**US418**

**Problem statement** -In this use case, the proposed problem is to determine the unloaded center of mass of each ship according to its characteristics. Along with this problem we had to take into account three main criteria:

1. Make a sketch of the vessel's geometric figure.
2. Identify/choose a reference for the calculation.
3. Determine the center of mass for the different vessels (consider that the  
   vessel is all made of the same material).

**Problem resolution** – For us to solve this problem, it was necessary to divide the question into five steps to reach the intended objective, that is, the calculation of the center of mass of the ship in question. The five steps of the process were:

* Ship dimensions.
* Sketch of the geometric figures used for the problem and their measurements.
* Calculation of the volume of the areas and allocation of the ship's density.
* Calculation of the mass referring to each area of the ship.
* Calculation of the center of mass.

**Ship dimensions**

The ship that has been chosen for calculation is a cargo ship with the following dimensions:

**Length – 390 meters**

**Width – 50 meters**

**Height – 30 meters**

**Sketch of geometric figures and their measurements**

The way we divided the ship was very simple, basically, it was assumed that the two bows of the ship would be two right triangles, that the rest of the ship's structure would be a rectangle and that it would contain another rectangle that corresponded to the ship's tower such as the following sketch shows:

a

b

A4

a

a

A1

A3

b

b

b

A2

a

Dimensions of the areas:

**A1 And A3:**

a = 30 m

b = 30 m

**A2:**

a = 330 m

b = 30 m

**A4:**

a = 20 m

b = 5 m

**Calculation of the volume of the areas and allocation of the ship's density**

In our solution, it was assumed that the entire ship was made of the same material. The material chosen was steel of density 7,8 kg/ m³.

**V (A1 e A3) =** Ab x Height => 30 x 30 = 900 m³

**V (A2) =** Length x Width x Height => 330 x 50 x 30 = 495 000 m³

**V (A4) =** Length x Width x Height => 20 x 50 x 5 = 5000 m³

**Mass calculation**

The formula that was used to calculate the mass for each area of the ship was as follows:

**mass = density x volume**

**m (A1 e A3) =** 7,8 x 900 = 7020 kg

**m (A2) =** 7,8 x 495 000 = 3 861 000 kg

**m (A4) =** 7,8 x 5000 = 39 000 kg

**Calculation of the center of mass**

Auxiliary Calculations

During the process of calculating the center of mass, it was necessary to calculate the center of mass in X and Y for the two triangular areas (A1 and A3), for which the following formulas were used:

X = b / 3 = > 30 / 3 = 10m

Y = Height / 3 => 30 / 3 = 10m

Note: Bearing in mind that the triangles meet with their axes inverted, these 10 meters in “Y” means that from the upper base, corresponding to our length “a”, 10 m is removed from the maximum height (30 m), assuming thus the value of 20 m in Y with respect to the calculation of the center of mass.

To calculate the ship's center of mass without cargo, the following formulas were used:

**Xcm** = m(A1) x X1 + m(A2) x X2 + m(A3) x X3 + m(A4) x X4

m(A1) + m(A2) + m(A3) + m(A4)

**Ycm** = m(A1) x Y1 + m(A2) x Y2 + m(A3) x Y3 + m(A4) x Y4

m(A1) + m(A2) + m(A3) + m(A4)

Xcm = 7,020 x 10 + 3861 x 195 + 7,020 x 380 + 23,4 x 195 / 7,020 + 3861 + 7,020 + 23,4

= > Xcm = 195,00 m

Ycm = 7,020 x 20 + 3861 x 15 + 7,020 x 20 + 39 x 35 / 7,020 + 3861 + 7,020 + 23,4

=> Ycm = 15,22 m

Note: The mass values have all been deducted from tons so that the calculation values are pleasant to work with.

**Conclusion**

In this conclusion, the objective is to make our analysis of the final result obtained and to refer to the differences in calculations between the different types of ships, more specifically with the ship's tower on the left side, in the center (the case that was calculated) and with the ship's turret on the right.

Regarding the different types of ships, the location of the tower more to the right or more to the left of the center would only contain a difference in relation to the calculation of the center of mass, which would be the “x” coordinate being slightly more displaced to where the body A4 (ship's turret) was located, this is because the mass of the body A4 is much less than the mass of the main body A2.

Finally, we believe that the results obtained are quite satisfactory and expected, since the mass of the A2 body, corresponding to most of the ship, is much higher than the rest.