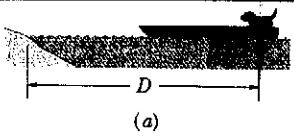
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•••17 In Fig. 9-47*a*, a 4.5 kg dog stands on an 18 kg flatboat at distance $D = 6.1$ m from the shore. It walks 2.4 m along the boat toward shore and then stops. Assuming no friction between the boat and the water, find how far the dog is then from the shore. (*Hint:* See Fig. 9-47*b*.)

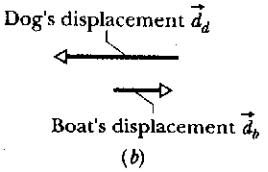
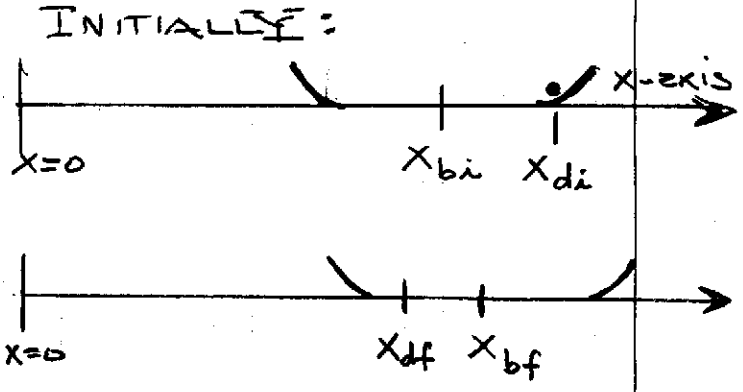


FIG. 9-47 Problem 17.



$$\vec{r}_{com} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2}{m_1+m_2} \Rightarrow X_{com} = \frac{m_b X_b + m_d X_d}{m_b+m_d}$$

$$\frac{d\vec{P}_{total}}{dt} = \vec{F}^{net}_{ext} = 0 \Rightarrow \vec{P}_{tot} = M\vec{v}_{com} = (m_b+m_d)\vec{v}_{com}$$

$$= m_b\vec{v}_b + m_d\vec{v}_d = \text{Constant} = 0$$

$$\Rightarrow \vec{v}_{com} \equiv 0 \Rightarrow \vec{r}_{cm} \text{ remains fixed}$$

$$\Rightarrow X_{com\,initial} = X_{com\,final}$$

$$\Rightarrow m_b X_{bi} + m_d X_{di} = m_b X_{bf} + m_d X_{df}$$

$$m_b X_{bi} + m_d X_{di} = m_b(X_{bi}+d) + m_d[X_{di} + (d-x)]$$

WHERE THE BOAT MOVES A DISTANCE d IN POSITIVE X-DIRECTION
THE DOG MOVES A DISTANCE X ALONG THE BOAT ($-\hat{x}$ DIRECTION)
THE DOG MOVES A DISTANCE $(d-X)$ RELATIVE TO EARTH.

THEREFORE: $0 = m_b d + m_d d - m_d X$

THE BOAT MOVES d AWAY FROM SHORE $d = \frac{m_d}{(m_b+m_d)} X = \frac{4.5}{18+4.5} 2.4 = 0.48\,m$

$\Rightarrow$ THE DOG MOVES $(d-x)$ AWAY FROM SHORE OR $-(d-x) = (x-d)$ CLOSER TO SHORE $= 2.4 - 0.48 = 1.92\,m$

$\Rightarrow$ DISTANCE FROM SHORE $= D-(x-d) = 6.1 - 1.9 = 4.2\,m$

THE ABOVE DIAGRM IS TO SCALE.

NOTE IN THE DIAGRAM, IT IS EASY TO SEE THAT AS THE DOG WALKS TO THE LEFT, HIS FEET EXERT A FORCE ON THE BOAT $= \vec{F}_{b,d} \longrightarrow$ TO THE RIGHT
THAT IS EQUAL & OPPOSITE TO THE FORCE ON THE DOG BY BOAT $= \vec{F}_{d,b} \longleftarrow$ TO THE LEFT