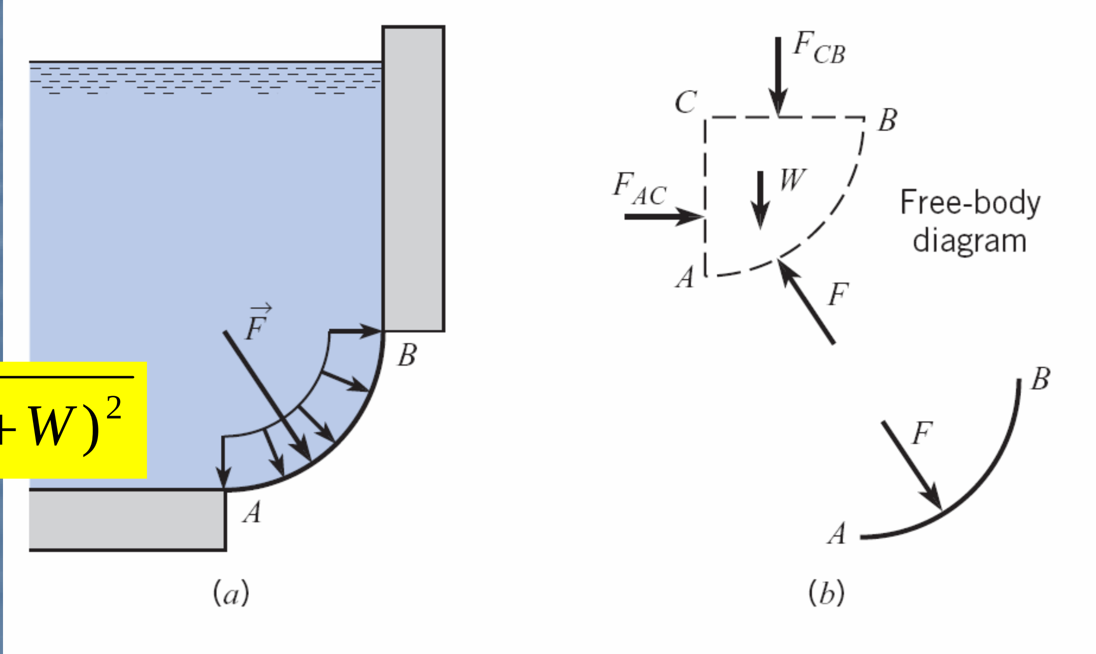
Fluid Statics

HYDROSTATIC FORCES ON CURVED SURFACES

Using the free body diagram,



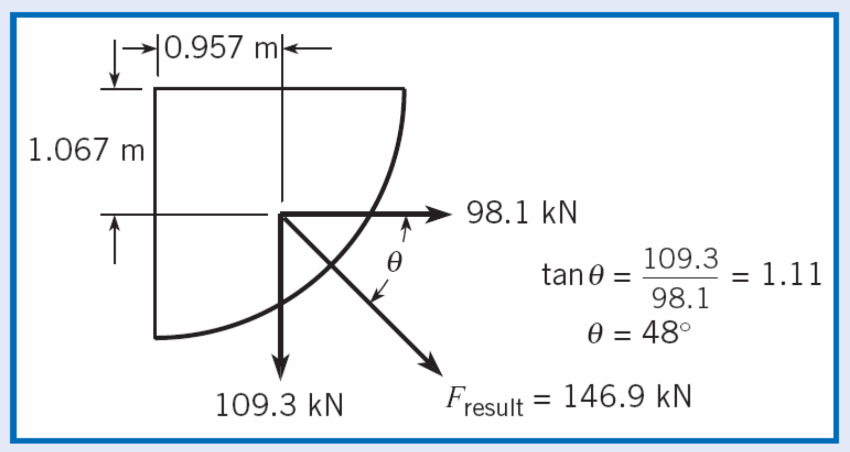
$$F_r = \sqrt{F_H^{\,2} + F_V^{\,2}} = \sqrt{F_{AC}^{\,2} + (F_{CB} + W)^2}$$

