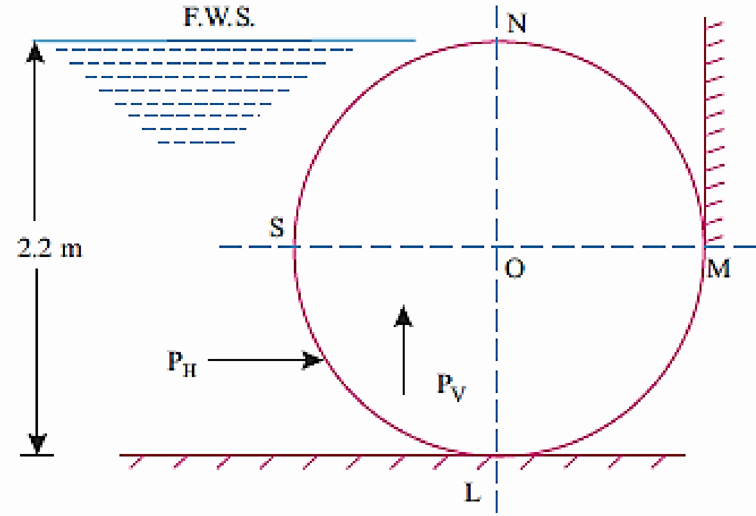
- A cylinder 2.2 m in diameter and 3.3 m long supported as shown in Fig. retains water on one side. If the cylinder weighs 165 kN, calculate the vertical reaction at L and horizontal reaction at M. Neglect the frictional effects.



- Radius of cylinder
- = 2.2 /2=1.1 m
- Length of cylinder = 3.3 m, Weight of cylinder = 165 kN
- The horizontal component of the resultant hydrostatic force
- acting on the gate is the horizontal force on the projected
- area of the curved surface on a vertical plane.
- i.e. PH = Hydrostatic pressure force on the curved area LSN
- projected on the vertical plane LON,

$$= wA\bar{x}$$

$$= 9.81 \times (2.2 \times 3.3) \times \frac{2.2}{2} = 78.34 \text{ kN}$$

Horizontal reaction at M = **78.34 kN (Ans.)**

- The vertical component of the resultant hydrostatic force is the weight of water supported by the curved surface LSN which represents a semicircle. PV = w × volume of surface LSN

$$\therefore \quad P_V = w \times \text{volume of surface LSN}$$

$$= w \times \left(\frac{\pi}{2} \times (\text{radius})^2 \times \text{length}\right)$$

$$= 9.81 \times \left[\frac{\pi}{2} \times (1.1)^2 \times 3.3\right] = 61.53 \text{ kN}$$

P_V is acting in the *upward direction*,

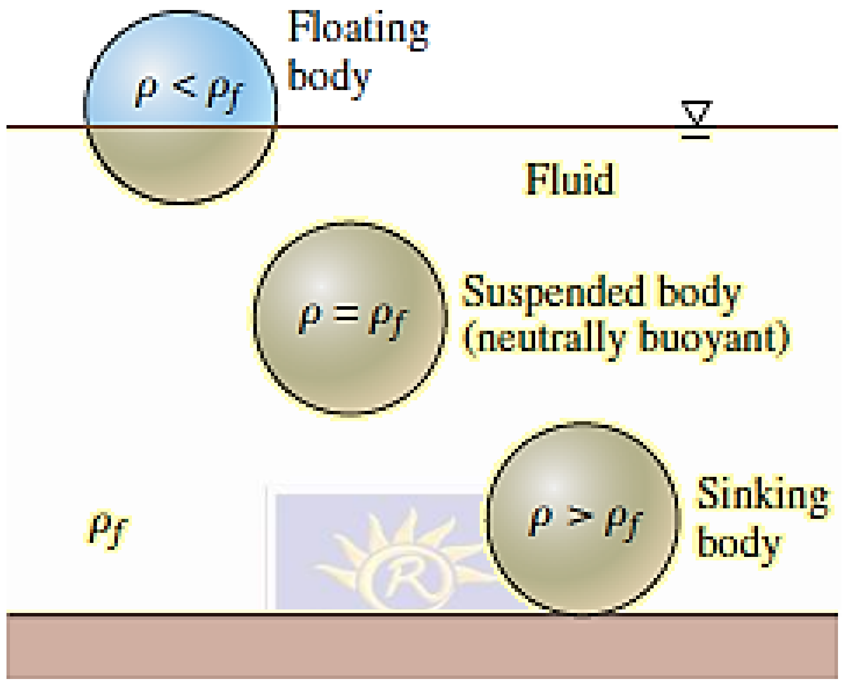
$\therefore$ For equilibrium of cylinder,

