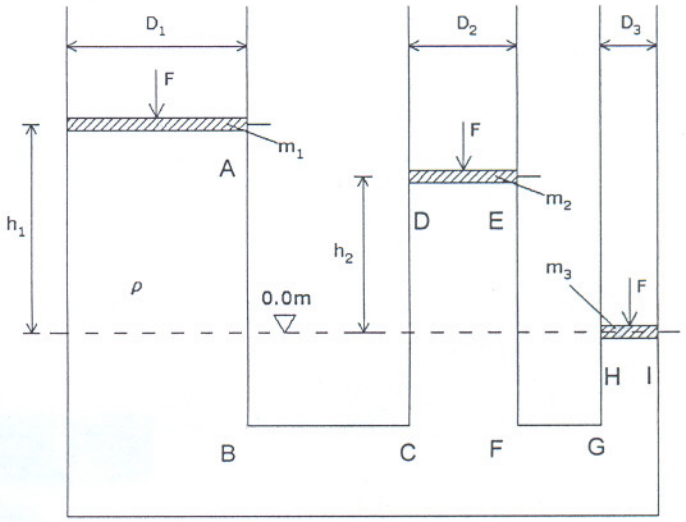
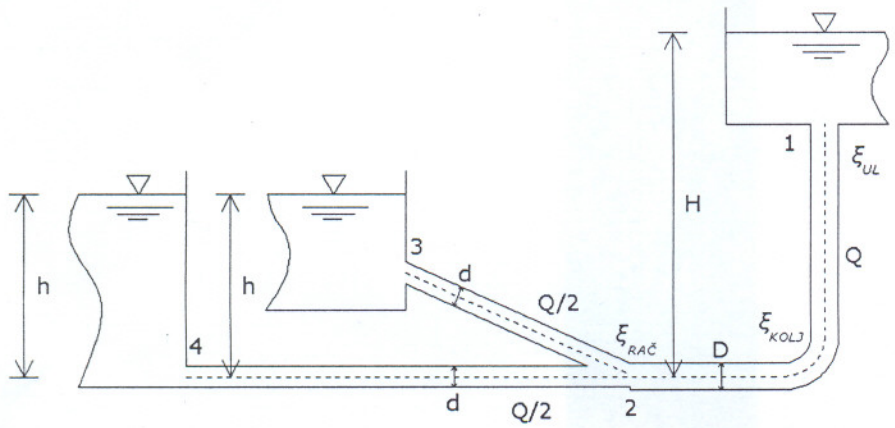
ISPIT IZ MEHANIKE TEKUĆINA 17.6.2010.

1. Na poklopce triju spojenih valjaka prema slici djeluju jednake sile F = 300 N. Mase klipova su m_1 = 50 kg, m_2 =30 kg i m_3 = 10 kg. Valjci su ispunjeni vodom. Izračunajte ravnotežni položaj poklopaca m_1 i m_2 odnosno odredite visine h_1 i h_2 ako je položaj poklopca m_3 na referentnoj ravnini odnosno na 0.0m visine. Nacrtajte dijagrame tlaka na konture posude od točke A do točke I. Promjeri valjaka su redom D_1 = 0.4 m, D_2 =0.3 m i D_3 = 0.2 m.

(*25 bodova*)

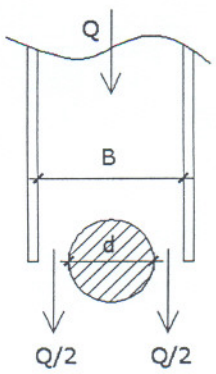


2. Odredite potrebnu visinu vodnog lica H da bi se u sustavu kao na slici ostvario protok Q=50 l/s. Nacrtajte energetsku i pijezometarsku liniju. Zadano je: ρ=1000 kg/m^3 ; v=10^{-6} m^2/s ; D=200 mm ; d=100 mm ; L_{12}=400 m ; L_{23}= L_{24}=700 m ; ε=0.02 mm ; h= 10 m ; ξ_{UL}=0.5 ; ξ_{KOLJ}=0.5 ; $\xi_{RAČ}$=f (nizvodne brzine)=0.3 (*25 bodova*)



