DINAMICA DEI FLUIDI PER L'INGEGNERIA BIOMEDICA

TEMI D'ESAME

IDROSTATICA

ESERCIZIO 1: /

ESERCIZIO 2: /

ESERCIZIO 3: /

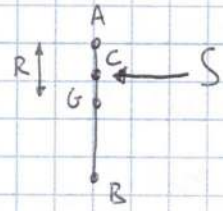
ESERCIZIO 4: /

ESERCIZIO 5: /

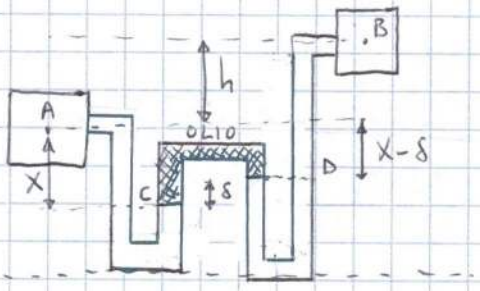
ESERCIZIO 6

$$M_{EXT} = S(y_c - y_G) = \frac{\cancel{S}\,\gamma I_x}{\cancel{S}} = 1{,}06\,\gamma_{ACQUA}\,\pi\frac{R^4}{4}$$

$$R = \sqrt[4]{\frac{4M_{EXT}}{1{,}06\,\gamma_{ACQUA}\,\pi}} = \sqrt[4]{\frac{4\cdot 4\cdot 10^{-4}\,Nm}{1{,}06\cdot 9810\,N/m^3\cdot\pi}} = 0{,}01488\,m = 1{,}488\,cm$$



ESERCIZIO 7



$$p_A = p_c - \gamma_{H_2O}\,x$$

$$p_c = p_D + \gamma_o\,\delta$$

$$p_B = p_D - \gamma_{H_2O}(h + x - \delta)$$

$$p_A - p_B = p_c - \gamma_{H_2O}x - (p_D - \gamma_{H_2O}(h+x-\delta)) = \cancel{p_D} + \gamma_o\delta - \cancel{\gamma_{H_2O}x} - \cancel{p_D} + \gamma_{H_2O}h + \cancel{\gamma_{H_2O}x} - \gamma_{H_2O}\delta = 1200\,p_a$$

$$h = \frac{1200\,p_a - \gamma_o\delta + \gamma_{H_2O}\delta}{\gamma_{H_2O}} = \frac{1200\,p_a - 0{,}8\,\gamma_{H_2O}\delta + \gamma_{H_2O}\delta}{\gamma_{H_2O}} =$$

$$= \frac{1200\,p_a - 0{,}8\cdot 9810\,N/m^3\cdot 0{,}1\,m + 9810\,N/m^3\cdot 0{,}1\,m}{9810\,N/m^3} = 0{,}142\,m$$

ESERCIZIO 8

$$S = S_{\widehat{AB}} - S_{\overline{BC}} = S_{\overline{AB}} + G - (F_{ARCHIMEDE} - S_{\overline{AB}}) = 2\,S_{\overline{AB}} + \cancel{G} - \cancel{F_{ARCHIMEDE}} =$$

$$= 2\,p_h A = \pi(p_t + \gamma h)\frac{b}{2}\cdot b = (p_t + \gamma h)\frac{b^2}{2}$$

$$\gamma = \frac{\frac{S}{b^2} - P_t}{h} = \frac{\frac{35N}{(0,1)^2} - 1000\,P_a}{0,3\,m} = 8333,333\ N/m^3$$

ESERCIZIO 9

$$P_G = 0 = P_{MAS} + \gamma_1 h_1 + \gamma_2\, 0,3\,m$$

$$h_1 = -\frac{P_{MAS} - \gamma_2\, 0,3\,m}{\gamma_1} = -\frac{(-5\,kPa) - 10\,kN/m^3\, 0,3\,m}{8\,kN/m^3} = 0,25\,m$$

DINAMICA

ESERCIZIO 1: /

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ESERCIZIO 3: /

ESERCIZIO 4: /

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ESERCIZIO 6: /

ESERCIZIO 7

$$P_U = \gamma Q H_P \Rightarrow H_P = \frac{P_U}{\gamma Q} = \frac{0,07\,W}{10,4\,kN/m^3 \cdot 1,2 \cdot 10^{-3}\,\frac{m^3}{60\,s}} = 0,337\,m$$

$$\rho = \frac{\gamma}{g} = \frac{10,4\,kN/m^3}{g} = 1060,14\ kg/m^3$$

$$\nu = \frac{\mu}{\rho} = \frac{0,004\,kg/(ms)}{1060,14\,kg/m^3} = 3,77 \cdot 10^{-6}\ m^2/s$$

