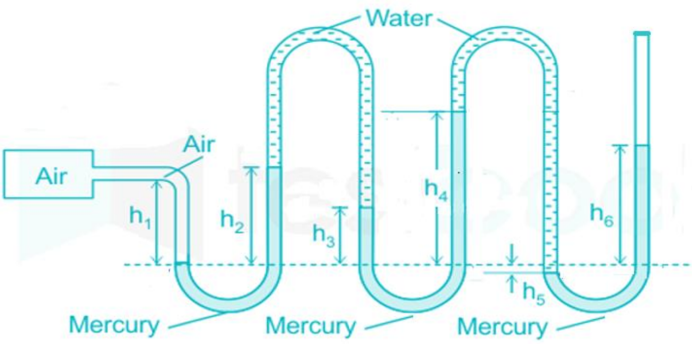
Dear students of Fluid Mechanics 0905241
Your homework consists of the problems below. Due date for this homework in on Tuesday May 06th 2025 by 5:00 PM on the link that will be shared with you on Moodle.
Good luck for all of you.
Dr. Abdullah Nasr

Q1: The below figure shows a multi-tube manometer using water and mercury that is used to measure the pressure of air in a vessel. It is given that $h_1 = 0.3$ m, $h_2 = 0.4$ m, $h_3 = 0.3$ m, $h_4 = 0.6$ m. $h_5 = 0.05$ m and $h_6 = 0.5$ m. Given that the specific gravity of mercury is 13.6, and the density of Air is 1.2 kg/m^3 for the given values of heights, Calculate the absolute pressure for Air in the tank. [take atmospheric pressure to be 99500 Pa]

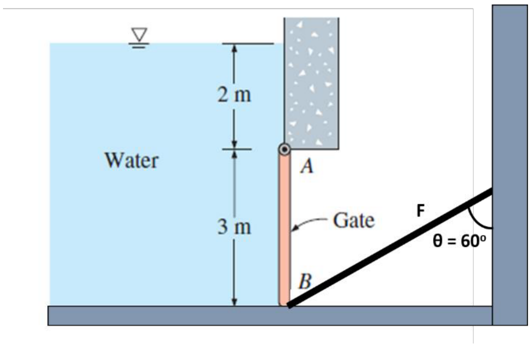


P =

Q2: Balloons are often filled with Helium gas because its specific gravity is 0.15. If the balloon has a diameter of 13 m and carries two people, 70 kg each, determine the acceleration of the balloon when it is first released.
[Hint: Take the density of air to be 1.16 kg/m^3. You can also assume that the balloon is a perfect sphere and that the weight of the balloon's skin, ropes, and the cage are negligible. Volume of a sphere = $4\pi R^3/3$, where R is the radius]

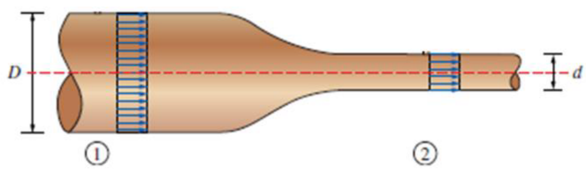
Acceleration =

Q3: A 3-m-high, 6-m-wide rectangular gate is hinged at the top edge at point (A) and is restrained at point (B) by a rod that makes 60º with a nearby wall as shown in the figure. **Determine the force (F) in the rod**



F =

Q4: Water at 40ºC (density is assumed to be 996 kg/m^3) flow steadily through the pipe shown in the figure. If D = 4d, determine the average water velocity in section 2 of the pipe given that the average water velocity in section 1 is 10 m/s.



V =

Q1:

Solution: (given)

$h_1 = .3m$, $h_2 = .4m$, $h_3 = .3m$, $h_4 = .6m$, $h_5 = .05m$, $h_6 = .5m$

$S.G_M = 13.6$, $\rho_{air} = 1.2\ kg/m^3$, $\rho_{water} = 1000\ kg/m^3$, $P_{atm} = 99500 Pa$

$$P_{atm} + \rho_M g(h_6 + h_5) - \rho_w g(h_4 + h_5) + \rho_M g(h_4 - h_3) - \rho_w g(h_2 - h_3)$$
$$+ \rho_M g(h_2) - \rho_{air} g(h_1) = P_{air}$$

$$99500 + (13.6 \times 10^3) * 9.81 * (.55) - (1000)(9.81)(.65) + (13.6 \times 10^3)(.3)(9.81)$$
$$- (1000 * 9.81 * .1) + (13600 * 9.81 * .4) - (1.2 * 9.81 * .3) = P_{air}$$

$$\boxed{P_{air} = 258.9\ KPa}$$

Q2:

Solution: (given)

$S.G$ of helium: $.15$, diameter $= 13m$, $(70 * 2)\,kg$ (2 people), $\rho_{air} = 1.16\ kg/m^3$

$V = \frac{4\pi R^3}{3}$, $R \rightarrow$ Radius. $(W \simeq 0)$.

$\rho_{helium} = .15 * 1.16 = .174\ kg/m^3$

$m_{total} = 140 + (.174 * \frac{4\pi}{3}(6.5)^3) = 340.16\ kg$ (mass of helium)

$\Sigma F = ma$

$F_B - F_W = ma$

$\rho_{air} g V - mg = ma$

$1.16 * 9.81 * 1150.3 - 340.16 * 9.81 = 340.16 * a$

$$\boxed{a = 28.67\ m/s^2}$$

Q3:

Solution:

$F_c = \rho g (h_c) A$

$= 1000 * 9.81 * (2 + \frac{3}{2}) * (3*6)$

$= 618 \text{ kN}$

$y_P = y_c + \frac{I_{xxc}}{y_c A}$

$= 3.5 + \frac{ab^3}{3.5\, ab * 12}$

$= 3.5 + \frac{(3)^2}{3.5 * 12} = 3.71 \text{ m}$

$P_c = \rho g h$

$= 1000 * 9.81 * 3.5$

$= 34335$

$\Sigma F = 0$

$\tau_1 - \tau_2 = 0 \rightarrow \tau_1 = \tau_2 \rightarrow F_c (y_c - 2) = F_r \sin 60$

$618 \text{ kN} (1.71) = F (3) \sin 60$

$F = 406.75 \text{ kN}$

Q4:

Solution:

$\dot{m}_1 = \dot{m}_2$

$\rho_1 V_1 A_1 = \rho_2 V_2 A_2$

$10 * \left(\frac{\pi (4d)^2}{4} \right) = V_2 \left(\frac{\pi d^2}{4} \right)$

$160 \text{ m/s} = V_2$