3. Kroz kanal pravokutnog poprečnog presjeka širine B = 2 m protječe Q = 10 m^3/s vode s dubinom h = 1.5 m. Na samom izlazu iz kanala ugrađen je valjak promjera d = 1.2 m. Pretpostavite idealno strujanje. Potrebno je izračunati silu F kojom voda djeluje na valjak.

(*20 bodova*)



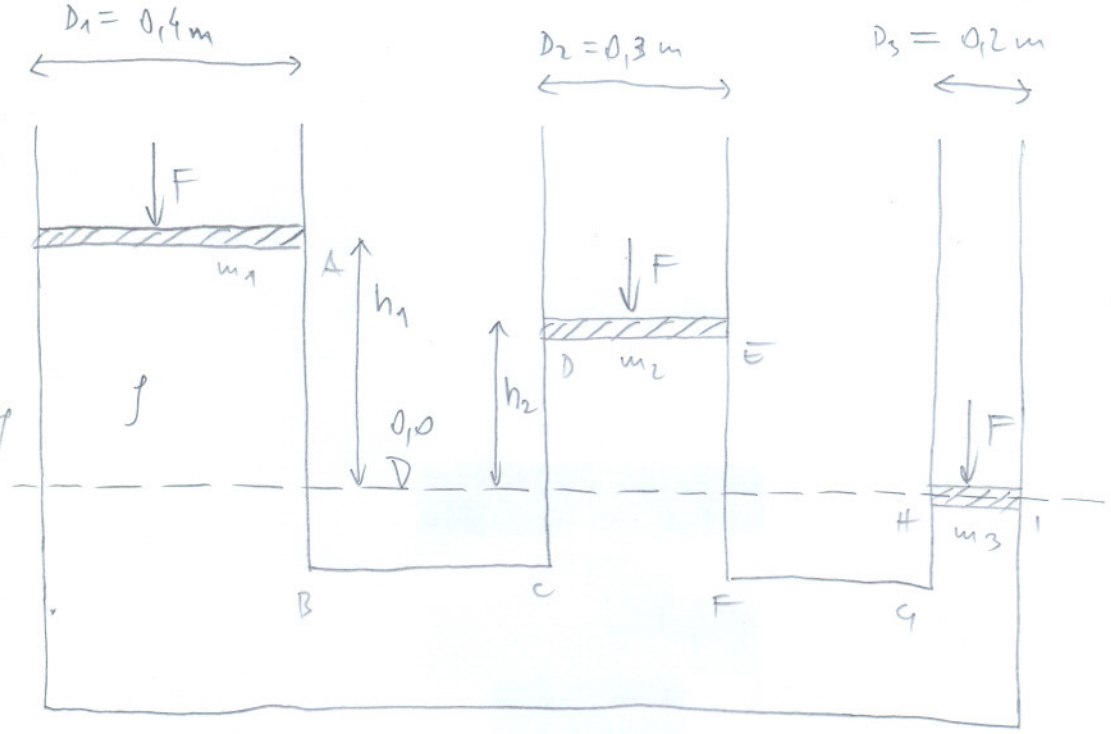
4. Hidraulički model preljeva izrađen je u geometrijskom mjerilu λ = 80. Uz pretpostavku zanemarenja viskoznih djelovanja potrebno je odrediti koje će se brzine i protoci pojaviti u prirodi ako su na modelu izmjerene sljedeće vrijednosti v_m = 1,0 m/s ; Q_m = 0.025 m^3/s. (*15 bodova*)

Teorija: (*15 bodova*)

Skicirajte dijagram specifične energije.
O čemu ovisi gubitak energije u laminarnom toku?
Što je trajektorija, a što strujnica?
Što je to vodni skok i koje vrste vodnog skoka poznajete?

