July 2, Week 5

Today: Chapter 9, Conservation of Momentum

No Office Hours on Friday.

Homework Assignment #5 - Due Monday, July 7. (Homework assignment #6 will be due Friday, July 11)

Test #5 on Tuesday, July 8

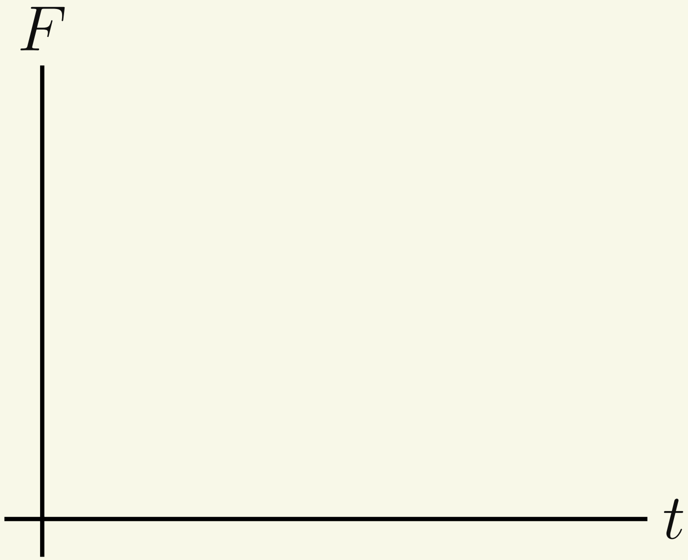
There will be a reading quiz due Monday.

Impulse-Momentum Theorem - Variable Forces

The Impulse-Momentum Theorem also holds for non-constant forces!

Impulse-Momentum Theorem - Variable Forces

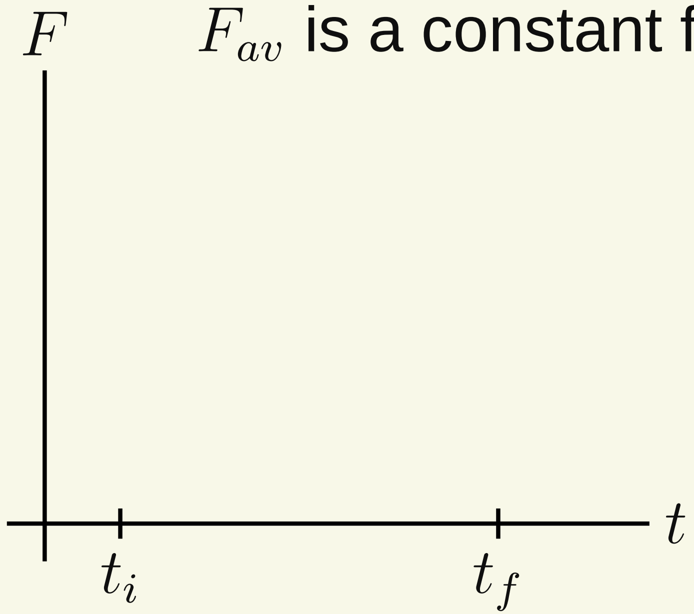
The Impulse-Momentum Theorem also holds for non-constant forces!



Impulse-Momentum Theorem - Variable Forces

The Impulse-Momentum Theorem also holds for non-constant forces!

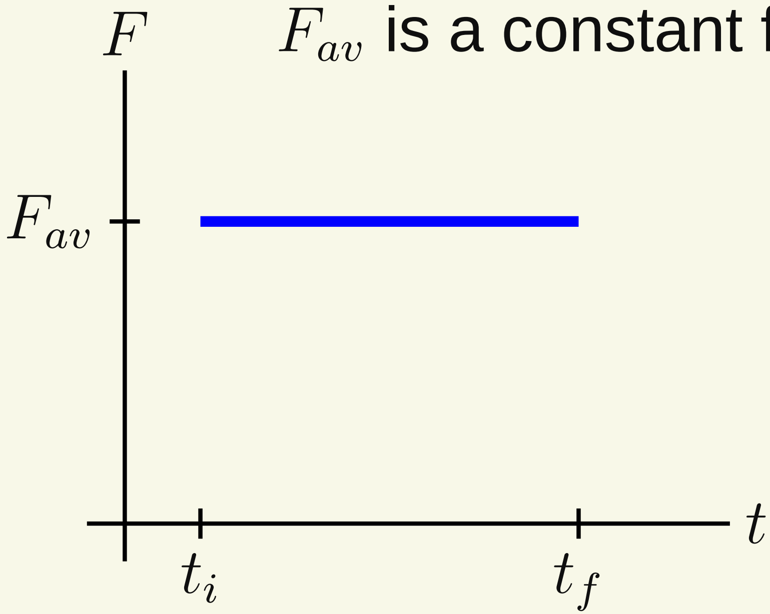
F_{av} is a constant force



Impulse-Momentum Theorem - Variable Forces

The Impulse-Momentum Theorem also holds for non-constant forces!

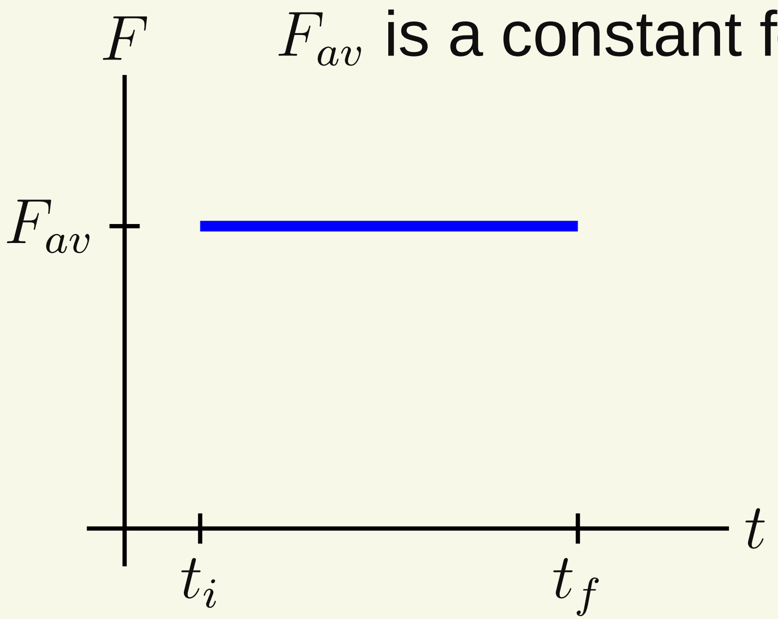
F_{av} is a constant force



Impulse-Momentum Theorem - Variable Forces

The Impulse-Momentum Theorem also holds for non-constant forces!

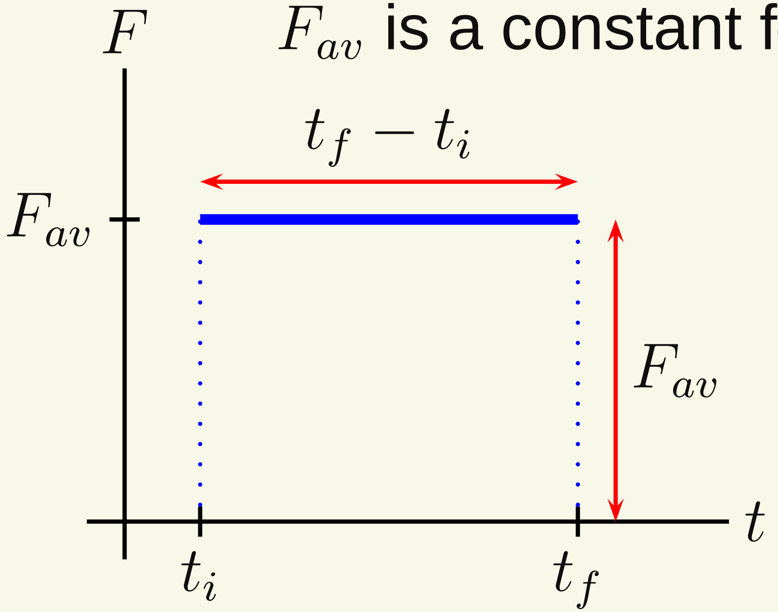
F_{av} is a constant force



$$J = F_{av}\Delta t = F_{av}\left(t_f - t_i\right)$$

The Impulse-Momentum Theorem also holds for non-constant forces!

F_{av} is a constant force

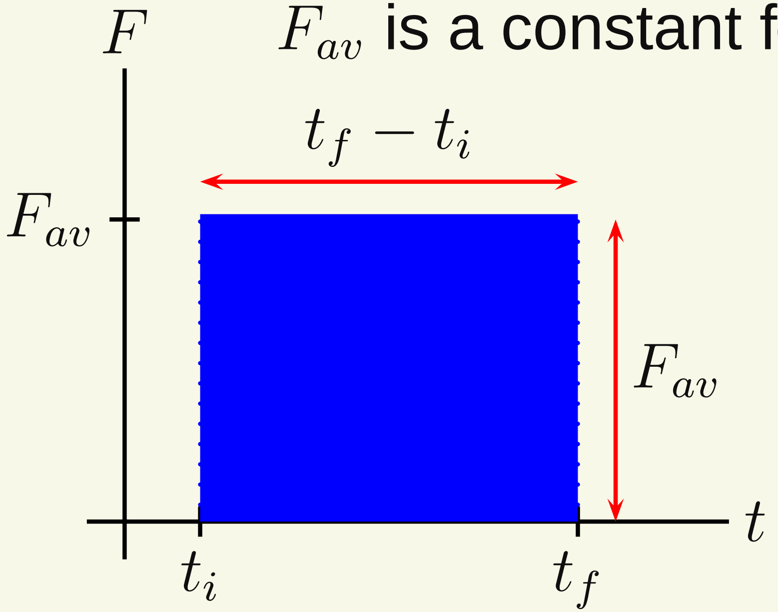


$$J = F_{av}\Delta t = F_{av}\left(t_f - t_i\right)$$

Impulse-Momentum Theorem - Variable Forces

The Impulse-Momentum Theorem also holds for non-constant forces!

F_{av} is a constant force

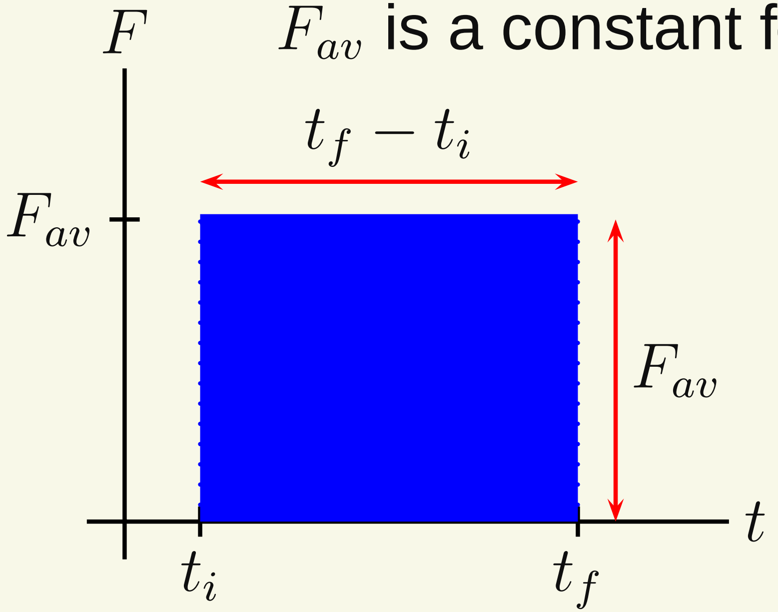


$$J = F_{av}\Delta t = F_{av}\left(t_f - t_i\right)$$

Impulse-Momentum Theorem - Variable Forces

The Impulse-Momentum Theorem also holds for non-constant forces!

F_{av} is a constant force



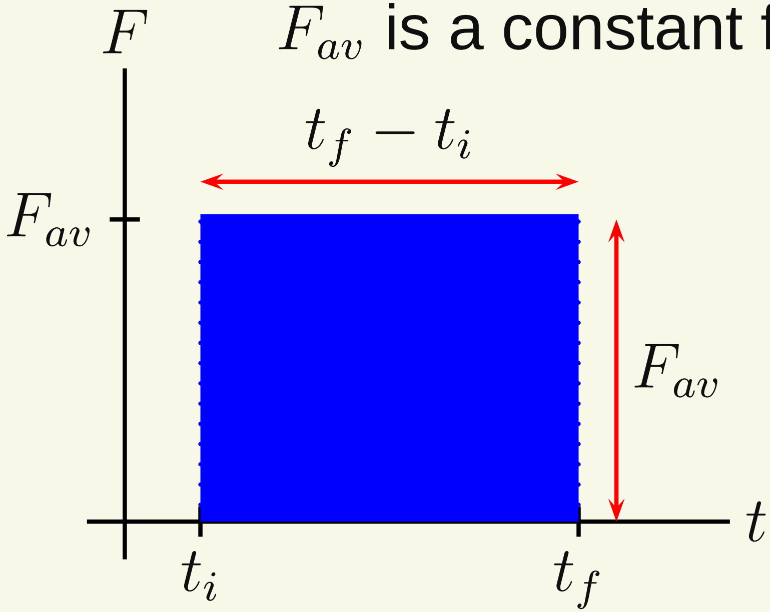
$$J = F_{av}\Delta t = F_{av}\left(t_f - t_i\right)$$

Impulse is the area under the curve

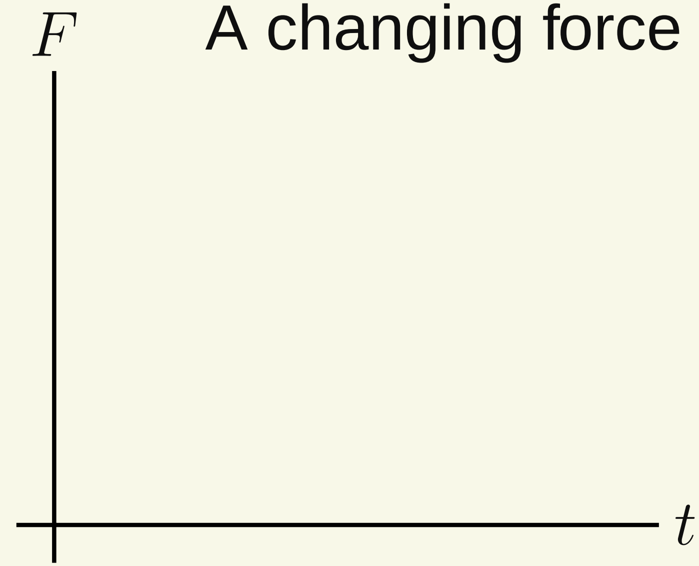
Impulse-Momentum Theorem - Variable Forces

The Impulse-Momentum Theorem also holds for non-constant forces!

F_{av} is a constant force



A changing force

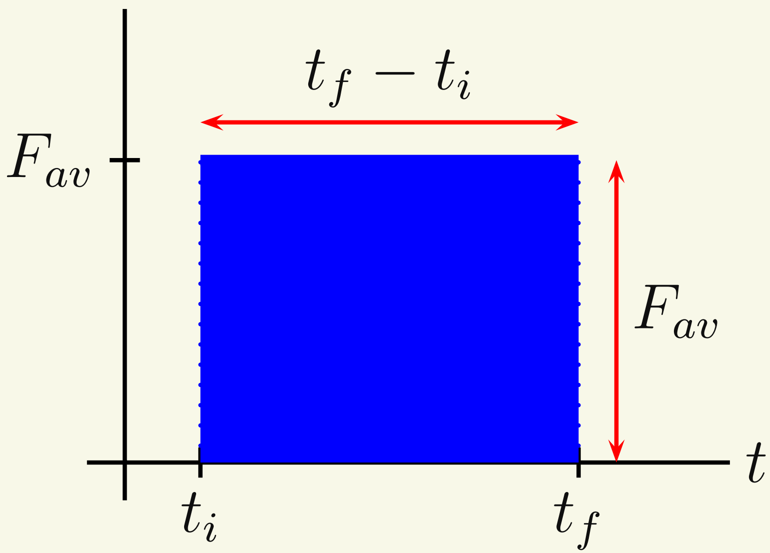


$$J = F_{av}\Delta t = F_{av}\left(t_f - t_i\right)$$

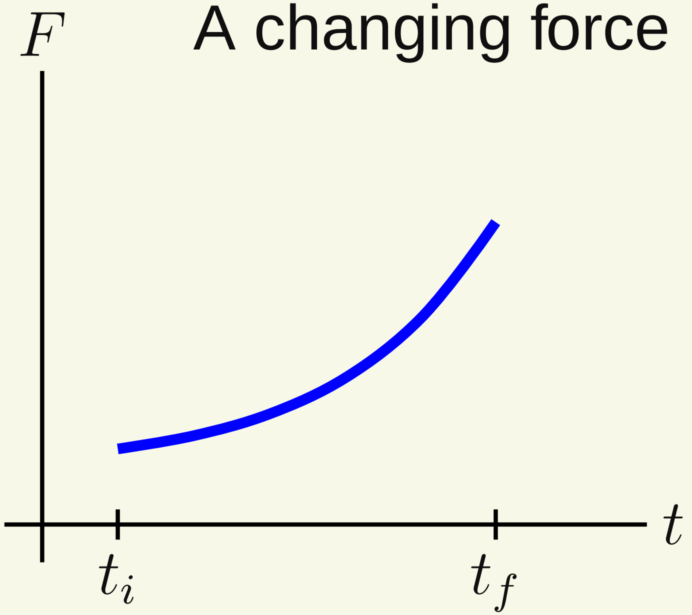
Impulse is the area under the curve

The Impulse-Momentum Theorem also holds for non-constant forces!

F_{av} is a constant force



A changing force



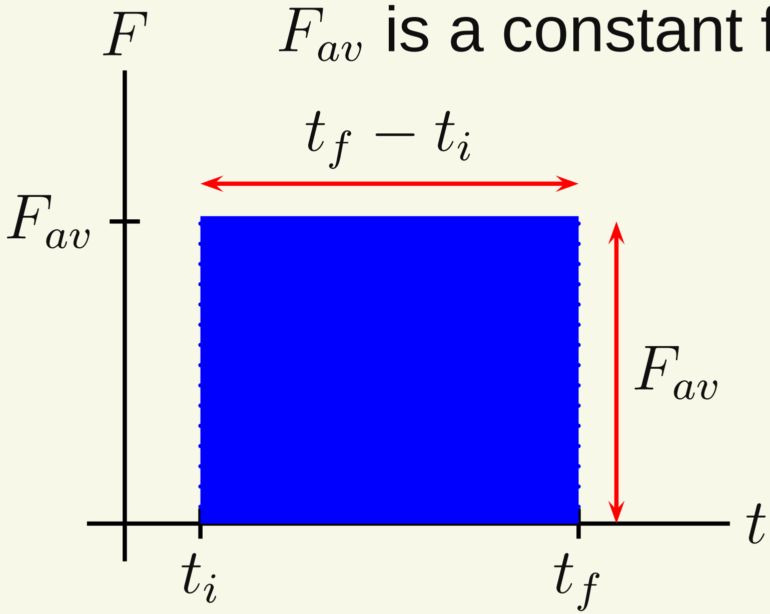
$$J = F_{av}\Delta t = F_{av}\left(t_f - t_i\right)$$

Impulse is the area under the curve

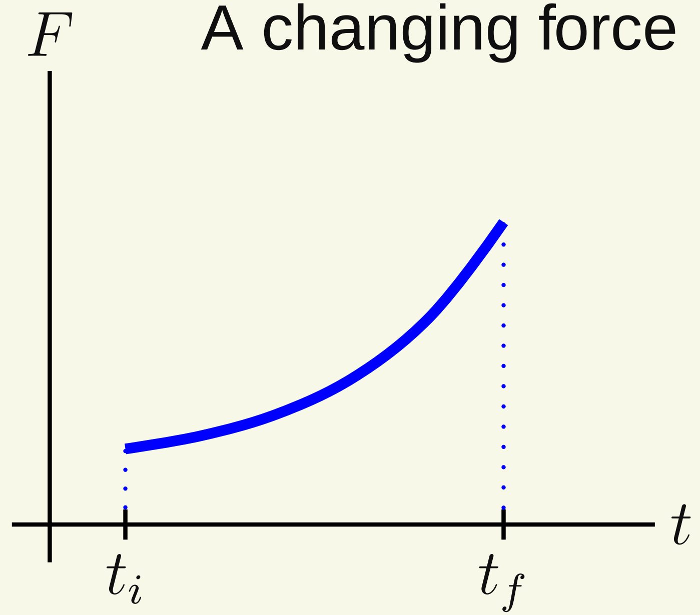
Impulse-Momentum Theorem - Variable Forces

The Impulse-Momentum Theorem also holds for non-constant forces!

F_{av} is a constant force



A changing force



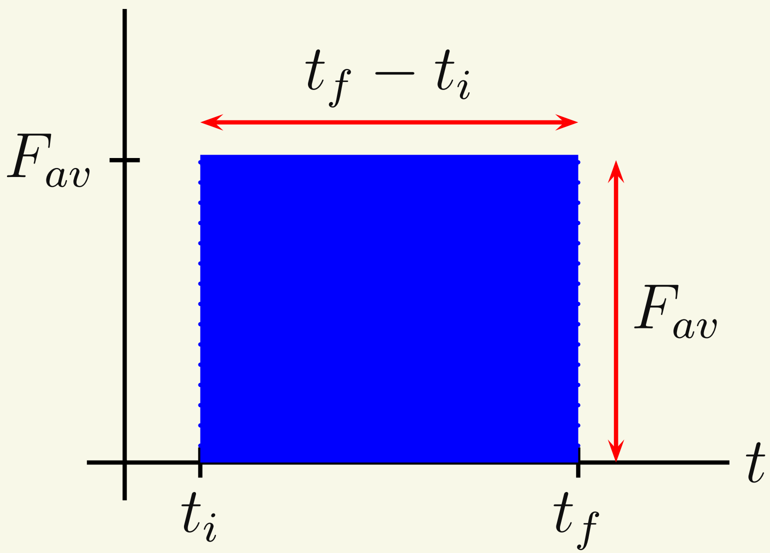
$$J = F_{av}\Delta t = F_{av}\left(t_f - t_i\right)$$

Impulse is the area under the curve

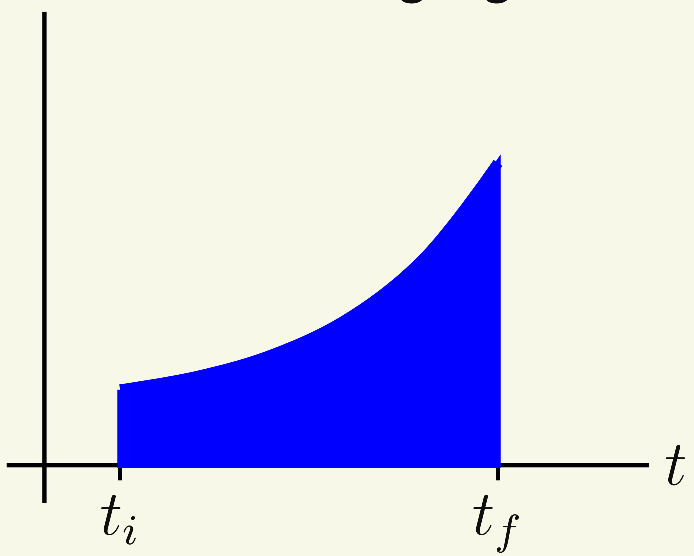
Impulse-Momentum Theorem - Variable Forces

The Impulse-Momentum Theorem also holds for non-constant forces!

