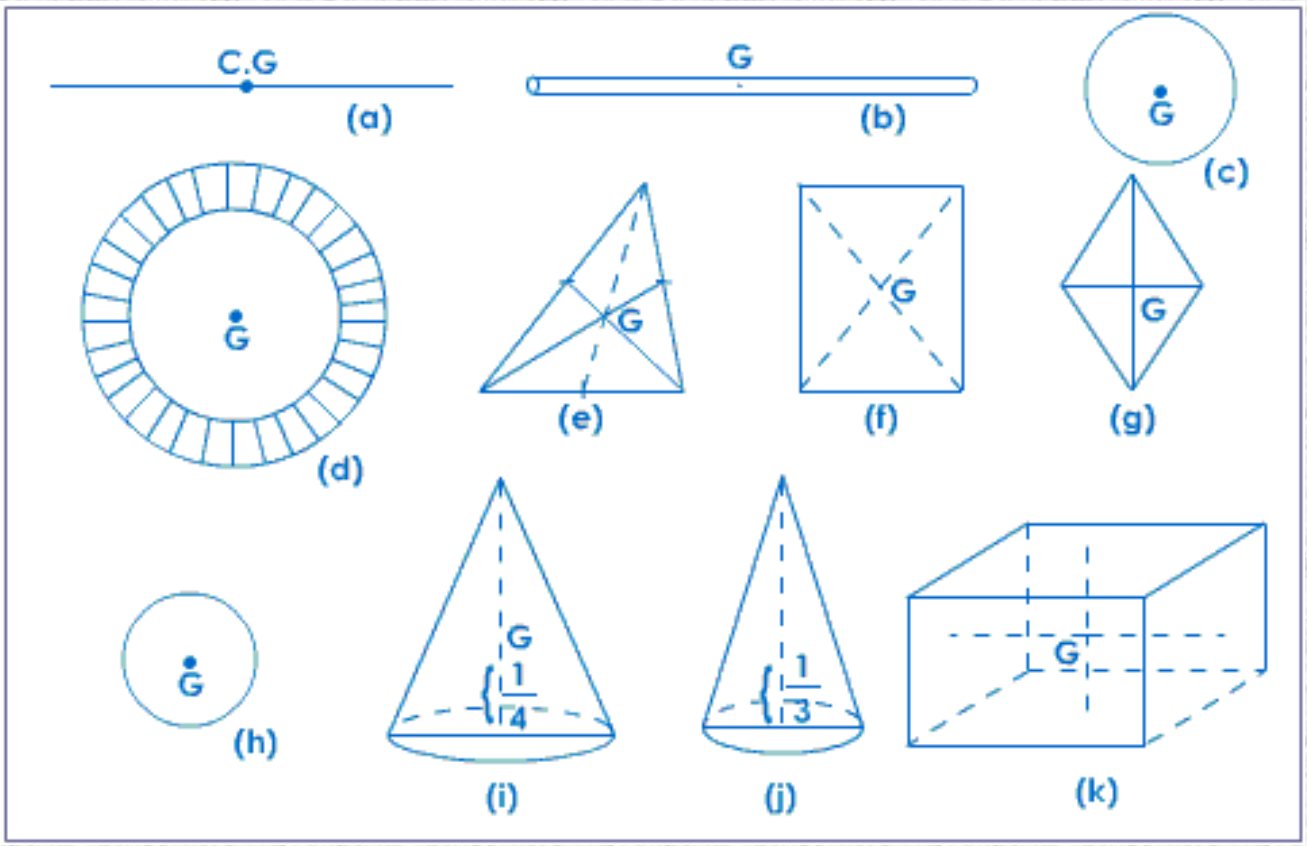
Introduction to Engineering Mechanics

Centroids
and
Center of Gravity

Centroids

The centroid of an area is situated at its **geometrical centre**. In each of the following figures **'G'** represents the centroid, and if each area was suspended from this point it would **balance**.



Center of gravity

The centre of gravity of a body is:

- **The point at which all the mass of the body may be assumed to be concentrated.**

- **The point through which the force of gravity is considered to act vertically downwards, with a force equal to the weight of the body.**

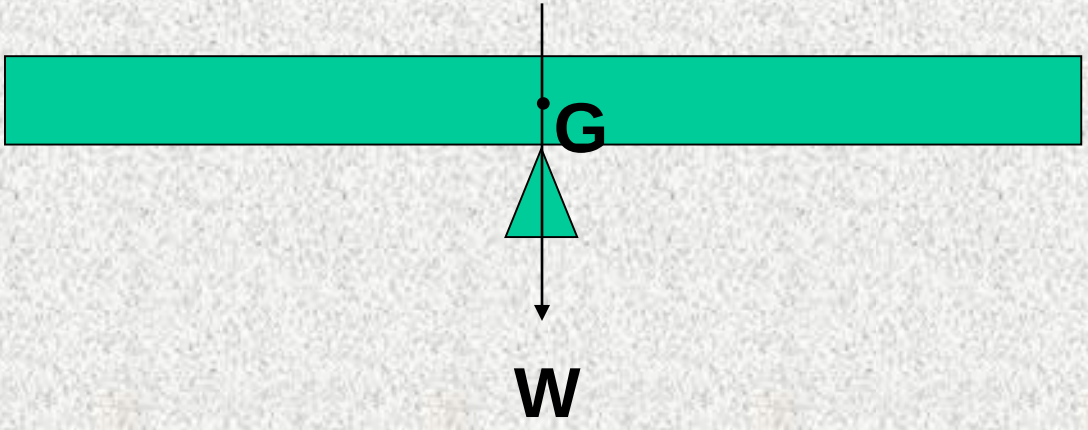
- **The point about which the body would balance.**

The centre of gravity of a homogeneous body is at its geometrical centre.