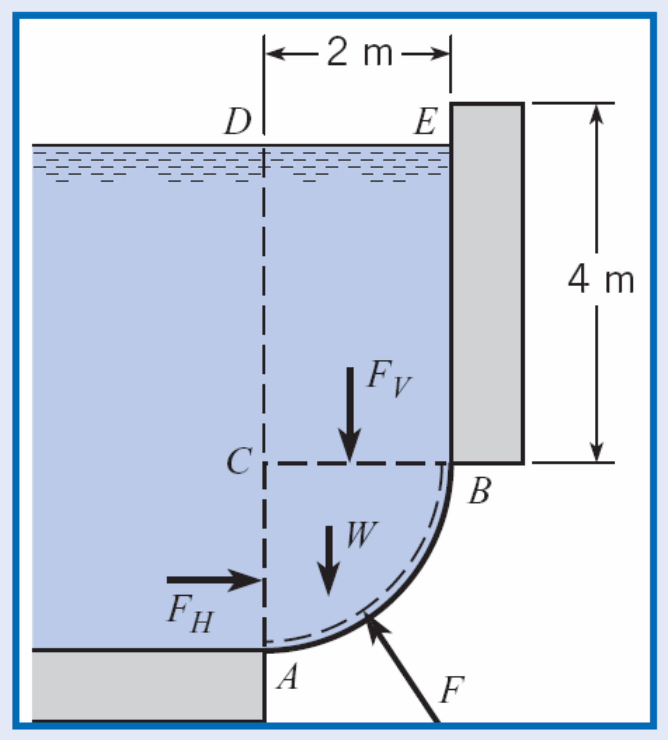
Where

F_{AC} = *Horizontal component of* F_r

F_{CB} = *Vertical component of* F_r

W = *Weight of the fluid*





Calculate: (1) (F_r) (2) $(y_{cp}), (x_{cp})$

$\sin\alpha$

$$F_x = F_H = (\bar{p}\,A)_H = (\gamma\,\bar{y}\,A)_H = 9810\times5\times(1\times2) = 98.1\ KN$$

$$F_V = (\bar{p}\,A)_V = (\gamma\,\bar{y}\,A)_V = 9810\times4\times(1\times2) = 78.5\ KN$$

Always Remeber $\bar{y}\sin\alpha = h_{CG}$ = *Vertical distance fromthe surfasce*

$$W = mg = \rho V_{ABC}\,g = \gamma V_{ABC} = \gamma\times(\frac{1}{4}\times\pi r^2)\times h = 9810\times\frac{\pi\times2^2}{4}\times1 = 30.8\ KN$$

$$F_y = F_V + W = 78.5 + 30.8 = 109.3\ kN$$

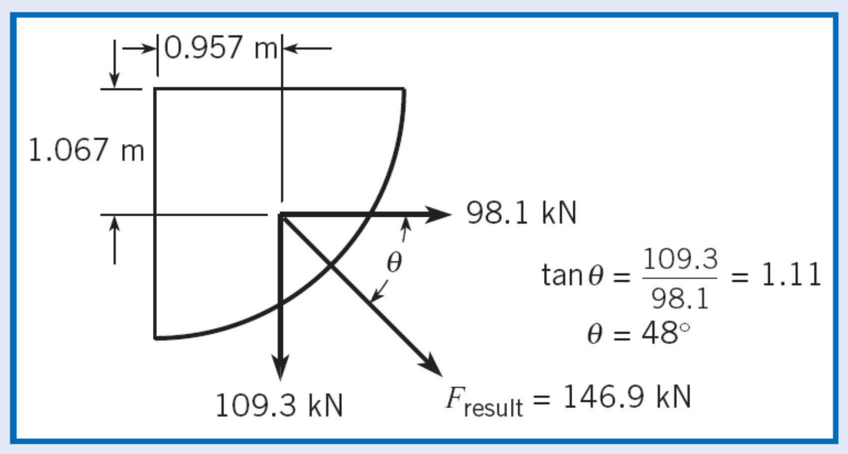
Line of action $(\bar{y}_{cp})$ for the (F_x) $= \bar{y}_{cp} = \bar{y}_c + \dfrac{\bar{I}}{\bar{y}_c A} = (4+1) + \dfrac{(1\times 2^3/12)}{(1+4)(2\times 1)} = 5.067m$

