

Depth (m)	p (mm H ₂ O)	Oil (m)	OP (mm H ₂ O)	OP / r mm H ₂ O / m	(3-7 سوال)
0	520				
0.186		0.5	-93	-186	
0.5	427				
0.152		0.5	-76	-152	
1	351				
		0.5	-63	-126	
1.5	288				
		0.5	-52	-104	
2	236				
		0.5	-48	-96	
2.5	188				
		0.5	-43	-86	
3	145				
		0.5	-36	-72	
3.5	109				
		0.5	-36	-72	
4	73				
		0.5	-37	-74	
4.5	36				
		0.5	-36	-72	
5	0				

$$OP = \frac{4r}{D} \tau_0 \rightarrow \tau_0 = \frac{OP D}{4r} = \left[\frac{(72 \text{ mm H}_2\text{O}) (9810 \text{ N/m}^3)}{1000 \text{ m/mm}} \right] \frac{0.05 \text{ m}}{4}$$

$$\rightarrow \tau_0 = 8.83 \text{ Pa}$$

(7-7) $\frac{DP}{L} = ? \leftarrow \tau = \frac{\mu}{R^2}$: تنش برشی بر روی دیواره (دایره ای)

$\Rightarrow \tau_0 = \frac{DP}{L} \times \frac{D}{4} \Rightarrow \frac{\mu}{R^2} = \left(\frac{DP}{L} \right) \times \frac{D}{4} \Rightarrow \frac{DP}{L} = \frac{\mu}{\frac{2R}{4}} = \frac{4\mu}{2R^3} = 2 \frac{\mu}{R^3}$: توزین سه

$Re = 1500$ $L = 20$ (m) $D = 0.05$ (m) $\nu = 2 \times 10^{-5}$ (m²/s) $g = 9.81$ (m/s²) (14-7)

$\Rightarrow Re = \frac{VD}{\nu} \Rightarrow V = \frac{Re \nu}{D} = \frac{1500 \times 2 \times 10^{-5}}{0.05} = 0.6$ (m/s)

$\Rightarrow h_f = \frac{DP}{\gamma} = \frac{32 \nu L V}{g D^3} = \frac{32 \times 2 \times 10^{-5} \times 20 \times 0.6}{9.81 \times (0.05)^3} = 0.313$ توزین ۲ درست است.

$\nu = 0.001$ (m²/s) $D = 0.4$ (m) $L = 4000$ (m) $Q = 0.126$ (m³/s) $g = 10$ (m/s²) (21-7)

$\Rightarrow h_f = \frac{128 \nu L Q}{g \pi D^4} = \frac{128 \times 0.001 \times 4000 \times 0.126}{10 \times 3.14 \times (0.4)^4} \approx 80.21$ (m) = h_f : توزین چهار درست است.

(27-7) \leftarrow معادله تومسون یافته در آرام
 با بلانزی: $\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 + h_p = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_T + h_L$

$\Rightarrow 0 + 0 + 0.2 + 0 = 0 + \frac{\sqrt{V}^2}{2g} + 0 + 0 + \frac{32 \nu L V}{g D^3} \Rightarrow 0.2 = \frac{V^2}{9.81} + \frac{32 \times 3.7 \times 10^{-6} \times 3 \times V}{9.81 \times (0.006)^3} \Rightarrow$

$\Rightarrow V^2 + 9.86 V - 1.96 = 0 \Rightarrow V = 0.195$ (m/s)

$\Rightarrow Re = \frac{VD}{\nu} = \frac{0.195 \times 0.006}{3.7 \times 10^{-6}} = 316 < 2000$: OK

$\Rightarrow Q = AV = \frac{\pi \times (0.006)^2 \times 0.195}{4} = 5.51 \times 10^{-6}$ (m³/s) ≈ 5.51 (cm³/s)