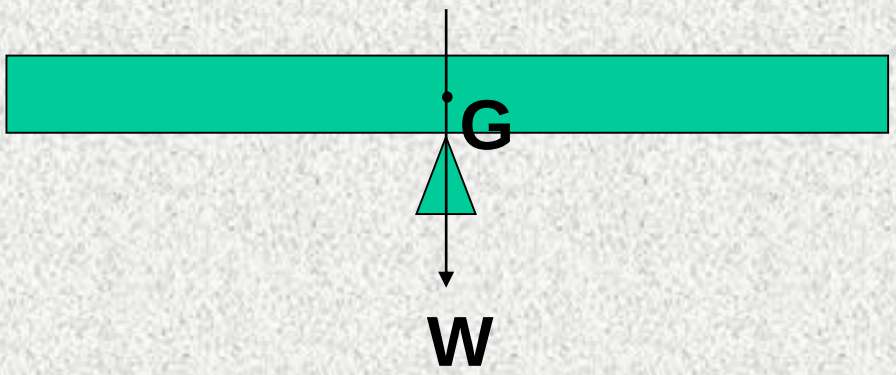
Consider a homo. Block of wood, its center of gravity will be its geometrical center,

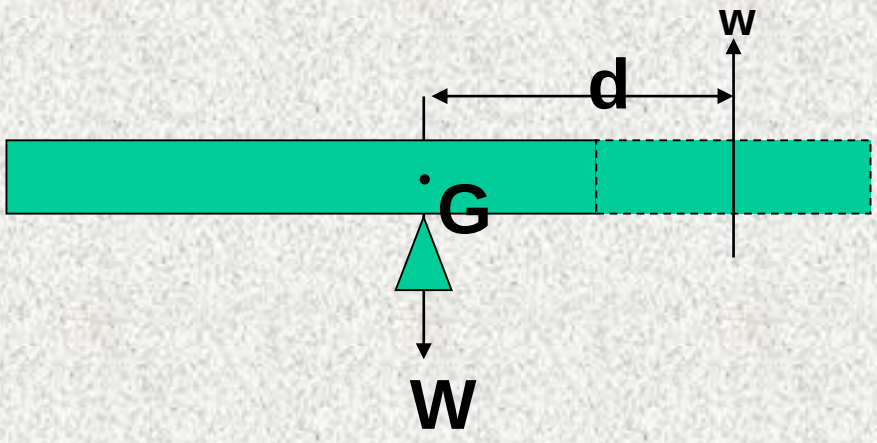
- half way of its length,
- half way of its breadth, and
- half way of its depth

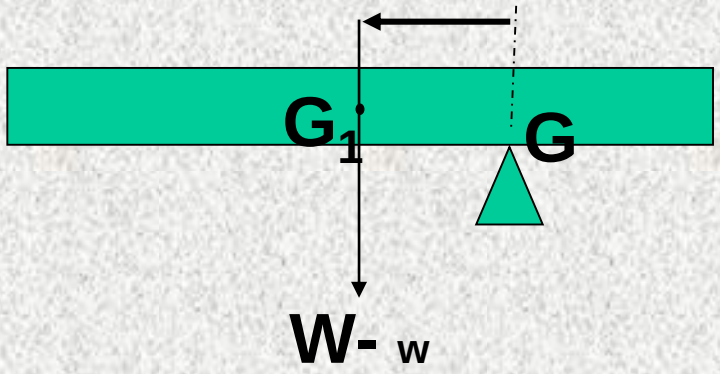
Place a wedge under its C.G, the block will balance



