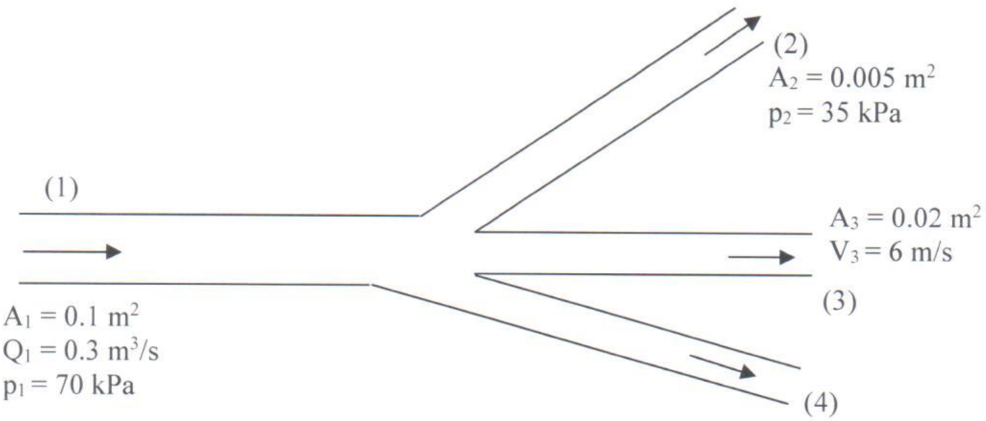
36) Water flows through the horizontal pipe shown in the figure at rate of 0.3 m^3/s. If viscous effects are negligible, determine the water speed at section (2), the pressure at section (3), and the flow rate at section (4).



Solution:

$$V_1 = \frac{Q_1}{A_1} = \frac{0.3}{0.1} = 3 \text{ m/s}$$

Energy equation between section 1 and section 2

$$\frac{p_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{p_2}{\gamma} + z_2 + \frac{V_2^2}{2g} + h_L$$

$$\frac{70}{9.81} + 0 + \frac{3^2}{19.62} = \frac{35}{9.81} + 0 + \frac{V_2^2}{2g} + 0$$

$V_2 = 8.889$ m/s

$Q_2 = V_2 A_2 = 8.889 \times 0.005 = 0.0445\ m^3/s$

Energy equation between section 1 and section 3

$$\frac{p_1}{\gamma} + z_1 + \frac{V_1^2}{2g} = \frac{p_3}{\gamma} + z_3 + \frac{V_3^2}{2g} + h_L$$

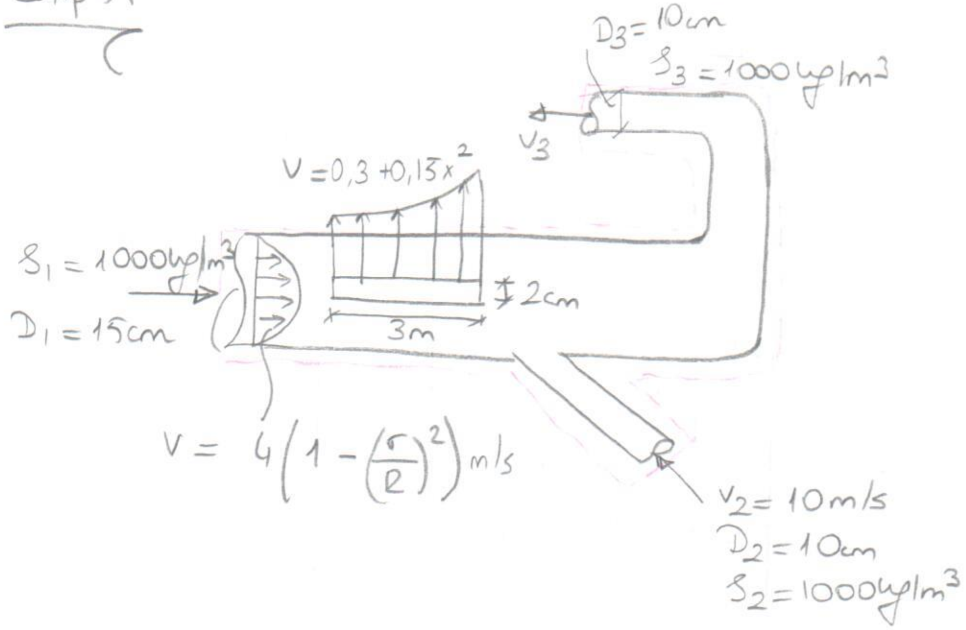
$$\frac{70}{9.81} + 0 + \frac{3^2}{19.62} = \frac{p_3}{\gamma} + 0 + \frac{6^2}{19.62} + 0$$

$$\frac{p_3}{\gamma} = 5.759 \text{ m} \ ; \ p_3 = 56.5 \text{ kN/m}^2$$

$Q_3 = V_3 A_3 = 6 \times 0.02 = 0.12\ m^3/s$

$$Q_4 = Q_1 - Q_2 - Q_3 = 0.3 - 0.0445 - 0.12 = 0.1355 \text{ m}^3/\text{s}$$

Exp 5:



Determine v_3!