(31-7) حل

$$Q = 4 \times 10^{-4} \text{ (m}^3/\text{s)} \Rightarrow V = \frac{Q}{A} = \frac{4 \times 10^{-4} \times 4}{\pi \times (0.02)^2} = 1.27 \text{ (m/s)}$$

$$\Rightarrow Re = \frac{VD}{\nu} = \frac{1.27 \times 0.02}{1.2 \times 10^{-4}} = 212 < 2000 \quad : \text{ جريان لامين}$$

$$\Rightarrow hf = \frac{DP}{\gamma} = \frac{128 \nu L Q}{g \pi D^4} \Rightarrow Q = \frac{\pi D^4 (DP \pm \gamma L)}{128 \mu L} \Rightarrow \begin{cases} DP = P_{up} - P_{down} = \frac{128 \mu L Q}{\pi D^4} - \gamma L \\ DP = -P_{up} + P_{down} = \frac{128 \mu L Q}{\pi D^4} + \gamma L \end{cases}$$

$$\Rightarrow P_{up} - P_{down} = (\gamma_g - \gamma) h - \gamma L$$

$$\Rightarrow \begin{cases} \text{جريان لامين} : (\gamma_g - \gamma) h - \gamma L = \frac{128 \mu L Q}{\pi D^4} - \gamma L \Rightarrow h = \frac{128 \times 1.2 \times 10^{-4} \times 0.87 \times 10^3 \times 4 \times 4 \times 10^{-4}}{\pi \times (0.02)^4 (1.3 - 0.87) 9810} = 10 \text{ (m)} \\ \text{جريان مضطرب} : -(\gamma_g - \gamma) h + \gamma L = \frac{128 \mu L Q}{\pi D^4} + \gamma L \Rightarrow h = -10 \text{ (m)} \end{cases}$$

$$\nu = 10^{-5} \text{ m}^2/\text{s} \quad , \quad Q = 0.14 \text{ m}^3/\text{s} \quad l = 200 \text{ m} \quad , \quad D = 0.2 \text{ m} \quad (7-39)$$

$$f = 0.316 Re^{-0.25} \quad (\text{معادلة ستوكس انستياواس})$$

$$Re = \frac{VD}{\nu} = \frac{(4.46 \text{ m/s})(0.2 \text{ m})}{10^{-5}} = 89200$$

$$V = \frac{Q}{A} = \frac{0.14 \text{ m}^3/\text{s}}{\pi (0.2 \text{ m})^2} = 4.46 \text{ m/s}$$

$$hf = f \frac{l}{D} \frac{V^2}{2g} = (0.316)(89200)^{-1/4} \left(\frac{200 \text{ m}}{0.2 \text{ m}} \right) \left(\frac{4.46^2}{2(9.81)} \right)$$

$$hf = 18.54 \text{ m}$$

$$\left\{ \begin{array}{l} \Delta Z = 25 \text{ m} \\ f = 0.02 \quad D = 0.4 \text{ m} \\ L = 2000 \text{ m} \\ P_A = 50 \text{ kW/m}^2 \\ Q = 0.2 \text{ m}^3/\text{s} \end{array} \right. \quad \frac{P_A}{\gamma} + Z_A + \frac{v_A^2}{2g} + h_p = \frac{P_B}{\gamma} + Z_B + \frac{v_B^2}{2g} + h_L$$

$KV-V$
بدرستی

$$\Rightarrow \frac{50 \times 10^3}{10^4} + 0 + \frac{v^2}{2g} + h_p = 0 + 25 + 0 + h_L$$

$$v = \frac{Q}{A} = \frac{0.2}{\pi \times \frac{0.4^2}{4}} = 1.591 \text{ m/s} \quad h_L = \frac{fL v^2}{2Dg} = \frac{0.02 \times 2000 \times 1.591^2}{2 \times 0.4 \times 10} = 12.665$$

$$\Rightarrow h_p = 25 + 12.665 - \frac{1.591^2}{20} - \frac{50 \times 10^3}{10^4} = 12.665$$

$$= 32.54 \text{ m} \quad P = h_p \times Q \times \gamma = 32.55 \times 0.2 \times 10^4 = \underline{165.1 \text{ kW}}$$

$$\Rightarrow h_{f_2} = f \frac{L}{D} \frac{v^2}{2g} = l \left(\frac{f v^2}{2g D} \right) \Rightarrow 20 \text{ (m)} = 0.01 L \Rightarrow L = 2000 \text{ (m)}$$

(56-7)

$$\Rightarrow \text{با توجه انرژی: } \frac{P_1}{\gamma} + \frac{v_1^2}{2g} + Z_1 + h_p = \frac{P_2}{\gamma} + \frac{v_2^2}{2g} + Z_2 + \underbrace{(h_{f_1} + h_{f_2})}_{h_f} \Rightarrow 0 + h_p = 0 + \frac{f v^2}{2g D} (l_1 + l_2)$$

$$\Rightarrow h_p = 0.1(500 + 2000) + 50 \Rightarrow h_p = 75 \text{ (m)}$$

گزینه 4 درست است.