Effect of removing or discharging mass





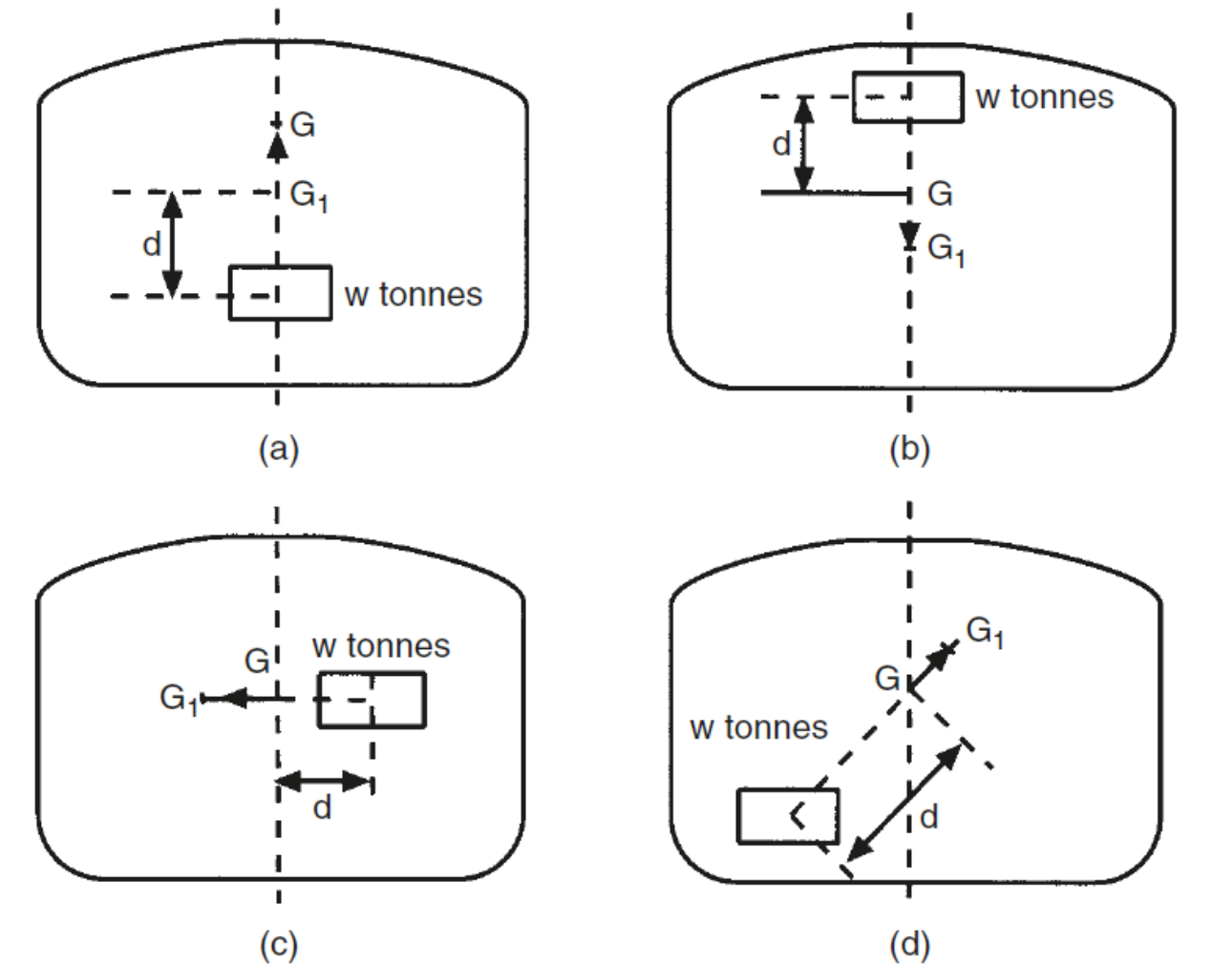


Moment = w x d

And also moment = (W- $_{w)}$ x GG

w x d =(W –w) x GG_1

Application to a ship Discharging

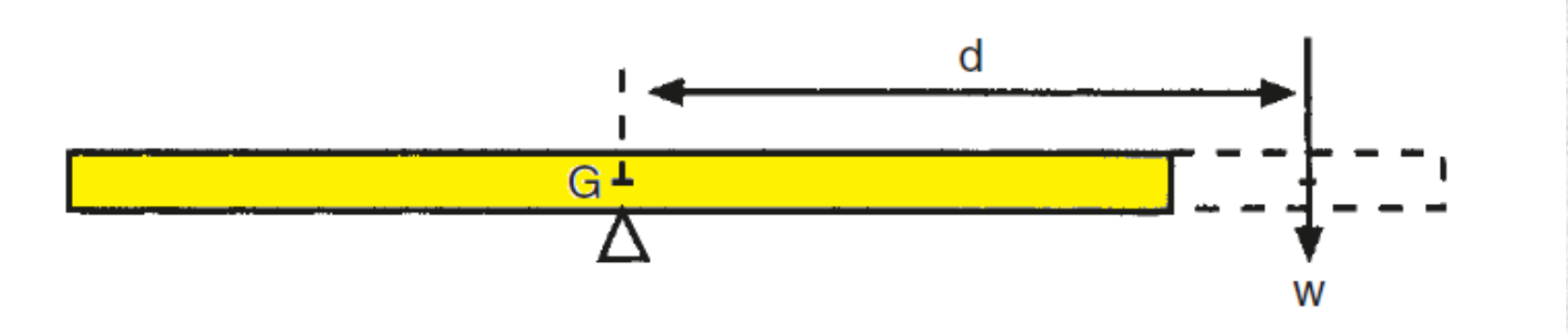


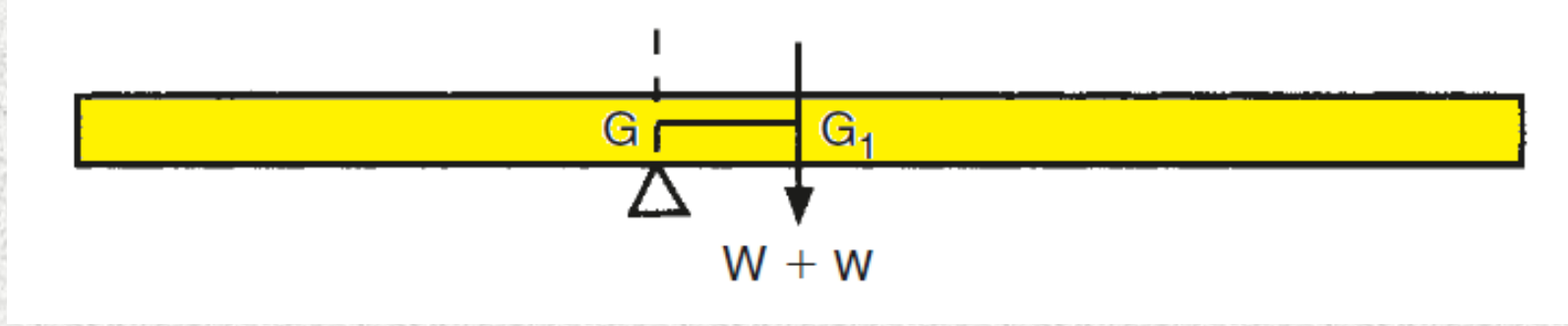