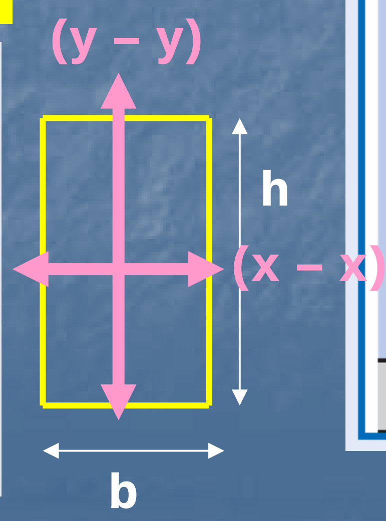
Line of action (x_{cp}) for the (F_v) can be found by taking moments about point (C) as follows:

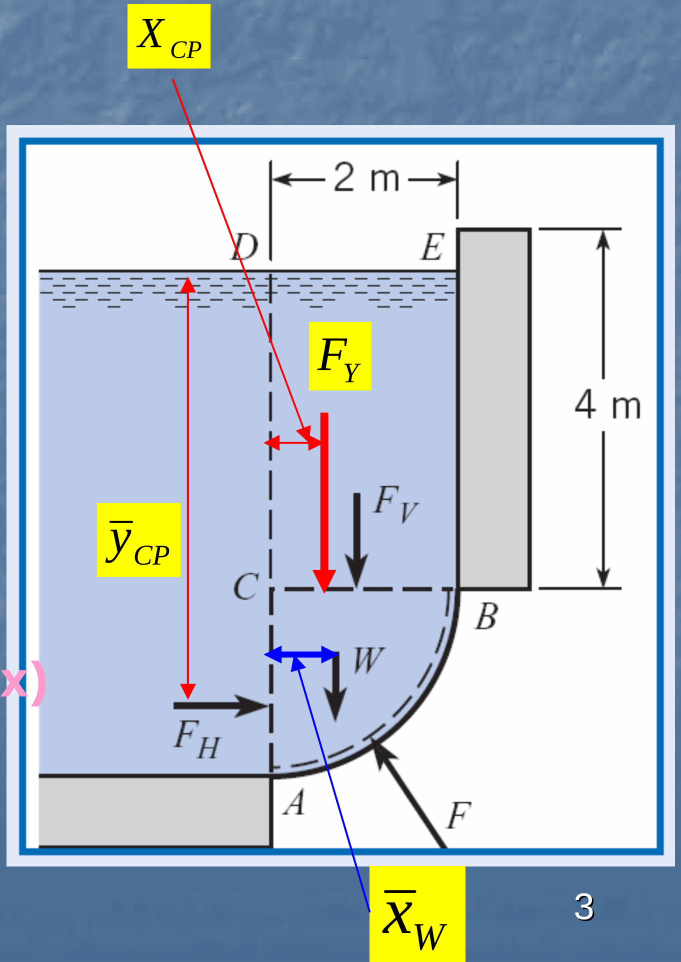
$$x_{CP} F_y = (F_V \times 1) + (W \times \bar{x}_W)$$

