Section B

BUOYANCY & STABILITY OF IMMERSED AND FLOATING BODIES

ARCHIMRDE'S PRINCIPLE

- Whenever a body immersed wholly or partially in a liquid it is acted upon by a vertical upward liquid thrust equal to the weight of the liquid displaced.

BUOYANCY

- It is an upward thrust exerted by a liquid on a body floating or immersed in it. It is equal to the weight of the liquid displaced by the body.
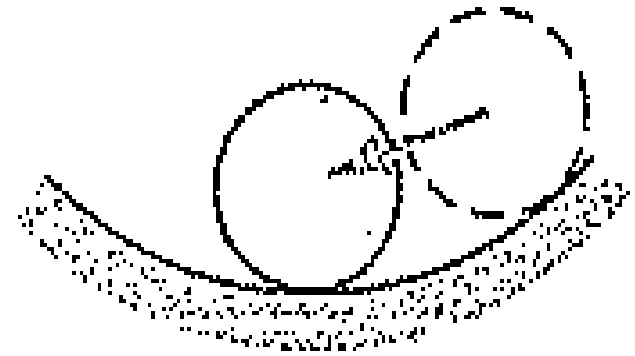
CENTRE OF BUOYANCY

- It is the point at which the buoyancy or upward liquid thrust acts. The centre of buoyancy will be the centre of gravity of the fluid displaced.
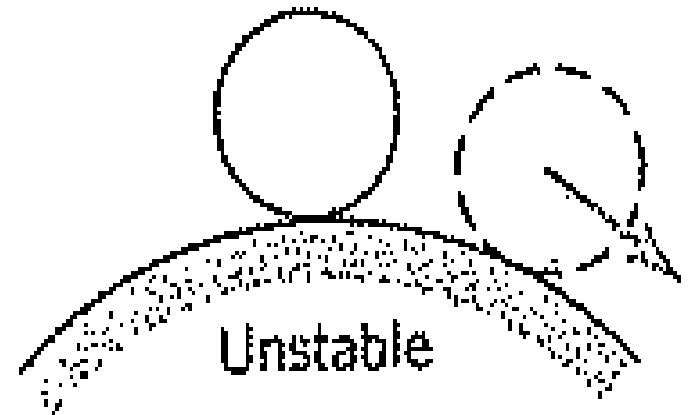
Depth of immersion: $h = \rho_b H / \rho$

STABILITY :

- The stability of a body can be determined by considering what happens when it is displaced from its equilibrium.
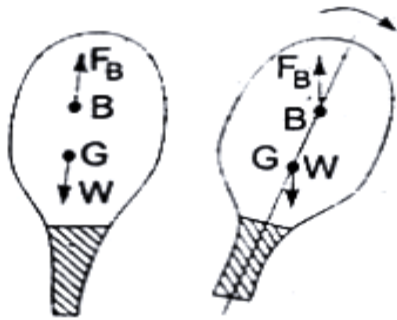

Stable

Unstable

STABILITY OF IMMERSED BODIES

- When a body is completely immersed in a liquid , its stability depends on the relative positions of the centre of gravity of the body and the centroid of the displaced volume of fluid, which is called the centre of buoyancy.

- The position of Centre of gravity and Centre of buoyancy in case of a completely sub-merged are fixed.
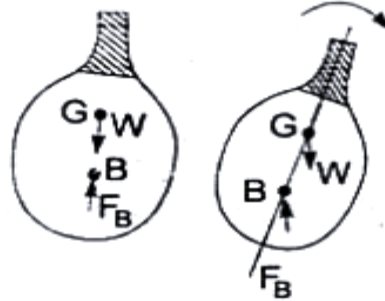
CONDITIONS OF EQUILIBRIUM OF IMMERSED BODIES

➢**STABLE EQUILIBRIUM**
➢**UNSTABLE EQUILIBRIUM**
➢**NEUTRAL EQUILIBRIUM**

Lets take an example of a balloon which is completely submerged in air

(a) STABLE EQUILIBRIUM (b) UNSTABLE EQUILIBRIUM (c) NEUTRAL EQUILIBRIUM

Where

F_B = buoyant force.

W = weight of balloon.

G = centre of gravity.

B = centre of buoyancy.

STABLE EQUILIBRIUM

▪When W=F_B and point B is above G , the body is said to be in stable equilibrium.

▪If the balloon is given an angular displacement in the clockwise direction, then W and F_B constitute a couple acting in the anti-clockwise direction and brings the balloon in the original position

UNSTABLE EQUILIBRIUM

- If $W = F_B$, but B is below G, the body is in unstable equilibrium.