Vertical reaction at L = Weight of cylinder – P_V

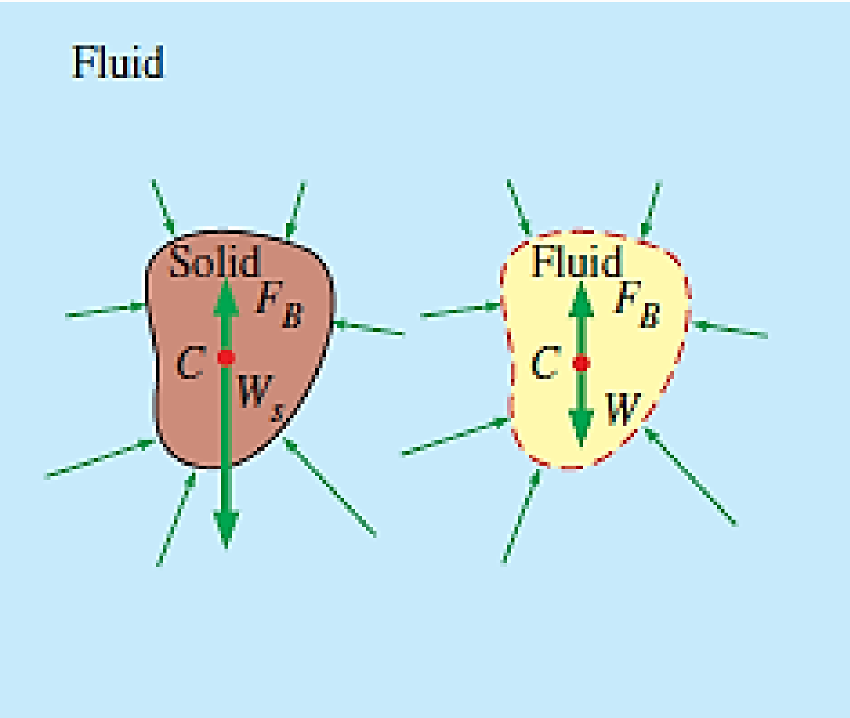
= 165 – 61.53 = **103.47 kN (Ans.)**

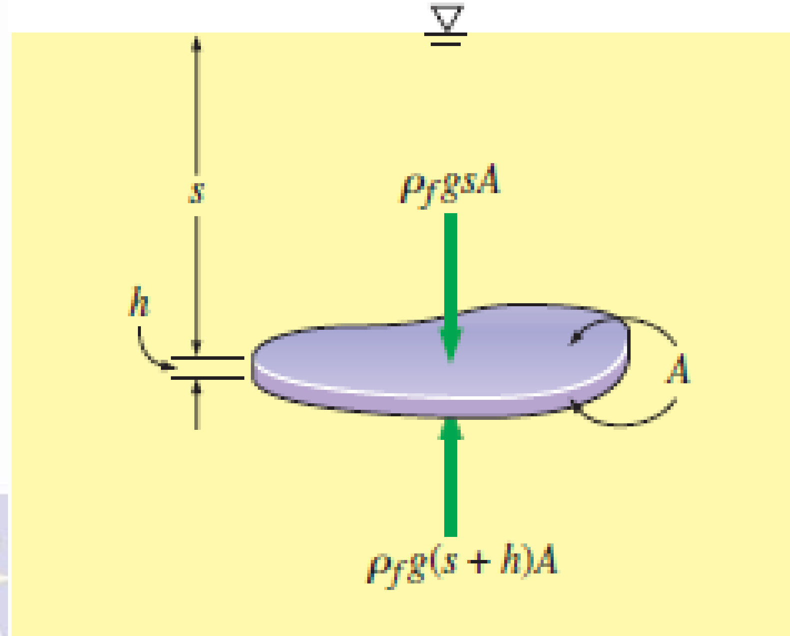
1. The intensity of pressure p is related to specific weight w of the liquid and vertical depth h of the point by the equation
   (*a*) $p = wh$ (*b*) $h = pw$
   (*c*) $p = wh^2$ (*d*) $p = wh^3$.
2. The point of application of the total pressure on the surface is
   (*a*) centroid of the surface
   (*b*) centre of pressure
   (*c*) either of the above
   (*d*) none of the above.
3. If A is the area of the immersed surface, w is the specific weight of the liquid and $\bar{x}$ is the depth of horizontal surface from the liquid surface, then the total pressure P on the surface is given by
   (*a*) $p = wA^2\bar{x}$ (*b*) $p = w^2A\bar{x}$
   (*c*) $p = wA\bar{x}$ (*d*) $p = wA\bar{x}^2$
4. Centre of pressure ($\bar{h}$) in case of an inclined immersed surface is given by
   (*a*) $\bar{h} = \dfrac{I_G \sin\theta}{A\bar{x}} + \bar{x}$ (*b*) $\bar{h} = \dfrac{I_G \sin\theta}{A^2\bar{x}} + \bar{x}$
   (*c*) $\bar{h} = \dfrac{I_G^2 \sin\theta}{A\bar{x}} + \bar{x}$ (*d*) $\bar{h} = \dfrac{I_G \sin^2\theta}{A\bar{x}} + \bar{x}$
5. The side of the dam to which the water from the river or the stream approaches is known as
   (*a*) downstream (*b*) upstream
   (*c*) either of the above (*d*) none of the above.
6. Which of the following is a possibility of dam failure?
   (*a*) Failure due to sliding along its base
   (*b*) Failure due to tension or compression
   (*c*) Failure due to shear at the weakest section