Where $\bar{x}_W = \dfrac{4r}{3\pi}$

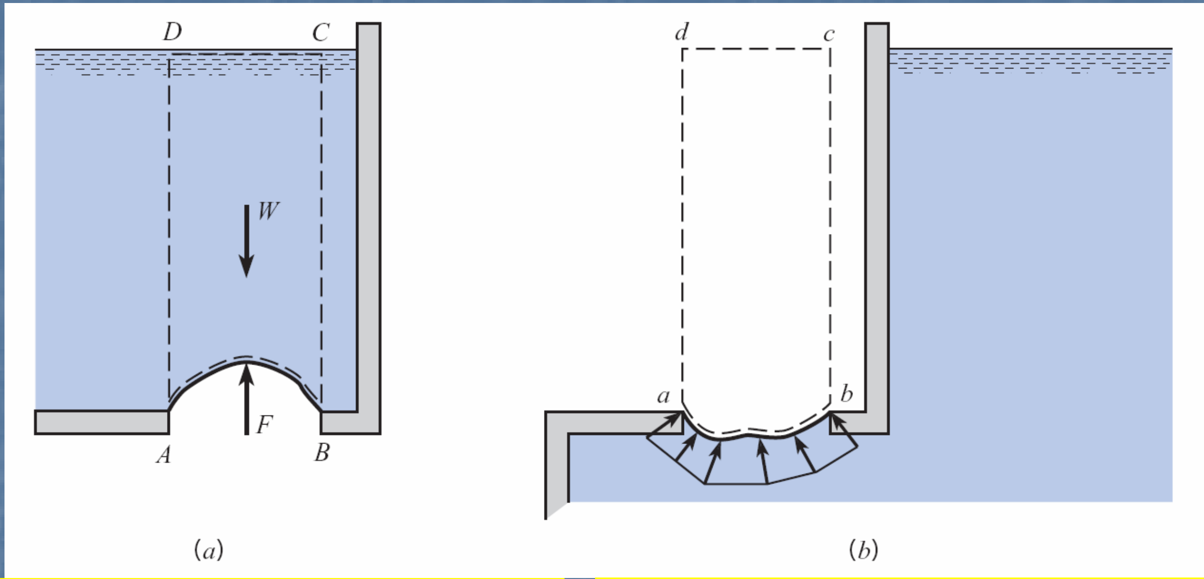
$$x_{cp} = \frac{(78.5\times 1) + (30.8)\times 0.849}{109.3} = 0.957m$$

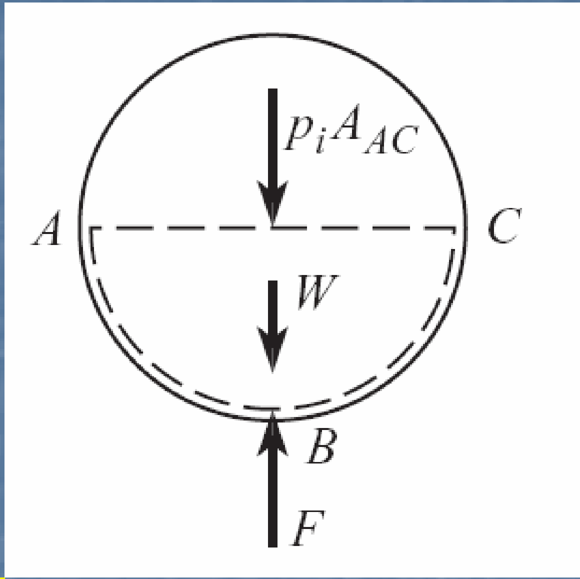






Forces on **Curved Surfaces** may be found by applying **Equilibrium concepts** to systems comprised of the fluid in contact with curved surfaces