- A slight displacement to the body in the clockwise direction, gives the couple due to W and F_B, also in the clockwise direction. Thus the body does not return to its original position .

NEUTRAL EQUILIBRIUM

- If W=F$_B$ and B and G are at the same point ,the body is said to be in Neutral Equilibrium

ANOTHER Figure is shown below for all three conditions.
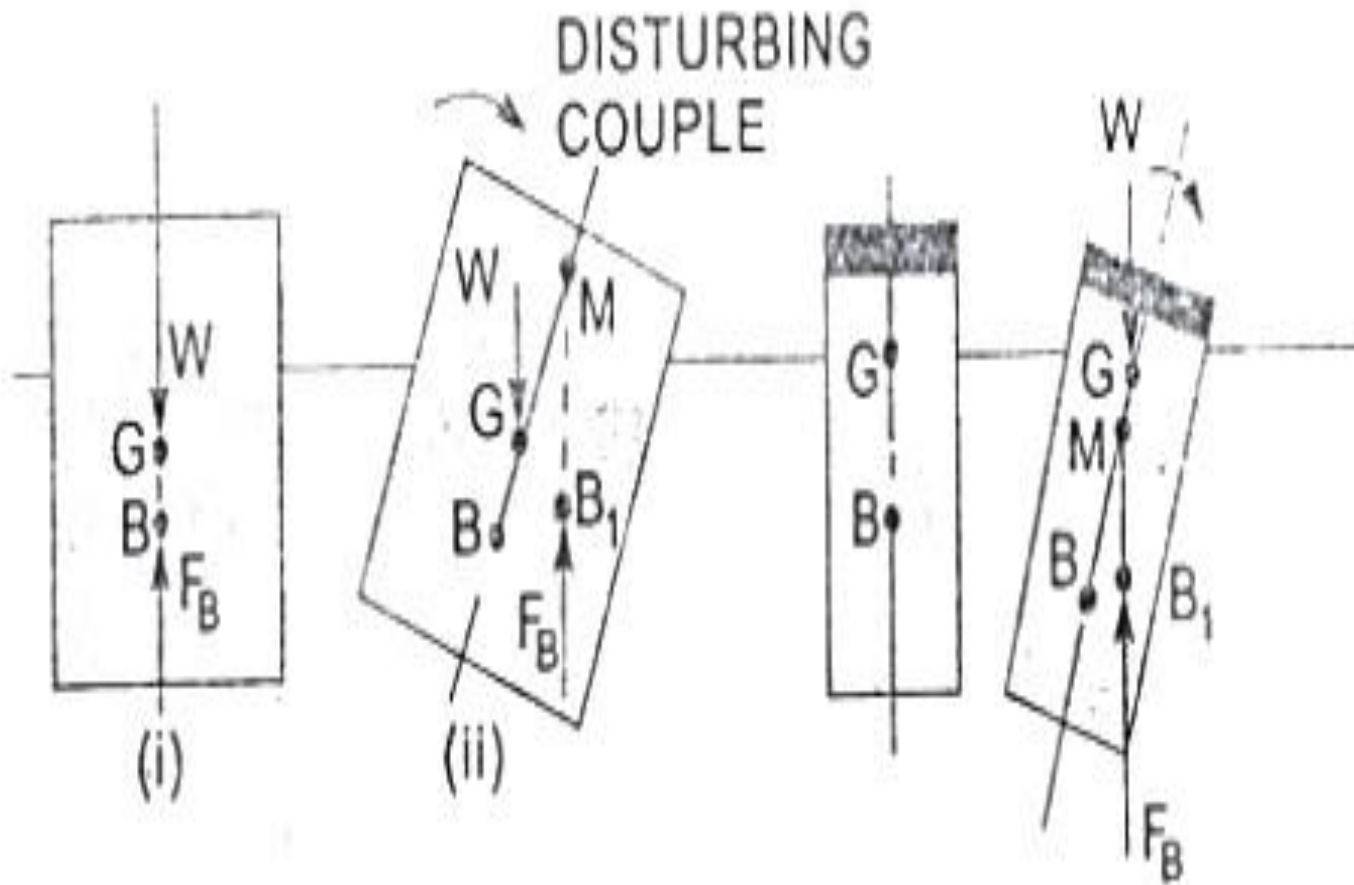

