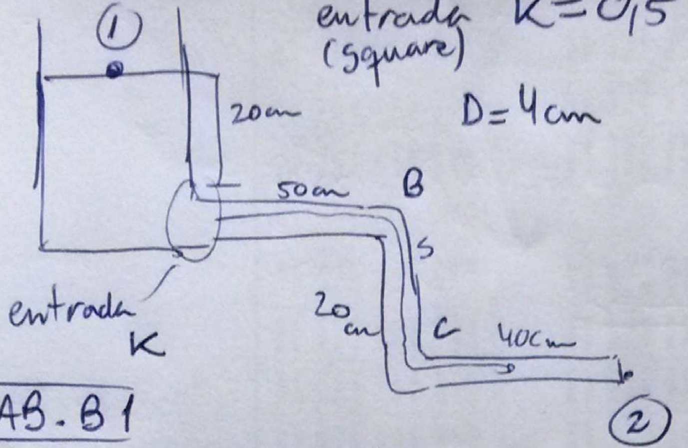
7.122

cotovelo standard elbow 2,5cm

K sing ver TAB 7.2 ~ $K \cong 1,5$

entrada (square) $K = 0,5$

$D = 4cm$



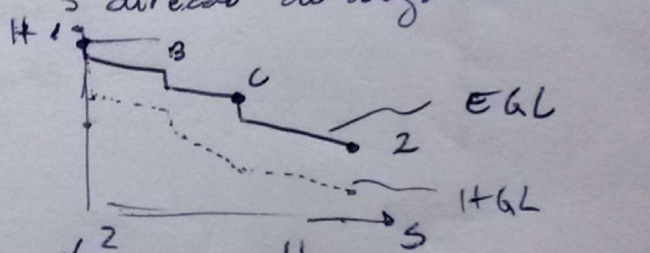
Hipóteses: - reg. perm.
- incompressível
- perdas modelo Darcy
- veloc. média seção
- Reserv. Grande

TAB. B1

Água 20°C $\rho = 998,2 \, kg/m^3$

$\mu = 1,005 \times 10^{-3} \, N.s/m^2$

s direção ao longo do tubo



Bern. modificado 1 → 2

$$\cancel{\frac{p_1}{\rho g}} + z_1 + \cancel{\frac{V_1^2}{2g}} = \cancel{\frac{p_2}{\rho g}} + z_2 + \frac{V_2^2}{2g} + H_{PERDAS}$$

$p_1 = p_2$ ~0 Reserv. Grande $p_1 = p_2$

$$z_1 - z_2 = \frac{V_2^2}{2g} + \left(f\frac{L}{D} + \sum K\right)\frac{V_2^2}{2g}$$

$$0,40 = \frac{V_2^2}{2 \cdot 9,81}\left(1 + f\frac{(0,5+0,2+0,4)}{0,04} + (0,5+1,5+1,5)\right) \quad \text{I}$$

$f(Re, e/D)$ ~ MOODY $e = 0,046mm$ wrought iron → $e/D = 0,00115$

chute $f = 0,02$ → $V_2 = 1,25 m/s$ → $Re = \frac{\rho V D}{\mu} = 4886$ ↲

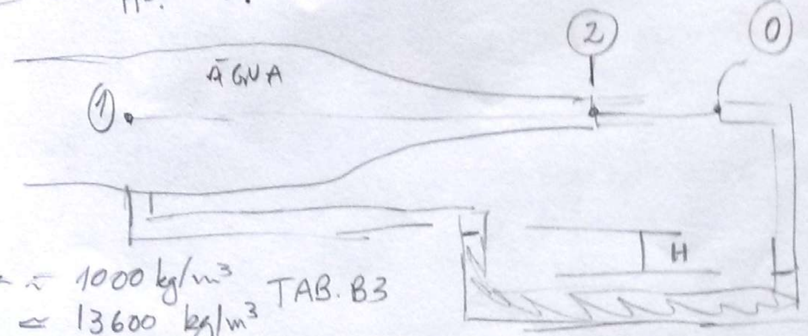
MOODY(Re, e/D) ou eq. Haaland

$f = 0,039$ → $V_2 = 1,19 \, m/s$ → $Re = 4651$ ↲

$f = 0,040$ → $V_2 = 1,18 m/s$ → OK $Q = \int v dA = 0,0014 m^3/s$

3.68

$P_1 = ?$ $V_1 = ?$ $V_2 = 20 m/s$



HIP.: → REG. PERM.
– INCOMPR.
– INVÍSCIDO
– linha de corrente na figura
↳ HORIZONTAL!!