Obavezno riješiti 1. i 2. zadatak

(1)



$m_1 = 50\,kp$

$m_2 = 30\,kp$

$m_3 = 10\,kp$

$F = 300\,N$

$$p_H = p_I = \frac{(F + m_3 \cdot g) \cdot 4}{D_3^2 \cdot \pi} = \frac{(300 + 10 \cdot 9{,}81) \cdot 4}{0{,}2^2 \cdot \pi} = 12671{,}9\,Pa$$

$$p_D = p_E = p_H - \rho \cdot g \cdot h_2$$

$$\frac{(F + m_2 \cdot g) \cdot 4}{D_2^2 \cdot \pi} = 12671{,}9 - 1000 \cdot 9{,}81 \cdot h_2$$

$$\frac{(300 + 30 \cdot 9{,}81) \cdot 4}{0{,}3^2 \cdot \pi} = 12671{,}9 - 9810 \cdot h_2$$

$$8407{,}6 = 12671{,}9 - 9810 \cdot h_2$$

$$h_2 = \frac{4264{,}3}{9810} = 0{,}435\,m$$

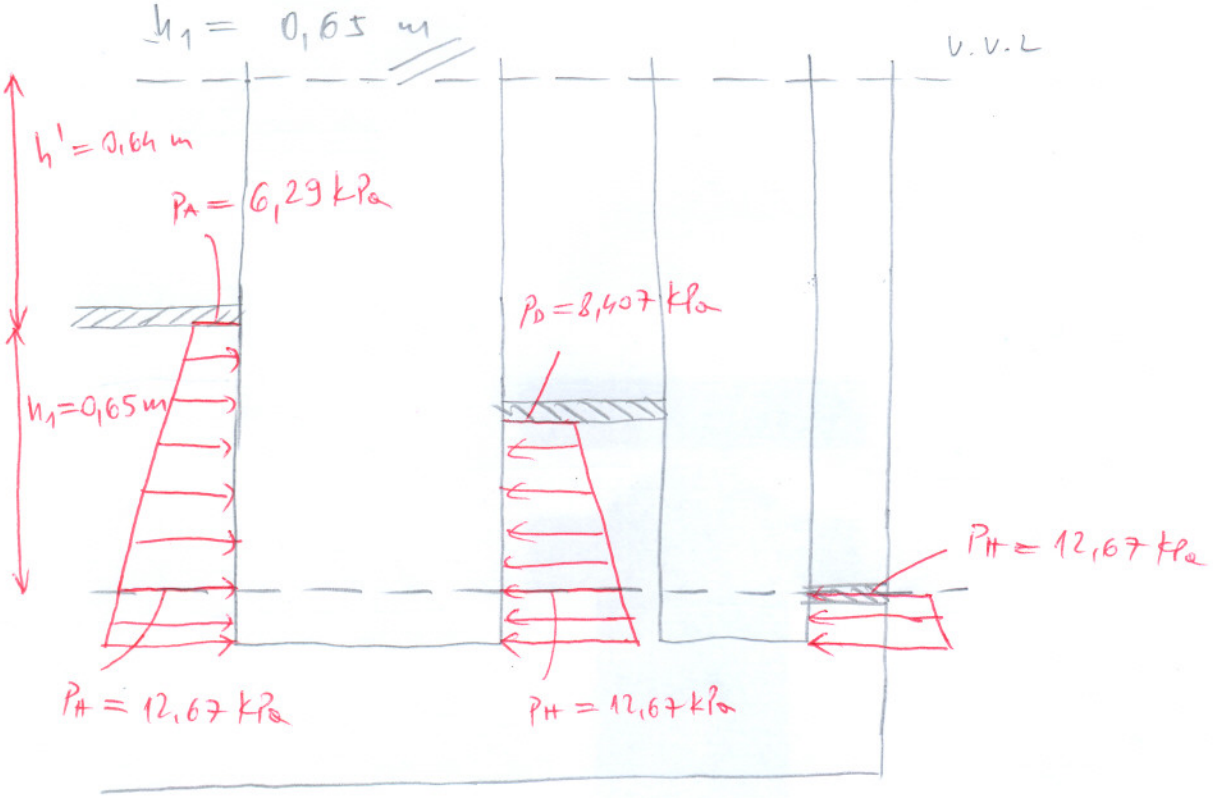
$$p_A = p_H - \rho \cdot g \cdot h_1$$

$$\frac{(F + m_1 \cdot g) \cdot 4}{D_1^2 \cdot \pi} = 12671{,}9 - 1000 \cdot 9{,}81 \cdot h_1$$

$$\frac{(300 + 50 \cdot 9{,}81) \cdot 4}{0{,}4^2 \cdot \pi} = 12671{,}9 - 9810 \cdot h_1$$

