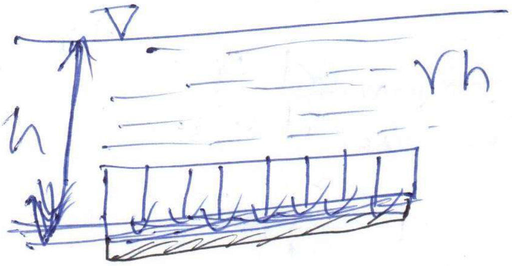
Sp-1

Hydrostatic (pressure) force :-

C.O.P : Centre of pressure

(1) Horizontal plate / plane | laminas



F = Hydrostatic pr. force

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$F = P \times A$

$\boxed{F = \gamma \cdot h \times A}$

$F = \gamma \cdot A \bar{x}$

$h = \bar{x}$

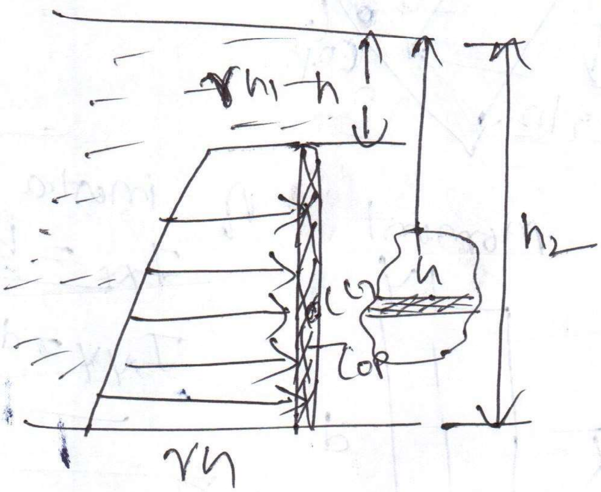
$\bar{x}$ = vertical depth of C.G from free surface

h = vertical depth of C.O.P from free surface

$h = \bar{x}$

	(force) F	h
(horizontal)	$\gamma A \bar{x}$	$\bar{x}$
(vertical)	$\gamma \cdot A \bar{x}$	$\left(\bar{x} + \frac{I_G}{A\bar{x}}\right)$
(inclined)	$\gamma A \bar{x}$	$\left(\bar{x} + \frac{I_G \sin\theta}{A \cdot \bar{x}}\right)$
F_x, F_y		

2) vertical plate :-



$F = P \times A = \int dF = \int P \cdot dA$

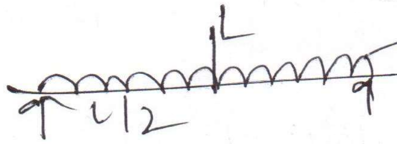
$F = \int \gamma \cdot h \cdot dA$

$F = \gamma \int h \cdot dA$

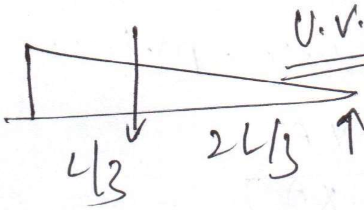
$\int y\, dA = A \bar{x}$

$\int y^2 dA = I_G + A(\bar{x})^2$

$\boxed{F = \gamma \cdot A \bar{x}}$



$\overline{h} > \overline{x}$

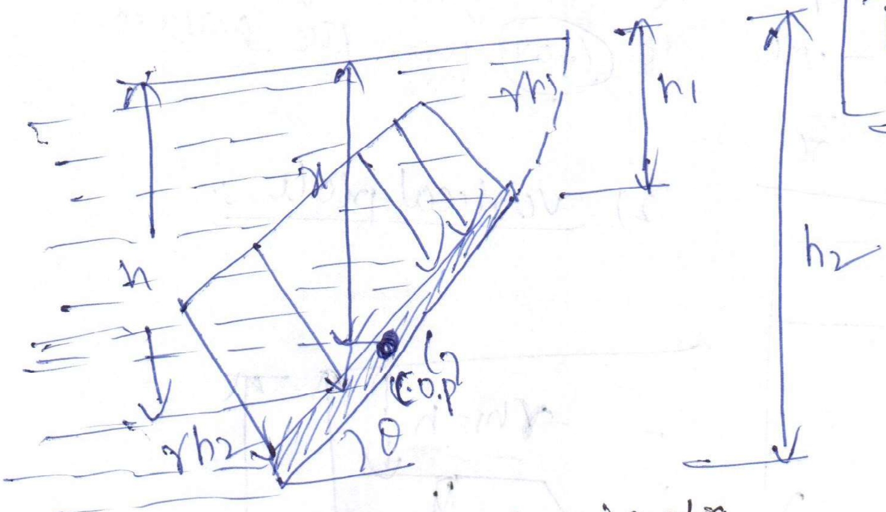


$\longrightarrow \overline{h} = \overline{x} + \left(\frac{I_G}{A\overline{x}}\right)$

I_G = Moment of inertia about C.G

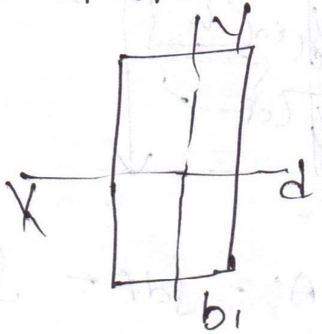
3) Inclined plane

$F = \gamma A \overline{x}$



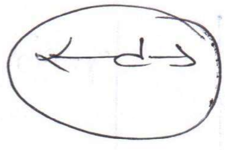
$$\boxed{\overline{h} = \overline{x} + \left(\frac{I_G \sin^2\theta}{A\,\overline{x}}\right)}$$

