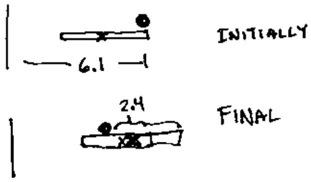
9.17 You know, this would have been an easy problem if they'd given us the length of the boat.

4.5 kg dog 18 kg boat



INITIAL

$$M_{TOT}\, x^{i}_{cm} = m_{dog}\, x^{i}_{dog} + m_{boat}\, x^{i}_{boat}$$

Final

$$M_{TOT}\, x^{f}_{cm} = m_{dog}\, x^{f}_{dog} + m_{boat}\, x^{f}_{boat}$$

distances measured from shore

Now subtract the two equations

$$0 = m_{dog}\, \underbrace{\Delta x_{dog}}_{\text{Negative number}} + m_{boat}\, \underbrace{\Delta x_{boat}}_{\text{positive number}}$$

so

$$\Delta x_{boat} = -\frac{m_{dog}}{m_{boat}}\Delta x_{dog}$$

We are told how far the dog moves along the length of the boat

$$-\Delta x_{dog} + \Delta x_{boat} = 2.4$$

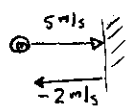
$$-\Delta x_{dog} + -\frac{m_{dog}}{m_{boat}}\Delta x_{dog} = 2.4$$

$$-\left[1 + \frac{m_{dog}}{m_{boat}}\right]\Delta x_{dog} = 2.4$$

$$-\left[1 + \frac{4.5}{18}\right]\Delta x_{dog} = 2.4$$

$$\Delta x_{dog} = -1.92 \text{ m}$$

9.18



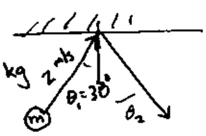
$m = 0.7$ kg

$$\overrightarrow{\text{Impulse}} = \Delta\vec{p} = \vec{p}_f - \vec{p}_i$$
$$= m\vec{v}_f - m\vec{v}_i$$

Just do x-components

$$\Delta p_x = m v_{fx} - m v_{ix}$$
$$= 0.7(-2) - 0.7(+5)$$
$$= -4.9 \text{ kg m/s}$$
$$|\Delta p_x| = 4.9 \text{ kg m/s}$$

9.22



a) $\theta_2 = 30^\circ$ also

b)

$$\vec{P}_{init} = m\vec{v}_{init}$$

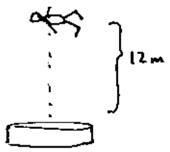
$$\vec{P}_{init} = m v_{x_i}\,\hat{\imath} + m v_{y_i}\,\hat{\jmath}$$
$$= (0.165)2\cos 60^\circ\,\hat{\imath} + (0.165)2\sin 60^\circ\,\hat{\jmath}$$
$$= 0.165\,\hat{\imath} + 0.286\,\hat{\jmath} \text{ kg m/s}$$

After the bounce

$$\vec{P}_{final} = 0.165\,\hat{\imath} - 0.286\,\hat{\jmath}$$

$$\Delta\vec{p} = \vec{P}_{final} - \vec{P}_{init} = 0\,\hat{\imath} - 0.572\,\hat{\jmath} \text{ kg m/s}$$

9.23



estimate mass = 80 kg

Calculate speed as he reaches water

$y = y_0 + v_{oy}t + \frac{1}{2}a_y t^2$

$v_y = v_{oy} + a_y t$

or we can use

$v_{y_f}^2 - v_{y_i}^2 = 2a_y \Delta y$

$v_{y_f}^2 - 0^2 = 2(-9.8)(-12)$

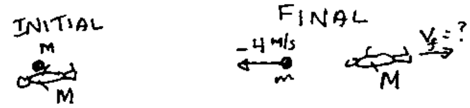
$|v_{y_f}| = 15.3$ m/s

$|\text{Impulse}| = |\Delta \vec{p}| \sim m\,\Delta v$

$\sim 80(15.3)$

~ 1227 kg m/s

9.39



$m = 0.068$ kg
$M = 91$ kg

Tot Init P_x = Tot Final P_x

$0 = m v_{stone} + M v_f$

$0 = 0.068(-4) + 91\,v_f$

$v_f = 0.0030$ m/s

Gee, he should have used a bigger rock.

