University of Khenchela
Faculty of Science and Technology
Department of Mechanical Engineering
Level : L2 GM

January 13th, 2026

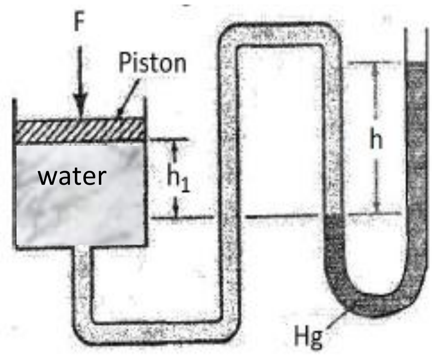
Exam: Fluid mechanics

Exercise 1

A piston of cross-sectional area S = 0.07 m^2 is mounted on the top of a cylindrical tank filled with water.

A U-tube mercury manometer is connected to the bottom of the tank, while the other limb is open to the atmosphere.

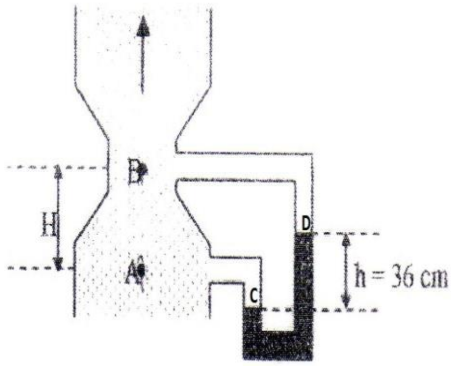
For h_1 = 60 mm and h = 100 mm, determine the magnitude of the force exerted by the piston, assuming that the weight of the piston is negligible.



Exercise 2

Water flows upward through a Venturi tube as shown in the figure. The following data are given:

- The diameter of the tube at section A is D_A = 30 cm.
- The diameter of the tube at section B is D_B = 15 cm.
- The difference in mercury levels in the differential manometer is h = 36 cm.



Questions:

1. Calculate the velocity of water at section B.
2. Determine the volumetric flow rate of water through the tube.

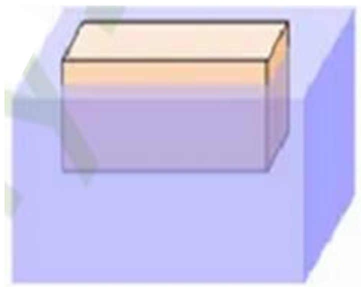
Exercise 3

A solid block floats at the surface of water and has the shape of a rectangular parallelepiped.

Its dimensions are: height *h* = 20 cm, length *L* = 60 cm, and width *l* = 20 cm.

Given that the immersed portion of the block has a height h′ = 3 cm:

- **Determine the mass and the density of the block.**



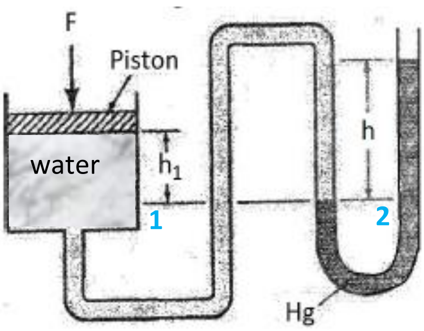
The following data are given:

Acceleration due to gravity: g = 10 m/s^2.

Densities: $\rho_{water} = 1\ g.cm^{-3}$, $\rho_{Hg} = 13.6\ g.cm^{-3}$

Exam correction

Exercise 1 (6 points)



$P_1 = P_{atm} + \frac{F}{S} + \rho_w g h_1$ 1.5

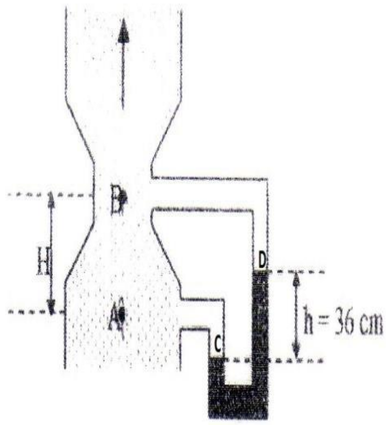
$P_1 = P_2$ 1.5

$P_2 = P_{atm} + \rho_{Hg} g h$ 1.5

$\Rightarrow F = (\rho_{Hg} g h - \rho_w g h_1)S$

$F = 910\ N$ 1.5

Exercise 2 (8 points)



From Bernoulli equation,

$P_A - P_B = \frac{1}{2}\rho_w(v_B^2 - v_A^2) + \rho_w g(Z_B - Z_A)$ 1

$= \frac{1}{2}\rho_w(v_B^2 - v_A^2) + \rho_w g H$ ....(1)

$P_C = P_A + \rho_w g(Z_A - Z_C)$ 0.5

$P_D = P_B + \rho_w g(Z_B - Z_D)$ 0.5

$P_C - P_D = P_A - P_B + \rho_w g(Z_A - Z_C - Z_B + Z_D)$

$= P_A - P_B + \rho_w g(h - H)$ 1

On the other hand :

$P_C - P_D = \rho_{Hg} g h$ 1

Then

$P_A - P_B = \rho_{Hg} g h - \rho_w g(h - H)$ ....(2)

By comparing equations (1) and (2),

$\frac{1}{2}\rho_w(v_B^2 - v_A^2) + \rho_w g H = \rho_{Hg} g h - \rho_w g(h - H)$

$v_B^2 - v_A^2 = \frac{2gh(\rho_{Hg} - \rho_w)}{\rho_w}$ ....(3) 1

And from continuity equation,

$Q_V = S_A v_A = S_B v_B \Rightarrow v_A = \frac{S_B v_B}{S_A}$ 1

By substituting into equation (3),

$v_B^2 = \frac{2gh(\rho_{Hg} - \rho_w)}{\rho_w\left(1 - \frac{S_B^2}{S_A^2}\right)}$

$v_B = 9.84\ m/s$ 1

$Q_V = S_B v_B = 0.174\ m^3/s$ 1

Exercise 3 (6 points)

From Archimedes' principle,

The buoyant force acting on a body immersed in a fluid is equal to the weight of the fluid displaced by the body,

$F_B = m_w g = \rho_w . L. l. (h - h'). g = 1000\text{x}0.6\text{x}0.2\text{x}(0.2 - 0.03)\text{x}10 = 204\ N$ 1.5

The block is in equilibrium under the action of two forces: Archimedes' buoyant force and the weight of the block

1.5 $F_B = m_{block} . g \quad \Rightarrow \quad m_{block} = \frac{F_B}{g} = 20.4\ kg$ 1

$m_{block} = \rho_{block} . V_{block} \quad \Rightarrow \quad \rho_{block} = \frac{m_{block}}{L.l.h} = \frac{20.4}{0.6\text{x}0.2\text{x}0.2}$ 1

$\rho_{block} = 850\ kg/m^3$ 1