F_{av} is a constant force



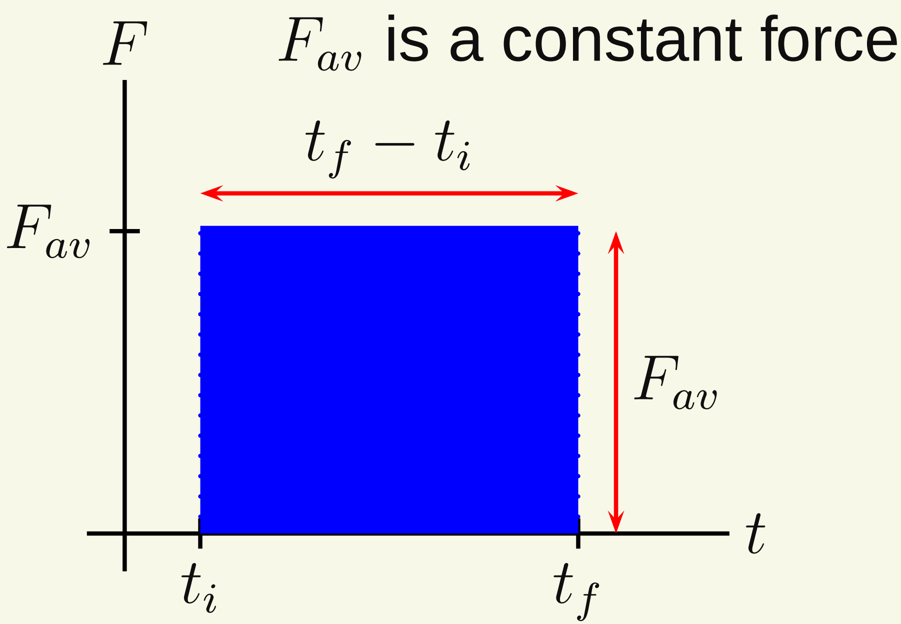
A changing force

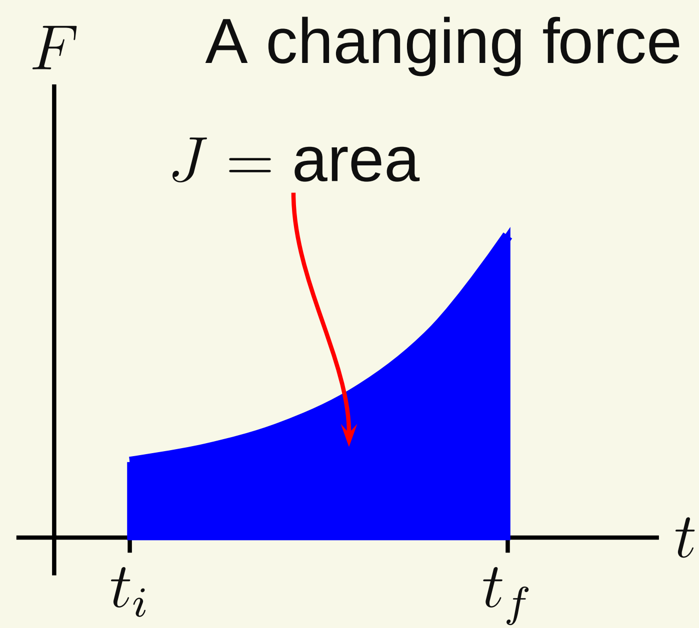


$$J = F_{av}\Delta t = F_{av}\left(t_f - t_i\right)$$

Impulse is the area under the curve

The Impulse-Momentum Theorem also holds for non-constant forces!





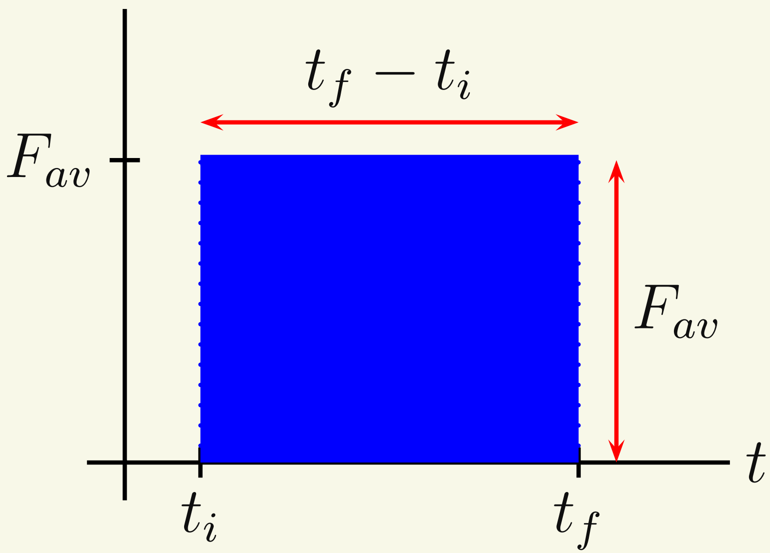
$$J = F_{av}\Delta t = F_{av}\left(t_f - t_i\right)$$

Impulse is the area under the curve

Impulse-Momentum Theorem - Variable Forces

The Impulse-Momentum Theorem also holds for non-constant forces!

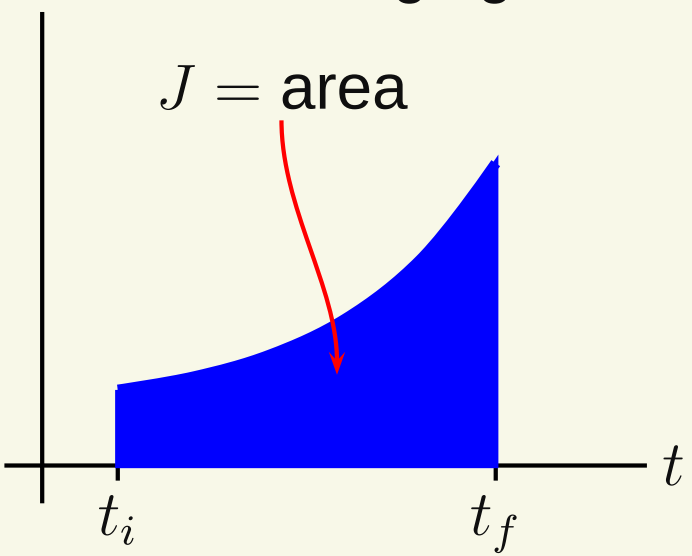
F_{av} is a constant force



$$J = F_{av}\Delta t = F_{av}\left(t_f - t_i\right)$$

Impulse is the area under the curve

A changing force

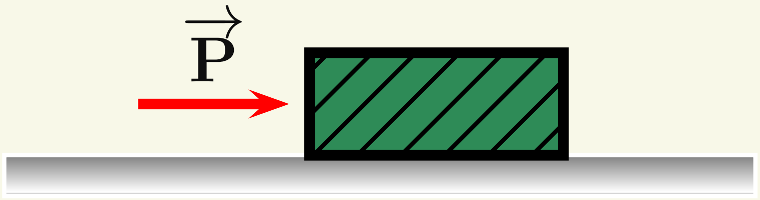


It is beyond the scope of this course but $\boxed{J = \Delta p}$ still!

Variable-Force Exercise I

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

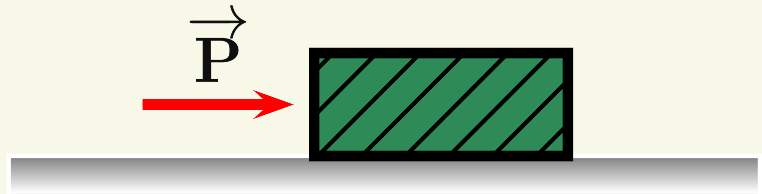
A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block for $1\ s$. What impulse is imparted?

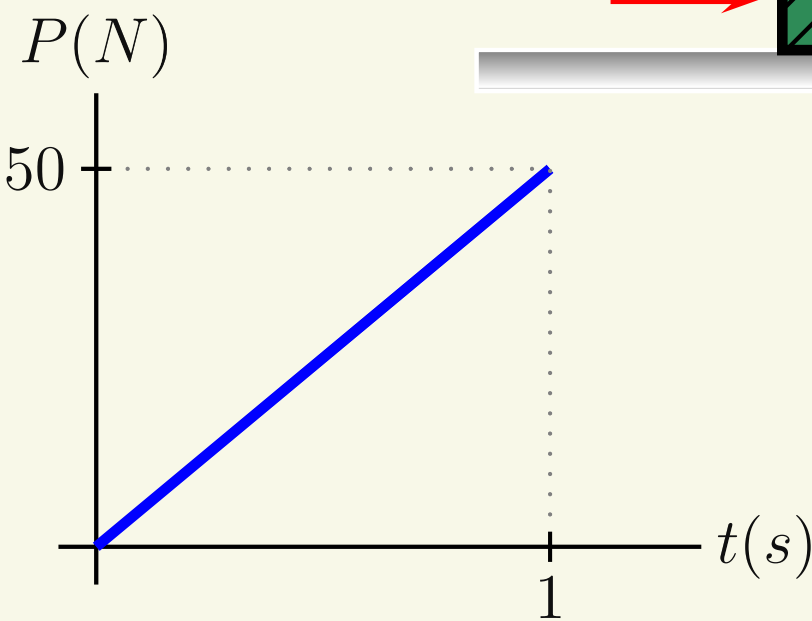


Variable-Force Exercise I

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block for $1\ s$. What impulse is imparted?

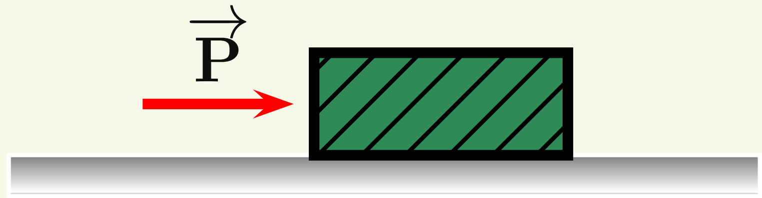


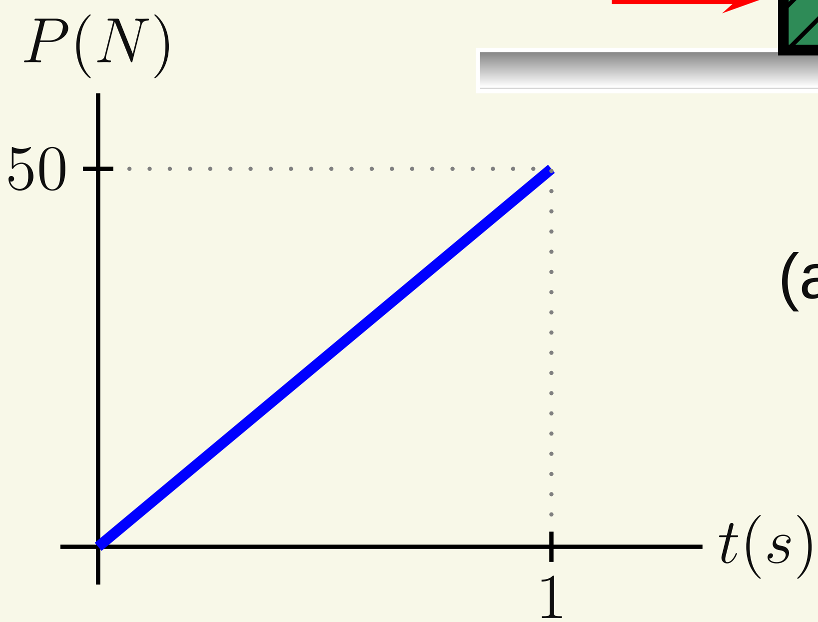


Variable-Force Exercise I

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block for $1\,s$. What impulse is imparted?



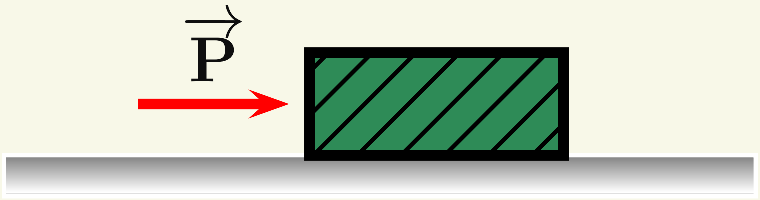


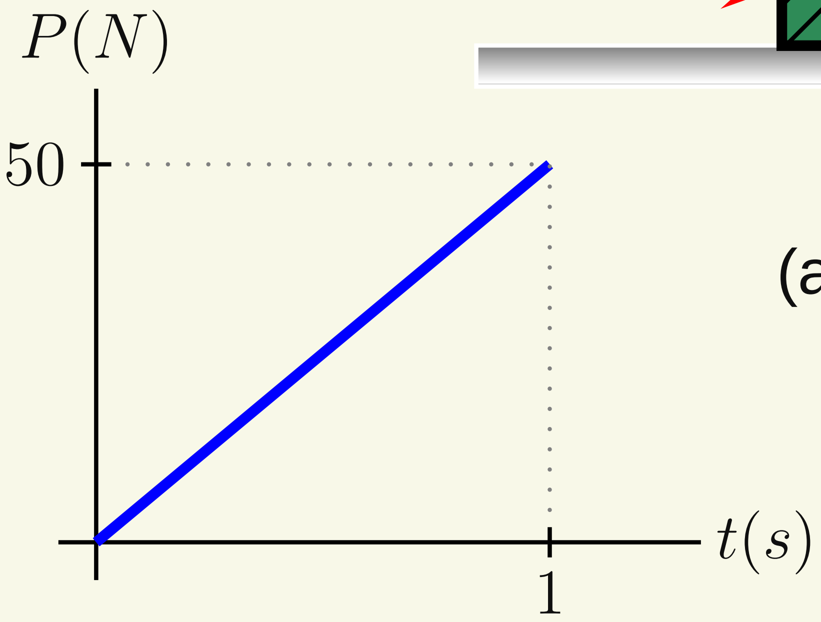
(a) $0\,kg \cdot m/s$

Variable-Force Exercise I

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block for $1\,s$. What impulse is imparted?



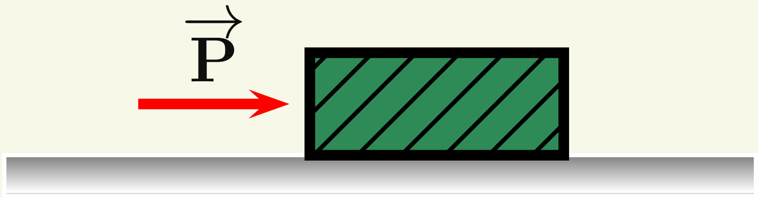


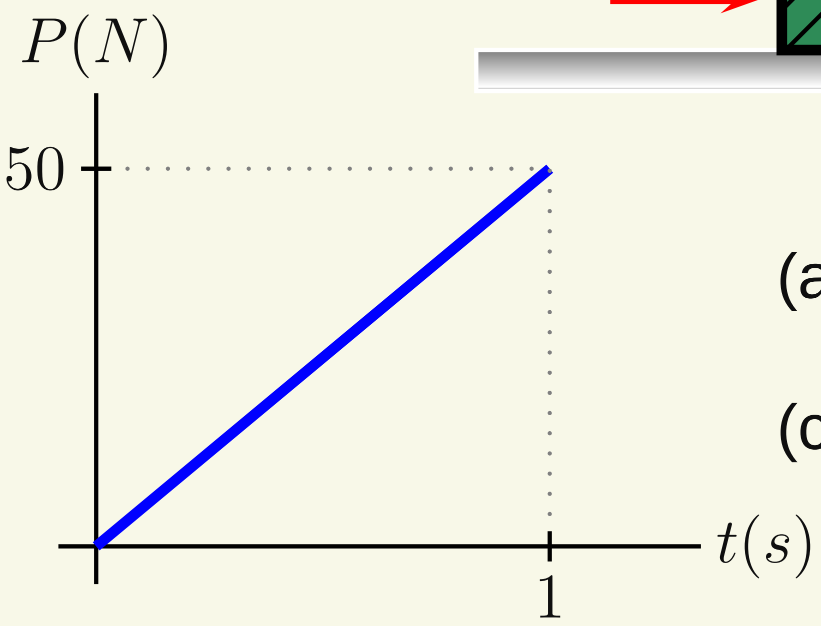
(a) $0\,kg \cdot m/s$ (b) $25\,kg \cdot m/s$

Variable-Force Exercise I

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block for $1\,s$. What impulse is imparted?





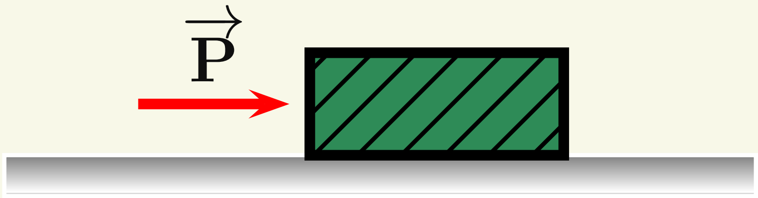
(a) $0\,kg \cdot m/s$ (b) $25\,kg \cdot m/s$

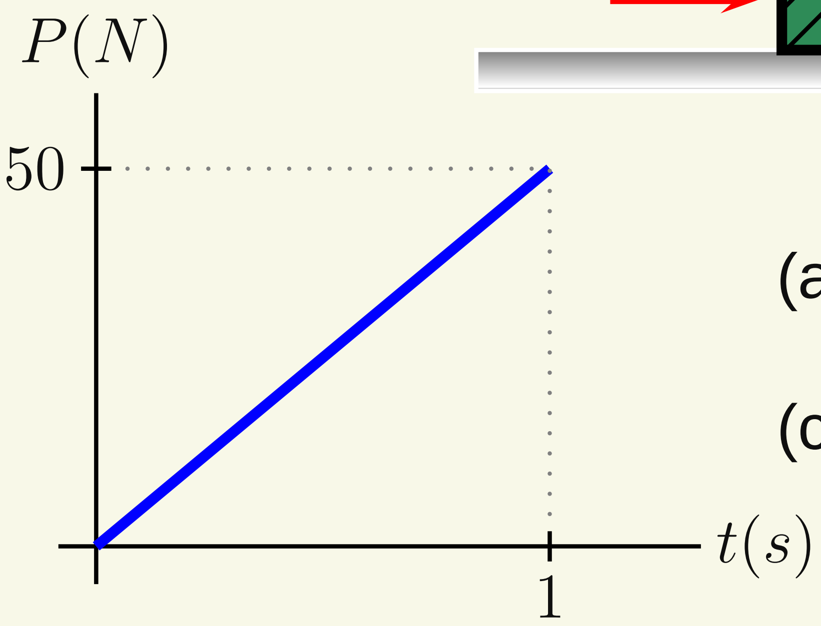
(c) $50\,kg \cdot m/s$

Variable-Force Exercise I

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block for $1\,s$. What impulse is imparted?





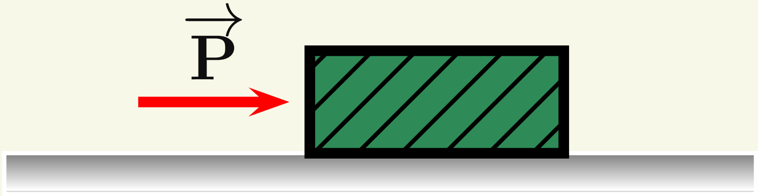
(a) $0\,kg \cdot m/s$ (b) $25\,kg \cdot m/s$

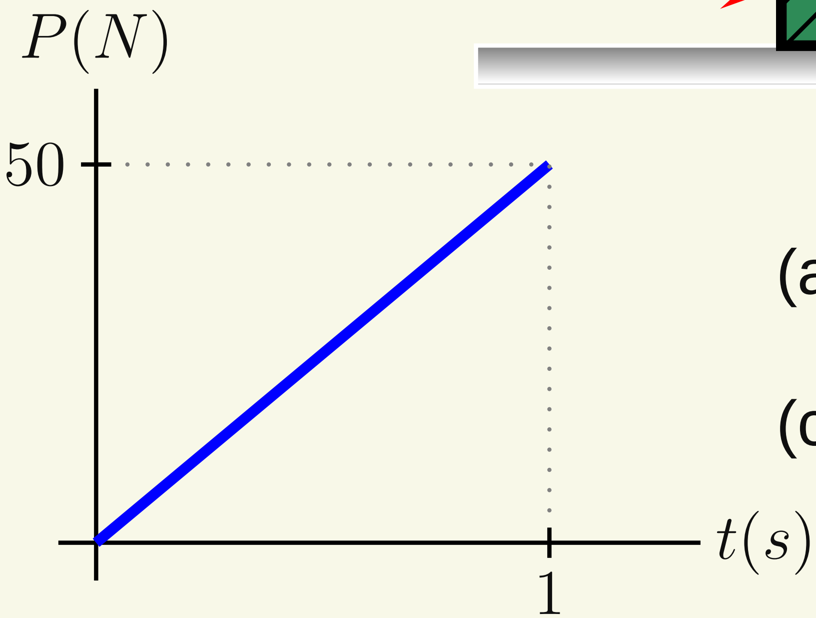
(c) $50\,kg \cdot m/s$ (d) $75\,kg \cdot m/s$

Variable-Force Exercise I

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block for $1\,s$. What impulse is imparted?





