Answer on Question #72673, Physics / Other

Girl is sitting with her dog at the left end of a boat of length 10.0 m. The mass of the girl, her dog and the boat are 60.0 kg, 30.0 kg and 100.0 kg respectively. The boat is at rest in the middle of the lake. Calculate the centre of mass of the system. If the dog moves to the other end of the boat, the girl staying at the same place, how far and in what direction does the boat move?

Solution:

The center of mass of the system is

$$x_{cm} = \frac{m_{girl}x_1 + m_{dog}x_2 + m_{boat}x_3}{m_{girl} + m_{dog} + m_{boat}}$$

where

$$x_1 = 0, \quad x_2 = 0, \quad x_3 = \frac{10.0}{2} = 5.0\ m$$

$$x_{cm} = \frac{60.0 \cdot 0 + 30.0 \cdot 0 + 100.0 \cdot 5}{60 + 30 + 100} = 2.63 \text{ m from the left end of boat}$$

Since there is no external force center of mass of the system should remain in the same point. If the dog moves a distance 10.0 m to the right his position is now x_{2f} = 10.0 m. The boat moves a distance d to the left so its new position is x_{3f} = 5.0-d.

$$x_{cm} = \frac{m_{girl}x_1 + m_{dog}x_{2f} + m_{boat}x_{3f}}{m_{girl} + m_{dog} + m_{boat}}$$

$$2.63 = \frac{60.0 \cdot 0 + 30.0 \cdot 10.0 + 100.0 \cdot (5 - d)}{60 + 30 + 100}$$

$$100.0 \cdot (5 - d) = 499.7 - 300$$

$$d = \frac{500 - 199.7}{100} = 3.0\ m$$

Answer: $x_{cm} = 2.63$ m; The boat moves a distance $d = 3.0\ m$ to the left