Note: Moment of inertia



$I_{xx} = bd^3/12$

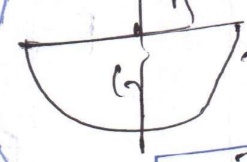
$I_{yy} = db^3/12$



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

$\frac{\pi(d_o^4 - d_i^4)}{64}$

circle $\frac{\pi d^4}{64}$



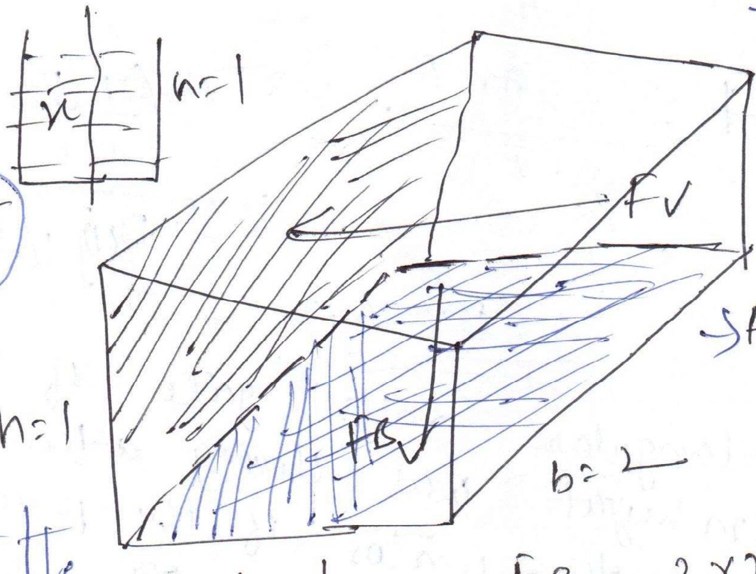
$4R/3\pi$

$I_G = 0.035\pi R^4$

(RSE) An open rectangular container with L : B : H ratio has 1 : 2 : 1 was most completely filled with water then the ratio of hydrostatic force acting at the bottom force to Force acting on any one of its larger vertical phase

Sol:

$A = 1 \times 2$
$\bar{x} = 1$



$\rightarrow F_{Bottom} = \gamma A \cdot \bar{x}$

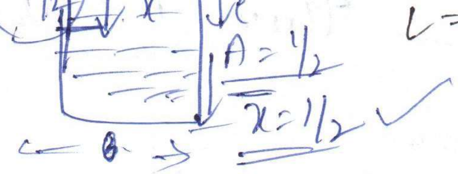
$= \gamma_w \times 1 \times 2 \times 1$

$$\boxed{F_B = 2 \cdot \gamma_w}$$

$\rightarrow F_{vertical} = \gamma_w A \bar{x}$

$= \gamma_w \times 1 \times \cancel{2} \times 1/\cancel{2}$

$$F_v = \gamma_w$$

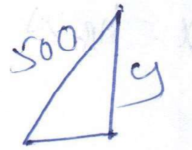


$$\frac{F_B}{F_V} = \frac{2 \times \cancel{\gamma_w}}{\cancel{\gamma_w}} = \boxed{2}$$

Gate-2001 A circular lamina 1000 mm in diameter was lying in water such that distance of its perimeter measured vertically below the free surface is varying from 500mm to 1200mm. Find F & $\bar{h}$? (hydrostatic force | Force from centre pressure)

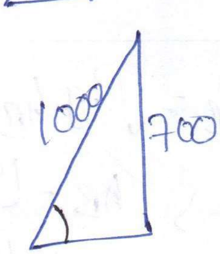
Sol

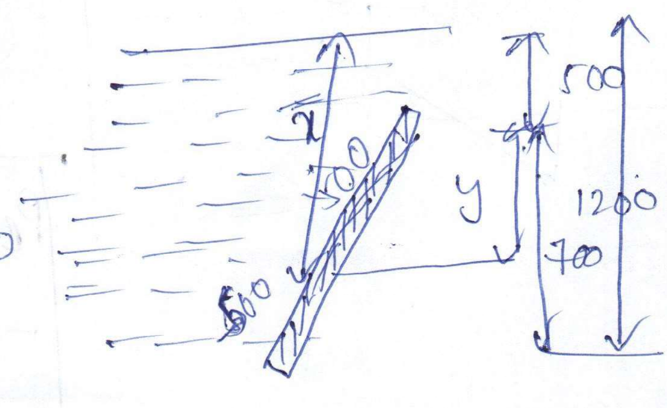
$$\boxed{F = \gamma A \bar{x}}$$



$$\frac{y}{700} = \frac{500}{1000}$$

$y = 350$





$F = \gamma A \cdot \bar{x}$, $\bar{h} = \bar{x} + \left(\frac{I_G \cdot \sin^2\theta}{A \cdot \bar{x}}\right)$

$\gamma = \gamma_w = 9810$ $\quad A = \pi R^2$

$\bar{x} = 500 + y = 500 + 350 = 850\,mm = 0.85\,m$

$\boxed{\sin\theta = \frac{700}{1000} = 0.7}$

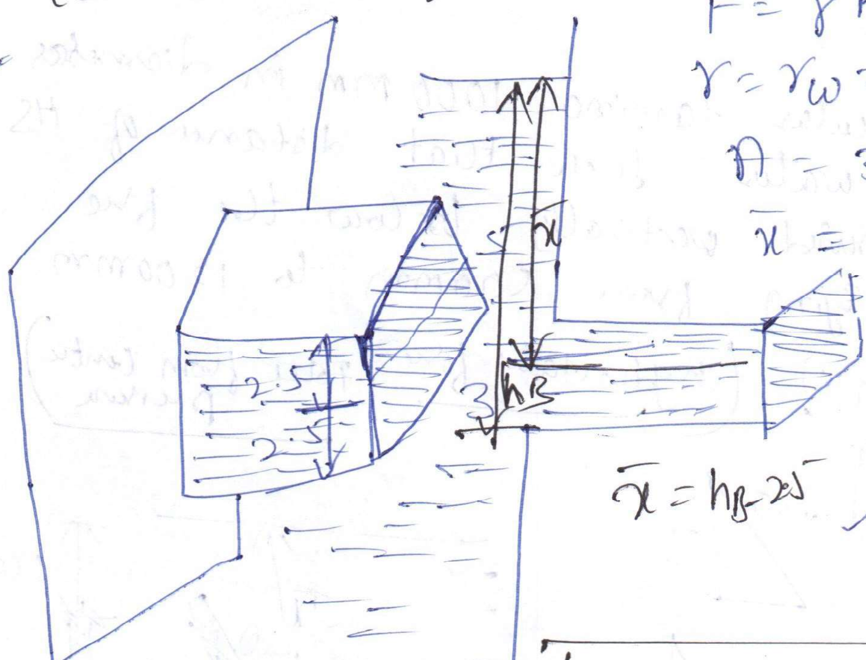
$F = 9810 \times \frac{\pi}{4} \times 1^2 \times 0.85 = 6.55\,kN$