$F = W \downarrow = mg = \rho g V = \gamma (V)_{ADBC}$

$F = W \uparrow = mg = \rho g V = \gamma (V)_{abcd}$

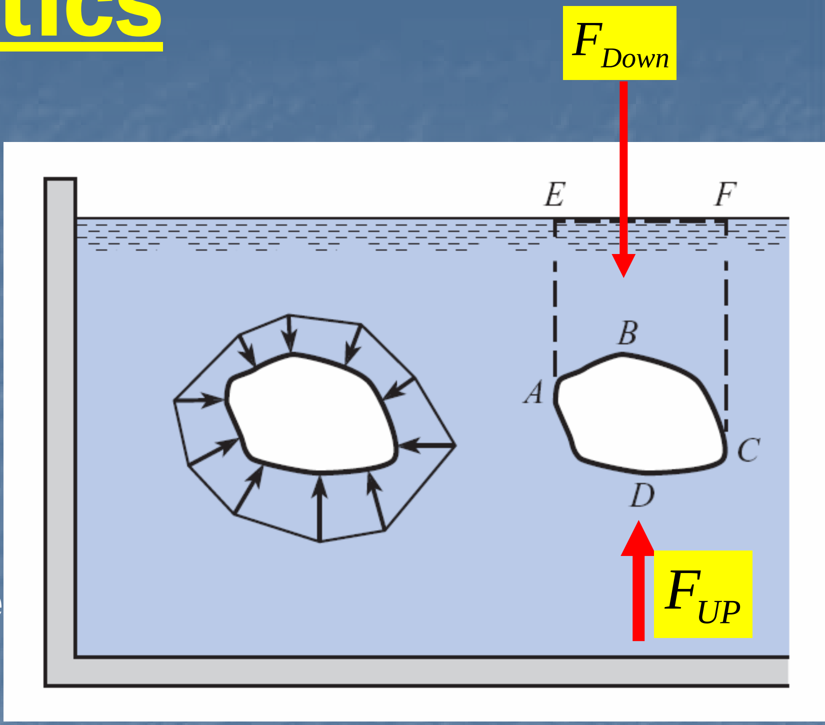
Sphere Holding a Gas

$F = (p_i A)_{AC} + W_{gas}$

(W) is the weight of the fluid needed to fill a volume that extends from the curved surface to free surface of the fluid

Fluid Statics

PRINCIPLE OF BUOYANCY



Force acting upwards due to pressure,

$$F\uparrow = \gamma(V)_{EADCF} = \gamma(V_{ABCD} + V_{EABCF})$$

Force acting downwards due to pressure

$$F\downarrow = \gamma V_{EABCF}$$

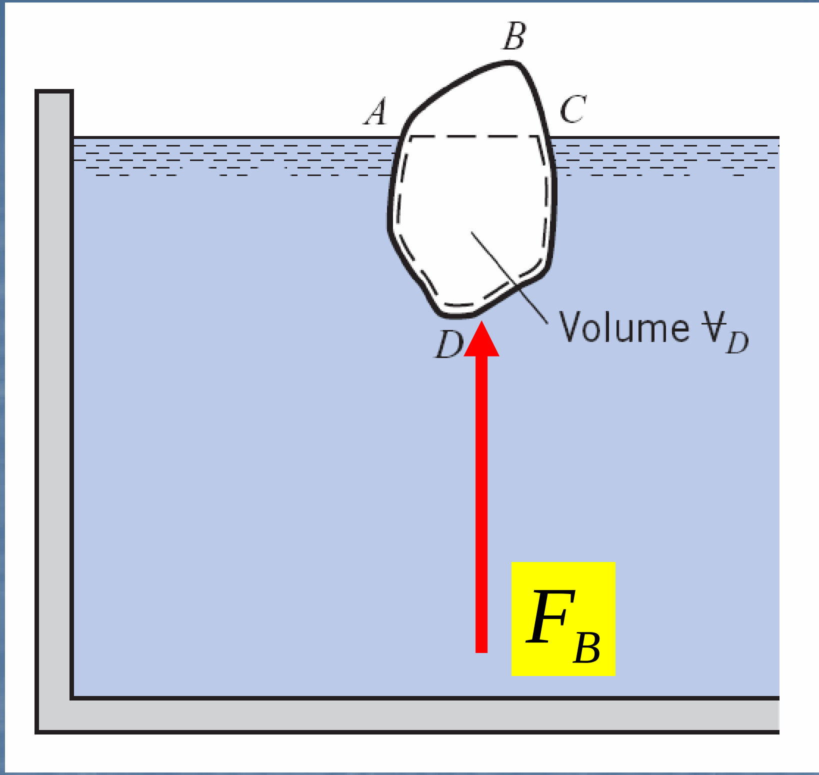
$$F_{Net} = F_{UP}\uparrow - F_{Down}\downarrow$$

The net force = Buoyant Force = $F_B\uparrow = \gamma V_{ABCD}$

Equation above means that the buoyant force (net force) equals the weight of liquid that would be needed to occupy the volume of the body.