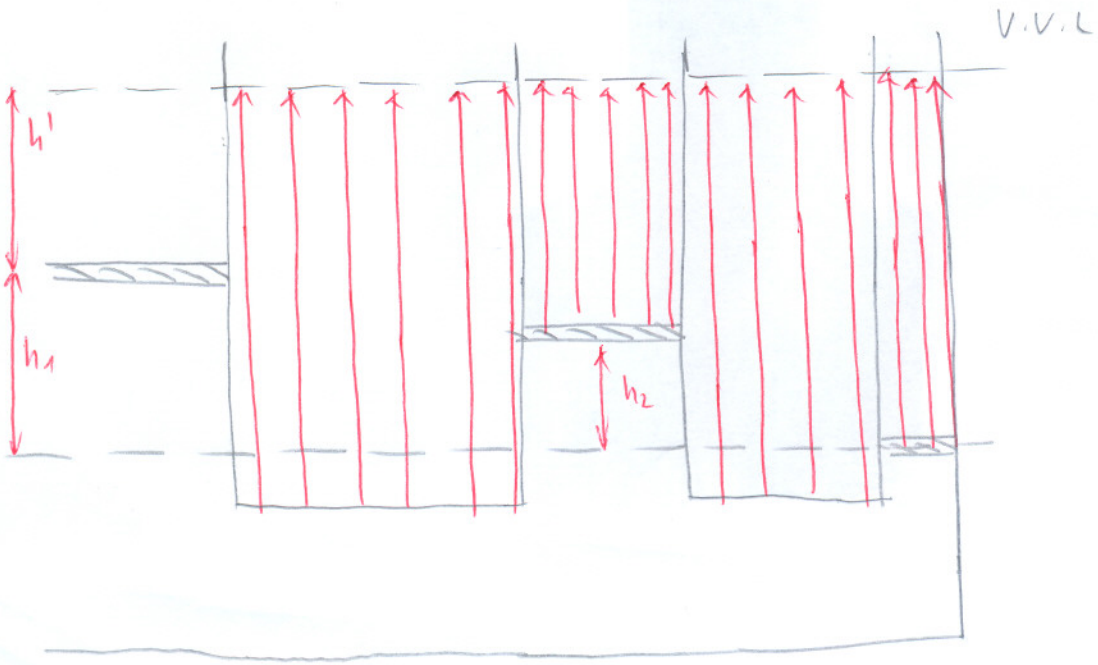
$6290,6 = 12671,9 - 9810\, h_1$

$h_1 = 0,65$ m

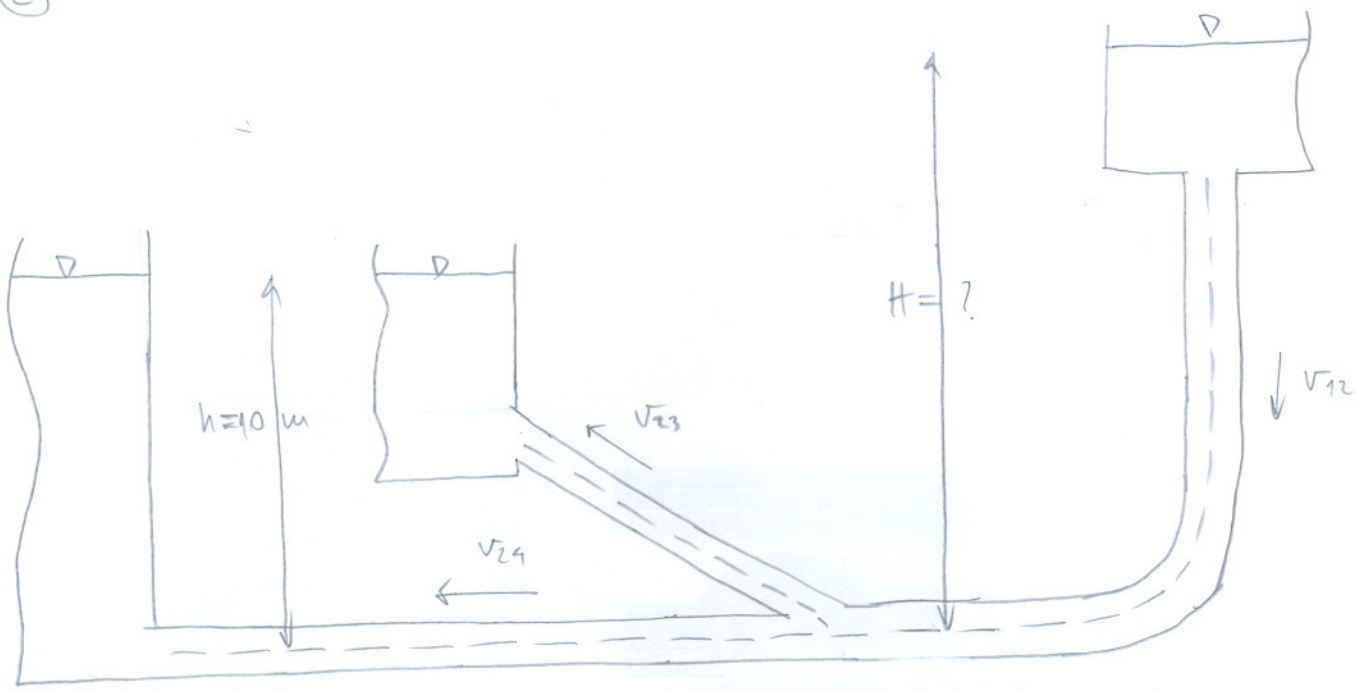


Virtualus vadas lice

$$h' = \frac{p_A}{\rho \cdot g} = \frac{6290,6}{1000 \cdot 9,81} = 0,64 \text{ m}$$



(2)



$v_{23} = v_{24}$

$$H = h + \frac{v_{12}^2}{2g}\left(\xi_{vl} + \lambda_{12}\frac{L_{12}}{D} + \xi_{kol}\right) + \frac{v_{23}^2}{2g}\left(\xi_{rov} + \lambda_{23}\frac{L_{23}}{d} + 1\right)$$

$$v_{12} = \frac{Q \cdot 4}{D^2 \pi} = \frac{0{,}05 \cdot 4}{0{,}2^2 \cdot \pi} = 1{,}59\ m/s$$

$$v_{23} = \frac{Q \cdot 4}{2 \cdot d^2 \pi} = \frac{0{,}05 \cdot 4}{2 \cdot 0{,}1^2 \cdot \pi} = 3{,}18\ m/s$$

$$\left.\begin{aligned} \frac{\varepsilon}{D} &= \frac{0{,}02}{200} = 0{,}0001 \\ Re_{12} &= \frac{v_{12} \cdot D}{\nu} = \frac{1{,}59 \cdot 0{,}2}{10^{-6}} = 3{,}18 \cdot 10^5 \end{aligned}\right\} \lambda_{12} = 0{,}0153$$

