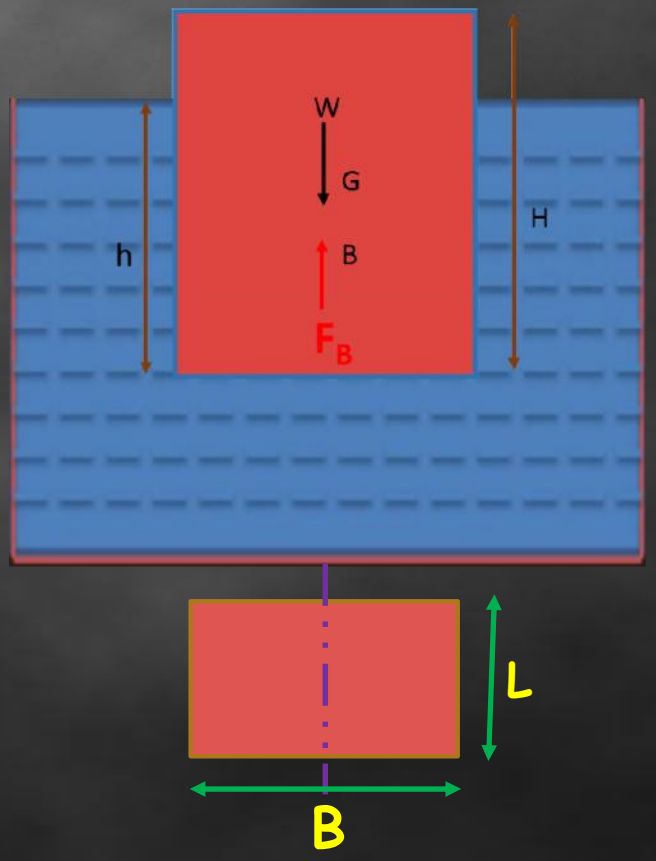
Numerical for calculating Metacentric Height

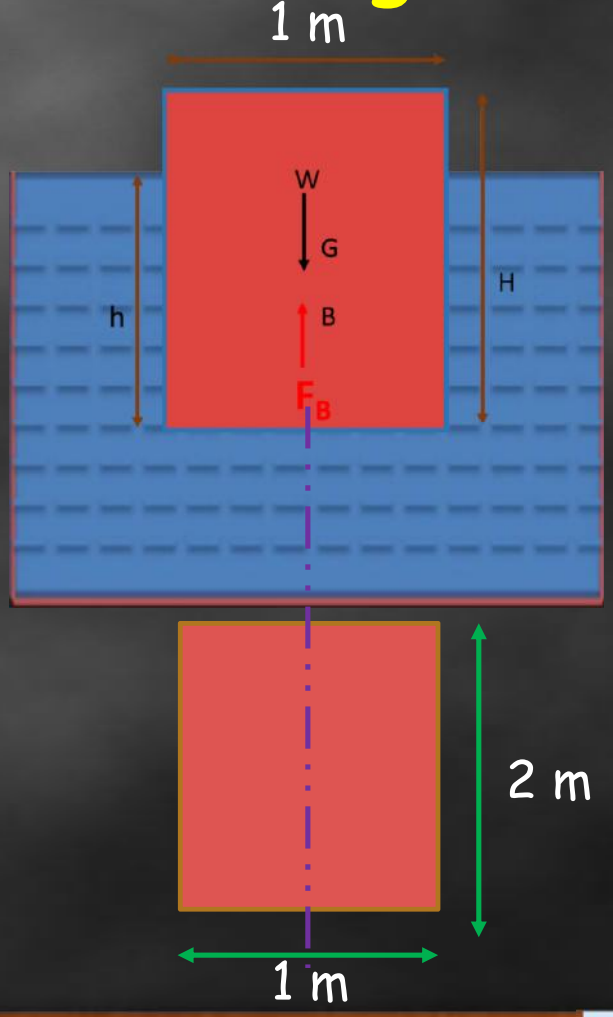
$$GM = BM - BG$$

$$GM = \frac{I}{V} - BG$$



Numerical to calculate Metacentric Height

Q.1 A Block of Wood of Specific Gravity 0.7 floats in water. Determine the Meta centric height of the block if its size is 2 m × 1 m × 0.8 m.



