PHYSICS 161, Spring 2003

Discussion Quiz , Tuesday, April 22

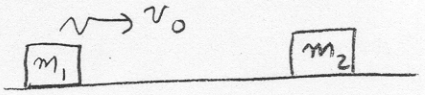
Q1). A block of mass m_1 is moving to the right with speed v_0 on a frictionless table. A block of masss m_2 is at rest on a frictionless table. The blocks then undergo an elastic collision.

a). Before doing any calculations, state what relationship you expect between the change in momentum of block 1 and change in momentum of block 2 and why?

Since there is no net external force acting on the system,

$\Delta \vec{P}_{system} = 0 \Rightarrow \Delta\vec{p}_1 + \Delta\vec{p}_2 = 0 \Rightarrow \Delta\vec{p}_1 = -\Delta\vec{p}_2$.

b). Solve for the final velocity v_{1f} of block 1 in terms of m_1, m_2 and v_0. Please do your algebra carefully. Watch your plus and minus signs as you move terms from one side to another.



$p_{ix} = p_{fx}$

$\Rightarrow \boxed{m_1 v_0 = m_1 v_{1f} + m_2 v_{2f}}$ eq1.

$v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$

$v_0 = -v_{1f} + v_{2f}$

$\Rightarrow \boxed{v_{2f} = v_0 + v_{1f}}$

Substituting into eq1

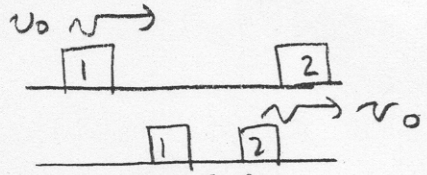
$\Rightarrow m_1 v_0 = m_1 v_{1f} + m_2 (v_0 + v_{1f})$

$\Rightarrow (m_1 - m_2) v_0 = (m_1 + m_2) v_{1f}$

$\Rightarrow \boxed{v_{1f} = \frac{(m_1 - m_2)}{m_1 + m_2} v_0}$

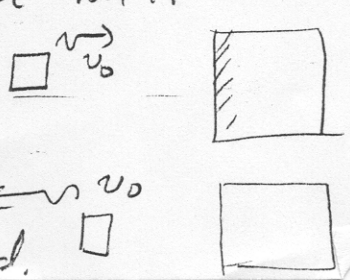
c). Suppose $m_1 = m_2$. Check that your expression from part (a) above gives the result you saw in the lecture or that you expect.

If $m_1 = m_2$, $v_{1f} = 0$ - Demo showed the situation in picture →



d). Now suppose that $m_2 >> m_1$ i.e. $m_1/m_2 \approx 0$. Check that your result from part (a) gives you the answer you expect in this case.

If $\frac{m_1}{m_2} \simeq 0 \Rightarrow$ Block 2 is essentially like a wall that block 1 simply bounces off of. Expct



$v_{1f} = \left(\frac{m_1^{\to 0} - m_2}{m_2 \quad m_2}\right) v_0 \Rightarrow \boxed{v_{1f} = -v_0}$ ⟶ ⟵ v_0 as expected.

$m_1^{\to 0} + m_2$

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Discussion Quiz, Thursday, April 24

Q1). On a terribly icy road, a truck of mass M moving with velocity v_0 collides with a parked car of mass m. Immediately after the collision, the truck and the car move together.

a). Without doing any calculations, state whether you expect the change in momentum of the car as a result of the collision to be equal, less than or greater than the change in momentum of the truck and why?

since there is no net external force acting on the system,

$\Delta\vec{p}_{system} = 0 \Rightarrow \Delta\vec{p}_{car} + \Delta\vec{p}_{truck} = 0 \Rightarrow \Delta\vec{p}_{truck} = -\Delta\vec{p}_{car}$.

b). Is the magnitude of the acceleration of the truck during the collision greater than, less than or equal to the magnitude of the acceleration of the car? Explain briefly. The car & the truck apply equal and opposite forces on each other. Since the truck is heavier, its acceleration is smaller in magnitude than the car's acceleration.

c). Calculate the final velocity of the truck and the car.

$$P_{ix} = P_{fx}$$

$$Mv_0 = (m+M)v_f$$

$$\Rightarrow \boxed{v_f = \frac{M}{m+M} v_0}$$

d). Is the kinetic energy of the truck+car system after the greater than, less than or equal to the kinetic energy before the collision? Support your answer with a calculation.

$$K.E_i = \frac{1}{2} M v_0^2 .$$

$$K.E_f = \frac{1}{2}(m+M) v_f^2$$

$$= \frac{1}{2}(m+M) \cdot \frac{M^2}{(m+M)^2} v_0^2$$

$$K.E_f = \frac{1}{2} \frac{M^2}{m+M} v_0^2$$

$$K.E_f = \left(\frac{M}{m+M}\right) \cdot \frac{1}{2} M v_0^2$$

$$K.E_f = \left(\frac{M}{m+M}\right) K.E_i$$

Since $\frac{M}{m+M} < 1$

$$\Rightarrow \boxed{K.E_f < K.E_i}$$

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Discussion Quiz, Friday, April 25

Q1). Block 1 and 2 with equal mass $m_1 = m_2 = m$ have an elastic collision. Before the collision, block 1 is moving on a frictionless table with velocity $v_1 i$ and block 2 is moving with velocity $v_2 i$.

a). Find the velocities $v_1 f$ and $v_2 f$ of each block after the collision.

$P_{ix} = P_{fx}$

$m v_{1i} + m v_{2i} = m v_{1f} + m v_{2f}$

eq1. $\boxed{v_{1i} + v_{2i} = v_{1f} + v_{2f}}$

$v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$

$\Rightarrow \boxed{v_{1i} - v_{2i} = -v_{1f} + v_{2f}}$ eq2.

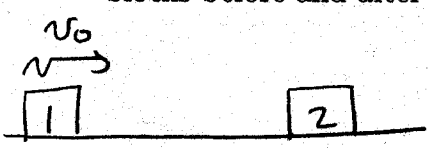
Solving eq's 1 & 2 simultaneously – we find

$\boxed{v_{1f} = v_{2i}}$ & $\boxed{v_{2f} = v_{1i}}$

i.e. the blocks simply exchange velocities.

b). Using your result from part (a) above, predict the result for the following initial conditions:

(i) Block 1 moving to the right with speed v_0, block 2 at rest. Draw a picture of the blocks before and after the collision, labeling their initial and final velocities.



Before

(ii) Block 1 moving to the right with speed $2v_0$, block 2 moving to the right (yes, I mean right) with speed v_0. Again, draw a before and after picture as instructed above.