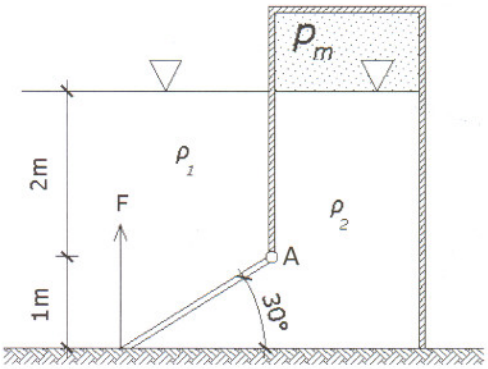
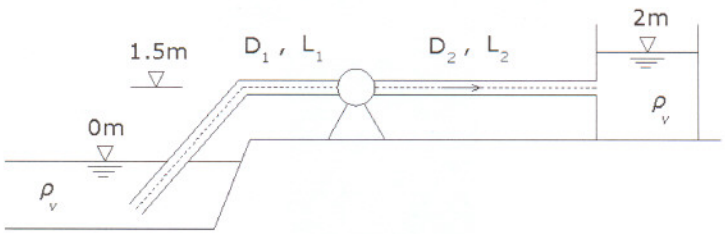
MEHANIKA TEKUĆINA 21. travnja 2011.

1) (20 bodova) Čelični zatvarač pravokutnog oblika pomičan je oko osi "A", širine je $B = 2$m i težine $m = 300$ kg. Tekućine koje se razdvajaju tim zatvaračem različite su gustoće ($\rho_1 = 750$ kg/m^3 i $\rho_2 = 1050$ kg/m^3). U komori s tekućinom ρ_2 vlada tlak $p_m = -10.3$kPa. Potrebno je izračunati silu F potrebnu za otvaranje (okretanje) zatvarača. Također nacrtati dijagram hidrostatskog tlaka po unutrašnjim konturama komore i zatvarača i označiti vrijednosti tlakova.

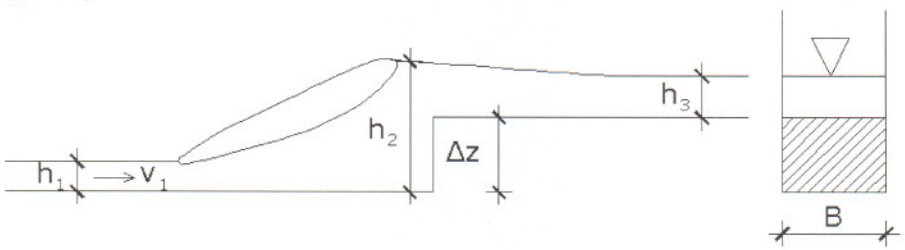


2) (25 bodova) Za sistem na slici treba proračunati snagu pumpe i nacrtati energetsku i piezometarsku liniju. Također je potrebno odrediti minimalni tlak u cjevovodu i označiti mjesto gdje se pojavljuje.

Zadano je: $D_1 = 100$ mm ; $D_2 = 60$ mm ; $Q = 0.015$ m^3/s ; $L_1 = 10$ m ; $L_2 = 15$ m ;
$\rho_V = 1000$ kg/m^2; $v = 1.01*10^{-6}$ m^2/s ; $\varepsilon = 0.2$ mm; $\xi_{UL} = 0.7$; $\xi_{KOLJ} = 0.15$; $\eta = 0.8$

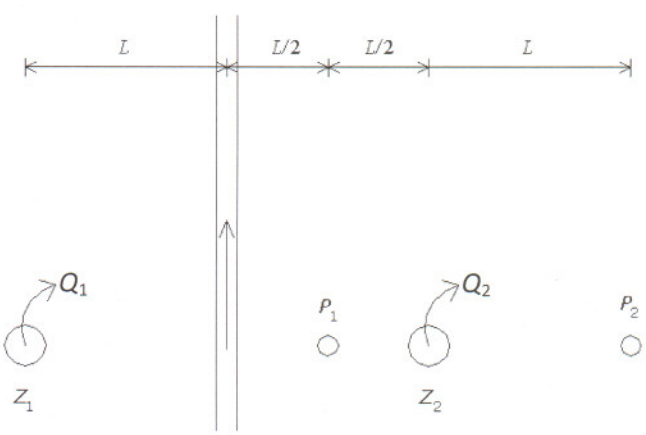


3) (20 bodova) Odrediti visinu praga Δz da bi se formirao normalni vodni skok ispred praga. Zadane su dubina $h_1 = 0.3$ m i brzina $v_1 = 8$ m/s prije vodnog skoka i normalna dubina nizvodnog korita $h_3 = 1.2$ m. Širina korita je $B = 3$ m. Odredite protok kroz korito. Odredite omjer energije toka prije (profil 1) i nakon vodnog skoka (profil 2). Linijske gubitke energije trenjem zanemarite.



