Faculty of matter Sciences and Computer Science
Department of Physics – L2_Physics
Exercise Series of Fluid Mechanics, 2025-2026
Exercise Series Number 4: Viscous Fluid Dynamics

Exercise 01 :

We consider a vertical volcanic conduit whose size (section) narrows upwards and with a simplified geometry:

A vent is circular in shape with a radius $R_2 = 10m$ while at depth, the conduit is connected to a magma reservoir with a horizontal section of radius $R_1 = 1km$. In addition, the velocity of ascent of magma v is considered to be uniform at each depth z and the density of magma ρ to be constant.

1. If the magma exit velocity v_2 during a Plinian eruption is of the order of , at what vertical speedv_1 moves magma into the reservoir?
2. How does the ratio of velocities vary with the Rays R_1 *and* R_2?

Exercise 02:

Determine the critical velocity v_C :

a) for a fuel oil at 15°C circulating in a pipe with 15 cm of diameter;

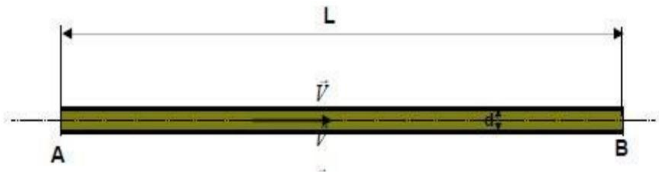
b) for water at 15°C circulating in the same pipe. The kinematic viscosity at 15°C is: $\nu = 4{,}47.10^{-6}\, m^2/s$ for fuel and $\nu = 1{,}142.10^{-6}\, m^2/s$ for water.

Exercise 03:

A pipeline with a diameter of $d = 25$ cm and length L is intended to transport crude oil from station A to station B with a mass flow rate .

The physical characteristics of oil are as follows:

- ✓ Mass density
- ✓ Dynamic viscosity $\mu = 0{,}261 Pa.s$.



We assume that the pipeline is horizontal.

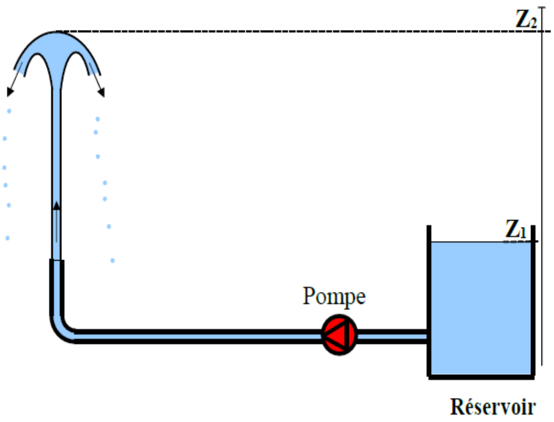
1) Calculate the volume flow rate q_V of oil.
2) Determine its Flow velocity v.
3) Calculate Reynolds number Re.
4) What is the nature of the flow?

Exercise 04 :

A water jet is fed from a reservoir by means of a pump with a volume flow rate and a pipe of length $L = 15\ m$ and diameter $d = 30\ mm$. The level of the free surface of the reservoir, assumed to be slowly variable, is at an altitude$Z_1 = 3m$ above the ground. The jet rises to a height$Z2 = 10\ m$.

It is assumed that:

- ✓ Pressures: $P1 = P2 = Patm$.
- ✓ The dynamic viscosity of water: $\mu = 10^{-3}\ Pa.s$.
- ✓ The density of mass of water:
- ✓ The acceleration of gravity: .



1. Calculate the velocity V of water flow in the pipe in m/s
2. Calculate the Reynolds number Re.
3. Specify the nature of the flow.

Exercise 05:

A petroleum oil with dynamic viscosity $\mu = 2\ poises$ and mass density , flows at a flow rate of in a horizontal pipe of diameter $D = 15\ cm$(1 Pa.s = 1 Poiseuille = 10 poises, 1 poise = 1 g/cm.s)

1. Under these conditions, calculate the Reynolds number.
2. Deduct the nature of the flow.

Exercise 06 :

1. Determine the type of flow that takes place in a pipe with a diameter of 30 cm when, at 15°C, water circulates at a velocity of 1 m/s ().
2. Determine the type of flow taking place in a pipe of 30 cm in diameter when, at 15°C, heavy fuel oil is circulating with the same velocity ().

Exercise 07 :

Heavy fuel oil with a dynamic viscosity $\mu = 0.11\ Pa.s$ and a density of $d = 0.932$ circulates in a pipe of length $L = 1650\ m$ and diameter $D = 25\ cm$ at a volume flow rate . The density of the water is given by .