(a) $0\,kg \cdot m/s$ (b) $25\,kg \cdot m/s$

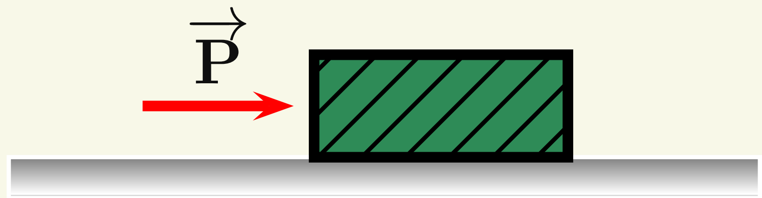
(c) $50\,kg \cdot m/s$ (d) $75\,kg \cdot m/s$

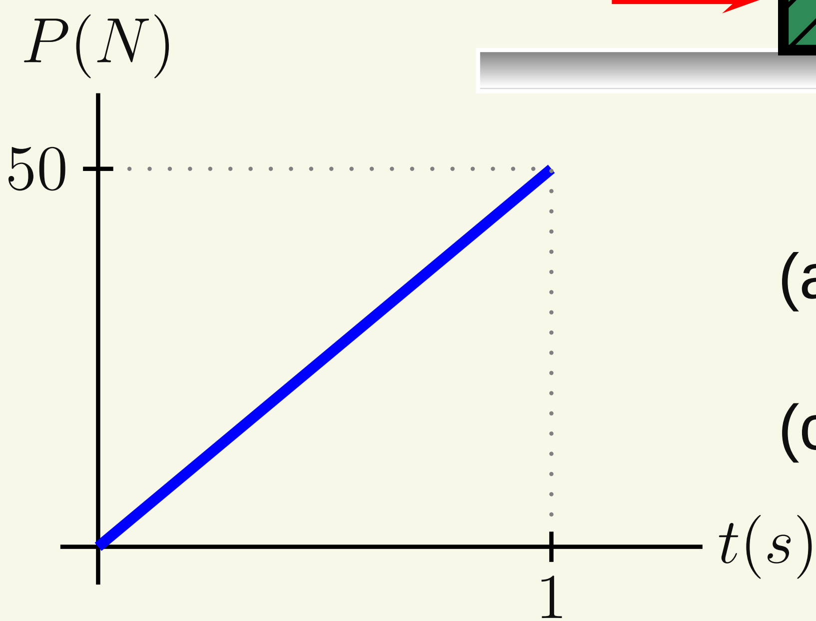
(e) $100\,kg \cdot m/s$

Variable-Force Exercise I

Impulse-Momentum Theorem: $J = \Delta p$ for any force

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block for $1\,s$. What impulse is imparted?





(a) $0\,kg \cdot m/s$

(b) $25\,kg \cdot m/s$

(c) $50\,kg \cdot m/s$

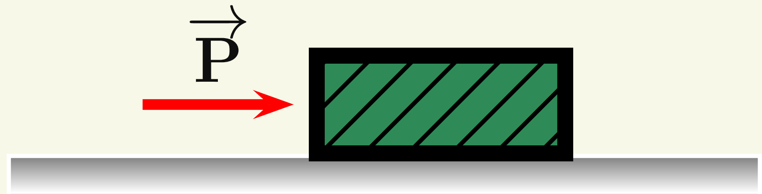
(d) $75\,kg \cdot m/s$

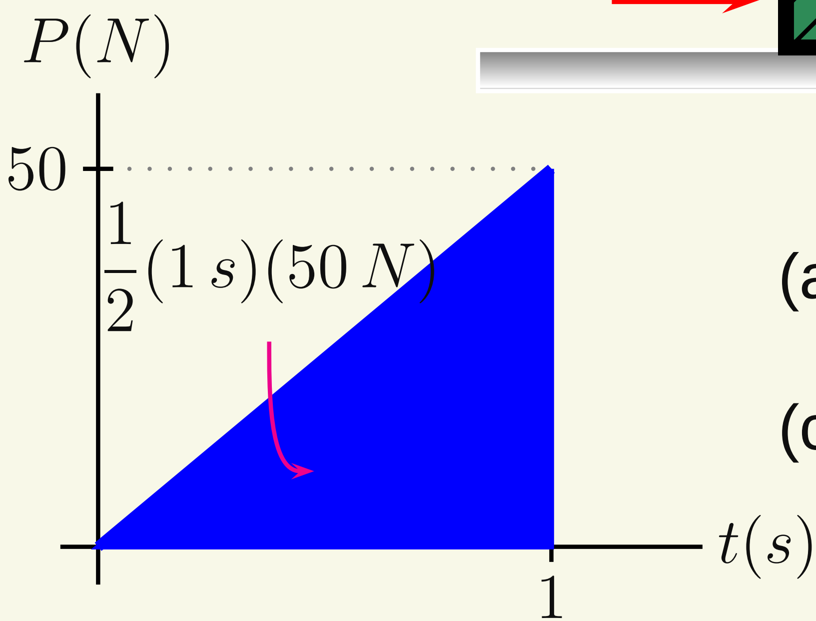
(e) $100\,kg \cdot m/s$

Variable-Force Exercise I

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block for $1\,s$. What impulse is imparted?





(a) $0\,kg \cdot m/s$

(b) $25\,kg \cdot m/s$

(c) $50\,kg \cdot m/s$

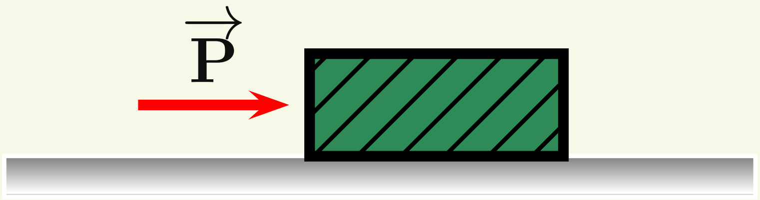
(d) $75\,kg \cdot m/s$

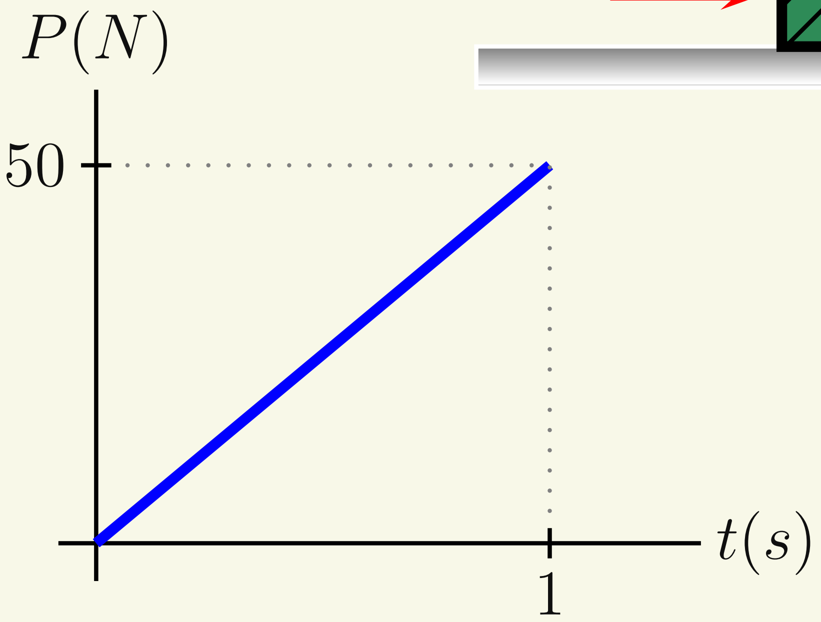
(e) $100\,kg \cdot m/s$

Variable-Force Exercise II

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block, how fast is it going after $1\ s$?

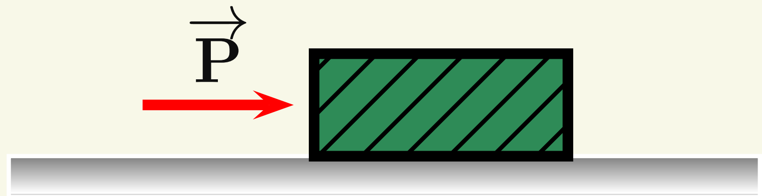


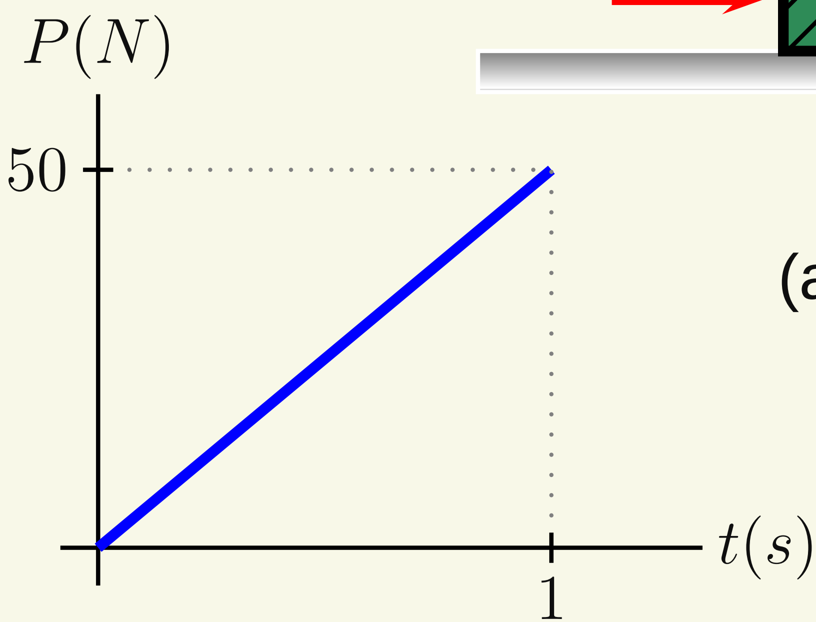


Variable-Force Exercise II

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block, how fast is it going after $1\,s$?



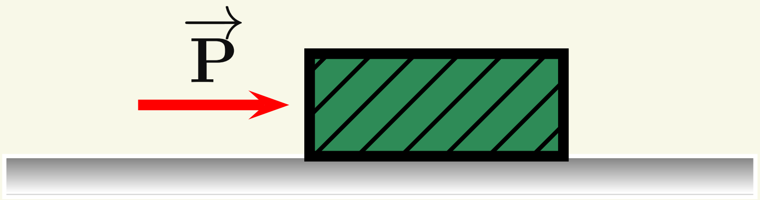


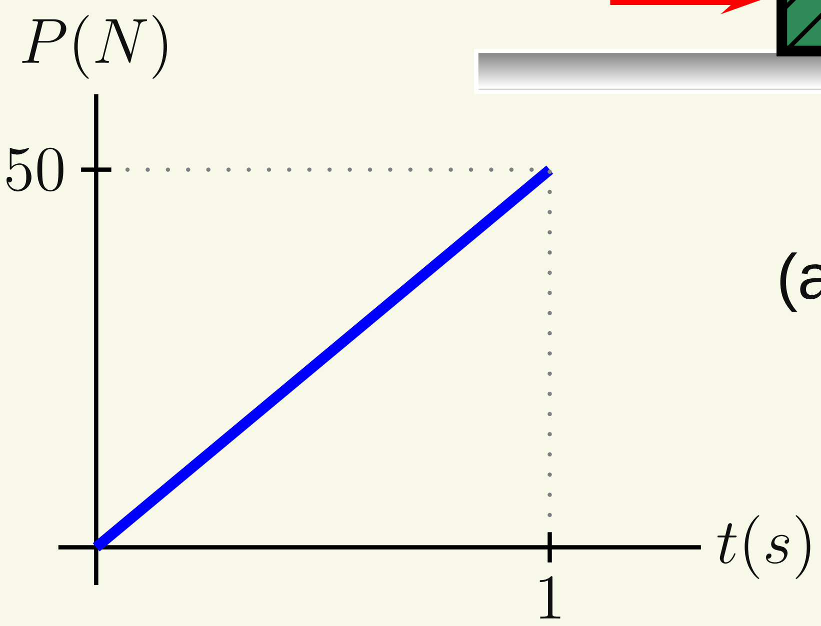
(a) $50\,m/s$

Variable-Force Exercise II

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block, how fast is it going after $1\ s$?



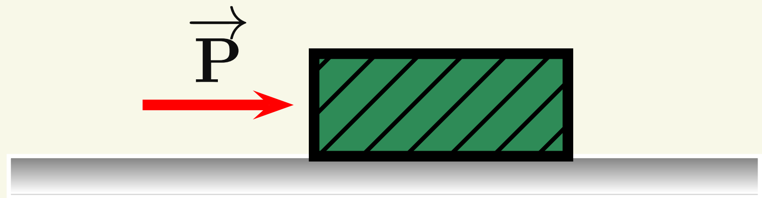


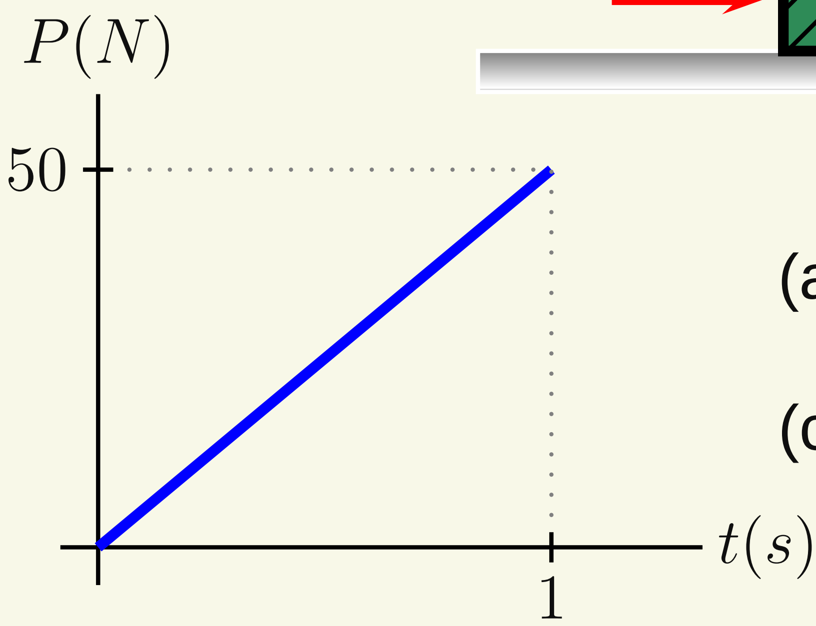
(a) $50\, m/s$ (b) $25\, m/s$

Variable-Force Exercise II

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block, how fast is it going after $1\ s$?





(a) $50\,m/s$

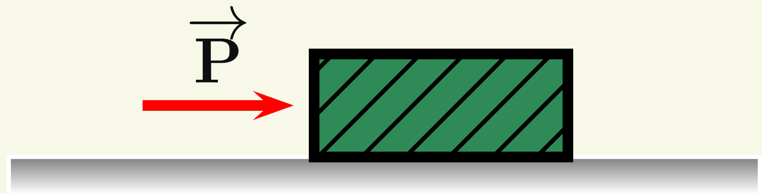
(b) $25\,m/s$

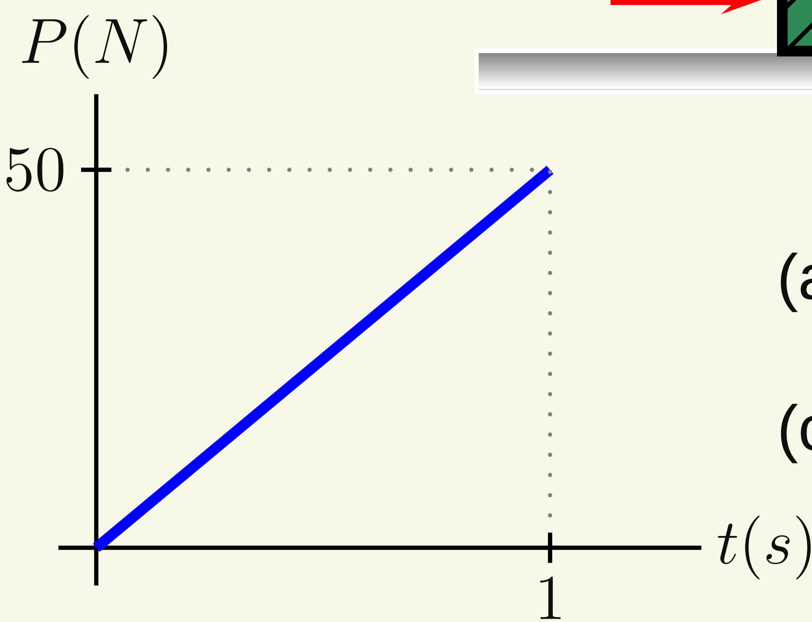
(c) $10\,m/s$

Variable-Force Exercise II

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block, how fast is it going after $1\ s$?





(a) $50\,m/s$

(b) $25\,m/s$

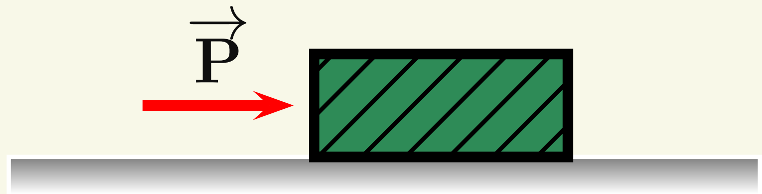
(c) $10\,m/s$

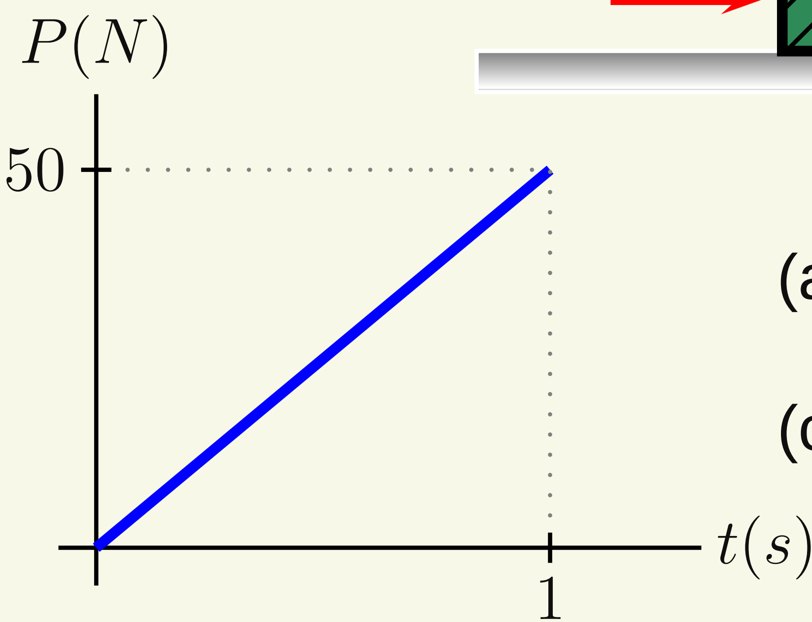
(d) $5\,m/s$

Variable-Force Exercise II

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block, how fast is it going after $1\,s$?





(a) $50\,m/s$

(b) $25\,m/s$

(c) $10\,m/s$

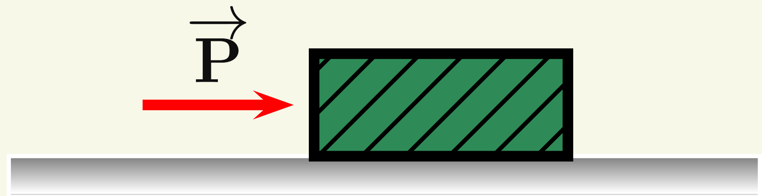
(d) $5\,m/s$

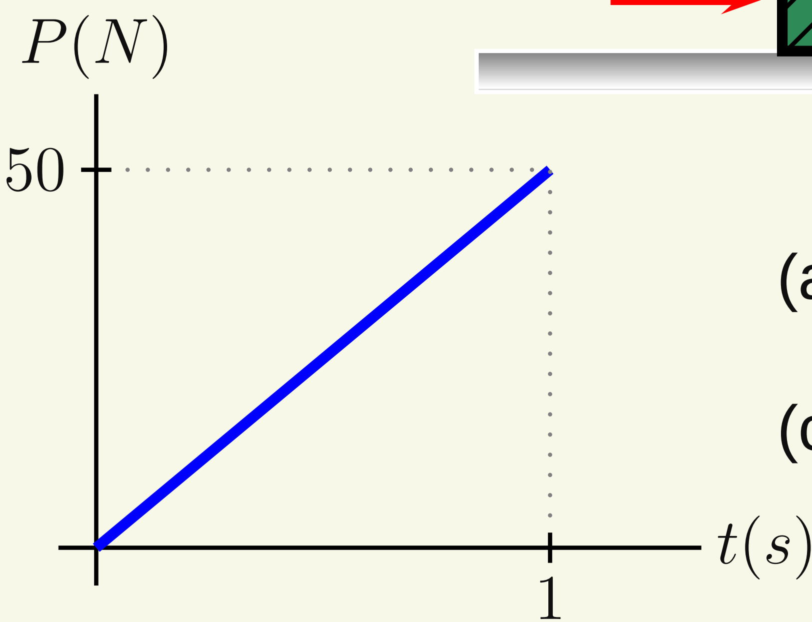
(e) $0\,m/s$

Variable-Force Exercise II

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block, how fast is it going after $1\,s$?