Sln:

$$V_{ort} = \frac{\int v\,dA}{A} = \frac{\int v\, 2\pi r dr}{\pi R^2}$$

$$V_{ort} = \frac{\int_0^{0,075} 4\left(1 - \left(\frac{r}{R}\right)^2\right) 2\pi r dr}{\pi (0,075)^2} = \frac{\int_0^{0,075} 8\pi \left(r - \frac{r^3}{0,075^2}\right) dr}{\pi\, 0,075^2}$$

$$= \frac{8\pi}{\pi (0,075)^2}\left[\frac{r^2}{2} - \frac{r^4}{4(0,075)^2}\right]_0^{0,075} \Rightarrow V_{ort} = 2m/s$$

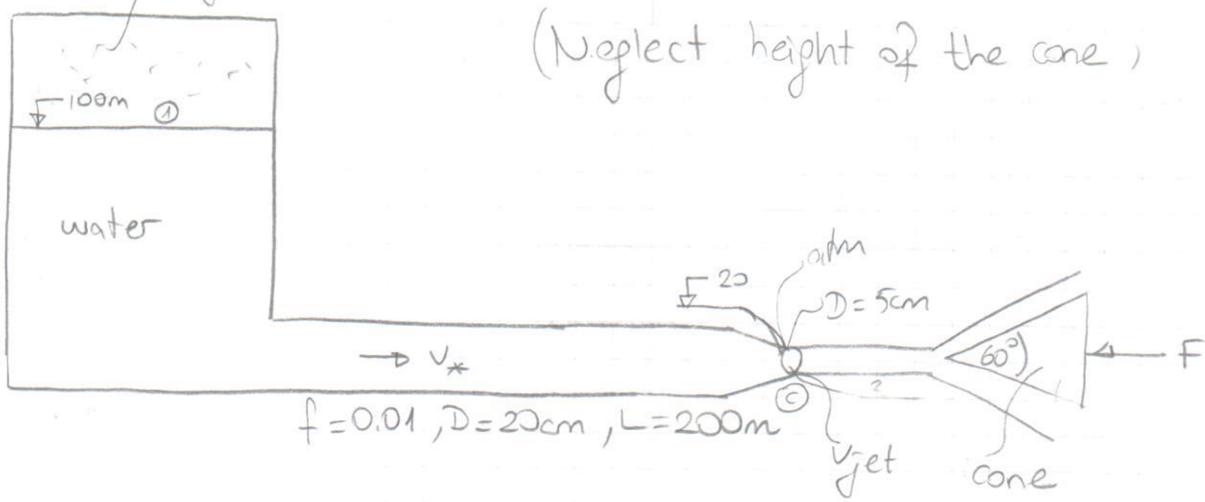
Continuity:

$$V_{1ort} A_1 + V_2 A_2 = \int_{x=0}^{x=3} (0,3 + 0.15x^2)\, 0.02\, dx + V_3 A_3$$

$$2\pi (0,075)^2 + 10\pi (0,1)^2/4 = 0,045 + V_3\ \pi \frac{0,1^2}{4} \Rightarrow V_3 = 8,77 m/s$$

Exp 4:

Determine F = ?
(Neglect height of the cone)



Slni:

Energy equation between ① & ©

$$\frac{v_1^2}{2g} + \frac{P_1}{\gamma} + z_1 = \frac{v_c^2}{2g} + \frac{P_c}{\gamma} + z_c + f\frac{L}{D}\frac{v_*^2}{2g}$$

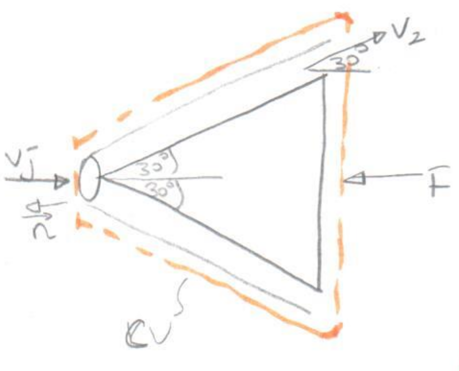
$$\frac{49050}{9810} + 100 = \frac{v_c^2}{2g} + 20 + 0{,}01\,\frac{200}{0{,}2}\,\frac{v_*^2}{2g}$$

$$Q_* = Q_c$$

$$v_*\frac{\pi\, 0{,}2^2}{4} = v_c\frac{\pi\, 0{,}05^2}{4} \Rightarrow v_* = 0{,}0625\, v_c$$

$$85 = \frac{1.0390625\, v_c^2}{19{,}62} \Rightarrow v_c = 40.04\ m/s$$

$$v_c = v_{jet}$$



Momentum in x-direction

$$-F = -\rho \overset{(+)}{v_j}\, \overset{(-)}{v_j}\, A_j + \rho \overbrace{v_2\cos 30}^{+}\, \overset{+}{v_2}\, A_2$$

$$Q_1 = Q_2 \Rightarrow v_j A_j = v_2 A_2$$

$$Q = 40.04\,\pi\frac{(0.05)^2}{4} = 0{,}079\ m^3/s$$

$$-F = -1000 \times 40.04 \times 0{,}079 + 1000 \times 40.04\cos 30° \times 0{,}079$$

$$F = 423{,}99\,N$$