Problem 2.1

Data

p in KN/m^2 = ?

$h = 5Km = 5000m$

$\gamma = 10.05\ KN/m^3 = 10050\ N/m^3$

Sol:

$p = \gamma h$

$= 10050 \times 5000$

$p = 50250\ KN/m^2$

Prob. 2.2

Data:

$Z_1 = 8m$

$p_1 = 57.4\ KN/m^2$

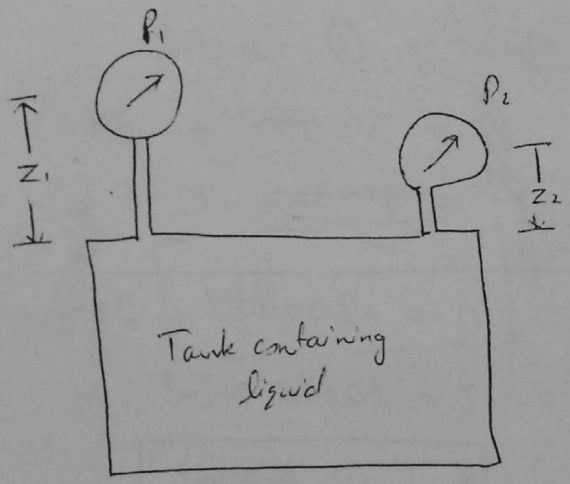
$= 57400\ N/m^2$

$Z_2 = 5m$

$p_2 = 80\ KN/m^2$

$= 80000\ N/m^2$

$\gamma = ?$ $\rho = ?$



Sol:

$p = p_1 + \gamma Z_1$ — (1)

$p = p_2 + \gamma Z_2$ — (2)

By equating (1) and (2)

$p = 57400 + \gamma(8)$

$p = 80000 + \gamma(5)$

$0 = -22600 + 3\gamma$

$\gamma = 7533.33\ N/m^3 = 7.533\ KN/m^3$

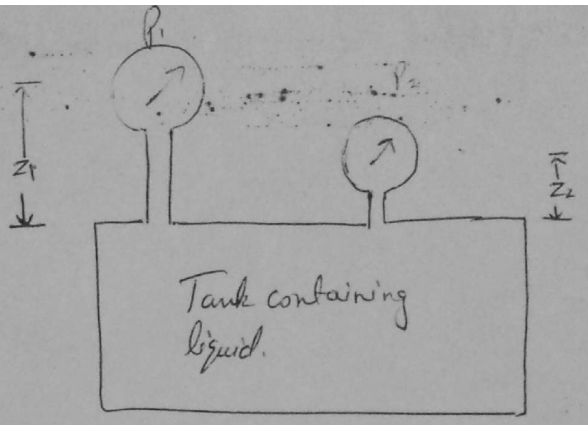
$\gamma = \rho g$

$\rho = \frac{\gamma}{g}$

$= \frac{7533.33}{9.81}$

$\rho = 767.92\ kg/m^3$

Problem 2.3



Data:

$Z_1 = 6m$

$P_1 = 90\ KN/m^2$

$= 90000 N/m^2$

$Z_2 = 4m$

$P_2 = 110 KN/m^2$

$= 110000\ N/m^2$

$\gamma = ?$

$\rho = ?$

$S = ?$

Sol:

$$P = P_1 + \gamma Z_1 \quad \text{(1)}$$

$$P = P_2 + \gamma Z_2 \quad \text{(2)}$$

By equating (1) and (2)

$$P = 90,000 + \gamma(6)$$

$$P = 110000 + \gamma(4)$$

$$0 = -20000 + 2\gamma$$

$$\gamma = 10000\ N/m^3$$

$$\boxed{\gamma = 10\ KN/m^3}$$

$$\gamma = \rho g$$

$$\rho = \frac{\gamma}{g}$$

$$= \frac{10,000}{9.81}$$

$$\boxed{\rho = 1019.3\ kg/m^3}$$

$$\rho = 1.01 * 10^3\ kg/m^3$$

$$S = \frac{\gamma_{fluid}}{\gamma_{water}}$$

$$= \frac{10,000}{9810}$$

$$\boxed{S = 1.01}$$

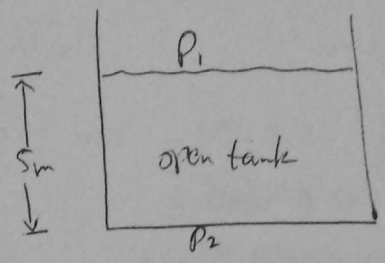
Prob 2.5

Data:

$h = 5m$

$\gamma = 8\ KN/m^3$

$= 8000\ N/m^3$



Pressure at interface $= P_1 = ?$

and Bottom of the tank $= P_2 = ?$

Sol:

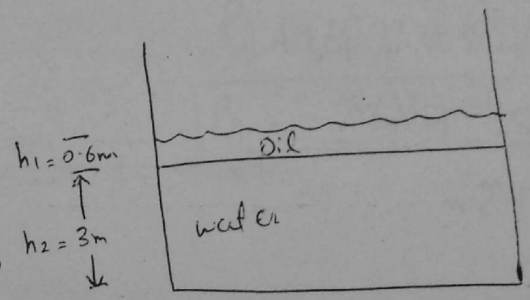
$$P_1 = \gamma h = \gamma(0) = 0\ N/m^2$$

$$P_2 = \gamma h = 8 \times 5 = 40\ KN/m^2$$

Prob 2.6

Data:

$S_{oil} = 0.86$



Pressure at interface b/w liquids $= P_1 = ?$

Pressure at bottom of the tank $= P_2 = ?$

Sol:

$$S_{oil} = \frac{\gamma_{oil}}{\gamma_{water}}$$

$$\gamma_{oil} = 0.86 \times 9810 = 8436.6\ N/m^3$$

$$P_1 = \gamma_{oil} \times h_1$$

$$= 8436.6 \times 0.6$$

$$= 5061.96\ N/m^2$$

$$P_1 = 5.06\ KN/m^2$$

$$P_2 = P_1 + \gamma_{water} h_2$$

$$= 5061.96 + 9810 \times 3$$

$$= 34491.96\ N/m^2$$

$$P_2 = 34.49\ KN/m^2$$

Prob. 2.7

Data:

$\gamma = 12\ N/m^3$

$h = ?$

$P = 100\ kN/m^2$

$= 100000\ N/m2$

Sol:

$P = \gamma h$

$h = \frac{P}{\gamma} = \frac{100000}{12} = 8333.33\ m$

Prob. 2.8

Data:

$\gamma = 10200 + 105h$

P in $N/m^2 = ?$

$h = 4.5\ m$

Sol:

γ_{min} at $h = 0 \implies \gamma = 10200 + 0 = 10200\ N/m^3$

γ_{max} at $h = 4.5 \implies \gamma = 10200 + 105 \times 4.5 = 10672.5\ N/m^2$

$\gamma_{avg} = \frac{10200 + 10672.5}{2} = 10436.25\ N/m^3$

$P = \gamma_{avg} h$

$= 10436.25 \times 4.5$

$P = 46963.125\ N/m2$

Prob. 2.10

Data:

$P_{abs} = 300\ kN/m^2 = 3 \times 10^5\ N/m^2$

$P_{atm} = 840\ mbar = 840 \times 10^{-3}\ bar = 840 \times 10^{-3} \times 10^5\ N/m^2$

$= 840 \times 10^2\ N/m^2$

$= 0.84 \times 10^5\ N/m^2$

P_g (kN/m^2 and $m\ bars$) = ?