$\bar{h} = \bar{x} + \frac{I_G \cdot \sin^2\theta}{A \cdot \bar{x}} = 0.85 + \frac{\left(\frac{\pi(1^4)}{64}\right) \times (0.7)^2}{\left[\frac{\pi(1)}{4}\right] \times 0.85}$

$\bar{h} = 0.886\,m$

105 A vertical rectangular lock gate of 3m wide and 5m height was closing a tunnel running full with water if the pressure at the bottom of gate 195 kN/m² Then $(F = ?)$

Sol.



$F = \gamma A \bar{x}$

$\gamma = \gamma_w = 9810\,N/m^3$

$A = 3 \times 5\,m^2$

$\bar{x} = h_B - 2.5$

$\bar{x} = 19.87 - 2.5$

$\bar{x} = 17.37\,m$

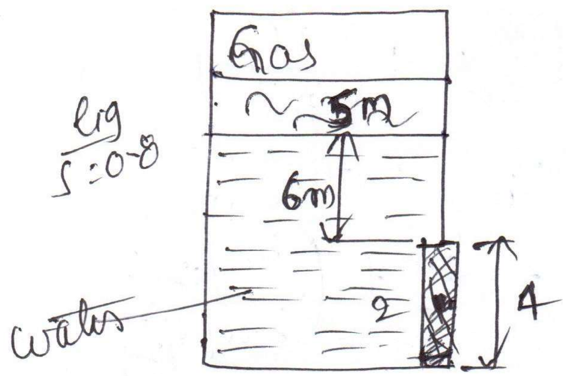
$\bar{x} = h_B - 2.5$

$F = 9810 \times 3 \times 5 \times 17.37$

$= 2.55\,MN$

$\boxed{P_B = \rho \cdot g\, h_B \quad \rightarrow h_B = \frac{195 \times 10^3}{10^3 \times 9.81} = 19.87\,m}$

Per unit width



(1) $F = \gamma A \bar{x}$; $\gamma = \gamma_w$, $A = 4 \times 1\,m^2$

$\rightarrow \bar{x} = 2 + 6 = 8\,m$

(2) $F = \gamma A \bar{x}$, $\gamma = \gamma_w$, $A = 4 \times 1$

$\rightarrow \bar{x} = (2+6) + 5_{s=0.8} = \cancel{X}$

$= 8_w + 0.8\,5_w = 12$ m of water

$S_1 h_1 = S_2 h_2$

$h_w = S_{liq} \times h_{liq}$

(3) $F = \gamma A \bar{x}$

$\gamma = \gamma_w$, $A = 4 \times 1$

1.01 bar → 10.3 m
5 bar = x m

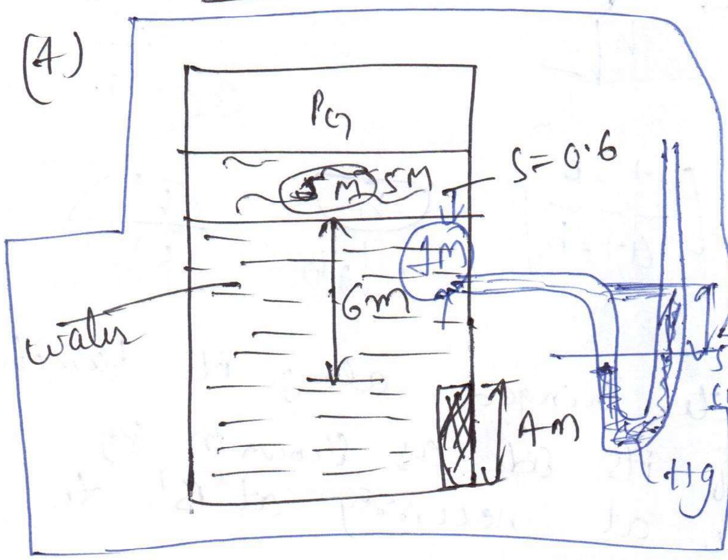
$\rightarrow \bar{x} = (2+6)_w + 5_{s=0.8} + P_G\,(5.0\,bar)$

$= 8_w + (0.8 \times 5)_w + \left(\frac{10.3}{1.0132} \times 5.0\right)$

$\bar{x} = (2+6)_w + (0.8 \times 5) + 50.99$

$\bar{x} = \underline{62.99\,m}$

(4)



F = ? → pressure of the gas = ?

$= \gamma A \bar{x}$

$\gamma = \gamma_w$

$A = 4 \times 1$

$\bar{x} =$

$P_G + 5_{s=0.6} + 1.5_w = \cancel{P_{atm}}^{0} + 0.5_{Hg}$

$F = ? = \gamma A \bar{x}$, $A = 4 \times 1$

$\bar{x} = ?$

$\bar{x} = (2+6)_w + 5_{s=0.6} + P_G$

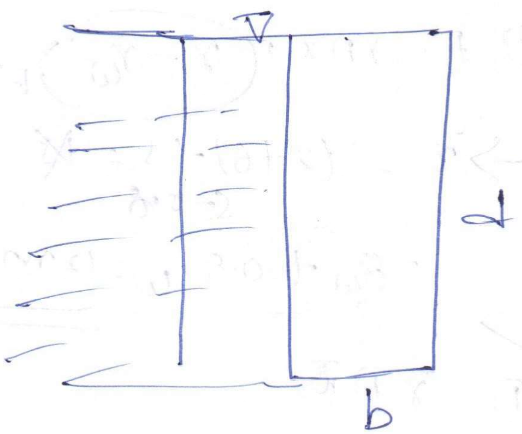
$= 6.5_w + (1.5_w + 5_{s=6} + P_G)$

$= 6.5_w + 0.5_{Hg}$

$\bar{x} = 6.5_w + 13.6 \times 0.5_w$

$\bar{x} = 6.5 + 6.8 \Rightarrow \underline{13.3}$ m of water

Standard Cases (centre of pressure) C.O.P ($\bar h$)



