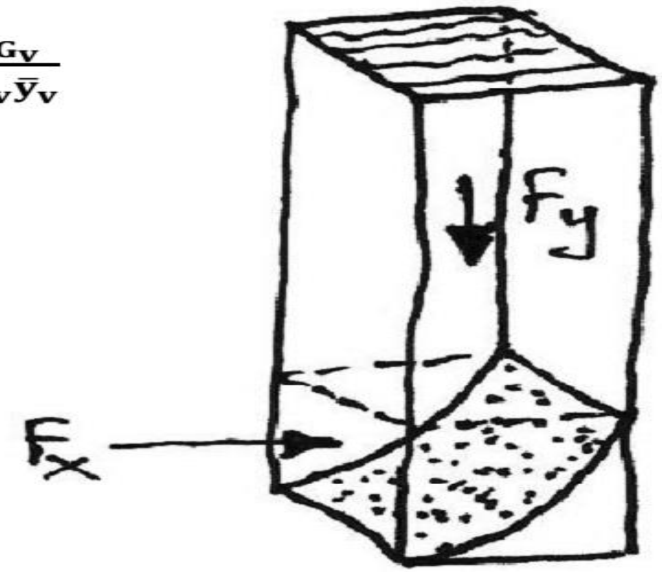
To find the location of this force, use the moment role:

$$F_H . y_{p_H} = \int dF_H . y \qquad \Longrightarrow \mathbf{y_{p_H} = \bar{y}_v + \frac{I_{G_v}}{A_v \bar{y}_v}}$$ اكتب المعادلة هنا.

By, similar procedure:

$$\Longrightarrow \mathbf{x_{p_H} = \bar{x}_v + \frac{I_{G_v}}{A_v \bar{y}_v}}$$



Now, the vertical component:

$$\mathbf{dF_V} = dF.\,cos\alpha = \gamma.\,y.\,\mathrm{ds}.\,cos\alpha = \gamma.\,y.\,\mathrm{dx}$$

$$\Longrightarrow \mathbf{F_V} = \int dF_V = \boldsymbol{\gamma} \int d\forall = \boldsymbol{\gamma}.\,\forall$$

Where,

$\forall$= closed volume between the curved surface and the fre surface.

Also, by the moment rule:

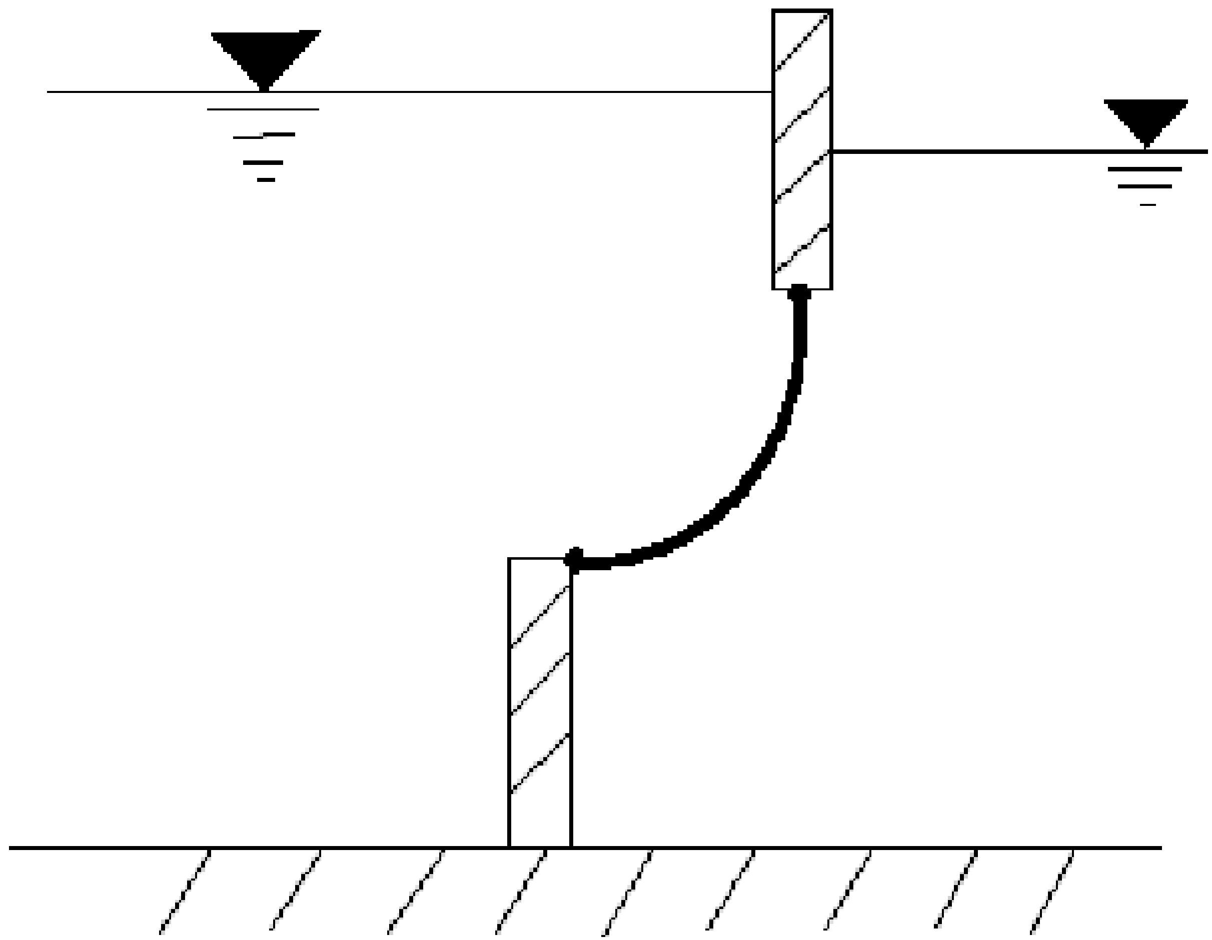
$$F_V . y_{p_v} = \int dF_V . y \qquad \Longrightarrow \mathbf{y_{p_v} = \bar{y}}$$

$$\Longrightarrow \mathbf{x_{p_v} = \bar{x}}$$

$$\Longrightarrow \mathbf{z_{p_v} = \bar{z}}$$

volume

Discuss the Example below:



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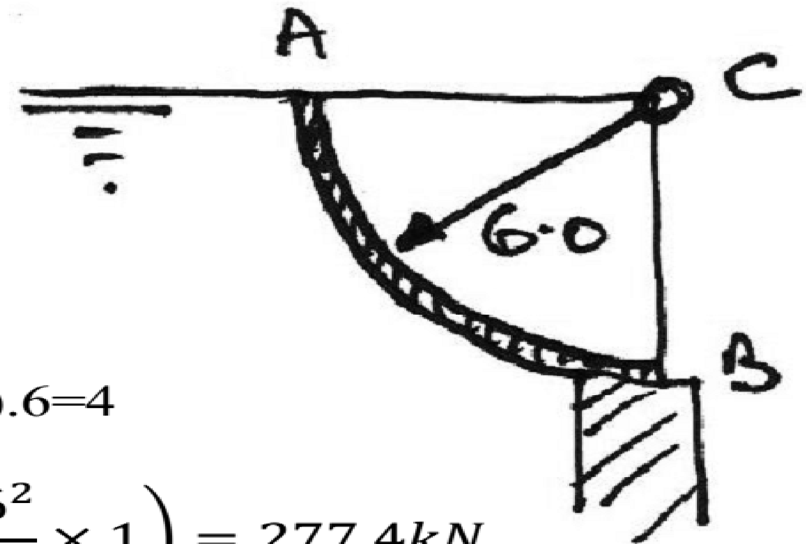
Curved Surfaces – Problem

Determine the resultant force and its direction on the gate shown:



$F_x = \gamma.A.\bar{y}$

$=10^3 x9.81x(6x1)x(\frac{6}{2})$

$=176.6kN$

And this acts at a depth h=(2/3).6=4

$$F_y = \gamma.\forall imaj = 10^3 \times 9.81\left(\frac{\pi 6^2}{4} \times 1\right) = 277.4kN$$

This vertical force is located at:

$$x = \frac{4R}{3\pi} = \frac{4 \times 6}{3\pi} = 2.55m$$

$$\Longrightarrow F = \sqrt{F_x^2 + F_y^2} = \sqrt{176.6^2 + 277.4^2} = 328.8kN$$

And acts at an angle:

$$\theta = tan^{-1}\frac{F_y}{F_x} = 57.5^o$$

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H.W.