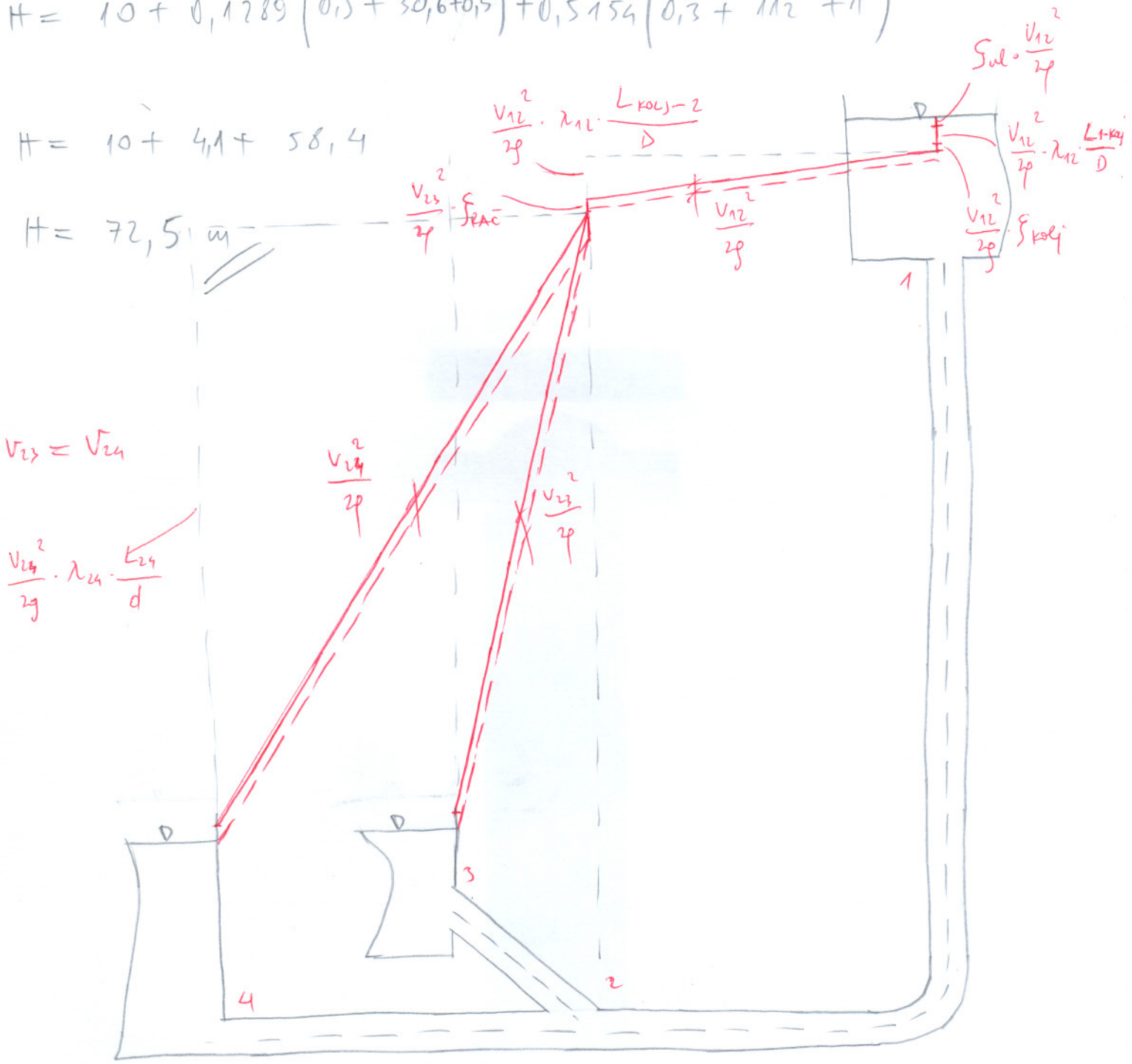
$$\left.\begin{aligned} \frac{\varepsilon}{d} &= \frac{0{,}02}{100} = 0{,}0002 \\ Re_{23} &= \frac{v_{23} \cdot d}{\nu} = \frac{3{,}18 \cdot 0{,}1}{10^{-6}} = 3{,}18 \cdot 10^5 \end{aligned}\right\} \lambda_{23} = 0{,}016 = \lambda_{24}$$