$$GG_1 = \frac{w \times d}{W - w}$$

CONCLUSION

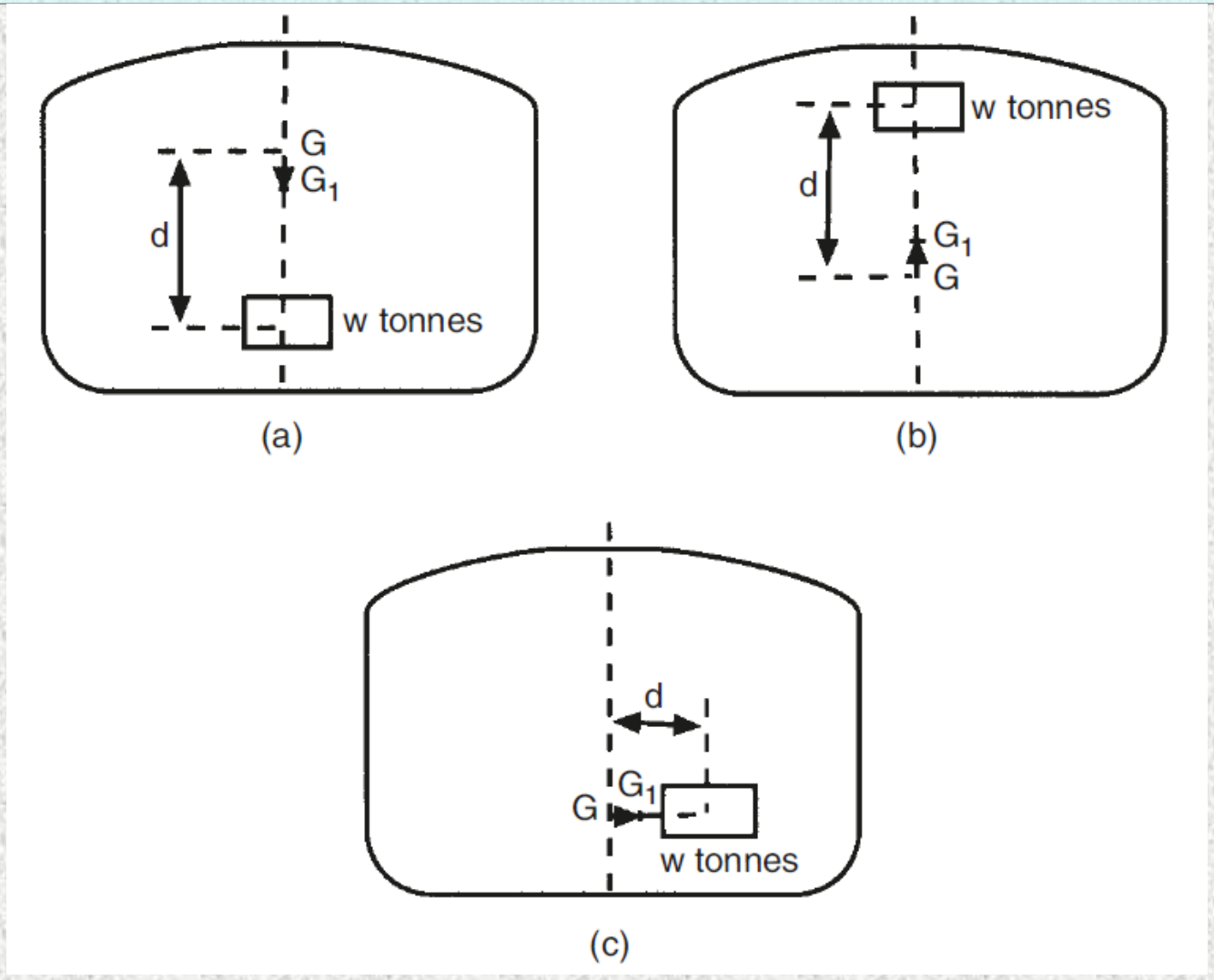
Effect of removing or discharging mass

When a mass is removed from a body, the center of gravity of the body will move directly away from the center of gravity of the mass removed