$g = 9{,}81 \frac{m}{s^2}$

$\rho_{água} \approx 1000 kg/m^3$ TAB. B3
$\rho_{Hg} \approx 13600 kg/m^3$

MANÔMETRO: → ESTÁTICO → INCOMPRESSÍVEL

$$P_0 + \rho_{H_2O}\, g H = P_1 + \rho_{Hg}\, g H \Rightarrow \boxed{P_0 - P_1 = (\rho_{Hg} - \rho_{H_2O})\, g H} \quad \text{(I)}$$

BERNOULLI (1) → (0)

0 ESTAGNAÇÃO

$$P_1 + \frac{\rho V_1^2}{2} + \cancel{\rho g z_1} = P_0 + \cancel{\frac{\rho V_0^2}{2}} + \cancel{\rho g z_0}$$

HORIZ. HORIZ.

ENTÃO

$$\boxed{V_1 = \sqrt{2\frac{(P_0 - P_1)}{\rho}} \underset{\text{USANDO EQ (I)}}{=} \sqrt{\frac{2(\rho_{Hg} - \rho_{água})\, g H}{\rho_{água}}}} \quad \text{(II)}$$

BERNOULLI (1) → (2)

$P_2 = P_{ATM} = 100 kPa$

$$P_1 + \frac{\rho V_1^2}{2} + \cancel{\rho g z_1} = P_2 + \frac{\rho V_2^2}{2} + \cancel{\rho g z_2}$$

HORIZ. HORIZ.

ENTÃO

$$\boxed{\underset{\text{ABSOLUTA}}{P_1} = P_{ATM} + \frac{\rho}{2}\left(\underset{\text{DADO}}{V_2^2} - \underset{\text{USAR EQ. II}}{V_1^2}\right)} \quad \text{Eq. (III)}$$

EXEMPLO

(b) $H = 5 cm$ → USANDO EQ. II ⇒ $V_2 = 3{,}516 m/s$

e usando EQ. III ⇒ $P_1 = 293{,}8 kPa$ (ABSOLUTA)

$P_{1_{REL}} = P_1 - P_{ATM} = 193{,}8 kPa$ Relativa

3.60 → Reg. Perm. → INCOMPR. → INVÍSCIDO

→ desprezar a parcela gravidade (variação de cota)

BERNOULLI

AO LONGE → ALGUM PONTO QUALQUER

$$\boxed{P_\infty + \frac{\rho U_\infty^2}{2} = P(x) + \frac{\rho\, u(x)^2}{2}} \Rightarrow P(x) = P_\infty + \frac{\rho}{2}\left[U_\infty^2 - \left(U_\infty + \frac{q}{2\pi x}\right)^2\right]$$

(a) eixo x neg. $U_\infty = 10\ m/s$ e $q = 20\pi\ m^2/s$ $u(x) = 10 + \frac{10}{x}$

$$P(x) = P_\infty + \frac{\rho}{2}\left[100 - \left(100 + \frac{200}{x} + \frac{100}{x^2}\right)\right] = P_\infty + \frac{\rho}{2}\left[\frac{200}{x} + \frac{100}{x^2}\right]$$

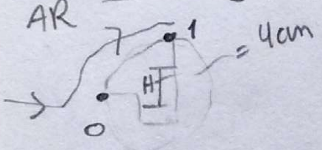
$$\boxed{P(x) - P_\infty = 50\rho\left[\frac{2}{x} + \frac{1}{x^2}\right]}$$

ok

3.66 HIPÓTESES: MESMAS DE 3.60 → VELOCIDADES DO 3.58

AR $\rho \approx 1{,}2\ kg/m^3$ TAB B3

$$v_r = U_\infty\left(1 - \frac{r_c^2}{r^2}\right)\cos\theta \quad , \quad v_\theta = U_\infty\left(1 + \frac{r_c^2}{r^2}\right)\operatorname{sen}\theta$$