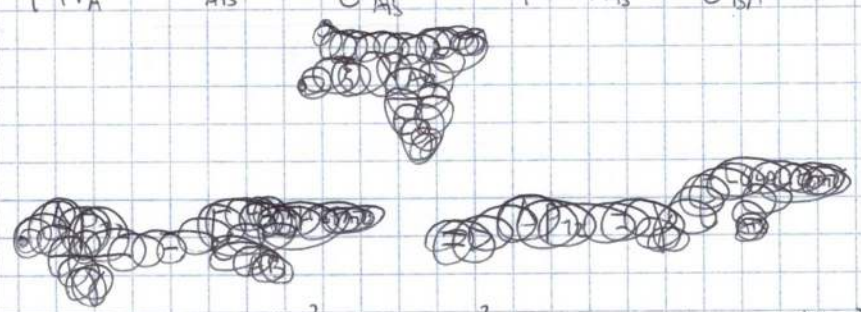
$$V_{AB} = \frac{Q}{A_{AB}} = \frac{1,2 \cdot 10^{-3}\,m^3/60\,s}{\frac{\pi\,(0,5 \cdot 10^{-2})^2}{4}} = 1,02\,m/s$$

$$V_{BA} = \frac{Q}{A_{BA}} = \frac{1,2 \cdot 10^{-3}\,m^3/60\,s}{\frac{\pi\,(0,75 \cdot 10^{-2})^2}{4}} = 0,45\,m/s$$

$$Re_{AB} = \frac{V_{AB}\, d_{AB}}{\nu} = \frac{1{,}02\ m/s \cdot 0{,}005 m}{3{,}77 \cdot 10^{-6}\ m^2/s} = 1352 \quad \text{MOTO LAMINARE}$$

$$Re_{BA} = \frac{V_{BA}\, d_{BA}}{\nu} = \frac{0{,}45\ m/s \cdot 0{,}0075 m}{3{,}77 \cdot 10^{-6}\ m^2/s} = 895 \quad \text{MOTO LAMINARE}$$

$$H_{P_A} - E_{AB}^{\text{CONTINUO}} - E_{AB}^{\text{LOCALIZZATO}} + H_{P_B} - E_{BA}^{\text{CONTINUO}} = 0$$



$$H_{P_A} - \frac{64}{Re_{AB} d_{AB}} \frac{V_{AB}^2}{2g} L_{AB} \xi \frac{V_{AB}^2}{2g} + H_{P_B} - \frac{64}{Re_{BA} d_{BA}} \frac{V_{BA}^2}{2g} L_{BA} = 0$$

$$\xi = \left(H_{P_A} - \frac{64}{Re_{AB} d_{AB}} \frac{V_{AB}^2}{2g} L_{AB} + H_{P_B} - \frac{64}{Re_{BA} d_{BA}} \frac{V_{BA}^2}{2g} L_{BA} \right) \frac{2g}{V_{AB}^2} =$$

$$= \left(0{,}337 m - \frac{64}{1352 \cdot 0{,}005 m} \frac{(1{,}02 m/s)^2}{2g} 0{,}6 m + 0{,}337 m - \frac{64}{895 \cdot 0{,}0075 m} \frac{(0{,}45 m/s)^2}{2g} 0{,}4 m \right) \frac{2g}{(1{,}02 m/s)^2} = 6{,}312$$

$$\frac{\Delta p_{12}}{\gamma} = E_{AB}^{\text{LOCALIZZATO}} = \xi \frac{V_{AB}^2}{2g} = \frac{6{,}312 \cdot (1{,}02 m/s)^2}{2g} = 0{,}333 m$$

$$\Delta p_{12} = 0{,}333 m \cdot \gamma = 0{,}333 m \cdot 10{,}4 kN/m^3 = 3458{,}822 Pa$$

ESERCIZIO 8

$$V = \frac{Q}{\pi \frac{d^2}{4}} = \frac{3{,}5 \cdot 10^{-3}\ m^3/s}{\pi \frac{(0{,}06 m)^2}{4}} = 1{,}24 m/s$$

$$Re = \frac{\rho V d}{\mu} = \frac{1000 kg/m^3 \cdot 1{,}24 m/s \cdot 0{,}06 m}{10^{-3}\ kg/(m s)} = 74400 \quad \text{MOTO TURBOLENTO}$$

$$E_A = E_{AB}^{\text{CONTINUO}} + E^{\text{LOCALIZZATO}} + E_B$$

$$h_A = \frac{f}{d} \frac{V^2}{2g} L + \frac{V^2}{2g} \left(1 + \frac{1}{2}\right) + h_B \Rightarrow f = \left(h_A - h_B - \frac{V^2}{2g} \frac{3}{2} \right) \frac{2g d}{V^2 L} = \left(0{,}6 m - 0{,}2 m - \frac{(1{,}24 m/s)^2}{2g} \frac{3}{2} \right) \frac{2g\, 0{,}06 m}{(1{,}24 m/s)^2 \cdot 6}$$