Floating Objects

Buoyant Force = $F_B = \gamma V_{ACD}$



Where V_{ACD} *represent the submerged part of the object*

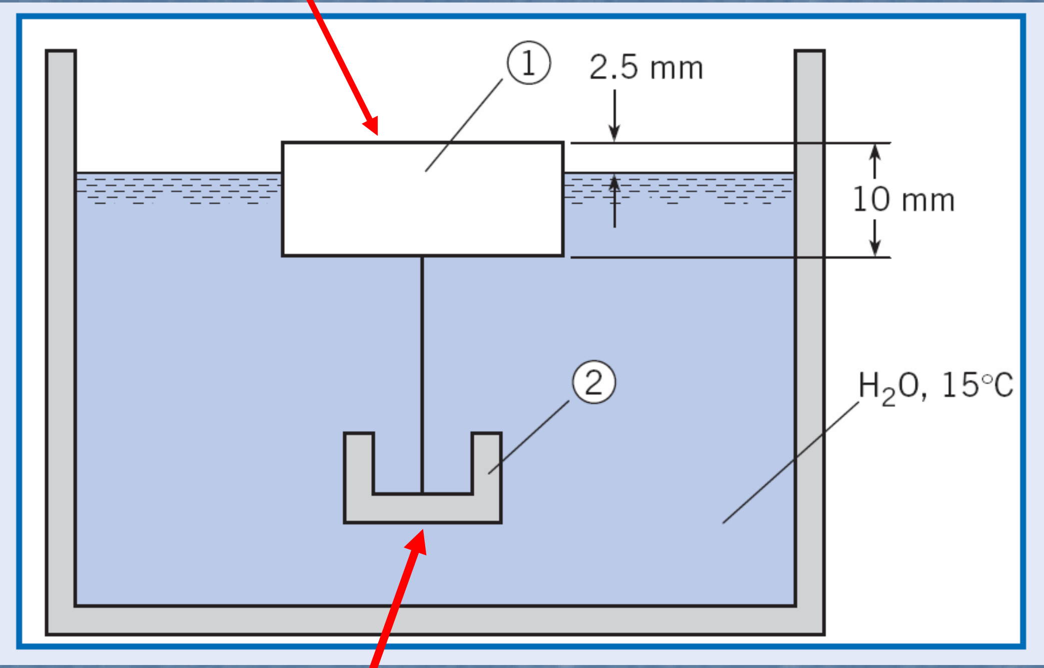
The Eqn. above is valid for liquids and gases

The general principle of Buoyancy is called Archimedes Principle which states that for an object which is partially or totally submerged in a fluid, there is a net up-ward force (buoyant force) equal to the weight of the fluid.

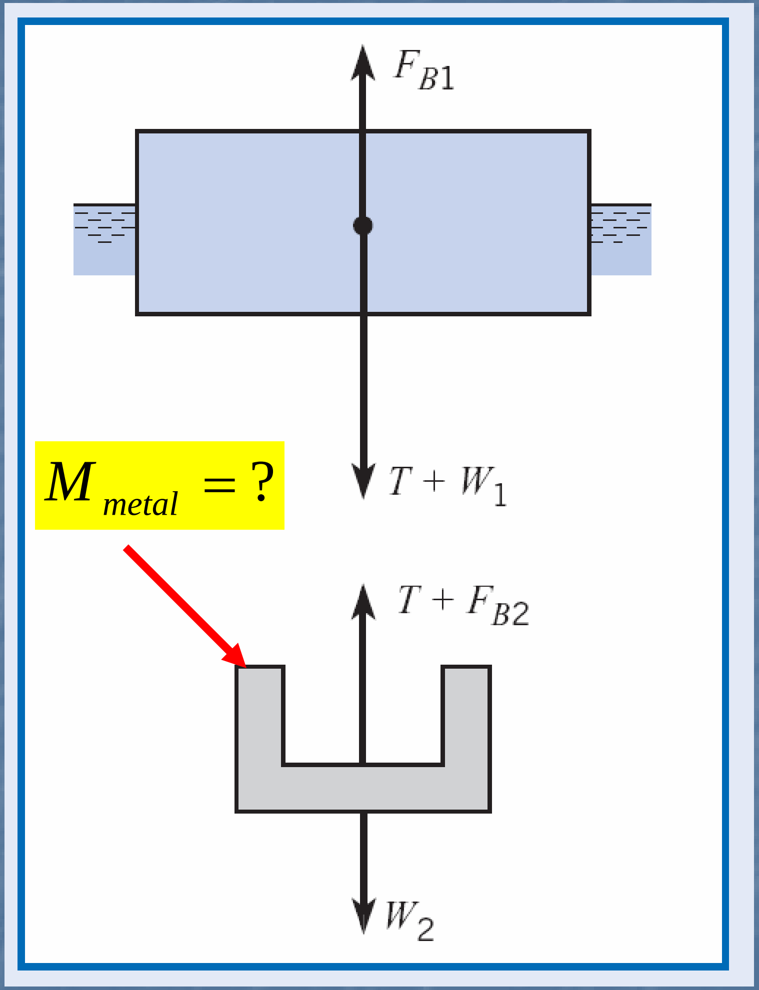
Example (3.15)