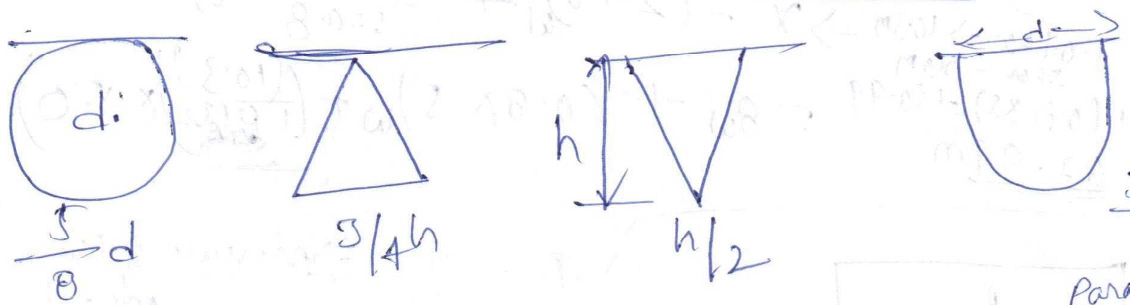
$$\bar h = \bar x + \left(\frac{I_G}{A\bar x}\right)$$

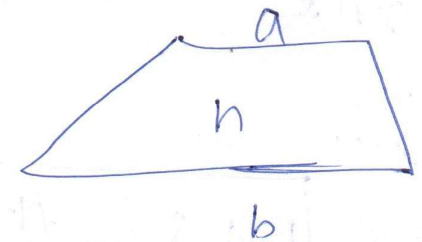
$$\bar h = \bar x + \left(\frac{I_G}{A\bar x}\right)$$

$$= \frac{d}{2} + \left(\frac{bd^3/12}{b\cdot d\,(d/2)}\right)$$

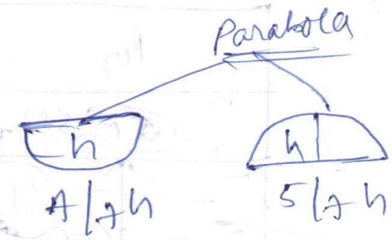
$$= 2d/3$$

$$\bar h = 2d/3$$





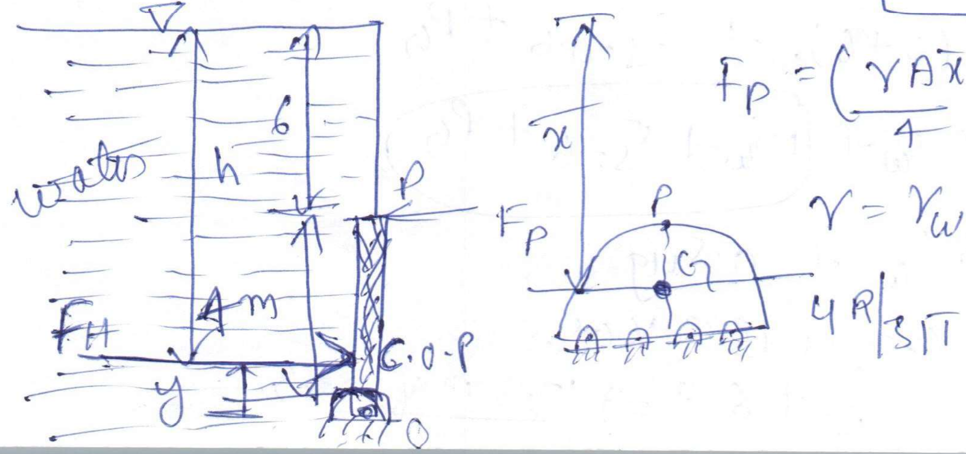
$$\frac{h}{2}\left[\frac{a+3b}{a+2b}\right]$$



Ex 1 A Semi circular gate hinged along its diameter with water on of its side, as shown in fig. Find the force at necessary at 'B' to keep the gate vertical.

$$\Sigma M_O = 0$$

$$\boxed{F_P \times 4 = F_H \times y}$$



$$F_P = \left(\frac{\gamma A \bar x}{4}\right) \times y$$

$$\gamma = \gamma_w, \quad A = \frac{\pi \cdot 4^2}{2}$$

$\boxed{F_p \times 4 = F_H \times y}$ $F_p = \dfrac{(\gamma A \bar{x}) \times y}{4}$

$\gamma = \gamma_w \, , \; A = \dfrac{\pi 4^2}{2}$

$\bar{x} = 10 - \dfrac{4R}{3\pi} = 10 - \dfrac{4 \times 4}{3\pi} = 8.3\,m$

Total distance (10) $y = 10 - \bar{h} \, ; \; \bar{h} = \bar{x} + \dfrac{I_G}{A\bar{x}}$

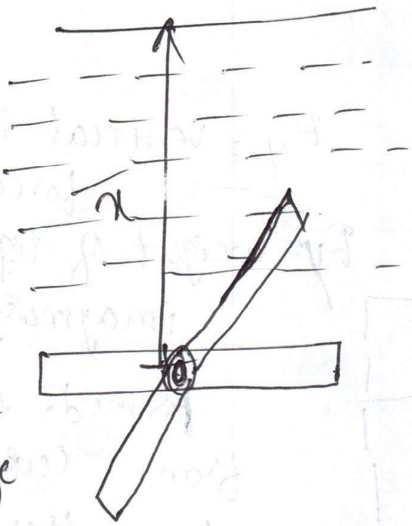
$\bar{h} = \dfrac{8.3 + 0.035\pi R^4}{(\pi R^2/2)\, 8.3} = 8.43\,m$