d
G
w


G
G1
W + w

Application to a ship Loading



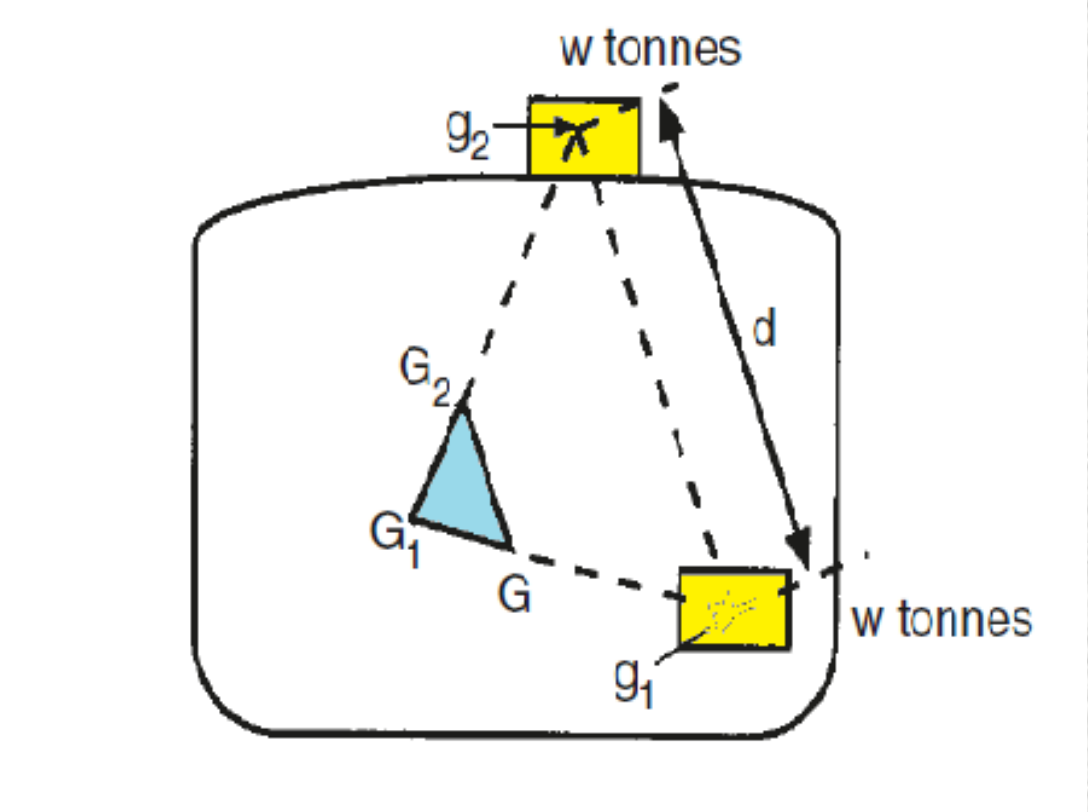
$$GG_1 = \frac{w \times d}{W+w}$$

CONCLUSION

Effect of adding or loading mass

When a mass is added to a body, the center of gravity of the body will move directly towards the center of gravity of the mass added

