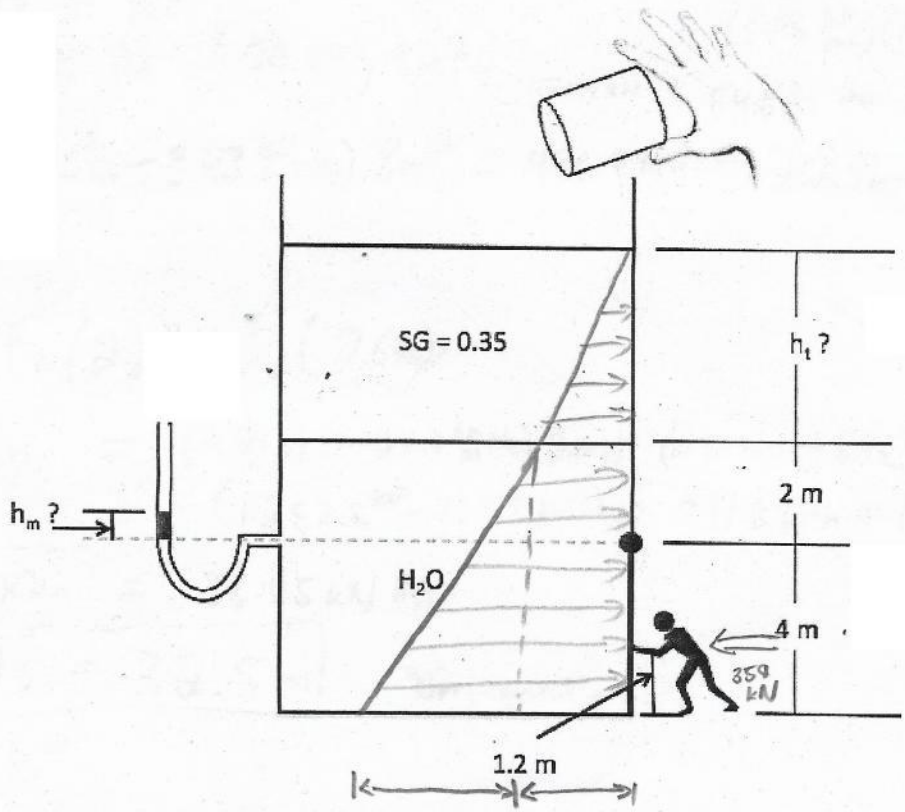
Quiz 1 – September 14, 2022

Please label units in all calculations and write all relevant equations explicitly. Make sure the units make sense!! Read the question carefully so you don't do more work then you have to!

1. An evil giant is dumping a toxic liquid (specific gravity = 0.35) into a tank of water that is filled to 6m. At the bottom of the tank is a door 4m tall and 2m wide (into the page), hinged at the top (see picture). It is held shut by Bionic Woman, who has the ability to push 359 kN before her arms give out. She pushes at a height of 1.2m from the ground.
   a. How high (h_t) can the toxic liquid be just before Bionic Woman gives out? Draw the pressure prism will help!
   b. Bionic woman has X-ray vision, and sees a manometer that is open to the atmosphere on the other side of the tank. It is at the same height as the hinge and contains mercury (specific gravity = 13.6). How high (h_m) will the manometer go before she has to call for help?

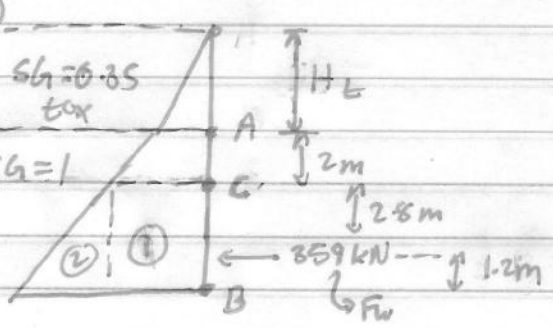


2. At Aquarium of the Bay, one of the exhibits is a viewing window into the Bay, which is round with diameter of 2 m. The top of the window is 3 m vertically from the waters surface, and the window is angled at 60 degrees with respect to the water surface. Given the specific gravity of seawater is 1.027, what is the hydrostatic force acting on the window and where is it applied (relative to the surface of the water along the slope of the window)? The moment of inertia for a circle is $\frac{\pi r^4}{4}$.

   HINT: DRAW a picture of the set up labeling all the distances!!