Sol:

$P_{abs} = P_{atm} + P_g$

$P_g = P_{abs} - P_{atm}$

$= 3 \times 10^5 - 0.84 \times 10^5$

$P_g = 2.16 \times 10^5\ N/m^2$

$\boxed{P_g = 216\ kN/m^2}$

$\Rightarrow P_g = \frac{2.16 \times 10^5}{10^5} = 2.16\ bars$

$P_g = 2.16 \times 10^3\ m\ bars$

$\boxed{P_g = 2160\ m\ bars}$

Prob. 2.11

Data:

$P_{atm} = 920\ mbars$

$= 920 \times 10^{-3}\ bars$

$= 920 \times 10^{-3} \times 10^5\ N/m^2$

$P_{atm} = 92000\ N/m^2$

$h_g = 400\ mm$ of Hg Vaccum

$= 0.4\ m$ of Hg

$P_{abs} = ?$

$S_{Hg} = 13.56$

Sol:

$S_{Hg} = \frac{\gamma_{Hg}}{\gamma_{water}}$

$\gamma_{Hg} = 13.56 \times 9810$

$= 133.02 \times 10^3\ N/m^3$

$P_{abs} = P_{atm} + \gamma h$

$= 92000 + (133.02 \times 10^3)(0.4)$

$P_{abs} = 38792\ N/m^2$

Prob: 2.12

Data:

$P_{atm} = 945$ mbar

$= 94500\ N/m^2$

$h = 20$ cm Hg

$= 0.2$ m of Hg vaccum

$P_{abs} = ?$

$S_{Hg} = 13.56$

$\gamma_{Hg} = 133.02 \times 10^3\ N/m^3$

Sol:

$P_{abs} = P_{atm} + \gamma h$

$= 94500 + (133.02 \times 10^3)(0.2)$

$= 67896\ N/m^2$

Prob. 2.14

Data:

$h = \frac{P_{atm}}{\gamma} = 760$ mm of Hg $= 0.76$ m of Hg

i) $h_w = ?$ $T = 32°C$

ii) $h_{Hg} = ?$ $T = 60°C$

Sol:

Consulting table A1 of appendix 3

T°C	γ_{water} (KN/m3)	P_{vap} (KN/m3)
30	9.764	4.24
40	9.730	7.38
1	3.4×10^{-3}	0.314
32	9.757	4.868
60	9.642	19.92

At $T = 32^\circ C$

$P_{atm} = P_{vap} + \gamma h_{water}$

$100551.73 = 4868 + (9757)(h)$

$h = 9.806$ m of water

$S_{Hg} = \frac{\gamma_{Hg}}{\gamma_{water}}$

$\gamma_{Hg} = 13.56 \times 9757$

$\gamma_{Hg} = 132304.92 \text{ N/m}^3$

$h = \frac{P_{atm}}{\gamma_{Hg}} = 0.76$

$P_{atm} = 0.76 \times 132304.92$

$P_{atm} = 100551.73 \text{ N/m}^2$

At $T = 60^\circ C$

$P_{atm} = P_{vap} + \gamma h_{water}$

$99366.59 = 19920 + 9642(h)$

$h = 8.239$ m of water

$h = \frac{P_{atm}}{\gamma_{Hg}} = 0.76$

$P_{atm} = 0.76 \times 130745.52$

$P_{atm} = 99366.59 \text{ N/m}^2$

$S_{Hg} = \frac{\gamma_{Hg}}{\gamma_{water}}$

$\gamma_{Hg} = 13.56 \times 9642$

$= 130745.52 \text{ N/m}^3$

Prob. 2.17

Data:

$h_w = \frac{P_{atm}}{\gamma_{water}} = 10 \text{ m} \Rightarrow P_{atm} = 10 \times 9810 = 98100 \text{ N/m}^2$

$h_{alcohol} = ?$

$S_{alc.} = 0.84 \Rightarrow \gamma_{alc.} = 0.84 \times 9810 = 8240.4 \text{ N/m}^3$

$P_{vap \text{ of alc.}} = 17 \text{ KN/m}^2 = 17000 \text{ N/m}^2$

Sol:

$P_{atm} = P_{vap} + \gamma h$

$98100 = 17000 + 8240.4 \times h$

$h = 9.84$ m of Alc.

Prob. 2.18

Data:

$P_{atm} = 940 \text{ mbars}$

$= 94000 \text{ N/m}^2$

$h = ?$

Liquid = Water

$T = 60°C$

γ_w at $60°C = 9642 \text{ N/m}^3$

P_{vap} at $60°C = 19920 \text{ N/m}^2$

Sol:

$P_{atm} = P_{vap} + \gamma h$

$94000 = 19920 + (9642)h$

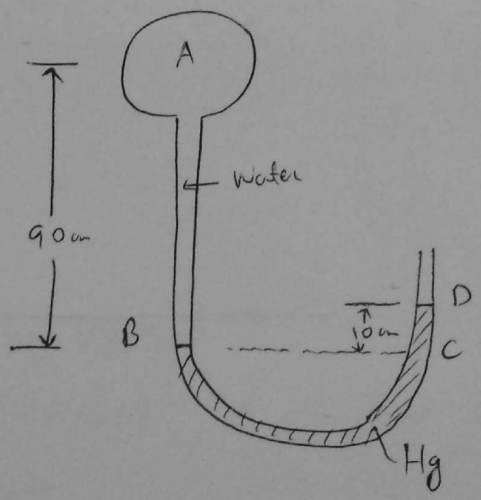
$h = 7.68 \text{ m of water}$

Prob. 2.20

Data:

$P_{atm} = 100 \text{ KN/m}^2$

$= 100000 \text{ N/m}^2$



$\Rightarrow P_B = P_A + \gamma_w (0.9)$ — (1)

$P_B = P_A + 9810 \times 0.9$

$P_B = P_A + 8829$ — (1)

Now

$P_B = P_C$

$\Rightarrow P_C = P_{atm} + \gamma_{Hg} (0.1)$

$= 100000 + 133023.6 \times 0.1$

$P_C = 113302.36 \text{ N/m}^2$

Putting in (1) $P_B = P_C$

$113302.36 = P_A + 8829$

$P_A = 104473.36 \text{ N/m}^2$

$S_{Hg} = \frac{\gamma_{Hg}}{\gamma_w}$

$\gamma_{Hg} = 13.56 \times 9810$

$\gamma_{Hg} = 133023.6 \text{ N/m}^3$

Multiplying absolute pressure at A by 2

$2P_A = 209346.72$

Due to increase in 'P', Z will become Z+x and y will become y+2x

$$2P_A + [9810(0.9+x)] = 100000 + [(0.1+2x) \times 133023.6]$$

$$x = 0.4\ m$$

New manometer reading will be

$$y = 0.1 + 2(0.4)$$
$$= 0.915 m$$

Prob. 2.22

Data:

Manometer = Differential

Fluid = Mercury

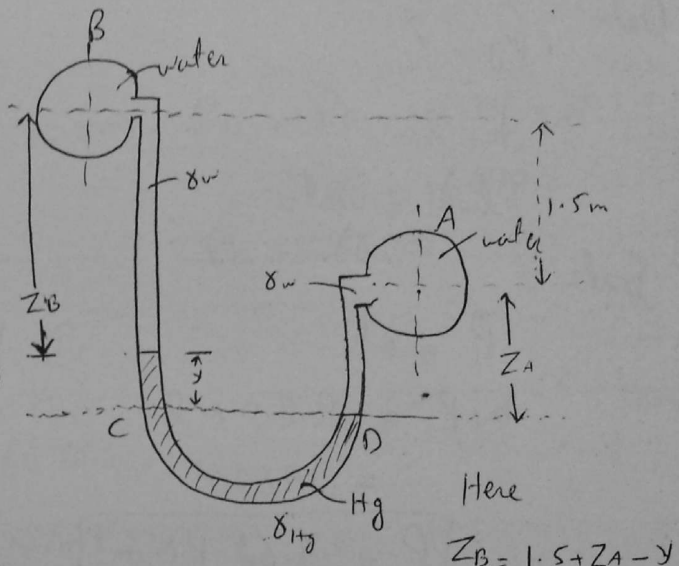
$S_{Hg} = 13.55$

Tubes have water

$y = 10\ cm = 0.1\ m$

a) $P_a - P_b = ?$ (m of H_2O, KN/m^2)

b) $y = ?$ (CCl_4, $S = 1.59$)



Sol:

$P_C \simeq P_D$

$P_C = P_B + \gamma_w Z_B + \gamma_M y$ $\qquad$ $P_D = P_A + \gamma_w Z_A$

Hence

$$P_B + \gamma_w Z_B + \gamma_M y = P_A + \gamma_w Z_A$$

$$P_A - P_B = \gamma_w Z_B + \gamma_M y - \gamma_w Z_A$$

$$= \gamma_M y + \gamma_w (Z_B - Z_A)$$

$$= \gamma_M y + \gamma_w (1.5 + Z_A - y - Z_A)$$

$$= \gamma_M y + \gamma_w (1.5 - y)$$

$$= (S \times \gamma_w) y + \gamma_w (1.5 - y)$$

$$P_A - P_B = (13.55 \times 9810)(0.1) + 9810(1.5 - 0.1)$$

$$P_A - P_B = 27.027\ KN/m^2$$

$$h = \frac{P_A - P_B}{\gamma_w} = \frac{27.027}{9.81} = 2.75\text{ m of } H_2O$$

b) $27.027 = (1.59 \times 9810)\,y + 9810(1.5 - y)$

$$\boxed{y = 2.12\text{ m}}$$

PART B

Prob. 1

Data: $P_g = ?$

$h = 2\text{ m}$

Fluid = water

Sol:

$P = \gamma h$

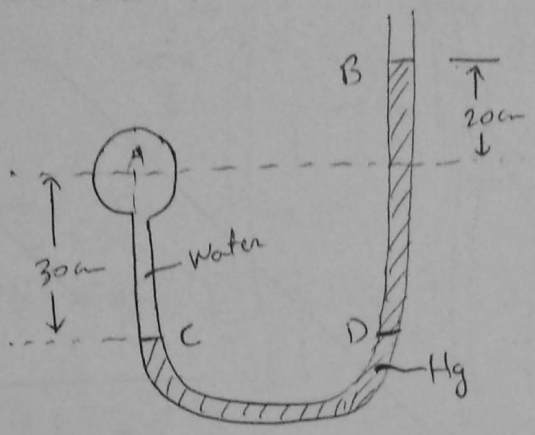
$P = 9810 \times 2$

$= 19620$

$$\boxed{P = 19.62\text{ KN/m}^2}$$

Prob. 2

Data:



$P_A = ?$

$S_M = 13.6$

$\gamma_M = 13.6 \times 9810 = 133416 N/m^3$

Sol:

Here $P_C = P_D$

$\Rightarrow P_C = P_A + 9810(0.3)$

$= P_A + 2943$ — (1)

$\Rightarrow P_D = P_B + (133416)(0.3+0.2)$

$= P_B + 66708$

$P_D = 66708$ — (2)

By equating (1) and (2)

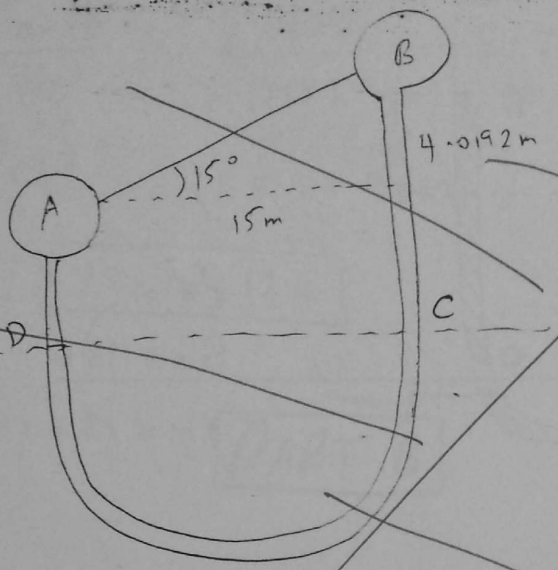
$P_A + 2943 = 66708$

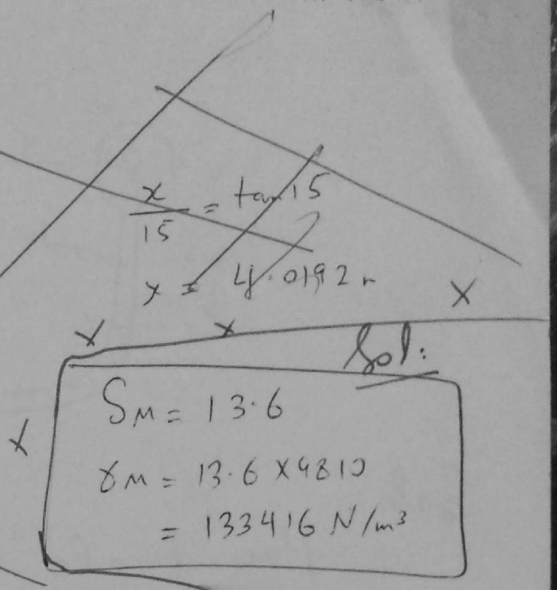
$P_A = 63765 N/m^2$

$\boxed{P_A = 63.765 KN/m^2}$

Problem 3

Data:





Sol:

$S_M = 13.6$

$\gamma_M = 13.6 \times 9810$

$= 133416\ N/m^3$

Sol:

$P_C = P_A + \gamma_w Z_A$

$P_D = P_B + \gamma_w Z_B + \gamma_M y$

$P_C = P_D$

$P_A + \gamma_w Z_A = P_B + \gamma_w Z_B + \gamma_M y$

$P_A - P_B = \gamma_w (Z_B - Z_A) + \gamma_M y$

From figure

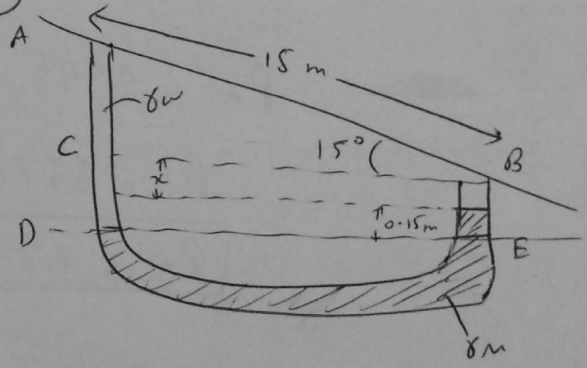
Vertical distance b/w A and B = 15

Sol:

from $\triangle ACB$

$\sin 15° = \frac{AC}{15}$

$AC = 3.882\ m$



Data

x = ht. of water in limb

$P_D = P_E$

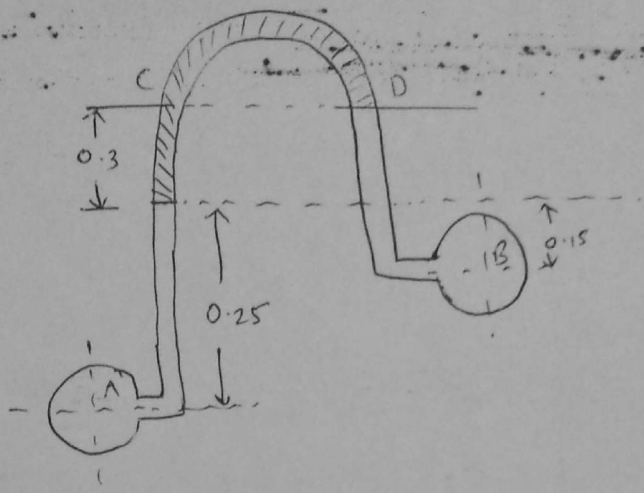
$P_A + (3.882 + x + 0.15)9810 = P_B + 9810x + 133416 \times 0.15$

$P_A - P_B = -19541.52$

$P_B - P_A = 19.54\ KN/m^2$

Prob 4

Data:



Sol:

a) AIR:

$$P_C = P_A - 9810(0.25) \qquad P_D = P_B - 9810(0.15+0.3)$$

$$P_C = P_D$$

$$P_A - 2452.5 = P_B - 4414.5$$

$$P_A - P_B = -1962 \text{ N/m}^2$$

b) Oil of relative density = 0.8

$$S_{oil} = 0.8 \quad \& \quad \gamma_{oil} = 0.8 \times 9810 = 7848 \text{ N/m}^3$$

$$P_C = P_A - 9810(0.25) - 7848(0.3) \qquad P_D = P_B - 9810(0.15+0.3)$$

$$P_C = P_D$$

$$P_A - 2452.5 - 2354.4 = P_B - 4414.5$$

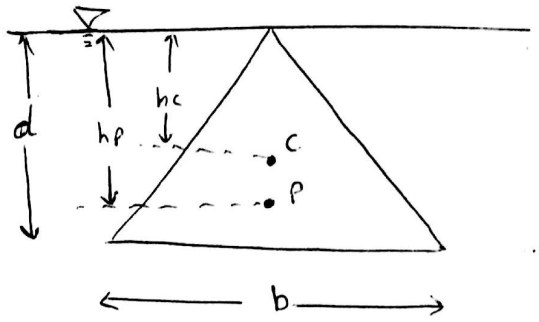
$$P_A - P_B = 392.4 \text{ N/m}^2$$

ASSIGNMENT -3

Prob 2.30

Data:

$h_p = ?$



Sol:

Here $I_c = \frac{bd^3}{36}$

$h_p = h_c + \frac{I_c}{Ah_c}$

$h_c = d - \frac{d}{3}$

$= \frac{2}{3}d$

$A = \frac{1}{2}bd$

$= \frac{2}{3}d + \frac{bd^3/36}{\left(\frac{1}{2}bd\right)\left(\frac{2}{3}d\right)}$

$= \frac{2}{3}d + \frac{bd^3/36}{bd^2/3}$

$= \frac{2}{3}d + \frac{d}{12}$

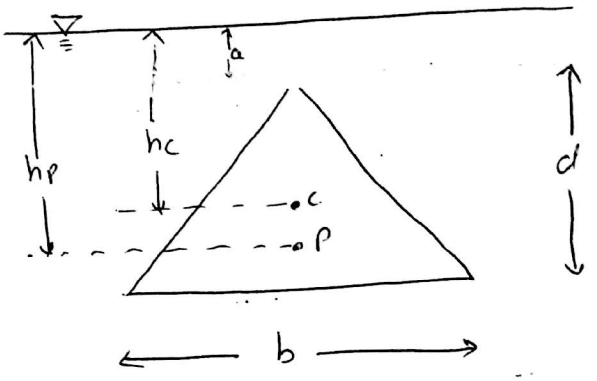
$= \frac{8d + d}{12} = \frac{9d}{12} = \frac{3}{4}d$

$$\boxed{h_p = \frac{3}{4}d}$$

Prob 2.31

Data:

$h_p = ?$



Sol:

$$h_p = h_c + \frac{I_c}{A h_c}$$

Here $h_c = a + \frac{2}{3}d$

$$= \left(a + \frac{2}{3}d\right) + \frac{bd^3/36}{\left(\frac{bd}{2}\right)\left(\frac{2}{3}d + a\right)}$$

$$= \left(a + \frac{2}{3}d\right) + \left[\frac{bd^3/36}{bd^2/3 + bda/2}\right]$$

$$= \left(a + \frac{2}{3}d\right) + \left[\frac{bd^3/36}{2bd^2 + 3bda/6}\right]$$

$$= \left(a + \frac{2}{3}d\right) + \left[\frac{bd^3}{6(2bd^2 + 3bda)}\right]$$

$$= \left(a + \frac{2}{3}d\right) + \left[\frac{d^2}{6(2d + 3a)}\right]$$

$$= \frac{6a(2d + 3a) + 4d(2d + 3a) + d^2}{6(2d + 3a)}$$

$$= \frac{12ad + 18a^2 + 8d^2 + 12ad + d^2}{6(2d + 3a)}$$

$$= \frac{18a^2 + 24ad + 9d^2}{6(2d + 3a)}$$

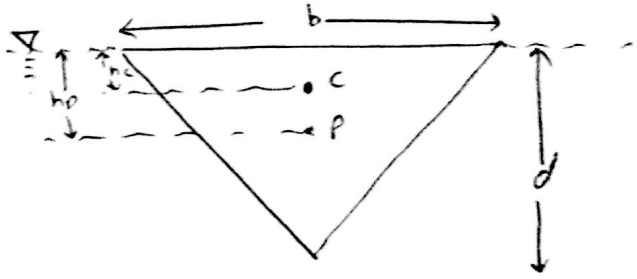
$$= \frac{3(6a^2 + 8ad + 3d^2)}{6(2d + 3a)}$$

$$= \frac{6a^2 + 8ad + 3d^2}{2(2d + 3a)} = \frac{6a^2 + 8ad + 3d^2}{4d + 6a}$$

Problem 2.32

Data:

$h_p = ?$



Sol:

$$h_p = h_c + \frac{I_c}{h_c A}$$

Here

$$h_c = \frac{d}{3}$$

$$I_c = \frac{bd^3}{36}$$

$$A = \frac{1}{2} bd$$

$$= \frac{d}{3} + \frac{bd^3/36}{(d/3)(bd/2)}$$

$$= \frac{d}{3} + \frac{bd^3/36}{bd^2/6}$$

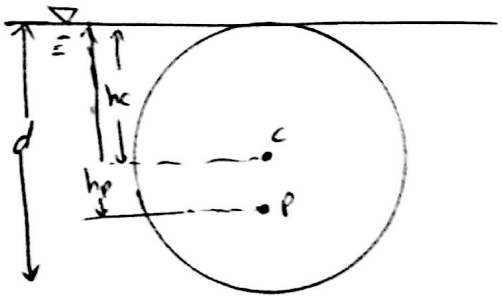
$$= \frac{d}{3} + \frac{d}{6}$$

$$\boxed{h_p = \frac{d}{2}} \checkmark$$

Prob 2.33

Data:

$h_p = ?$



Here

$$h_c = \frac{d}{2}$$

$$I_c = \frac{\pi d^4}{64}$$

$$A = \frac{\pi d^2}{4}$$

Sol:

$$h_p = h_c + \frac{I_c}{h_c A}$$

$$= \frac{d}{2} + \frac{\pi d^4/64}{(d/2)(\pi d^2/4)}$$

$$= \frac{d}{2} + \frac{d}{8}$$

$$\boxed{h_p = \frac{5d}{8}} \checkmark$$

Prob 2.34

Data:

Area is semi circular as in figure

Centroid $= h_c = \frac{4r}{3\pi} = 0.424r$

Area of semi circle $= A = \frac{\pi r^2}{2}$

Second moment of area about centroid $= I_c = \frac{\pi r^4}{8} - \left[\frac{\pi r^2}{2}\left(\frac{4r}{3\pi}\right)^2\right]$

2nd moment of Inertia of semicircle $- A\bar{y}^2$, $A \times h_c^2$

$I_c = I_0 + Ay^2$

$I_c = \frac{\pi r^4}{8} - \frac{8r^4}{9\pi}$

$I_c = 0.11r^4$

Sol:

$h_p = h_c + \frac{I_c}{Ah_c}$

$= 0.424r + \frac{0.11r^4}{\left(\frac{\pi r^2}{2}\right)(0.424r)}$

$h_p = 0.424r + 0.165r$

$h_p = 0.589r$ ✓

$h_p = \frac{4r}{3\pi} + \frac{\frac{\pi r^4}{8} - \frac{8r^4}{9\pi}}{\left(\frac{\pi r^2}{2}\right)\left(\frac{\pi r^4}{8} - \frac{8r^4}{9\pi}\right)}$

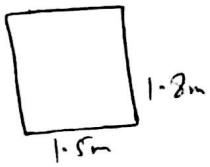
Prob236

Data:

$A = 1.5 \times 1.8 = 2.7 m^2$

$F = ?$

$h_p = ?$



Sol: When top edge is

a) At water surface:

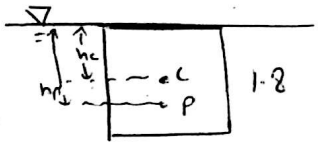
$F = \gamma h_c A$

$= 9810 \times 0.9 \times 2.7$

$\boxed{F = 23.83 KN}$

Here

$h_c = \frac{1.8}{2} = 0.9$



$I_c = \frac{bh^3}{12} = \frac{(1.5)(1.8)^3}{12} = 0.729 m^4$

$h_p = h_c + \frac{I_c}{h_c A}$

$= 0.9 + \frac{0.729}{(0.9)(2.7)}$

$\boxed{h_p = 1.2m}$

b) 0.3 m below water surface:

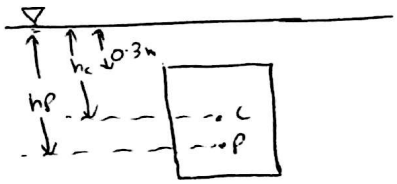
$F = 9810 \times 1.2 \times 2.7$

$\boxed{F = 31.78 KN}$

Here

$h_c = 0.9 + 0.3$

$= 1.2m$



$h_p = 1.2 + \frac{0.729}{(1.2)(2.7)}$

$\boxed{h_p = 1.425m}$

c) 30m below water surface:

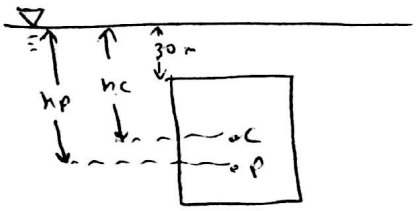
$F = 9810 \times 30.9 \times 2.7$

$\boxed{F = 818.4 KN}$

Here

$h_c = 0.9 + 30$

$h_c = 30.9m$



$h_p = 30.9 + \frac{0.729}{(30.9)(2.7)}$

$\boxed{h_p = 30.908m}$

Prob: 2.38

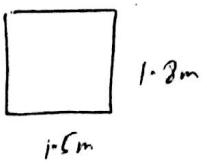
Data:

$A = 1.5 \times 1.8 = 2.7 m^2$

$\theta = 30°$

$F = ?$

$h_p = ?$



Sol: When top edge is :

a) At water surface :

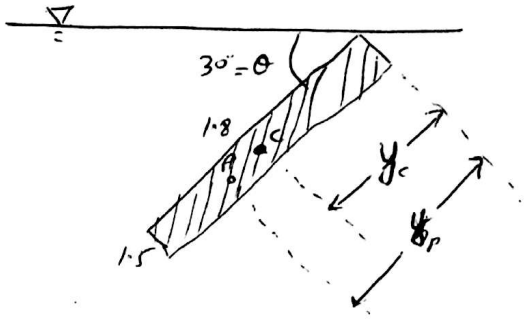
$F = \gamma h_c A$

Here $y_c = \frac{1.8}{2} = 0.9$

$F = \gamma y_c \sin\theta A$

$= (9810)(0.9)(\sin 30°)(2.7)$

$\boxed{F = 11.91 kN}$



$h_p = y_p \sin\theta$

$= \left(y_c + \frac{I_c}{A y_c}\right) \sin\theta$

$= \left(0.9 + \frac{0.729}{2.7 \times 0.9}\right) \sin 30°$

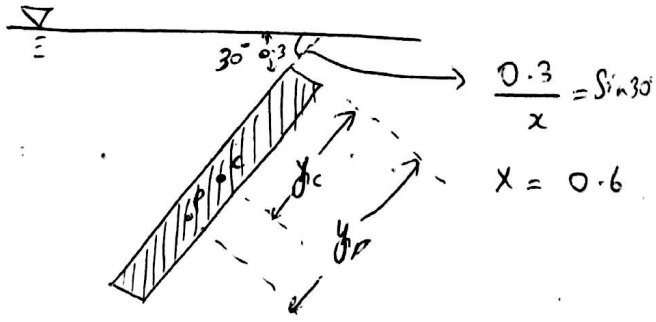
Here $I_c = \frac{bh^3}{12} = \frac{(1.5)(1.8)^3}{12} = 0.729$

$\boxed{h_p = 0.6m}$

b) 0.3m below water surface:

$F = (9810)(1.5)(\sin 30)(2.7)$

$\boxed{F = 19.861 kN}$



$h_p = \left(1.5 + \frac{0.729}{2.7 \times 1.5}\right) \sin 30°$

$\boxed{h_p = 0.84 m}$

Here

$y_c = 0.9 + 0.6$

$y_c = 1.5m$

Prob 2.39

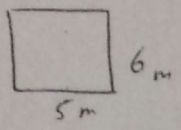
Data:

$A = 5 \times 6 = 30 m^2$

$h_c = 4m$

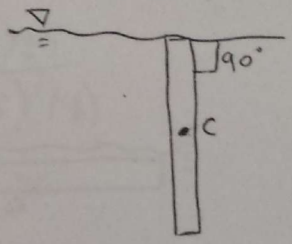
$F = ?$

$y_p - y_c = ?$



Here $I = \frac{bh^3}{12} = \frac{5 \times 6^3}{12} = 90 m^4$

Sol: when $\theta = 90°$



$h_c = y_c \sin\theta$

$h_c = y_c \sin 90°$

$h_c = y_c = 4m$

$\therefore y_p = y_c + \frac{I_c}{A y_c}$

$y_p - y_c = \frac{I_c}{A y_c}$

$y_p - y_c = \frac{90}{(4)(30)}$

$y_p - y_c = 0.750 m$

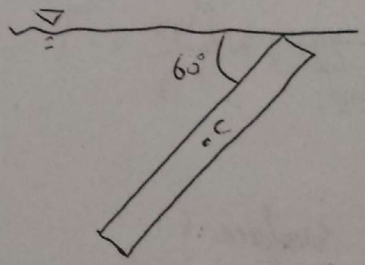
As long as the location of centroid is fixed, magnitude of Force acting on the plane will remain same i.e

$F = \gamma h_c A$

$= 9810 \times 4 \times 30$

$F = 1177.2 kN$

when $\theta = 60°$



$h_c = y_c \sin\theta$

$y_c = \frac{h_c}{\sin\theta} = \frac{4}{\sin 60°}$

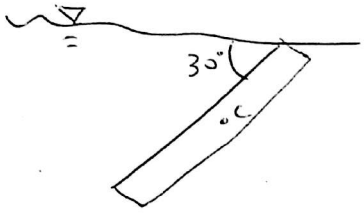
$y_c = 4.618m$

$\therefore y_p - y_c = \frac{I_c}{A y_c}$

$= \frac{90}{(4.618)(30)}$

$y_p - y_c = 0.649 m$

when $\theta = 30°$



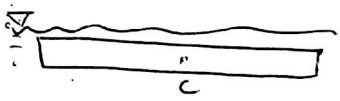
$h_c = y_c \sin\theta$

$y_c = \frac{4}{\sin 30°} = 8$

$y_p - y_c = \frac{I_c}{A y_c}$

$= \frac{90}{(8)(30)} = 0.375 m$

when $\theta = 0°$



$h_c = y_c \sin\theta$

$y_c = \frac{4}{\sin\theta} = \infty$

$y_p - y_c = 0 m$ ✓

Prob 2.40

Data:

oil layer = 0.6m

$S_{oil} = 0.8$

$\gamma_{oil} = 7848 N/m^3$

Sol:

a) At water surface:

$F = \gamma_{oil} h_c A + \gamma_{H_2O} h_c A$

$= (7848)(0.6)(2.7) + (9810)(1.2)(2.7)$

$F = 44.1 kN$

Hydrostatic force due to water

$F_1 = \gamma h_c A$

$F_1 = (9810)(0.9)(2.7) = 23.83 kN$

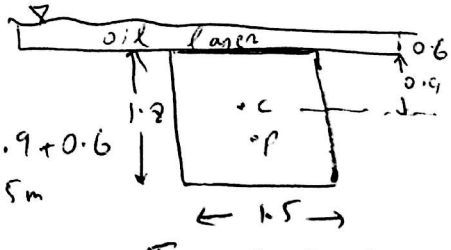
Hydrostatic force due to oil

$F_2 = PA$

$= \gamma h A$

$F_2 = (7848)(0.6)(2.7)$

$= 12.71 kN$



Here $h_c = 0.9 + 0.6$

$h_c = 1.5 m$

$I_c = 0.729$

$F_{total} = F_1 + F_2$

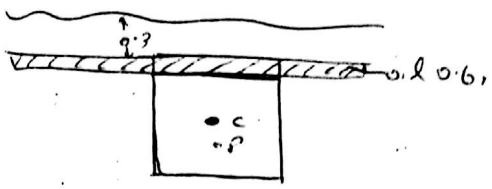
$= 36.54 kN$

$h_p = h_c + \frac{I_c}{A h_c}$

$= 1.5 + \frac{0.729}{(2.7)(1.5)}$

$h_p = 1.68 m$

b) 0.3 m below water surface



$$F = \underbrace{\gamma_{oil} \times h_c A}_{\text{By oil}} + \underbrace{\gamma_{H_2O} h_c A}_{\text{By water}}$$

$$= (7848)(0.6)(2.7) + (9810)(1.2)(2.7)$$

$$\boxed{F = 44.49\ KN}$$

$$h_p = h_c + \frac{I_c}{A h_c}$$

$$= 1.8 + \frac{0.729}{(2.7)(1.8)}$$

$$\boxed{h_p = 1.95\ m}$$ ✓

$h_c = 0.3 + 0.6 + 0.9$

$\boxed{h_c = 1.8}$

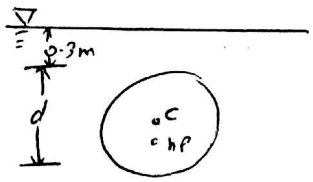
Prob 2.41

Data:

$d = 1.2\ m \Rightarrow A = 1.13\ m^2$

$F = ?$

$h_p = ?$



Sol:

Here $h_c = 0.6 + 0.3 = 0.9m$

$$I_c = \frac{\pi d^4}{64} = \frac{\pi (1.2)^4}{64} = 0.101\ m^4$$

$$F = \gamma h_c A$$

$$= (9810)(0.9)\left(\frac{\pi \times 1.2^2}{4}\right)$$

$$\boxed{F = 9.98\ KN}$$

$$h_p = h_c + \frac{I_c}{A h_c}$$

$$= 0.9 + \frac{0.101}{1.13 \times 0.9}$$

$$\boxed{h_p = 0.999\ m}$$ ✓

Prob 2.42

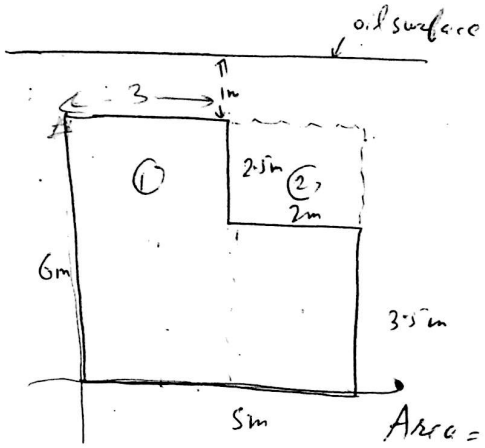
Data:

$S = 0.82$

$\gamma_{oil} = 8044.2\ N/m^3$

$F = ?$

$h_p = ?$



Sol:

Calculating centroid location (h_c) vertically:

$$y = \frac{(3.0 \times 3) - (5 \times 4.75)}{25}$$

$$y = \frac{\sum A\bar{y}}{\sum A} = 2.65$$

$$h_c = 6 - 2.65 + 1$$

$$\boxed{h_c = 4.35\ m}$$

Area $= 5 \times 3.5 + 2.5 \times 3 = 25\ m^2$

$$\bar{y} = \frac{A_1 y_1 + A_2 y_2}{A}$$

Calculating 2nd moment of Area (I_c): about centroidal axis

$$I_1 = \frac{bd^3}{12} = \frac{5(6)^3}{12} = 90\ m^4$$

$$I_{c_1} = I_1 + (A)(0.35)^2$$

$$I_{c_1} = 90 + (30)(0.35)^2$$

$$I_{c_1} = 93.675\ m^4$$

$$I_2 = bd^3/12 = \frac{2(2.5)^3}{12} = 2.60\ m^4$$

$$I_{c_2} = I_2 + (A_2)(2.1)^2$$

$$I_{c_2} = 2.60 + (5)(2.1)^2$$

$$I_{c_2} = 24.65\ m^4$$

$$I_c = I_{c_1} - I_{c_2}$$

$$I_c = 93.675 - 24.65 = 69.025\ m^4$$

$$\Rightarrow F = \gamma h_c A$$

$$= 8044.2 \times 4.35 \times 25$$

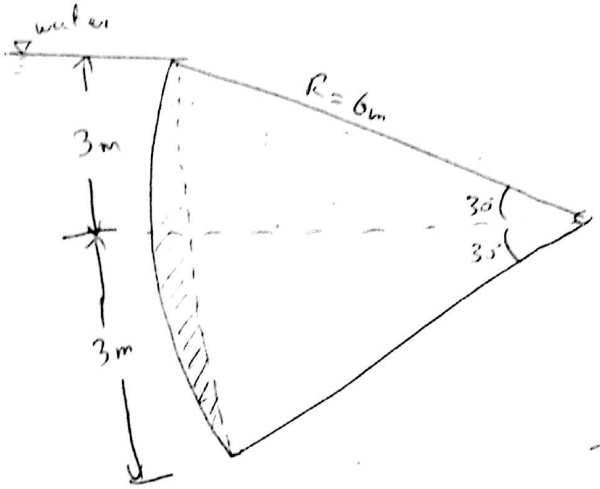
$$F = 874.80\ KN$$

$$\Rightarrow h_p = h_c + \frac{I_c}{h_c A}$$

$$= 4.35 + \frac{69.025}{(4.35)(25)}$$

$$\boxed{h_p = 4.984\ m}$$

Prob 2.55
Data:



Find Force per unit length:

Sol:

$F_x = \gamma h \cdot A$

$= (9810)(3)(6)$

$F_x = 176.58 \text{ KN}$

$F_y = \gamma V$

$= 9810 \times 3.2$

$F_y = 31.339 \text{ KN}$

$\Rightarrow F = \sqrt{F_x^2 + F_y^2}$

$= \sqrt{176.58^2 + 31339^2}$

$\boxed{F = 179.5 \text{ KN}}$

$\Rightarrow \theta = \tan^{-1} \frac{F_y}{F_x}$

$= \tan^{-1} \left(\frac{31.339}{176.58} \right)$

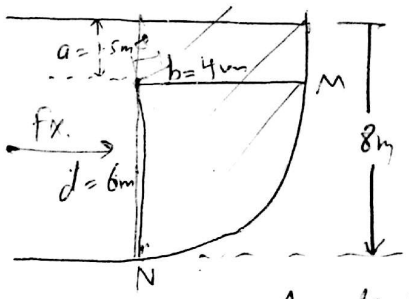
$\boxed{\theta = 10.08^\circ}$ to the horizontal

$\frac{x}{6} = \sin 30^\circ$

Prob 2.56

Solution:

length of tank = 8m



$F_x = \gamma h_c A$ $\quad$ Area = d × l $\quad$ $h_c = 3 + 1.5$

$F_x = (9810)(6)(8)(4.5)$

$F_x = 2118.96\ kN$

$F_y = \gamma V$

$= (9810)(198.72)$

$F_y = 1949.44\ kN$

$F = \sqrt{F_x^2 + F_y^2}$

$\boxed{F = 2879.28\ kN}$

$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right)$

$\theta = 42.61°$

Area of rectangle 4×1.5

For Volume

Area for ellipse $\leftarrow \boxed{A = \frac{\pi bh}{4}} + 6$

$= \frac{\pi(4)(6)}{4} + 6$

$A = 18.84 + 6$

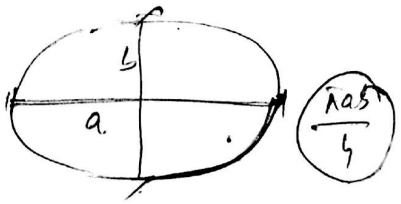
$\boxed{A = 24.84}$

$V = 24.84 \times l$

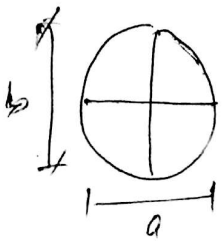
$= 24.84 \times 8$

$\boxed{V = 198.72\ m^3}$

Find centroid of rectangle



$\frac{\pi ab}{4}$



πa^2

Prob 2.57

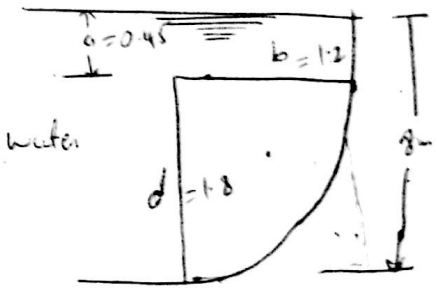
Data:

$a = 0.45m$

$b = 1.2m$

$d = 1.8m$

$l = 8m$



Sol:

$F_x = \gamma h_c A$ → $h_c = 0.9 + 0.45 = 1.35$

$= (9810)(1.35)(1.8 \times 8)$

$\gamma \quad h_c \quad A \quad (d \times l)$

$F_x = 190.706\ kN$

$F_y = \gamma V$

$= (9810)(15.84)$

$F_y = 155.34$

$F = \sqrt{F_x^2 + F_y^2}$

$\boxed{F = 245.99\ kN}$

$\theta = \tan^{-1}\left(\frac{F_y}{F_x}\right)$

$\boxed{\theta = 39.17°}$

Area of parabola

Area of rectangle 0.45×1.2

$Area = \boxed{\frac{2bh}{3}} + 0.54$

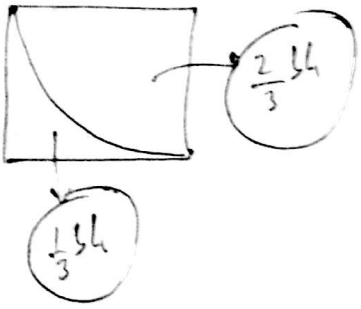
$= \frac{2(1.2)(1.8)}{3}$

$= 1.98\ m^2$

$V = A \times l$

$= 1.98 \times 8$

$= 15.84\ m^3$



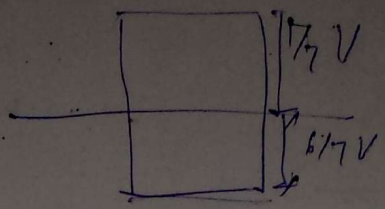
Prob 2.66
Data:

64 pcf

$S =$

$\gamma_{ocean\ water} = 10.05\ kN/m^3$

pure



γV

$W = \gamma_{liq} V_{submerged}$

$\gamma_{ice} V_{ice} = \gamma_{ocean\ water} \times \frac{6}{7} V$

$\gamma_{ice} \times V = 10.05 \times \frac{6}{7} V$

$\gamma_{ice} = 8.61\ kN$

$S = \frac{\gamma_{ice}}{\gamma_{ocean}} = 0.88$

$8.61 \times V = 9.81 \times V_s$

9.81

$0.877 V = V_s$

Submerged = 87.76 %

Above = 12.23 %

2.66

Data:

Vol. of ice berg above surface $= \frac{1}{7}V$ $\quad S = ?$

Sol.

