Linear Momentum

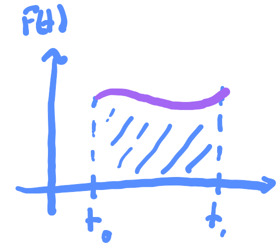
— very important for problem solving

$$\vec{P} = m\vec{V}$$

$$\frac{d\vec{P}}{dt} = m\frac{d\vec{V}}{dt} = m\vec{a} = \vec{F}_{net}$$

$$\Rightarrow \vec{F}_{net} = \frac{d\vec{P}}{dt} = \frac{d(m\vec{v}_1 + \dots m\vec{v}_n)}{dt} = \vec{F}_1 + \dots \vec{F}_n$$

$$\vec{P} = \int_{t_1}^{t_2} \vec{F}(t)\,dt$$



For a system of particles

$$\vec{P}_{system} = \sum_i \vec{p}_i = m_1\vec{V}_1 + m_2\vec{V}_2 + m_3\vec{V}_3 + \dots$$

$$W = \int_{x_1}^{x_2} \vec{F}\,d\vec{x}$$

$$\vec{F}_{net} = \frac{d\vec{P}_{system}}{dt}$$

Impulse and linear momentum

$$d\vec{p} = \vec{F}(t)dt$$

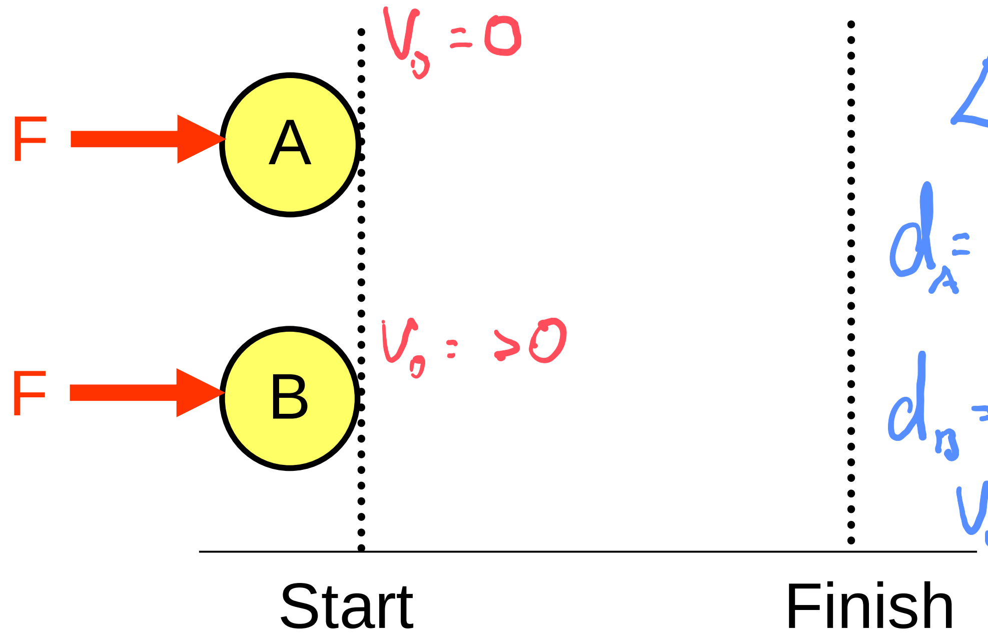
$$\Delta\vec{p} = \int_{\vec{p}_i}^{\vec{p}_f} d\vec{p} = \int_{t_i}^{t_f} \vec{F}(t)dt$$

**Change of momentum is force integrated over time.*
**Change of energy – work – is force integrated over displacement.*

Impulse

$$\Delta\vec{p} = \vec{I} = \vec{p}_f - \vec{p}_i = \vec{F}_{avg}\Delta t$$

Identical constant forces F push ***<u>identical</u>*** Blocks A and B from the start line to the finish line. ***<u>Block A is initially at rest, but block B is initially moving to the right.</u>*** Which block incurs the greater change in momentum while moving from the start to the finish line?



