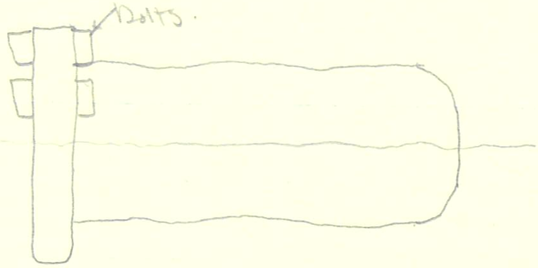
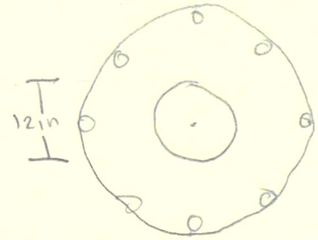
Ch4: 2, 10, 17, 26, 42, 54
MS: 8, 24, 41, 61

Chapter 4

problem 2

The flat left tank end shown below is secured with a bolted flange. If the inside diameter of the tank is 30 inches and the internal pressure is +14.4 psig, calculate the total force that must be resisted by the bolts in the flange.





8 bolts.

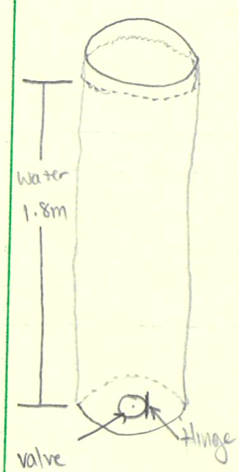
$$A = \frac{\pi \cdot D^2}{4} = \frac{\pi \cdot (30\,in)^2}{4} = 706.858\,in^2$$

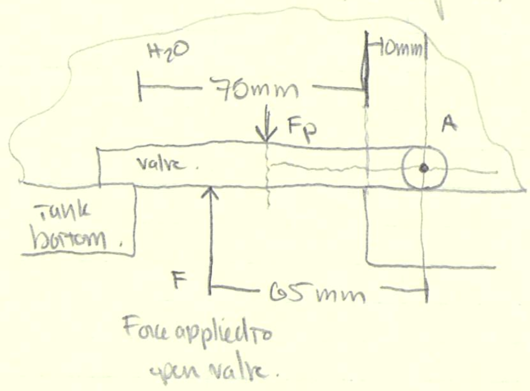
$$F = p \cdot A = 14.4\,\frac{lb}{in^2} \times 706.858\,in^2 = 10178.76\,lb.$$

across 8 bolts = $1272.345\,\frac{lb}{bolt}$

problem 10

A simple shower for remote locations is designed with a cylindrical tank 500mm in diameter and 1.8m high as shown below. The water flows through a flapper valve in the bottom through a 75mm-diameter opening. The flapper must be pushed upward to open the valve. How much force is required to open the valve?





+ M

$$F_p = p \cdot A = 0.078\,kN = 78N$$

$$P_{bottom} = \gamma_{H_2O} \times 1.8m = 9.81\,\frac{kN}{m^3} \times 1.8m = 17.658\,\frac{kN}{m^2} = 17.658\,kPa.$$

$$A = \frac{\pi D^2}{4} = \frac{\pi \cdot (0.075m)^2}{4} = 4.418 \times 10^{-3}\,m^2$$

$$\Sigma M = \emptyset$$

$$\Sigma M_A = \emptyset = -F \times 0.065m + F_p \times 0.045m$$

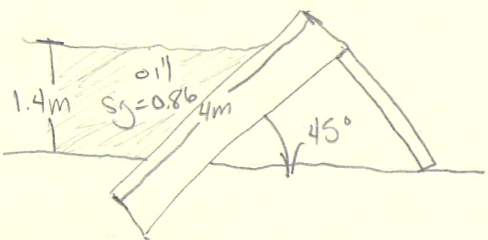
=>

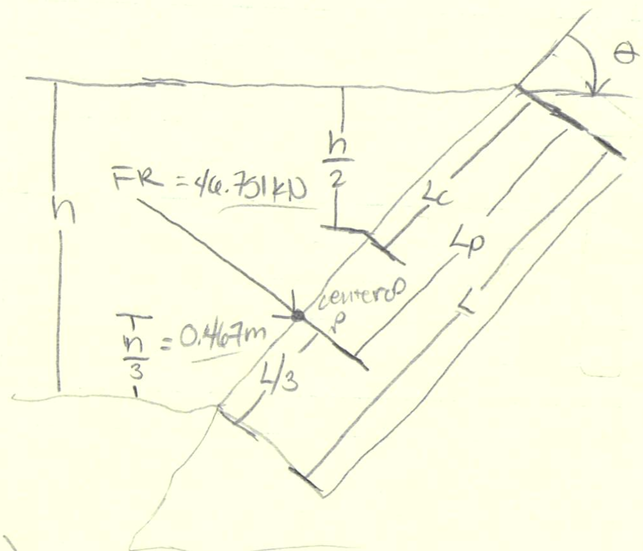
$$F = \frac{F_p \times 0.045m}{0.065m} = \frac{780N \times 0.045m}{0.065m} = 540N$$

F must be 540N +

problem 17

If the wall below is 4m long, calculate the total force on the wall due to the oil pressure. Also determine the location of the center of pressure and show the resultant force on the wall.





