Fluid flow

2^{nd} stage

Petrol. Ref. & Gas Eng. Dept.

Determination of the center of pressures

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Aims

<u>The objectives of this experiment are:</u>

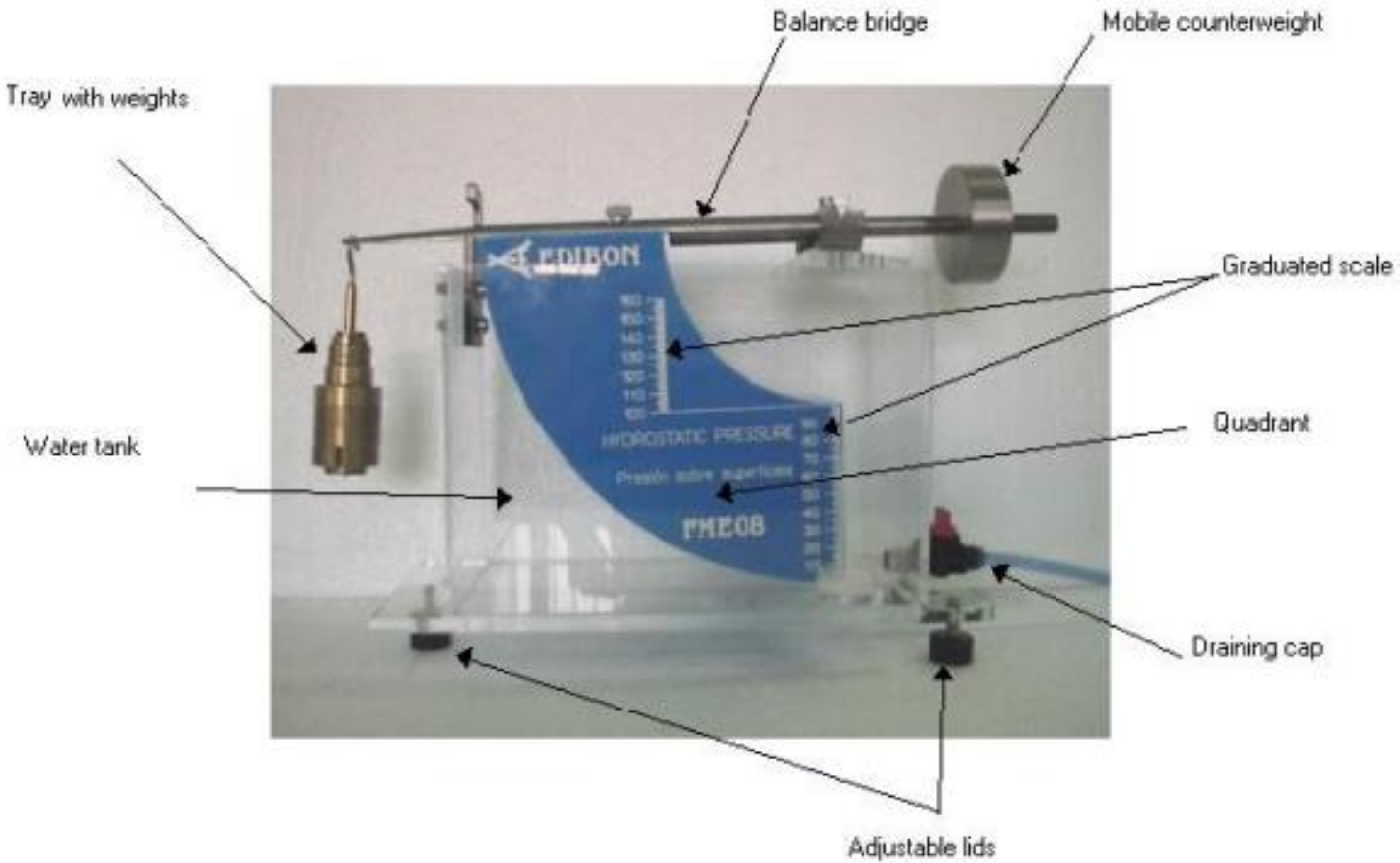
- Determine the hydrostatic force due to water acting on partially or fully submerged surfaces.
- To determine, both experimentally and theoretically, the center of pressure.

Description of the unit

The accessory consists of a quadrant (a fourth of a ring) that will float on the fluid. This element is mounted on an arm of a balance that swings around an axle. When the quadrant is submerged into the water tank, the force that acts against the frontal surface (flat and rectangular) will cause a momentum about the supporting axle.