Data given:

Length of the Body, L = 2 m
Width of the body, B = 1 m
Height of the body, H = 0.8 m
Specific Gravity of the body, S_B = 0.7
Metacentric Height GM = ?

Numerical to calculate Metacentric Height

Answer:

Density of the Body, $\rho = 0.7 * 1000 = 700\ kg/m^3$

Surface area of the Body, $A = L \times B = 2 \times 1 = 2\ m^2$

Step 1: Find height of submerge body.

Weight of Body = Weight of Water displaced

$\rho_B \times g \times A \times H = \rho_W \times g \times A \times h$

$\rho_B \times H = \rho_w \times h$

$h = \rho_B / \rho_w \times H = 700/1000 \times 0.8 = \mathbf{0.56\ m}$

Numerical to calculate Metacentric Height

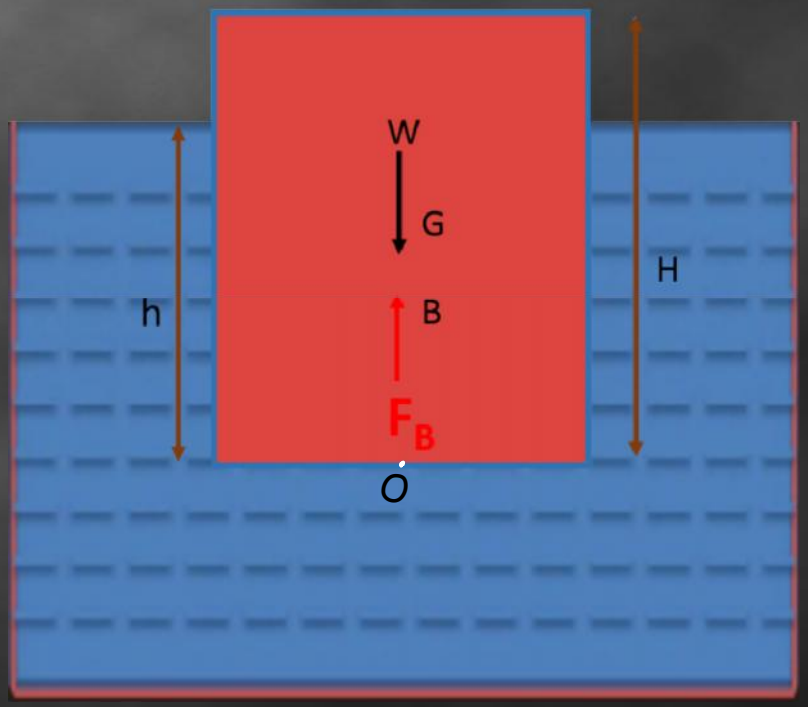
Answer:

Step 2: Volume of the Submerge Body

Volume of submerged body, V = A × h

= 2 × 0.56

= **1.12 m^3**



Step 3: Distance between Point B And G.