Quiz 1 CE100

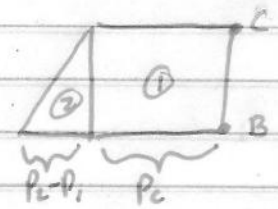
1)



$A_{door} = 2 \times 4 = 8\ m^2$

$h_B = 6m$. $\gamma = 9.81\ \frac{kN}{m^3}$

$h_{door} = 4m$



$\rightarrow 2m$

$P_C = \gamma_{H2O} h_2 + SG_{tox} \gamma_{H2O} H_t$

$\rightarrow 6m$

$P_B = \gamma_{H2O} h_6 + SG_{tox} \gamma_{H2O} H_t$

$F_1 = P_C A = (h_2 + SG_t H_t)\gamma_{H2O} A = 156.96kN + 27.74 H_t\ \frac{kN}{m}$

$F_2 = \frac{1}{2}(P_B - P_C)A = \frac{1}{2}(\gamma h_6 SG\gamma H_t - SG\gamma H_t - \gamma h_2)A = 156.96kN$

$\Sigma M_C = 0 = F_1(\frac{1}{2} h_{door}) + F_2(\frac{2}{3} h_{door}) - F_w(h_w)$

$F_w h_w = F_1(\frac{1}{2} h_{door}) + F_2(\frac{2}{3} h_{door})$

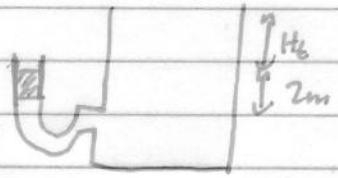
$(359\ kN)(2.8m) = (156.96kN + 27.47 H_t \frac{kN}{m})(2m) + (156.96kN)(\frac{5}{3}m)$

$272.7kNm = 54.94 H_t\ kN$

a) $H_t = 4.96\ m$

b) $P_c = \gamma_{H2O} h_2 + SG_{tox} \gamma_{H2O} h_t$

$= 36.7\ kPa$



$P_{mercury} = P_C$

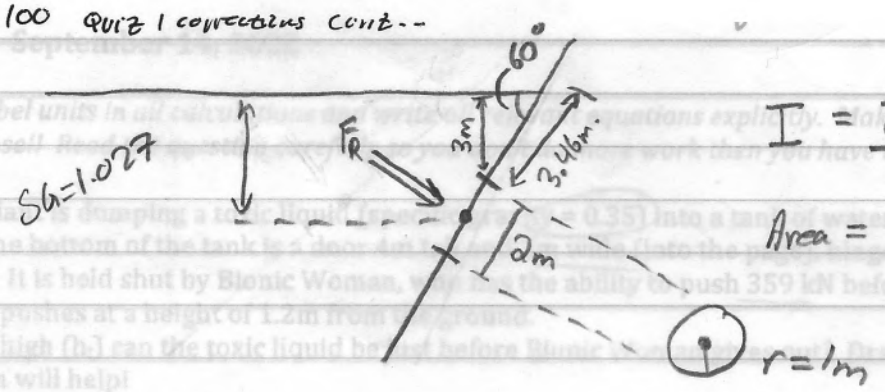
$SG_m \gamma_{H2O} h_m = P_C$

$h_m = \frac{P_C}{SG_m(\gamma_{H2O})} = \frac{36.7\ kPa}{(13.6)(9.8\ \frac{kN}{m})}$

b) $h_m = 0.275m$

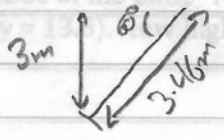
CE 100 QUIZ 1 corrections cont--

②



$$I = \frac{\pi r^4}{4}$$

$$Area = \pi r^2 = \pi m^2$$



SOH

$$\sin\theta = \frac{opp}{hyp} \rightarrow h = \frac{3m}{\sin 60}$$

$$h = 3.46m.$$

$$y_c = 1m. + 3.46m = 4.46m.$$

$$F_R = SG_{sea}\,\gamma_{H_2O}\,y_c \sin\theta\, A$$
$$= (1.027)(9810\ N/m^3)(4.46m)(\sin 60)(\pi m^2)$$
$$= 122251.7\ N$$

$$\boxed{F_R = 122.3\ kN}$$

$$y_R = \frac{I_x}{y_c A} + y_c \qquad y_c = 4.46m.$$

$$= \frac{(\frac{\pi}{4}(1m)^4)}{(4.46m)(\pi m^2)} + 4.46m.$$

$$\boxed{y_R = 4.51\ m}$$

+0.1