The balance bridge has a support for weights, where we can place different weights, and a counterweight that can move in the direction of the system. The tank includes adjustable supporting legs that determine its correct levelling with the help of the bubble level, located in one of the legs. It has a draining valve. The level reached by water inside the tank is indicated in a graduated scale placed inside the ballcock.

General sight of the unit



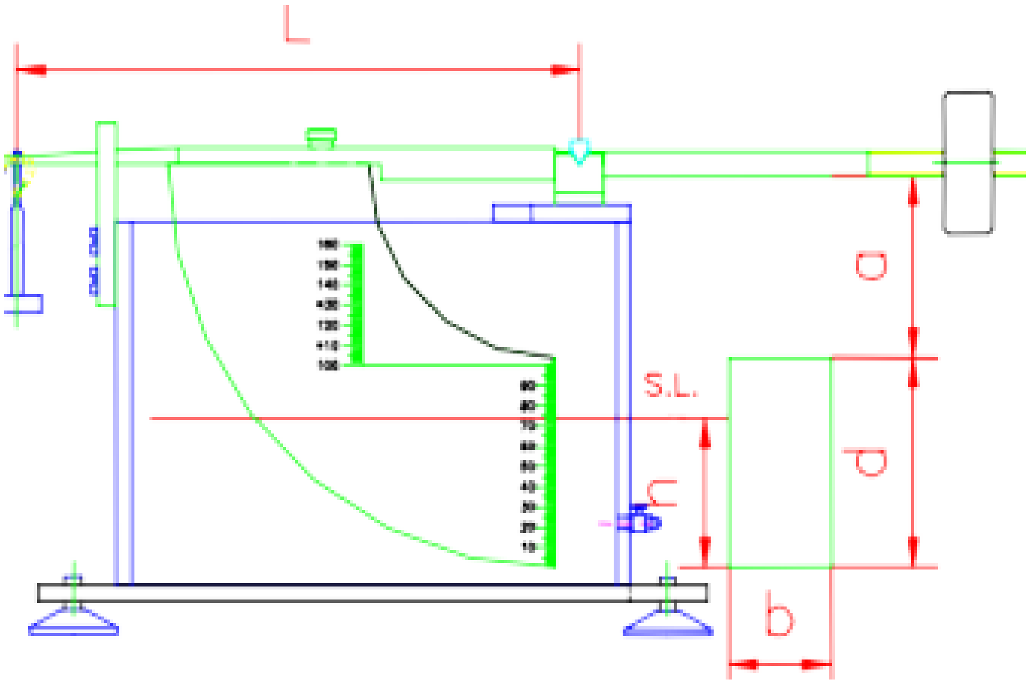
Dimensions of the unit

-a = 100mm

-b = 70mm

-d =100mm

-L =285mm



Practical possibilities

- Experimental determination of the center of pressures on a flat surface, partially submerged into a liquid at rest, and comparison with the theoretical positions.

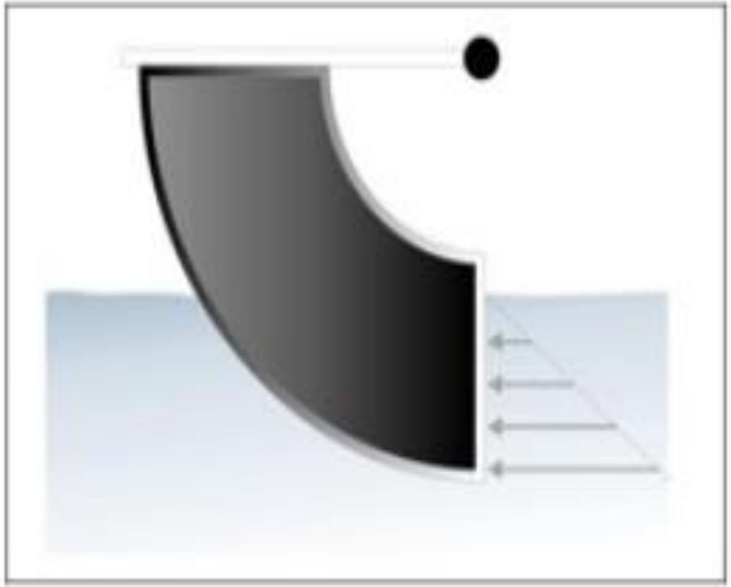
- Experimental determination of the center of pressures on a flat surface, totally submerged into a liquid at rest, and comparison with the theoretical positions.

