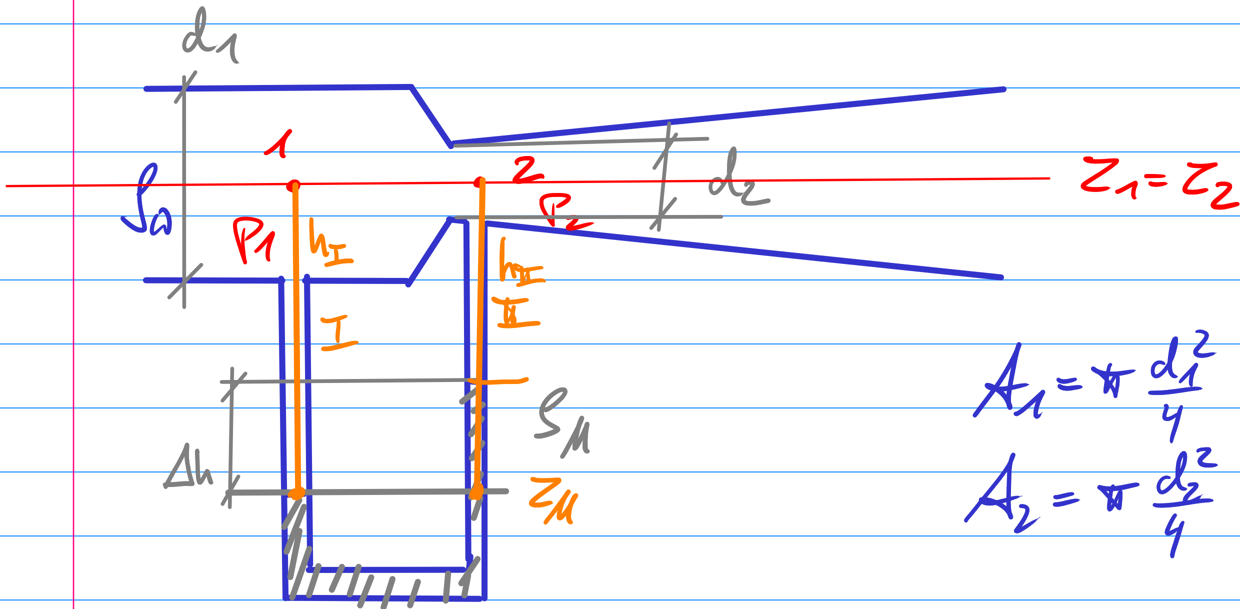
Task 3.3



$$A_1 = \pi \frac{d_1^2}{4}$$

$$A_2 = \pi \frac{d_2^2}{4}$$

(**) $\dot{V} = V_2 \cdot A_2 = V_1 A_1 \quad \Rightarrow \quad V_1 = V_2 \frac{A_2}{A_1}$

$V_2 = ?$

$\Rightarrow$ Bernoulli-Eq:

$$p_1 + \rho \frac{V_1^2}{2} + \cancel{g \rho z_1} = p_2 + \rho \frac{V_2^2}{2} + \cancel{g \rho z_2} \quad \Big| - p_2$$

(*) $$\underbrace{p_1 - p_2}_{\Delta p = ?} + \rho \frac{1}{2}\left(V_2 \frac{A_2}{A_1}\right)^2 = \rho \frac{V_2^2}{2}$$

at z_M: pressure left and right are equal.

pressure in column I: $p_1 + g \rho_w h_I = p_I$ at z_M

pressure in column II: $p_2 + g \rho_w h_{II} + g \rho_M \Delta h = p_{II}$ at z_M

$$\Rightarrow \quad p_{I} = p_{II}$$

$$\Rightarrow \; p_1 + g \rho_w h_I = p_2 + g \rho_w h_{II} + g \rho_M \Delta h$$

$$\Rightarrow \; p_1 - p_2 = g \rho_w \underbrace{(h_2 - h_1)}_{-\Delta h} + g \rho_M \Delta h$$

$$= -g \rho_w \Delta h + g \rho_M \Delta h$$

$$= g \Delta h \, \underline{(\rho_M - \rho_w)} = \underline{g \Delta h \Delta \rho}$$

$$(*) \Rightarrow \; p_1 - p_2 = \frac{\rho}{2} \left(v_2^2 - v_2^2 \frac{A_2^2}{A_1^2} \right)$$

