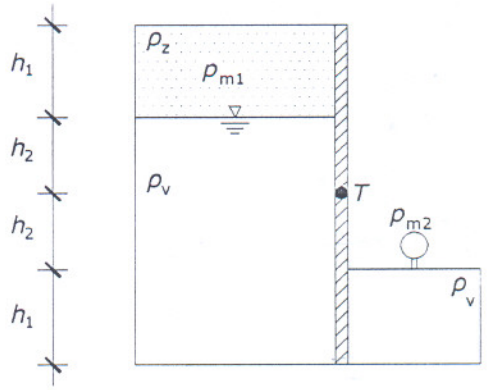
MEHANIKA TEKUĆINA/HIDROMEHANIKA 9. veljače 2012.

1) Dva rezervoara su napunjena vodom i zrakom kao što je prikazano na slici i razdvojena pregradom koja može rotirati oko točke T. Potrebno je izračunati tlak u manometru p_{m2} koji će omogućiti da pregrada ne rotira i bude u ravnoteži u vertikalnom položaju kao na slici. Nacrtajte dijagrame hidrostatskog tlaka na pregradu s obje strane. Zadatak je ravninski (računati na 1m širine rezervoara).

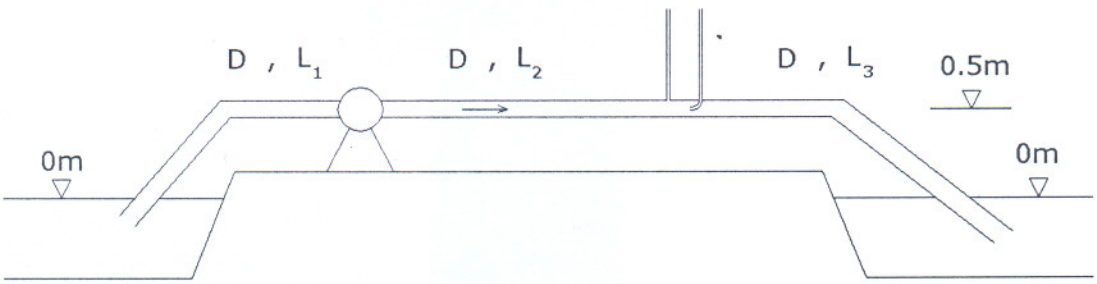
(20 bodova)

Zadano je: h_1=0.6m; h_2=0.45m; p_{m1}= -7 kPa;
ρ_V=1000kg/m^3; ρ_Z=0kg/m^3



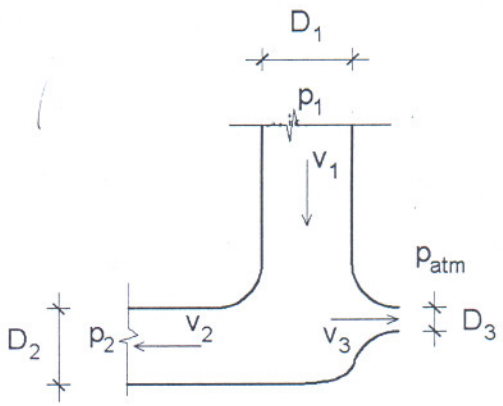
2) Za sistem na slici treba proračunati snagu pumpe koja ostvaruje tečenje vode iz lijevog rezervoara u desni. Također je potrebno odrediti razine vode u piezometru i Pitotovoj cijevi koje se nalaze na udaljenosti L_2 nizvodno od pumpe i nacrtati energetsku i piezometarsku liniju. Udaljenost između piezometra i Pitotove cijevi zanemariti. (25 bodova)

Zadano je: Q=0.015m^3/s; D=0.1m; L_1=10m; L_2= L_3=15m; ε=0.2mm; ν=10^{-6} m^2/s; ξ_{UL}=0.7; ξ_{KOLJ}=0.2; η_P=0.8



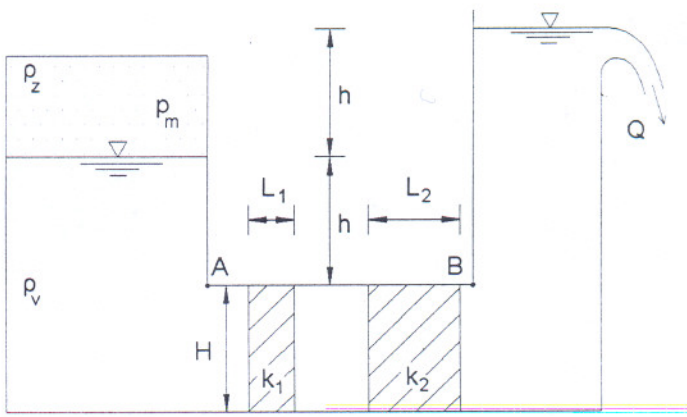
3) Potrebno je odrediti smjer i veličinu rezultantne sile kojom voda djeluje na račvu položenu u horizontalnoj ravnini. Pretpostavite idealno tečenje.