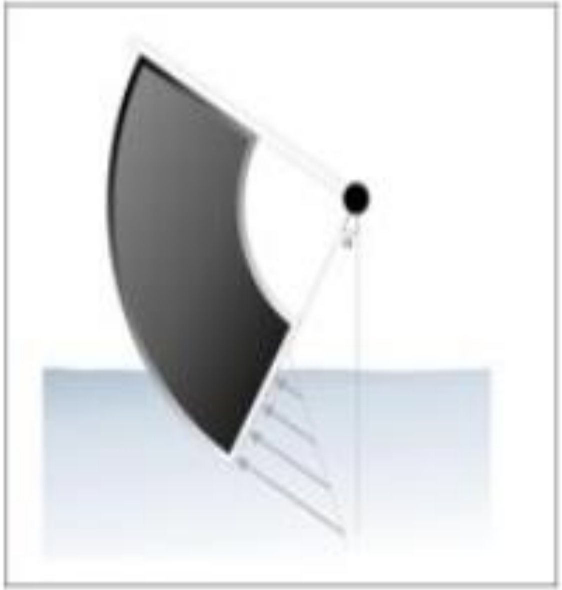
Practical possibilities

- The objective of this equipment is to measure the force made on the surfaces that are in contact with it. To do it, we will take a geometry in which the pressure made on its surfaces do not generate momentum in relation to a point (with the exception of one of them, that will be the surface upon which we will carry out the experiment).

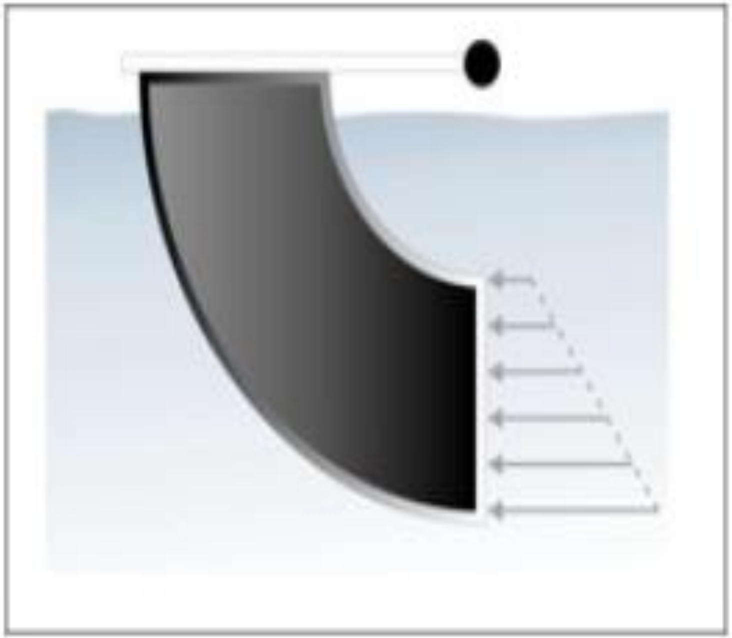
- If we have a submerged pressure, the pressure done on it by the fluid is proportional to the depth. In the figure, we see that the pressure increases as the distance with the surface of the fluid varies.

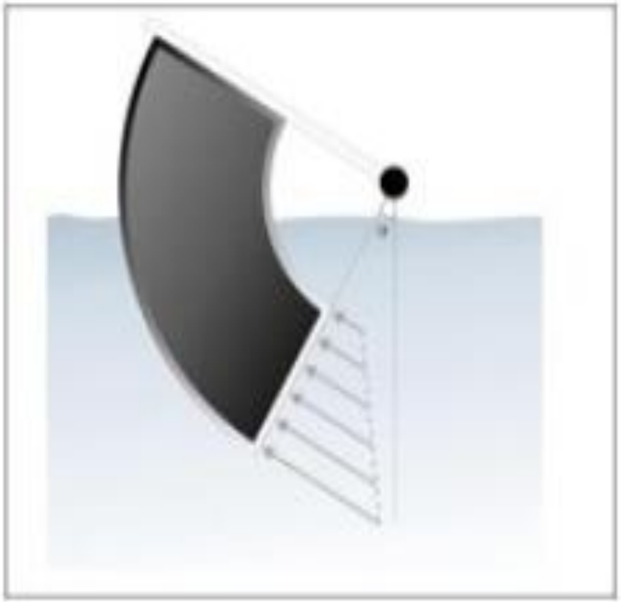
Distribution of pressures – Partially immersed





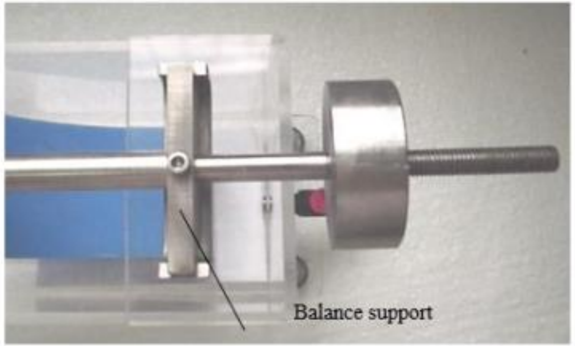
Distribution of pressures – Fully immersed

