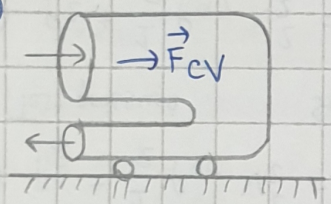
Nguyen Xuan Binh 887799 Round 3 Problem 2

The four devices rest on frictionless wheels are restricted to move in x-direction only and are stationary initially. The pressure at inlets and outlets of each is atmospheric and flow is incompressible. Each device has unknown contents. When released, which ones will move to the left and to the right?

a)



Let control volume be the whole device

Conservation of momentum in steady-state case

$$\rho V_{x,o} A_o \vec{V}_{out} - \rho V_{x,in} A_{in} \vec{V}_{in} = \vec{F}_{CV}$$

Since the total velocity is also in x-direction and $\vec{V}_{out} \times \vec{V}_{in}$

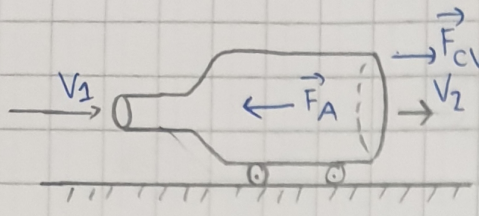
$$\Rightarrow \rho V_{out} A_{out} \vec{V}_{out} + \rho V_{in} A_{in} \vec{V}_{in} = \vec{F}_{CV}$$

Conservation of mass: $\rho V_{out} A_{out} = \rho V_{in} A_{in} = \dot{m}$

$\Rightarrow \dot{m}(\vec{V}_{out} + \vec{V}_{in}) = \vec{F}_{CV}$ ($\dot{m}$ always positive) $\Rightarrow \vec{F}_{CV}$ has same direction with $\vec{V}_{in}$

$\Rightarrow$ device moves to the right

b)



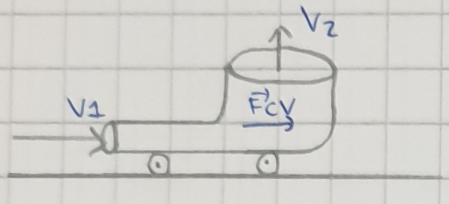
Due to mass conservation, momentum conservation of the system will be : $\dot{m}V_2 - \dot{m}V_1 = F_A$ (anchoring force)

According to figure : $V_2 < V_1$

$\Rightarrow F_A = \dot{m}(V_2 - V_1) < 0 \Rightarrow$ opposed $\vec{F}_{CV}$ is positive

$\Rightarrow \vec{F}_{CV}$ has same direction with V_1 and V_2 $\Rightarrow$ The device moves to the right

c)



The device is only allowed to move horizontally

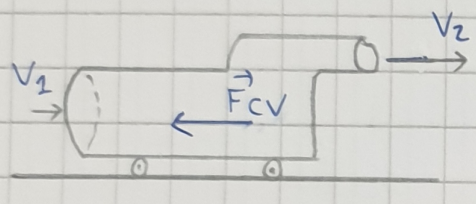
$\Rightarrow V_{2,x} = 0$

$\Rightarrow \vec{F}_{CV} = \dot{m}(V_{1,x} - V_{2,x}) = \dot{m}(V_1 - 0)$

$= \dot{m}V_1 > 0$

$\Rightarrow$ The device moves to the right

d)



According to figure : $V_2 > V_1 \Rightarrow V_1 - V_2 < 0$ $\Rightarrow$

$\Rightarrow \vec{F}_{CV} = \dot{m}(V_{1,x} - V_{2,x}) = \dot{m}(V_1 - V_2)$

$\Rightarrow \vec{F}_{CV} < 0 \Rightarrow \vec{F}_{CV}$ has opposite direction with V_1 & V_2 $\Rightarrow$ The device moves to the left