Zadano je: Q_1=0.26m^3/s; D_1=0.3m; D_2=0.2m; D_3=0.1m;
p_1=30kPa;



4) Potrebno je odrediti tlak u komori p_m ispunjenoj zrakom zbog kojeg se ostvaruje strujanje vode kroz filterske slojeve kvadratnog poprečnog presjeka kao na slici. Potrebno je nacrtati piezometarsku liniju od točke A do točke B i izračunati silu tlaka kojom voda djeluje na filterski sloj s koeficijentom propusnosti k_2.

Zadano je: Q=0.005m^3/s; k_1 = 0.001m/s; k_2 = 0.002 m/s;
H=1 m; L_1=0.1m; L_2 = 0.2m; h=1m

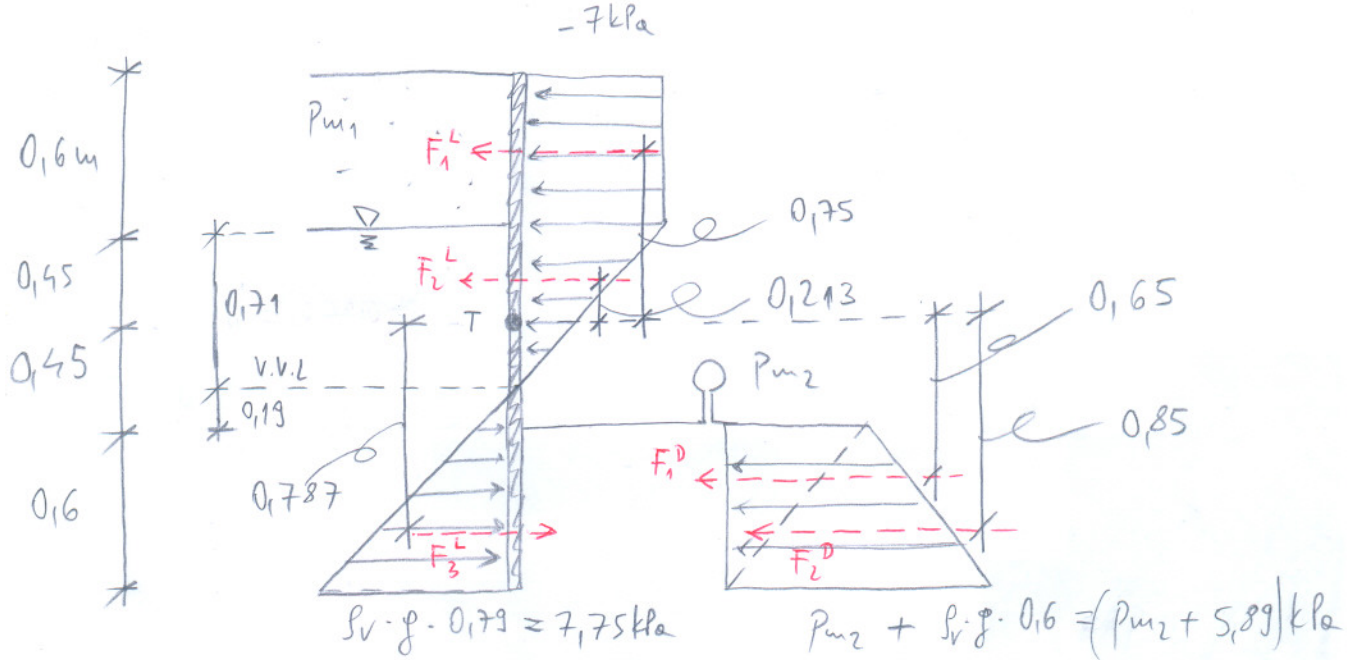


Teorija: (15 bodova)

1. Koje sve vrste energije sadrži Bernoullijeva jednadžba?
2. Skicirajte dijagram specifične energije.
3. Što je trajektorija, a što strujnica?
4. Zašto se i gdje kod zdenca uz vodotok za rješenje sniženja postavlja fiktivni zdenac?