Floating wood block (S.G =0.3)

(L x W x H=50x50x10 mm)



Metal object (Vol. = 6600 cubic meter)



Free Body Diagram

Sum forces on the block:

$$T = F_{B1} - W_1$$

The buoyant force on the floating block is $F_{B1} = \gamma \mathcal{V}_{D1}$, where $\mathcal{V}_{D1}$ is the submerged volume:

$$F_{B1} = \gamma \mathcal{V}_{D1} = (9800\ \text{N/m}^3)(50 \times 50 \times 7.5\ \text{mm}^3)(10^{-9}\ \text{m}^3/\text{mm}^3)$$
$$= 0.184\ \text{N}$$

The weight of the block is

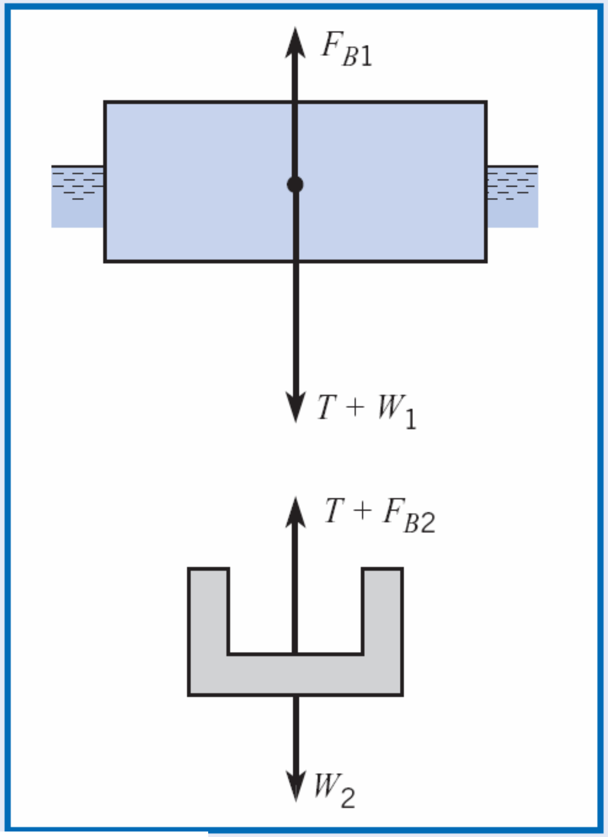
$$W_1 = \gamma S_1 \mathcal{V}_1 = (9800\ \text{N/m}^3)(0.3)(50 \times 50 \times 10\ \text{mm}^3)(10^{-9}\ \text{m}^3/\text{mm}^3)$$
$$= 0.0735\ \text{N}$$

Hence the tension on the cord is

$$T = (0.184 - 0.0735) = 0.110\ \text{N}$$

Apply force equilibrium to the metal part:

$$W_2 = T + F_{B2}$$



Because the metal part is submerged, use the volume of the part to calculate the buoyant force:

$$F_{B2} = \gamma \mathcal{V}_2 = (9800\ \text{N/m}^3)(6600\ \text{mm}^3)(10^{-9}) = 0.0647\ \text{N}$$

Hence, the weight is given by $W_2 = (0.110 + 0.0647) = 0.175$ N, and the mass is found from

$$m_2 = W_2/g = 17.8\ \text{g}$$ ◁

END OF LECTURE (5)

THANK YOU