The face of a dam is curved according to the relation

$$y = \frac{x^2}{2.4}$$

where y and x are in meters, as shown in the diagram. Calculate the resultant force on each metre run of the dam. Determine the position at which the line of action of the resultant force passes through the bottom of the dam.

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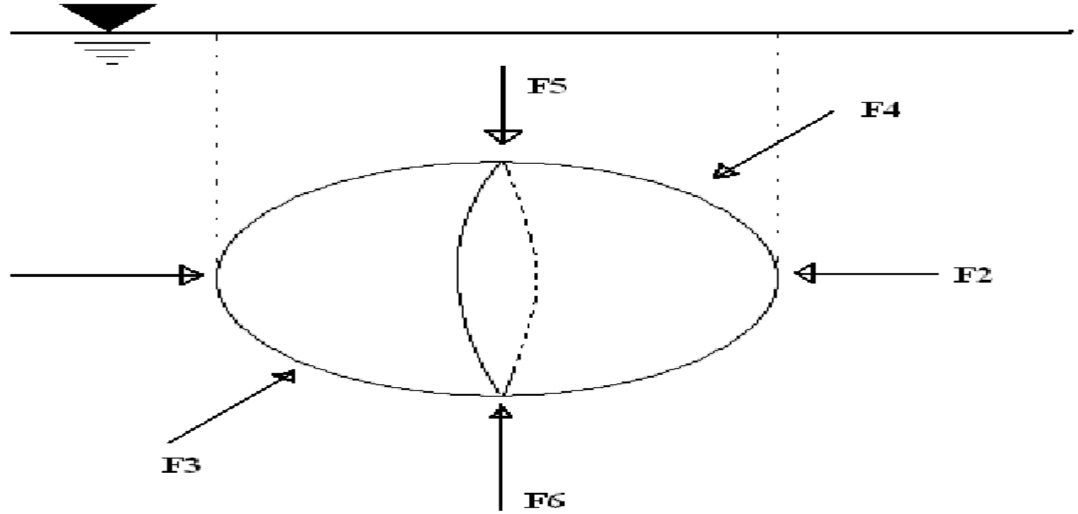
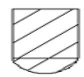
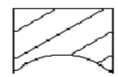
2.6 Buoyancy:



$$\sum^{\rightarrow +} F_X = R_X = F_1 - F_2 = 0$$

$$\sum^{\swarrow +} F_Z = R_Z = F_3 - F_4 = 0$$

$$\sum^{\uparrow +} \mathbf{F_Y} = \mathbf{R_Y} = \mathbf{F_6} - \mathbf{F_5} = \boldsymbol{\gamma}_{\mathbf{f}}.$$  $$-\boldsymbol{\gamma}_{\mathbf{f}}.$$  $$= \boldsymbol{\gamma}_{\mathbf{f}}.$$ 

$$= \boldsymbol{\gamma}_{\mathbf{f}}\,.\, \forall_{displaced}$$

$$\mathbf{R} = \sqrt{\mathbf{R_x^2} + \mathbf{R_y^2} + \mathbf{R_z^2}} = \mathbf{F_B}$$

$$\Longrightarrow \mathbf{F_B} = \boldsymbol{\gamma}_{\mathbf{f}}\,.\, \forall_{disp.}$$

Where,

$\mathbf{F_B}$= Buoyancy force
$\boldsymbol{\gamma}_{\mathbf{f}}$.= Specific weight of fluid
$\forall_{disp.}$= Displaced volume

Note:

$\mathbf{F_B}$ ... which is the centroid of the displaced volume.