Za pristupanje usmenom dijelu ispita potrebno je ostvariti minimalno 50 bodova i točno riješiti 1. i 2. zadatak!

(1)



V.V.L.

$$h' = \frac{p_{m_1}}{\rho g} = -\frac{7}{9,81} = -0,71\ m$$

$$M_T^L = M_T^D$$

$$F_1^L \cdot 0,175 + F_2^L \cdot 0,213 + F_3^L \cdot 0,787 = F_1^D \cdot 0,65 + F_2^D \cdot 0,85$$

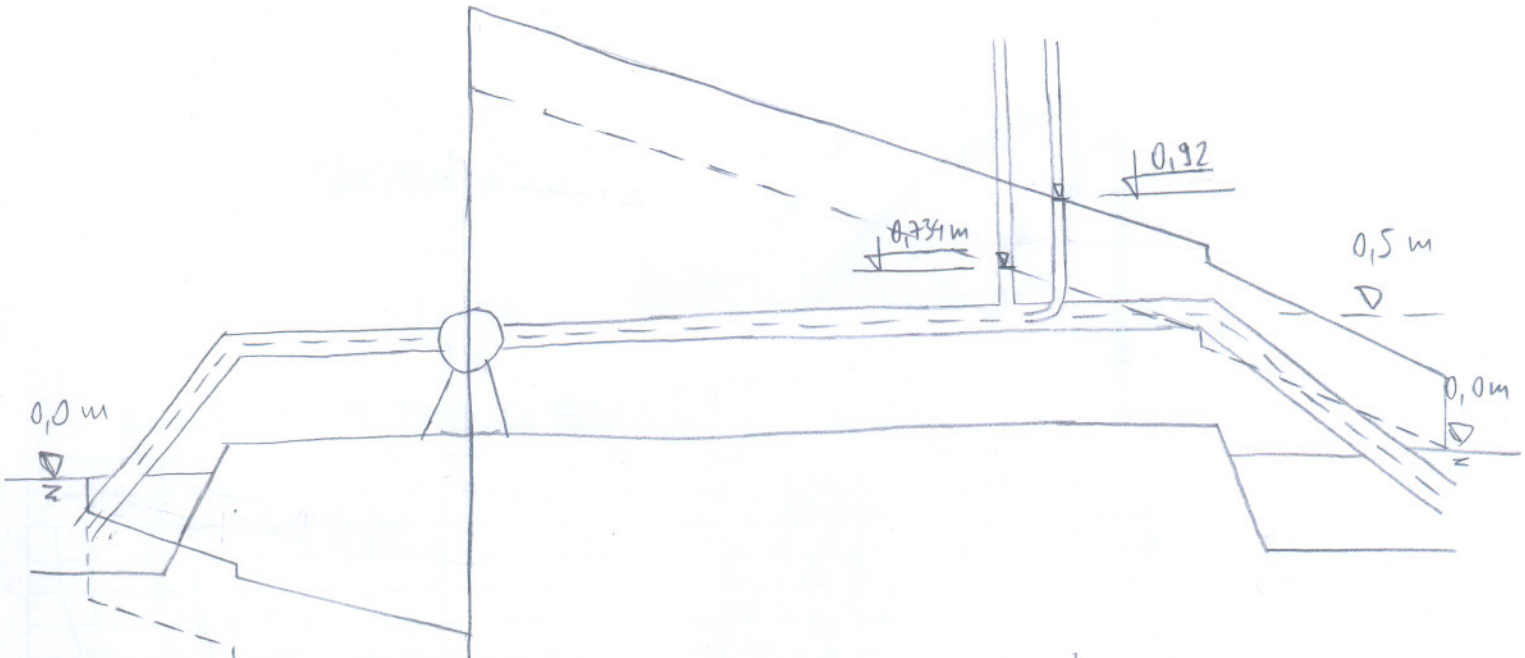
$$7 \cdot 0,6 \cdot 0,175 + 7 \cdot 0,71 \cdot \frac{1}{2} \cdot 0,213 + 7,75 \cdot 0,79 \cdot \frac{1}{2} \cdot 0,787 = p_{m_2} \cdot 0,6 \cdot \frac{1}{2} \cdot 0,65 + \left(p_{m_2} + 5,89\right) \cdot 0,6 \cdot \frac{1}{2} \cdot 0,85$$

