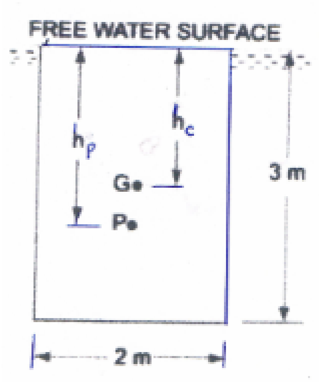
Problems of chapter Three

Dr.Abdulkareem A. Wahab

Problem 3.1 /

A rectangular plane surface is 2 m wide and 3 m deep. It lies in vertical plane in water. Determine the total pressure and position of center of pressure on the plane surface when its upper edge is horizontal and (a) coincides with water surface, (b) 2.5 m below the free water surface.

Solution:



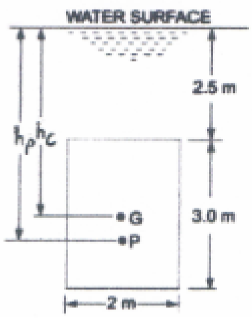
(a) Area (A) = 2 × 3 = 6 m^2 , $h_c = \frac{1}{2} \times 3 = 1.5$ m

$F = \rho\, g\, A\, h_c$, F = 1000 × 9.81 × 6 × 1.5 = 88290 N

$h_p = \frac{I_G}{A\, h_c} + h_c$, $I_G = \frac{b\, d^3}{12} = \frac{2 \times 3^3}{12} = 4.5$ m^4

$h_p = \frac{4.5}{6 \times 1.5} + 1.5 = 0.5 + 1.5 = 2$ m

(b)



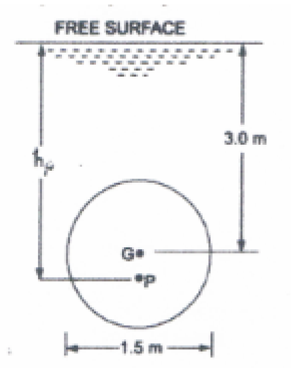
$h_c = 2.5 + \frac{3}{2} = 4$ m , $F = \rho\, g\, A\, h_c$ = 1000×9.81×6×4 = 235440 N

$$h_p = \frac{I_G}{A h_c} + h_c \quad , \quad h_p = \frac{4.5}{6 \times 4} + 4 = 0.1875 + 4 = 4.1875 \text{ m}$$

Problem 3.2 /

Determine the total pressure force on a circular plate of diameter 1.5 m which is placed vertically in water in such a way that the center of the plate is 3 m below the free surface of water. Find the position of center of pressure also.

Solution:



$$A = \frac{\pi}{4} \times (1.5)^2 = 1.767 \text{ m}^2 \quad , \quad h_c = 3 \text{ m}$$

$$F = \rho\, g\, A\, h_c = 1000 \times 9.81 \times 1.767 \times 3 = 52002.81 \text{ N}$$

$$h_p = \frac{I_G}{A h_c} + h_c \quad , \quad I_G = \frac{\pi\, d^4}{64} = \frac{\pi\,(1.5)^4}{64} = 0.2485 \text{ m}^4$$

$$h_p = \frac{0.2485}{1.767 \times 3} + 3 = 0.0468 + 3 = 3.0468 \text{ m}$$

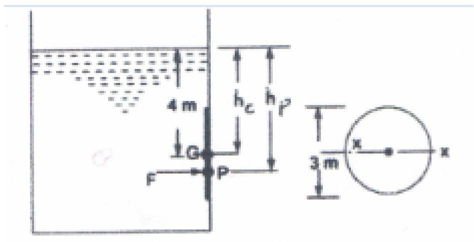
Problem 3.3 /

A circular opening, 3 m diameter, in a vertical side of a tank is closed by a disc of 3 m diameter which can rotate about a horizontal diameter, calculate (1) the force on the disc, (2 when the head of water above the horizontal diameter is 4 m, what is the value of center pressure (h_P)?

