Change in Centre of Gravity – Practice Problems

1. A ship displaces 10000 t and has an initial KG of 6 m. Calculate the final KG (or KG_1) if:
   a) 1000 t of cargo is loaded into the lower deck hold at Kg 3 m.
   b) 1200 t of cargo is loaded onto the main deck at Kg 10 m.

2. A ship displaces 11200 t and has an initial KG of 5 m. Calculate the final KG (or KG_1) if:
   a) 500 t of cargo is discharged from the lower deck hold at Kg 3 m.
   b) 450 t of cargo is discharged from the main deck at Kg 10 m.

3. A ship displaces 15000 t and has an initial KG of 6 m. Calculate the final KG if a weight of 50 t is moved vertically downwards through a distance 3 m

4. A ship with mass of 25000 tonnes has its centre of gravity 12 metres above the keel. Find the new centre of gravity if the following cargo is loaded to the ship:
   100 t 16 m above the keel
   300 t 15 m above the keel
   1600 t 8 m above the keel
   500 t 4 m above the keel

5. A ship with mass of 12000 tonnes has its centre of gravity 15 metres above the keel. Find the new centre of gravity if 2000 tonnes and 200 tonnes of cargo has been loaded 11 metres and 8 metres above the keel respectively , a 800 t of cargo has been discharged from a position 6 metres above the keel and 500 t of cargo is shifted from Kg = 3 m to Kg = 12 m.

Answers:

1. a) 5.763 m b) 6.429 m
2. a) 5.093 m b) 4.791 m
3. 5.99 m
4. 11.67 m
5. 15.17 m

Step by step solutions:

1. We are given that W = 10000 t and KG = 6 m
   a) In this case w = 1000 t and Kg = 3 m. Therefore,

$$d = KG - Kg = 6 - 3 = 3\ m$$

$$GG_1 = \frac{wd}{W + w} = \frac{1000 \times 3}{10000 + 1000} = \frac{3000}{11000} = 0.273$$

   Since the centre of gravity moves in the direction of loaded weight, therefore

$$KG_1 = KG - GG_1 = 6 - 0.273 = 5.763\ m$$

   b) In this case, w = 1200 t and Kg = 10 m.
   So, $d = Kg - KG = 10 - 6 = 4\ m$
   And

$$GG_1 = \frac{wd}{W + w} = \frac{1200 \times 4}{10000 + 1200} = \frac{4800}{11200} = 0.429$$

   Again the centre of gravity will move in the direction of loaded weight. Therefore,

$$KG_1 = KG + GG_1 = 6 + 0.429 = 6.429\ m$$

2. We are given that W = 11200 t and KG = 5 m
   a) In this case w = 500 t and Kg = 3 m. Therefore,

$$d = KG - Kg = 5 - 3 = 2\ m$$

$$GG_1 = \frac{wd}{W - w} = \frac{500 \times 2}{11200 - 500} = \frac{1000}{10700} = 0.093$$

   Since the centre of gravity moves away from the direction of discharged weight, therefore

$$KG_1 = KG + GG_1 = 5 + 0.093 = 5.093\ m$$

   b) In this case, w = 450 t and Kg = 10 m.
   So, $d = Kg - KG = 10 - 5 = 5\ m$
   And

$$GG_1 = \frac{wd}{W - w} = \frac{450 \times 5}{11200 - 450} = \frac{2250}{10750} = 0.209$$

   Again the centre of gravity will move away from the direction of discharged weight. Therefore,

$$KG_1 = KG - GG_1 = 5 - 0.209 = 4.791\ m$$

3. We are given that W = 15000 t, w = 50 t, KG = 6 m and d = 3 m. Therefore,

$$GG_1 = \frac{wd}{W} = \frac{50 \times 3}{15000} = \frac{150}{15000} = 0.01$$

   The centre of gravity will move parallel to and in the same direction as the shift, therefore we get :

$$KG_1 = KG - GG_1 = 6 - 0.01 = 5.99\ m$$

4. Table of calculations:

	Weight (t)	Distance (m)	Moment
Ship	25000	12	300000
Load (+)	100	16	1600
Load (+)	300	15	4500
Load (+)	1600	8	12800
Load (+)	500	4	2000
FINAL	**27500**	**x**	**320900**

To balance the ship the total moment should be balanced by the new centre of gravity. Therefore,

$$27500 \times x = 320900$$

$$x = \frac{320900}{27500} = 11.669 \approx 11.67$$

Hence, KG_1 = 11.67 m

5. Table of calculations:

	Weight (t)	Distance (m)	Moment
Ship	12000	15	180000
Load (+)	2000	11	22000
Load (+)	200	8	1600
Discharge (-)	-800	6	-4800
Shift:			
Load (+)	500	12	6000
Discharge (-)	-500	3	-1500
FINAL	**13400**	**x**	**203300**

To balance the ship the total moment should be balanced by the new centre of gravity. Therefore,

$$13400 \times x = 203300$$

$$x = \frac{203300}{13400} = 15.1716 \approx 15.17\ m$$

Hence, KG_1= 15.17 m