HYDROMETRY

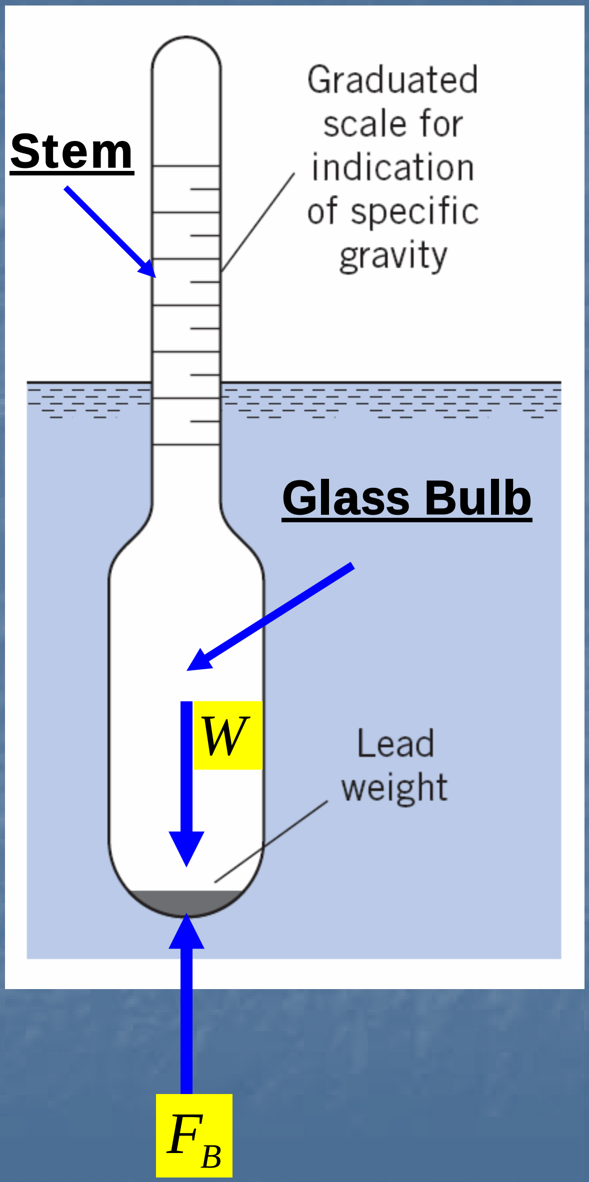
Hydrometer is used to measure the Specific Weight

Principle of Operation

The weight of the hydrometer = Buoyant Force

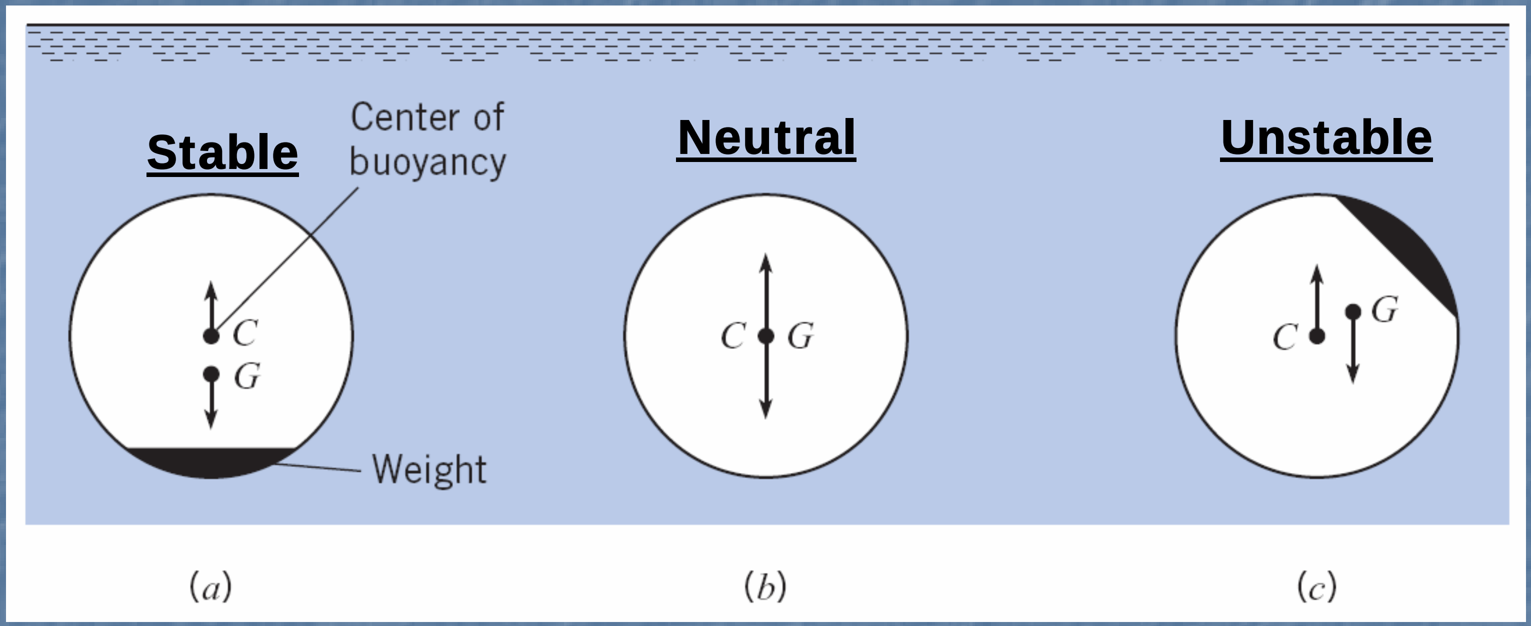
The hydrometer will float deeper or shallower depending on the **Specific Weight** of the liquid.