   (*d*) Failure due to overturning
   (*e*) All of the above.
7. Lock gates are provided to
   (*a*) change the water level in a canal or river for irrigation
   (*b*) store water for irrigation purpose
   (*c*) either of the above
   (*d*) none of the above.
8. Total force on a curved surface is given by
   (*a*) $P = (P_H^2 + P_V^2)^{3/2}$ (*b*) $P = \sqrt{P_H^2 + P_V^2}$
   (*c*) $P = \left(P_H^2 + P_V^2\right)^{5/2}$ (*d*) $P = P_H + P_V$
9. Resultant pressure on a sluice gate is given by
   (*a*) $P = P_1 - P_2$ (*b*) $P = P_1 + P_2$
   (*c*) $P = \sqrt{P_1^2 + P_2^2}$ (*d*) $P = (P_1^2 + P_2^2)^{3/2}$.
10. The term........ means the study of pressure exerted by a fluid at rest.
    (*a*) hydrostatics (*b*) fluid mechanics
    (*c*) continuum (*d*) kinetics.

1. (*a*) **2.** (*b*) **3.** (*c*) **4.** (*d*) **5.** (*b*) **6.** (*e*) **7.** (*a*) **8.** (*b*) **9.** (*a*) **10.** (*a*)



A solid body dropped into a fluid will sink, float, or remain at rest at any point in the fluid, depending on its average density relative to the density of the fluid.





The buoyant forces acting on a solid body submerged in a fluid and on a fluid body of the same shape at the same depth are identical. The buoyant force FB acts upward through the centroid C of the displaced volume and is equal in magnitude to the weight W of the displaced fluid, but is opposite in direction. For a solid of uniform density, its weight Ws also acts through the centroid, but its magnitude is not necessarily equal to that of the fluid it displaces. (Here Ws . W and thus Ws . FB; this solid body would sink.)