$$= 0{,}03676$$

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{e/d}{3{,}71} + \frac{2{,}52}{Re\sqrt{f}}\right) \Rightarrow e = \left(10^{-\frac{1}{2\sqrt{f}}} - \frac{2{,}52}{Re\sqrt{f}}\right) 3{,}71\, d =$$

$$= \left(10^{-\frac{1}{2\sqrt{0{,}03616}}} - \frac{2{,}52}{74400\sqrt{0{,}03616}}\right) 3{,}71 \cdot 0{,}06\,m = 4{,}85 \cdot 10^{-4}\,m = 0{,}485\,mm$$

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{e/d}{3{,}71}\right) \Rightarrow f = \left(-2\log_{10}\left(\frac{e/d}{3{,}71}\right)\right)^{-2} = \left(-2\log_{10}\left(\frac{4{,}85\cdot 10^{-4}\,m / 0{,}06\,m}{3{,}71}\right)\right)^{-2} =$$

$= 0{,}03528 \neq 0{,}03616$ MOTO NON È SU PARETI IDRAULICAMENTE SCABRA

ESERCIZIO 9

$$\rho = \frac{\gamma_{acqua}}{g} = \frac{3 \cdot 9810\ N/m^3}{g} = 3000\ kg/m^3$$

$$\mu = \rho\, 2\nu_{ACQUA} = 3000\ kg/m^3 \cdot 2 \cdot 10^{-6}\ m^2/s = 6 \cdot 10^{-3}\ kg/(m\,s)$$

$$\begin{cases} \tau = \frac{\gamma i r}{2} \Rightarrow i = \frac{2\tau}{\gamma r} = \frac{2 \cdot 10 P_a}{3 \cdot 9810\ N/m^3 \cdot 1{,}072 \cdot 10^{-3}\,m} = 0{,}6718 \\ Q = \gamma i \frac{\pi r^4}{8\mu} = \frac{\gamma \tau}{\gamma r} \frac{\pi r^3}{8\mu} \Rightarrow r = \sqrt[3]{\frac{Q 4 \mu}{2\pi}} = \sqrt[3]{\frac{5 \cdot 10^{-3}\ m^3/60^2\ s \cdot 4 \cdot 6 \cdot 10^{-3}\ kg/(m\,s)}{10 P_a \cdot \pi}} = 1{,}072 \cdot 10^{-3}\,m = \end{cases}$$

$$= 1{,}072\,mm$$

$$V = \frac{Q}{A} = \frac{5 \cdot 10^{-3}\ m^3/60^2\ s}{\pi (1{,}072 \cdot 10^{-3}\,m)^2} = 0{,}43\ m/s$$

$$Re = \frac{Vd}{2\nu_{ACQUA}} = \frac{0{,}43\ m/s \cdot 2 \cdot 1{,}072 \cdot 10^{-3}\,m}{2 \cdot 10^{-6}\ m^2/s} = 435 \quad \text{MOTO LAMINARE}$$

$$E_A = E_{AB}^{CONTINUO} + E_B \Leftrightarrow h_A^* + a\frac{V^2}{2g} = \frac{64}{Re\, d}\frac{V^2}{2g} L + h_B$$

$$h_B = h_A^* + a\frac{V^2}{2g} - \frac{64}{Re\, d}\frac{V^2}{2g} L = 0{,}4\,m + \pi\frac{(0{,}43\ m/s)^2}{2g} - \frac{64}{435 \cdot \pi \cdot 1{,}072 \cdot 10^{-3}\,m}\frac{(0{,}43\ m/s)^2}{2g} \cdot 0{,}5\,m = 0{,}0825\,m$$

$$Q = \Omega \frac{\delta}{t} \Rightarrow t = \frac{\Omega^2 \delta}{Q} = \frac{(0{,}1\,m)^2 (0{,}03)}{5 \cdot 10^{-3}\,m^3/60^2\ s} = 216\,s$$

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$$Re = \frac{Vd}{\nu} \Rightarrow V = \frac{Re\,\nu}{d} = \frac{2 \cdot 10^5 \cdot 10^{-6}\ m^2/s}{0{,}2\,m} = 1\ m/s$$

$$Q = vA = 1\ m/s\ \pi\,(0{,}2)^2 = 0{,}03\ m^3/s$$

$$H_P = \frac{f}{d}\frac{V^2}{2g} L = \frac{0,04878}{0,2\,m}\frac{50\,m}{2g} = 0,62\,m$$