62-7) ابتدایی حوضی ماشین را حساب می‌کنیم. $Q = 100 \text{ لیتر در ثانیه} \Rightarrow 1.11 \text{ (hr)}$: سرعت : $90 \frac{\text{km}}{\text{hr}}$

$$\Rightarrow Q_{\text{حوضی}} = \frac{25 \text{ Lit}}{1.11 \text{ hr}} = \frac{0.025}{1.11 \times 60 \times 60} = 6.25 \times 10^{-6} \text{ (m}^3\text{/s)} = Q$$

② \Rightarrow رابطه انرژی برین برود و چون $\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 + h_p = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_L \Rightarrow 0 + 0 + 0 + h_p = 0 + 0 + 1 + h_L$

$\Rightarrow h_p = 1 + h_L + h_f$ $h_L = K_m \frac{V^2}{2g} \Rightarrow h_L = 0.35 \times \frac{0.884^2}{2 \times 9.81} = 0.014 \times 5 \approx 0.07 \text{ (m)}$
 انت هزانوی ما :

$\frac{R}{D} = \frac{20}{3} \approx 6.67 \Rightarrow K_m \approx 0.35$ $\leftarrow \frac{\epsilon}{D} = \frac{0.03}{3} = 0.01 \leftarrow \epsilon = 0.03$: فرسنگ لوله صسی باشد :

$\Rightarrow V = \frac{Q}{A} \Rightarrow \frac{6.25 \times 10^{-6}}{\frac{\pi}{4} \times (0.003)^2} = 0.884 \text{ (m/s)}$

$\Rightarrow h_f = \frac{32 \cdot \nu \cdot L \cdot Q}{g \cdot D^4} = \frac{32 \times 4 \times 10^{-7} \times 3 \times 6.25 \times 10^{-6}}{9.81 \times \pi \times (0.003)^4} = 0.01 \text{ (m)}$ $\Rightarrow h_p = 1 + 0.01 + 0.07 \approx 1.08 \text{ (m)}$

$\Rightarrow \text{ip} = \gamma Q h_p = 7200 \times 6.25 \times 10^{-6} \times 1.08 \times 2 = 0.11 \text{ W}$

70-7) $\Rightarrow 0 + 0 + Z_1 = 0 + \frac{V^2}{2g} + 0 + h_f$: $h_f = \left(\frac{fL}{D} \sum K_m \right) \frac{V^2}{2g}$

$\Rightarrow 5 = \left[1 + f \frac{10}{0.02} + (0.5 + 2 \times 1.5) \right] \frac{V^2}{2g} \Rightarrow V = \sqrt{\frac{98.1}{4.5 + 500f}}$ ①

ضریب انت زانوی : 1.5

ضریب انت گردی : 0.5

$Re = \frac{VD}{\nu} \Rightarrow V = \frac{Re \nu}{D}$ ②

$\Rightarrow V = 2.08 \text{ (m/s)} \Rightarrow \frac{V^2}{2g} = h \Rightarrow h = \frac{(2.08)^2}{2 \times 9.81} = 0.22$

با از من و خلاصه مقدار f می‌شویم : 0.0365

$$Q = 0.28 \text{ (m}^3\text{/s)}$$

$$L = 3500 \text{ (m)}$$

$$D_2 = 8 \text{ (m)}$$

77-7) تیب 3 ←

$$\Rightarrow \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + hf \Rightarrow 0 + 0 + 8 = 0 + 0 + 0 + \frac{fL}{D} \frac{Q^2}{12.1} \Rightarrow \frac{f}{D^5} = 0.353$$