Consequently, **Graduation on the Stem** can be made to indicate the **Specific Weight** of the liquid being measured.



STABILITY OF IMMERSED BODIES

The stability of an immersed body depends on the relative positions of Center of gravity (CG) and the centroid of the displaced volume of fluid

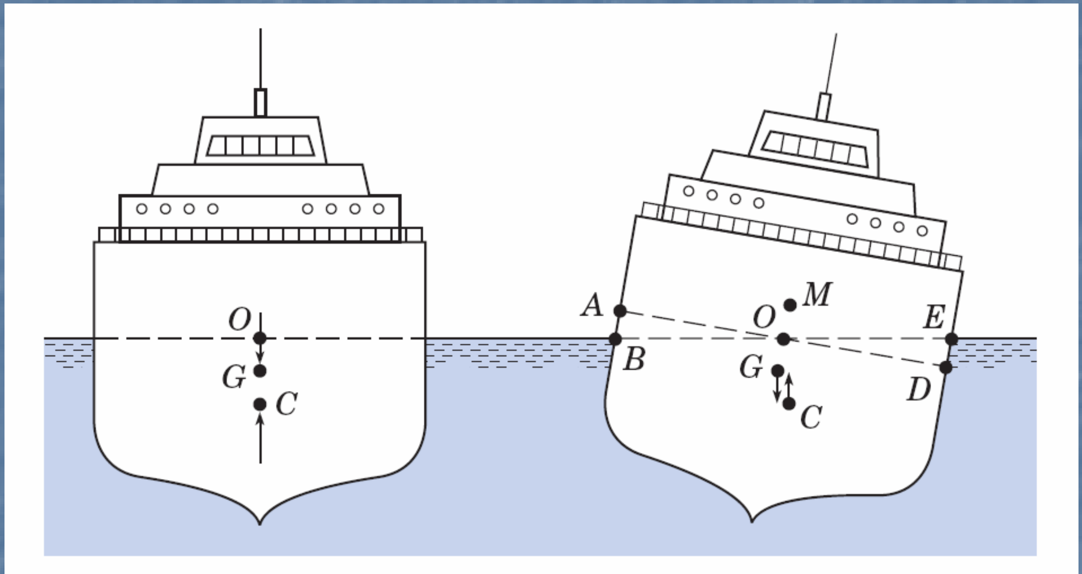


C = Center of Buoyancy
G = Center of Gravity

Case (a): Body is stable as (C above G)
Case (b): Body is neutral as (C & G are coincident)
Case (c): Body is unstable as (C below G)

Fluid Statics

STABILITY OF FLOATING BODIES



(a) (b)

The point of intersection of the lines of action of the buoyant force before and after heel is called metacenter (M) and the distance (GM) is called the metacentric height

If GM is positive (i.e. M above G), the ship is **Stable**.

If GM is negative (i.e. M below G), the ship is **Unstable**.