$F_R = \gamma_{oil} \times \frac{h}{2} \cdot A$

$\gamma_{oil} = 0.86 \times 9.81 \frac{kN}{m^3} = 8.437 \frac{kN}{m^3}$

$h = 1.4m$ (given)

so, L of wall given as 4m but this is not L? I think? ;·

on 4m into page?

$L = \frac{h}{\sin\theta} = \frac{1.4m}{\sin 45°} = 1.979m.$

A = Length of face × length into page
= 1.979m × 4m
$A_{dam} = 7.916m^2$

$F_R = \gamma_{oil} \times \frac{h}{2} \cdot A = 8.437 \frac{kN}{m^3} \times \frac{1.4m}{2} \times 7.916m^2 = 46.751kN$ resultant force

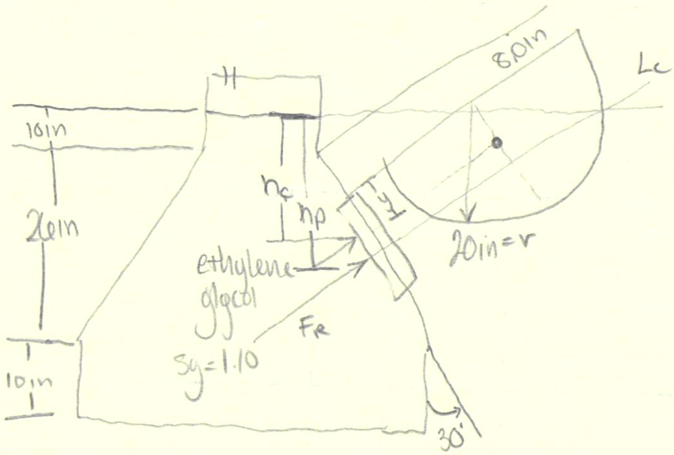
center of pressure located at

$\frac{h}{3} = \frac{1.4m}{3} = 0.467m$ from bottom of dam.

$\frac{L}{3} = \frac{1.979m}{3} = 0.66m$ from bottom along the face of the dam.

problem 28 "forces on submerged plane areas"

For the case shown below, compute the magnitude of the resultant force on the indicated area & the location of the pressure. Show the resultant force on the area & clearly dimension its location.



$\gamma_{eg} = sg \times \gamma_{water}$

$= 1.10 \times 62.4 \frac{lb}{ft^3} = 68.64 \frac{lb}{ft^3}$

$F_R = \gamma_{eg} \times h_c \times A$

$L_p = L_c + \frac{I_c}{L_c \cdot A}$

$h_c = L_c \cdot \sin\theta$

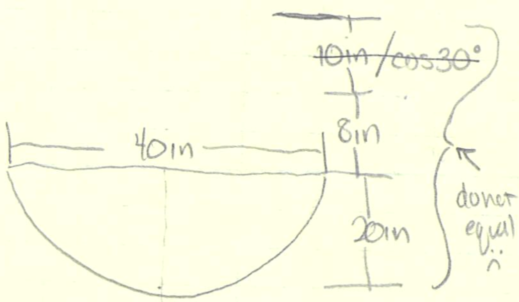
$h_p = L_p \cdot \sin\theta$

in semicircle, distance to centroid is

$y = 0.212 \times D = 0.212 \times 2 \times 20in = 8.48in$

$I_c = (6.86 \times 10^{-3}) \times D^4 = (6.86 \times 10^{-3}) \times (2 \times 20in)^4 = 17484.8\ in^4$

$A = \frac{\pi \cdot D^2}{8} = \pi \times \frac{(2 \times 20in)^2}{8} = 628.3185\ in^2$



$h_c = 10in + \frac{\frac{26in}{\cos 30°}}{2} = 25.011in$

$\rightarrow L_c = \frac{h_c}{\sin 30°} = 50.022\ in$

$F_R = \gamma_{eg} \cdot h_c \cdot A = 68.64 \frac{lb}{ft^3} \cdot \left(25.011\ in \cdot \frac{1ft}{12in}\right) \cdot \left(628.3185in^2 \cdot \frac{1ft^2}{144in^2}\right)$

$\boxed{F_R = 624.23\ lb}$

$h_p = L_p \cdot \sin\theta$

$L_p = L_c + \frac{I_c}{L_c \cdot A} = \left(50.022in \times \frac{1ft}{12in}\right) + \frac{\left(17484in^4 \times \frac{1ft^4}{20736in^4}\right)}{\left(50.022in \times \frac{1ft}{12in}\right) \cdot \left(628.3185in^2 \times \frac{1ft^2}{144in^2}\right)}$

$L_p = 4.267\ ft$

$h_p = L_p \cdot \sin 30° = \boxed{2.1335\ ft \text{ from surface}}$

I really do not get this chapter.

is $h_p > h_c$ always?
is F_R always below the centroid of the shape?