$y = 10 - \bar{h} = 10 - 8.43 = 1.57\,m$

$F_p = \dfrac{9810 \times \left(\frac{\pi \times 4^2}{2}\right) \times 8.3 \times 1.57}{4}$

$F_p = 800\,kN$

Gate 16



Centre of gravity is on centre so that no change

$F_1 = 11\,N$

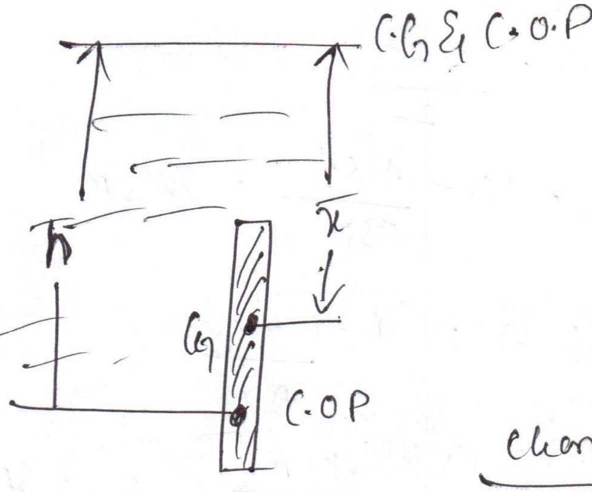
$= 45^0$

$F_2 = ?$

$F_2 = 11\,N$

$\gamma A \bar{x}$

E.Q

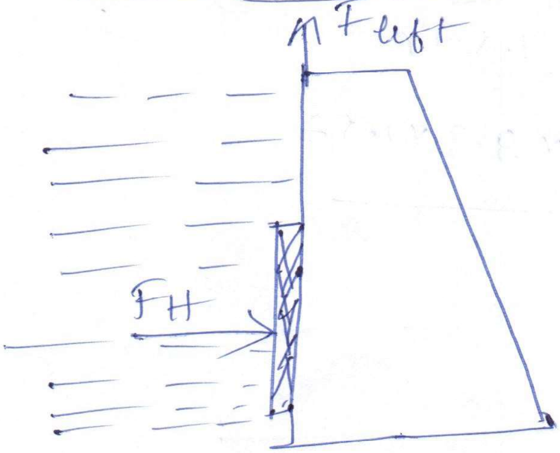


$$\bar{h} = \bar{x} + \frac{I_G}{A \cdot \bar{x}}$$

$$\bar{h} - \bar{x} \downarrow = \frac{I_G}{A \cdot \bar{x}} \uparrow \quad C$$

changes the $\bar{x}$

* μ = coefficient of friction



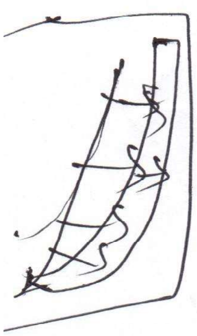
$F_{lift} = W + \mu F_H$

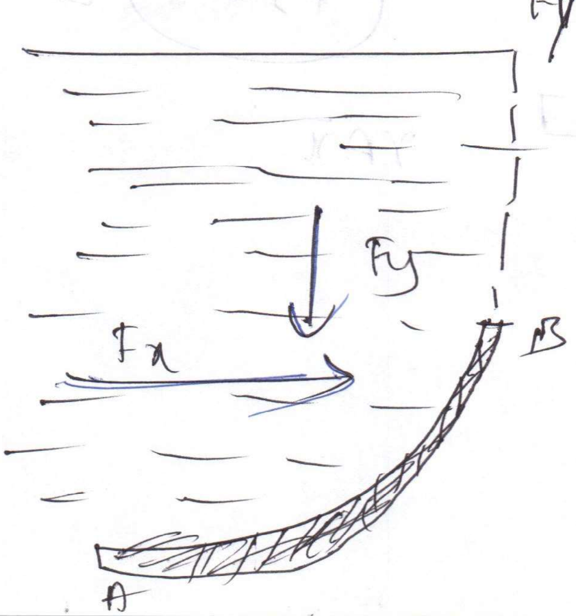
W = weight

F_H = Hydrostatic force

(4) case

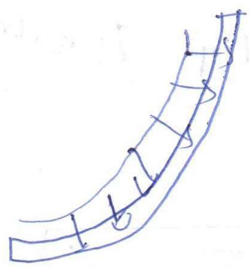
Curved surface :-



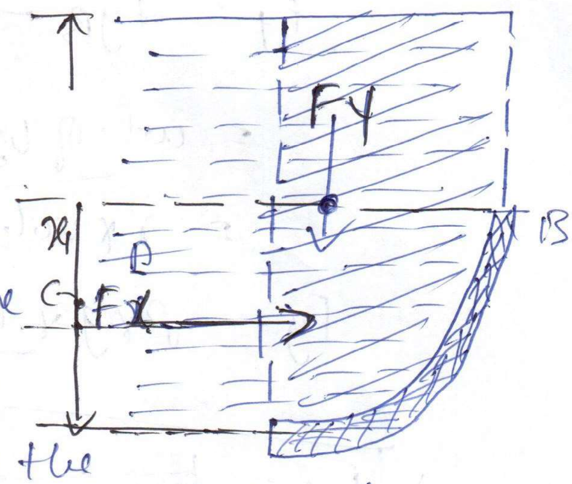


F_y = vertical hyd. stc. pressure force

F_y = weight of liquid in the imaginary volume formed extending from curved surface till free surface



Force is different



F_y = vertical hyd. static pressure force

F_y = weight of liquid in the imaginary volume formed ~~externally~~ extending from curved surface till free surface & will be acting through C.G of imaginary volume

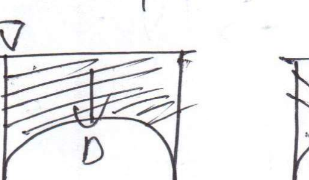
F_x = Horizontal hyd. static pressure force

F_x = Net hyd. static ~~pr~~ force on vertically projected area of the curved surface.