Take moments of volumes about the plane of symmetry,

$$\bar{x}V = \sum x_i \Delta V_{i(AOB)} + \sum x_i \Delta V_{i(EOD)}$$

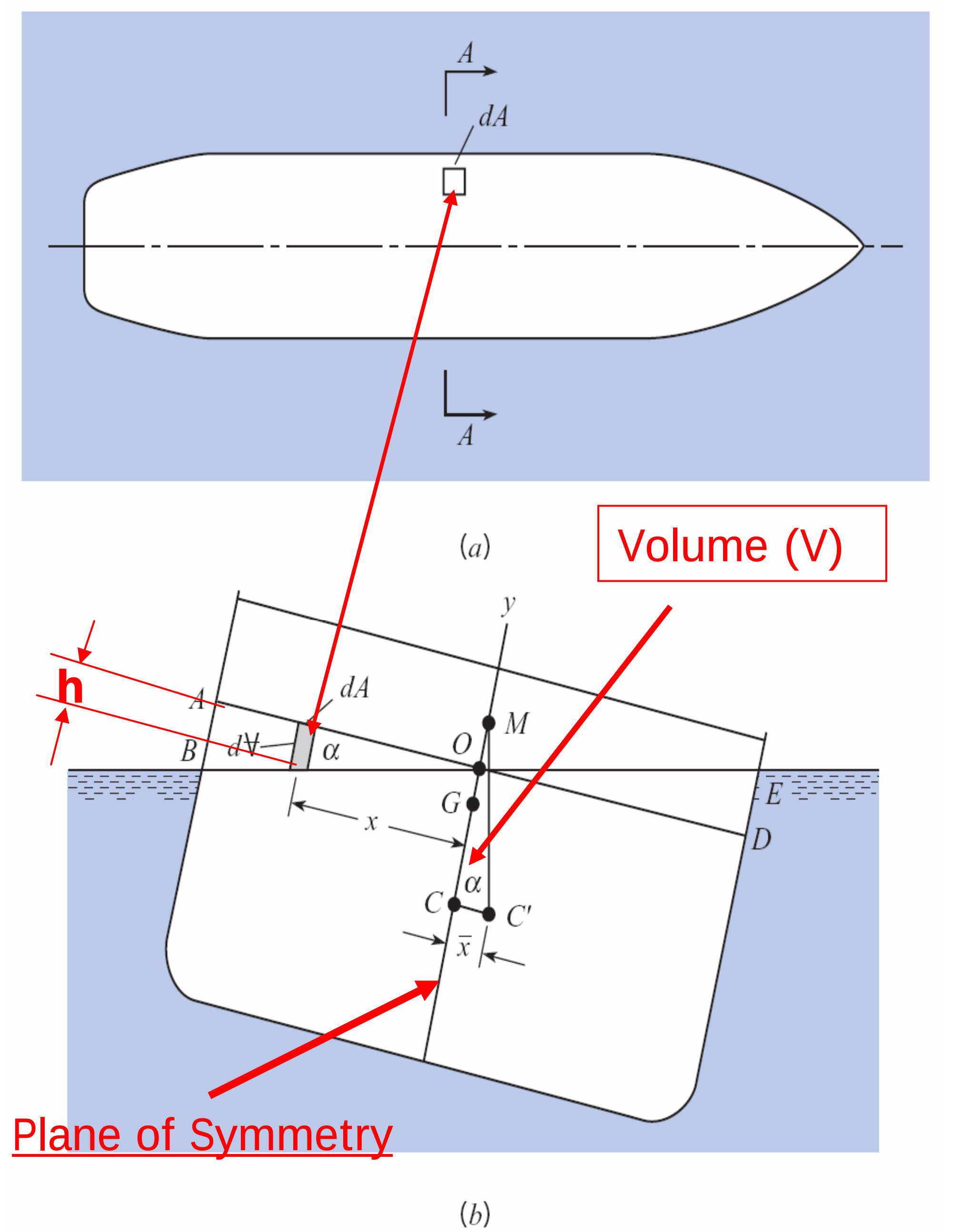
$$\bar{x}V = \int_{AOB} x dV + \int_{EOD} x dV$$