Application to a ship shifting weights



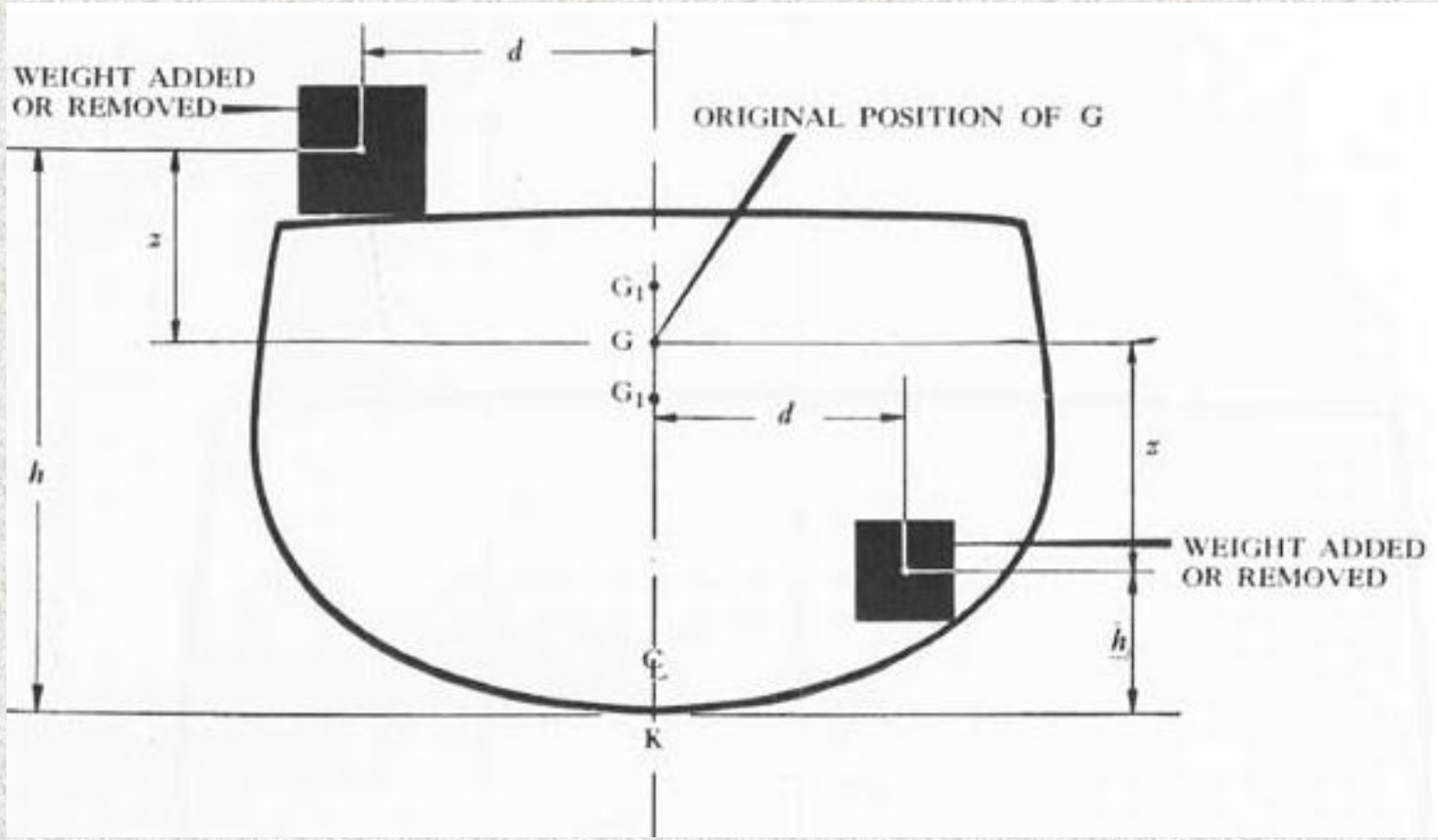
$$GG_1 = \frac{w \times d}{W}$$

CONCLUSION

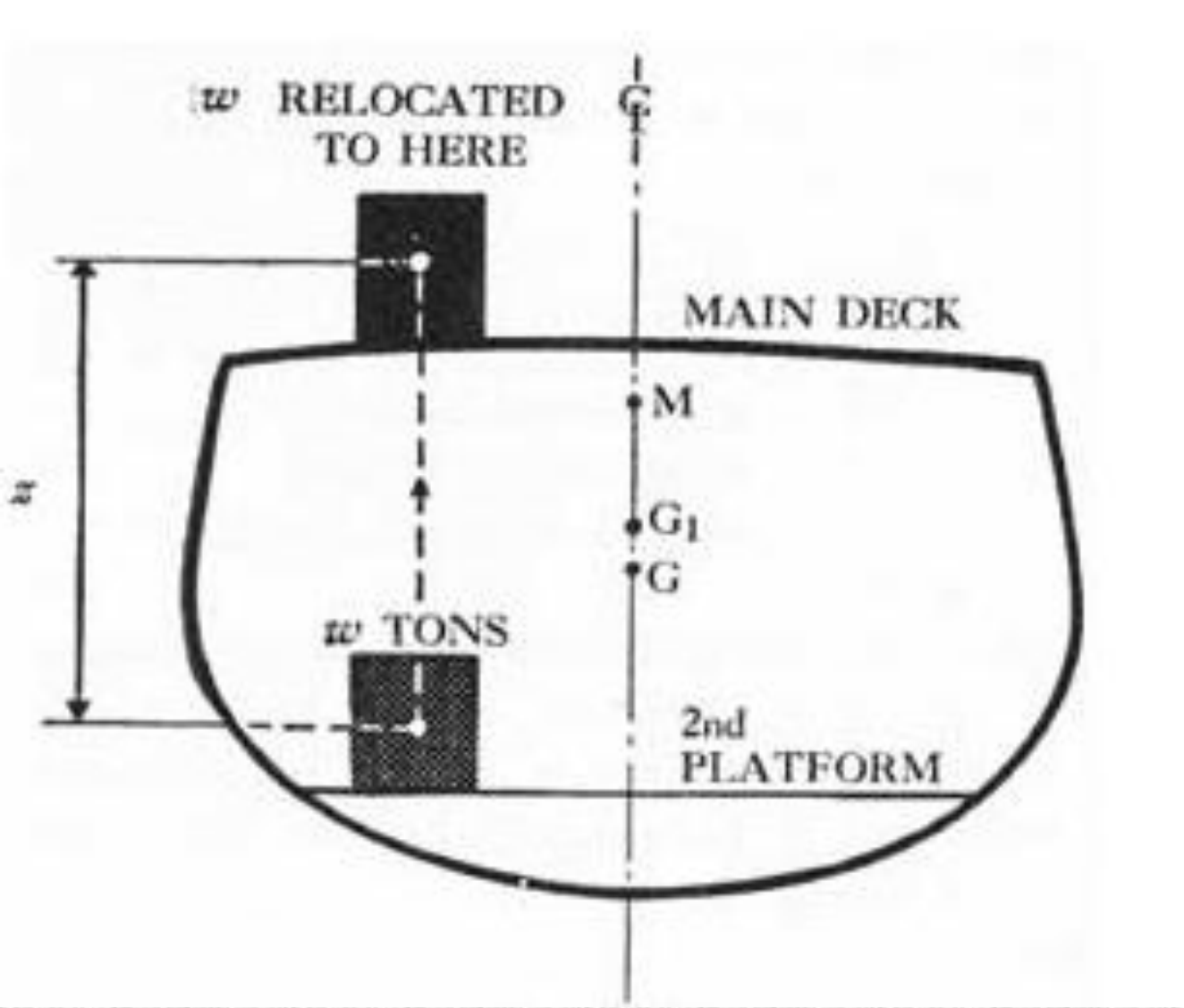
Effect of shifting weights

The centre of gravity of the body will always move parallel to the shift of the centre of gravity of any weight moved within the body.