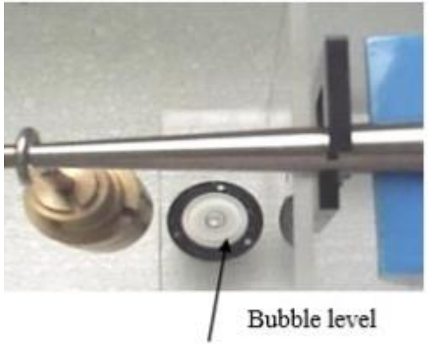




Experimental procedure

- Level the tank, acting conveniently on the supporting feet, which are adjustable, while checking the "bubble level".





- With the tank placed on the Hydraulic Bench or on the Hydraulic Group, locate the balance bridge on the support. Hang the tray at the end of the arm.

- Close the draining tap of the bottom of the tank. Move the counterweight of the bridge balance until the flat surface will be perpendicular to the base of the tank (base that we will level previously). With the balance, we will be able to start with the measures totally balanced, so all changes will be done with a difference in the water volume or with a difference of the masses placed on the tray. This step is very important in order to get good measurements (the equipment has several mortises in the "end hook", the central one identifies this balance point)

Experimental procedure

- Introduce water into the tank until the free surface of this will be tangent to the lowest edge of the quadrant (until the inferior point of the floating element is reached).

- Place a calibrated weight on the balance tray and add water slowly until the flat surface will be perpendicular to the base of the tank.

- Repeat the above process several times, steadily increasing the weight of the tray each time until the balance bridge is level.

