Read 7.4 - 7.5

H.w # 7 Due Friday

Group problem for this week is a block sliding down an incline plane, hitting a spring and going back up.

Review your notes on this lecture for tomorrow

Chapter 7

Conservation of linear momentum

momentum $\boxed{\vec{p} = m\vec{v}}$

Note momentum is a vector!

Newton's 2nd Law

$$\Sigma \vec{F} = m\vec{a} = m\frac{\Delta \vec{v}}{\Delta t} = \frac{m(\vec{v}_f - \vec{v}_i)}{\Delta t}$$

$$= \frac{\vec{p}_f - \vec{p}_i}{\Delta t} = \frac{\Delta \vec{p}}{\Delta t}$$

Rewrite Newton's 2nd Law

$$\boxed{\Sigma \vec{F} = \frac{\Delta \vec{p}}{\Delta t} \rightarrow \Delta \vec{p} = \Sigma \vec{F}\,\Delta t}$$

(1) (2)

(1) Rate of change of momentum is proportional to the net force applied

② $\Delta\vec{p} = \Sigma\vec{F}\Delta t$

Net force acting over a period of time produces a <u>change</u> in momentum

If only 1 force $\Rightarrow \vec{F}\Delta t = \Delta\vec{p}$

Define $\boxed{\vec{F}\Delta t \leftrightarrow \text{impulse}}$

ex) A 100 g ball is dropped from a height of 2.0 m above ground. It rebounds to a height of 1.5 m. What was the average force exerted by the floor if the ball was in contact with the floor for 0.1 s

$\vec{F} = \frac{\Delta \vec{p}}{\Delta t}$ $E_i = E_f$ $mgh = \frac{1}{2}mv^2$ $v = \pm\sqrt{2gh}$

$v = -\sqrt{2 \cdot 9.8 \text{ m/s}^2 \cdot 2.0 \text{ m}}$ velocity ball hits ground

$v = -6.26 \text{ m/s}$

bounces up

$\frac{1}{2}mv^2 = mgh \Rightarrow v = \sqrt{2gh}$

$v = \sqrt{2 \cdot 9.8 \text{ m/s}^2 \cdot 1.5 \text{ m}} = 5.42 \text{ m/s}$

$\Delta p = mv_f - mv_i$

$(0.1 \text{ kg})(5.42 \text{ m/s}) - (0.1 \text{ kg})(-6.26 \text{ m/s})$

$\Delta p = 1.17 \text{ kg-m/s}$

$\vec{F} = \frac{\Delta \vec{p}}{\Delta t} = \frac{1.17 \text{ kg-m/s}}{.1 \text{ s}} = 11.7 \text{ N}$

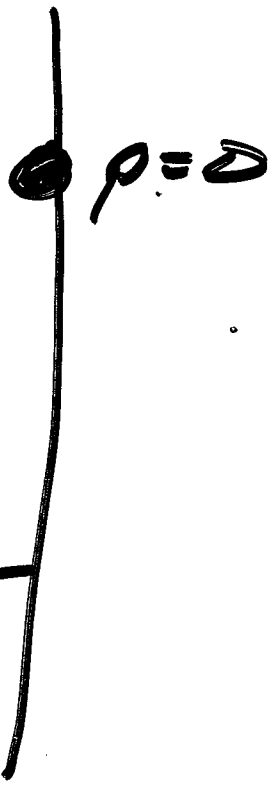
Interactive Question

A rubber ball and a lump of putty have equal mass. They are thrown with equal speed against a wall. The ball bounces back with nearly the same speed with which it hit. The putty sticks to the wall. Which object experiences the greater momentum change?