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{e/d}{3,71}\right) \Rightarrow f = \left(-2\log_{10}\left(\frac{e/d}{3,71}\right)\right)^{-2} = \left(-2\log_{10}\left(\frac{0,004\,m\,/\,0,2\,m}{3,71}\right)\right)^{-2} = 0,04858$$

f_{TENT} f_{CALC}

$0,04858 \neq 0,04878$

$0,04878 = 0,04878$

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left(\frac{e/d}{3,71} + \frac{2,52}{Re\sqrt{f}}\right) \Rightarrow f = \left(-2\log_{10}\left(\frac{e/d}{3,71} + \frac{2,52}{Re\sqrt{f}}\right)\right)^{-2} = 0,04878$$

$$P_U = \gamma Q H_P = 9810\,N/m^3 \cdot 0,03\,m^3/s \cdot 0,62\,m = 182,47\,W$$

$$E_A + H_P = E_B \iff h_A + H_P = \frac{p_{ass}}{\gamma} + h_B \Rightarrow h_B = h_A + H_P - \frac{p_{ass}}{\gamma} = 1\,m + 0,62\,m - \frac{8\,kPa}{9810\,N/m^3} = 0,8\,m$$

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$$Q_3 = Q_1 + Q_2 = Q_1 + 2Q_1 = 3Q_1 = 3 \cdot 0,035 \cdot 10^{-3}\,m^3/s = 1,05 \cdot 10^{-4}\,m^3/s$$

$$\begin{cases} E_A + H_{P_1} = E_N \\ E_A + H_{P_2} = E_N \\ E_N = E_{NB}^{CONTINUE} + E_B \end{cases} \Rightarrow H_{P_1} = H_{P_2} = H_P \Rightarrow E_A + H_P = E_{NB}^{CONTINUE} + E_B$$

$$V_1 = \frac{Q_1}{A} = \frac{0,035 \cdot 10^{-3}\,m^3/s}{\pi\frac{(0,01\,m)^2}{4}} = 0,45\,m/s$$

$$Re_1 = \frac{V_1 d}{\nu} = \frac{0,45\,m/s \cdot 0,01\,m}{2 \cdot 10^{-5}\,kg/(m\,s)} = 225 \text{ MOTO LAMINARE}$$

$$V_2 = \frac{Q_2}{A} = \frac{2 \cdot 0,035 \cdot 10^{-3}\,m^3/s}{\pi\frac{(0,01\,m)^2}{4}} = 0,9\,m/s$$

$$Re_2 = \frac{V_2 d}{\nu} = \frac{0,9\,m/s \cdot 0,01\,m}{2 \cdot 10^{-5}\,kg/(m\,s)} = 450 \text{ MOTO LAMINARE}$$

$$V_3 = \frac{Q_3}{A} = \frac{1,05 \cdot 10^{-4}\,m^3/s}{\pi\frac{(0,01\,m)^2}{4}} = 1,34\,m/s$$

$$Re_3 = \frac{V_3 d}{\nu} = \frac{1,34\,m/s \cdot 0,01\,m}{2 \cdot 10^{-5}\,kg/(m\,s)} = 670 \text{ MOTO LAMINARE}$$

$E_A = \alpha \frac{V^2}{2g}$

$E_{A1} = \alpha \frac{V_1^2}{2g} = 2 \frac{(0,45\ m/s)^2}{2g} = 0,02\ m$

$E_{A2} = \alpha \frac{V_2^2}{2g} = 2 \frac{(0,9\ m/s)^2}{2g} = 0,08\ m$

$E_{NB}^{CONTINUS} = ; L_{NB} = \frac{f}{d} \frac{V^2}{2g} L_{NB} = \frac{64}{Re_3 d} \frac{V_3^2}{2g} L_{NB} = \frac{64}{670\ (0,01\ m)} \frac{(1,34\ m/s)^2}{2g} 2\ m = 1,75\ m$

$E_B = h = 0,3\ m$

$H_{P_1} = E_{NB}^{CONTINUS} + E_B - E_{A1} = 1,75\ m + 0,3\ m - 0,02\ m = 2,03\ m$

$H_{P_2} = E_{NB}^{CONTINUS} + E_B - E_{A2} = 1,75\ m + 0,3\ m - 0,08\ m = 1,97\ m$

$\Rightarrow H_{P_1} \simeq H_{P_2}$

$P_1 = \gamma Q_1 H_{P_1} = 10800\ N/m^3 \cdot 0,035 \cdot 10^{-3}\ m^3/s \cdot 2,03\ m = 0,77\ W$

$P_2 = \gamma Q_2 H_{P_2} = 10800\ N/m^3 \cdot 2 \cdot 0,035 \cdot 10^{-3}\ m^3/s \cdot 1,97\ m = 1,49\ W$