I went through the example problem independently and in class and do not understand.

looking to formulas, $h_p > h_c$ because $L_p > L_c$

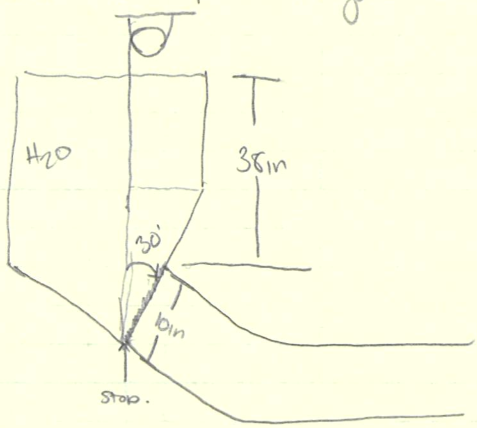
Trying to write it out to understand.

h_c is depth from surface of fluid to centroid of weird shape.
L_c is dist from surface of fluid to centroid of area using the angle of inclination.
L_p is dist from surface of fluid to center of pressure of the → main container? measured along inclination
h_p is vertical distance from surface of fluid to L_p.

well, that didn't really help, but at least I have it to reference.

problem 42

The figure below shows a tank of water with a circular pipe connected to its bottom. A circular gate seals the pipe opening to prohibit flow. To drain the tank, a winch is used to pull the gate open. Compute the amount of force that the winch cable must exert to open the gate.

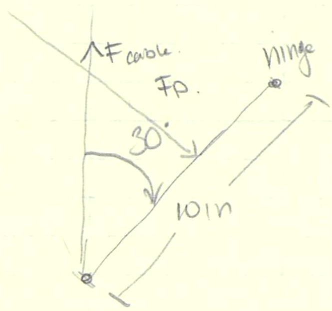


$F_R = \gamma_{H_2O} \cdot h_c \cdot A$

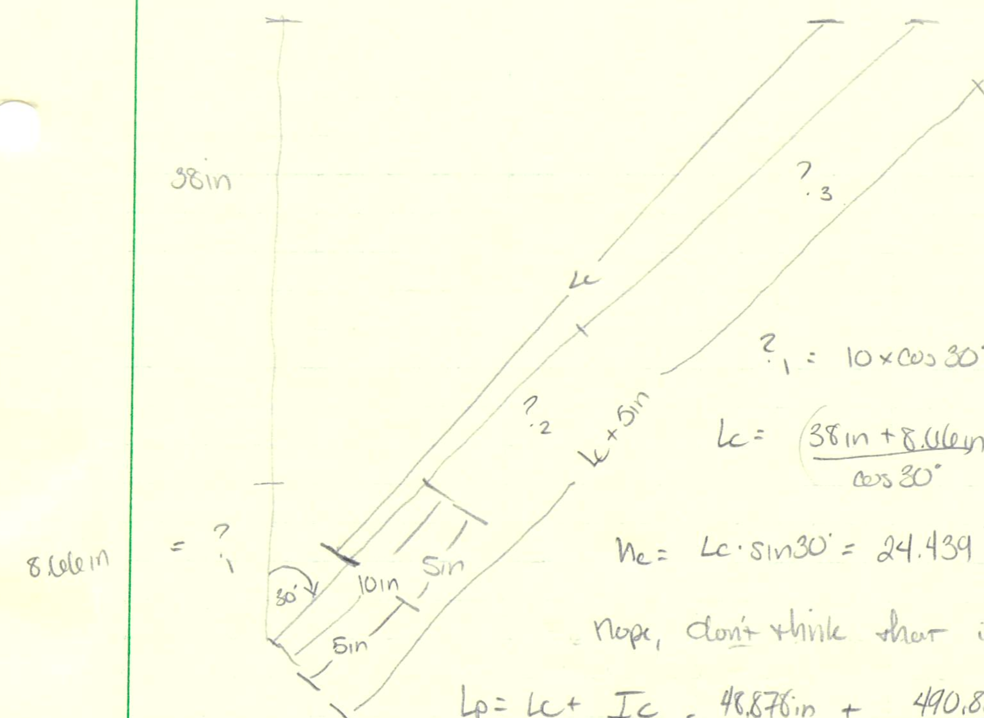
$A = \frac{\pi D^2}{4} = 78.54 \text{ in}^2$

$y = \frac{D}{2} = 5 \text{in}$

$I_c = \frac{\pi D^4}{64} = 490.834 \text{in}^4$



- so, moment by F_{p_y} must equal moment of Fcable.
- F_{p_y} will be L_p from surface



$?_1 = 10 \times \cos 30° = 8.66\text{in}$

$Lc = \left(\dfrac{38\text{in} + 8.66\text{in}}{\cos 30°}\right) - 5\text{in} = 48.878\text{in}$

