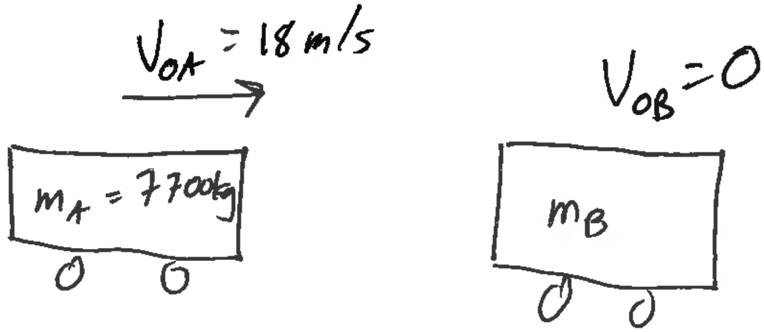
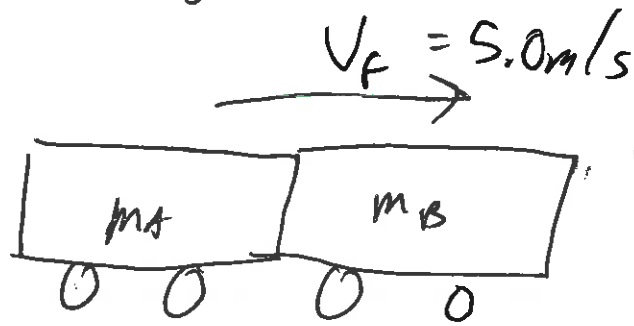
9



← implied from the problem's wording



$$P_0 = P_f$$

$$m_A V_{0A} + m_B \cancel{V_{0B}}^{\,0} = (m_A + m_B) V_f$$

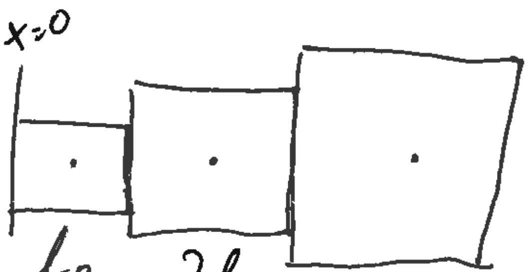
$$m_A V_{0A} = m_A V_f + m_B V_f$$

$$m_B V_f = m_A (V_{0A} - V_f)$$

$$m_B = m_A \frac{(V_{0A} - V_f)}{V_f} = 7700\left(\frac{18-5}{5}\right)$$

$$\boxed{m_B = 20{,}020\ kg}$$

64 Assume each block same density so mass depends on volume.



ℓ_0	$2\ell_0$	$3\ell_0$
ℓ_0^3	$8\ell_0^3$	$27\ell_0^3$
m	$8m$	$27m$

$$M_{tot} X_{cm} = m_1 x_1 + m_2 x_2 + m_3 x_3$$

$$(1+8+27)\cancel{m} X_{cm} = \cancel{m}\left(\frac{\ell_0}{2}\right) + 8\cancel{m}(2\ell_0) + 27\cancel{m}\left(4\tfrac{1}{2}\ell_0\right)$$

$$36 X_{cm} = \frac{1}{2}\ell_0 + \frac{32}{2}\ell_0 + \frac{243}{2}\ell_0$$

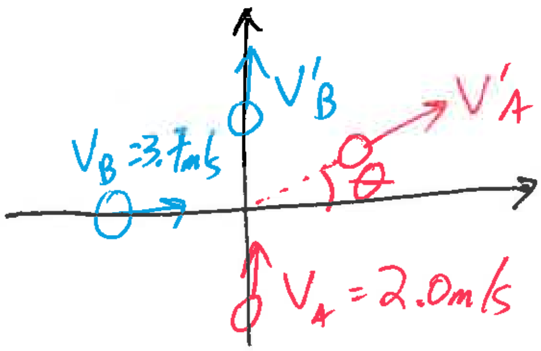
$$36 X_{cm} = \frac{276}{2}\ell_0$$

$$\boxed{X_{cm} = 3.83\bar{3}\ell_0 = 3.83\ \ell_0}$$

Sanity check: I expect it to be inside the third box, but left of its center.