$$H = 10 + \frac{1{,}59^2}{2 \cdot 9{,}81}\left(0{,}5 + 0{,}0153 \cdot \frac{400}{0{,}2} + 0{,}5\right) + \frac{3{,}18^2}{2 \cdot 9{,}81}\left(0{,}3 + 0{,}016 \cdot \frac{700}{0{,}1} + 1\right)$$

$$H = 10 + 0{,}1289\left(0{,}5 + 30{,}6 + 0{,}5\right) + 0{,}5154\left(0{,}3 + 112 + 1\right)$$

$$H = 10 + 4{,}1 + 58{,}4$$

$$H = 72{,}5\ m$$



(3)

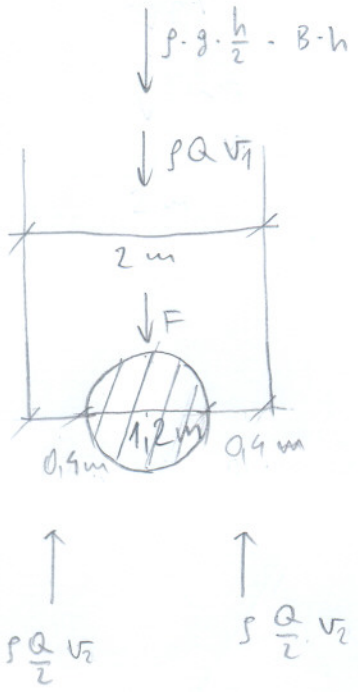
$Q = 10\ m^3/s$ $\qquad d = 1{,}2\ m$

$B = 2\ m$

$h = 1{,}5\ m$

$$v_1 = \frac{Q}{B \cdot h} = \frac{10}{2 \cdot 1{,}5} = 3{,}33\ m/s$$

$$v_2 = \frac{Q}{2h \cdot 0{,}4} = \frac{10}{2 \cdot 1{,}5 \cdot 0{,}4} = 8{,}33\ m/s$$



$$1000 \cdot 9{,}81 \cdot \frac{1{,}5}{x} \cdot x \cdot 1{,}5 + 1000 \cdot 10 \cdot 3{,}33 + F = x \cdot 1000 \cdot \frac{10}{x} \cdot 8{,}33$$

$$22072{,}5 + 33300 + F = 83300$$

$$F = 83300 - 22072{,}5 - 33300$$

$$F = 27{,}93\ kN$$

(4) $\lambda = 80$

Froudesche Ähnlichkeit

$$\frac{v_p}{\sqrt{g \cdot h_p}} = \frac{v_m}{\sqrt{g \cdot h_m}} \rightarrow v_p = v_m \sqrt{\frac{h_p}{h_m}}$$

$$v_p = v_m \cdot \sqrt{\lambda}$$

$$= 1 \frac{m}{s} \cdot \sqrt{80}$$

$$= 8{,}94 \text{ m/s}$$

$$\frac{Q_p}{Q_m} = \frac{A_p}{A_m} \cdot \frac{v_p}{v_m}$$

λ^2 $\sqrt{\lambda}$

$$Q_p = Q_m \cdot \sqrt{\lambda} \cdot \lambda^2$$

$$= 0{,}025 \frac{m^3}{s} \cdot \sqrt{80} \cdot 80$$

$$= 1431{,}1 \text{ m}^3/\text{s}$$