$h_c = Lc \cdot \sin 30° = 24.439\text{ in}$

nope, don't think that is right

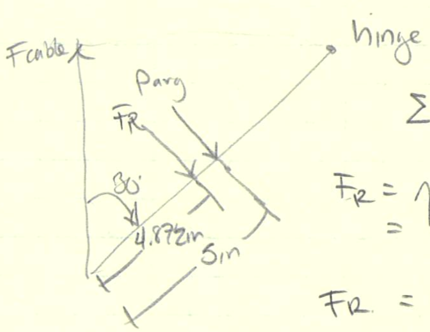
$Lp = Lc + \dfrac{Ic}{Lc \cdot A} = 48.878\text{in} + \dfrac{490.834\text{in}^4}{48.878\text{in} \cdot 78.54\text{in}^2}$

$Lp = 49.006\text{in}$ from surface

$h_p = Lp \cdot \sin\theta = 49.006 \times \sin 30° = 24.503\text{in}$

full length of angle of inclination $= 53.878\text{in}$

$53.878\text{in} - Lp = 4.872\text{in}$



$\overset{+}{\curvearrowleft} M$

$\Sigma M_{Hinge} = \emptyset$

$F_R = \gamma \cdot h_c \cdot A$
$= 62.4\frac{lb}{ft^3} \cdot \left(24.439\text{in} \times \dfrac{1ft}{12in}\right) \cdot \left(78.54\text{in}^2 \cdot \dfrac{1ft^2}{144\text{in}^2}\right)$

$F_R = 69.313\text{ lb}$

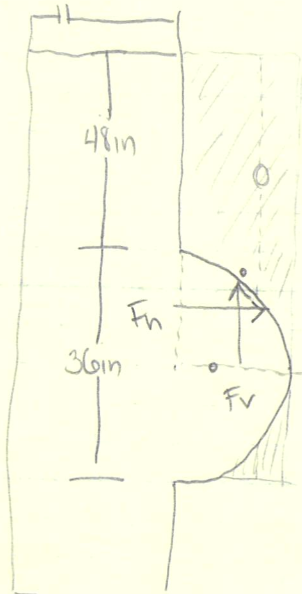
$\emptyset = F_R \cdot (10\text{in} - 4.872\text{in}) - (F_{cable} \cdot \cos 30° \cdot 10\text{in})$

$\dfrac{F_R \cdot 5.128\text{in}}{\cos 30° \cdot 10\text{in}} = F\ cable$

$\boxed{F_{cable} = 41.042\text{ lb}}$

problem 54.

Compute the magnitude of the horizontal component of the force & compute the vertical component of the force exerted by the fluid on the curved surface shown restraining a body of static fluid. Then compute the resultant force's magnitude & direction. Show the resultant force acting on the curved surface. The length of the cylinder's surface is 60in long.