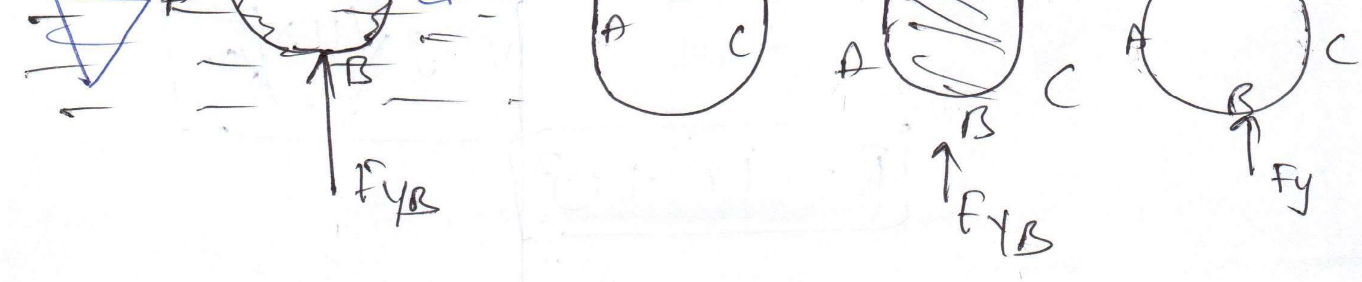
$F_x = \gamma A \bar{x}$

$\bar{h} = \bar{x} + (I_G / A\bar{x})$

Cylinder in water :-



$F_y = F_{yT} - F_{yB}$



$F_y = F_{yB} - F_{yT}$ T=Top & Bottom

$= $ wt. of liq ABCD. Cylinder

$= \gamma \times$ volume

$\boxed{R = \sqrt{F_x^2 + F_y^2}}$

$F_y = \rho \times g \times \frac{\pi d^2}{4} \times L$

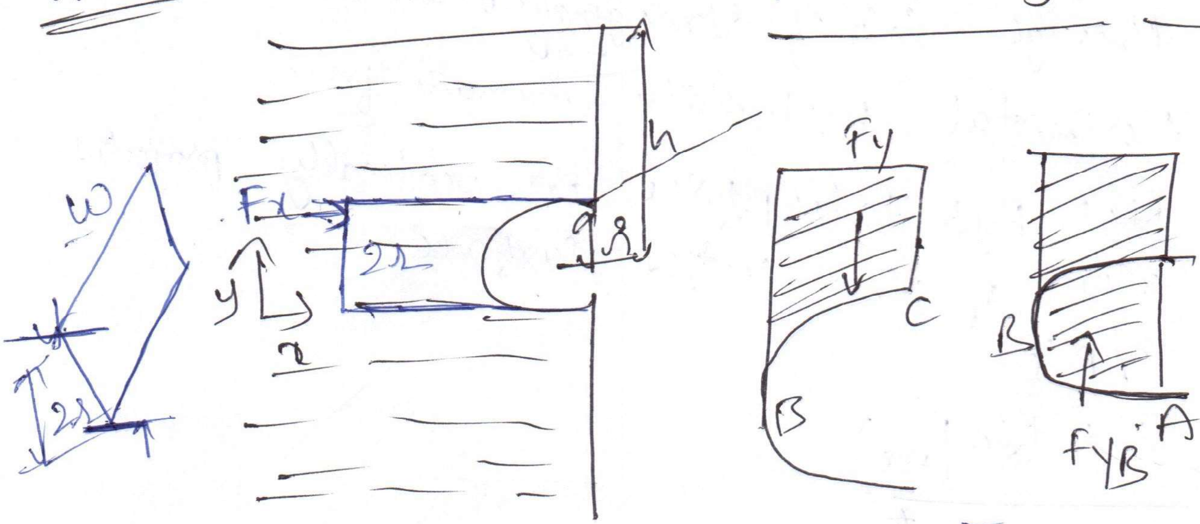
$\rightarrow \boxed{F_x = F_{xR} = \gamma A \bar{x}}$

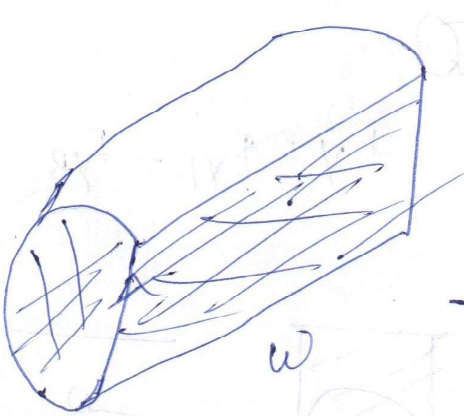
$\boxed{F_x = \cancel{F_{xL}} - \cancel{F_{xR}} = 0}$

$\boxed{R = \sqrt{F_x^2 + F_y^2}}$

Gate : 16

Find F_x & F_y width w?