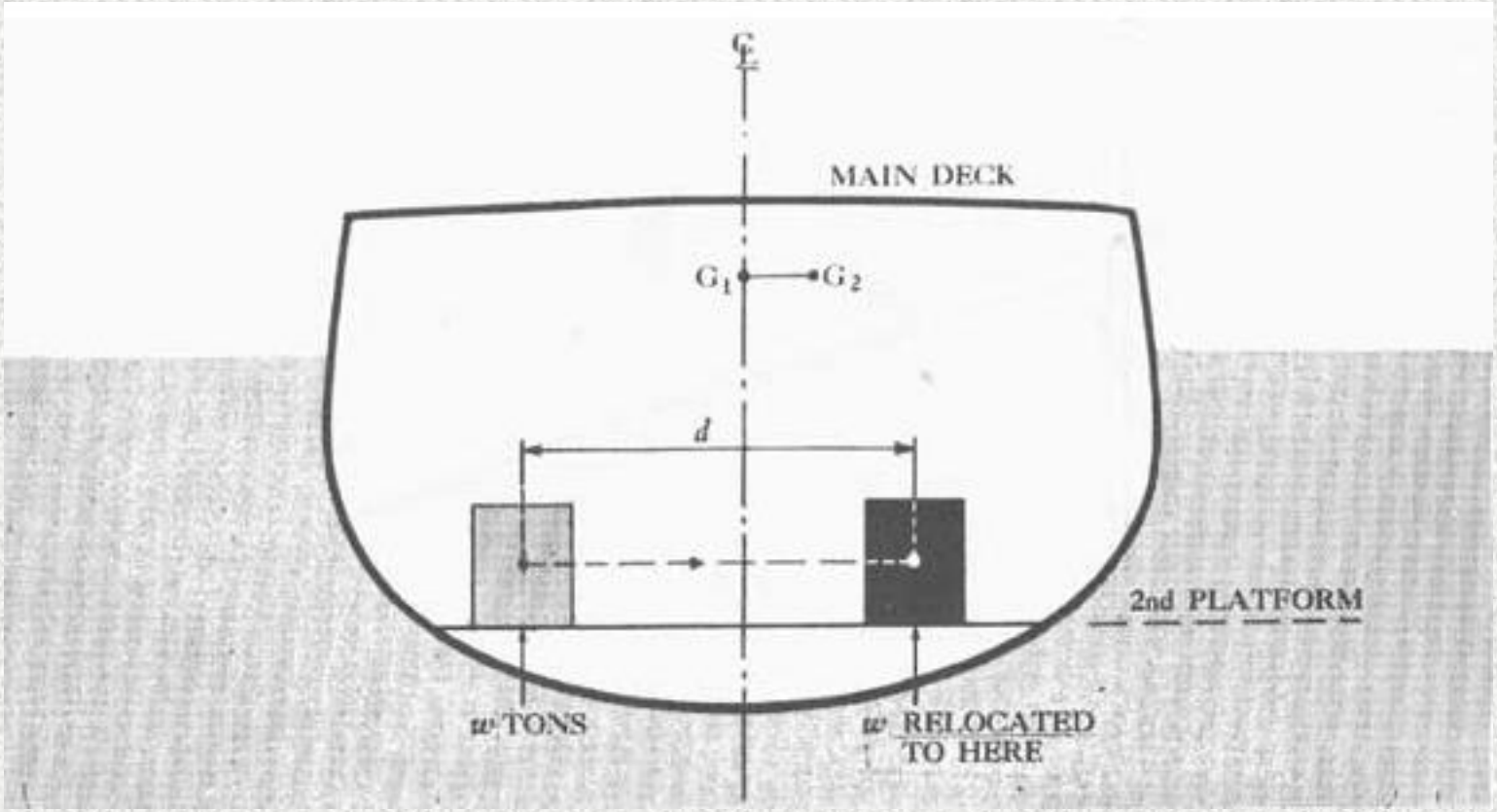
Application to a ship shifting weights



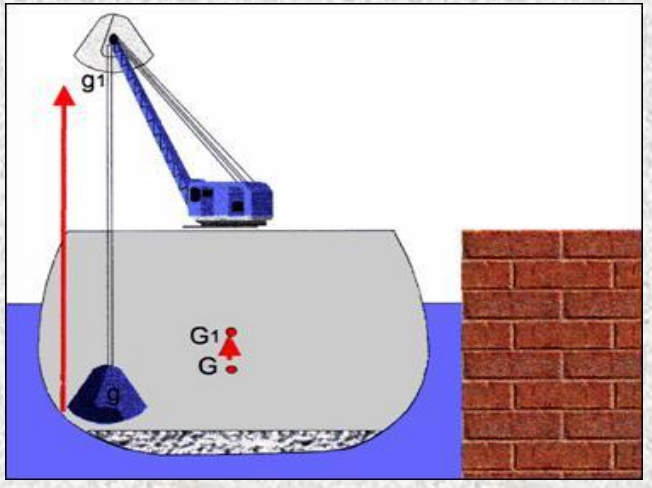
Application to a ship shifting weights

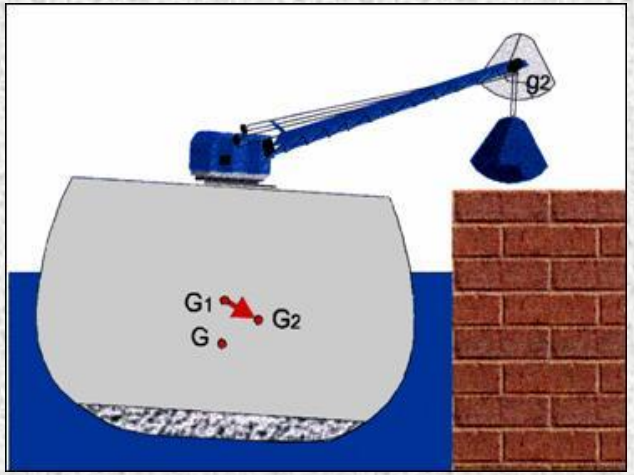


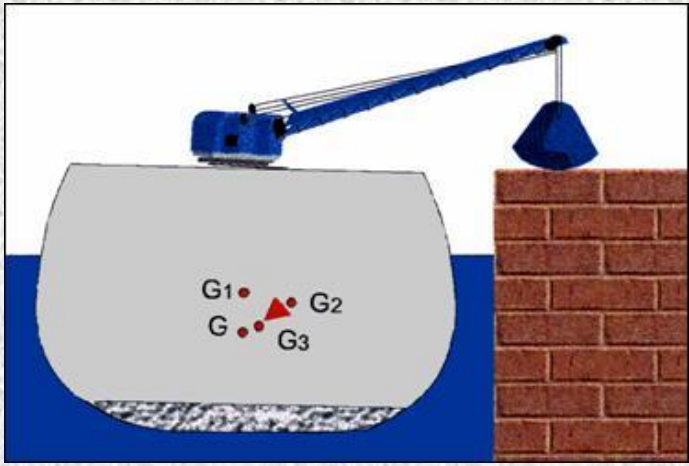
Application to a ship shifting weights



Effect of suspended weights

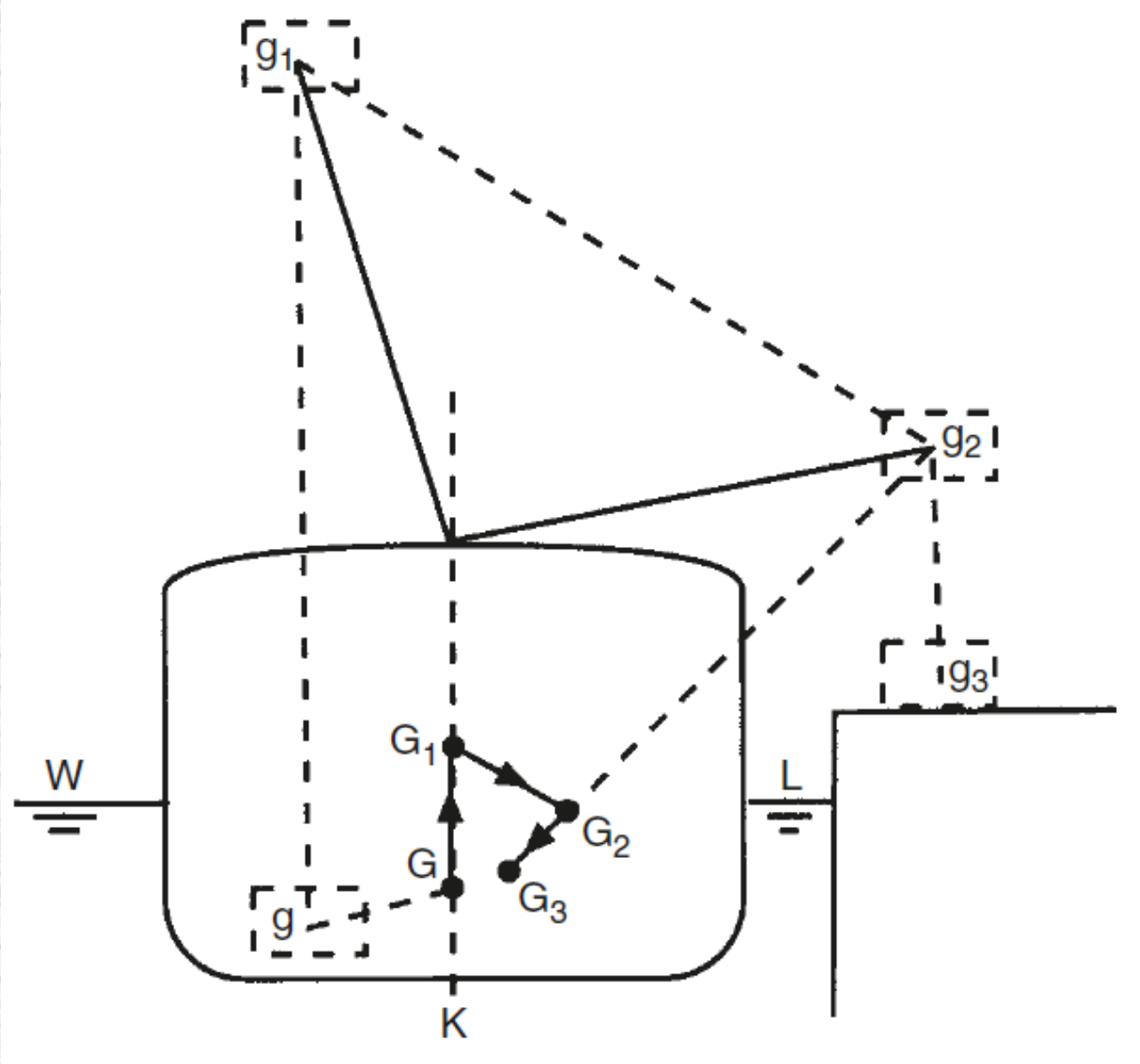






the centre of gravity of a suspended weight is considered to be at the point of suspension.

Effect of suspended weights



Conclusions

1. The centre of gravity of a body will move directly towards the centre of gravity of any weight added.

2. The centre of gravity of a body will move directly away from the centre of gravity of any weight removed.

3. The centre of gravity of a body will move parallel to the shift of the centre of gravity of any weight moved within the body.

4. No matter where the weight ‘w’ was initially in the ship relative to G, when this weight is moved downwards in the ship, then the ship’s overall G will also be moved downwards to a lower position. Consequently, the ship’s stability will be improved.

5. No matter where the weight ‘w’ was initially in the ship relative to G, when this weight is moved upwards in the ship, then the ship’s overall G will also be moved upwards to a higher position.

Consequently, the ship’s stability will be decreased.

6. The shift of the centre of gravity of the body in each case is given by the formula: where