56) "Assumed elastic" – so may need to use energy

$m_A = m_B = m$



3 Unknowns: V'_B, V'_A, θ

so need

3 equations: x-momentum ①

y-momentum ②

Energy ③

① $P_{0x} = P_{fx}$

$$\boxed{\cancel{m} V_B = \cancel{m} V'_A \cos\theta}$$

② $P_{0y} = P_{fy}$

$$\boxed{\cancel{m} V_A = \cancel{m} V'_B + \cancel{m} V'_A \sin\theta}$$

③ $E_0 = E_f$

$K_{A0} + K_{B0} = K_{Af} + K_{Bf}$

$\boxed{\frac{1}{2}\cancel{m}V_A^2 + \frac{1}{2}\cancel{m}V_B^2 = \frac{1}{2}\cancel{m}V_A'^2 + \frac{1}{2}\cancel{m}V_B'^2}$

56. Write momentum conservation in the x and y directions, and kinetic energy conservation. Note that both masses are the same. We allow $\vec{v}'_A$ to have both x and y components.

$$p_x: \quad mv_B = mv'_{Ax} \rightarrow v_B = v'_{Ax}$$

$$p_y: \quad mv_A = mv'_{Ay} + mv'_B \rightarrow v_A = v'_{Ay} + v'_B$$

$$K: \quad \tfrac{1}{2}mv_A^2 + \tfrac{1}{2}mv_B^2 = \tfrac{1}{2}mv_A'^2 + \tfrac{1}{2}mv_B'^2 \rightarrow v_A^2 + v_B^2 = v_A'^2 + v_B'^2$$

Substitute the results from the momentum equations into the kinetic energy equation.

$$\left(v'_{Ay} + v'_B\right)^2 + \left(v'_{Ax}\right)^2 = v_A'^2 + v_B'^2 \rightarrow v_{Ay}'^2 + 2v_{Ay}'^2 v'_B + v_B'^2 + v_{Ay}'^2 = v_A'^2 + v_B'^2 \rightarrow$$

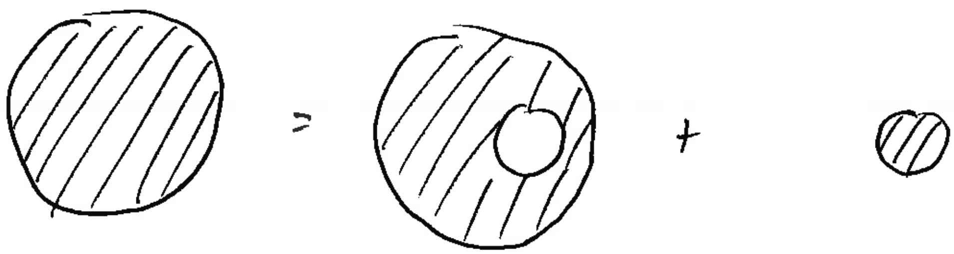
$$v_A'^2 + 2v_{Ay}'^2 v'_B + v_B'^2 = v_A'^2 + v_B'^2 \rightarrow 2v_{Ay}'^2 v'_B = 0 \rightarrow v'_{Ay} = 0 \text{ or } v'_B = 0$$

Since we are given that $v'_B \neq 0$, we must have $v'_{Ay} = 0$. This means that the final direction of A is the $\boxed{x \text{ direction}}$. Put this result into the momentum equations to find the final speeds.

$$v'_A = v'_{Ax} = v_B = \boxed{3.7\,\text{m/s}} \qquad v'_B = v_A = \boxed{2.0\,\text{m/s}}$$

66

We're trying to find out info about the funny donut shape, . We can easily find info about the large circle  and the small circle / donut hole , so compare those:



So the big circle is made up of the funny shape & the small circle. Therefore

$$\underbrace{M_{TOT} X_{CM}}_{\text{Big circle}} = \underbrace{m_1 x_1}_{\text{Funny shape}} + \underbrace{m_2 x_2}_{\text{small circle}}$$

Solve for this.

Assume constant surface density ($\sigma = M/A$)

$$M_{TOT} = \pi (2R)^2 \sigma = 4\pi R^2 \sigma$$

$$m_2 = \pi R^2 \sigma$$

$$m_1 = M_{TOT} - m_2 = 3\pi R^2 \sigma$$

For easier math, set $x=0$ in big circle's center

$$M_{TOT} X_{CM} = m_1 x_1 + m_2 x_2$$

$$\cancelto{0}{4\pi R^2\sigma \cdot 0} = 3\pi R^2 \sigma x_1 + \pi R^2 \sigma x_2$$

$$0 = 3\pi \cancel{R^2} \sigma x_1 + \cancel{\pi R^2} \sigma x_2$$

$$0 = 3x_1 + x_2$$

$$0 = 3x_1 + 0.8R$$

$$\boxed{x_1 = -0.27R}$$ (from center)

If you set $x=0$ at left edge of big circle, that's $2R$ left, so then $\boxed{x_1 = +1.73}$ (from left)

Sanity check: Where is this position located on the funny shape?