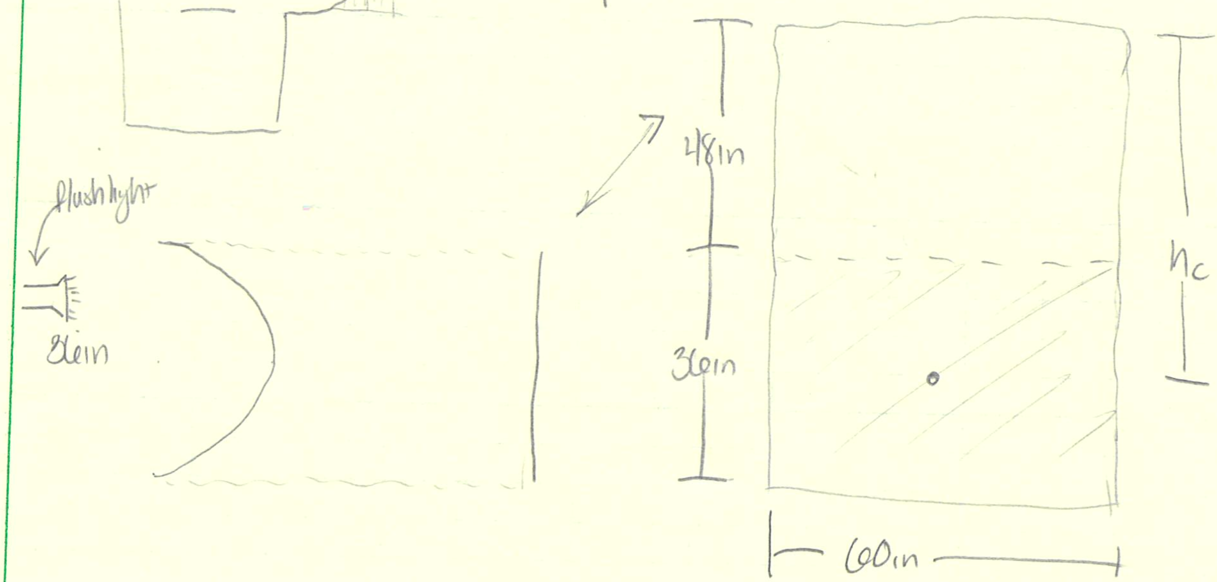
alcohol has sg = 0.79

$$\gamma_{alc} = 0.79 \times 62.4 \frac{lb}{ft^3} = 49.269 \frac{lb}{ft^3}$$

$$F_v = W = \gamma \cdot V$$

$$F_v = \gamma \cdot (V_{rectangle} - V_{1/2\ circle})$$

$$F_h = \gamma \cdot h_c A$$



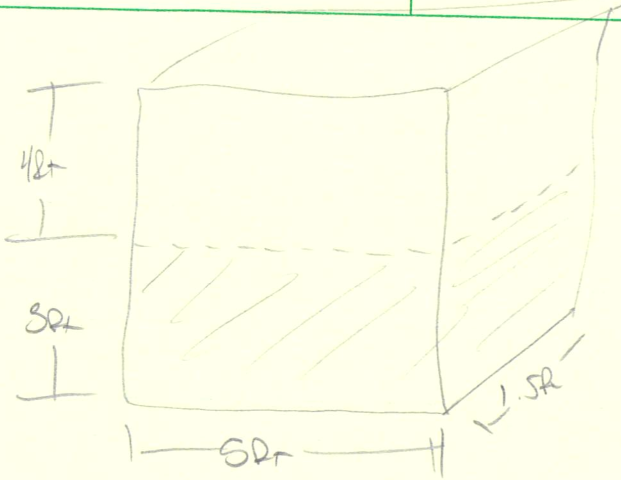
A being the area of this projection

Starting with Fv

$$F_v = \gamma \cdot (V_{rect} - V_{1/2\ circ}) = 49.269 \frac{lb}{ft^3} \cdot \left(\left[\left((48in + 36in) \times \frac{1ft}{12in} \right) \times \left(60in \times \frac{1ft}{12in} \right) \right] - \left[\frac{\pi \cdot \left(36in \times \frac{1ft}{12in} \right)^2}{8} \times 60in \times \frac{1ft}{12in} \right] \right)$$

$$F_v = 49.269 \frac{lb}{ft^3} \cdot (35ft^2 - 17.67ft^2) = 853.$$

@_@ nope, messed up.



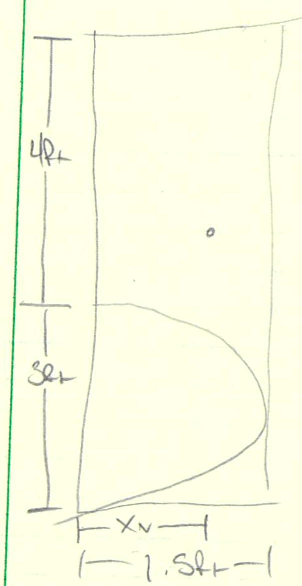
$$F_v = 49.269\,\frac{lb}{ft^3} \cdot \left(7ft \times 5ft \times 1.5ft\right) - \left(\frac{\pi \cdot 3ft^2}{8} \times 5ft\right)$$

$$= 49.269\,\frac{lb}{ft^3} \cdot \left(52.5ft^3 - 17.671ft^3\right)$$

$$\boxed{F_v = 1715.99\,lb}$$

this force is located at the composite of the area.

$$A \cdot X_v = A_{rect} \cdot X_{rect} - A_{1/2\,circ} \cdot X_{1/2\,circ}$$



$$X_v = \frac{\overset{A}{(7ft \cdot 1.5ft)} \times \overset{x}{\left(\frac{1.5ft}{2}\right)} - \overset{A_{circ}}{\left(\frac{\pi \cdot 3ft^2}{8}\right)} \times \overset{X}{(0.212 \times 3ft)}}{\underbrace{(7ft \times 1.5ft) - \left(\frac{\pi \cdot 3ft^2}{8}\right)}_{A_{total}}}$$

$$\boxed{X_v = 0.8078\,ft}$$

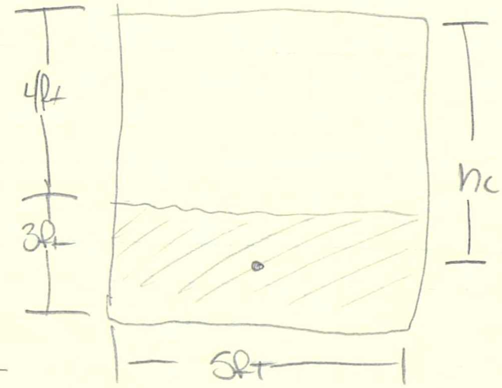
$\underline{F_n}$

why? Centroid of a rectangle is $\frac{1}{2}$ height

$$F_n = \gamma \cdot h_c \cdot A$$
$$= 49.269 \frac{lb}{ft^3} \times \underbrace{(4ft + 1.5ft)}_{} \times (3ft \times 5ft)$$

$$\boxed{F_n = 4064.693 lb}$$

this force is located at $\underline{h_p}$



$$h_p = h_c + \frac{I_c}{h_c \cdot A}$$
$$= (4ft + 1.5ft) + \frac{\frac{(5ft \times 3ft^3)}{12}}{(4ft + 1.5ft) \times (3ft \times 5ft)}$$

$$h_p = 5.5ft + \frac{11.25}{5.5ft \times 15ft^2} = \boxed{5.636 ft}$$

$$F_R = \sqrt{F_v^2 + F_n^2} = \sqrt{1715.99 lb^2 + 4064.693 lb^2}$$

$$\boxed{F_R = 4412.064 lb}$$

$$\theta = \tan^{-1}\left(\frac{F_v}{F_n}\right) = \tan^{-1}\left(\frac{1715.99 lb}{4064.693 lb}\right)$$

