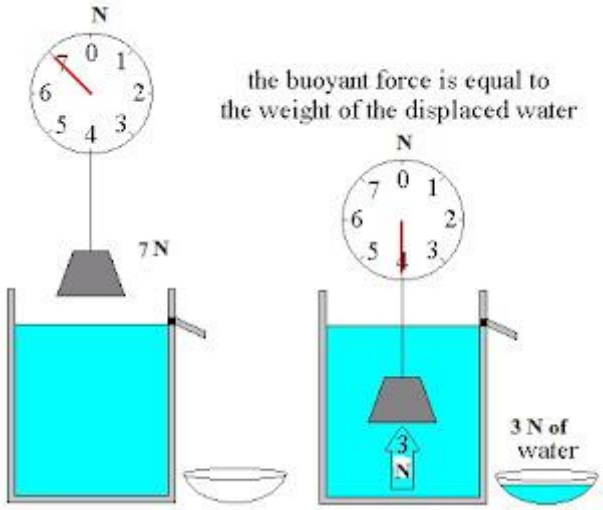
1.5 BUOYANCY AND FLOATATION

Buoyancy or buoyancy force

When a body is immersed in fluid, an upward force is exerted by the fluid on the body. This force will be equal to the weight of the fluid displaced by the body and this force will be termed as force of buoyancy or buoyancy.

Let us consider we have one container filled with water as displayed here in following figure. We have one object of weight 7 N. Let us think that we are now immersing the object in to the liquid i.e. water.



Once object will be immersed in the water, some amount of water will be displaced by the object and one upward force will be applied over the object by the water.

Weight of the displaced water will be equal to this upward force which will be exerted by the water on the object. As we can see from above figure that, water of weight 3N is displaced here and one upward force of 3N is exerted by the water over the object.

Conclusion for buoyancy force

Buoyancy force is the force which will be exerted on the object by the surrounding fluid. When one object will be immersed in the water, object will push the water and water will push back the object with as much force as it can.

Force of buoyancy = Weight of the displaced fluid

Force of buoyancy = Weight of the object in air – Weight of the object in given water

Positive buoyancy

Force of buoyancy will be greater than the weight of the object. Hence, object will float and this case will be termed as positive buoyancy.

Neutral buoyancy

Force of buoyancy will be equal to the weight of the object. Hence, object will be suspended in the fluid and this case will be termed as neutral buoyancy.

Negative buoyancy

Force of buoyancy will be less than the weight of the object. Hence, object will be sunk and this case will be termed as negative buoyancy.

Centre of buoyancy

As we know that when a body is immersed in fluid, an upward force is exerted by the fluid on the body. This force will be equal to the weight of the fluid displaced by the body and this force will be termed as force of buoyancy or buoyancy.

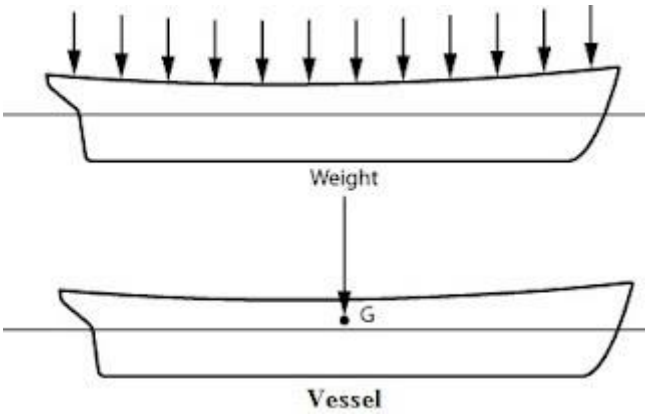
Buoyancy force will act through the centre of gravity of the displaced fluid and that point i.e. centre of gravity of the displaced fluid will be termed as centre of buoyancy.

Therefore we can define the term centre of buoyancy as the point through which the force of buoyancy is supposed to act.

Centre of buoyancy = Centre of gravity of the displaced fluid = Centre of gravity of the portion of the body immersed in the liquid

Let us explain the term centre of buoyancy

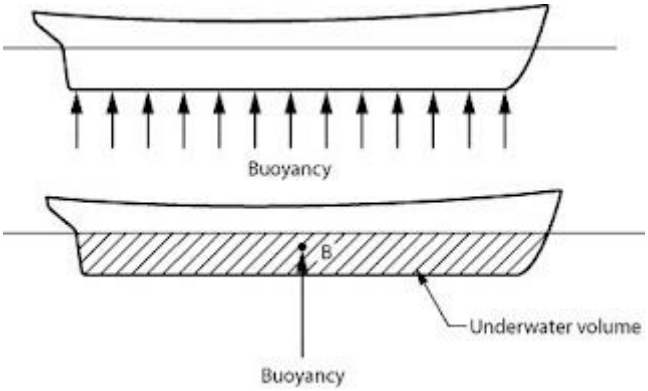
Let us consider one vessel as displayed here in following figure. Weight of vessel will be distributed throughout the length of vessel and will act downward over the entire structure of vessel.



But, what do we consider?

We consider that complete weight of the vessel will act downward vertically through one point and that point will be termed as the centre of gravity of that vessel.

In similar way, buoyancy force will be supposed to act vertically in upward direction through a single point and that point will be termed as centre of buoyancy.



Meta-centre

Meta-centre is basically defined as the point about which a body in stable equilibrium will start to oscillate when body will be displaced by an angular displacement.

We can also define the meta-centre as the point of intersection of the axis of body passing through the centre of gravity and original centre of buoyancy and a vertical line passing through the centre of buoyancy of the body in tilted position.

Let us consider a body which is floating in the liquid. Let us assume that body is in equilibrium condition. Let us think that G is the centre of gravity of the body and B is the centre of buoyancy of the body when body is in equilibrium condition.

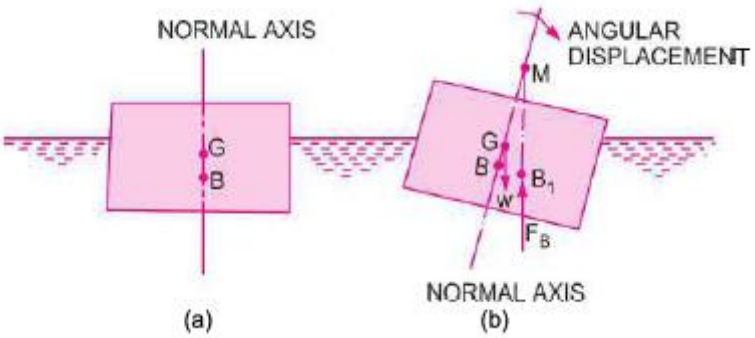


Figure 1.7.1 Meta-centre

[Source: "Fluid Mechanics and Hydraulics Machines" by Dr.R.K.Bansal, Page: 136]

In equilibrium situation, centre of gravity G and centre of buoyancy B will lie on same axis which is displayed here in above figure with a vertical line.

Let us assume that we have given an angular displacement to the body in clockwise direction as displayed here in above figure.

Centre of buoyancy will be shifted now towards right side from neutral axis and let us assume that it is now B1.

Line of action of buoyancy force passing through this new position will intersect the normal axis passing through the centre of gravity and centre of buoyancy in original

position of the body at a point M as displayed here in above figure. Where, M is the meta-centre.

Meta-centric height

Meta-centric height is basically defined as the distance between the meta-centre of the floating body and the centre of gravity of the body.

Therefore, MG in above figure will be termed as meta-centric height.