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FORCES ON PLANE AND CURVED SURFACES

HYDROSTATIC FORCE

Hydrostatic force refers to the total pressure acting on the layer or surface which is in touch with the liquid or water at rest. If the liquid is at rest then there is no tangential force, and hence the total pressure will act perpendicular to the surface with contact.

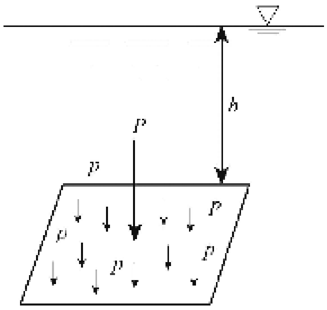
CENTER OF PRESSURE

The location of total pressure is referred as the center of pressure which is always below the center of gravity of the surface in contact.

Forces on the horizontal planes

Show the element submerged in the liquid distance (h) from the liquid surface as in Figure (1).

Figure (1).

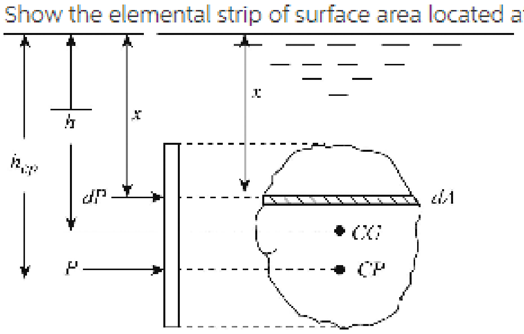


Express the forces on the horizontal plane.

$$F_H = \text{Pressure} \times \text{surface area}$$
$$= p \times A$$
$$F_H = \gamma h \times A$$

Forces on the vertical planes

Show the elemental strip of surface area located at x from the free liquid surface as in Figure (2).



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Express the forces on the horizontal plane.

$$p = \frac{W}{A}$$
$$= \frac{\gamma \times V}{A}$$
$$= \frac{\gamma \times A \times x}{A}$$
$$p = \gamma x$$

Express the total pressure on the plane.

$$\begin{Bmatrix} \text{Total pressure on} \\ \text{the elemental strip} \end{Bmatrix} = \begin{Bmatrix} \text{pressure} \\ \text{intensity} \end{Bmatrix} \times \begin{Bmatrix} \text{Surface Area} \\ \text{in contact} \end{Bmatrix}$$
$$dP = p \times dA$$
$$= (\gamma x) dA$$
$$dP = \gamma \times dA \times x$$

Consider the number of elemental strips and applying the integration to get total hydrostatic force. Therefore, the total pressure is expressed as,

$$\int dP = \int \gamma \times dA \times x$$

Forces on the curved surface

For forces on the curved surface, there will be two forces required to determine the resultant hydrostatic force.

- Horizontal force
- Vertical force

Horizontal force on curved surface

The vertical plane shall be considered to determine the horizontal force, which is the vertical projection of the curved surface generally rectangle. But in case of hemispherical or spherical, it becomes circular shape.

Express the horizontal component of force.

Vertical force on curved surface

It is the weight of the liquid acting on the curved surface in contact with the liquid which may be in upward direction due to buoyancy or downward direction due to the weight of the fluid.

Express the vertical component of force

$$F_V = \gamma A L$$

Therefore, the resultant force on the curved surface is,

$$F_R = \sqrt{F_H^2 + F_V^2}$$