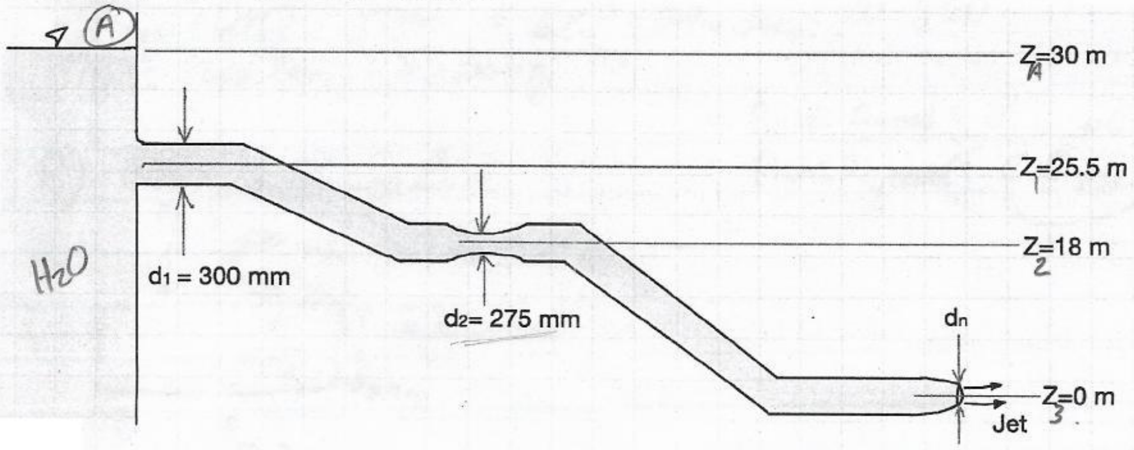
Quiz 2 – September 28, 2022

Please label units in all calculations and write all relevant equations explicitly. Make sure the unit: make sense!!

1. To accommodate the rising population of sea lions in Pier 39, a rectangular float was constructe that has the dimensions of 6 m wide, 7 m long, and 0.4 m deep, weighing 2 kN. The specific gravity of seawater is 1.027.
   a. The float needs at least 10 cm freeboard (depth above water). What is the buoyant force of the float given this arrangement? If how many large male sea lions (mass = 2200 kg), the predominant demographics at the Pier, can the float carry?
   b. Given this number of sea lions, what will the actual freeboard be?

2. If cavitation anywhere in this pipe system is to be avoided,
   a. Where does cavitation first occur? Justify your answer with numbers!
   b. What is the diameter of the largest nozzle that may be used? Assume atmospheric pressure = 100 kPa and vapour pressure = 10.3 kPa.



CE100 Quiz 2

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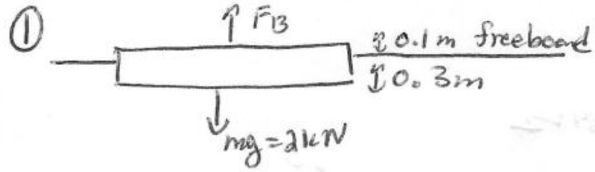


$\forall_{sub} = 6m \times 7m \times 0.3m = 12.6m^3$

$F_B = \gamma \forall$

$= SG_{salt} \gamma_{H_2O} \forall$

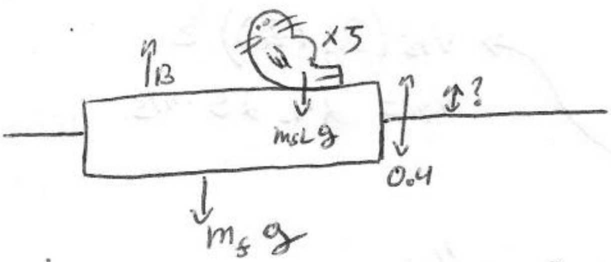
$F_B = 126.9kN$

$\Sigma F = 0 = F_B - m_o g - m_{SL} g$

$m_{tot_{SL}} = \frac{F_B - m_o g}{g} = \frac{126.9 \times 10^3 N - 2 \times 10^3 N}{9.8\ m/s^2}$

$= \frac{12749.3\ kg}{2200\ kg/sea\ lion} = 5.795$ sealions

a) Float can carry 5 sealions



$\Sigma F = 0 = F_B - m_f g - 5(m_{SL} g)$

$SG \gamma \forall = m_f g - 5(m_{SL} g)$

$\forall = \frac{m_f g - 5(m_{SL} g)}{SG \gamma} = 10.90m^3$

$\text{Submerged} = \frac{\forall}{wL} = \frac{10.90m^3}{(6m)(7m)} = 0.259m.$

Freeboard $= 0.4m - 0.259m$

b) Freeboard = 0.14m = 14cm

2) a) $\frac{V_1^2}{2g} + \frac{P_1}{\gamma} + z_1 = \frac{V_2^2}{2g} + \frac{P_2}{\gamma} + z_2$

$Q_1 = Q_2$

$A_1 V_1 = A_2 V_2$

$V_1 = \frac{A_2 V_2}{A_1} = 0.84 V_2$

$\frac{(0.84 V_2)^2}{2g} + \frac{P_1}{\gamma} + z_1 = \frac{V_2^2}{2g} + \frac{P_2}{\gamma} + z_2$

$(P_1 - P_2) = \gamma\left(\frac{V_2^2(1-0.84^2)}{2g} + z_2 - z_1\right)$

$P_1 - P_2 = \gamma\left(\frac{0.294 V_2^2}{2g} - 7.5m\right)$

$\frac{V_0^2}{2g} + \frac{P_0}{\gamma} + z_0 = \frac{V_2^2}{2g} + \frac{P_2}{\gamma} + z_2$ (with $V_0 \to 0$, $P_0 \to 0$, $P_2 \to 0$)

$V_2 = (2g(z_0 - z_2))^{1/2}$

$V_2 = 15.34 m/s.$

if $V_2 = 0$ — if $V_2 = 15.34 m/s$

$P_1 - P_2 = \gamma(-7.5m)$ — $P_1 - P_2 = \gamma(-3.972m)$

b/c $P_1 - P_2$ is negative, $P_2 > P_1$
thus cavitation occurs at $d_1 = 300mm$

b) $\frac{V_1^2}{2g} + \frac{P_1}{\gamma} + z_1 = \frac{V_n^2}{2g} + \frac{P_n}{\gamma} + z_n$ ($P_1 \to$ Vapor pressure, $P_n \to$ atm, $z_n \to 0$)

$V_n = (2g(z_0))^{1/2}$

$V_n = 24.25 m/s.$

$V_1 = \left(\left(\frac{V_n^2}{2g} + \frac{100\times10^3 Pa}{\gamma} - \frac{10.3\times10^3 Pa}{\gamma} - 25.5\right)2g\right)^{1/2}$

$V_1 = 13.39 m/s.$

$Q_1 = Q_n$

$V_1 A_1 = V_n A_n$

$A_n = \frac{V_1 A_1}{V_n} = 0.039 m^2$

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$d_n = \left(\frac{A_n}{\pi}\right)^{1/2} \cdot 2$

$d_n = 223 mm$