March 27, Week 10

Today: Chapter 8, Momentum

Homework Assignment #7 - Due March 29

Mastering Physics: 6 problems from chapter 7

Written Questions: 7.60

Homework Assignment #8 - Due Monday, April 8. (Special Office hours to be held that Monday.)

Homework Assignment #9 - Due Friday, April 12.

Exam #3, Next Wednesday, April 3. Practice Exam available on webpage. Review session: Tuesday, April 2, 5:15-7:00 PM. Room 114 of Regener Hall.

Reading Quiz #15 due *Tonight* at 11:59pm.

Impulse and Momentum

Momentum: $\boxed{\overrightarrow{\mathbf{p}} = m\overrightarrow{\mathbf{v}}}$ - $\sum \overrightarrow{\mathbf{F}} = \frac{d\overrightarrow{\mathbf{p}}}{dt}$

Impulse and Momentum

Momentum: $\boxed{\overrightarrow{\mathbf{p}} = m\overrightarrow{\mathbf{v}}}$ - $\sum \overrightarrow{\mathbf{F}} = \frac{d\overrightarrow{\mathbf{p}}}{dt}$

Impulse: $\boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t}$

Impulse and Momentum

Momentum: $\boxed{\overrightarrow{\mathbf{p}} = m\overrightarrow{\mathbf{v}}}$ - $\sum \overrightarrow{\mathbf{F}} = \frac{d\overrightarrow{\mathbf{p}}}{dt}$

Impulse: $\boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t}$

Impulse-Momentum Theorem (Average Force Version):

Impulse and Momentum

Momentum: $\boxed{\overrightarrow{\mathbf{p}} = m\overrightarrow{\mathbf{v}}}$ - $\sum \overrightarrow{\mathbf{F}} = \frac{d\overrightarrow{\mathbf{p}}}{dt}$

Impulse: $\boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t}$

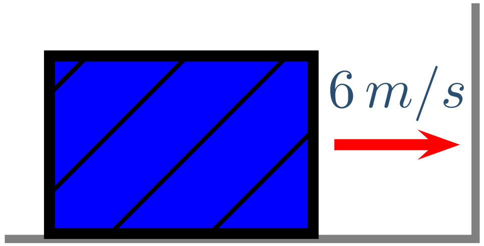
Impulse-Momentum Theorem (Average Force Version):

$$\sum \overrightarrow{\mathbf{F}} = \frac{d\overrightarrow{\mathbf{p}}}{dt} \Rightarrow \overrightarrow{\mathbf{F}}_{av} = \frac{\Delta\overrightarrow{\mathbf{p}}}{\Delta t} \Rightarrow \boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}}$$

Impulse-Momentum Exercise I

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?



BEFORE

Impulse-Momentum Exercise I

$$\boxed{\vec{\mathbf{J}} = \vec{\mathbf{F}}_{av}\Delta t = \Delta\vec{\mathbf{p}}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

Impulse-Momentum Exercise I

$$\boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\,\overrightarrow{\mathbf{p}}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$

Impulse-Momentum Exercise I

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

(a) $60\,kg\cdot m/s, \leftarrow$ (b) $60\,kg\cdot m/s, \rightarrow$

Impulse-Momentum Exercise I

$$\boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$ (b) $60\,kg \cdot m/s, \rightarrow$ (c) $30\,kg \cdot m/s, \leftarrow$

Impulse-Momentum Exercise I

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

(a) $60\,kg\cdot m/s, \leftarrow$ (b) $60\,kg\cdot m/s, \rightarrow$ (c) $30\,kg\cdot m/s, \leftarrow$

(d) $30\,kg\cdot m/s, \rightarrow$

Impulse-Momentum Exercise I

$$\boxed{\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$ (b) $60\,kg \cdot m/s, \rightarrow$ (c) $30\,kg \cdot m/s, \leftarrow$

(d) $30\,kg \cdot m/s, \rightarrow$ (e) $15\,kg \cdot m/s, \leftarrow$

Impulse-Momentum Exercise I

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. What impulse is imparted to the block?

$$J_x = \Delta p_x = 0 - 30\,kg \cdot m/s = -30\,kg \cdot m/s$$

(a) $60\,kg \cdot m/s, \leftarrow$

(b) $60\,kg \cdot m/s, \rightarrow$

(c) $30\,kg \cdot m/s, \leftarrow$

(d) $30\,kg \cdot m/s, \rightarrow$

(e) $15\,kg \cdot m/s, \leftarrow$

Impulse-Momentum Exercise II

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. If the block stops in $0.1\,s$, what is the average force acting on it?