با استفاده از معادله دarcy و معادله D و V را حساب کنیم و معادله ای در دسترس داریم:

$$\Rightarrow f = 0.0175 \Rightarrow D = 0.548 \Rightarrow V = \frac{Q}{A} = \frac{0.28}{\frac{\pi}{4}(0.548)^2} = 1.19 \text{ (m/s)}$$

$$\Rightarrow \frac{L}{D} = \frac{3500}{0.548} = 6386.88 \Rightarrow Re = \frac{VD}{\nu} = 5.8 \times 10^5 \Rightarrow f = 0.0175 : \text{OK}$$

$$D = 548 \approx 550 \text{ (mm)}$$

$$\Rightarrow -fV^2 A = -R_w + PA$$

78-7) رابطه انداز، عرض و طول برای معادله کنترل:

$$\Rightarrow -40^3 \times V^2 \times \frac{\pi D^2}{4} = -30 \times 10^3 + P_1 \left(\frac{\pi D^2}{4} \right) \quad (1)$$

برای سطح مقطع ورودی اوله:

$$\Rightarrow P_2 + \frac{fV^2}{2} + \gamma Z_2 = P_1 + \frac{fV^2}{2} + \gamma Z_1 \Rightarrow 0 + 0 + 9810 \times 32 = P_1 + 500 V^2 + 0 \quad (2)$$

$$(1), (2) \Rightarrow D^2 \left(313.9 + \frac{V^2}{2} \right) = 38.2 \quad (3)$$

برای ورودی و خروجی اوله:

$$\Rightarrow \frac{313920 - 500V^2}{\gamma} + \frac{V^2}{2g} + 32 = 0 + \frac{V^2}{2g} + 0 + \frac{fLV^2}{D2g} \Rightarrow D = \frac{81fV^2}{628 - V^2} \quad (4)$$

$$(3), (4) \Rightarrow \left(\frac{81fV^2}{628 - V^2} \right)^2 \left(313.9 + \frac{V^2}{2} \right) = 38.2 \Rightarrow$$

با آزمون و خطا

$$\Rightarrow f = 0.013 \Rightarrow D = 0.31 \Rightarrow V = 12.7 \Rightarrow \text{OK}$$

$$Q_1 = Q_2 \Rightarrow h_{L1} = h_{L2}$$

91-7)

$$\Rightarrow \frac{8f_1 L_1 Q^2}{g \pi^2 D_1^5} = \frac{8f_2 L_2 Q^2}{g \pi^2 D_2^5} \Rightarrow \frac{f_1 L_1}{D_1^5} = \frac{f_2 L_2}{D_2^5} \Rightarrow 0.02 \left(\frac{100}{0.2^5} \right) = 0.04 \left(\frac{L_2}{0.4^5} \right) \Rightarrow L_2 = 1600$$

7-99) فرض کنیم فریب (بیانازل) باشد 0.96

$$\beta = \frac{d}{D} = \frac{1.5}{3} = 0.5 \quad A_n = \frac{\pi d^2}{4} = 1.767 \times 10^{-4} \text{ (m}^2\text{)}$$

$$\Rightarrow Q = A_n C_n \sqrt{\frac{2(P_1 - P_2)}{f(1 - \beta^4)}} \Rightarrow Q = 1.767 \times 10^{-4} \times 0.96 \sqrt{\frac{2 \times 4000}{624.4 \times (1 - 0.5^4)}} = 0.627 \text{ (L/s)}$$

$$\Rightarrow v = \frac{Q}{A} = \frac{0.627 \times 10^{-3}}{\frac{\pi}{4} (0.03)^2} = 0.887 \text{ (m/s)} \Rightarrow Re = \frac{fVD}{\nu} = \frac{624.4 \times 0.887 \times 0.03}{1.697 \times 10^{-4}} = 9.79 \times 10^4$$

$$\Rightarrow C_n = 0.9975 - \frac{6.53 \beta^{0.5}}{Re^{0.5}} \Rightarrow 0.9975 - \frac{6.53 (0.5)^{0.5}}{9.79 \times 10^4} = 0.98 = C_n$$