Let "V" be the total volume of iceberg. $\quad 1 - \frac{1}{7} = \frac{6}{7}$

while floating, iceberg is in equilibrium i.e

W = Buoyant Force

$\gamma_{ice} V = (\gamma_w)\left(\frac{6}{7}V\right)$

sea water $\gamma_w = 10.05\ KN/m^3 \Rightarrow$ given

$\gamma_{ice} = 8.61\ KN/m^3$ $\quad S = \gamma_{ice}/\gamma_{water}$

Specific gravity $= S = 8.61/9.81$

$S = 0.877$

$\Rightarrow$ If ice were floating in pure water, then

Let, "x" be the submerged volume of iceberg

γV $\quad \gamma_w V$

$(8.61)(V) = (9.810)(x)$

$x = 0.877V$

Volume above surface $= 1 - 0.877$

$= 0.122\ V$

OR

$= 12.2\%$.

Prob 2.67

Data:

cylinder (d) = 8 mm = 8×10^{-3} m = 4×10^{-3} m (r)

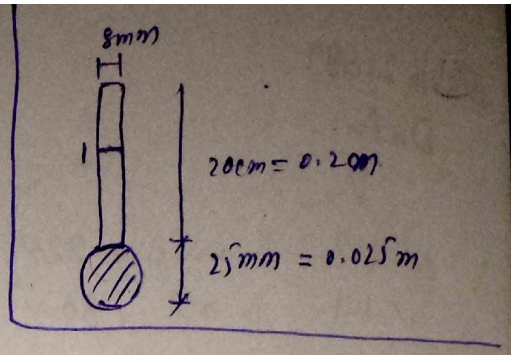
l = 20 cm = 0.2 m

sphere (d) = 25 mm = 0.025 m R = 0.0125 m

mass of cylinder = 1.2 g = 1.2×10^{-3} kg

mass of sphere = 12.8 g = 0.0128 kg

At what level will this device float when 1) S = 0.8 2) S = 1 3) S = 1.2



$W = 1.2 \times 10^{-3} \times 9.81 + 12.8$

$W = 14 \times 10^{-3} \times 9.81$

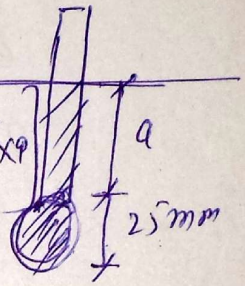
$W = 0.13734\ N$

1) 7848
2) 9810
3) 11772

1) S = 0.8

$W = \gamma V$

$0.13734 = 0.8 \times 9.81 \times \left[\frac{4}{3}\pi \left(\frac{0.025}{2}\right)^3 + \pi \left(\frac{0.008}{2}\right)^2 \times a \right]$



$1.75 \times 10^{-5} =$

$a = 0.185$

$a = 18.5$ cm

Sol:

Weight of hydrometer = (Mass of cylinder + mass of ~~tube~~ sphere) 9.81

$= ((1.2 \times 10^{-3}) + (0.128))\ 9.81$

$W = 1.267\ N$

Case 1

$W = \gamma V$

$1.267 = (7848)\left[\frac{4}{3}\pi (0.0125)^3 + \pi (4 \times 10^{-3})^2 l \right]$

Prob 2.689

Data:

$V = ?$

✓ Wt. in water = 22N

✓ Wt. in oil = 30N

$S = 0.82 \Rightarrow \gamma = 8044.2 N/m^3$

$\gamma_{obj} = ?$

Sol.

In water (object + water)

$W = 22 + (9810)V$ —①

In oil

$W = 30 + (8044)V$ —②

equating ① and ②

$22 + (9810)V = 30 + 8044V$

$V = 4.53 \times 10^{-3} m^3$

Putting in ①

$W = 66.43 N$

$W = \gamma V$

$\gamma = \frac{W}{V} = \frac{66.43}{4.53 \times 10^{-3}} \Rightarrow \gamma = 14666.53 N/m^3$

F_b = Real wt − Apparent

In water

$\gamma_{liq} V_{obj} = W - 22$

$9810V + 22 = W$ ⟶ ②

$V \rightarrow 4.53 \times 10^{-3}$

In oil

$\gamma_{liq} V_{obj} = W - 30$

$W = 8044.2V + 30$ ⟶ ①

Prob 2.70

Data:

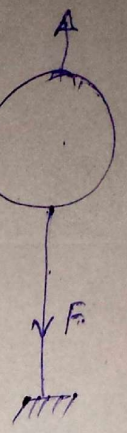
$W = 1100 N$

$V = 400 m^3$

$\gamma_{He} = 1.76 N/m^3$

$\gamma_{air} = 12.7 N/m^3$

$F = ?$



Sol:

Net downward force: balloon + helium (γV)

$= 1100 + (400 \times 1.76)$ — 704

$= 1804 N$

Net upward force (air)

$= 400 \times 12.7$

$= 5080$

Load that it can support $= P$

$P = 5080 - 1804$ — 3957.648

$P = 3276 N$

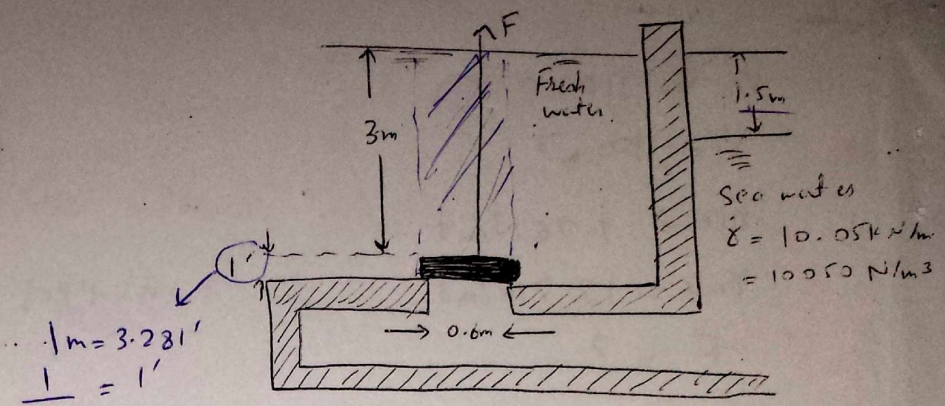
Prob. 2.71

Data:

$\gamma_{concrete} = 24\ kN/m^3$

$= 24000\ N/m^3$

$F = ?$



1m = 3.281'

$\frac{1}{3.281} = 1'$

0.3 m = 1'

Sol:

Net downward 'F' :-

F

(V) × (γ) — γ h A × 1

$= (0.3 \times 0.6 \times 24) + (9.810 \times 3 \times 0.6)$

$= 21.978$

γ × V

$0.6 \times 3 \times 9.81$

$= 17.658$

Net upward 'F' :-

$= F + (10.05 \times 1.8 \times 0.6)$

(γ, A)

$= F + 10.854$

$= 0.6 \times 0.3 \times 1 \times 24$

$= 4.32$

Upward = Downward

$21.978 = F + 19.854$

$F = 2.071\ kN$

5.2