Partially Immersed

F, M_1, M_2

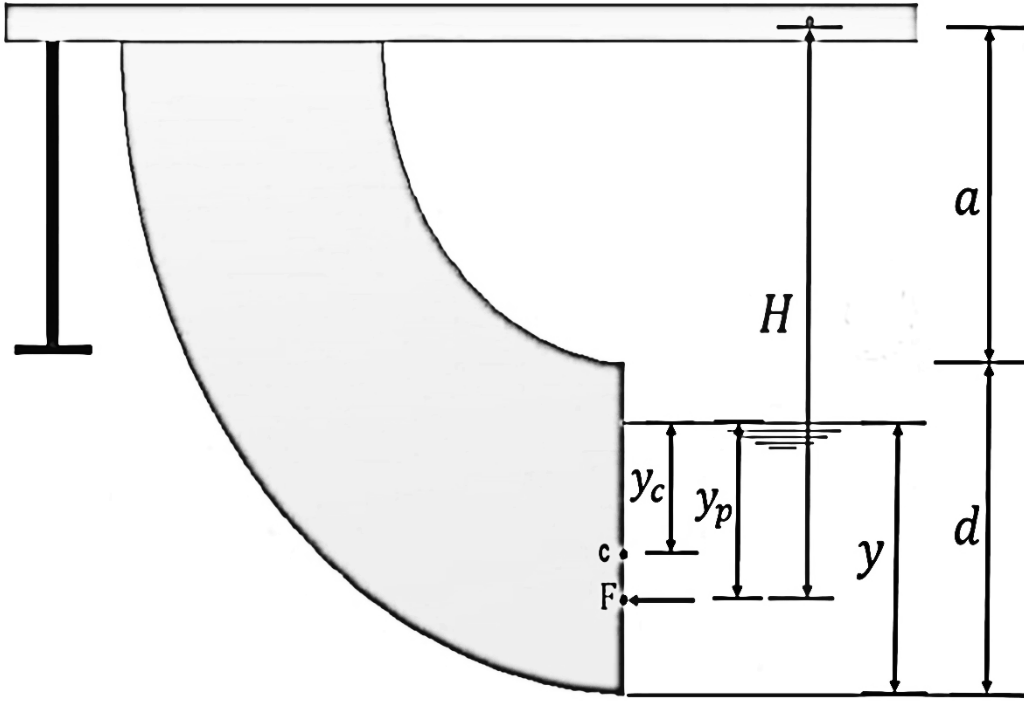
$$\boxed{F = \gamma * y_c * A}$$

$\gamma = 9.81\ KN/M^3$

$$\because\ y_c = \frac{y}{2} \quad \& \quad A = y * b$$

$$\boxed{\therefore F = \frac{1}{2} * \gamma * b * y^2}$$

$$\boxed{\because\ M_1 = F * H}$$



$$H = \left[a + d - \frac{y}{2} + (y_p - y_c)\right]$$

Partially Immersed

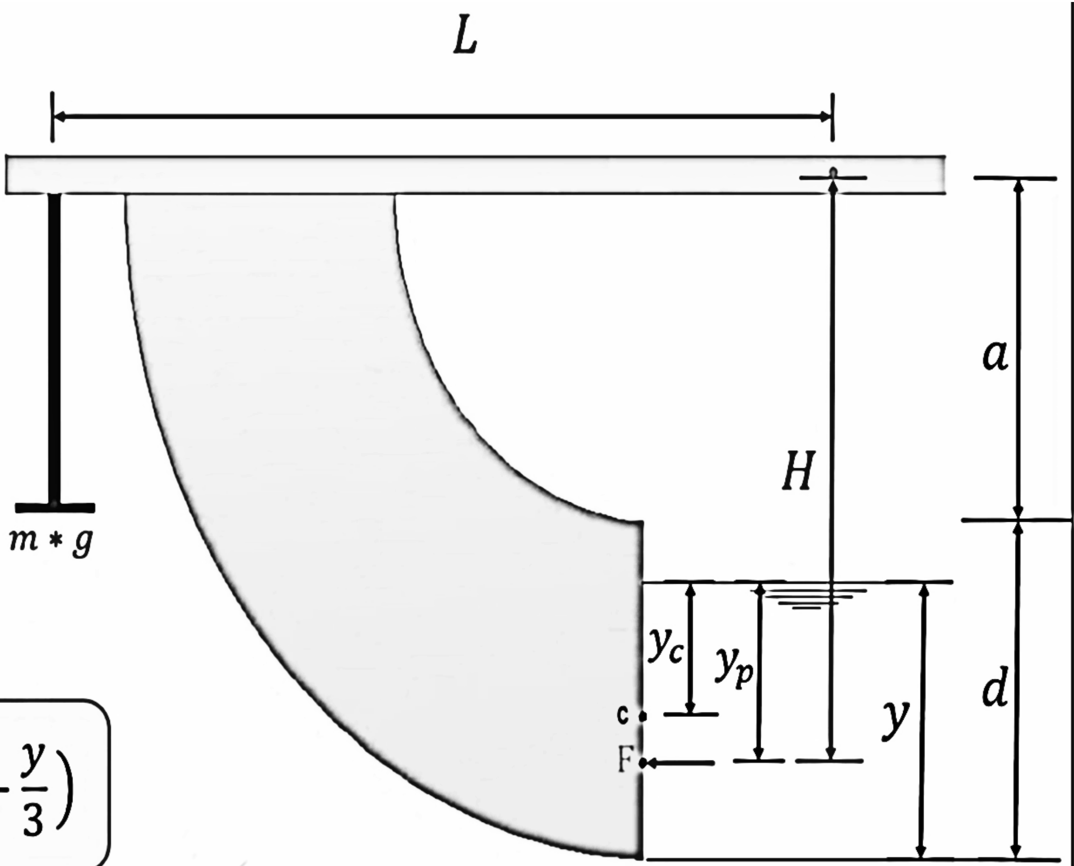
$$(y_p - y_c) = \frac{I_G}{A * y_c} \quad \& \quad I_G = \frac{b * y^3}{12}$$

$$\therefore (y_p - y_c) = \frac{y}{6}$$

$$H = \left(a + d - \frac{y}{3}\right)$$

$$M_1 = \left(\frac{1}{2} * \gamma * b * y^2\right) * \left(a + d - \frac{y}{3}\right)$$