(a) $50\,m/s$

(b) $25\,m/s$

(c) $10\,m/s$

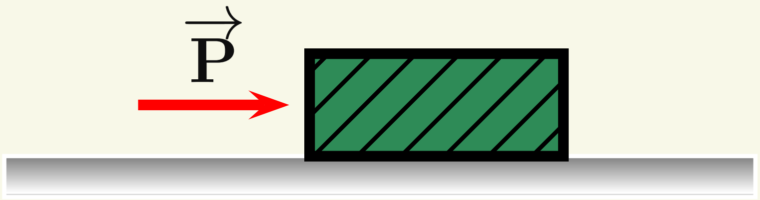
$\boxed{\text{(d) } 5\,m/s}$

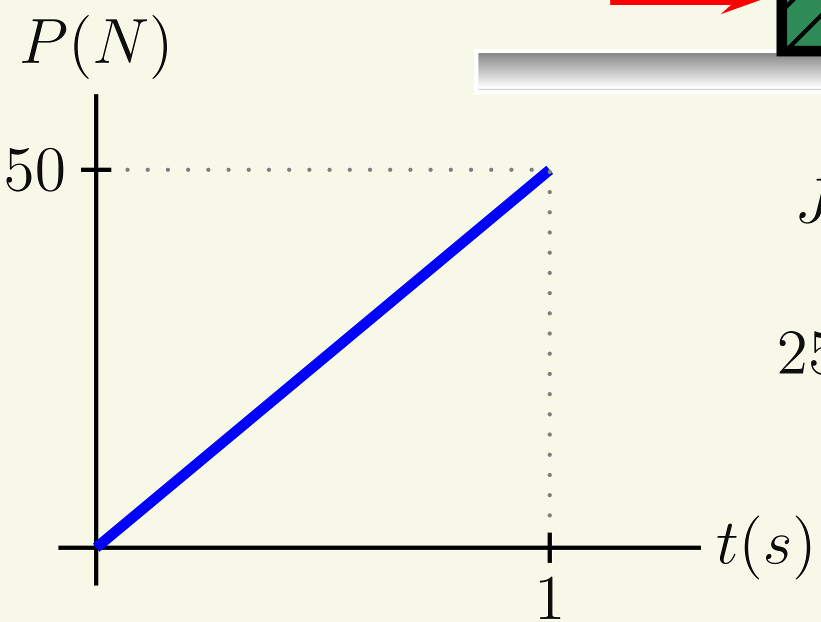
(e) $0\,m/s$

Variable-Force Exercise II

Impulse-Momentum Theorem: $\boxed{J = \Delta p \text{ for any force}}$

A 5-kg block is sitting on a horizontal, frictionless floor. The force shown is applied to the block, how fast is it going after $1\,s$?





$$J_x = m(v_x)_f - m(v_x)_i \Rightarrow$$

$$25\,kg \cdot m/s = (5\,kg)(v_x)_f - 0$$

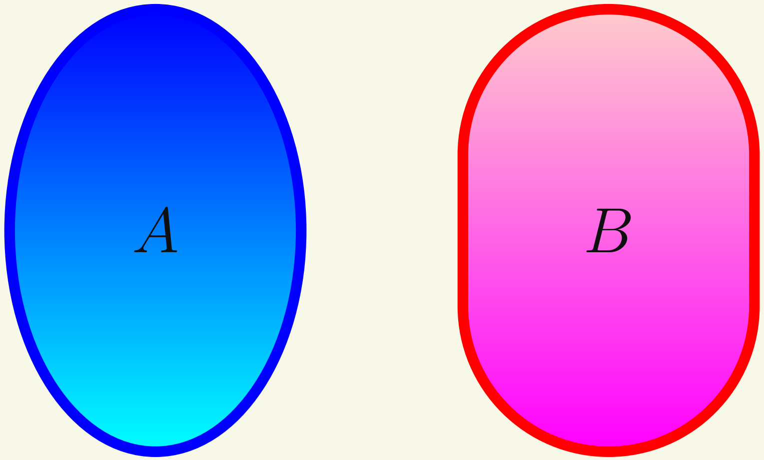
$\boxed{\text{(d) } 5\,m/s}$

Conservation of Momentum

Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.

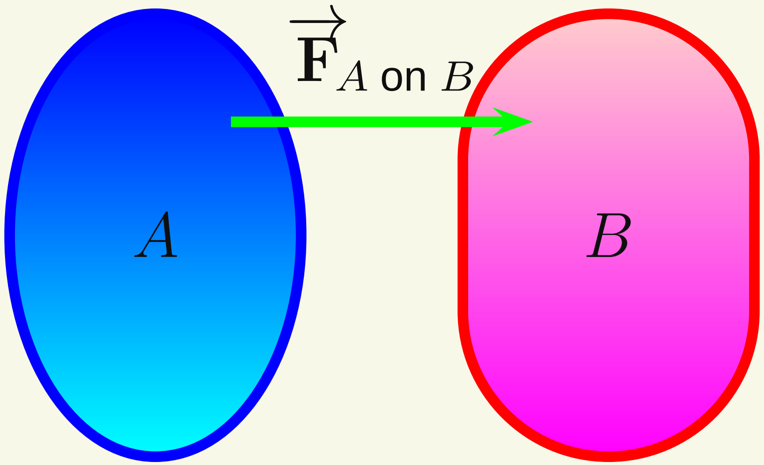
Conservation of Momentum

Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.



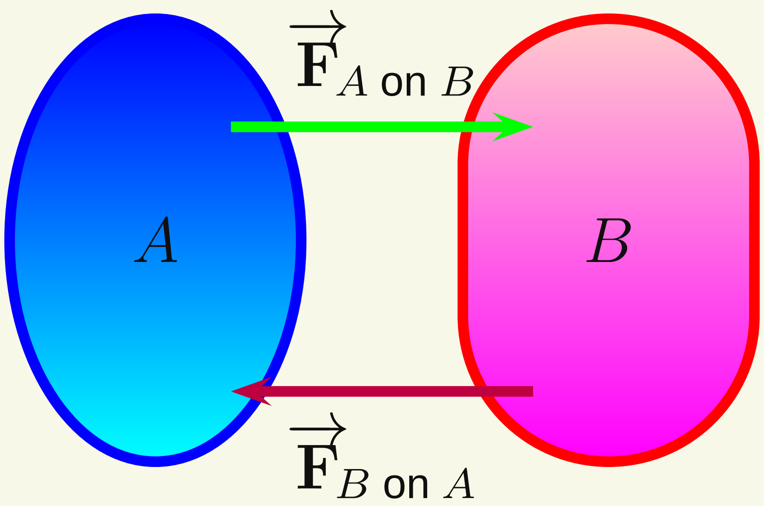
Conservation of Momentum

Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.



$\overrightarrow{\mathbf{F}}_{A \text{ on } B} =$ Force on B due to A

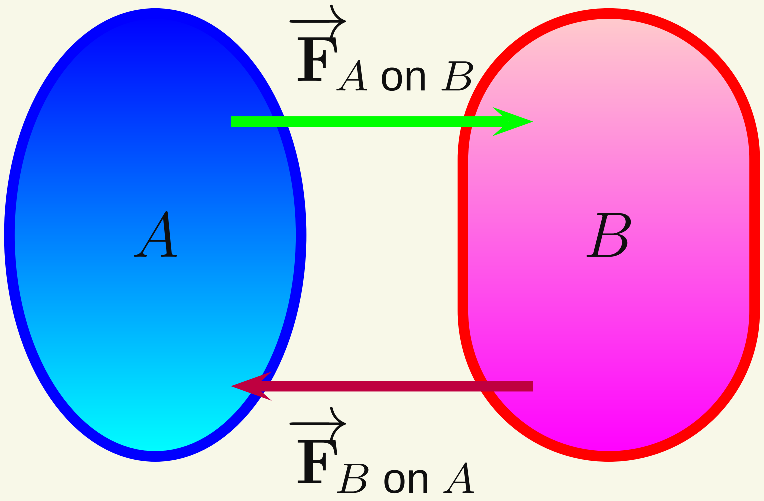
Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.



$\overrightarrow{\mathbf{F}}_{A \text{ on } B} =$ Force on B due to A

$\overrightarrow{\mathbf{F}}_{B \text{ on } A} =$ Force on A due to B

Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.

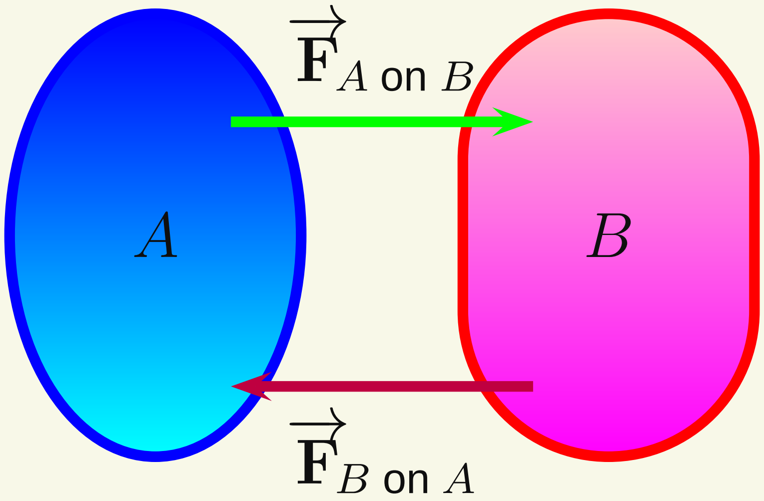


$\overrightarrow{\mathbf{F}}_{A \text{ on } B} =$ Force on B due to A

$\overrightarrow{\mathbf{F}}_{B \text{ on } A} =$ Force on A due to B

3rd Law: $\overrightarrow{\mathbf{F}}_{B \text{ on } A} = -\overrightarrow{\mathbf{F}}_{A \text{ on } B}$

Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.



$\overrightarrow{\mathbf{F}}_{A \text{ on } B} =$ Force on B due to A

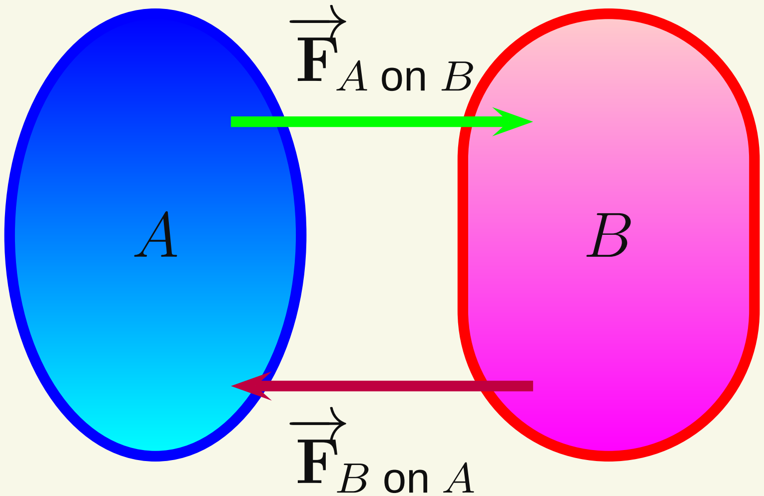
$\overrightarrow{\mathbf{F}}_{B \text{ on } A} =$ Force on A due to B

3rd Law: $\overrightarrow{\mathbf{F}}_{B \text{ on } A} = -\overrightarrow{\mathbf{F}}_{A \text{ on } B}$

$$\overrightarrow{\mathbf{F}}_{B \text{ on } A} + \overrightarrow{\mathbf{F}}_{A \text{ on } B} = 0$$

Conservation of Momentum

<u>Conservation of Momentum</u> - In the absence of external forces, the total momentum of the system cannot change.



$$\overrightarrow{\mathbf{F}}_{B \text{ on } A} = \frac{\Delta \overrightarrow{\mathbf{p}}_A}{\Delta t}$$

$\overrightarrow{\mathbf{F}}_{A \text{ on } B} =$ Force on B due to A

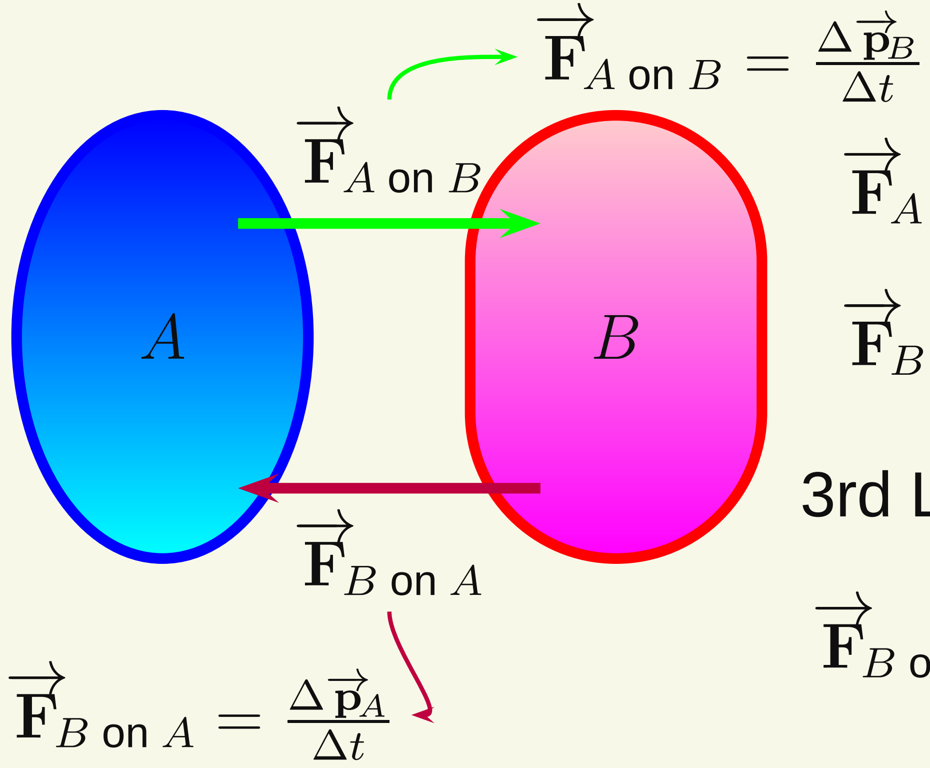
$\overrightarrow{\mathbf{F}}_{B \text{ on } A} =$ Force on A due to B

3rd Law: $\overrightarrow{\mathbf{F}}_{B \text{ on } A} = -\overrightarrow{\mathbf{F}}_{A \text{ on } B}$

$$\overrightarrow{\mathbf{F}}_{B \text{ on } A} + \overrightarrow{\mathbf{F}}_{A \text{ on } B} = 0$$

Conservation of Momentum

<u>Conservation of Momentum</u> - In the absence of external forces, the total momentum of the system cannot change.



$\overrightarrow{\mathbf{F}}_{A \text{ on } B} =$ Force on B due to A

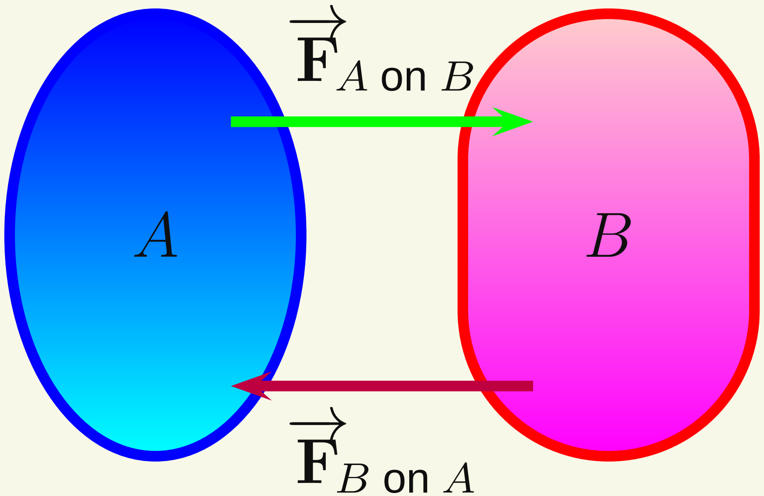
$\overrightarrow{\mathbf{F}}_{B \text{ on } A} =$ Force on A due to B

3rd Law: $\overrightarrow{\mathbf{F}}_{B \text{ on } A} = -\overrightarrow{\mathbf{F}}_{A \text{ on } B}$

$$\overrightarrow{\mathbf{F}}_{B \text{ on } A} + \overrightarrow{\mathbf{F}}_{A \text{ on } B} = 0$$

<u>Conservation of Momentum</u> - In the absence of external forces, the total momentum of the system cannot change.

$$\vec{\mathbf{F}}_{A \text{ on } B} = \frac{\Delta \vec{\mathbf{p}}_B}{\Delta t}$$



$$\vec{\mathbf{F}}_{A \text{ on } B} = \text{Force on } B \text{ due to } A$$

$$\vec{\mathbf{F}}_{B \text{ on } A} = \text{Force on } A \text{ due to } B$$

3rd Law: $\vec{\mathbf{F}}_{B \text{ on } A} = -\vec{\mathbf{F}}_{A \text{ on } B}$

$$\vec{\mathbf{F}}_{B \text{ on } A} + \vec{\mathbf{F}}_{A \text{ on } B} = 0$$

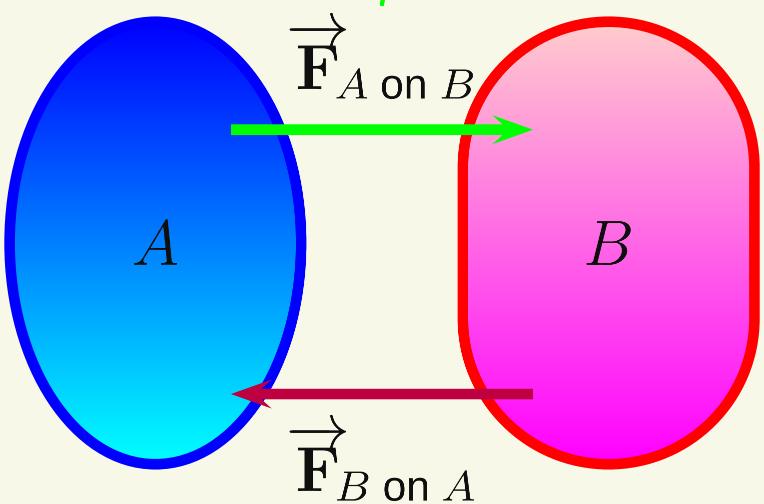
$$\vec{\mathbf{F}}_{B \text{ on } A} = \frac{\Delta \vec{\mathbf{p}}_A}{\Delta t}$$

$$\frac{\Delta \vec{\mathbf{p}}_A}{\Delta t} + \frac{\Delta \vec{\mathbf{p}}_B}{\Delta t} = 0$$

Conservation of Momentum

<u>Conservation of Momentum</u> - In the absence of external forces, the total momentum of the system cannot change.

$$\overrightarrow{\mathbf{F}}_{A \text{ on } B} = \frac{\Delta \overrightarrow{\mathbf{p}}_B}{\Delta t}$$



$$\overrightarrow{\mathbf{F}}_{A \text{ on } B} = \text{Force on } B \text{ due to } A$$

$$\overrightarrow{\mathbf{F}}_{B \text{ on } A} = \text{Force on } A \text{ due to } B$$

3rd Law: $\overrightarrow{\mathbf{F}}_{B \text{ on } A} = -\overrightarrow{\mathbf{F}}_{A \text{ on } B}$

$$\overrightarrow{\mathbf{F}}_{B \text{ on } A} = \frac{\Delta \overrightarrow{\mathbf{p}}_A}{\Delta t}$$

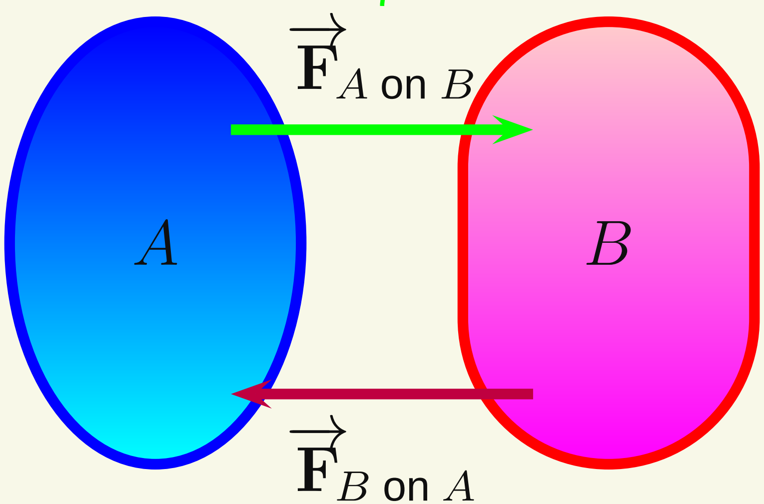
$$\overrightarrow{\mathbf{F}}_{B \text{ on } A} + \overrightarrow{\mathbf{F}}_{A \text{ on } B} = 0$$

$$\frac{\Delta \overrightarrow{\mathbf{p}}_A}{\Delta t} + \frac{\Delta \overrightarrow{\mathbf{p}}_B}{\Delta t} = 0$$

$$\frac{\Delta}{\Delta t}\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0$$

Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.

$$\overrightarrow{\mathbf{F}}_{A \text{ on } B} = \frac{\Delta \overrightarrow{\mathbf{p}}_B}{\Delta t}$$



$$\overrightarrow{\mathbf{F}}_{A \text{ on } B} = \text{Force on } B \text{ due to } A$$

$$\overrightarrow{\mathbf{F}}_{B \text{ on } A} = \text{Force on } A \text{ due to } B$$

3rd Law: $\overrightarrow{\mathbf{F}}_{B \text{ on } A} = -\overrightarrow{\mathbf{F}}_{A \text{ on } B}$

$$\overrightarrow{\mathbf{F}}_{B \text{ on } A} = \frac{\Delta \overrightarrow{\mathbf{p}}_A}{\Delta t}$$

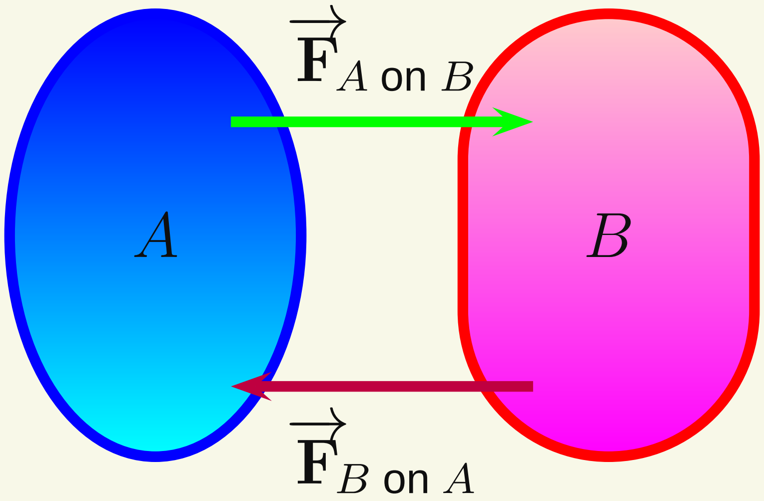
$$\overrightarrow{\mathbf{F}}_{B \text{ on } A} + \overrightarrow{\mathbf{F}}_{A \text{ on } B} = 0$$

$$\frac{\Delta \overrightarrow{\mathbf{p}}_A}{\Delta t} + \frac{\Delta \overrightarrow{\mathbf{p}}_B}{\Delta t} = 0$$

$$\frac{\Delta}{\Delta t}\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0 \Rightarrow \boxed{\Delta\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0}$$

<u>Conservation of Momentum</u> - In the absence of external forces, the total momentum of the system cannot change.