9.52

Tot Init P_x = Tot Final P_x

$m v_0 = M_1 v_1 + m v_{b1}$

$0.0035\,v_0 = 1.2(0.63) + 0.0035\,v_{b1}$

THEN

Tot Init P_x = Tot Fin P_x

$m v_{b1} = (M_2 + m)\,v_2$

$0.0035\,v_{b1} = 1.8035\,(1.4)$

$v_{b1} = 721.4$ m/s

$0.0035\,v_0 = 1.2\,(0.63) + 0.0035\,(721.4)$

$v_0 = 937$ m/s

9.60

Tot Init P_x = Tot Final P_x

$$m_A v_{Ai} + m_B v_{Bi} = m_A v_{Af} + m_B v_{Bf}$$

$$1.6(5.5) + 2.4(2.5) = 1.6\, v_{Af} + 2.4(4.9)$$

$$v_{Af} = 1.9 \text{ m/s}$$

this would be toward the right

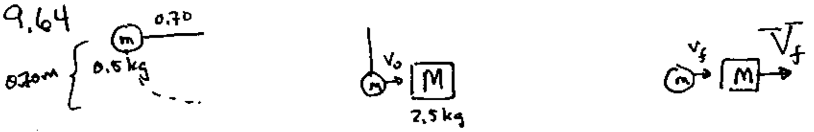
Is this elastic?

KE before collision = $\frac{1}{2}\, 1.6(5.5)^2 + \frac{1}{2}\, 2.4(2.5)^2$
$= 31.7$ Joules

KE after collision = $\frac{1}{2}\, 1.6(1.9)^2 + \frac{1}{2}\, 2.4(4.9)^2$
$= 31.7$ Joules

Yes, this was an elastic collision.

9.64



Total Init Energy at top of swing = Tot Energy at bottom of swing

$$\cancel{m}gh = \frac{1}{2}\cancel{m} v_0^2$$

$$9.8(0.7) = \frac{1}{2} v_0^2$$

$$v_0 = 3.7 \text{ m/s}$$

Total Momentum Before = Total Momentum After

$$m v_0 = m v_f + M \bar{V}_f$$

$$0.5(3.7) = 0.5 v_f + 2.5 \bar{V}_f$$

$$1.85 = 0.5 v_f + 2.5 \bar{V}_f$$

$$1.85 - 2.5 \bar{V}_f = 0.5 v_f$$

$$3.7 - 5 \bar{V}_f = v_f$$

Since perfectly elastic

Energy before = Energy after

$$\frac{1}{2} m v_0^2 = \frac{1}{2} m v_f^2 + \frac{1}{2} M \bar{V}_f^2$$

$$\frac{1}{2}\, 0.5(3.7)^2 = \frac{1}{2}\, 0.5 v_f^2 + \frac{1}{2}\, 2.5 \bar{V}_f^2$$

$$3.42 = 0.25 v_f^2 + 1.25 \bar{V}_f^2$$

$$3.42 = 0.25(3.7 - 5\bar{V}_f)^2 + 1.25 \bar{V}_f^2$$

$$= 0.25\left[13.69 - 18.5 \bar{V}_f + 25 \bar{V}_f^2\right] + 1.25 \bar{V}_f^2$$

$\cancel{= 6.75}$

$$= 3.375 - 4.625 \bar{V}_f + 6.25 \bar{V}_f^2 + 1.25 \bar{V}_f^2$$

$$3.42 = 3.375 - 4.625 \bar{V}_f + 7.75 \bar{V}_f^2$$

$$0 = -0.045 - 4.625 \bar{V}_f + 7.75 \bar{V}_f^2$$

$$\bar{V}_f = \frac{4.625 \pm \sqrt{(4.625)^2 - 4(7.75)(-0.045)}}{2(7.75)}$$

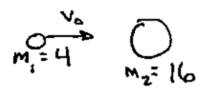
$$\bar{V}_f = \frac{4.625 \pm 4.773}{2(7.75)} = 0.606 \text{ m/s}$$

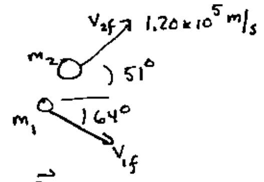
only need (+) option

$$3.7 - 5(0.606) = v_f$$

$$0.668 \text{ m/s} = v_f$$

9.71





Total Init $\vec{P}$ = Tot Final $\vec{P}$

Tot Init P_x = Tot Final P_x

$m_1 v_o = m_1 v_{1f}\cos 64^\circ + m_2 v_{2f}\cos 51^\circ$

Tot Init P_y = Tot Final P_y

$0 = (-) m_1 v_{1f}\sin 64^\circ + m_2 v_{2f}\sin 51^\circ$

$0 = (-)\,4\,v_{1f}\sin 64^\circ + 16\,(1.2\times10^5)\sin 51^\circ$

$v_{1f} = 4.15\times10^5$ m/s

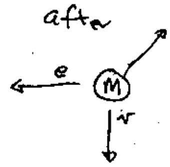
$4\,v_o = 4\,(4.15\times10^5)\cos 64^\circ + 16\,(1.2\times10^5)\cos 51^\circ$

