocity of v_2 and a pressure $P_2 = P_{atm} = 1\ bar$.



1. Write the continuity equation and determine the expression for the velocity v_1 as a function of v_2.
2. Applying Bernoulli's equation, find the expression for the flow velocity $v_2$as a function of P_1, P_{atm} and ρ. (we assume that the cylinders are in a horizontal position ($Z_1 = Z_2$)).
3. Deduct Volume Flow q_V.

Exercise 07:

A pipeline with a main cross-sectional S_A and diameter d undergoes a constriction at B where its cross-section is S_B. We denote by $a = S_A/S_B$ The report of the sections. A perfect and incompressible fluid with a density ρ, flows inside this pipe. Two tubes plunge into the pipe having ends A and B respectively. By direct reading of the difference in height h, the two tubes allow to measure the volume flow rate, q_V that passes through the pipe.



1. Write the continuity equation. Deduce the expression of the velocity v_A as a function of v_B and a.
2. Write the Bernoulli relation between points A and B. deduce the expression of the pressure difference ($P_A - P_B$) as a function of ρ, v_A and a.
3. Write the fundamental relationship of hydrostatics between points A and A'.
4. Write the fundamental relationship of hydrostatics between points B and B'.
5. deduce the expression of the flow velocity v_A as a function of g, h and a.
6. Giv the expression of volume flow q_V as a function of d, g, h and a.

   Make a numerical application:

   - A diameter of the main section d=50cm.
   - A section report a = 2,
   - An acceleration of gravity g = 9,81 m/s2,
   - A difference in height h = 10 mm.