$$\vec{\mathbf{F}}_{A \text{ on } B} = \frac{\Delta \vec{\mathbf{p}}_B}{\Delta t}$$



$$\vec{\mathbf{F}}_{A \text{ on } B} = \text{Force on } B \text{ due to } A$$

$$\vec{\mathbf{F}}_{B \text{ on } A} = \text{Force on } A \text{ due to } B$$

3rd Law: $\vec{\mathbf{F}}_{B \text{ on } A} = -\vec{\mathbf{F}}_{A \text{ on } B}$

$$\vec{\mathbf{F}}_{B \text{ on } A} + \vec{\mathbf{F}}_{A \text{ on } B} = 0$$

$$\vec{\mathbf{F}}_{B \text{ on } A} = \frac{\Delta \vec{\mathbf{p}}_A}{\Delta t}$$

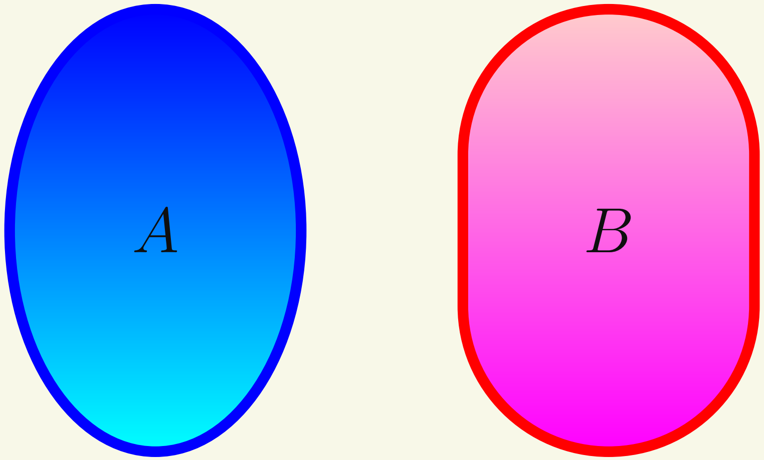
$$\frac{\Delta \vec{\mathbf{p}}_A}{\Delta t} + \frac{\Delta \vec{\mathbf{p}}_B}{\Delta t} = 0$$

$$\frac{\Delta}{\Delta t}\left(\vec{\mathbf{p}}_A + \vec{\mathbf{p}}_B\right) = 0 \Rightarrow \boxed{\Delta\left(\vec{\mathbf{p}}_A + \vec{\mathbf{p}}_B\right) = 0}$$

The *total* momentum can't change

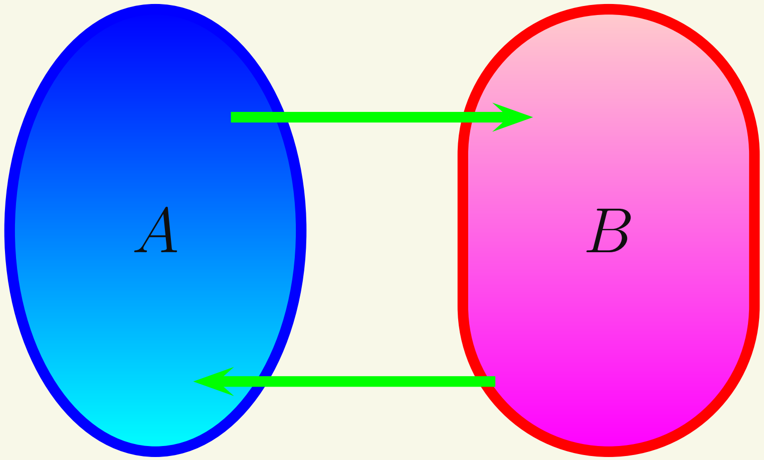
Conservation of Momentum II

<u>Conservation of Momentum</u> - In the absence of external forces, the total momentum of the system cannot change.



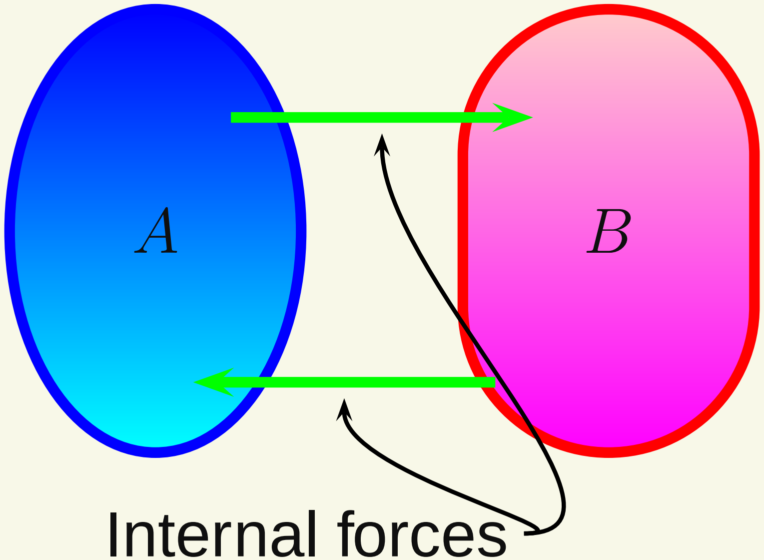
Conservation of Momentum II

<u>Conservation of Momentum</u> - In the absence of external forces, the total momentum of the system cannot change.



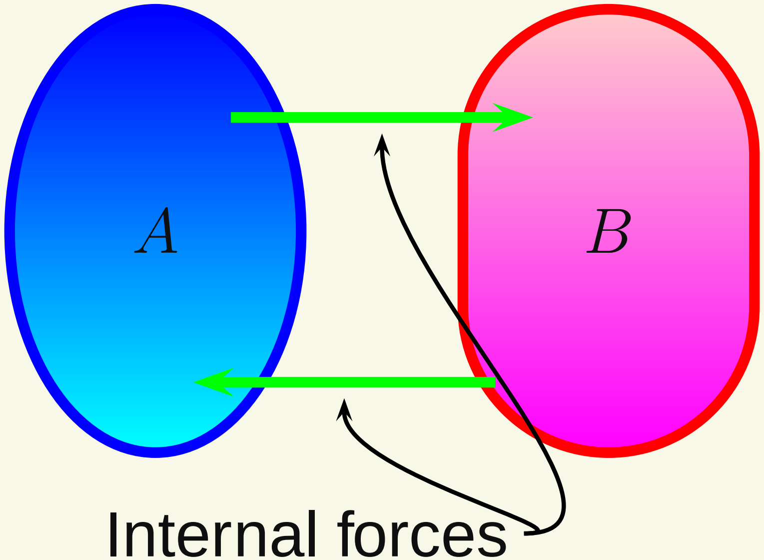
Conservation of Momentum II

Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.



Conservation of Momentum II

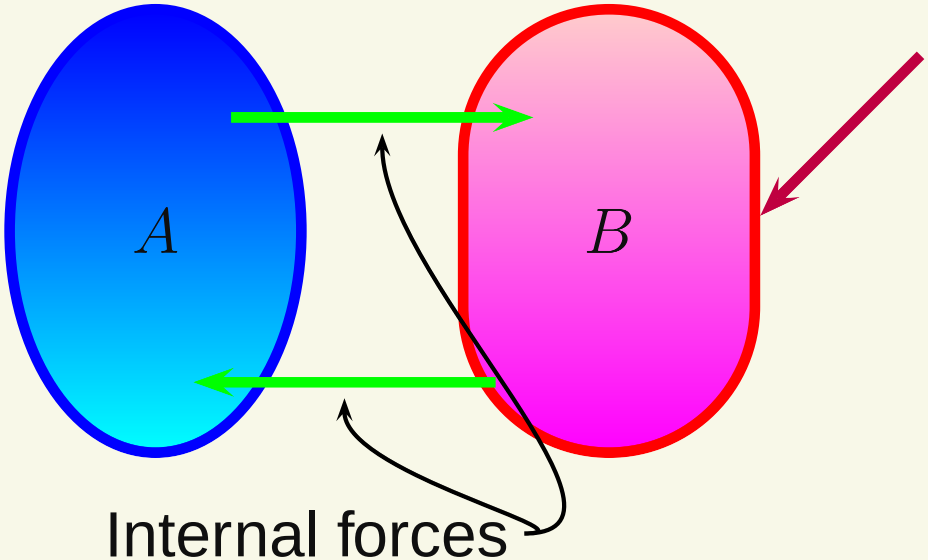
Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.



Internal Forces - Forces inside the system. Always come in action/reaction pairs

Conservation of Momentum II

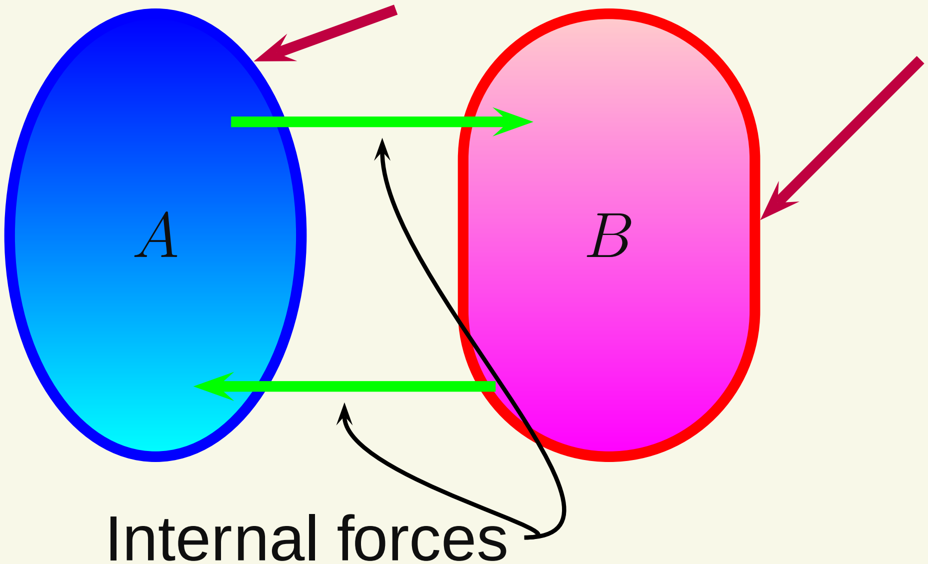
<u>Conservation of Momentum</u> - In the absence of external forces, the total momentum of the system cannot change.



<u>Internal Forces</u> - Forces inside the system. Always come in action/reaction pairs

Conservation of Momentum II

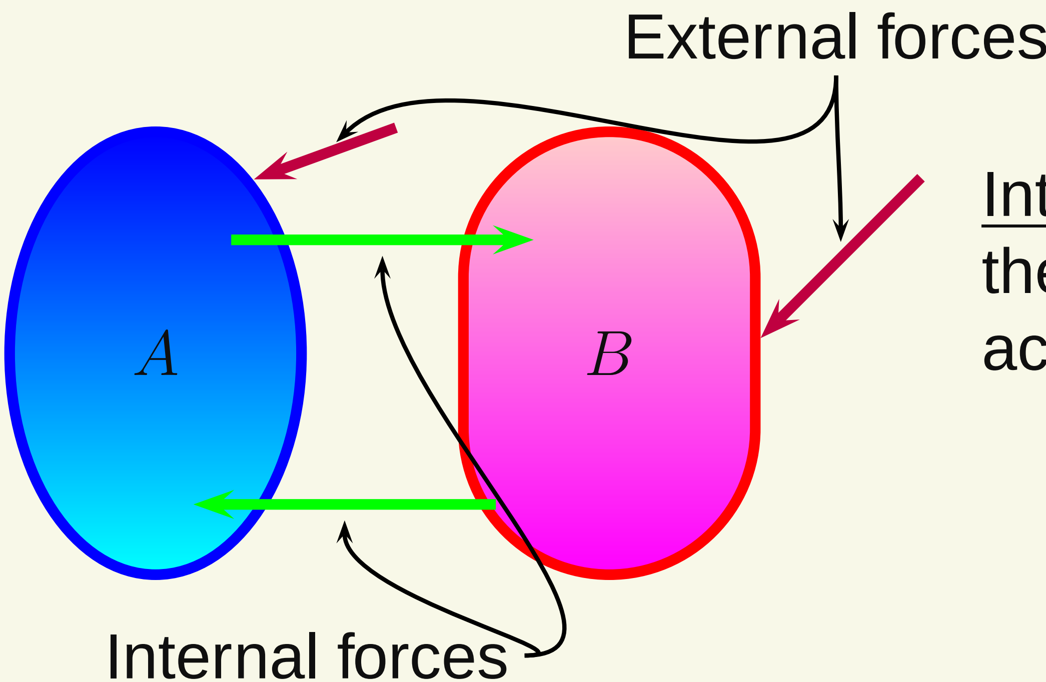
Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.



Internal Forces - Forces inside the system. Always come in action/reaction pairs

Conservation of Momentum II

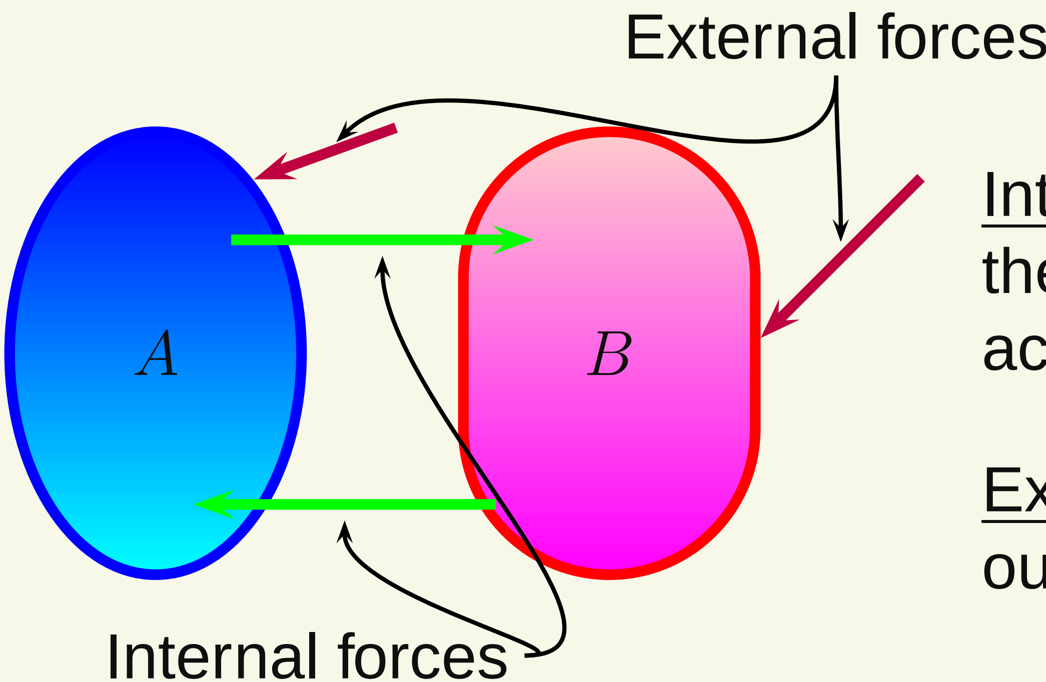
Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.



Internal Forces - Forces inside the system. Always come in action/reaction pairs

Conservation of Momentum II

Conservation of Momentum - In the absence of external forces, the total momentum of the system cannot change.

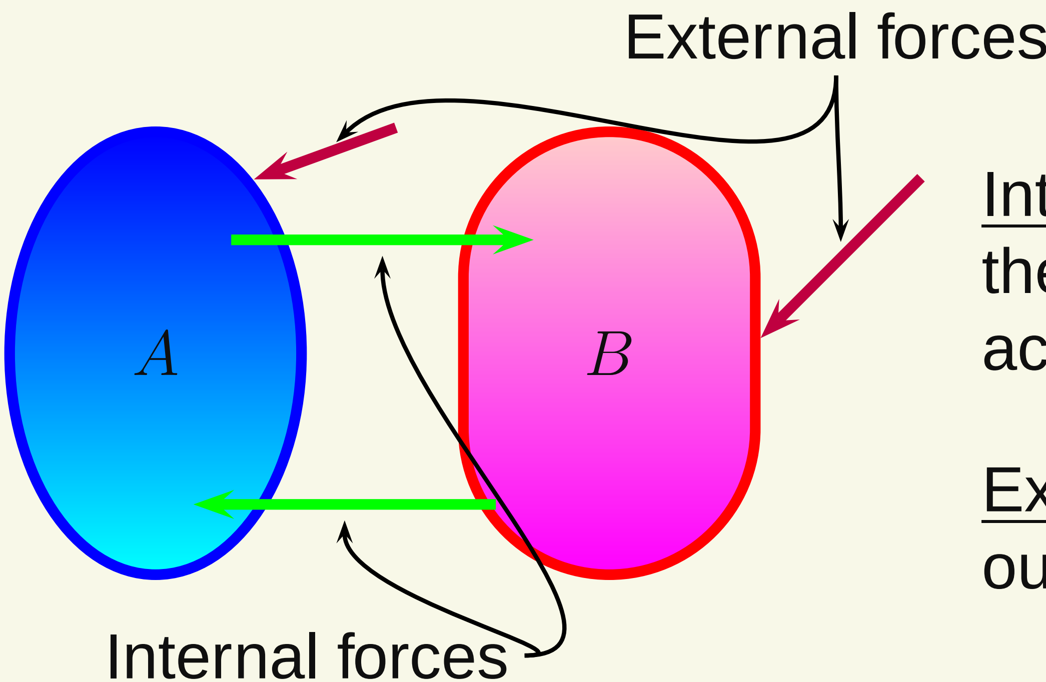


Internal Forces - Forces inside the system. Always come in action/reaction pairs

External Forces - Forces from outside the system

Conservation of Momentum II

<u>Conservation of Momentum</u> - In the absence of external forces, the total momentum of the system cannot change.



<u>Internal Forces</u> - Forces inside the system. Always come in action/reaction pairs

<u>External Forces</u> - Forces from outside the system

<u>Impulse Hypothesis</u> - During the small times that a collision lasts, the external forces are small compared to the internal forces so we can ignore them

Using Conservation of Momentum

$\Delta\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.

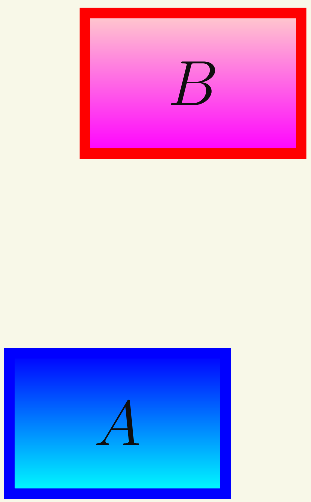
Using Conservation of Momentum

$\Delta\left(\vec{\mathbf{p}}_A + \vec{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.

Before

Using Conservation of Momentum

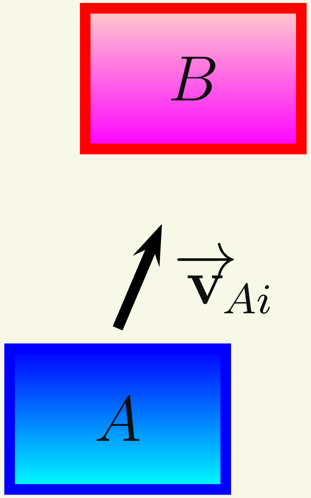
$\Delta\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.



Before

Using Conservation of Momentum

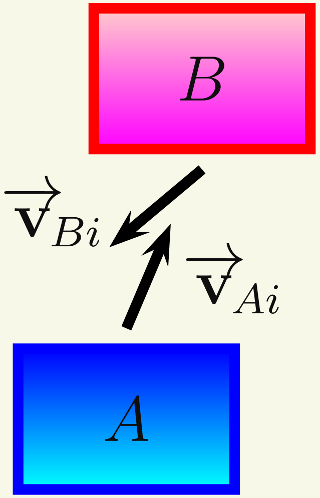
$\Delta\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.



Before

Using Conservation of Momentum

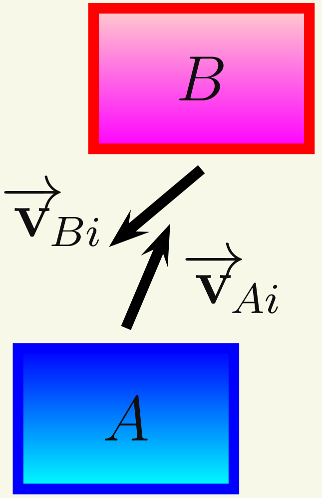
$\Delta\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.



Before

Using Conservation of Momentum

$\Delta\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.

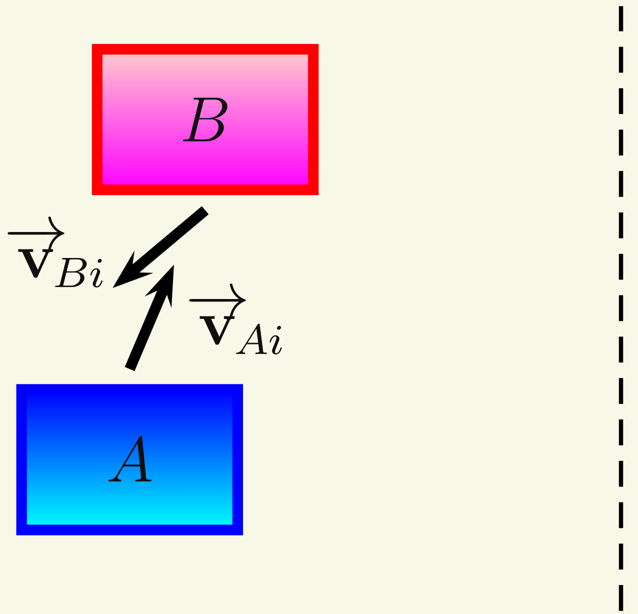


Before

$$m_A\overrightarrow{\mathbf{v}}_{Ai} + m_B\overrightarrow{\mathbf{v}}_{Bi}$$

Using Conservation of Momentum

$\Delta\left(\vec{\mathbf{p}}_A + \vec{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.