1. A
2. B
3. Both have the same change in momentum.
4. Can't tell from the information given.

$\Delta P = Ft$

$d_A = V_0 t_1 + \frac{1}{2} a t_1^2$

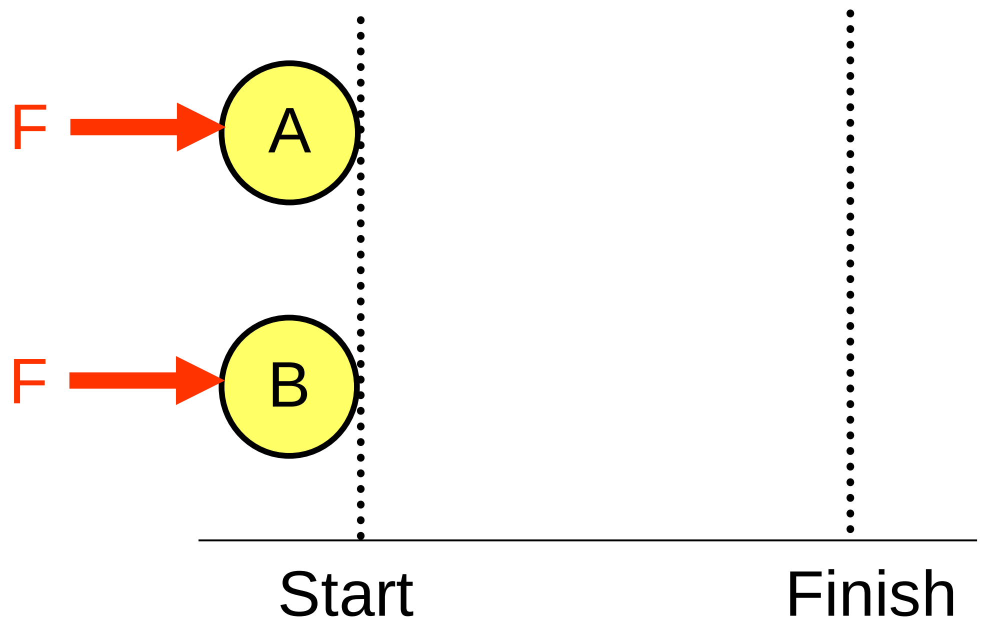
$d_B = V_0 t_2 + \frac{1}{2} a t_2^2$

$V_0 t_2 + \frac{1}{2} a t_2^2 - d = 0$

$t_2 = \frac{-V_0 \pm \sqrt{V_0^2 - 4(\frac{1}{2}a)(-d)}}{2 \cdot \frac{1}{2}a}$

Quadratic

Identical constant forces F push identical Blocks A and B from the start line to the finish line. Both blocks start at rest, but block A has ***<u>4 times as much mass</u>*** as block B. Which block incurs the greater change in momentum while moving from the start to the finish line?



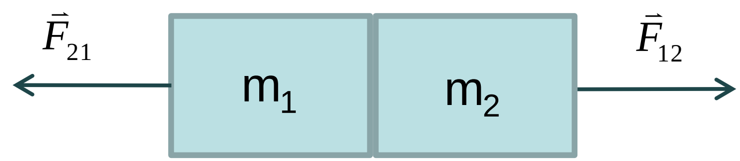
1. A
2. B
3. Both have the same change in momentum
4. Can't tell from the information given

$$\frac{d\vec{P}}{dt} = m\frac{d\vec{V}}{dt} = m\vec{a} = \vec{F}_{net} \Rightarrow \vec{F}_{net} = \frac{d\vec{P}}{dt}$$

$$When \quad \vec{F}_{net} = 0 \Rightarrow \frac{d\vec{P}_{system}}{dt} = 0 \qquad \vec{P}_{system} = \text{Constant}$$

Momentum Conservation

When in a collision:



$$\vec{F}_{21} = -\vec{F}_{12}$$

$$\Delta\vec{p}_1 = \vec{F}_{21\_avg} \cdot \Delta t$$

$$\Delta\vec{p}_2 = \vec{F}_{12\_avg} \cdot \Delta t$$

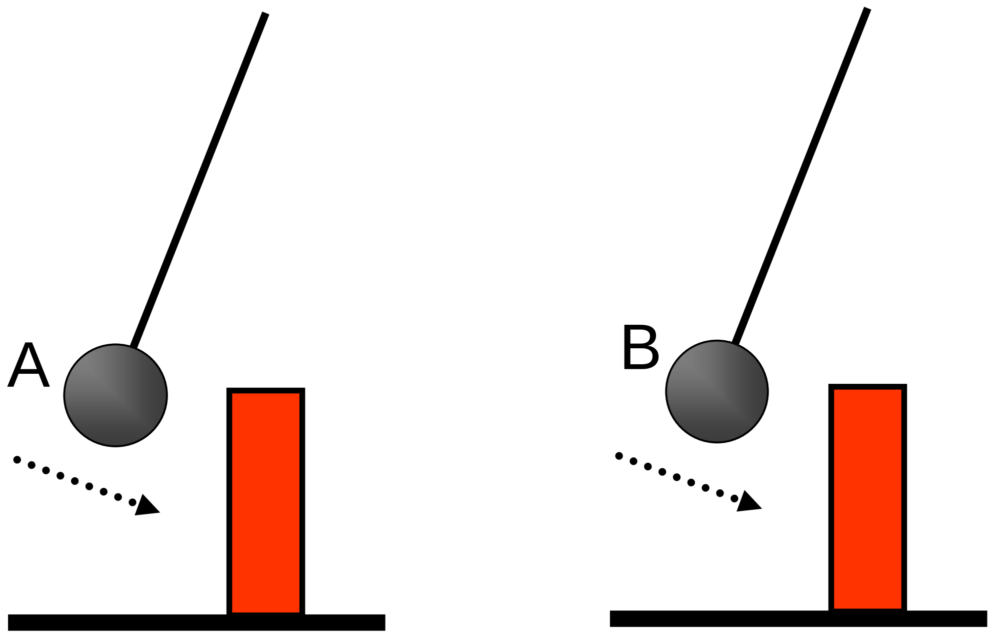
$$\Delta\vec{p}_1 = -\Delta\vec{p}_2$$

$$\Delta p_1 + \Delta p_2 = 0 = \Delta P_{system}$$

$$P_{sys\_i} = P_{sys\_f}$$

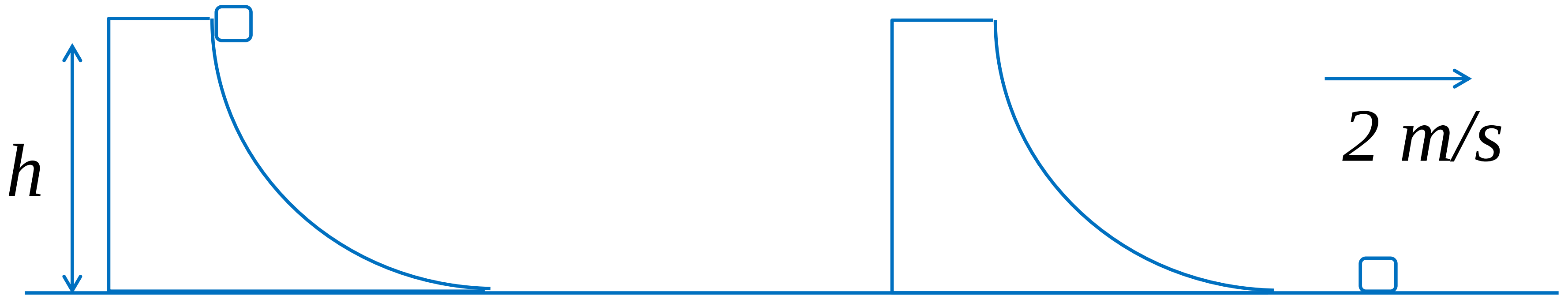
$$m_1\vec{V}_{1i} + m_2\vec{V}_{2i} = m_1\vec{V}_{1f} + m_2\vec{V}_{2f}$$

Two equal-mass balls swing down and hit identical bricks while traveling at identical speeds. Ball A bounces back, but ball B just stops when it hits the brick. Which ball has a better chance of knocking the brick over?



1. A
2. B
3. They both have the same chance.

A small block of 1.0 kg is set on a irregular ramp at an initial height of *h*. The ramp has a mass of 10.0 kg and can move freely without friction on the ground. Both the ramp and the block are at rest initially. After the block is released, it glides down the ramp and moving the right on the ground with a speed of 2 m/s. What is the velocity of the ramp? (There are no frictions on all surfaces.)



No friction on all surfaces