Q. 1

Wednesday, January 13, 2021
11:11 AM

Determine the total pressure on a circular plate of diameter 1.5 m which is placed vertically in water in such a way that the centre of the plate is 2 m below the free surface of water. Find the position of centre of pressure also.

Given Data

$D = 1.5 m$

$\bar{h} = 2.0 m$

$\rho = 1000 \; kg/m^3$

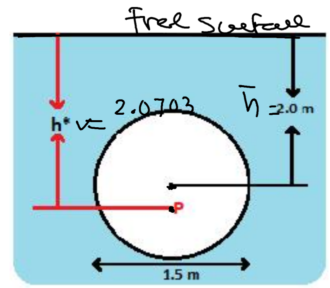
$g = 10 \; m/s^2$

Pressure force on surface

$F = \rho g A \bar{h}$

$= 1000 \times 10 \times \pi/4 \, (1.5)^2 \times 2$

$\boxed{F = 3.54 \times 10^4 \, N}$



Centre of pressure (h^*)

$I_G = \pi/64 \, D^4$

$= \pi/64 \, (1.5)^4$

$= 0.248 \; m^4$

$h^* = \dfrac{I_G}{A\bar{h}} + \bar{h}$

$h^* = \dfrac{0.248}{1.767 \times 2} + 2 = 0.0703 + 2$

$\boxed{h^* = 2.0703 \, m}$

Q.1

Friday, January 15, 2021
10:40 AM

A rectangular plate 3m X 5m is immersed vertically in water such that the 3m side is parallel to the water surface. Determine the hydrostatic force and the depth of centre of pressure if the top edge of the plate is 2m below water surface.

Given Data

$A = 3 \times 5 = 15\,m^2$

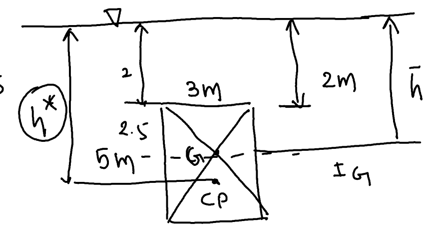
$I_G = \frac{bd^3}{12} = \frac{3 \times 5^3}{12} = 31.25\,m^4$

$\rho = 1000\,kg/m^3$

$g = 10\,m/s^2$

$\bar{h} = 2 + 2.5$

$= 4.5\,m$



Total Pressure force

$F = \rho g A \bar{h}$

$= 1000 \times 10 \times 15 \times 4.5$

$= 675 \times 10^3\,N$

$= 675\,kN$

Centre of Pressure h^*

$h^* = \frac{I_G}{A\bar{h}} + \bar{h}$

$= \frac{31.25}{15 \times 4.5} + 4.5$

$= 4.962\,m$ ✓

Q-2

A rectangular plane surface 2 m wide and 3 m high immerged in water, it plan is making an angle 45 with the free surface of water. The upper edge of rectangular plate is 1.5 m below the free surface. Calculate the position of center of pressure.

Given Data

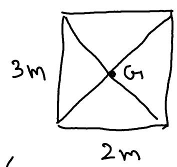
$A = 3 \times 2 = 6\ m^2$

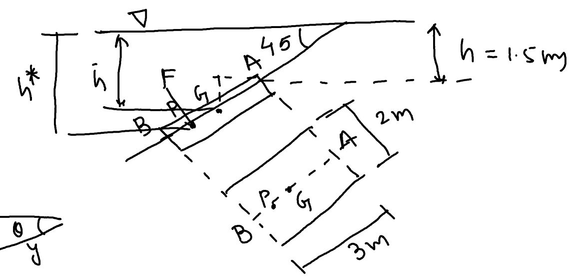
$\bar{h} = 1.5 + AG \sin\theta$

$= 1.5 + 1.5 \sin 45$

$= 2.56\ m$

$I_G = \frac{bd^3}{12} = \frac{2 \times 3^3}{12} = 4.5\ m^4$



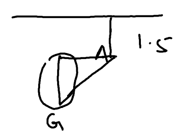


(i) Total Pressure Force

$F = \rho g A \bar{h}$

$= 1000 \times 10 \times 6 \times 2.56$

$= 150.72\ KN$



(ii) Centre of pressure (h^*)

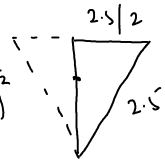
$h^* = \frac{I_G \sin^2\theta}{A\bar{h}} + \bar{h} = \frac{4.5 \times (\sin 45)^2}{6 \times 2.56} + 2.56$

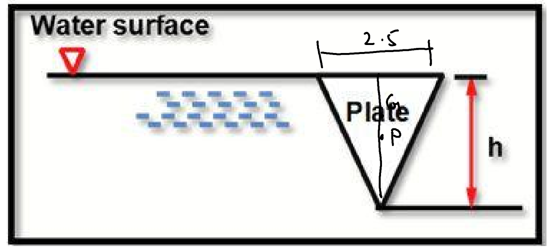
$= 2.707\ m$

Q.3

An equilateral triangular plate having 2.5 m side is immersed in water with its base coinciding with the free surface. Calculate total force and center of pressure if, i) the plate is vertical and, ii) angle of inclination of the plate with the free surface is 60.