$$= \frac{\rho}{2} v_2^2 \left(1 - \frac{A_2^2}{A_1^2} \right)$$

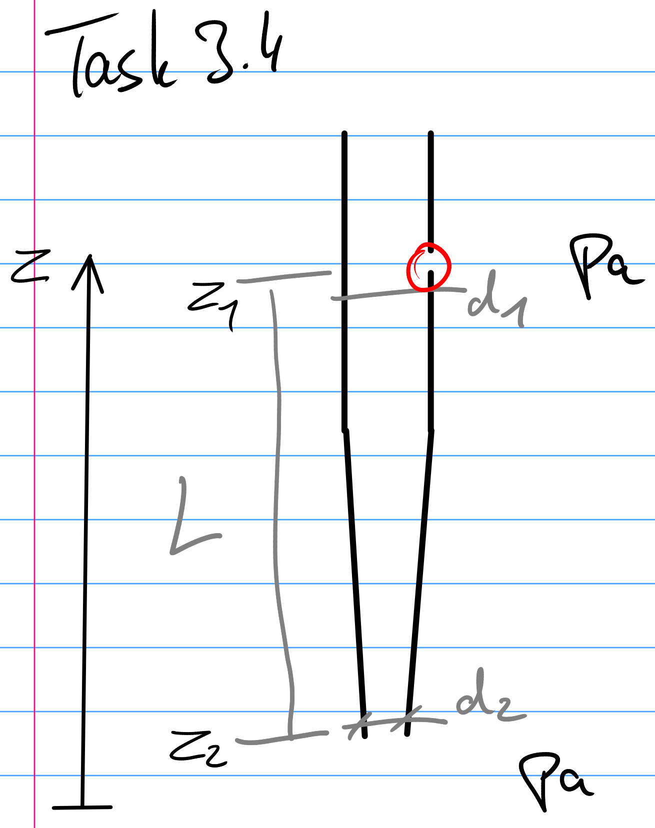
$$= \frac{\rho}{2} v_2^2 \left(1 - \frac{\left(\frac{\cancel{\pi} d_2^2}{4} \right)^2}{\left(\frac{\cancel{\pi} d_1^2}{4} \right)^2} \right)$$

$$= \frac{\rho}{2} v_2^2 \left(1 - \frac{d_2^4}{d_1^4} \right)$$

$$\Rightarrow \quad v_2 = \sqrt{\frac{\frac{2 (p_1 - p_2)}{\rho}}{\left(1 - \frac{d_2^4}{d_1^2} \right)}} \quad \Rightarrow (**)$$

$$\dot{V} = \ldots$$

Task 3.4



$$\dot{V} = v_1 A_1 = v_2 A_2 \quad (**)$$

$$\Rightarrow v_1 = v_2 \frac{A_2}{A_1}$$

$\Rightarrow$ need v_2

Bernoulli-Eq: $\cancel{p_1} + \rho \frac{v_1^2}{2} + g\rho z_1 = \cancel{p_2} + \rho \frac{v_2^2}{2} + g\rho z_2$

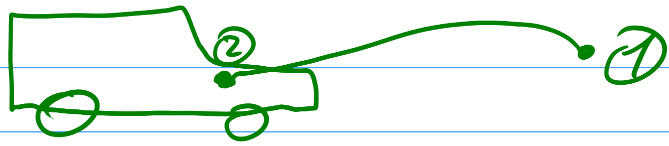
$p_1 = p_a$, $v_1^2 = \left(v_2 \frac{A_2}{A_1}\right)^2$, $p_2 = p_a$