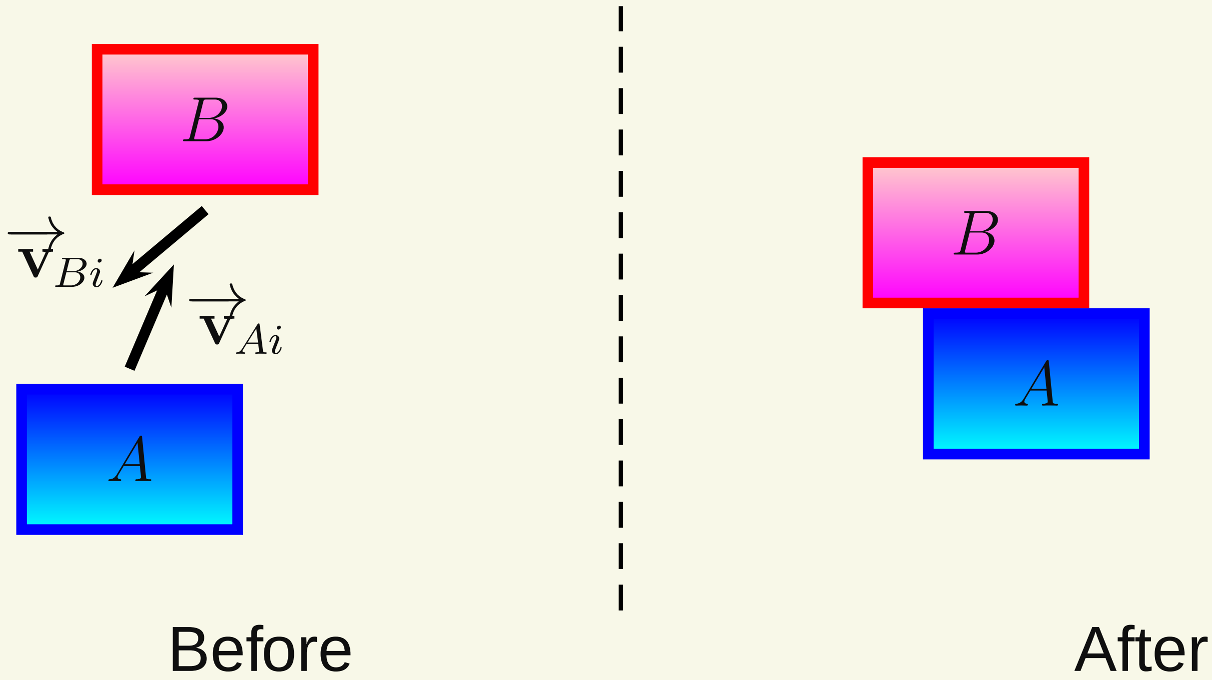
Before

After

$$m_A\vec{\mathbf{v}}_{Ai} + m_B\vec{\mathbf{v}}_{Bi}$$

Using Conservation of Momentum

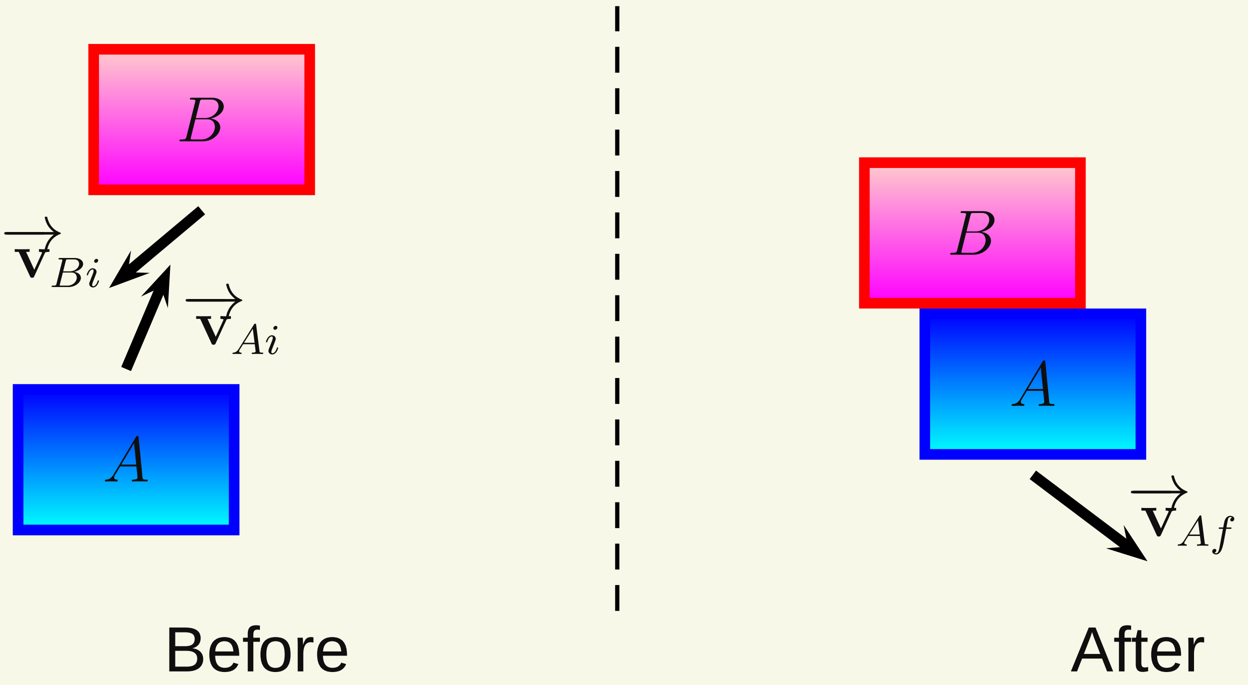
$\Delta\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.



$$m_A \overrightarrow{\mathbf{v}}_{Ai} + m_B \overrightarrow{\mathbf{v}}_{Bi}$$

Using Conservation of Momentum

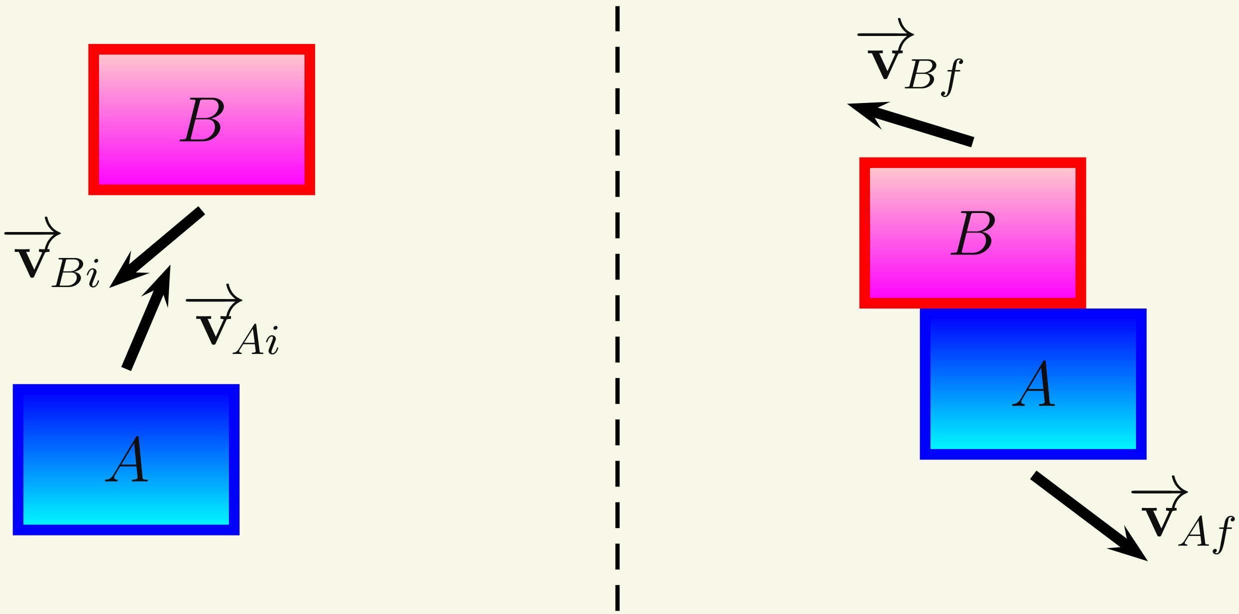
$\Delta\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.



$$m_A \overrightarrow{\mathbf{v}}_{Ai} + m_B \overrightarrow{\mathbf{v}}_{Bi}$$

Using Conservation of Momentum

$\Delta\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.



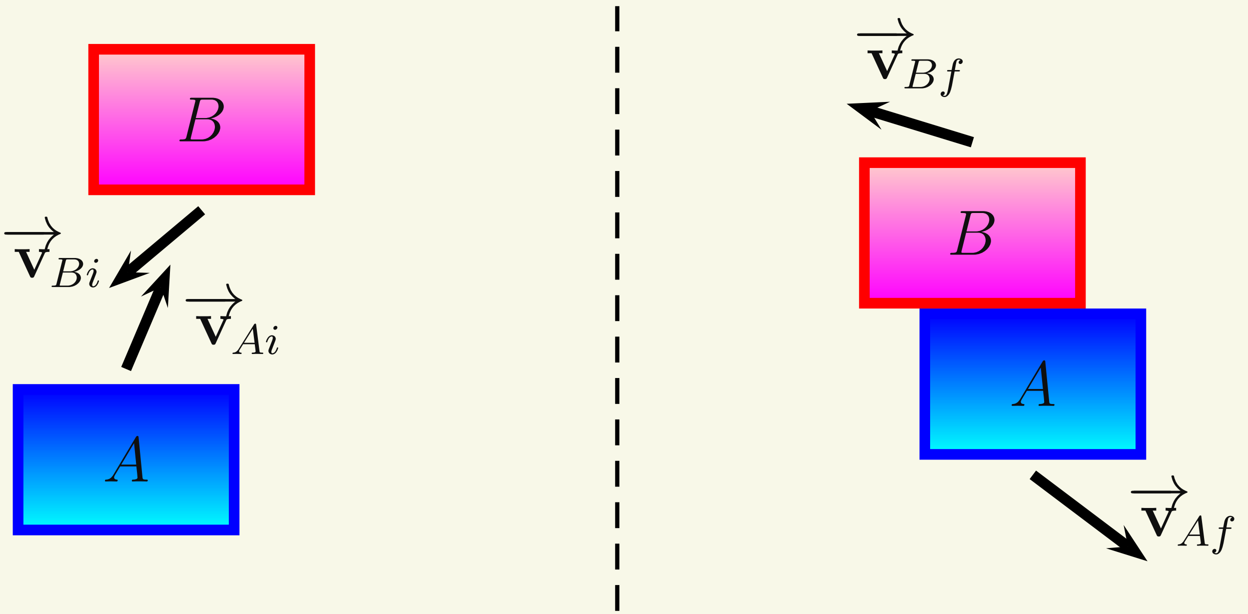
Before

After

$$m_A \overrightarrow{\mathbf{v}}_{Ai} + m_B \overrightarrow{\mathbf{v}}_{Bi}$$

Using Conservation of Momentum

$\Delta\left(\vec{\mathbf{p}}_A + \vec{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.



Before

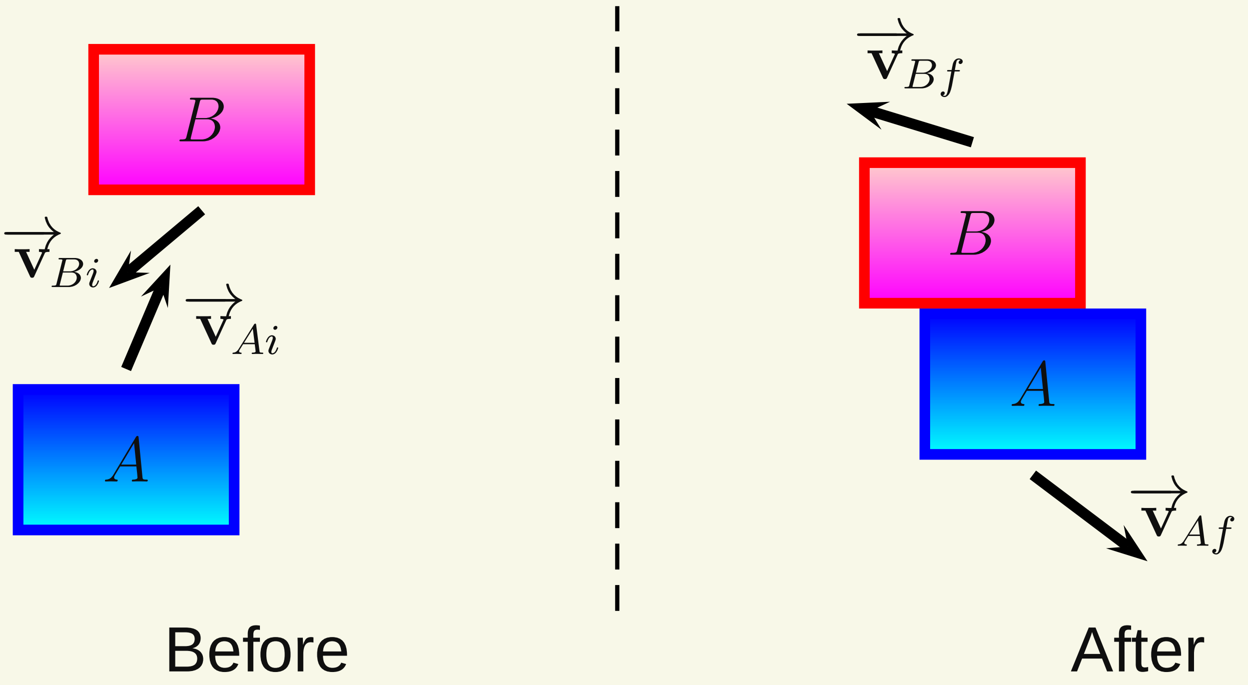
After

$m_A \vec{\mathbf{v}}_{Ai} + m_B \vec{\mathbf{v}}_{Bi}$

$m_A \vec{\mathbf{v}}_{Af} + m_B \vec{\mathbf{v}}_{Bf}$

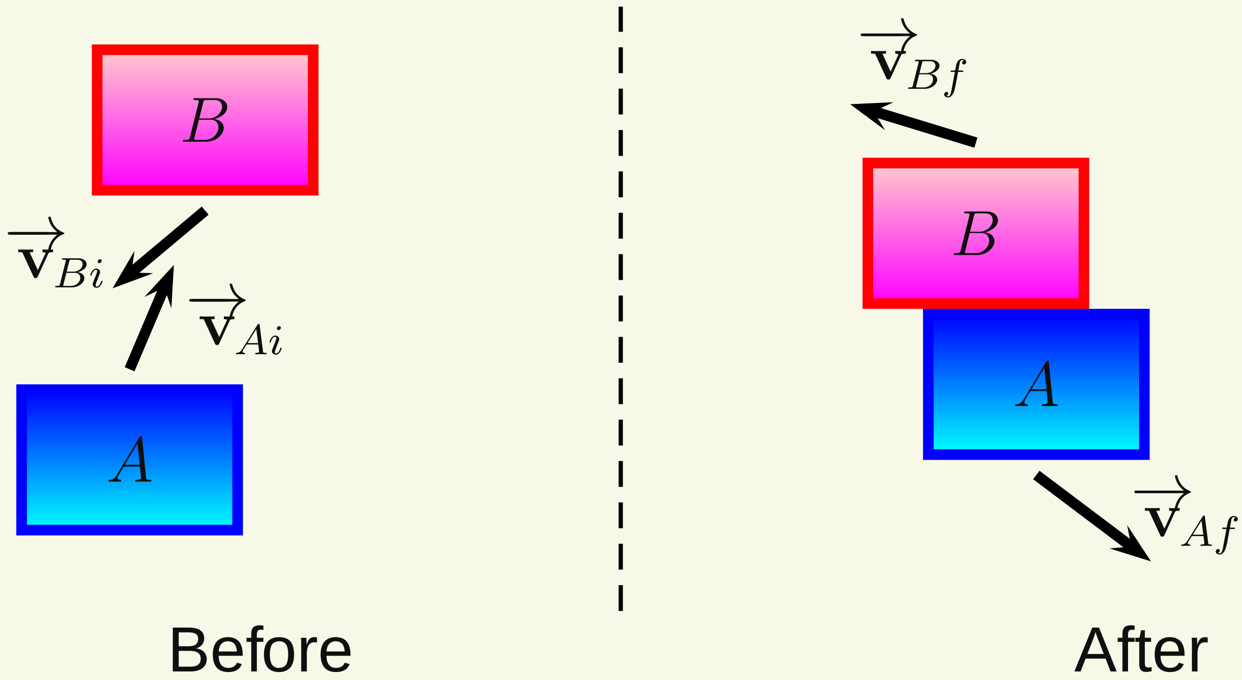
Using Conservation of Momentum

$\Delta\left(\overrightarrow{\mathbf{p}}_A + \overrightarrow{\mathbf{p}}_B\right) = 0 \Rightarrow$ the total momentum of the system can't change.



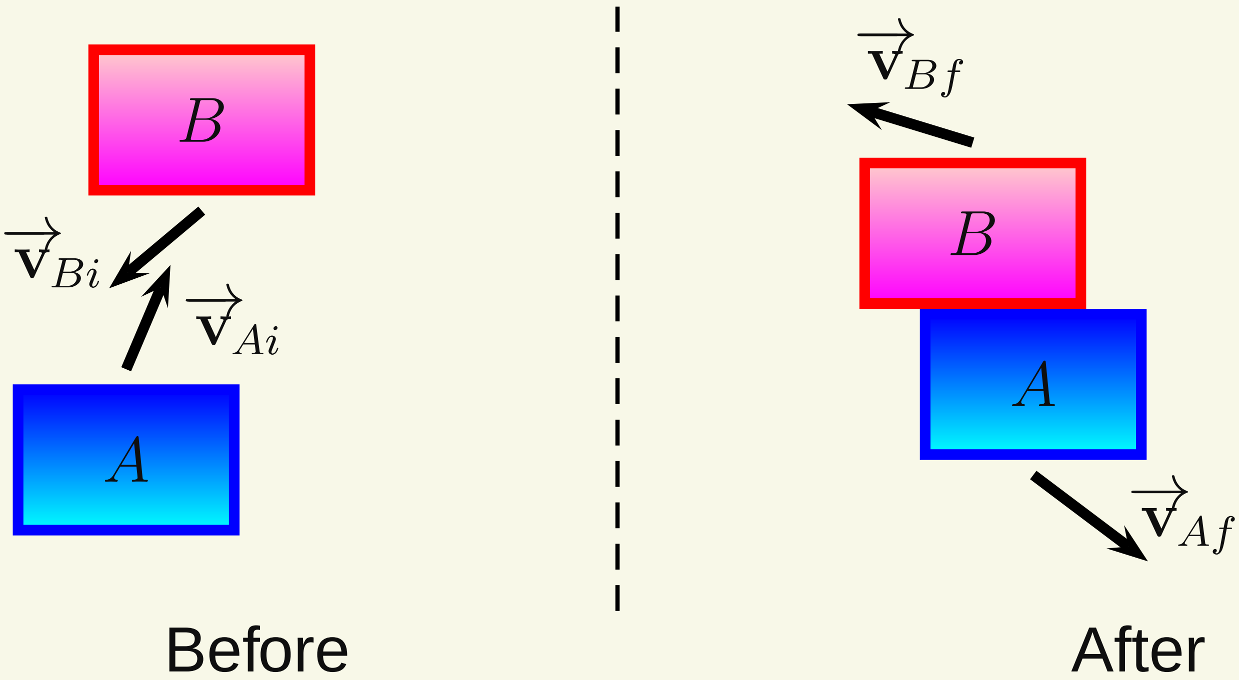
$$m_A \overrightarrow{\mathbf{v}}_{Ai} + m_B \overrightarrow{\mathbf{v}}_{Bi} \quad = \quad m_A \overrightarrow{\mathbf{v}}_{Af} + m_B \overrightarrow{\mathbf{v}}_{Bf}$$

Using Conservation of Momentum II



$$m_A \overrightarrow{\mathbf{v}}_{Ai} + m_B \overrightarrow{\mathbf{v}}_{Bi} = m_A \overrightarrow{\mathbf{v}}_{Af} + m_B \overrightarrow{\mathbf{v}}_{Bf}$$

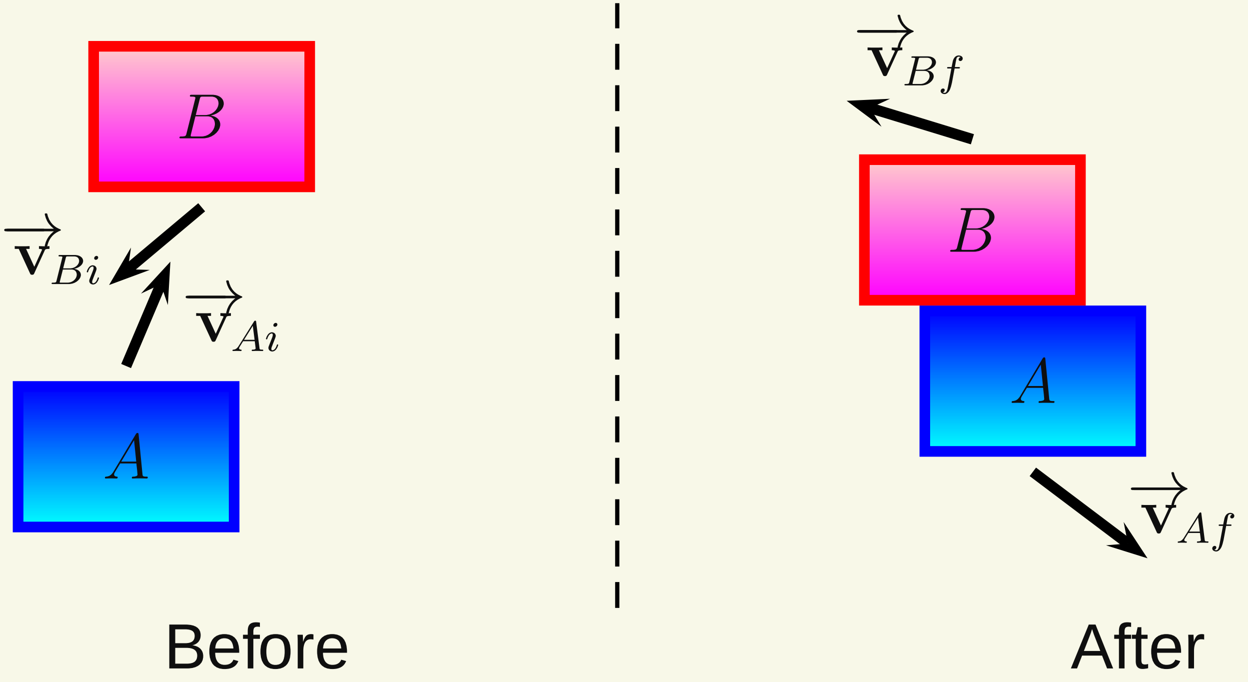
Using Conservation of Momentum II



$$m_A \vec{\mathbf{v}}_{Ai} + m_B \vec{\mathbf{v}}_{Bi} = m_A \vec{\mathbf{v}}_{Af} + m_B \vec{\mathbf{v}}_{Bf}$$

