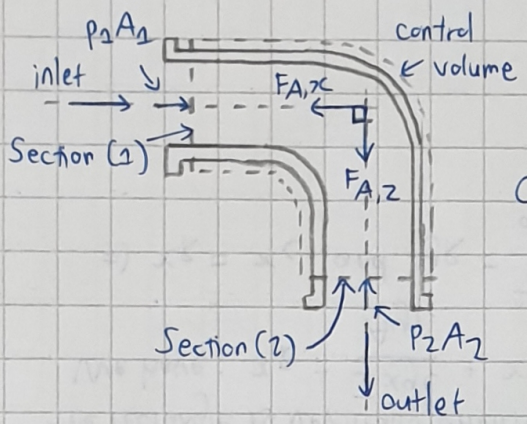
Nguyen Xuan Binh 887799 Exam Question 2

$D = 400mm = 0.4m$ $V = 0.2 m^3$ $Q = 0.5 m^3/s$ $p_1 = 100 kPa$ $p_2 = 80 kPa$

$m = 10 kg$

A) Draw the control volume to define the forces



The boundary control volume is defined within ---- region as shown in the sketch. The control volume is oriented along the curve of the pipe elbow

C) The anchoring forces components are defined as along the center line of the cross section like the sketch, which are $F_{A,x}$ and $F_{A,z}$. They intersect each other at the center of the elbow and are perpendicular to each other.

B) There are two forces resulting from pressure to cross section (1) and (2): p_1A_1 and p_2A_2 as shown in the sketch

From linear momentum equation along the x-direction:

$F_{A,x} = \rho A_{in} V_{in} V_{x,in} + p_2A_1$, where $V_{in} = V_{x,in}$ and $Q = A_{in} V_{in}$

$\Rightarrow V_{in} = \frac{Q}{A_{in}} = \frac{0.5}{\pi(0.4^2/4)} \approx 3.97 m/s \Rightarrow F_{A,x} = 1000 \cdot \pi \frac{0.4^2}{4} \cdot 3,97^2 + 100 \cdot 10^3 \cdot \pi \frac{0.4^2}{4}$

14546.9

$\Rightarrow F_{A,x} = \sim\sim 1989.4 \sim\sim N$ (Direction like sketch)

For linear momentum equation along the z-direction:

$\sim\sim F_{A,z} + \rho A_{out} V_{out} V_{z,out} = P_z V_z \sim\sim$

$V_{out} \rho V_{out,z} A_{out} = -P_2A_2 + F_{A,z} + W_{water} + W_{elbow}$

We have $V_{out} = V_{in} = 3.97 m/s$, $A_2 = A_1 = \pi 0.4^2/4 = 0.125 m^2$

$\Rightarrow V_{out} \rho V_{out,z} A_{out} = -P_2A_2 + F_{A,z} + \rho g Volume + m_{elbow} g$

$\Rightarrow 3.97 \cdot 1000 \cdot 3,97 \cdot 0.125 = -80 \cdot 10^3 \cdot 0.125 + F_{A,z} + 1000 \cdot 9,81 \cdot 0,2 + 10 \cdot 9,81$

$\Rightarrow F_{A,z} = 9910 N$

Answer: $F_{A,x} = 14546.9 N$, $F_{A,z} = 9910 N$