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1) B) $NPSH_A = \frac{(176-2.5)\times 10^3}{10^3 \times 7.5} - 4 - \frac{2\times 0.009 \times 134.4}{7.5 \times 0.5}(0.01^2) - \frac{1}{2}(0.01)^2$

$= 19.13\,m$

as $NPSH_A > NPSH_R$, there is no risk of cavitation

c) Greater pressure difference between tank at atmosphere →

↑ in mechanical energy through pressure head supplied by pump

Greater gravitational force to pump against.

D) There has to be a resistive force to flow.

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2) A. $\Delta P = 1000 \times 8.2 (0.3 \times 1 - 0.15 \times 0.8 + 0.15 \times 13.6 - 0.1 \times 1)$

$= 17384 \text{ Pa}$

$P_2 = (17384 + 101300) \text{ Pa}$

$= 118.684 \text{ kPa}$.

B. $P_2 = 101300 + \frac{9.8}{8.2} \times 17384$

$= 122.076 \text{ kPa}$.

C decreased atmospheric pressure = less pressure in the tank

as

$P_2 - P_1 = \underbrace{\Sigma \rho g h}_{\uparrow \text{ constant}}$

so if $P_1 \downarrow$, then $P_2 \downarrow$.

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3) A assuming highturbulence zone

$$\frac{e}{D} = 0.02$$

$$f_F = 0.012$$

$$\frac{(1.3\times10^{-14}\times10^3)^2 - (101300)^2}{\dfrac{2\times 8.314\times 296}{28.9\times10^{-3}}} + \left(\frac{G}{A}\right)^2\left[\ln\left(\frac{101300}{1.3\times10^{-11}}\right) + \frac{2\times200\times0.012}{0.05}\right] = 0$$

$$\left(\frac{G}{A}\right)^2 = 7.496$$

$$\frac{G}{A} = 2.74$$

$$G = 0.00538 \text{ kg/s.}$$

$$\rho_e = \frac{P_e}{RT/M} = \frac{1.3\times10^{-11}}{\dfrac{8.314\times296}{28.9\times10^{-3}}} = 1.53\times10^{-16} \text{ kg/m}^3$$

$$V_e = \frac{G}{A\rho_e} = 1.79\times10^{16} \text{ m/s.}$$

checking choked flow

$$L_{min} = \frac{0.05}{4\times0.012}\left[\left(\frac{P_1}{P_2}\right)^2 - \ln\left(\frac{P_1}{P_2}\right)^2 - 1\right]$$

$$= 6.33\times10^{31} \text{ m}$$

$L_{pipe} < L_{min} \rightarrow$ choked

$$V = \sqrt{\frac{RT}{M}} = 291.8 \text{ m/s.}$$

B) repeat but with $P_1 = 0.57\times101300 = 57741$

$$\left(\frac{G}{A}\right)^2 = 148$$

$$\frac{G}{A} = 12.177$$

$$\frac{G}{A\rho_e} = 7.96\times10^{16} \text{ m/s.}$$

choked? = 2.05×10^{31} m Lmin

L ✓

$$V = \sqrt{\frac{RT}{M}} = 291.8 \text{ m/s}$$

C) ignore ln term ?

$$\frac{4\times200\times0.012}{0.05} = \left(\frac{101300}{P_w}\right)^2 - 1$$

$$P_w = 7292 \text{ Pa}$$

$$G_{max} = A\times\frac{P_w}{\sqrt{RT/M}}$$

$$= \frac{\pi\times0.05^2}{4}\times\frac{7292}{\sqrt{\dfrac{8.314\times296}{28\times10^{-3}}}} = 0.048$$

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3) D. $V = 50 L$

$PV = nRT$

$101300 \times 50 \times 10^{-3} = \frac{m}{28.9 \times 10^{-3}} RT$ P=

$m_1 = 0.05948 \ kg$

$0.57 \times 101300 \times 50 \times 10^{-3} = \frac{m}{28.9 \times 10^{-3}} RT$

$m_2 = 0.0339 \ kg$

$\frac{m_1 - m_2}{G} = \frac{0.05948 - 0.0339}{0.048} = 0.53 s$ //

E) Less time? volume will not be fixed, as P ↓ then ↑V and thus m_2 ↑ = smaller diff = less time.

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1) A.

$\swarrow$ elbow

totallength = $2+1.5+4+5+2+1 + 4 \times 60 \times 0.5$

$= 135.5$

$V = \frac{Q}{A}$

$= \frac{2 \times 10^{-3} \, m^3/s}{\frac{\pi \times 0.5^2}{4} \, m^2} = 0.01 \, m/s$

$Re = \frac{1000 \times 0.01 \times 0.5}{0.89 \times 10^{-3}} = 5618$

$f_F = 0.009$ // MEB between free surface of tank + lake

$\frac{\Delta P}{\rho} + g\Delta z + \frac{L\Delta v^2}{2} + W_s + F = 0$

$\frac{(200 - P_{atm}) \times 10^3}{1000} + g \times 9m + 0 - 92 + \frac{2 \times 0.009 \times 135.5 \times 0.01^2}{0.5} + \frac{1}{2} \times 2 \times 0.01^2 = 0$

$(200 - P_{atm}) + 9g = 92.$

trial and error

planet A

$200 - 70.5 + 9 \times 12.2 = 239.3.$ X

planet B

$200 - 101.3 + 9.8 \times 9 = 186.9$ X

planet C

$200 - 176 + 7.5 \times 9 = 91.5$ ✓✓

∴ planet C.

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6) $E_1 = E_2$. (frictionless means no decrease in energy)

$$\frac{Q^2}{2\times9.8\times12^2\times1^2}+1=\frac{Q^2}{2\times9.8\times5^2\times0.8^2}+0.8$$

$$0.00283\,Q^2 = 0.2$$

$$Q=\sqrt{\frac{0.2}{0.00283}}$$

$$= 8.4\ m^3/s$$

7)

$$Q=\bar{V}A$$

$$=\frac{1}{n}Rh^{2/3}S^{1/2}\times b\times h$$

$Rh = \frac{h\times b}{b+2h}$ where $h=b$

$$=\frac{h^2}{3h}=\frac{1}{3}h$$

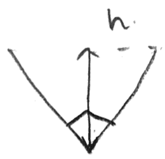
$$2=\frac{1}{0.012}\left(\frac{1}{3}\right)^{2/3}h^{8/3}\left(\frac{1}{1000}\right)^{1/2}$$

$h = 1.19\ m$

wood required

$3h\times L\times$ thickness

3×1.19



$$Q=\bar{V}A$$

$$=\frac{1}{n}Rh^{2/3}S^{1/2}\times\frac{1}{2}(h)(2h)$$

$$Rh=\frac{\frac{1}{2}\times h\times2h}{2\times\frac{h}{\cos45}}=\frac{h^2}{2\sqrt{2}h}=\frac{1}{2\sqrt{2}}h$$

$$2=\frac{1}{0.012}\times\left(\frac{1}{2\sqrt{2}}\right)h^{2/3}S^{1/2}\times h^2$$

$h = 1.169\ m$

wood required

$2\sqrt{2}\times1.169\times L\times$ thickness.

↑ triangle W

$$\frac{3\times1.19-2\sqrt{2}\times1.169}{3\times1.19}\times100\%$$

$= 7.13\%$ less