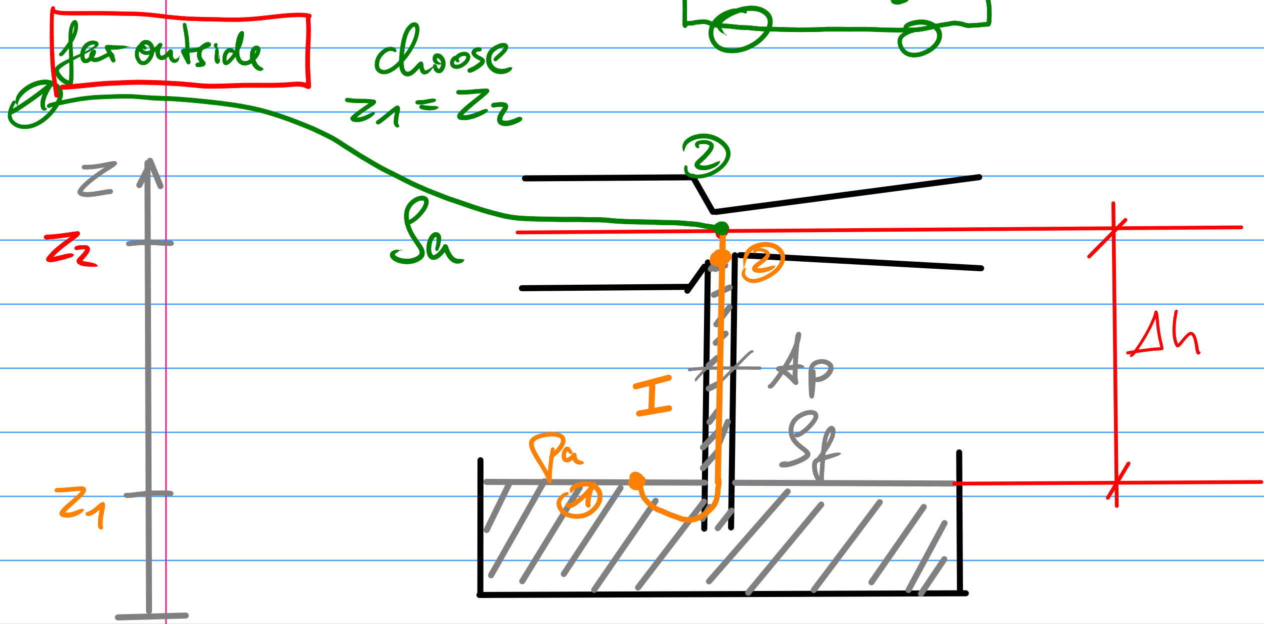
$$\Rightarrow g\cancel{\rho}\underbrace{(z_1 - z_2)}_{L} = \rho \frac{v_2^2}{2} - \frac{\rho}{2}\left(v_2 \frac{A_2}{A_1}\right)^2$$

$$= \frac{\cancel{\rho}}{2} v_2^2 \left(1 - \left(\frac{A_2}{A_1}\right)^2\right)$$

$$\Rightarrow v_2 = \sqrt{\frac{2gL}{\left(1 - \frac{A_2^2}{A_1^2}\right)}} \Rightarrow (**) \text{ for } \dot{V}$$

Task 3.5





choose
$z_1 = z_2$

$$\dot V_{fuel} = 7.2\,\frac{l}{h} = 7.2 \cdot \frac{1000^{-1}\,m^2}{3600\,s} =$$

$$= \frac{7.2 \cdot \frac{1}{1000} \cdot m^3}{3.6 \cdot 1000 \cdot s} = 2 \cdot 10^{-6}\,\frac{m^3}{s}$$

$$\dot V_{fuel} = v_f \cdot A_p \Rightarrow v_f = \frac{\dot V_{fuel}}{A_p} = \ldots$$

streamline I for fuel:

$$p_1 + \rho_f \frac{v_{f①}^2}{2} + g\rho_f z_1 = p_2 + \rho_f \frac{v_{f②}^2}{2} + g\rho_f z_2$$

$$p_a + \cancel{\rho_f \frac{v_{f①}^2}{2}} + g\rho_f \underbrace{(z_1 - z_2)}_{-\Delta h} = p_2 + \rho_f \frac{v_{f②}^2}{2} \qquad \text{I}$$

< big reservoir

streamline I for air

$$p_1 + \rho_a \frac{v_{a1}^2}{2} + \cancel{g\rho_a z_1} = p_2 + \rho_a \frac{v_2^2}{2} + \cancel{g\rho_a z_2}$$

choose start on same hight

p.t.o.

① „far outside" = big reservoir of air

= big cross section to draw air from

⇒ $V_{a,1}$ very small compared to the velocity of air at point 2

$$\underbrace{p_1}_{p_a} + \cancel{\rho_a \frac{V_{a,1}^2}{2}} = p_2 + \rho_a \frac{V_{a,2}^2}{2} \qquad \text{II}$$

back to term $\rho_f \frac{V_f^2}{2}$ at ② in Bernoulli-Eq for fuel:

fuel carried away as droplets at air speed...

In I & II p_a is the same ⇒

$$\underbrace{\cancel{p_2} + \rho_f \frac{V_f^2}{2} + g\rho_f \Delta h}_{\text{I}} = \underbrace{\cancel{p_2} + \rho_a \frac{V_{a,2}^2}{2}}_{\text{II}}$$

⇒ solve for air velocity $V_{a,2}$:

$$V_{a,2} = \sqrt{\frac{\rho_f}{\rho_a} V_f^2 + 2g \frac{\rho_f}{\rho_a} \Delta h}$$