4) (20 bodova) Zdenci Z_1 i Z_2 te piezometri P_1 i P_2 postavljeni su u vodonosnik pod tlakom. Između zdenaca nalazi se vodotok. Potrebno je odrediti sniženja u piezometrima P_1 i P_2.

Zadano je: $k = 0.001$ m/s ; $M = 10$m (debljina vodonosnog sloja) ; $R = 250$m (radijus utjecaja zdenaca) ; L=100m ; $Q_1 = 0.02$ m^3/s ; $Q_2 = 0.01$ m^3/s.

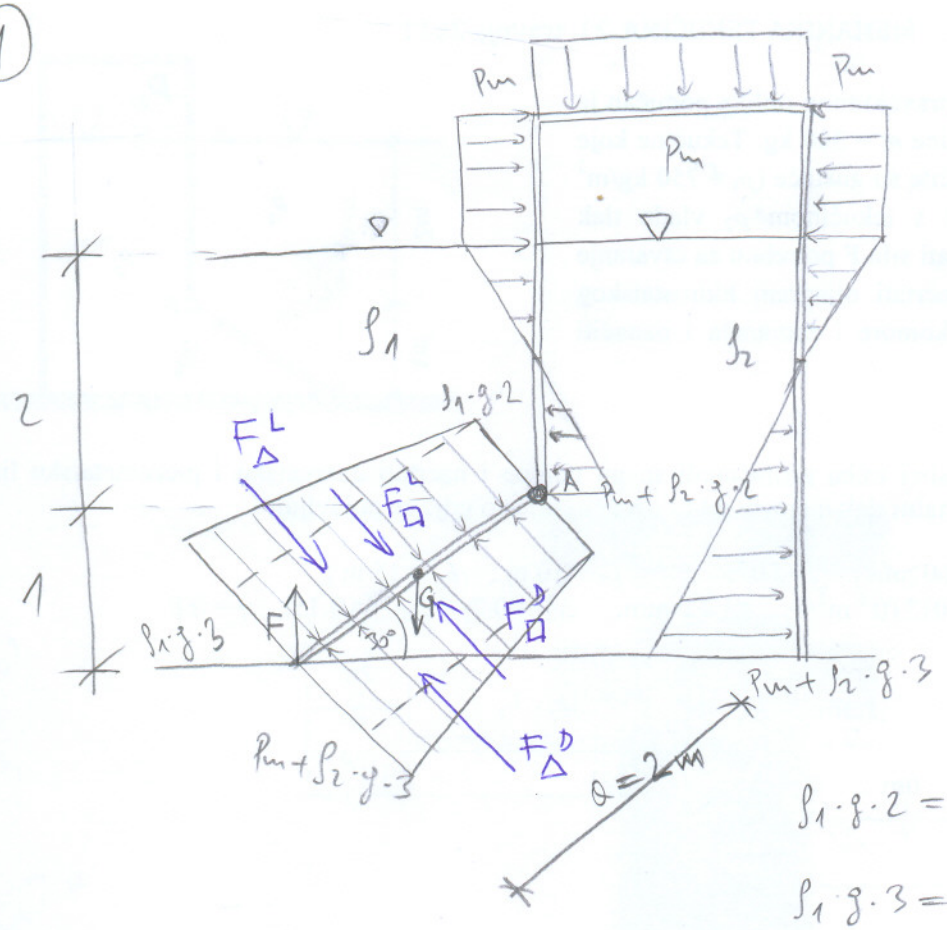


Teorija: (15 bodova)

1. Objasnite što je to homogeno, a što nehomogeno polje.
2. Koje sve vrste energije sadrži Bernoullijeva jednadžba ?
3. Što je to bučnica i kolika najmanje treba biti njena duljina?
4. Objasnite riječima i skicom što je to Pitot cijev, a što Prandtl-Pitot cijev?