$v_o = 4.84\times10^5$ m/s

9.90

before

after



Assume initial & final nuclei have close to the same mass

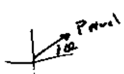
Tot Init $\vec{P}$ = Tot Final $\vec{P}$

$0 = \bar{P}_\nu + \bar{P}_e + \bar{P}_{nucleus}$

$0 = \left[-6.4\times10^{-23}\,\hat{j}\right] + \left[-1.2\times10^{-22}\,\hat{i}\right] + \vec{P}_{nucleus}$

so

$\bar{P}_{nucleus} = 1.2\times10^{-22}\,\hat{i} + 6.4\times10^{-23}\,\hat{j}$



$|\bar{P}| = \sqrt{P_x^2 + P_y^2} = 1.36\times10^{-22}$ kg m/s

$\tan\theta = \frac{P_y}{P_x} = \frac{0.64\times10^{-22}}{1.2\times10^{-22}}$

$\rightarrow \theta = 28.1^\circ$

If $M = 5.8\times10^{-26}$ kg

$|\bar{P}| = m|v|$

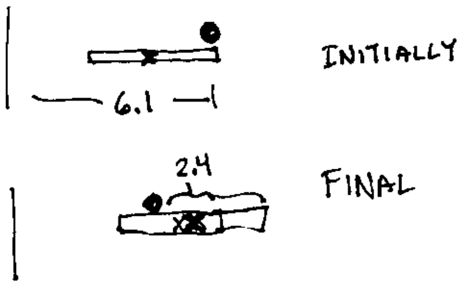
$1.36\times10^{-22} = 5.8\times10^{-26}$

$|v| = 2345$ m/s

$KE = \frac{1}{2}Mv^2 = \frac{1}{2}(5.8\times10^{-26})(2345)^2 = 1.59\times10^{-19}$ Joules

9.17 You know, this would have been an easy problem if they'd given us the length of the boat.

4.5 kg dog   18 kg boat



INITIAL

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Final

$$M_{TOT} x^f_{cm} = m_{dog} x^f_{dog} + m_{boat} x^f_{boat}$$

distances measured from shoreline

Now subtract the two equations

$$0 = m_{dog} \underbrace{\Delta x_{dog}}_{\text{Negative number}} + m_{boat} \underbrace{\Delta x_{boat}}_{\text{positive number}}$$

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$$\Delta x_{boat} = -\frac{m_{dog}}{m_{boat}} \Delta x_{dog}$$

We are told how far the dog moves along the length of the boat

$$-\Delta x_{dog} + \Delta x_{boat} = 2.4$$

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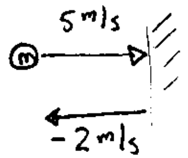
$$-\left[1 + \frac{m_{dog}}{m_{boat}}\right] \Delta x_{dog} = 2.4$$

$$-\left[1 + \frac{4.5}{18}\right] \Delta x_{dog} = 2.4$$

$$\Delta x_{dog} = -1.92 \text{ m}$$

9.18



$m = 0.7$ kg

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$= m\bar{v}_f - m\bar{v}_i$

Just do x-components

$\Delta p_x = m v_{fx} - m v_{ix}$

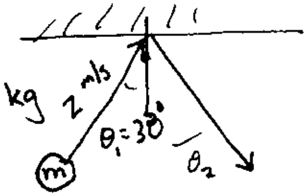
$= 0.7(-2) - 0.7(+5)$

$= -4.9$ kg m/s

$|\Delta p_x| = 4.9$ kg m/s

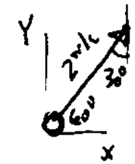
9.22

$m = 0.165$ kg



a) $\theta_2 = 30°$ also

b)



$\vec{p}_{init} = m\vec{v}_{init}$

$\vec{p}_{init} = m v_{x_i}\hat{i} + m v_{y_i}\hat{j}$

$= (0.165)2\cos 60°\,\hat{i} + (0.165)2\sin 60°\,\hat{j}$

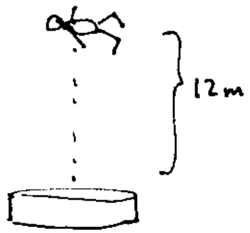
$= 0.165\,\hat{i} + 0.286\,\hat{j}$ kg m/s