Center of buoyancy
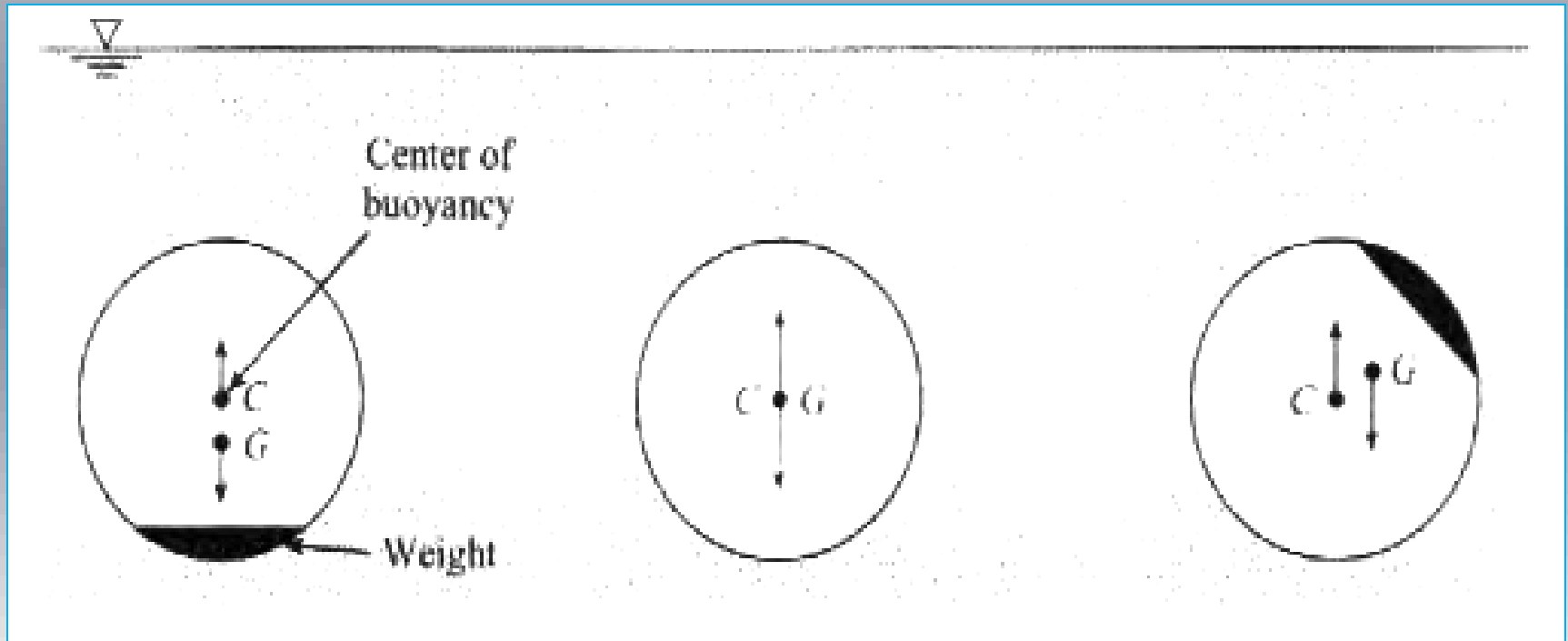
Weight

STABILITY OF FLOATING BODIES

- The stability of a floating body is determined from the position of Meta – centre(M).In case of floating body ,the weight of body is equal to the weight of the liquid displaced.
- The centre of buoyancy may take different positions w.r.t centre of gravity, depending on the shape of the body and the position in which it is floating.

CONDITIONS OF EQUILIBRIUM OF FLOATING BODIES

➢**STABLE EQUILIBRIUM**
➢**UNSTABLE EQUILIBRIUM**
➢**NEUTRAL EQUILIBRIUM**

DISTURBING COUPLE

W

M

G

B

B₁

F_B

(i)

(ii)

W

G

B

W

G

M

B

B₁

F_B

(a) Stable equilibrium M is above G

(b) Unstable equilibrium M is below G.

STABLE EQUILIBRIUM

- If the point M is above G, the floating body will be in stable equilibrium.

- Centre of Buoyancy will shift from B to B_1, Such that the vertical line through B_1, cuts at M.

- Then the buoyant force F_B through B_1, and weight W through G constitute a couple acting in the anticlockwise direction and thus bringing the floating body in the original position.

UNSTABLE EQUILIBRIUM

- If point M is below G, the floating body will be in unstable equilibrium

- The disturbing couple is acting in the clockwise direction. The couple due to buoyant force F_B and W is also acting in the clockwise direction and thus overturning the body.

NEUTRAL EQUILIBRIUM

- If the point M is at the centre of gravity of the body, the floating body will be in neutral equilibrium.