Uvjeti za usmeni dio ispita: minimalno 50 bodova i točno riješeni 1. i 2. zadatak!

(1)



$m = 300$ kg

$B = 2$ m

$\rho_1 = 750$ kg/m³

$\rho_2 = 1050$ kg/m³

$p_m = -10{,}3$ kPa

$\rho_1 \cdot g \cdot 2 = 0{,}75 \cdot 9{,}81 \cdot 2 = 14{,}72$ kPa

$\rho_1 \cdot g \cdot 3 = 0{,}75 \cdot 9{,}81 \cdot 3 = 22{,}07$ kPa

$p_m + \rho_2 \cdot g \cdot 2 = -10{,}3 + 1{,}05 \cdot 9{,}81 \cdot 2 = 11{,}3$ kPa

$p_m + \rho_2 \cdot g \cdot 3 = 20{,}6$ kPa

$\Sigma M_{(A)} = 0$

G*(a*cos30)/2

F*a*cos30

$$- F \cdot a \cdot \cos 30 - F_\Delta^D \cdot \frac{2}{3} \cdot a - F_\square^D \cdot \frac{a}{2} + F_\square^L \cdot \frac{a}{2} + F_\Delta^L \cdot \frac{2}{3} a + \frac{G \cdot (a \cdot \cos 30)}{2} = 0$$

$$-F \cdot 1{,}73 - \frac{10{,}3 \cdot 4}{2} \cdot \frac{2}{3} \cdot 2 - 10{,}3 \cdot 4 \cdot \frac{2}{2} + 14{,}72 \cdot 4 \cdot \frac{2}{2} + \frac{7{,}35 \cdot 4}{2} \cdot \frac{2}{3} \cdot 2 + 0{,}3 \cdot 9{,}81 \cdot \frac{1{,}73}{2} = 0$$

$$-F \cdot 1{,}73 = 27{,}47 + 41{,}2 - 58{,}88 - 19{,}6 - 2{,}55$$

$$F = 7{,}14 \text{ kN}$$

(2)

