2 Free Jet

Water flows steadily from a large tank and exits through a constant diameter pipe as shown in Figure 2. The air in the tank is pressurized to $50kPa$. Assuming inviscid flow and gravitational acceleration $g = 10\,m/s^2$, determine

(a) the maximum possible height of water in the system, h.
(b) the water velocity in the pipe.
(c) the maximum pressure of water in the system and where it happens.

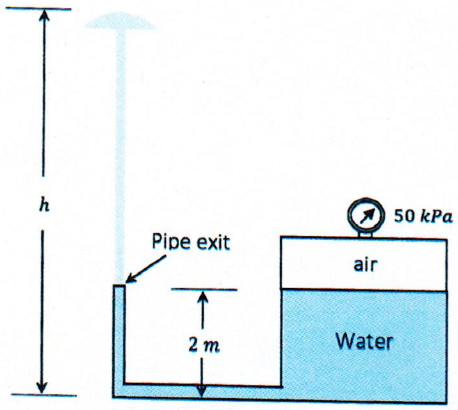

Figure 2: Problem 2

a) I can use the Bernoulli equation in this system: £ ①

? ②

$$\frac{1}{2}\cancel{\rho v_1^2} + p_1 + \rho g z_1 = \frac{1}{2}\cancel{\rho v_2^2} + \cancel{p_2} + \rho g z_2$$

Inserting the numbers in SI-units £③

$$50\cdot 10^3 + 10^3 \cdot 10 \cdot 2 = 10^3 \cdot 10 \cdot z_2$$

$$50 + 20 = 10 \cdot z_2$$

$$\underline{z_2 = 7\,m}$$

The height is 7m.

(✓) ④

Comments:

① Missing:
- State all assumptions required to apply the Bernoulli equation
- Define your stream line

② State why terms cancel, e.g. by "$p_2 = 0$"

③ Wrong "="-signs because physical quantities have units which must appear in all equations.
Defining everything "SI" does not make the equations below correct.

④ It is good practise to use a final sentence but be precise:
"The max. possible height of the jet is 7m."

b) The Bernoulli equation applies (for the same reasoning as in a). Selecting a streamline between ✓⑤ top of the jet and exit of the pipe OK ⑥

$$\frac{1}{2}\rho v_e^2 + p_e + \rho g z_e = 7[m]\rho g \quad (v) ⑦$$

?⑧

$$\frac{v_e}{2g} + \frac{p_e}{\gamma} + z_e = 7[m] \quad ?⑨$$

with gauge pressure very good!

$p_e = 0[Pa]$, $z_e = 2[m]$, $g = 10[\frac{m}{s^2}]$, $\rho = 10^3[\frac{kg}{m^3}]$

$$\Rightarrow \frac{v_e^2}{2g} = 7[m] - 2[m]$$

$$\Rightarrow \underline{\underline{v_e = 10[\frac{m}{s}]}}$$

c) It is obvious that the maximum of the pressure must be at the bottom of the tank:

p_B @ $z_B = 0$ f ⑩

Comparing with top of the jet

$$\underbrace{\cancel{\frac{v_B}{2g}}}_{v_B=0} + \frac{p_B}{\gamma} + \underbrace{\cancel{z_B}}_{z_B=0} = 7m$$

very good

$$\Rightarrow p_B = 10^3\frac{kg}{m^3} \cdot 10\frac{m}{s^2} \cdot 7m = 70kPa$$

The pressure is $\underline{70\,kPa}$.

→ ④

⑤ It is correct to do this, if assumptions are written in a)

⑥ Better indicate points in the figure of the problem.

⑦ Better start with the most general equation and remove terms based on justifications. Here, it is OK because you follow results from a)

⑧ Allow the reader to understand your calculations and note down the operations, e.g. by ($: \rho g = \gamma$

⑨ The brackets are not necessary here!

⑩ We expect you to derive results "step-by-step", even if they seem trivial to you!