$$dV = dA \times h = dA \times (x \tan \alpha)$$

$$\bar{x}V = \int_{AOB} x^2 \tan \alpha dA + \int_{EOD} x^2 \tan \alpha dA$$

$$\bar{x}V = \tan \alpha \int_{waterline} x^2 \, dA = I_{00} \tan \alpha$$

$$\bar{x} = C\bar{C} = CM \tan \alpha$$



Substituting for $\bar{x}$ we have

$$\bar{x} = CC' = CM \tan\alpha$$

$$\bar{x}V = \tan\alpha \int_{waterline} x^2 \, dA = I_{00} \tan\alpha$$

$$CM = \frac{I_{00}}{V}$$

$$GM = CM - CG$$

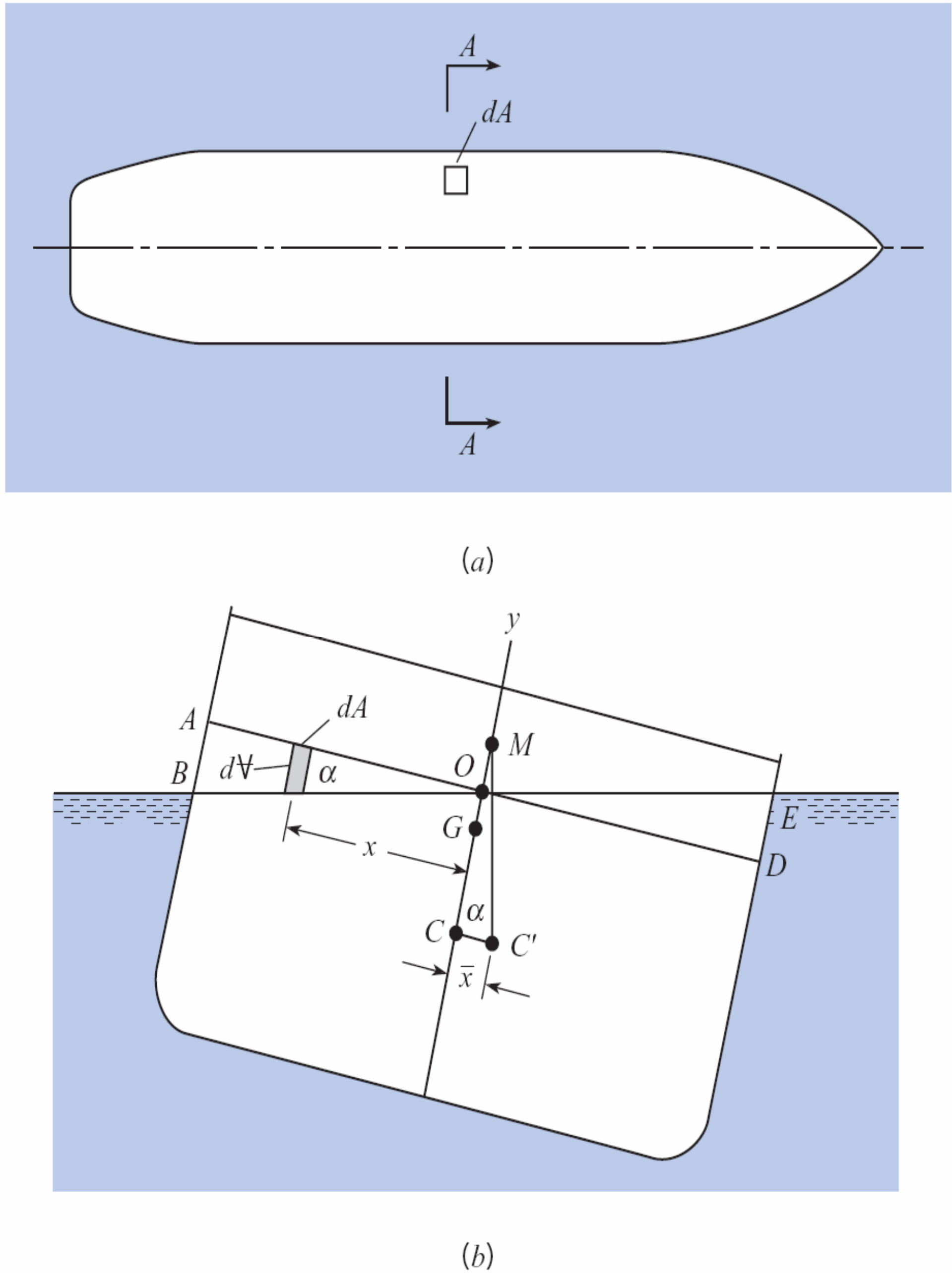
The Metacentric Height (GM)