$$M_2 = (m * g) * L$$



Fully Immersed

$$F = \gamma * y_c * A$$

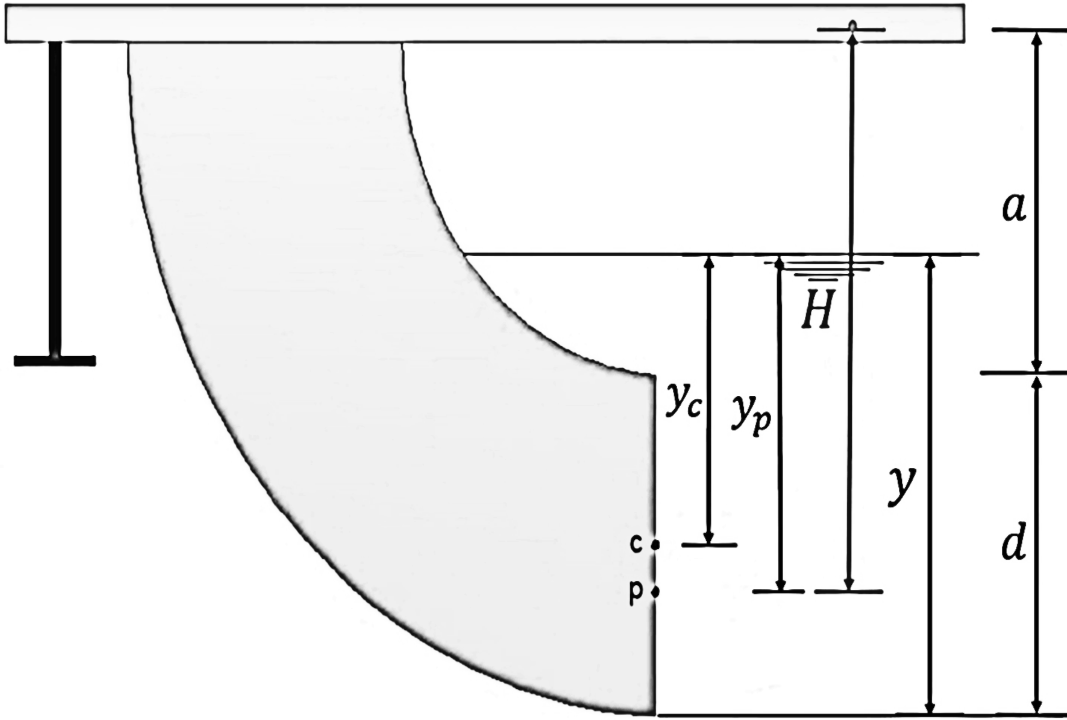
$$\gamma = 9.81\ KN/M^3$$

$$\because y_c = \left(y - \frac{d}{2}\right)\ \&\ A = b * d$$

$$\therefore F = \gamma * \left(y - \frac{d}{2}\right) * (b * d)$$

$$\because\ M_1 = F * H$$

$$H = \left[a + d - \frac{d}{2} + (y_{p} - y_c)\right]$$



Fully Immersed

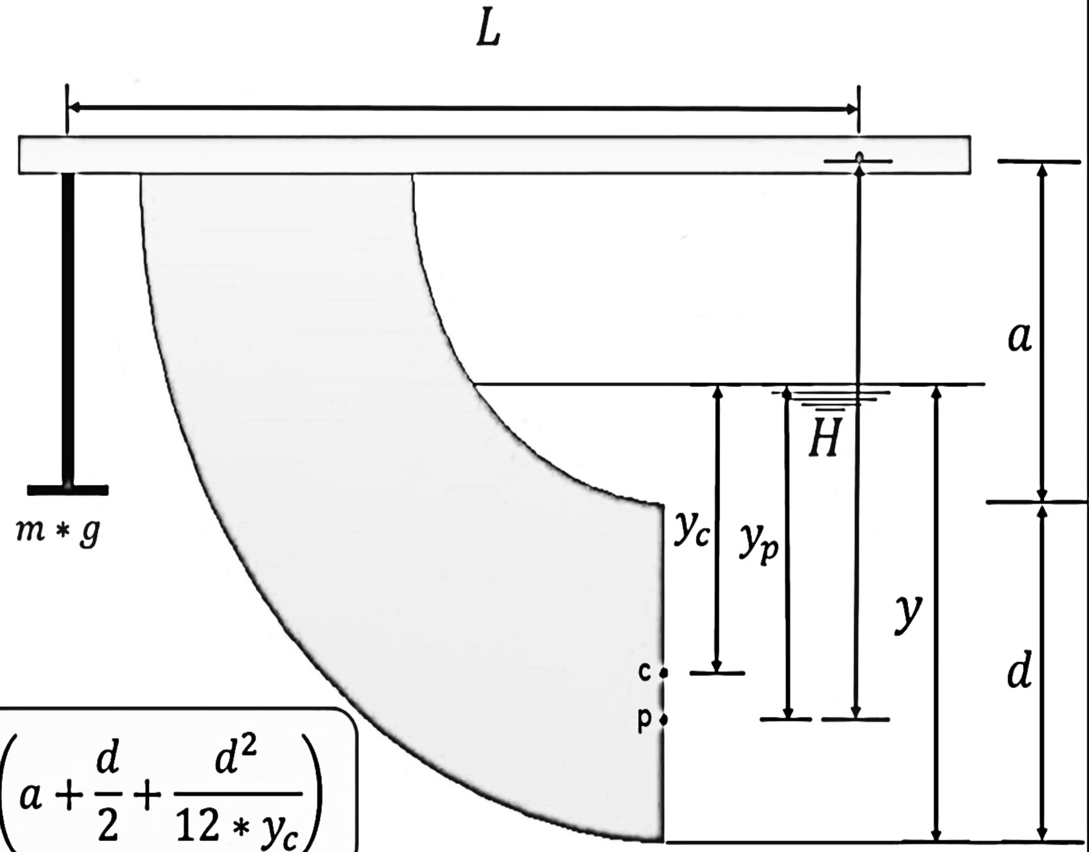
$$(y_p - y_c) = \frac{I_G}{A * y_c} \quad \& \quad I_G = \frac{b * d^3}{12}$$