w is the mass of the weight added, removed or shifted,

W is the final mass of the body, and

d is, in 1 and 2, the distance between the centres of gravity, and in 3,the distance through which the weight is shifted.

7. When a weight is suspended its centre of gravity is considered to be at the point of suspension.

Exercise 2

1 A ship has displacement of 2400 tonnes and KG = 10.8 metres. Find the new KG if a weight of 50 tonnes mass already on board is raised 12 metres vertically.

2 A ship has displacement of 2000 tonnes and KG = 10.5 metres. Find the new KG if a weight of 40 tonnes mass already on board is shifted from the 'tween deck to the lower hold, through a distance of 4.5 metres vertically.

3 A ship of 2000 tonnes displacement has KG = 4.5 metres. A heavy lift of 20 tonnes mass is in the lower hold and has KG = 2 metres. This weight is then raised 0.5 metres clear of the tank top by a derrick whose head is 14 metres above the keel. Find the new KG of the ship.

4 A ship has a displacement of 7000 tonnes and KG = 6 metres. A heavy lift in the lower hold has KG = 3 metres and mass 40 tonnes. Find the new KG when this weight is raised through 1.5 metres vertically and is suspended by a derrick whose head is 17 metres above the keel.

5 Find the shift in the centre of gravity of a ship of 1500 tonnes displacement when a weight of 25 tonnes mass is shifted from the starboard side of the lower hold to the port side on deck through a distance of 15 metres.