After the bounce

$\vec{p}_{final} = 0.165\,\hat{i} - 0.286\,\hat{j}$

$\Delta\bar{p} = \bar{p}_{final} - \bar{p}_{init} = 0\,\hat{i} - 0.572\,\hat{j}$ kg m/s

9.23



estimate mass = 80kg

Calculate speed as he reaches water

$y = y_0 + v_{0y}t + \frac{1}{2}a_y t^2$

$v_y = v_{0y} + a_y t$

or we can use

$v_{y_f}^2 - v_{y_i}^2 = 2a_y \Delta y$

$v_{y_f}^2 - 0^2 = 2(-9.8)(-12)$

$|v_{y_f}| = 15.3 \text{ m/s}$

$|\text{Impulse}| = |\Delta \vec{p}| \simeq m\Delta v$

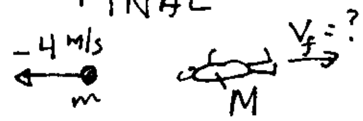
$\sim 80(15.3)$

$\sim 1227 \text{ kg m/s}$

9.39

INITIAL

FINAL



$m = 0.068\text{kg}$
$M = 91 \text{ kg}$

Tot Init P_x = Tot Final P_x

$0 = mv_{stone} + Mv_f$

$0 = 0.068(-4) + 91 v_f$

$v_f = 0.0030 \text{ m/s}$

Gee, he should have used a bigger rock.

9.52

$$\text{Tot Init } P_x = \text{Tot Final } P_x$$

$$m v_o = M_1 v_1 + m v_{b1}$$

$$0.0035\, v_o = 1.2\,(0.63) + 0.0035\, v_{b1}$$

THEN

$$\text{Tot Init } P_x = \text{Tot Fin } P_x$$

$$m v_{b1} = (M_2 + m)\, v_2$$

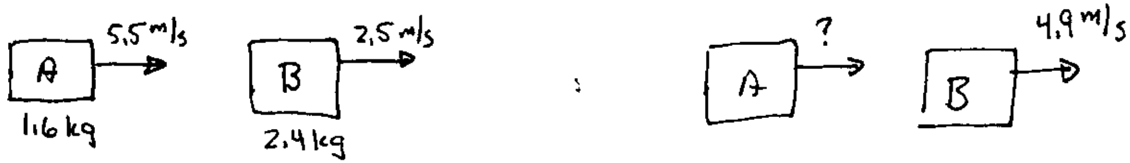
$$0.0035\, v_{b1} = 1.8035\,(1.4)$$

$$v_{b1} = 721.4 \text{ m/s}$$

$$0.0035\, v_o = 1.2\,(0.63) + 0.0035\,(721.4)$$

$$v_o = 937 \text{ m/s}$$

9.60



Tot Init P_x = Tot Final P_x

$$m_A v_{Ai} + m_B v_{Bi} = m_A v_{Af} + m_B v_{Bf}$$

$$1.6(5.5) + 2.4(2.5) = 1.6\, v_{Af} + 2.4(4.9)$$

$$v_{Af} = 1.9 \text{ m/s}$$

this would be toward the right

Is this elastic?

KE before collision $= \frac{1}{2}\, 1.6 (5.5)^2 + \frac{1}{2}\, 2.4 (2.5)^2$

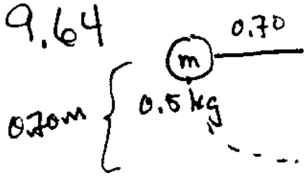
$= 31.7$ Joules

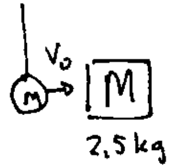
KE after collision $= \frac{1}{2}\, 1.6 (1.9)^2 + \frac{1}{2}\, 2.4 (4.9)^2$

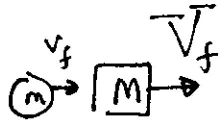
$= 31.7$ Joules

Yes, this was an elastic collision.