Impulse-Momentum Exercise II

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. If the block stops in $0.1\,s$, what is the average force acting on it?

(a) $300\,N, \leftarrow$

Impulse-Momentum Exercise II

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. If the block stops in $0.1\,s$, what is the average force acting on it?

(a) $300\,N, \leftarrow$ (b) $300\,N, \rightarrow$

Impulse-Momentum Exercise II

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\,\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. If the block stops in $0.1\,s$, what is the average force acting on it?

(a) $300\,N, \leftarrow$ (b) $300\,N, \rightarrow$ (c) $3\,N, \leftarrow$

Impulse-Momentum Exercise II

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta \overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. If the block stops in $0.1\,s$, what is the average force acting on it?

(a) $300\,N, \leftarrow$ (b) $300\,N, \rightarrow$ (c) $3\,N, \leftarrow$

(d) $3\,N, \rightarrow$

Impulse-Momentum Exercise II

$$\vec{\mathbf{J}} = \vec{\mathbf{F}}_{av}\Delta t = \Delta\vec{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. If the block stops in $0.1\,s$, what is the average force acting on it?

(a) $300\,N, \leftarrow$ (b) $300\,N, \rightarrow$ (c) $3\,N, \leftarrow$

(d) $3\,N, \rightarrow$ (e) $600\,N, \leftarrow$

Impulse-Momentum Exercise II

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the right when it hits a wall and stops. If the block stops in $0.1\,s$, what is the average force acting on it?

(a) $300\,N, \leftarrow$ (b) $300\,N, \rightarrow$ (c) $3\,N, \leftarrow$

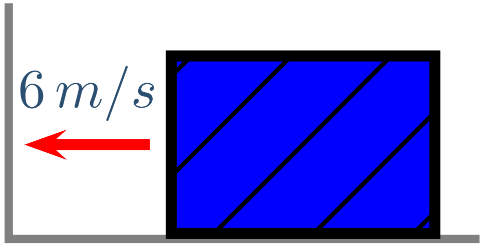
(d) $3\,N, \rightarrow$ (e) $600\,N, \leftarrow$

Average force, impulse, and change in momentum always have the same direction

Impulse-Momentum Exercise III

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. What impulse is imparted to the block?

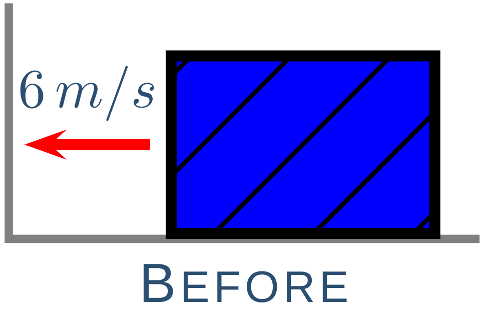


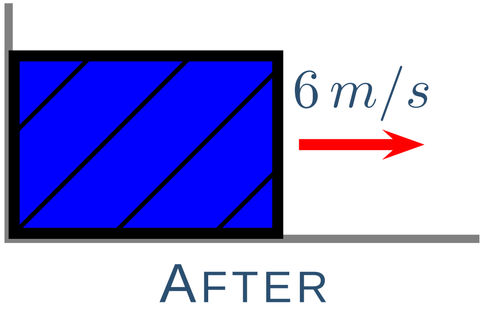
BEFORE

Impulse-Momentum Exercise III

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. What impulse is imparted to the block?





Impulse-Momentum Exercise III

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$

Impulse-Momentum Exercise III

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$ (b) $60\,kg \cdot m/s, \rightarrow$

Impulse-Momentum Exercise III

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$ (b) $60\,kg \cdot m/s, \rightarrow$ (c) $30\,kg \cdot m/s, \leftarrow$

Impulse-Momentum Exercise III

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$

(b) $60\,kg \cdot m/s, \rightarrow$

(c) $30\,kg \cdot m/s, \leftarrow$

(d) $30\,kg \cdot m/s, \rightarrow$

Impulse-Momentum Exercise III

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. What impulse is imparted to the block?