$$3,15 + 0,53 + 2,41 = p_{m_2} \cdot 0,195 + p_{m_2} \cdot 0,255 + 1,50$$

$$4,59 = p_{m_2} \cdot 0,45$$

$$p_{m_2} = 10,2\ kPa$$

(2)



$$v = \frac{Q \cdot 4}{D^2 \pi} = \frac{0,015 \cdot 4}{0,1^2 \pi} = 1,91 \text{ m/s} \quad \rightarrow \quad \frac{v^2}{2g} = 0,186$$

$$\frac{\varepsilon}{D} = \frac{0,2}{100} = 0,002 \quad ; \quad Re = \frac{v \cdot D}{\nu} = \frac{1,91 \cdot 0,1}{10^{-6}} = 1,9 \cdot 10^5 \Rightarrow \lambda = 0,025$$

$$H_p = \frac{v^2}{2g} \left(\xi_{ul} + 2\xi_{kol} + \lambda \frac{L_1}{D} + \lambda \frac{L_2}{D} + \lambda \frac{L_3}{D} + 1 \right)$$

$$H_p = 0,186 \left(0,7 + 2 \cdot 0,2 + 0,025 \cdot \frac{10}{0,1} + 2 \cdot 0,025 \cdot \frac{15}{0,1} + 1 \right)$$

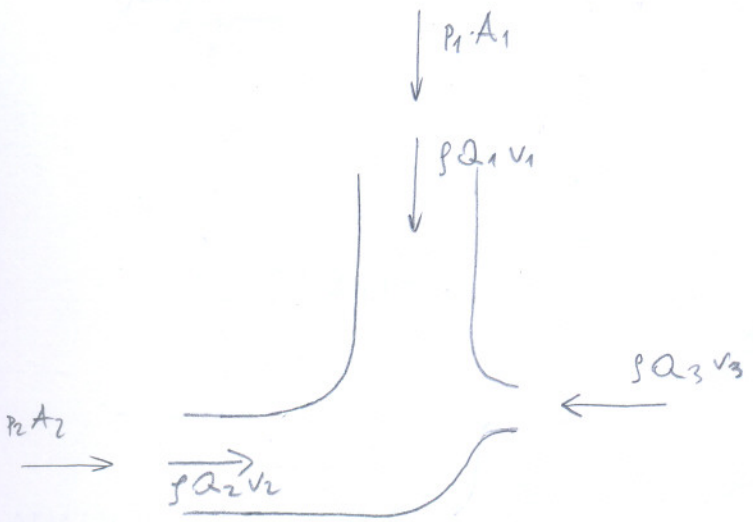
$$H_p = 0,13 + 2 \cdot 0,037 + 0,465 + 2 \cdot 0,698 + 0,186$$

$$H_p = 2,25 \text{ m}$$

$$N_p = \frac{\rho g Q H}{\eta} = \frac{1 \cdot 9,81 \cdot 0,015 \cdot 2,25}{0,8} = 0,41 \text{ kW}$$

$$H_{pietometr} = 0 - 0,13 - 0,037 - 0,465 + 2,25 - 0,698 - 0,186 = 0,734 \text{ m}$$

(3)



$$A_1 = \frac{D_1^2 \pi}{4} = \frac{0{,}3^2 \pi}{4} = 0{,}071\ m^2$$

$$A_2 = \frac{D_2^2 \pi}{4} = \frac{0{,}2^2 \pi}{4} = 0{,}031\ m^2$$

$$A_3 = \frac{D_3^2 \pi}{4} = \frac{0{,}1^2 \pi}{4} = 0{,}008\ m^2$$

$$v_1 = \frac{Q_1}{A_1} = \frac{0{,}26}{0{,}071} = 3{,}66\ m/s$$

Strujnica 1-3

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} = 0 + \frac{v_3^2}{2g}$$

$$\frac{30}{9{,}81} + \frac{3{,}66^2}{2 \cdot 9{,}81} = \frac{v_3^2}{2 \cdot 9{,}81}$$