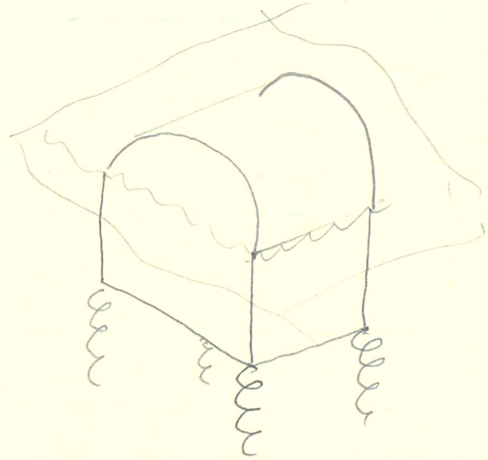
$$\boxed{\theta = 22.89°}$$

Chapter 5

"Buoyancy"

problem 8

The figure below shows a pump partially submerged in oil ($sg = 0.90$) and supported by springs. If the total weight of the pump is 14.6 lb & the submerged volume is 40 in^3, calculate the supporting force exerted by the springs

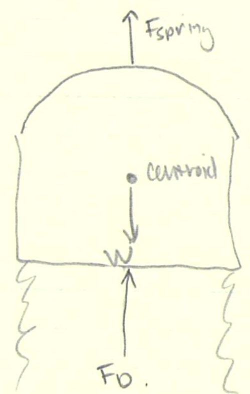


$\gamma_{oil} = 0.90 \times 62.4\ lb/ft^3 = 56.16\ lb/ft^3.$

$W_{pump} =$

$F_b = \gamma_f \cdot V_d$

$W = \gamma$



$\Sigma F_y = \emptyset$

$F_b + F_{spring} - W = \emptyset$

$F_{spring} = W - F_b$

$= 14.6\ lb - \left(56.16\ lb/ft^3 \times 40\ in^3 \times \frac{1\ ft^3}{1728\ in^3}\right)$

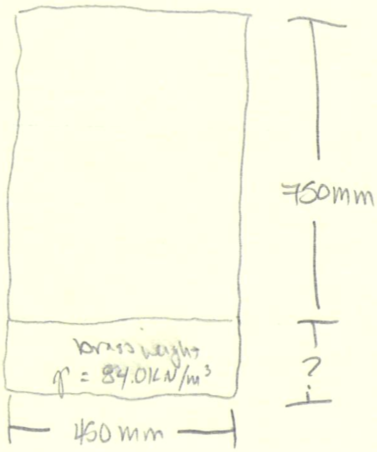
$\boxed{F_{springs} = 13.3\ lb}$

problem 24

A brass weight is attached to the bottom of the cylinder shown below so the cylinder is completely submerged & neutrally buoyant in water at 95 C. The brass is to be a cylinder with the same diameter as the original cylinder. What is the required thickness of the brass?

'typo in prompt says 958C

=>



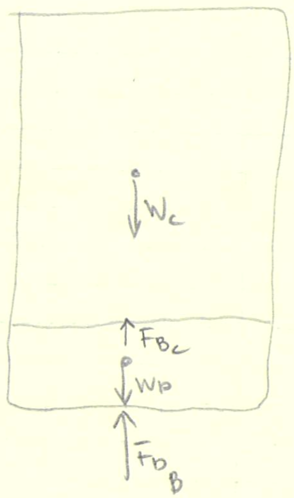
$\gamma_{H_2O @ 95C} = 9.44\ kN/m^3$

$\gamma_{brass} = 84.0\ kN/m^3$

$V_{cylinder} = \frac{\pi D^2 \cdot H}{4}$

$F_b = \gamma_{fluid} \cdot V_{d\,fluid}$

$W = \gamma_{obj} \times V_{obj}$



$\Sigma F_y = \emptyset$

$\emptyset = F_{B_C} + F_{B_D} - W_c - W_D$

$F_{B_C} = 9.44 \frac{kN}{m^3} \times \left(\frac{\pi \cdot (0.45m^2) \cdot 0.75m}{4}\right)$

$F_{B_C} = 1.126\ kN$

$F_{B_D} = 9.44 \frac{kN}{m^3} \times \frac{\pi (0.45m^2) \cdot H}{4}$

$F_{BD} = 1.501 \frac{kN}{m} \cdot H$

$W_D = 84.0 \frac{kN}{m^3} \times \frac{\pi \cdot 0.45m^2 \cdot H}{4}$

$W_D = 13.36 \frac{kN}{m} \cdot H$

To find the weight of this cylinder, need γ_{of} the cylinder.

→ or... $W_c = F_{B_c}$? ~ don't think that works here.