$\rightarrow F_x = \gamma A \bar{x}$

$= \rho \times g (2 r w) h$

$= \boxed{2 \rho \times g \cdot h r w}$

$\rightarrow F_y =$ wt. of liquid in ABC

$= \gamma \times$ vol of semi cylinder

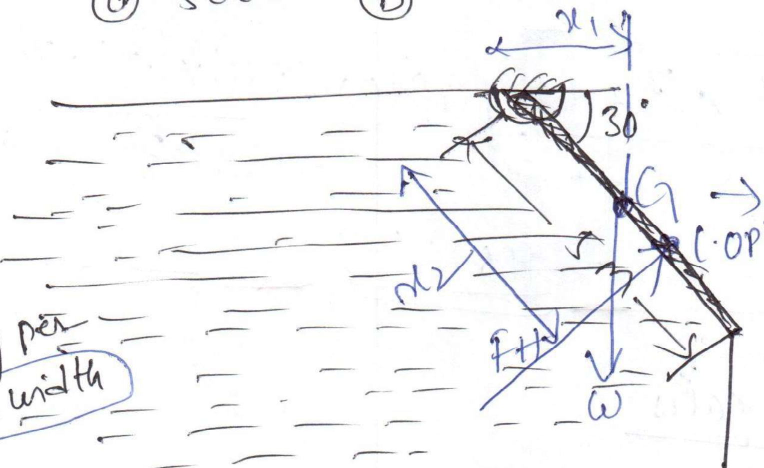
$= \boxed{\rho \times g \times \left(\frac{\pi r^2}{2}\right) \times w}$

$\boxed{R = F_x^2 + F_y^2}$

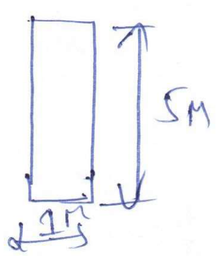
Gate 13 A Rectangular ~~is~~ hinged gate of 5 m length inclined at 30° with water mass on its left as shown in the figure. ~~Fig~~ Find the minimum mass of the gate in kg/meter width ⊥ lar plane of paper required to keep it closed?

(a) 5000 (b) 6600 (c) 7546 (d) 9623

fig.



$\Sigma M_0 = 0$ (moments)



$$\boxed{W \times x_1 = F_H \times x_2}$$

$\Rightarrow m \times g \times x_1 = (\gamma A \bar{x}) \times x_2$

$$m = \frac{(\gamma A \bar{x}) \cdot x_2}{g \cdot x_1}$$

$$\boxed{M = \frac{(\gamma A \bar{x}) \cdot x_2}{g \cdot x_1}}$$

$\gamma = \gamma_w = 9810$

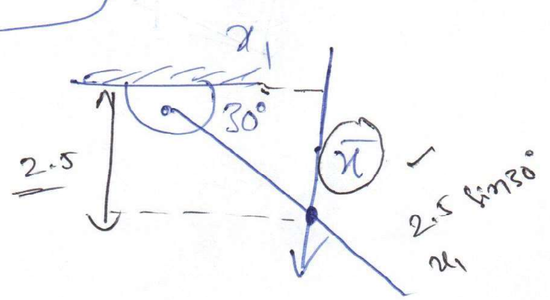
$A = 5 \times 1 m^2$

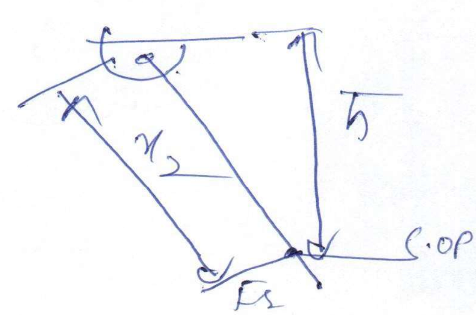
$\bar{x} = 2.5 \sin 30°$

$= 1.25 m$

$x_1 = 2.5 \cos 30°$

$$\boxed{x_2 = \frac{h}{\sin 30°}}$$





$$\bar{h} = \bar{x} + \frac{I_G \sin^2\theta}{A\bar{x}} = \frac{1.25 + \left(\frac{1\times 5^3}{12}\right)(\sin 30)^2}{5\times 1\times 1.25}$$

$$= \underline{1.667\ m}$$

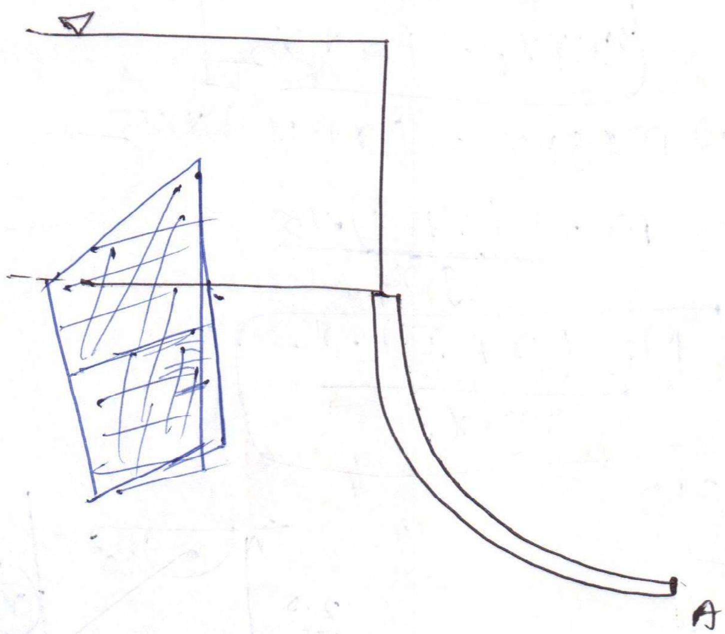
$$x_2 = \frac{h}{\sin 30} = 3.334$$

$$m = \frac{(\gamma \cdot A\bar{x}) \cdot x_2}{g \cdot x_1} \Rightarrow \frac{9810\times(5\times 1)\times 1.25\times 3.334}{9.81\times 2.5\cos 30}$$