(a) $60\,kg \cdot m/s, \leftarrow$ (b) $60\,kg \cdot m/s, \rightarrow$ (c) $30\,kg \cdot m/s, \leftarrow$

(d) $30\,kg \cdot m/s, \rightarrow$ (e) $0\,kg \cdot m/s, \leftarrow$

Impulse-Momentum Exercise III

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. What impulse is imparted to the block?

$$J_x = \Delta p_x = +30\,kg\cdot m/s - (-30\,kg\cdot m/s) = +60\,kg\cdot m/s$$

(a) $60\,kg\cdot m/s, \leftarrow$

(b) $60\,kg\cdot m/s, \rightarrow$

(c) $30\,kg\cdot m/s, \leftarrow$

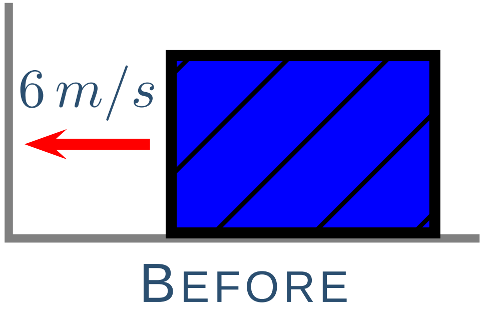
(d) $30\,kg\cdot m/s, \rightarrow$

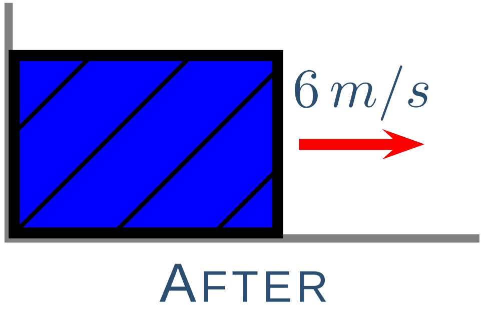
(e) $0\,kg\cdot m/s, \leftarrow$

Impulse-Momentum Exercise IV

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. If this bounce takes $0.1\,s$, what is the average force?





Impulse-Momentum Exercise IV

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. If this bounce takes $0.1\,s$, what is the average force?

(a) $6\,N, \rightarrow$

Impulse-Momentum Exercise IV

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. If this bounce takes $0.1\,s$, what is the average force?

(a) $6\,N, \rightarrow$ (b) $300\,N, \leftarrow$

Impulse-Momentum Exercise IV

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. If this bounce takes $0.1\,s$, what is the average force?

(a) $6\,N, \rightarrow$ (b) $300\,N, \leftarrow$ (c) $300\,N, \rightarrow$

Impulse-Momentum Exercise IV

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. If this bounce takes $0.1\,s$, what is the average force?

(a) $6\,N, \rightarrow$ (b) $300\,N, \leftarrow$ (c) $300\,N, \rightarrow$

(d) $600\,N, \leftarrow$

Impulse-Momentum Exercise IV

$$\overrightarrow{\mathbf{J}} = \overrightarrow{\mathbf{F}}_{av}\Delta t = \Delta\overrightarrow{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. If this bounce takes $0.1\,s$, what is the average force?

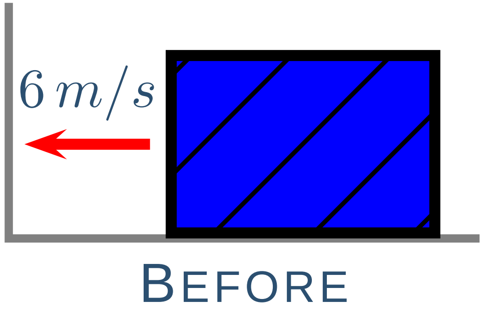
(a) $6\,N, \rightarrow$ (b) $300\,N, \leftarrow$ (c) $300\,N, \rightarrow$

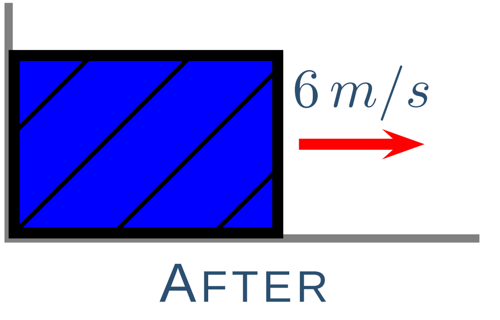
(d) $600\,N, \leftarrow$ (e) $600\,N, \rightarrow$