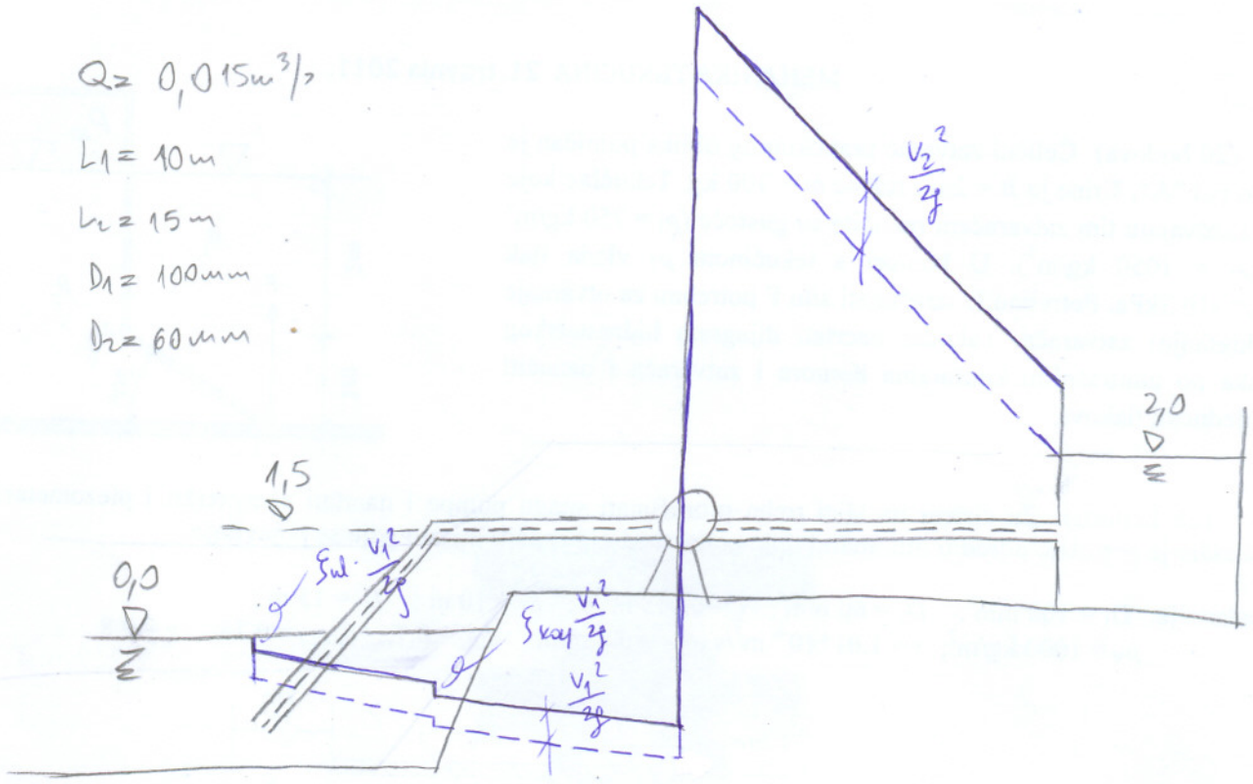
$Q = 0{,}015\ m^3/s$

$L_1 = 10\ m$

$L_2 = 15\ m$

$D_1 = 100\ mm$

$D_2 = 60\ mm$



$$v_1 = \frac{Q \cdot 4}{D_1^2 \pi} = \frac{0{,}015 \cdot 4}{0{,}1^2 \cdot \pi} = 1{,}91\ m/s \qquad v_2 = \frac{Q \cdot 4}{D_2^2 \pi} = \frac{0{,}015 \cdot 4}{0{,}06^2 \cdot \pi} = 5{,}3\ m/s$$

$$\frac{\varepsilon}{D_1} = \frac{0{,}2}{100} = 0{,}002 \quad ; \quad Re_1 = \frac{v_1 \cdot D_1}{\nu} = \frac{1{,}91 \cdot 0{,}1}{1{,}01 \cdot 10^{-6}} = 1{,}9 \cdot 10^5 \Rightarrow \lambda_1 = 0{,}025$$

$$\frac{\varepsilon}{D_2} = \frac{0{,}2}{60} = 0{,}003 \quad ; \quad Re_2 = \frac{v_2 \cdot D_2}{\nu} = \frac{5{,}3 \cdot 0{,}06}{1{,}1 \cdot 10^{-6}} = 3{,}1 \cdot 10^5 \Rightarrow \lambda_2 = 0{,}027$$

$$H_p = 2 + \frac{v_1^2}{2g}\left(\zeta_{ul} + \lambda_1 \frac{L_1}{D_1} + \zeta_{kol}\right) + \frac{v_2^2}{2g}\left(\lambda_2 \frac{L_2}{D_2} + 1\right)$$

$$H_p = 2 + \frac{1{,}91^2}{2g}\left(0{,}7 + 0{,}025 \cdot \frac{10}{0{,}1} + 0{,}15\right) + \frac{5{,}3^2}{2g}\left(0{,}027 \frac{15}{0{,}06} + 1\right)$$

$$= 2 + 0{,}186\left(0{,}7 + 2{,}5 + 0{,}15\right) + 1{,}43\left(6{,}75 + 1\right)$$

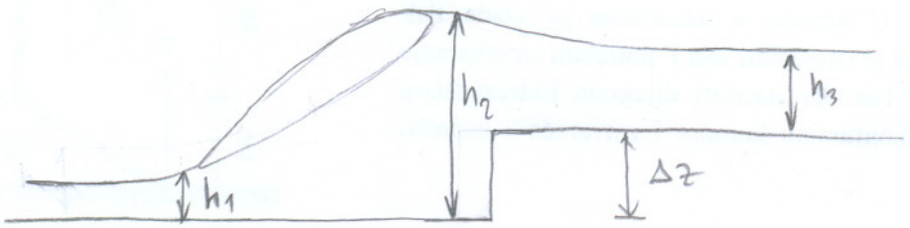
$$= 13{,}71\ m$$

$$N_p = \frac{\rho g H_p \cdot Q}{\eta} = 2{,}52\ kW$$

$$p_{min} = -\rho g\left(1{,}5 + \frac{v_1^2}{2g}\left(\zeta_{ul} + \zeta_{kol} + \lambda_1 \frac{L_1}{D_1} + 1\right)\right) = -22{,}65\ kPa$$

(úpred pumpe)

(3)