ρ água = 1000 kg/m³ $g = 9{,}81\ m/s^2$

MANÔMETRO
(– ESTÁTICO
– INCOMPRESSÍVEL

$$\boxed{P_0 = P_1 + \rho_{ag}\, g H \Rightarrow P_0 = P_1 + 392{,}4} \quad \text{(I)}$$

BERNOULLI DE (0) → (1) (OBS: aí $r = r_c$!! então $v_r = 0$)

desprezado

$$P_0 + \frac{\rho V_0^2}{2} + \cancel{\rho g z} = P_1 + \frac{\rho V_1^2}{2} + \cancel{\rho g z}$$

0 desprezado

$V_0 = v_\theta(r = r_c, \theta = 0°) = 0\ m/s$, $V_1 = v_\theta(r = r_c, \theta = 90°) = 2U_\infty$

então

$$P_0 + 0 = P_1 + \frac{\rho(2U_\infty)^2}{2}$$, usando (I)

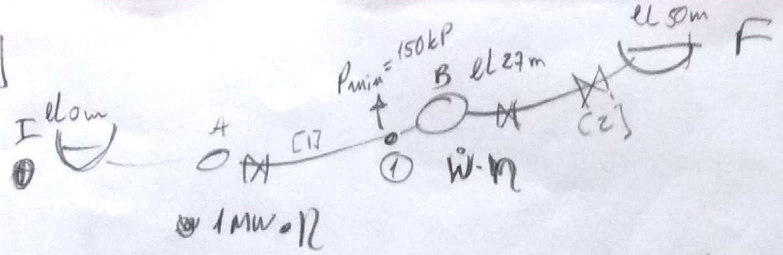
e $\rho_{AR} = 1{,}2\ kg/m^3$

$$392{,}4 = \frac{1{,}2 \cdot 4U_\infty^2}{2} \Rightarrow \boxed{U_\infty = 12{,}78\ m/s}$$

↳ pouco diferente do LIVRO

PROVAVELMENTE ρ aproximado

11.20



$\eta = 0{,}76$

Bombas

$\eta \dot{W} = \gamma Q H$

$P_{ATM} = 100\,kPa$

$\frac{\rho}{\rho_{H_2O}} = \frac{\gamma}{\gamma_{H_2O}} = 0{,}81$

$\gamma = 0{,}81 \cdot 9{,}81 \cdot 1000 = 7{,}9461 \times 10^3\ N/m^3$

ASSUMINDO → Reg. Perm. → Incompr. → Perdas Darcy → Vel. média secção
→ Reserv. GRANDE

!!

TOMAR CONDIÇÃO QUE P = 150 kPa ~~ABSOLUTA~~ RELATIVA na sucção de B. (pos. 1)

Bern. I → 1 $\quad H = \left(\frac{P}{\gamma} + z\right)$

$K_{eq\,I} = \frac{8fL}{\pi^2 g D^5} + \frac{\Sigma K \cdot 8}{\pi^2 g D^4} = 40{,}56$ [S.I.]

$K_{eq\,II} = \ldots = 62{,}674$ [S.I.]

$$H_I + H_{P_A} = H_1 + \overset{\text{cinética}}{\frac{V_1^2}{2g}} + K_{eq\,I}\, Q_1^2$$

$$\left(\frac{100\times10^3}{7{,}946\times10^3} + 0\right) + \frac{1\times10^6 \cdot 0{,}76}{7{,}946\times10^3\, Q} = \left(\frac{150\times10^3}{7{,}946\times10^3} + 27\right) + \frac{Q^2}{2\cdot 9{,}81 \cdot \frac{\pi^2 (0{,}75)^4}{16}} + 40{,}56 \cdot Q^2$$

!! elevação B

MUITO PEQUENO ~ 0

OK desprezar EN. CINÉTICA

OBS:
- P = 150 kPa Relativa
- elevação B é 27m

$$\frac{95{,}65}{Q} = 45{,}88 + 40{,}82\, Q^2$$

$$\to \boxed{Q = 1{,}05\ m^3/s}$$

$$H_{PA} = \frac{\eta \dot{W}_A}{\gamma Q} = \frac{0{,}76 \cdot 1\times10^6}{7{,}946\times10^3 \cdot 1{,}05} = \boxed{91{,}09\ m}$$