Fluid Properties

- A fluid exerts an upward force on a body immersed in it. This force that tends to lift the body is called the buoyant force and is denoted
- by FB.
- The buoyant force is caused by the increase of pressure with depth in a fluid.
- **“The buoyant force acting on a body of uniform density immersed in a fluid is equal to the weight of the fluid displaced by the body, and it acts upward through the centroid of the displaced volume.”**
- The magnitude of the buoyant force can be determined by Archimedes’ principle

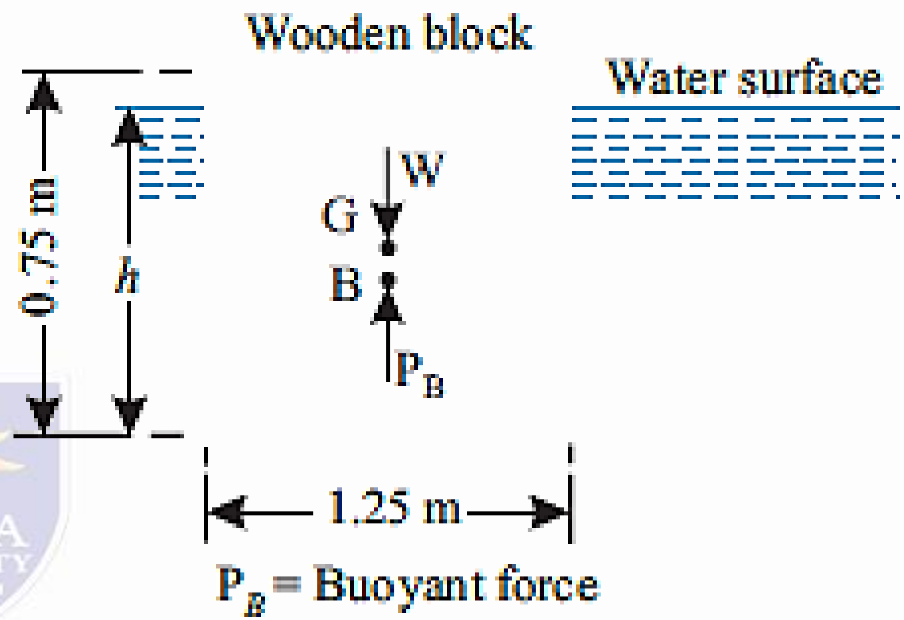
- “When a body is immersed in a fluid either wholly or partially, it is buoyed or lifted up by a force which is equal to the weight of fluid displaced by the body.”
- For floating bodies, the weight of the entire body must be equal to the buoyant force, which is the weight of the fluid whose volume is

$$F_B = W \rightarrow \rho_f g V_{\text{sub}} = \rho_{\text{avg, body}} g V_{\text{total}} \rightarrow \frac{V_{\text{sub}}}{V_{\text{total}}} = \frac{\rho_{\text{avg, body}}}{\rho_f}$$

- CENTRE OF BUOYANCY
- The point of application of the force of buoyancy on the body is known as the centre of buoyancy. It is always the centre of gravity of the volume of fluid displaced

- A wooden block of width 1.25 m, depth 0.75 m and length 3.0 m is floating in water. Specific weight of the wood is 6.4 kN/m3. Find:
- (i) Volume of water displaced, and (ii) Position of centre of buoyancy. Solution. Width of the wooden block.

- Solution. Width of the wooden block = 1.25 m
- Depth of the wooden block = 0.75 m
- Length of the wooden block = 3.0 m
- Volume of the block = 1.25 × 0.75 × 3 = 2.812 m3
- Specific weight of wood, w = 6.4 kN/m3
- Weight of the block = 6.4 × 2.812 = 18 kN
- (i) Volume of water displaced:
- For equilibrium the weight of water displaced
- = Weight of wooden block = 18 N



Volume of water displaced

$$= \frac{\text{Weight of water displaced}}{\text{Weight density of water}}$$

$$= \frac{18}{9.81} = 1.835 \text{ m}^3 \text{ (Ans)} \quad (\because \text{Weight density of water} = 9.81 \text{ kN/m}^3)$$

(ii) Position of centre of buoyancy:

We know that,

Volume of wooden block in water = Volume of water displaced.

or, $1.25 \times h \times 3.0 = 1.835$

(where, h = depth of wooden block in water)

$$\therefore \quad h = \frac{1.835}{1.25 \times 3.0} = 0.489 \text{ m}$$

$$\text{Hence centre of buoyancy} = \frac{0.489}{2} = \mathbf{0.244 \text{ from the base (Ans.)}}$$