$h_1 = 0{,}3\,m \qquad h_3 = 1{,}2\,m \qquad v_1 = 8\,m/s \qquad B = 3\,m$

$$Q = h_1 \cdot B \cdot v_1 = 7{,}2\ m^3/s$$

$$Fr_1 = \frac{v_1}{\sqrt{g h_1}} = \frac{8}{\sqrt{9{,}81 \cdot 0{,}3}} = 4{,}66$$

$$h_2 = \frac{h_1}{2}\left(-1 + \sqrt{8 Fr_1^2 + 1}\right) = \frac{0{,}3}{2}\left(-1 + \sqrt{8 \cdot 4{,}66^2 + 1}\right)$$

$$= 1{,}83\,m$$

$$v_2 = \frac{Q}{h_2 \cdot B} = 1{,}31\ m/s$$

$$v_3 = \frac{Q}{h_3 \cdot B} = 2{,}0\ m/s$$

NORMALNI VODNI SKOK + ZANEMARENO TRENJE

IZMEDU PROFILA 2 1 3 $\Longrightarrow E_2 = E_3$

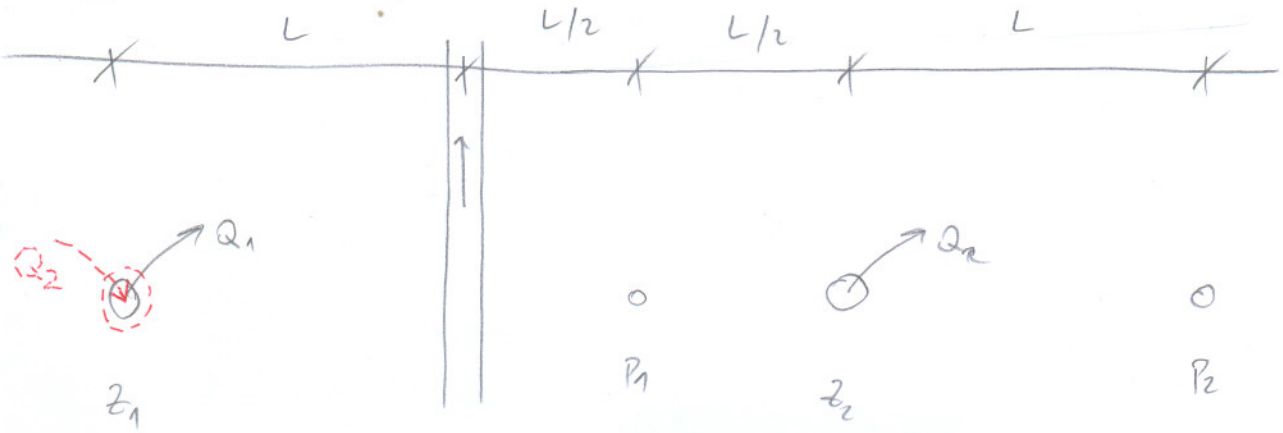
$$h_2 + \frac{v_2^2}{2g} = \Delta z + h_3 + \frac{v_3^2}{2g}$$

$$1{,}83 + 0{,}09 = \Delta z + 1{,}2 + 0{,}2$$

$$\Delta z = 0{,}52\,m$$

$$\frac{E_1}{E_2} = \frac{h_1 + \frac{v_1^2}{2g}}{h_2 + \frac{v_2^2}{2g}} = \frac{0{,}3 + \frac{8^2}{2g}}{1{,}83 + \frac{1{,}31^2}{2g}} = \frac{3{,}56}{1{,}91} = 1{,}8$$

(4)



Utjecaj z_1 se ne osjeća preko vodotoka na piezometrima P_1 i P_2 pa ga u ovom slučaju treba zanemariti. Isto bi bilo i da je umjesto vodotoka zadana nepropusna granica.

$$\Delta p_1 = \frac{Q_2}{2\pi kM}\left(\ln\frac{R}{L/2} - \ln\frac{R}{3L/2}\right)$$

$$= \frac{0{,}01}{2\pi \cdot 0{,}001 \cdot 10}\left(\ln\frac{250}{50} - \ln\frac{250}{150}\right)$$

$$= 0{,}159\ (1{,}609 - 0{,}511)$$

$$= 0{,}174\ m$$ (sniženje vodnog lica u piezometru P_1)

$$\Delta p_2 = \frac{Q_2}{2\pi kM}\ln\frac{R}{L}$$

$$= \frac{Q_2}{2\pi kM}\ln\frac{250}{100}$$

$$= 0{,}159 \cdot 0{,}916$$

$$= 0{,}146\ m$$