Component Form:

Using Conservation of Momentum II

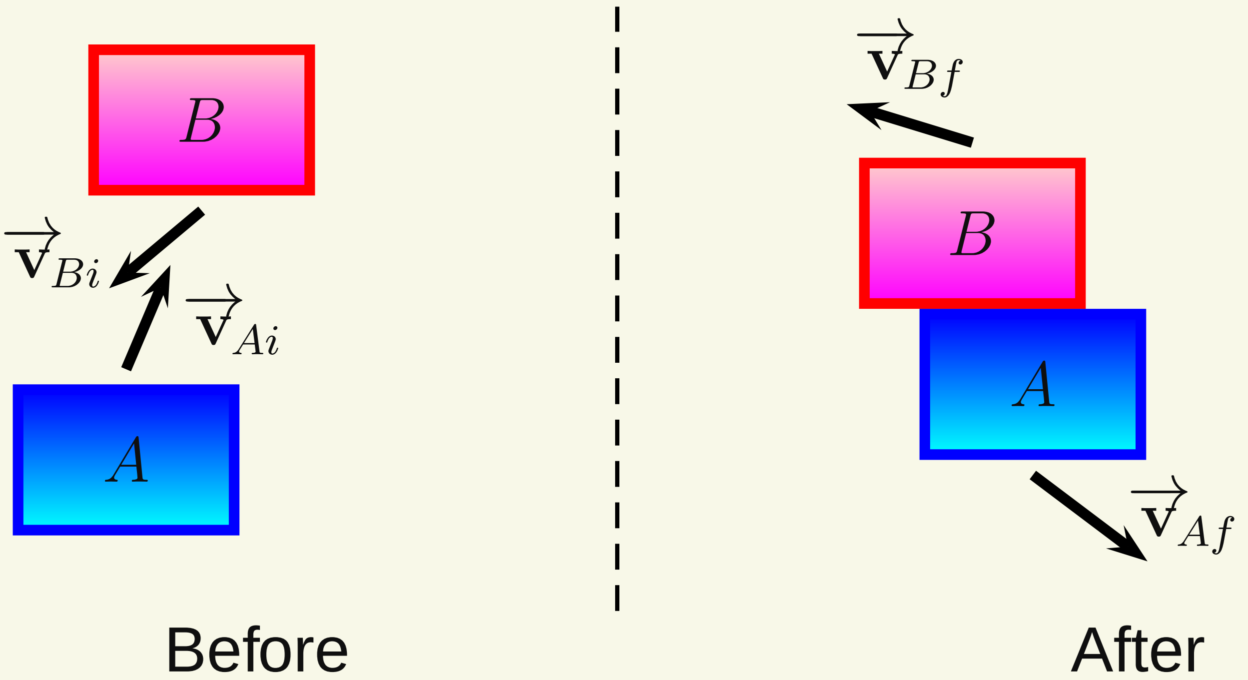


$$m_A \vec{\mathbf{v}}_{Ai} + m_B \vec{\mathbf{v}}_{Bi} = m_A \vec{\mathbf{v}}_{Af} + m_B \vec{\mathbf{v}}_{Bf}$$

Component Form:

$$m_A \left(v_{Ax}\right)_i + m_B \left(v_{Bx}\right)_i = m_A \left(v_{Ax}\right)_f + m_B \left(v_{Bx}\right)_f$$

Using Conservation of Momentum II



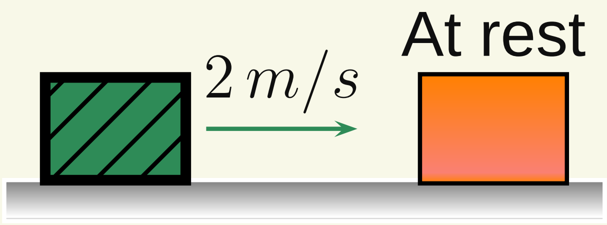
$$m_A \vec{\mathbf{v}}_{Ai} + m_B \vec{\mathbf{v}}_{Bi} = m_A \vec{\mathbf{v}}_{Af} + m_B \vec{\mathbf{v}}_{Bf}$$

Component Form:

$$m_A \left(v_{Ax}\right)_i + m_B \left(v_{Bx}\right)_i = m_A \left(v_{Ax}\right)_f + m_B \left(v_{Bx}\right)_f$$
$$m_A \left(v_{Ay}\right)_i + m_B \left(v_{By}\right)_i = m_A \left(v_{Ay}\right)_f + m_B \left(v_{By}\right)_f$$

Conservation Exercise I

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with another 1-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?



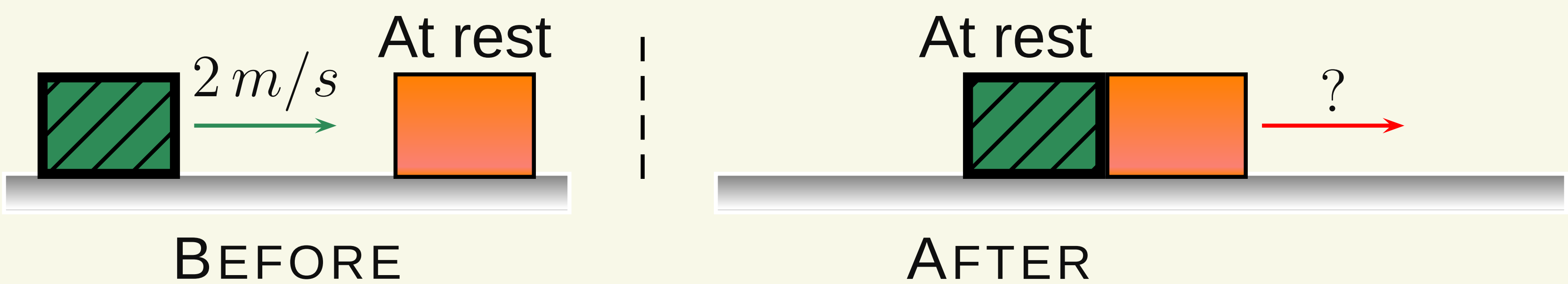
BEFORE

Conservation Exercise I

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with another 1-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?

Conservation Exercise I

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with another 1-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?



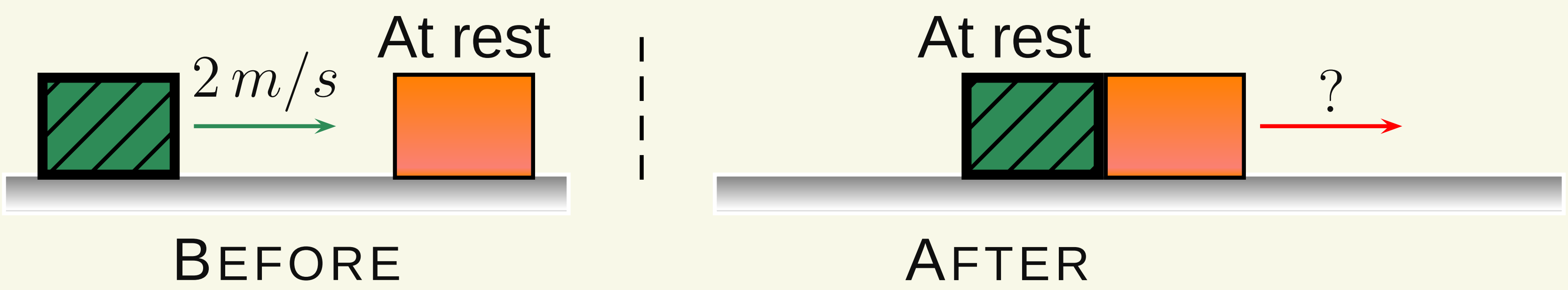
(a) $0\,m/s$

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with another 1-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?

(a) $0\,m/s$ (b) $1\,m/s$

Conservation Exercise I

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with another 1-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?



(a) $0\,m/s$ (b) $1\,m/s$ (c) $2\,m/s$

Conservation Exercise I

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with another 1-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?

(a) $0\,m/s$

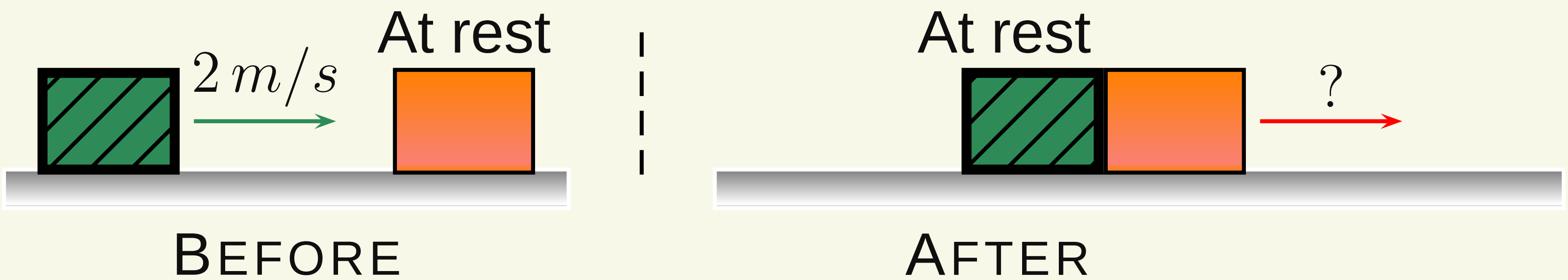
(b) $1\,m/s$

(c) $2\,m/s$

(d) $3\,m/s$

Conservation Exercise I

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with another 1-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?

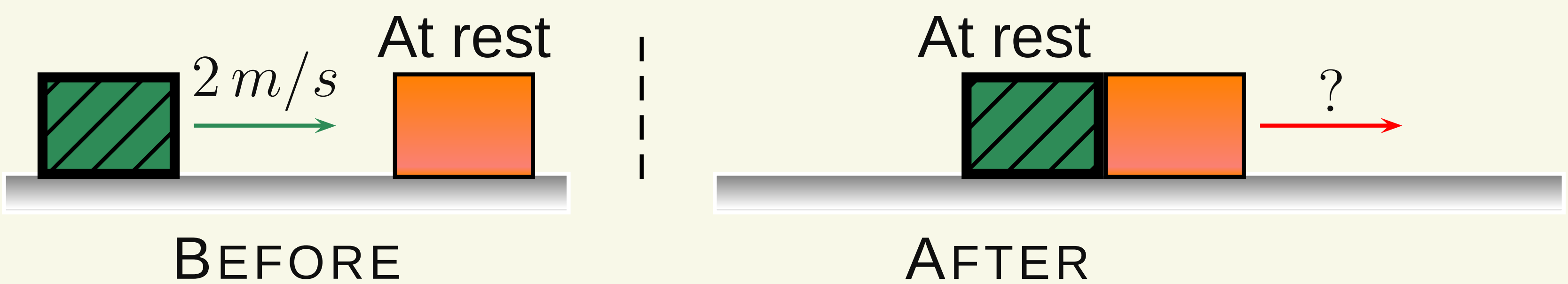


(a) $0\,m/s$ (b) $1\,m/s$ (c) $2\,m/s$

(d) $3\,m/s$ (e) $4\,m/s$

Conservation Exercise I

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with another 1-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?

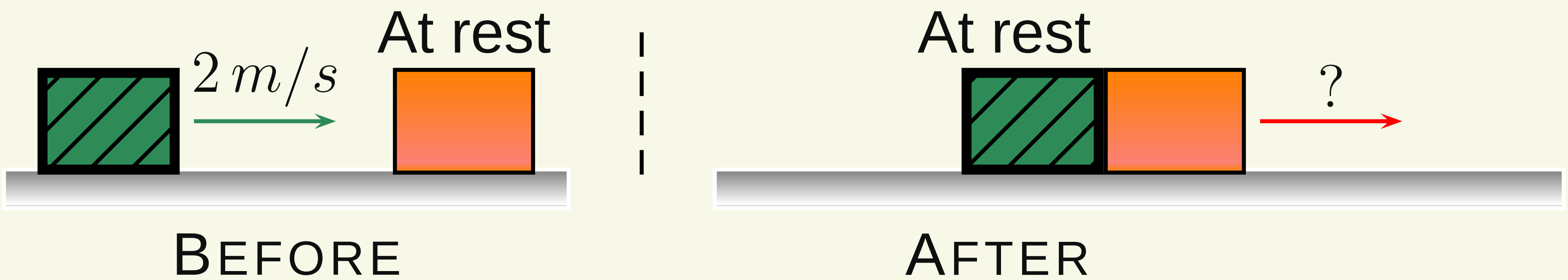


(a) $0\,m/s$ (b) $1\,m/s$ (c) $2\,m/s$

(d) $3\,m/s$ (e) $4\,m/s$

Conservation Exercise I

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with another 1-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?



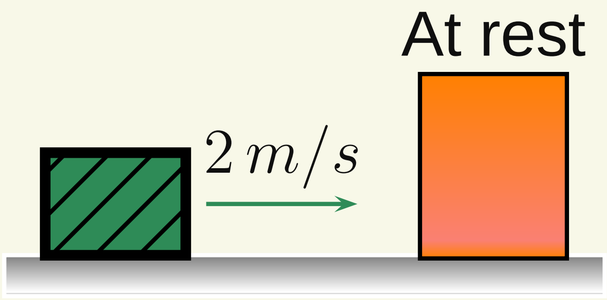
(a) $0\,m/s$ (b) $1\,m/s$ (c) $2\,m/s$

(d) $3\,m/s$ (e) $4\,m/s$

Conservation: $(1\,kg)(2\,m/s) + 0 = 0 + (1\,kg)(v_{Bx})_f \Rightarrow (v_{Bx})_f = 2\,m/s$

Conservation Exercise II

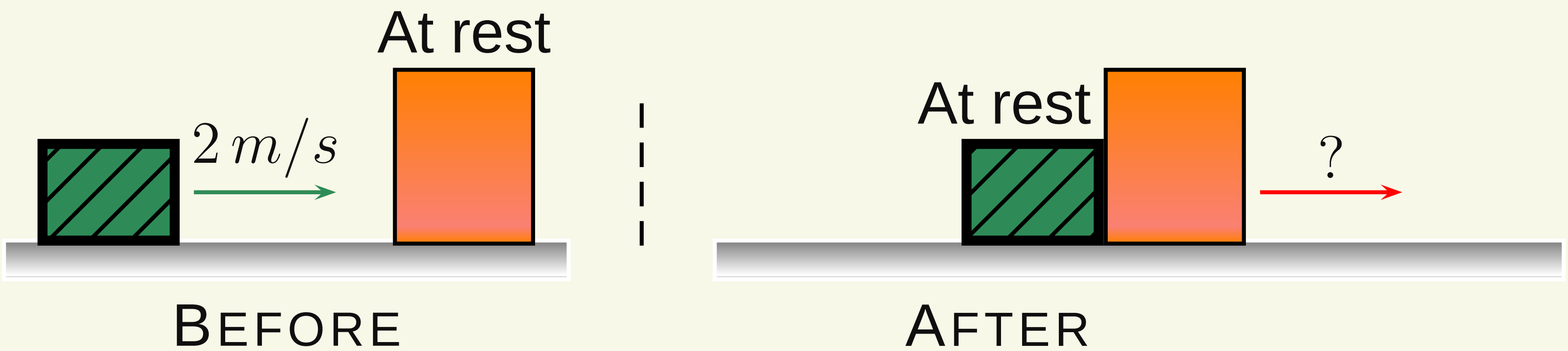
A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with a 2-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?



BEFORE

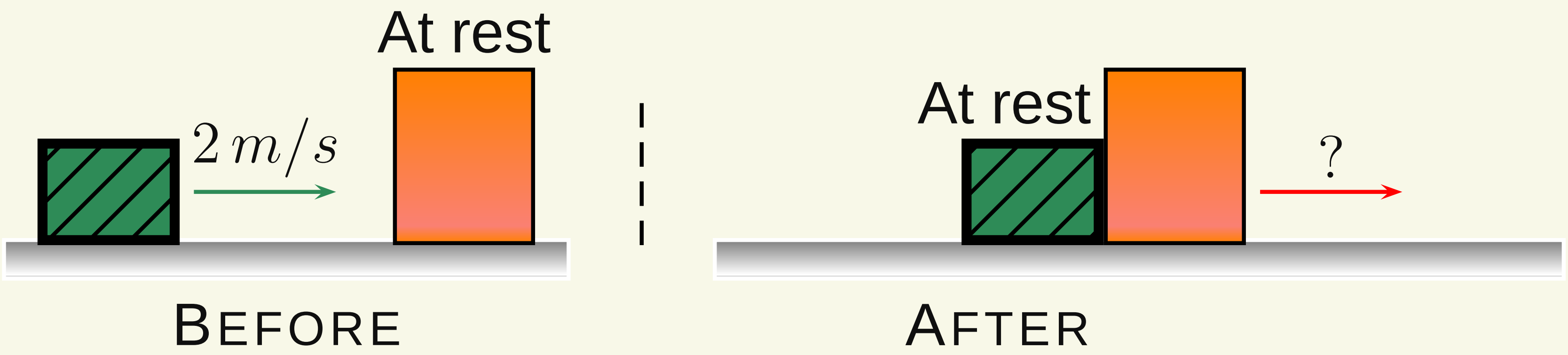
Conservation Exercise II

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with a 2-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?



Conservation Exercise II

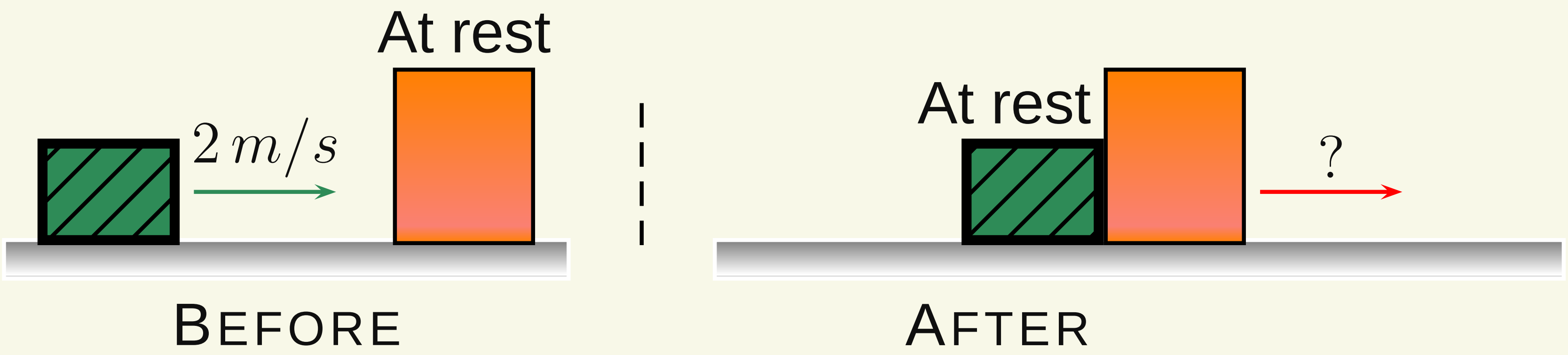
A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with a 2-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?



(a) $0\,m/s$

Conservation Exercise II

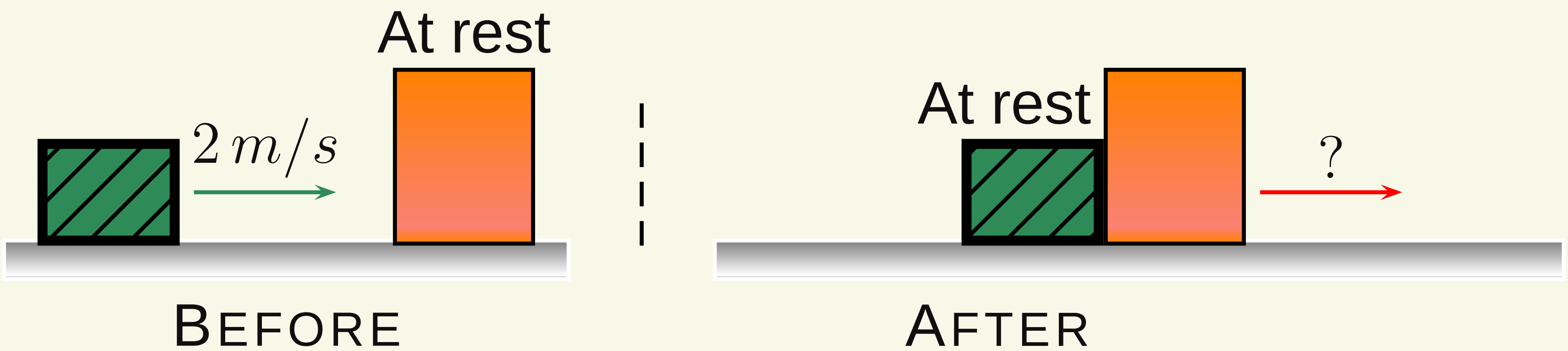
A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with a 2-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?



(a) $0\,m/s$ (b) $1\,m/s$

Conservation Exercise II

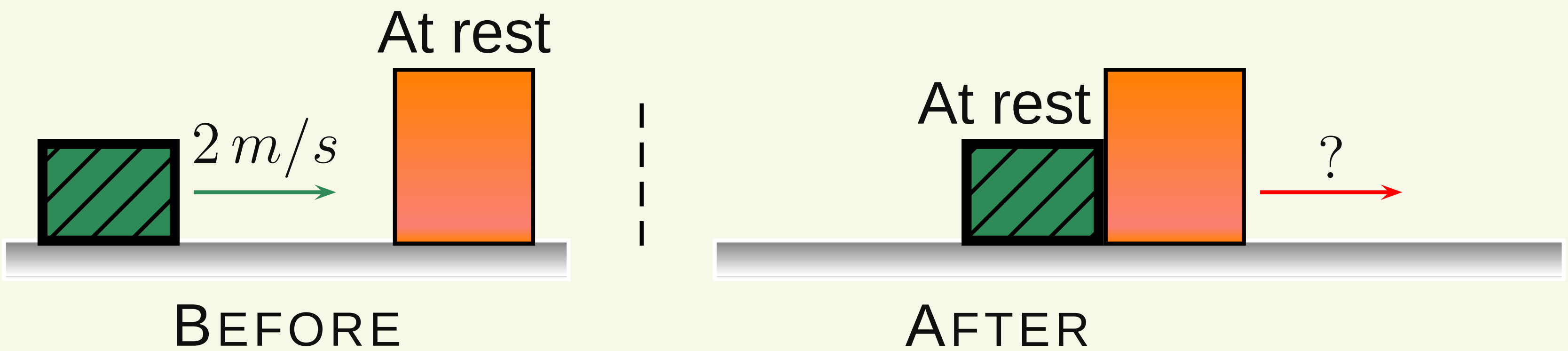
A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with a 2-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?