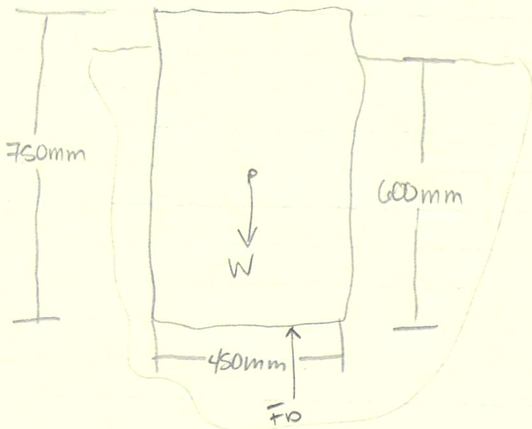
$F_{B_c} + F_{B_D} = W_c + W_D$

$(\gamma_{H20} \times V_{d_C}) + (\gamma_{H20} \times V_{d_B}) = (\gamma_{cyl} \times V_{cyl}) + (\gamma_{brass} \times V_{brass})$

has H. has H.

unown, but this problem cascades from another. maybe we find $\gamma_{cylinder}$ in that.

problem 5.22



fluid is kerosene @ 25C

$$\Sigma F_y = \phi$$

$$\phi = F_D - W$$
$$F_D = W$$

$$\gamma_{kero} \times V_{kero} = \gamma_{obj} \times V_{object}$$

$$\gamma_{kero} = 8.07 \frac{kN}{m^3}$$

$$\gamma_{obj} = \frac{\gamma_{kero} \times V_{kero}}{V_{obj}} = \frac{8.07 \frac{kN}{m^3} \times \frac{\pi \times 0.45m^2}{4} \times 0.6m}{\frac{\pi \cdot 0.75m^2}{4}}$$

$$\gamma_{obj} = 1.743\ kN/m^3$$

will be equal

back to problem 24.

has H.

has H

$$\gamma_{H20} \times V_{dc} + \gamma_{H20} \times V_{dB} = \gamma_{cyl} \times V_{cyl} + \gamma_{brass} \times V_{brass}$$

$$\underbrace{(\gamma_{H20} \times V_{dc}) - (\gamma_{cyl} \times V_{cyl})}_{\text{also equal? yes!}} = \gamma_{brass} \cdot V_{brass} - \gamma_{H20} \cdot V_{dB}.$$

$$\frac{\gamma_{H20} \times V_{dc} - \gamma_{cyl} \times V_{cyl}}{\gamma_{brass} - \gamma_{H20}} = V_{brass}$$

$$V_{brass} = \frac{V_{dc}(\gamma_{H20} - \gamma_{cyl})}{\gamma_{brass} - \gamma_{H20}}$$

=>

$$V_{brass} = \frac{\frac{\pi \cdot 0.45m^2 \cdot 0.75m}{4} \times \left(9.44\frac{kN}{m^3} - 1.743\frac{kN}{m^3}\right)}{84.0\frac{kN}{m^3} - 9.44\frac{kN}{m^3}}$$

$$V_{brass} = 0.0123\ m^3$$

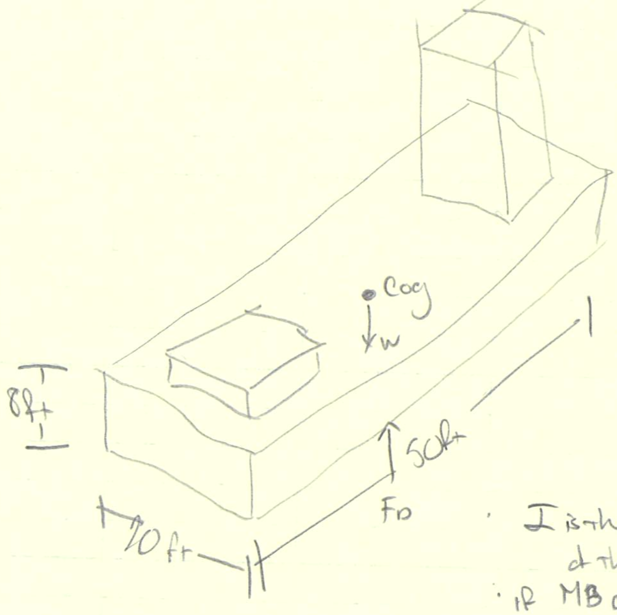
$$V_{brass} = \frac{\pi \cdot D^2 \cdot H}{4}$$

$$\Rightarrow H = \frac{V_{brass} \times 4}{\pi \cdot D^2} = \frac{0.0123m^3 \times 4}{\pi \cdot 0.45m^2} = 0.0774m.$$

$\boxed{\text{H of brass is } 77.4mm}$

problem 41 "stability"

The large platform shown below carries equipment + supplies to offshore installations. The total weight of the system is 450,000lb and its center of gravity is even with the top of the platform, 8ft from the bottom. Will the platform be stable in seawater as shown?



To be stable, Cog must be below metacenter.

$W_{system} = 450{,}000lb.$

MB is dist to metacenter from center of buoyancy.

$$MB = \frac{I}{V_d}$$

. I is the least moment of inertia of a horizontal section of the body taken at the surface of the fluid

. if MB above Cog, body is stable.