$$3{,}06 + 0{,}68 = \frac{v_3^2}{19{,}62} \Longrightarrow v_3 = 8{,}57\ m/s$$

$$Q_3 = v_3 \cdot A_3 = 8{,}57 \cdot 0{,}008 = 0{,}069\ m^3/s$$

$$Q_2 = Q_1 - Q_3 = 0{,}26 - 0{,}069 = 0{,}191\ m^3/s$$

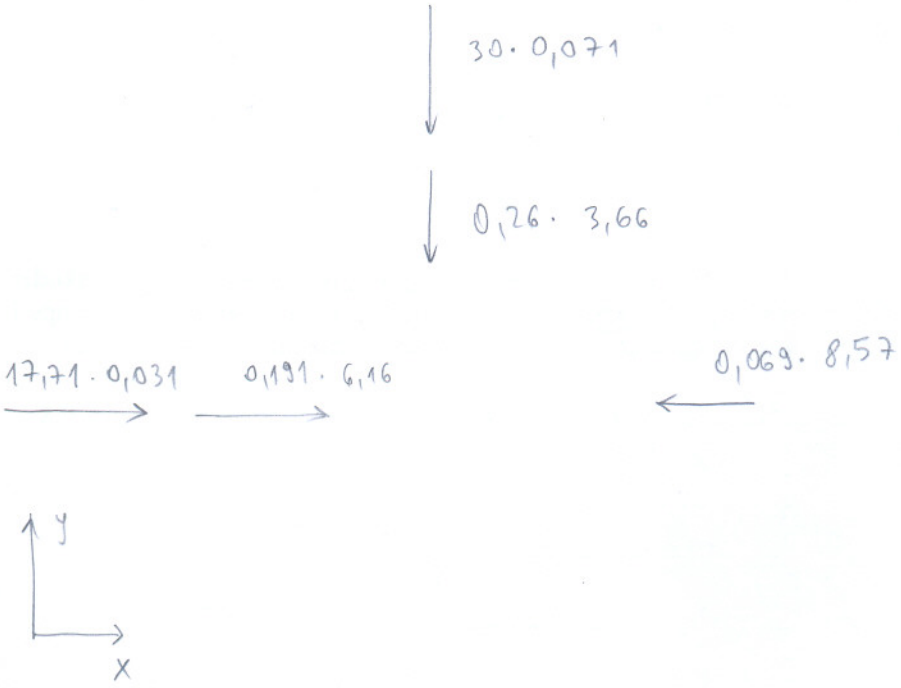
$$v_2 = \frac{Q_2}{A_2} = \frac{0{,}191}{0{,}031} = 6{,}16\ m/s$$

strujnica 1-2

$$\frac{p_1}{\rho g} + \frac{v_1^2}{2g} = \frac{p_2}{\rho g} + \frac{v_2^2}{2g} \Longrightarrow p_2 = \left(\frac{p_1}{\rho g} + \frac{v_1^2}{2g} - \frac{v_2^2}{2g} \right) \rho g$$

$$p_2 = \left(3{,}06 + 0{,}68 - \frac{6{,}16^2}{2g} \right) \rho g$$

$p_2 = 17,71$ kPa

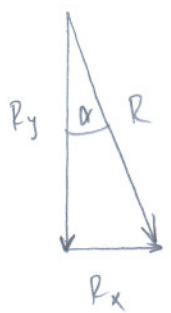


Rezultantna sila na nosač:

$R_y = -30 \cdot 0,071 - 0,26 \cdot 3,66 = -3,08$ kN

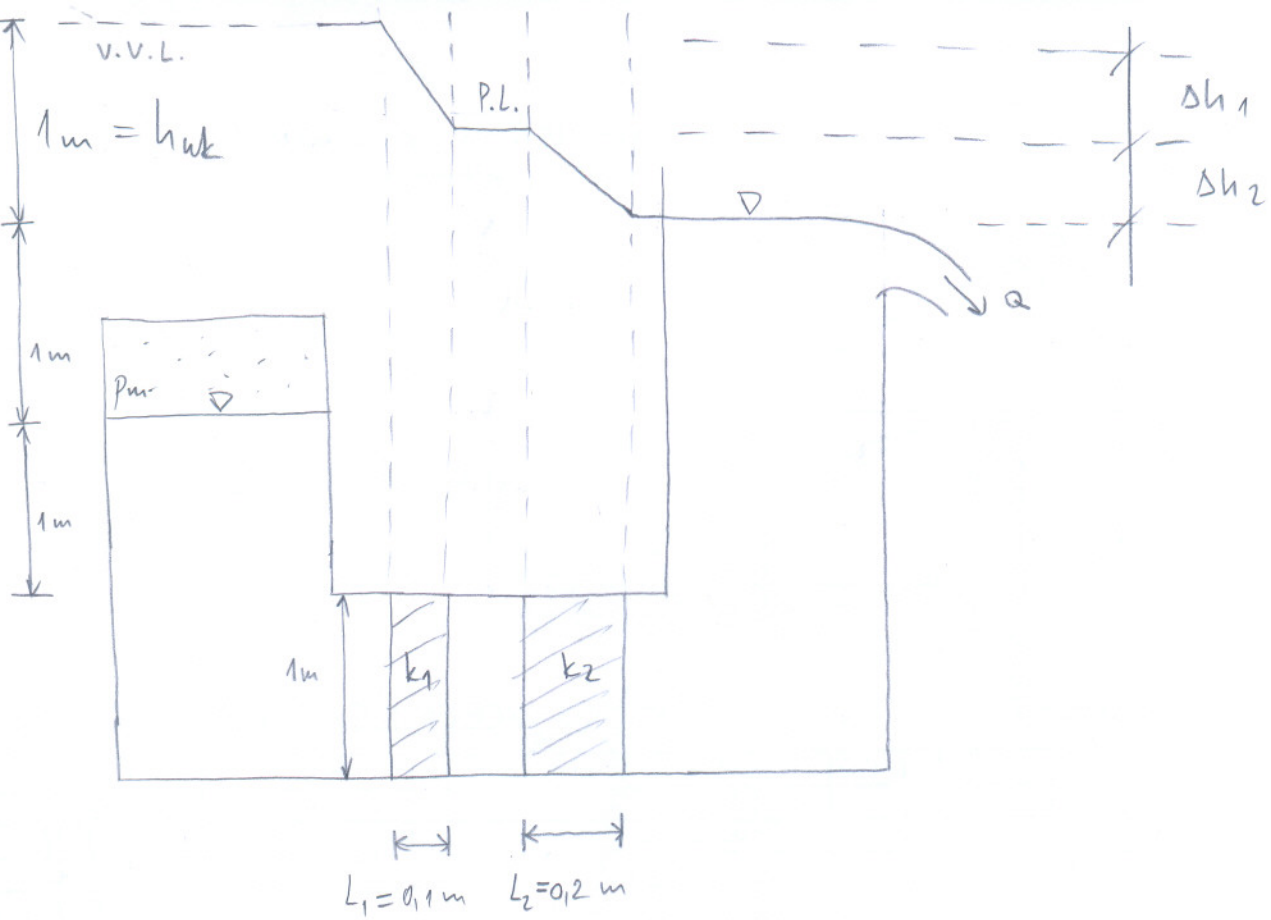
$R_x = 17,71 \cdot 0,031 + 0,191 \cdot 6,16 - 0,069 \cdot 8,57 = 1,13$ kN

$R = \sqrt{R_y^2 + R_x^2} = 3,28$ kN



$\operatorname{tg}\alpha = \frac{|R_x|}{|R_y|} = \frac{1,13}{3,08} = 0,367 \rightarrow \alpha = 20,15°$

(4)



$$v = \frac{Q}{A} = \frac{Q}{H^2} = \frac{0{,}005}{1^2} = 0{,}005 \text{ m/s}$$

$$v = k \cdot J = k \cdot \frac{\Delta h}{\Delta l} \quad \rightarrow \quad \Delta h = \frac{v \cdot \Delta l}{k}$$

$$\Delta h_1 = \frac{v \cdot L_1}{k_1} = \frac{0{,}005 \cdot 0{,}1}{0{,}001} = 0{,}5 \text{ m}$$

$$\Delta h_2 = \frac{v \cdot L_2}{k_2} = \frac{0{,}005 \cdot 0{,}2}{0{,}002} = 0{,}5 \text{ m}$$

$$\Delta h_{uk} = \Delta h_1 + \Delta h_2 = 1 \text{ m}$$

$$\frac{p_m}{\rho g} = h + \Delta h_{uk} = 2 \text{ m}$$

$$p_m = 19{,}62 \text{ kPa}$$

$$F = \Delta p \cdot A = \rho g (h_{uzv} - h_{uiz}) \cdot H^2 = \rho \cdot g \cdot 0{,}5 \cdot 1^2 = 4{,}905 \text{ kN}$$