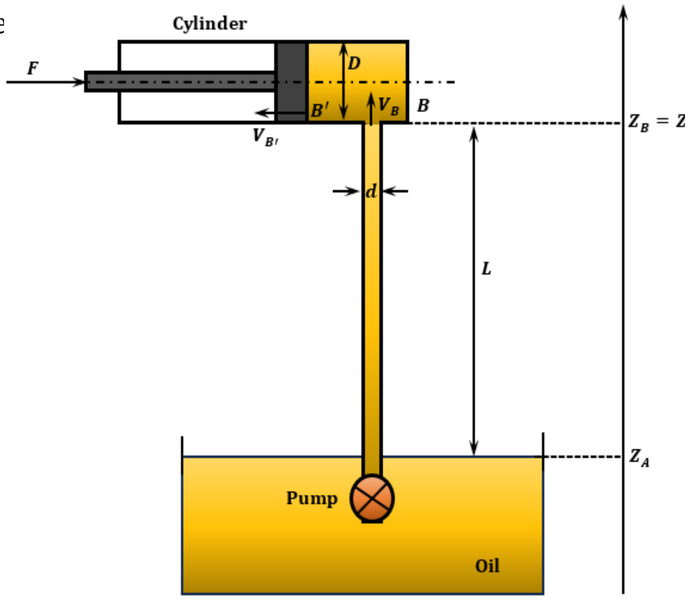
1) Determine the kinematic viscosity ν of the fuel oil.
2) Calculate the flow velocity V.
3) Calculate the Reynolds number Re.
4) Deduce the nature of the flow.

Exercise N°08 :

The diagram proposed below represents a hydraulic installation composed of:

- ✓ A reservoir containing oil with mass density $\rho = 900\, kg/m^3$ and kinematic viscosity
- ✓ A pump with volume flow rate $q_V = 16\, L/Min$
- ✓ A vertical tube with a length of $L = 50\ cm$ and diameter $d = 5\ mm$ to deliver pressurized oil discharged by the pump,
- ✓ A cylinder with horizontal single-acting equipped with a piston that moves in translation under the effect of oil pressure.

1. From the pump flow rate, calculate the flow velocity v_B in the pipe.
2. Similarly, determine the velocity of moveme diameter $D = 10cm$.
3. The piston is subjected to a compressive force $F = 6151\ N$ which opposes its displacement. Calculate the pressure of Oil $P_{B'}$ at the point B'.
4. Applying Bernoulli's theorem between B' and B. Calculate the admission pressure in the cylinder P_B (We suppose that $Z_B = Z_{B'}$)
5. Calculate Mass Flow Rate of the pump
6. Calculate Reynolds number R_e.
7. Specify the nature of the flow.



Exercise 09

The following figure shows an installation used in an amusement park. The installation is composed of:

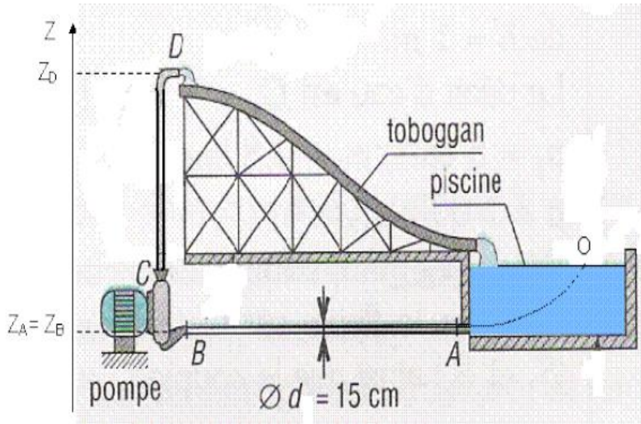
- ➢ A horizontal AB suction pipe with a diameter of d=15 cm and length $L_1 = AB = 10m$
- ➢ A centrifugal pump draws water at a volume flow rate from a swimming pool and discharges it in D, towards a waterslide.
- ➢ A vertical CD discharge pipe with a diameter of d=15 cm and a length of $L_2 = CD = 8m$

➢ A waterslide forming a downward channel that allows water to flow back to the swimming pool by gravity.

The water remains in a closed circuit: swimming pool – AB tube – pump – CD tube – waterslide – swimming pool – etc.

We give:

- The mass density of water:
- The dynamic viscosity of water: $\mu = 10^{-3} Pa.s$
- The acceleration of gravity:
- Pressure $P_O = P_D = P_{atm} = 1\ bar$
- $Z_O = 1.5\ m$ (O is a point on the free surface of the water in the pool)
- $Z_A = Z_B = 0$; $Z_C = 0.3m$; $Z_D = 8.3\ m$.



1. Calculate the flow velocity V in the pipe.
2. Applying Bernoulli's theorem between a point O of the free surface of the pool and the point A, calculate the pressure P_A. It is assumed that the water level in the swimming pool remains constant($v_0 = 0$)
3. Determining the Reynolds Number R_e in the Pipe .
4. Deduce the nature of the flow.