A) The ball
B) The putty
C) Both experience the same momentum change
D) Cannot be determined from the information given

Putty

$\Delta p = mv - 0 = mv$

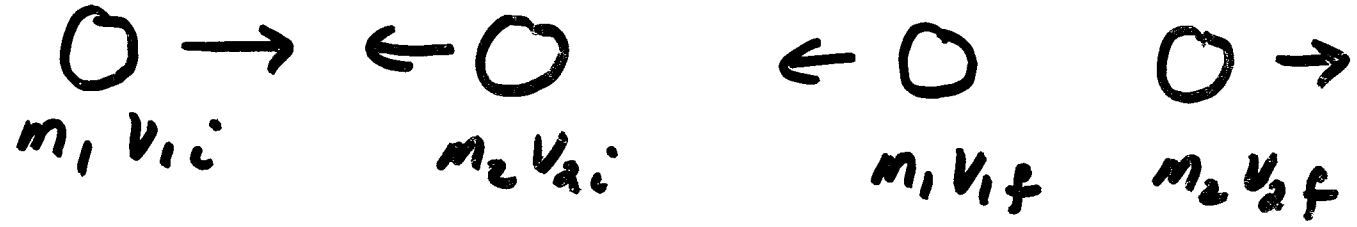


ball

$\Delta p = mv - (-mv)$

$2mv$

Look at 2 balls colliding



ball 1

$$\vec{F}_1 \Delta t = \Delta \vec{p}_1 = m_1 \vec{v}_{1f} - m_1 \vec{v}_{1i}$$

ball 2

$$\vec{F}_2 \Delta t = \Delta \vec{p}_2 = m_2 \vec{v}_{2f} - m_2 \vec{v}_{2i}$$

F_1 = Force of ball 2 on ball 1

F_2 = Force of ball 1 on ball 2

Newton's 3rd Law

$$F_1 = -F_2 \Rightarrow F_1 \Delta t = -F_2 \Delta t$$

This leads to 2 very important results.

$F_1 \Delta t = -F_2 \Delta t \Rightarrow \boxed{\Delta p_1 = -\Delta p_2}$

When 2 objects collide, the magnitude of the <u>change</u> in momentum for each object is the same

$$\Delta p_1 = -\Delta p_2$$

$$m_1 \vec{v}_{1f} - m_1 \vec{v}_{1i} = -(m_2 \vec{v}_{2f} - m_2 \vec{v}_{2i})$$

algebra

$$m_1 \vec{v}_{1i} + m_2 \vec{v}_{2i} = m_1 \vec{v}_{1f} + m_2 \vec{v}_{2f}$$

$$\vec{p}_{1i} + \vec{p}_{2i} = \vec{p}_{1f} + \vec{p}_{2f}$$

in general

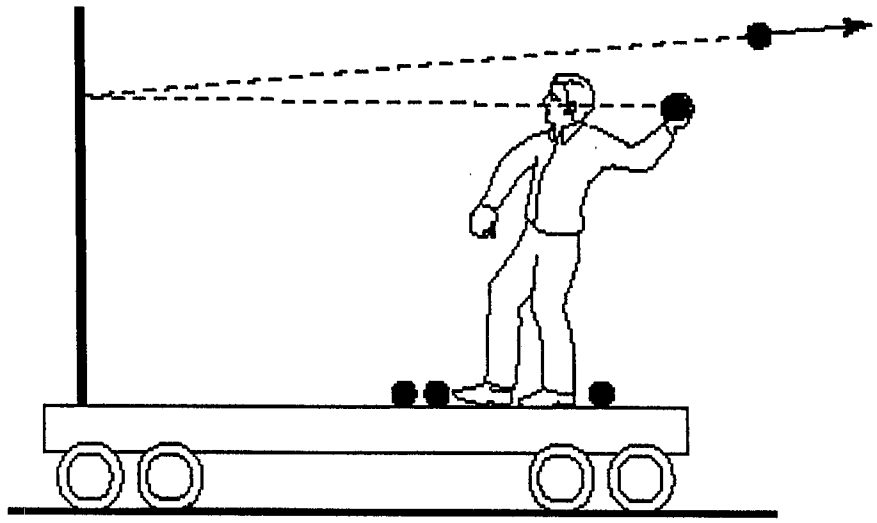
$$\Sigma \vec{p}_i = \Sigma \vec{p}_f$$

IF there are no external forces acting (isolated system)

momentum is conserved

Interactive Question

You are on a cart initially at rest on a track with no friction. You throw balls at a partition that is rigidly mounted on the cart. If the balls bounce straight back as shown, is the cart put in motion?



A) Yes, it moves to the right.
B) Yes, it moves to the left.
C) No, it remains in place.