$$\therefore (y_p - y_c) = \frac{d^2}{12 * y_c}$$

$$H = \left(a + \frac{d}{2} + \frac{d^2}{12 * y_c}\right)$$

$$M_1 = \left(\gamma * \left(y - \frac{d}{2}\right) * (b * d)\right) * \left(a + \frac{d}{2} + \frac{d^2}{12 * y_c}\right)$$

$$M_2 = (m * g) * L$$



■ *Calculation of partially immersed*

$Number$	$y\ (mm)$	$m\ (gm)$	F	M_1	M_2	m/y^2
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	-	-	-	-	-	-
4	-	-	-	-	-	-

1- (a , b , d and, L) are given

2- (y & m) $from\ experiment\ data$

3- $F = \frac{1}{2} * \gamma * b * y^2$

4- $M_1 = F * \left(a + b - \frac{y}{3}\right)$

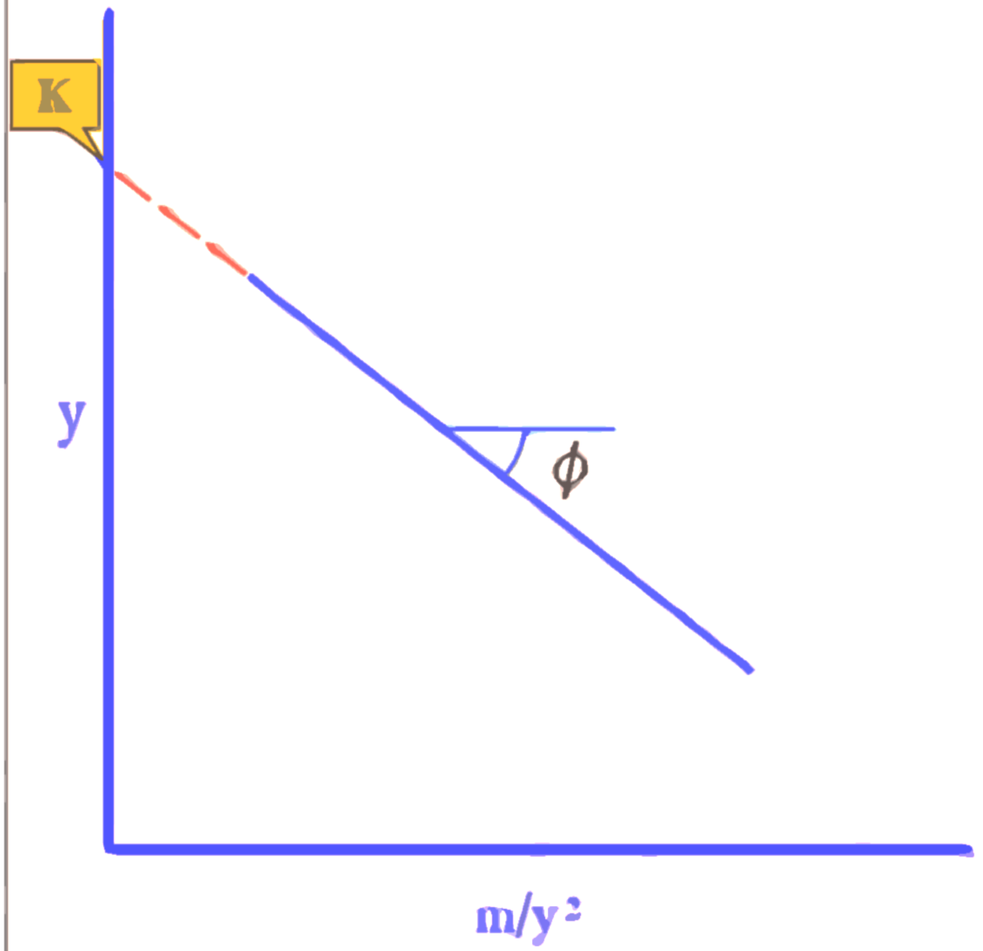
5- $M_2 = (\,m * g) * L$

- **Method of sketch**

1- Sketch between y & m/y^2

$$\tan \phi = \frac{-\rho \cdot b}{6 \cdot L}$$

$$K = \frac{\rho \cdot b(a+b)}{2 \cdot L}$$



■ ***Calculation of fully immersed***

$Number$	$y\ (mm)$	$m\ (gm)$	$y_c\ (mm)$	F	M_1	M_2	m/y_c	
1	-	-	-	-	-	-	-	
2	-	-	-	-	-	-	-	
3	-	-	-	-	-	-	-	
4	-	-	-	-	-	-	-	