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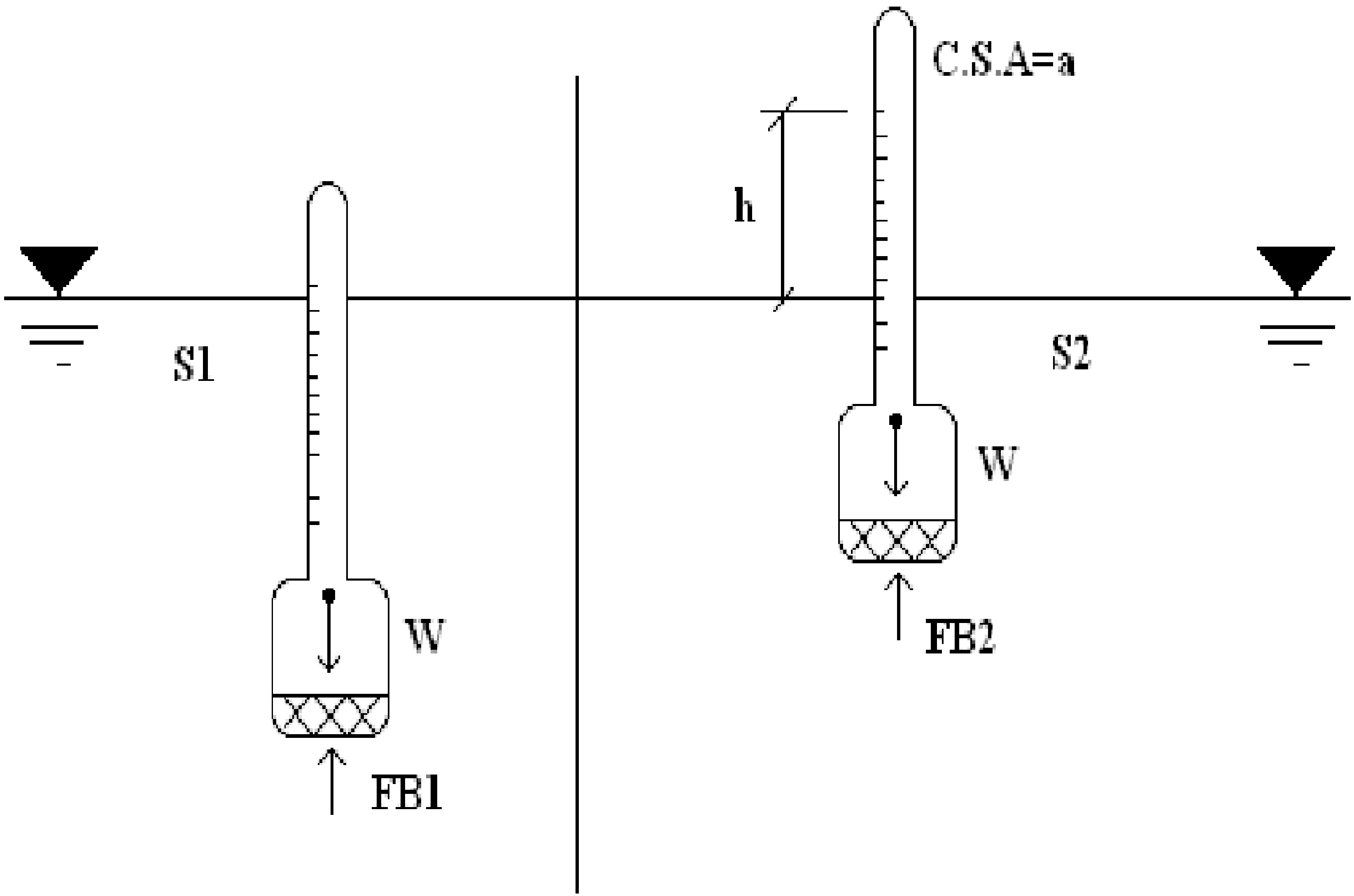
- **Hydrometer:**



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$$W = F_{B1} = S1.\gamma_w.\forall_o$$

Where $\forall_o$ = displaced volume

$$\Rightarrow \ S1.\gamma_w.\forall_o = \ S2.\gamma_w.(\forall_o - a.h)$$

Or: $$\mathbf{h} = \frac{\forall_o}{a} = \frac{S2-S1}{S2}$$

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EXAMPLE: A block of concrete weighs 100 kg in air and weighs 60 kg when immersed in water. What is the average specific weight of the block?