BG = OG – OB

= H/2 - h/2

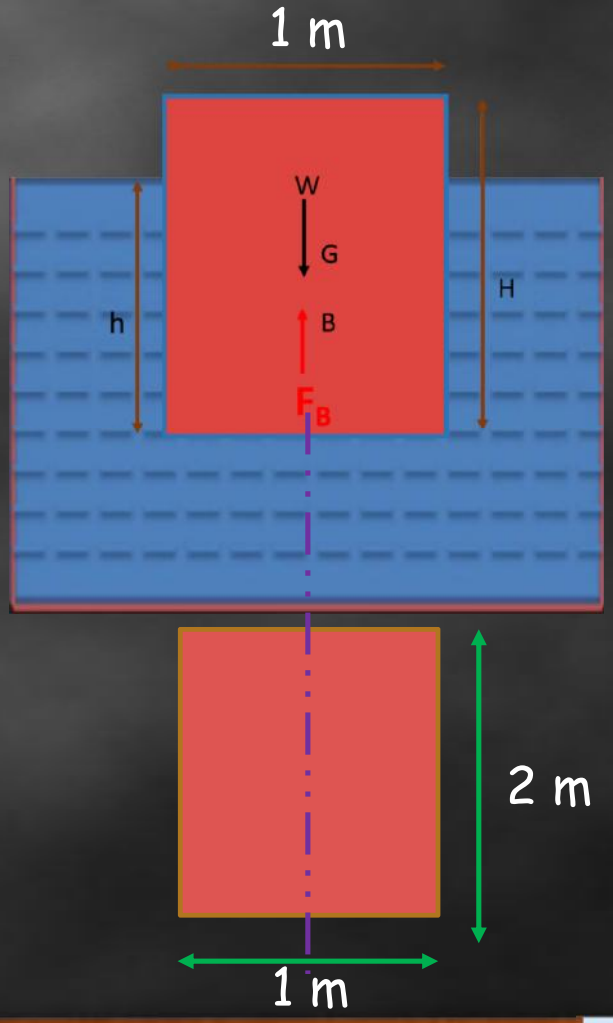
= 0.8/2 - 0.56/2

= 0.4 – 0.28

= **0.12 m**

Numerical to calculate Metacentric Height

Answer:



Step 4: Find Moment of inertia for Top view about the axis shown in figure.

$I = \frac{B \times D^3}{12}$ as per formula,

$= \frac{L \times B^3}{12}$

$= \frac{2 \times 1^3}{12} = 2/12 = 0.1666\ m^4$

Numerical to calculate Metacentric Height

Answer:

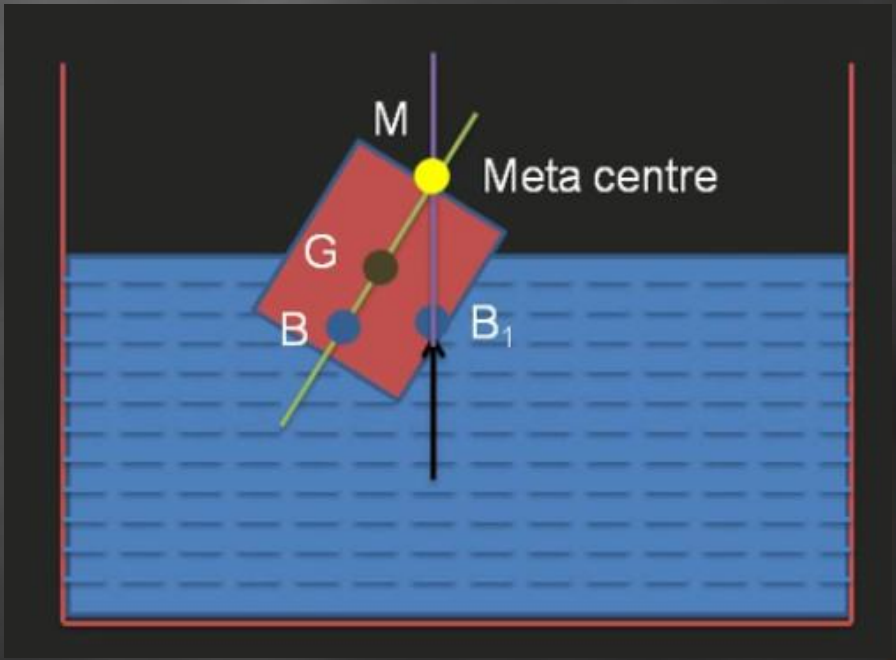
Step 5: Calculate Metacentric height

GM = I/V – BG

= (0.1666/1.2) - 0.12

= 0.1388 – 0.12

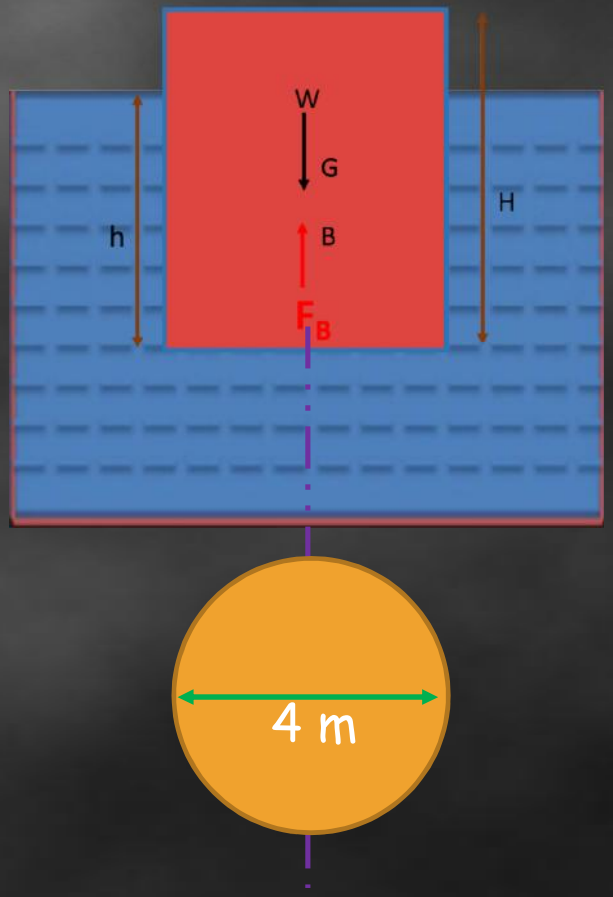
GM = 0.01888 m



Value of Metacentric height is greater than 0.
Means GM > 0
So we can say that body will be in stable equilibrium.

Numerical to calculate Metacentric Height

Q.2 A Solid Cylinder of Diameter 4 has a height of 4m. Find the metacentric height of the cylinder if the specific gravity of the material cylinder is 0.7 and it is floating in water with its axis vertical. State whether the equilibrium is stable or unstable



Data given:

Diameter of cylinder D = 4 m
Height of the cylinder H = 4 m
Specific Gravity of the body, S_B = 0.7
Metacentric Height GM = ?

Numerical to calculate Metacentric Height

Answer:

Density of the Body, $\rho = 0.7 * 1000 = 700\ kg/m^3$

Surface area of the Body, $A = pi * d^2 / 4$

$= 3.14 \times 4\text{^}2 / 4$

$= 12.56\ m^2$

Step 1: Find height of submerge body.

Weight of Body = Weight of Water displaced

$\rho_B \times g \times A \times H = \rho_W \times g \times A \times h$

$\rho_B \times H = \rho_w \times h$

$h = \rho_B / \rho_w \times H = 700/1000 \times 4 = \mathbf{2.8\ m}$

Numerical to calculate Metacentric Height

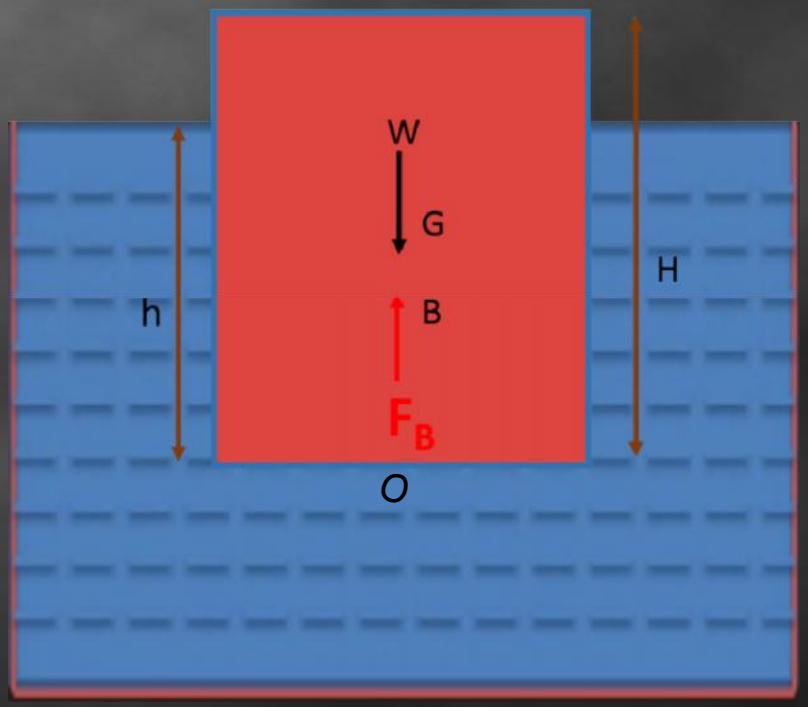
Answer:

Step 2: Volume of the Submerge Body

Volume of submerged body, V = A × h

= 12.56 × 2.8

= **35.18 m^3**



Step 3: Distance between Point B And G.

BG = OG – OB

= H/2 - h/2

= 4/2 - 2.8/2

= 2 – 1.4

= **0.6 m**

Numerical to calculate Metacentric Height

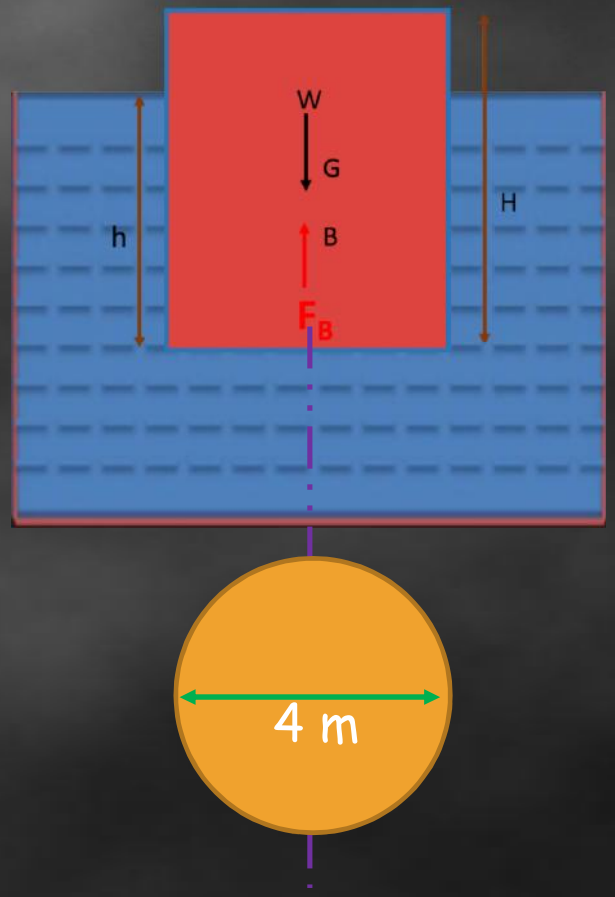
Answer:

Step 4: find Moment of inertia of plan of the body about y-y

I = pi/64 * D^4

= 3.14* 4^4 / 64

= 12.56 m^4



Numerical to calculate Metacentric Height

Answer:

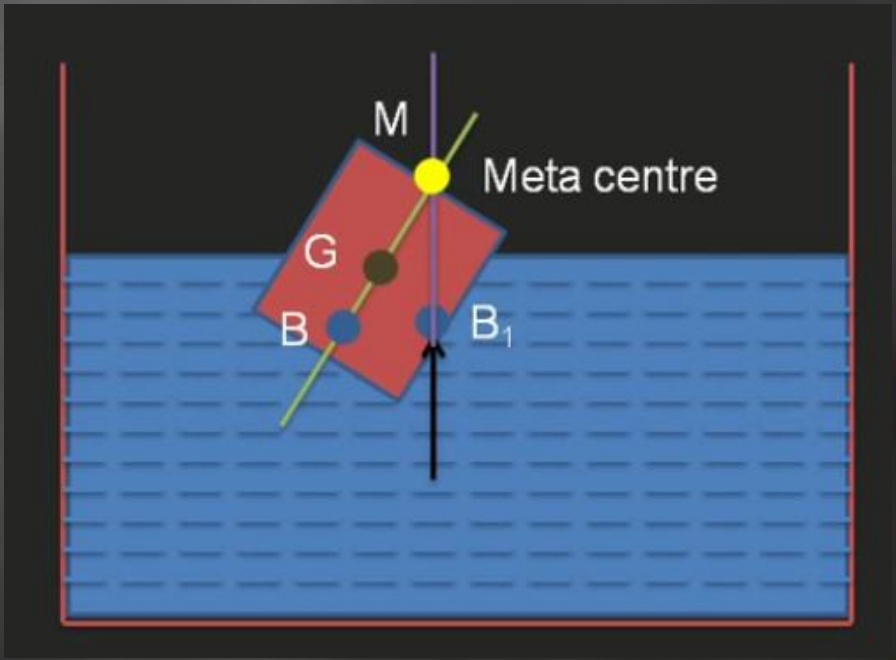
Step 5: Calculate Metacentric height

GM = I/V – BG

= (12.56/35.168) - 0.6

= 0.3571 – 0.6

GM = -0.242 m



Value of Metacentric height is Less than 0.
Means GM < 0
So we can say that body will be in unstable equilibrium.

3.34

Given Data

$W = 22\ kN$

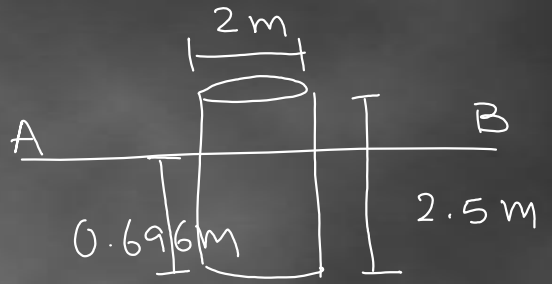
$D = 2\ m$

$h = 2.5\ m$

$S = 1.025$

Step

1) height of object inferred



$W_F = W_{cylinder}$

$S_w A \times h \times g = \boxed{S_B \times A \times h \times g}$

$W = mg$

$W = Svg$

$1.025 \times 1000 \times \pi/4 d^2 \times h \times 9.81 = 22 \times 10^3\ N$

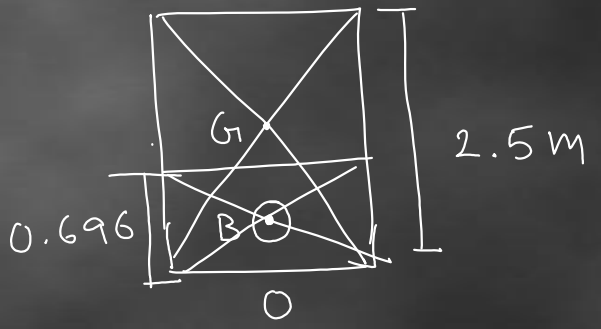
$h = 0.696\ m$

(2) Volume of submerged body

$$\forall = A \times h$$

$$= \pi/4 \times 2^2 \times 0.696$$

$$= 2.189\ m^3$$



(3)

$$BG = OG - OB$$

$$= 1.25 - 0.348$$

$$= 0.9018\ m$$

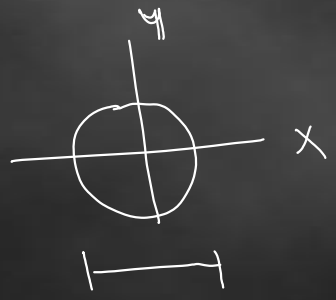
$$OG = H/2 = \frac{2.5}{2} = 1.25m$$

$$OB = h/2 = \frac{0.696}{2}$$

$$= 0.348\ m$$

(4) $I = \pi/64\ D^4$

$$= \pi/64 \times (2)^4 = 0.785\ m^4$$



(5)

$$MG = \frac{I}{\forall} - BG$$

$$= \frac{0.785}{2.189} - 0.9018$$

$$= -0.5432 \text{ m}$$

$GM < 0$

Unstable equilibrium