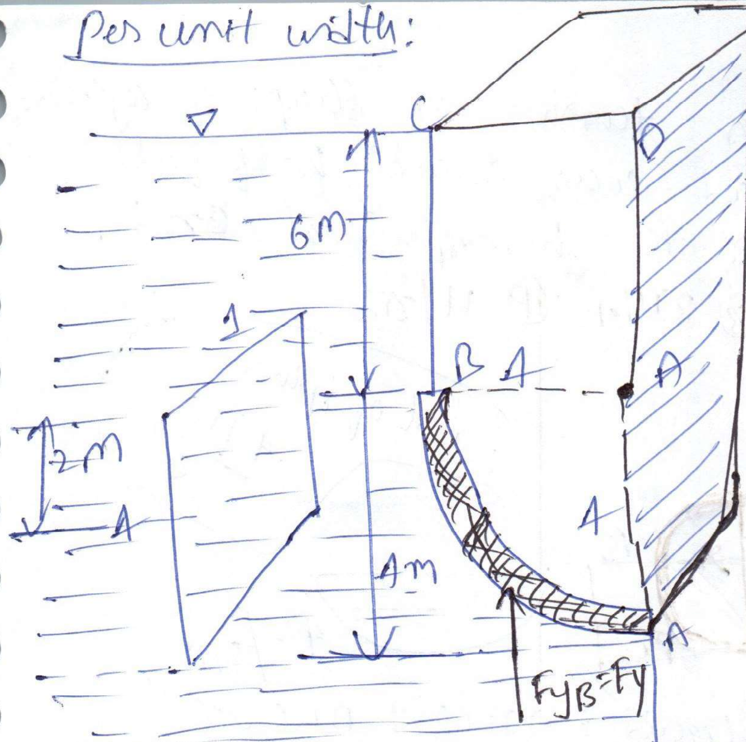
$$= \underline{9623\ kg}$$

28/6/17

Dock gates



Per unit width:



$F_x = \gamma A \bar{x}$

$\gamma = \gamma_w$

$A = 4 \times 1$

$\bar{x} = 2 + 6 = 8$

$F_x = \gamma A \bar{x}$

$1000 \times 9.81 \times 4 \times 8$

$= 313920$

$= 0.31 \, N/m^2 \times 10^{-3}$

$0.3 \times 10^{-3} \, kN/m^2$

F_y = wt of liq in imaginary vol ABCDA

$= \gamma \times vol_{ABCDA}$

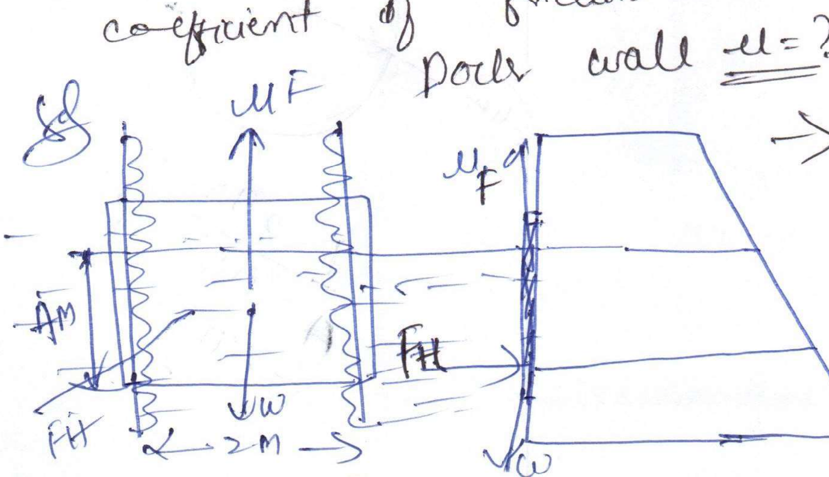
$= \gamma_w \times (\text{Area} \times \text{width})$

$= 9810 \times \left[4 \times 6 \times \frac{\pi \cdot 4^2}{4}\right] \times 1$

$F_y = \cancel{2958626}$ $\underline{2957.126} = \underline{2.9 \times 10^{-3} \, kN/m^2}$

(1) A vertical dock gate of 2m wide Remains its in position because water on of its side if the weight of the gate is 800 kg and just started sliding downwards when the level of the water from the bottom of the gate reaches to 4M then the coefficient of friction b/w ~~top~~ Dock gate & Dock wall $\mu = ?$

Sol



$\rightarrow W = \mu \cdot F_H = \mu \cdot \gamma A \bar{x}$

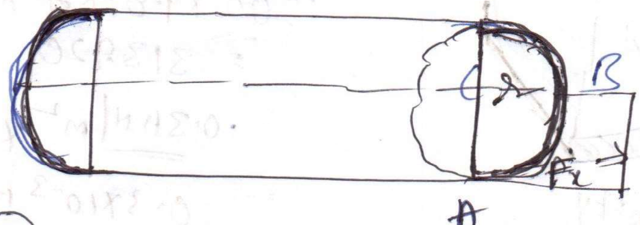
$800 \times g = \mu \cdot 10^3 \times g \times 4 \times 2 \times 2$

$\mu \; 1/20 = 0.05$

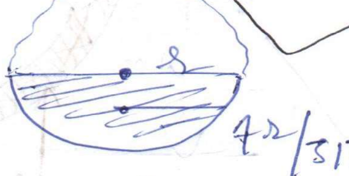
(IAS) 2) A horizontal water tank in shape of cylinder with hemispherical head was exactly half full. Find F_x / F_y on one of its hemispherical end.

(1) π (2) $2/\pi$ (3) $3\pi/4$ (4) $4/3\pi$

Sol:



$\because$ vol of sphere $\frac{4\pi r^3}{3}$



$A = \pi r^2$

F_y = wt of the liquid imaginary ABC vol

$= \gamma \times vol = \gamma \times \frac{1}{4}\left(\frac{4}{3}\pi r^3\right)$

$F_y = \gamma \pi r^3/3 \rightarrow F_y = \gamma \pi \cdot r^3/3$

$F_x = 2\gamma \cdot r^3/3 \rightarrow F_x = \gamma \frac{\pi r^2}{2} \times 4r/3\pi = \frac{2\gamma \cdot r^3}{3}$ ✓

$\frac{F_x}{F_y} = \frac{\frac{2\pi r^3}{3}}{2\gamma \cdot \pi \cdot r^3/3} = \frac{2\pi r^3}{3} \times \frac{3}{\gamma \cdot \pi r^3} = \frac{2}{\pi}$

$\frac{F_x}{F_y} = \frac{2\gamma r^3/3}{\gamma \cdot \pi \cdot (r^3/3)} = \frac{2}{\pi}$ ✓

$P = 2\pi r$

$A = \pi r^2$

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