Case(I)





$h = \sqrt{(2.5)^2 - \left(\frac{2.5}{2}\right)^2}$

$= 2.165\,m$

$\bar{h} = h/3 = 2.165/3 = 0.72\,m$

$A = \frac{1}{2} \times b \times h = 1/2 \times 2.5 \times 2.165 = 2.706\,m^2$

$I_G = \frac{bh^3}{36}$

$= \frac{2.5 \times (2.16)^3}{36}$

$= 0.7047\,m^4$

Total Pressure (F)

$F = \rho g A \bar{h}$

$= 1000 \times 10 \times 2.706 \times 0.72$

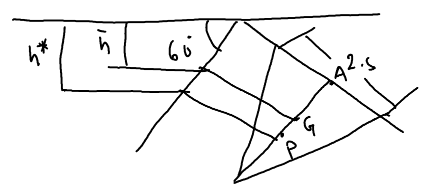
$= 19.11\,KN$

Centre of Pressure (h^*)

$h^* = \frac{I_G}{A\bar{h}} + \bar{h}$

$= \frac{0.7047}{2.706 \times 0.72} + 0.72 \Rightarrow h^* = 1.082\,m$

Case-II



$\bar{h} = \bar{y} \sin\theta$

$= 0.72 \sin 60$

$= 0.623\,m$

Total Pressure Force

$F = \rho g A \bar{h}$

$= 1000 \times 10 \times 2.706 \times 0.623$

$= 16.53\,KN$

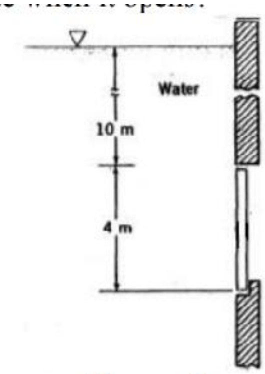
Centre of Pressure

$h^* = \frac{I_G \sin^2\theta}{A\bar{h}} + \bar{h}$

$= \frac{(0.7047)(\sin 60)^2}{2.706 \times 0.623} + 0.623$

$h^* = 0.936\,m$

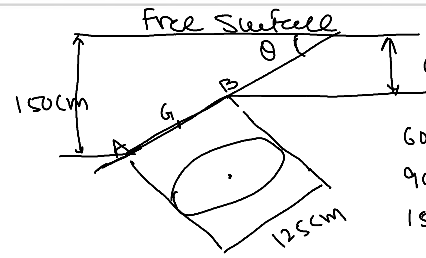
A rectangular gate that is 2 m wide is located in the vertical wall of a tank containing water as shown in figure.2. It is desired to have the gate open automatically when the depth of water above the top of the gate reaches 10 m. (a) At what distance “d” should the frictionless horizontal shaft be located? (b) What is the magnitude of the force on the gate when it opens?

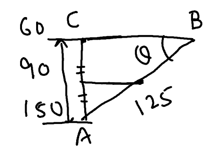


Friday, January 15, 2021
10:37 AM

Q. 4

A circular lamina 125 cm in diameter is immersed in water so that the distance of it's edge measured vertically below the free surface varies 60cm to 150 cm. Find the total force due to water on one side of the lamina,and the vertical distance of the center of pressure below the water surface.





$A = \pi/4\, d^2$

$= \pi/4 \times (1.25)^2$

$= 1.22\ m^2$

$I_G = \pi/64\, d^4$

$= 0.119\ m^4$

$\bar{h} = h_1 + \frac{AC}{2}$

$= 60 + \frac{90}{2}$

$= 1.05m$

$\Delta ABC \quad \sin\theta = \frac{AC}{AB}$

$\sin\theta = \frac{150-60}{125} = 0.72$

$\theta = 46.05°$

Total Pressure (F)

$F = \rho g A \bar{h}$

$= 1000 \times 10 \times 1.22 \times 1.05$

$\boxed{= 12640.61\ N}$

Centre of Pressure (h^*)

$h^* = \frac{I_G \sin^2\theta}{A\bar{h}} + \bar{h} = \frac{0.11 \times (\sin 46.05)^2}{1.22 \times 1.05} + 1.05 \Rightarrow \boxed{h^* = 1.098m}$