Solution:

$$(1) \quad \text{Area}(A) = \frac{\pi}{4} d^2 = \frac{\pi}{4} \times (3)^2 = 7.068 \text{ m}^2 \quad , \quad h_c = 4 \text{ m}$$

$$F = \rho\, g\, A\, h_c = 1000 \times 9.81 \times 7.068 \times 4 = 277368 \text{ N}$$



(2)

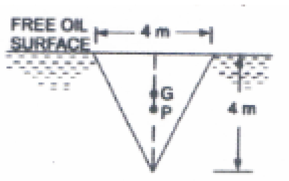
$$h_p = \frac{I_G}{A\,h_c} + h_c \quad , \; I_G = \frac{\pi}{64} d^4 = \frac{\pi}{64} \times 3^4 = 3.974 \;\; m^4$$

$$h_p = \frac{3.974}{7.068 \times 4} + 4 = 0.14 + 4 = 4.14 \text{ m}$$

Problem 3.4 /

Determine the total pressure force and center of pressure on an isosceles triangular plate of base 4 m and altitude 4 m, when its immersed vertically in an oil of sp. gr. 0.9. The base of the plate coincides with the free surface of oil.

Solution :



$$\text{Area (A)} = \frac{b \times h}{2} = \frac{4 \times 4}{2} = 8 \;\; m^2 \quad , \; h_c = \frac{1}{3} h = \frac{1}{3} \times 4 = 1.33 \text{ m}$$

$$F = \rho\, g\, A\, h_c = 0.9 \times 1000 \times 9.81 \times 1.33 = 9597.6 \quad N$$

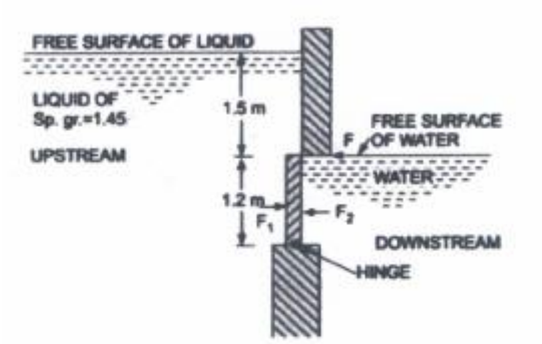
$$h_p = \frac{I_G}{A\,h_c} + h_c \quad , \; I_G = \frac{b\,h^3}{36} = \frac{4 \times 4^3}{36} = 7.11 \; m^4$$

$$h_p = \frac{7.11}{8 \times 1.33} + 1.33 = 0.666 + 1.33 = 1.99 \;\; m$$

Problem 3.5 /

A vertical sluice gate is used to cover an opening in a dam. The opening is 2 m wide and 1.2 m high. On the upstream of the gate, the liquid of sp.gr. 1.45, lies up to a height of 1.5 m above the top of the gate, whereas on the downstream side the water is available up to height touching the top of the gate. Find the resultant force acting on the gate and position of center of pressure.

Solution:



(1)

Area (A) = b × d = 2 × 1.2 = 2.4 m^2

For liquid : $h_{cL} = 1.5 + \frac{1.2}{2} = 2.1$ m

$F_1 = \rho_L\, g\, A\, h_{cL} = 1{,}45 \times 1000 \times 9.81 \times 2.4 \times 2.1 = 71691$ N

$h_{pL} = \frac{I_G}{A\, h_{cL}} + h_{cL}$, $I_G = \frac{b\, d^3}{12} = \frac{2 \times 1.2^3}{12} = 0.288\ m^4$

$h_{pL} = \frac{0.288}{2.4 \times 2.1} + 2.1 = 0.0571 + 2.1 = 2.1571$ m

For water : $h_{cw} = \frac{1}{2} \times 1.2 = 0.6$ m

$F_2 = \rho_w\, g\, A\, h_{cw} = 1000 \times 9.81 \times 2.4 \times 0.6 = 14126$ N

$h_{pw} = \frac{I_G}{A\, h_{cw}} + h_{cw}$, $h_{pw} = \frac{0.288}{2.4 \times 0.6} + 0.6 = 0.2 + 0.6 = 0.8$ m

Resultant force on the gate (R) = $F_1 - F_2 = 57565$ N

(2) position of center pressure of resultant force (R):

Take the moments of forces at the hinge:

$57565 \times h_p = 71691 \times [(1.5 + 1.2) - 2.1571] - 14126 \times (1.2 - 0.8)$

$h_p = 0.578$ m

Problem 3.6 /

A square aperture in the vertical side of a tank has one diagonal vertical and is completely covered by a plane hinged along one of the upper sides of