1- (a , b , d and, L) are given

2- (y & m) *from experiment data*

3- $y_c = \left(y - \frac{d}{2} \right)$

4- $F = \gamma * \left(y - \frac{d}{2} \right) * (b * d)$

5- $M_1 = F * \left(a + \frac{d}{2} + \frac{d^2}{12 * y_c}\right)$

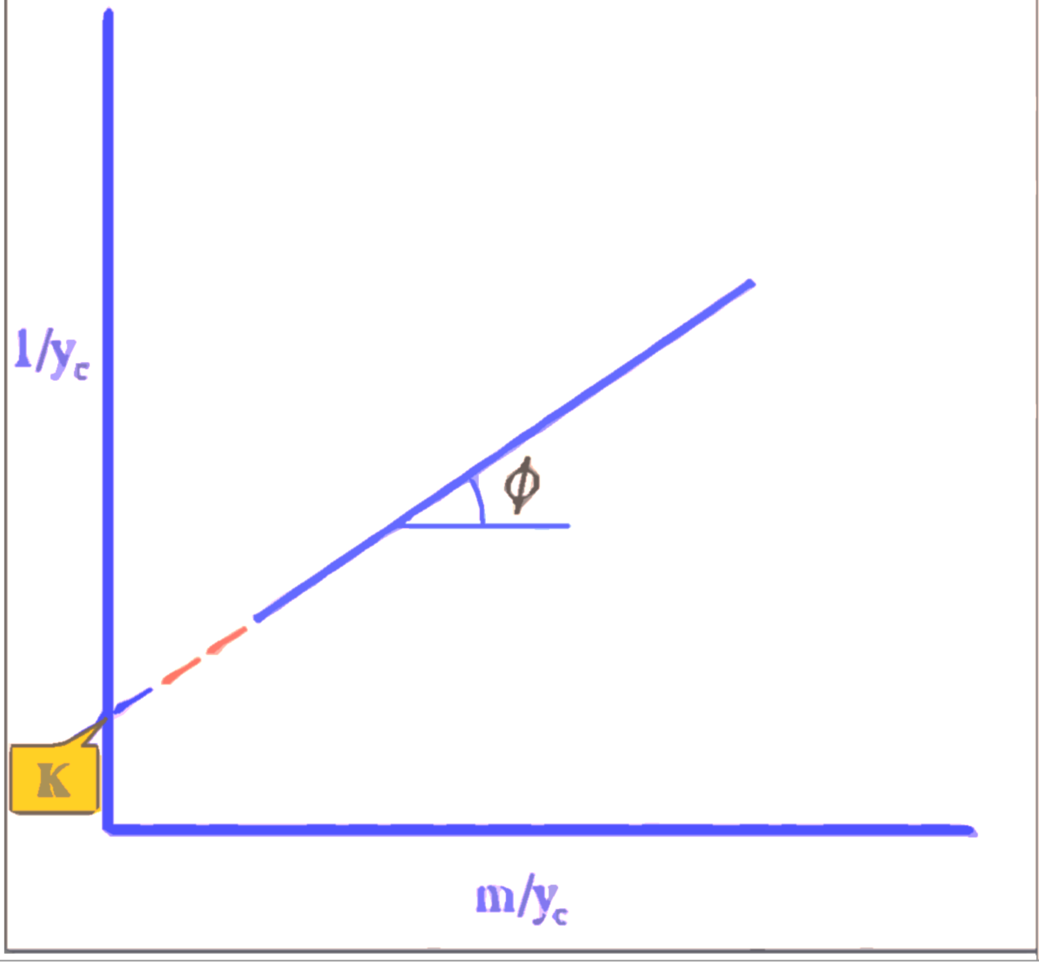
6- $M_2 = (m * g) * L$

■ Method of sketch

1- Sketch between $1/y_c$ & m/y_c

$$\tan\phi = \frac{\rho \cdot b \cdot d^3}{12 \cdot L}$$

$$K = \frac{\rho \cdot b \cdot d}{L}\left(a + \frac{d}{2}\right)$$



Good Luck