9.64







Total Init Energy at top of swing = Tot Energy at bottom of swing

$$\cancel{m}gh = \tfrac{1}{2}\cancel{m}v_0^2$$

$$9.8(0.7) = \tfrac{1}{2}v_0^2$$

$$v_0 = 3.7\ m/s$$

Total Momentum Before = Total Momentum After

$$mv_0 = mv_f + M\bar{V}_f$$

$$0.5(3.7) = 0.5v_f + 2.5\bar{V}_f$$

$$1.85 = 0.5v_f + 2.5\bar{V}_f$$

$$1.85 - 2.5\bar{V}_f = 0.5v_f$$

$$3.7 - 5\bar{V}_f = v_f$$

Since perfectly elastic

Energy before = Energy after

$$\tfrac{1}{2}mv_0^2 = \tfrac{1}{2}mv_f^2 + \tfrac{1}{2}M\bar{V}_f^2$$

$$\tfrac{1}{2}0.5(3.7)^2 = \tfrac{1}{2}0.5v_f^2 + \tfrac{1}{2}2.5\bar{V}_f^2$$

$$3.42 = 0.25v_f^2 + 1.25\bar{V}_f^2$$

$$3.42 = 0.25(3.7 - 5\bar{V}_f)^2 + 1.25\bar{V}_f^2$$

$$= 0.25\left[13.69 - 18.5\bar{V}_f + 25\bar{V}_f^2\right] + 1.25\bar{V}_f^2$$

$$\cancel{= 6.75}$$

$$= 3.375 - 4.625\bar{V}_f + 6.25\bar{V}_f^2 + 1.25\bar{V}_f^2$$

$$3.42 = 3.375 - 4.625\bar{V}_f + 7.75\bar{V}_f^2$$

$$0 = -0.045 - 4.625\bar{V}_f + 7.75\bar{V}_f^2$$

$$\bar{V}_f = \frac{4.625 \pm \sqrt{(4.625)^2 - 4(7.75)(-0.045)}}{2(7.75)}$$

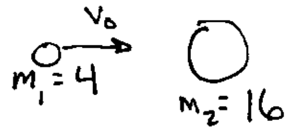
$$\bar{V}_f = \frac{4.625 \pm 4.773}{2(7.75)} = 0.606\ m/s$$

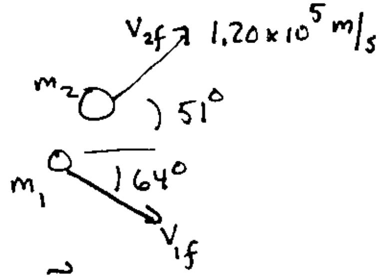
only need (+) option

$$3.7 - 5(0.606) = v_f$$

$$0.668\ m/s = v_f$$

9.71





Total Init $\vec{P}$ = Tot Final $\vec{P}$

Tot Init P_x = Tot Final P_x

$m_1 v_0 = m_1 v_{1f} \cos 64^\circ + m_2 v_{2f} \cos 51^\circ$

Tot Init P_y = Tot Final P_y

$0 = (-) m_1 v_{1f} \sin 64^\circ + m_2 v_{2f} \sin 51^\circ$

$0 = (-)\, 4 v_{1f} \sin 64^\circ + 16\,(1.2 \times 10^5) \sin 51^\circ$

$v_{1f} = 4.15 \times 10^5$ m/s

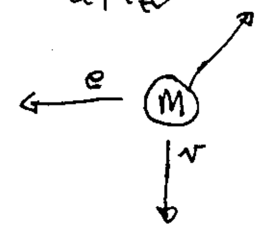
$4 v_0 = 4\,(4.15 \times 10^5) \cos 64^\circ + 16\,(1.2 \times 10^5) \cos 51^\circ$

$v_0 = 4.84 \times 10^5$ m/s

9.90

before

after



Assume initial + final nuclei have close to the same mass

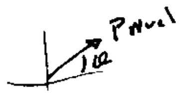
$$\text{Tot Init } \vec{P} = \text{Tot Final } \vec{P}$$

$$0 = \bar{P}_v + \bar{P}_e + \bar{P}_{nucleus}$$

$$0 = \left[-6.4\times10^{-23}\hat{j}\right] + \left[-1.2\times10^{-22}\hat{i}\right] + \vec{P}_{nucleus}$$

so

$$\bar{P}_{nucleus} = 1.2\times10^{-22}\hat{i} + 6.4\times10^{-23}\hat{j}$$



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$$|\bar{P}| = m|v|$$

$$1.36\times10^{-22} = 5.8\times10^{-26}$$

$$|v| = 2345\ m/s$$

$$KE = \tfrac{1}{2}Mv^2 = \tfrac{1}{2}(5.8\times10^{-26})(2345)^2 = 1.59\times10^{-19}\ \text{Joules}$$