SOLUTION: The buoyant force is,

By, $\sum F_y = 0$

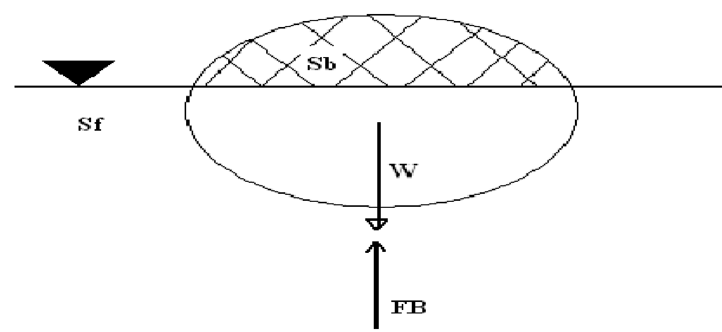
$60 + F_B - 100 = 0 \;\; \therefore F_B = 40\text{kg} = \gamma_{water} \times \text{Volume of block}$

$\Longrightarrow \forall = \frac{40}{1000} = 0.04m^3$

Therefore, $\gamma = \frac{100}{0.04} = 2500kg/m^3 = 2.5\,ton/m^3$

EXAMPLE 2: Find $\overline{\forall}/\forall$ when $\forall = total\ volume, \overline{\forall} =$ displaced volume.

By, $\sum F_y = 0$



$\Longrightarrow W = F_B \qquad\qquad \therefore \boldsymbol{S_b}.\gamma_w.\forall = \boldsymbol{S_f}.\gamma_w.\overline{\forall}$

$\Longrightarrow \frac{\forall}{\overline{\forall}} = \frac{\boldsymbol{S_b}}{\boldsymbol{S_f}}$

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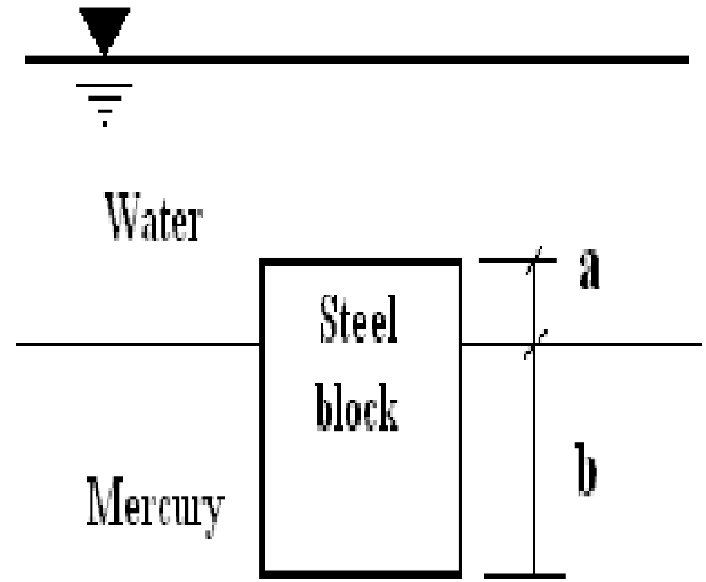
EXAMPLE: A block of steel (S = 7.85) floats at a mercury – water interface as shown. Find the ratio (a/b) for this condition.



SOLUTION:

$$by \quad \sum F_y = 0$$

$$W = F_{B\,total} = F_{B(w)} + F_{B(Hg)}$$

$$\Rightarrow \; 7.85\gamma_w.A.(a+b) = \gamma_w.A.a + 13.6\gamma_w.A.b$$

$$\Rightarrow \; 7.85(a+b) = a + 13.6.b$$

$$\Rightarrow \; \frac{a}{b} = 0.839$$

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