(a) $0\,m/s$ (b) $1\,m/s$ (c) $2\,m/s$

Conservation Exercise II

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with a 2-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?

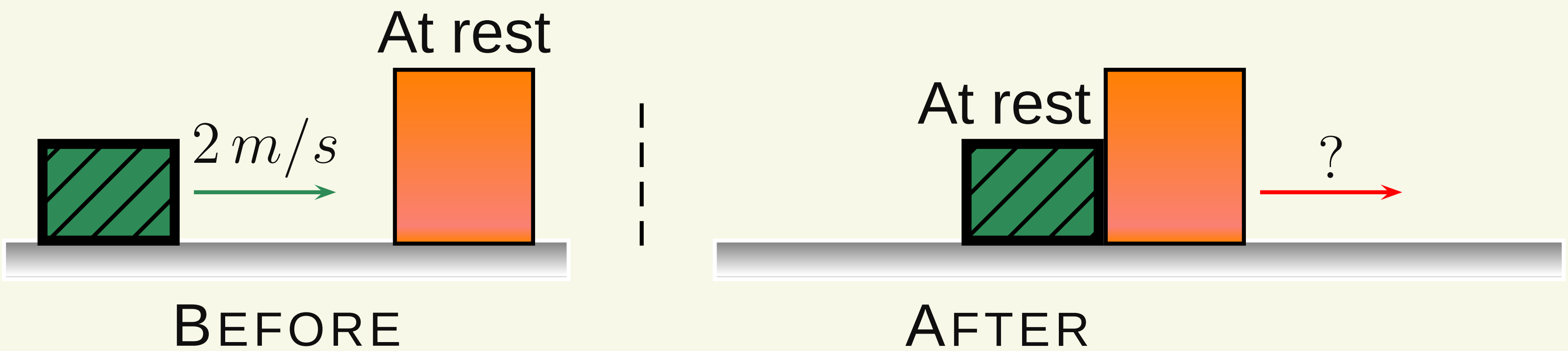


(a) $0\,m/s$ (b) $1\,m/s$ (c) $2\,m/s$

(d) $3\,m/s$

Conservation Exercise II

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with a 2-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?

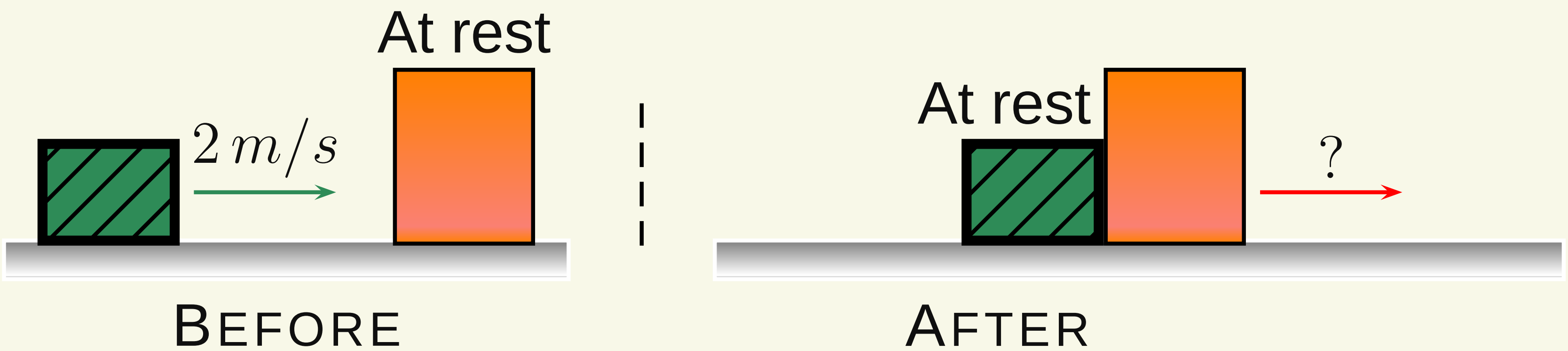


(a) $0\,m/s$ (b) $1\,m/s$ (c) $2\,m/s$

(d) $3\,m/s$ (e) $4\,m/s$

Conservation Exercise II

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with a 2-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?

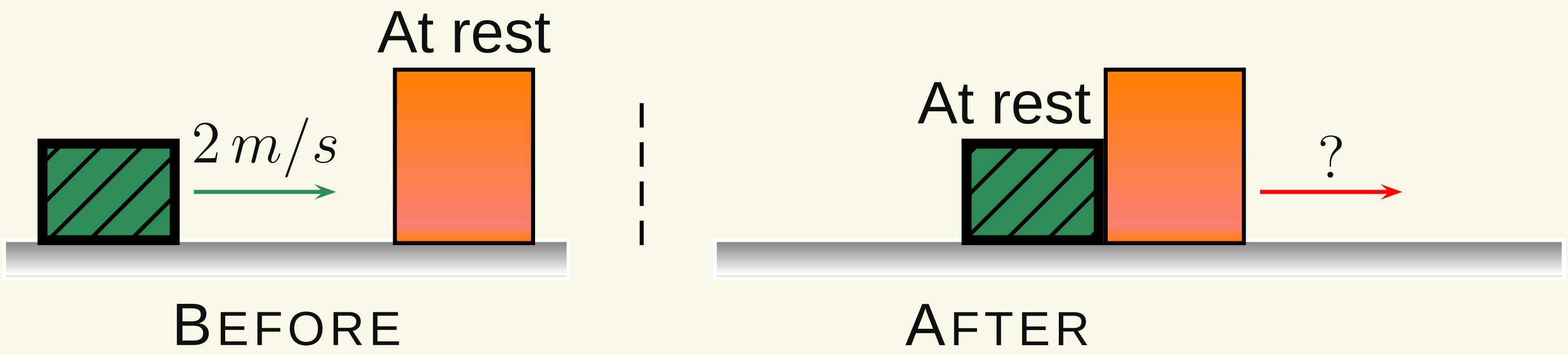


(a) $0\,m/s$ $\boxed{\text{(b) } 1\,m/s}$ (c) $2\,m/s$

(d) $3\,m/s$ (e) $4\,m/s$

Conservation Exercise II

A 1-kg mass sliding to the right with speed $2\,m/s$ on a frictionless floor collides with a 2-kg mass at rest. If the first mass stops after the collision, how fast must the second mass be going?



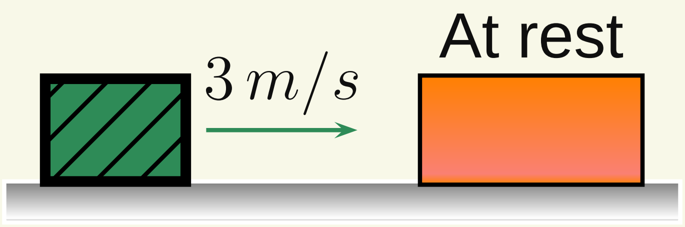
(a) $0\,m/s$ $\qquad$ $\boxed{\text{(b) } 1\,m/s}$ $\qquad$ (c) $2\,m/s$

(d) $3\,m/s$ $\qquad$ (e) $4\,m/s$

Conservation: $(1\,kg)(2\,m/s) + 0 = 0 + (2\,kg)(v_{Bx})_f \Rightarrow (v_{Bx})_f = 1\,m/s$

Conservation Exercise III

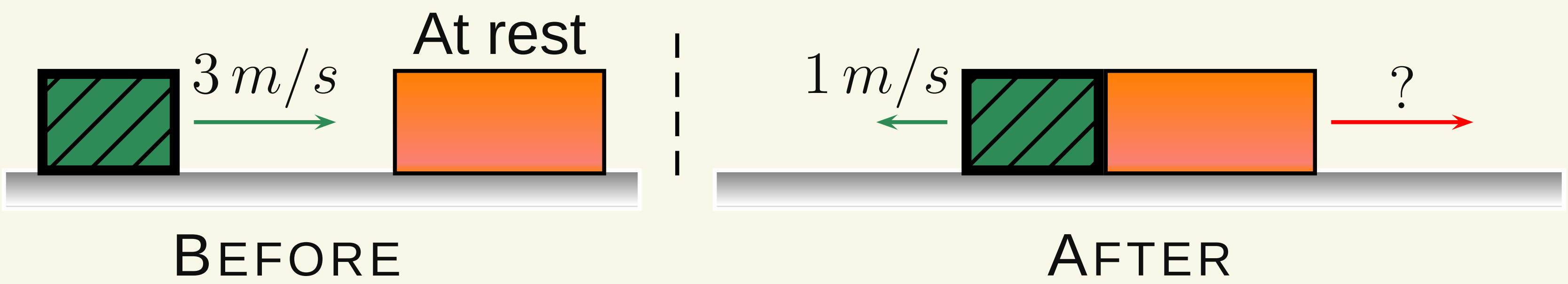
A 1-kg mass sliding to the right with speed $3\,m/s$ on a frictionless floor collides with a 4-kg mass at rest. If the first mass bounces back with a speed of $1\,m/s$, how fast must the second mass be going?



BEFORE

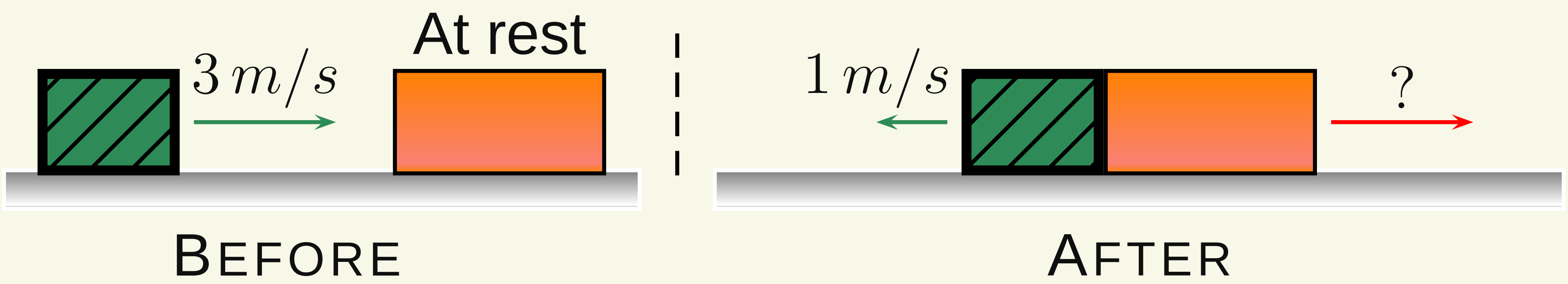
Conservation Exercise III

A 1-kg mass sliding to the right with speed $3\,m/s$ on a frictionless floor collides with a 4-kg mass at rest. If the first mass bounces back with a speed of $1\,m/s$, how fast must the second mass be going?



Conservation Exercise III

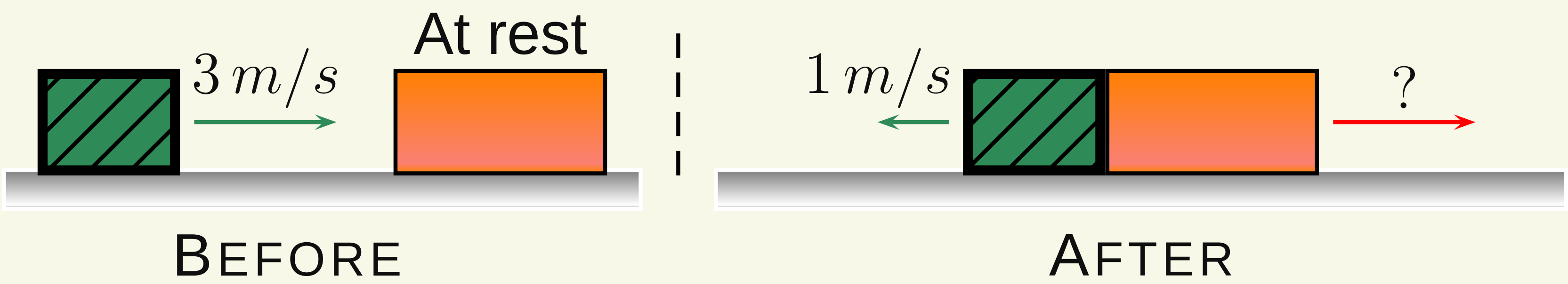
A 1-kg mass sliding to the right with speed $3\,m/s$ on a frictionless floor collides with a 4-kg mass at rest. If the first mass bounces back with a speed of $1\,m/s$, how fast must the second mass be going?



(a) $0\,m/s$

Conservation Exercise III

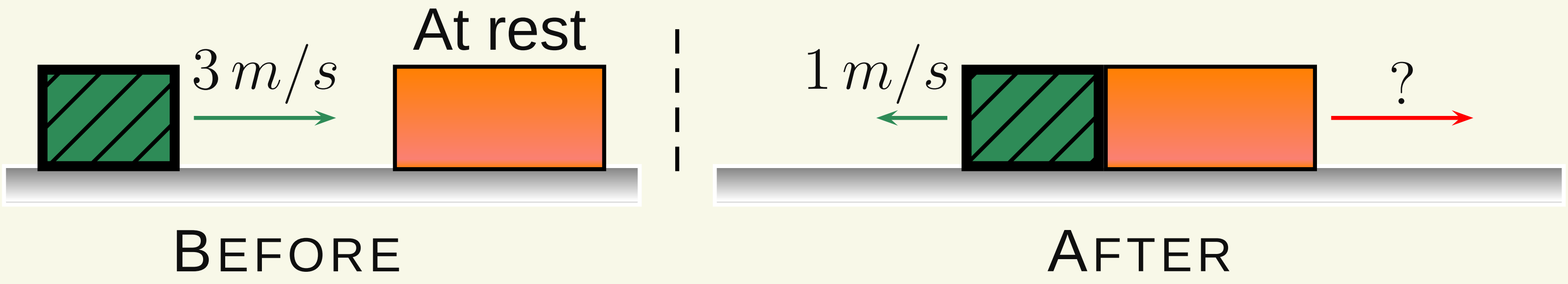
A 1-kg mass sliding to the right with speed $3\,m/s$ on a frictionless floor collides with a 4-kg mass at rest. If the first mass bounces back with a speed of $1\,m/s$, how fast must the second mass be going?



(a) $0\,m/s$ (b) $0.5\,m/s$

Conservation Exercise III

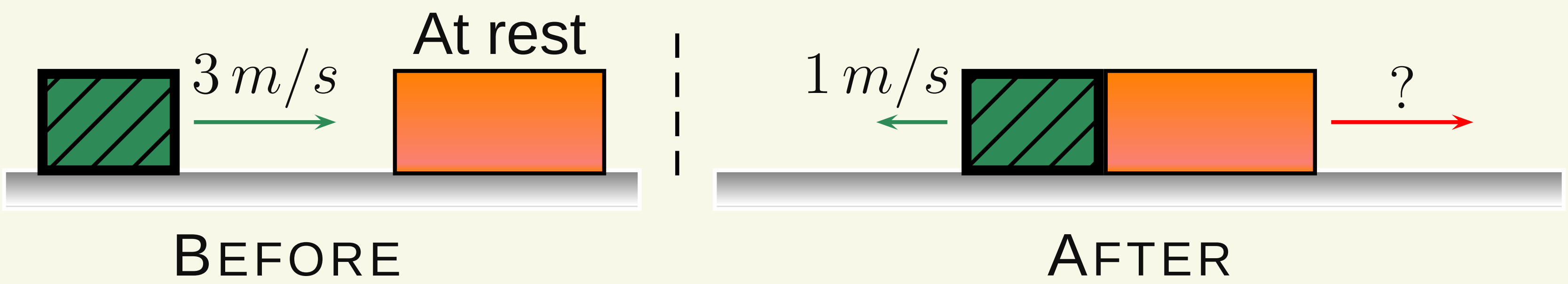
A 1-kg mass sliding to the right with speed $3\,m/s$ on a frictionless floor collides with a 4-kg mass at rest. If the first mass bounces back with a speed of $1\,m/s$, how fast must the second mass be going?



(a) $0\,m/s$ (b) $0.5\,m/s$ (c) $1\,m/s$

Conservation Exercise III

A 1-kg mass sliding to the right with speed $3\,m/s$ on a frictionless floor collides with a 4-kg mass at rest. If the first mass bounces back with a speed of $1\,m/s$, how fast must the second mass be going?

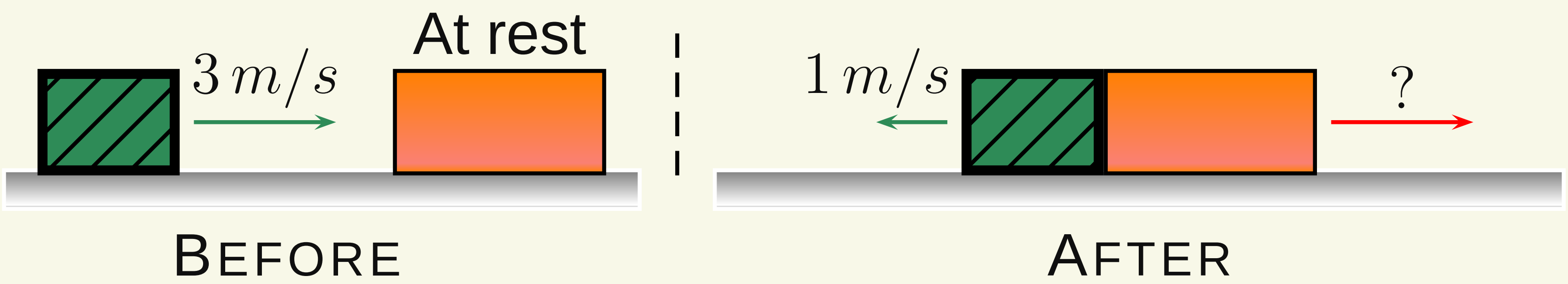


(a) $0\,m/s$ (b) $0.5\,m/s$ (c) $1\,m/s$

(d) $3\,m/s$

Conservation Exercise III

A 1-kg mass sliding to the right with speed $3\,m/s$ on a frictionless floor collides with a 4-kg mass at rest. If the first mass bounces back with a speed of $1\,m/s$, how fast must the second mass be going?

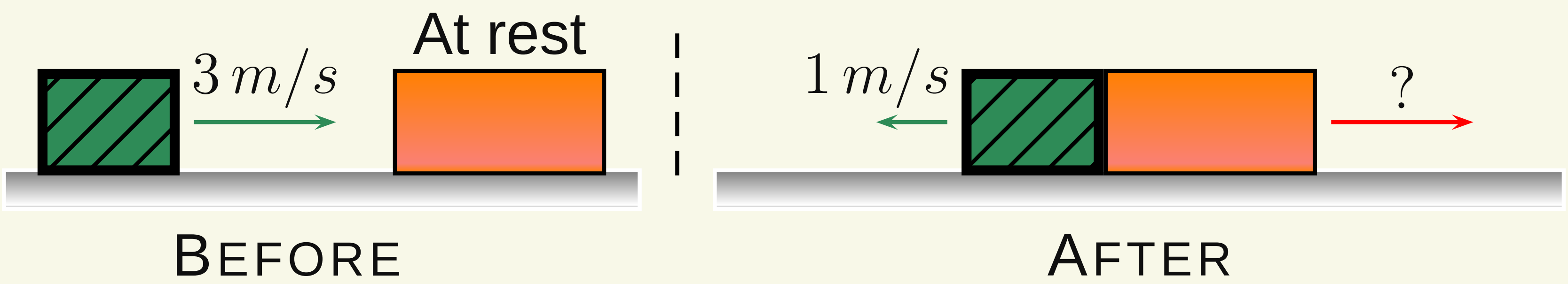


(a) $0\,m/s$ (b) $0.5\,m/s$ (c) $1\,m/s$

(d) $3\,m/s$ (e) $4\,m/s$

Conservation Exercise III

A 1-kg mass sliding to the right with speed $3\,m/s$ on a frictionless floor collides with a 4-kg mass at rest. If the first mass bounces back with a speed of $1\,m/s$, how fast must the second mass be going?



(a) $0\,m/s$

(b) $0.5\,m/s$

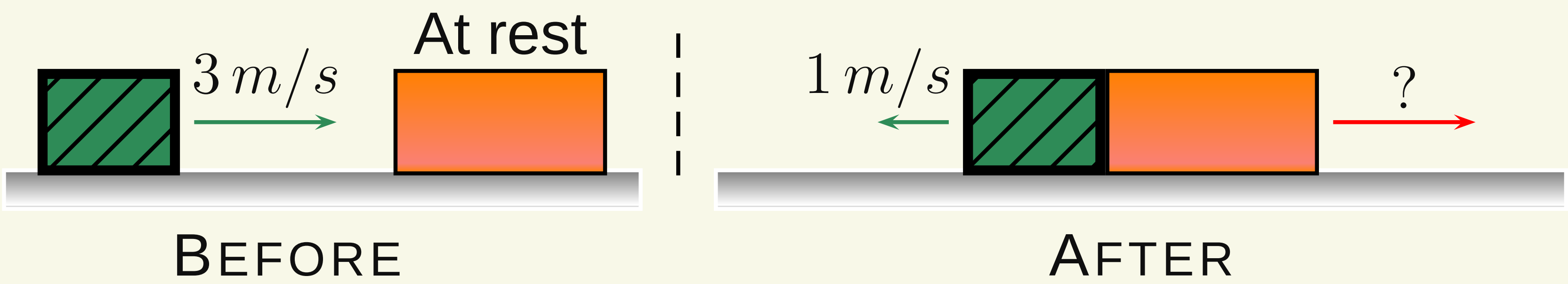
(c) $\boxed{1\,m/s}$

(d) $3\,m/s$

(e) $4\,m/s$

Conservation Exercise III

A 1-kg mass sliding to the right with speed $3\,m/s$ on a frictionless floor collides with a 4-kg mass at rest. If the first mass bounces back with a speed of $1\,m/s$, how fast must the second mass be going?



(a) $0\,m/s$ (b) $0.5\,m/s$ $\boxed{\text{(c) } 1\,m/s}$

(d) $3\,m/s$ (e) $4\,m/s$

Conservation: $(1\,kg)(3\,m/s) + 0 = (1\,kg)(-1\,m/s) + (4\,kg)(v_{Bx})_f$

$(3\,kg \cdot m/s) = -(1\,kg \cdot m/s) + (4\,kg)(v_{Bx})_f \Rightarrow (4\,kg \cdot m/s) = (4\,kg)(v_{Bx})_f$