$\Sigma F_y = \emptyset$

$\emptyset = F_b - W$

$F_b = W$

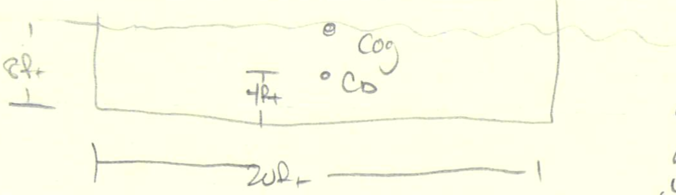
$F_b = \gamma_{fluid} \times 8 \times 20 \times 50 (ft^3)$

$\gamma_{seawater} = 1.030 \times 62.4 lb/ft^3$

$= 64.272 lb/ft^3$ ✓

~~$F_b = 64.272 \times 8ft \times 20ft \times 50ft$~~

~~$F_b = 514{,}176\ lb$~~



~~$y_{cog} = 8ft$ (given)~~

~~$y_{cb} = \frac{1}{2} \cdot$ submerged height $= 4ft$~~

~~$I_{c_{rect}} = \frac{B \cdot H^3}{12} = 20ft \times$~~

'seem to have misunderstood, 8ft is not submerged height, but full height of platform.

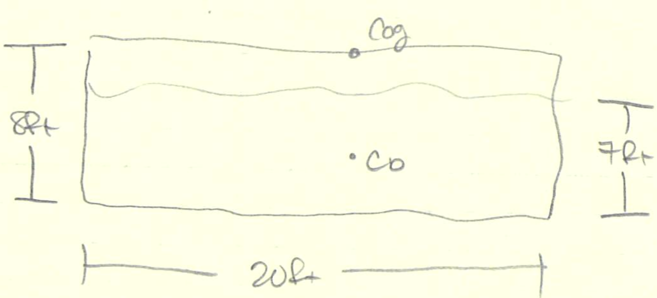
'so, I guess I have to find how much it is submerged?

$$F_b = W$$

$$450{,}000\ lb = \gamma_{fluid} \times \underbrace{B \times H \times W}_{Vd}$$

$$W \rightarrow 450{,}000 = 64.272\ \frac{lb}{ft^3} \times 20ft \times H \times 50ft$$

$$H = 7.00ft$$



$y_{cog} = 8ft$

$y_{CB} = 3.5ft$ (½ submerged height)

$$I_c = \frac{L \cdot B^3}{12} = \frac{50ft \times 20ft^3}{12} = 33{,}333.33ft^4$$

$$Vd = 20ft \times 50ft \times 7ft = 7000\ ft^3.$$

$$MB = \frac{I}{Vd} = \frac{33{,}333.33ft^4}{7000ft^3} = 4.762\ ft$$

this is the distance from center of buoyancy to metacenter.

$$y_{metacenter} = y_{mc} = y_{cB} + MB$$

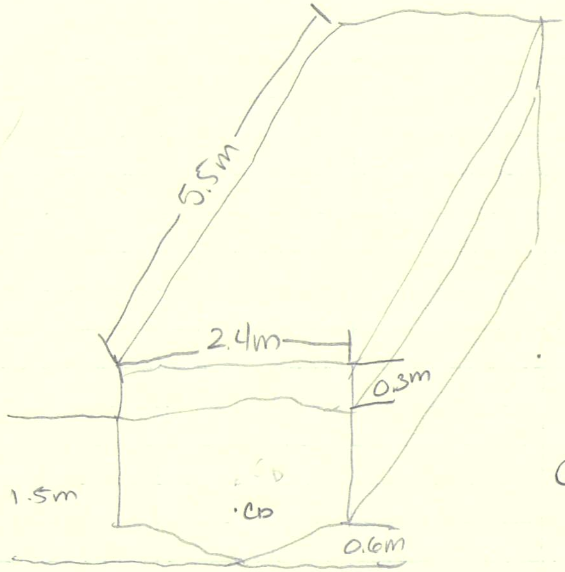
$$= 3.5ft + 4.762ft$$

$$\boxed{y_{mc} = 8.262ft}$$

'above CoG, so stable!

problem 6)

A boat is shown below. Its geometry at the water line is the same as the top surface. The hull is solid. Is the boat stable?



$$MB = \frac{I}{V_d}$$

problem only says water, so assuming

$$\gamma_{H_2O} = 9.81 \frac{kN}{m^3}$$

· centroid of submerged area is location of center of buoyancy

$$C_b = \frac{H}{2} + \frac{H}{3}$$

$$= \frac{1.5m - 0.6m}{2} + \frac{0.6m}{3}$$

$$\boxed{y_{cb} = 0.65m}$$

$$I_c = \frac{BH^3}{12} + \frac{BH^3}{36}$$

→ is that right?

$$V_d = V_{rect} + V_{Triangle}$$

$$V_d = \Big(\underbrace{(1.5m - 0.6m) \times 2.4m \times 5.5m}_{rect}\Big) + \left(\frac{1}{2} \cdot 2.4m \times 0.6m \times 5.5m\right)$$

$$\boxed{V_d = 15.84 m^3}$$

going to see if a more relevant example covered in 10/13 class.