Bern. 1 → F

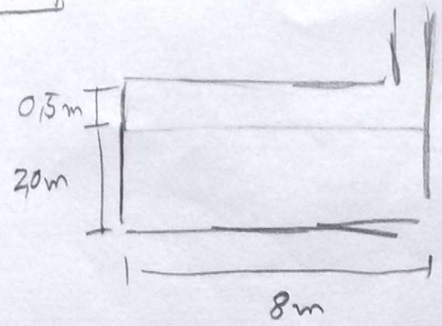
$$H_1 + H_{P_B} + \overset{\text{CIN.}}{\frac{Q^2}{2gA^2}} = H_F + R_{II}\, Q^2$$

$$\left(\frac{(150+100)\times10^3}{7{,}946\times10^3} + 27\right) + H_{P_B} + \frac{(1{,}05)^2}{2\cdot 9{,}81 \left(\frac{\pi^2\, 0{,}75^4}{16}\right)} = \left(\frac{100\times10^3}{7{,}946\times10^3} + 50\right) + 62{,}674 (1{,}05)^2$$

$$\boxed{H_{P_B} = 72{,}93\ m}$$

$$\eta \dot{W}_B = \gamma Q H_B \Rightarrow \boxed{\dot{W}_B = 800{,}6\ kW}$$

2.98



- ESTÁTICO - $a_y = 0$, aceler. cte
- INCOMPRESSÍVEL

$$\nabla p = -\rho(\vec{a} + g\hat{k})$$

$$\Downarrow$$

$$dp = \left(-a_x dx - (a_z + g)dz\right) \cdot \rho$$

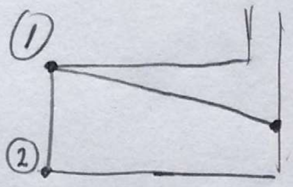
$\rho = 1000\, kg/m^3$

integrando entre 2 pontos

$$\boxed{(p_2 - p_1) = -\rho a_x (x_2 - x_1) - \rho(a_z + g)(z_2 - z_1)} \quad \text{EQ.}$$

Testar caso Limitante

② ⇒ B e ① marcado ⇒ $\Delta x = 0$

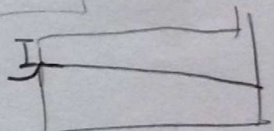


B $P_B = 60\,kPa$

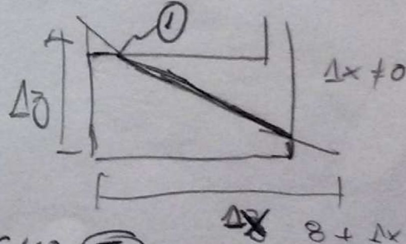
então $(P_B - P_1) = -\rho(a_z + g)(0 - 2{,}5)$

$60 = 2{,}5(a_z + g)$ teste

Ⓘ se $2{,}5(a_z + g) > 60 \Rightarrow$ ①

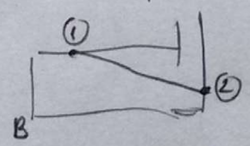


Ⓘ Ⓘ se $2{,}5(a_z + g) < 60 \Rightarrow$

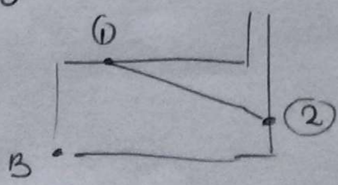


(a) $a_z = 0 \xrightarrow{\text{TESTE}} 2{,}5(0 + 9{,}81) = 24{,}525 < 60 \Rightarrow$ CASO Ⓘ Ⓘ

usar EQ. para ① → Ⓑ + ② até Ⓑ + VOLUME CONSERVADO



(b) $a_z = 10\,m/s^2 \xrightarrow{\text{TESTE}} 2{,}5(10 + 9{,}81) = 49{,}525 < 60$ (idem acima)



(c) mesma situação