$$GM = \frac{I_{00}}{V} - CG$$

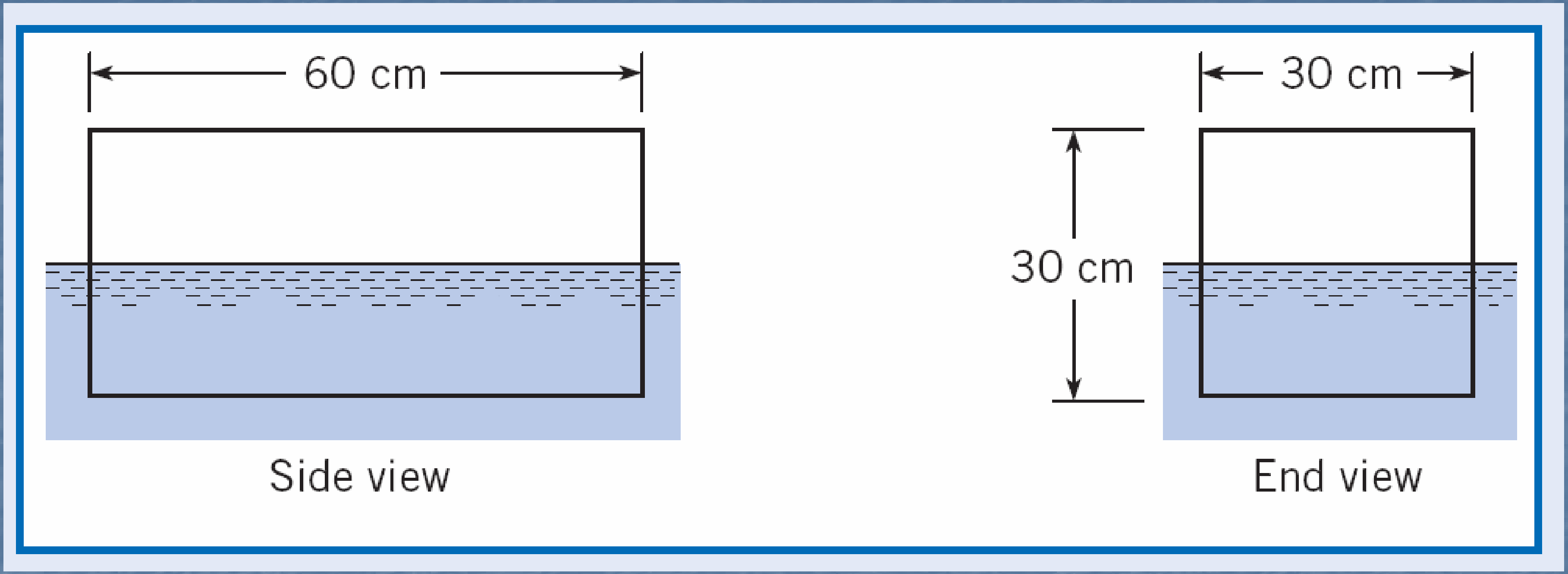
(V): Submerged volume of object

If (GM) is +Ve: Body is Stable

If (GM) is -Ve: Body is Unstable

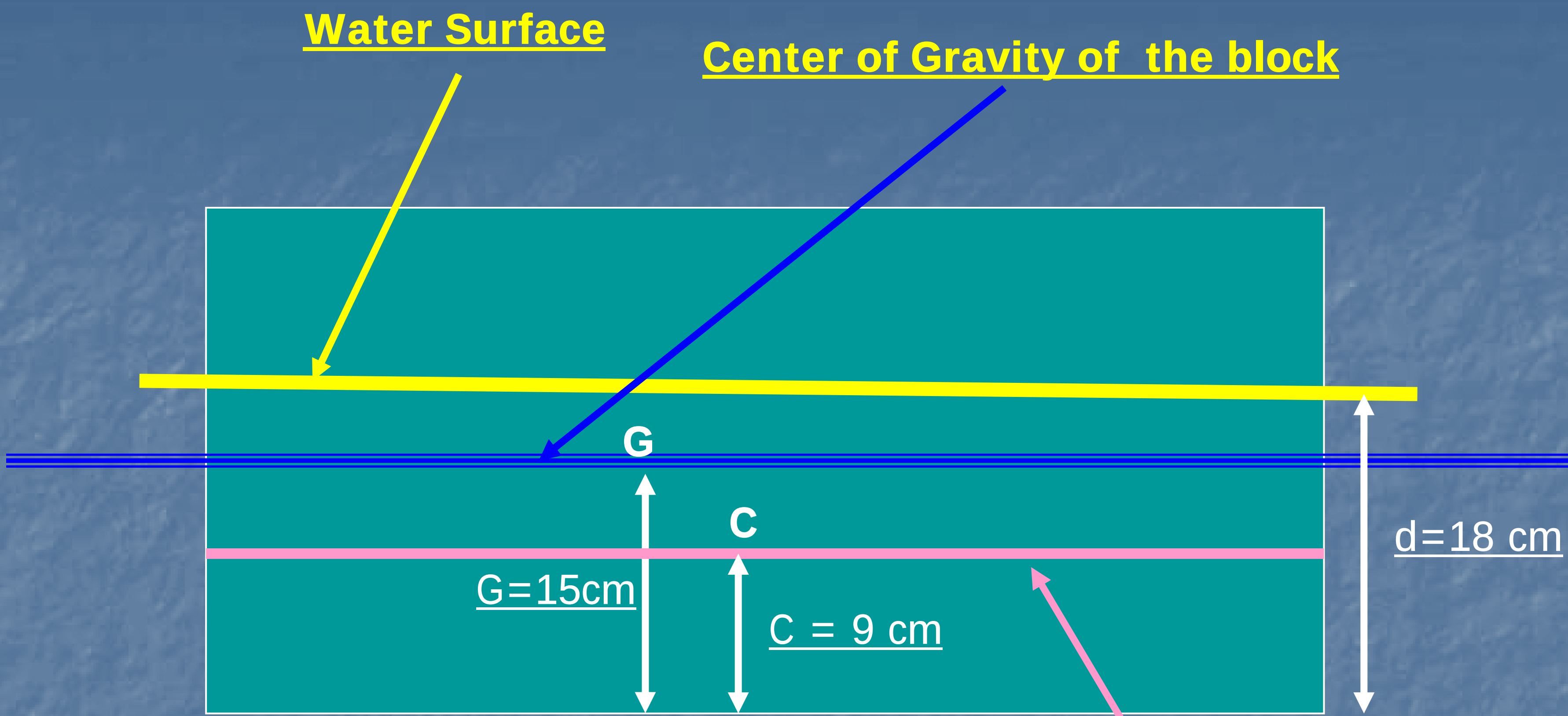


Example (3.16)



Weight of the block = 318 N

Question: Will the block float with sides vertical?

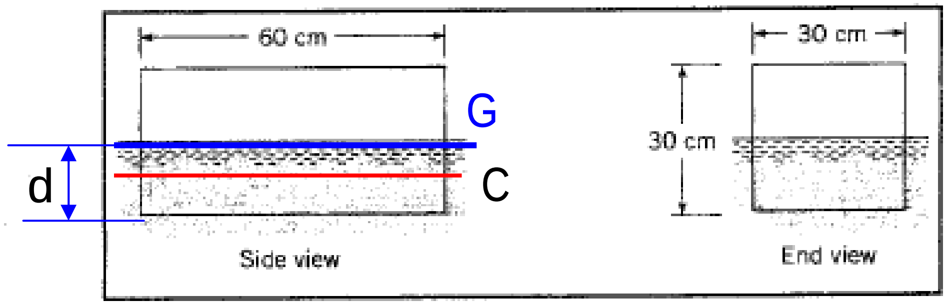


$$GM = \frac{I_{00}}{(V)_{immersed\ part}} - CG$$

Center of Buoyancy

G: Center of Gravity of the block

C: Center of Buoyancy of the block



Solution First determine the depth of submergence of the block. This is calculated by applying the equation of equilibrium in the vertical direction.

$$\Sigma F_y = 0$$

$$-\text{weight} + \text{buoyant force} = 0$$

$$-318 \text{ N} + 9810 \text{ N/m}^3 \times 0.30 \text{ m} \times 0.60 \text{ m} \times d = 0$$

$$d = 0.18 \text{ m} = 18 \text{ cm}$$

Determine whether the block is stable about the longitudinal axis:

$$GM = \frac{I_{00}}{V} - CG = \frac{\frac{1}{12} \times 60 \times 30^3}{18 \times 60 \times 30} - (15 - 9)$$

$$(I_{00})_{X\_X} = \frac{1}{12} bh^3 \quad (b = 60cm,\ h = 30cm)$$

$$= 4.167 - 6 = -1.833 \text{ cm}$$

Because the metacentric height is negative, the block is not stable about the longitudinal axis. Thus a slight disturbance will make it tip. Next, check to see if the block is stable about the transverse axis:

$$(I_{00})_{Y\_Y} = \frac{1}{12} bh^3 \quad (b = 30cm,\ h = 60cm)$$

$$GM = \frac{\frac{1}{12} \times 30 \times 60^3}{18 \times 30 \times 60} - 6 = 10.67 \text{ cm} \quad \triangleleft$$

The block is stable about the transverse axis and will float with the short sides vertical.

END OF LECTURE (7)

THANK YOU