Impulse-Momentum Exercise IV

$$\vec{\mathbf{J}} = \vec{\mathbf{F}}_{av}\Delta t = \Delta\vec{\mathbf{p}}$$

A 5.0-kg block is sliding on a frictionless, horizontal surface going $6.0\,m/s$ to the left when it hits a wall and bounces back with the same speed. If this bounce takes $0.1\,s$, what is the average force?





(a) $6\,N, \rightarrow$ (b) $300\,N, \leftarrow$ (c) $300\,N, \rightarrow$

(d) $600\,N, \leftarrow$ (e) $600\,N, \rightarrow$

Bouncing doubles the force

Impulse-Momentum Theorem

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

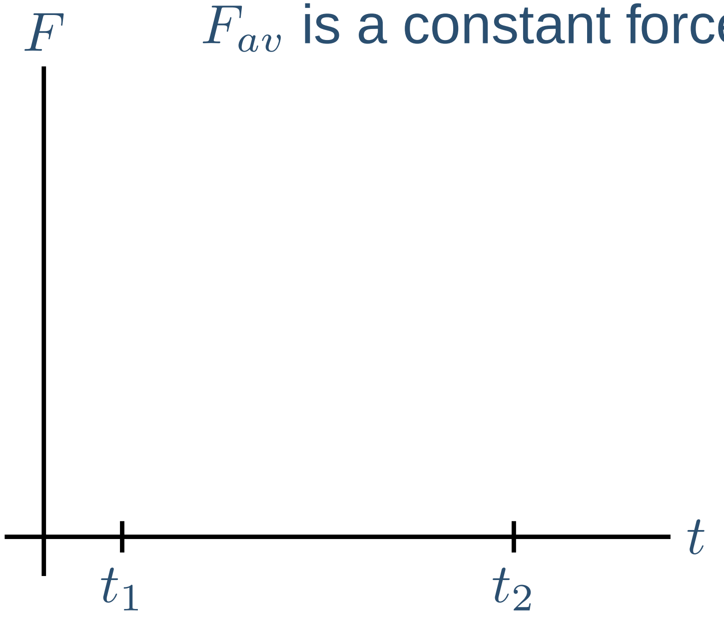
Impulse-Momentum Theorem

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

Impulse-Momentum Theorem

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

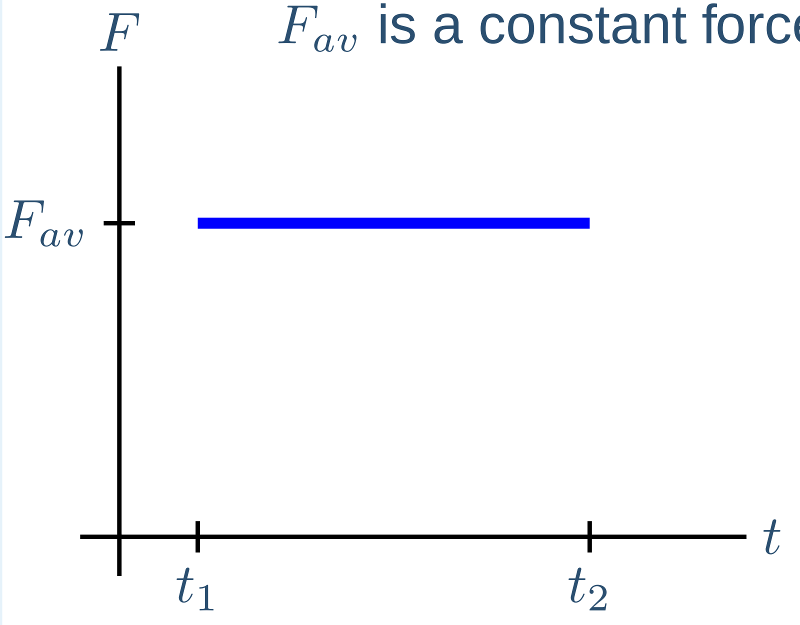
F_{av} is a constant force



Impulse-Momentum Theorem

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

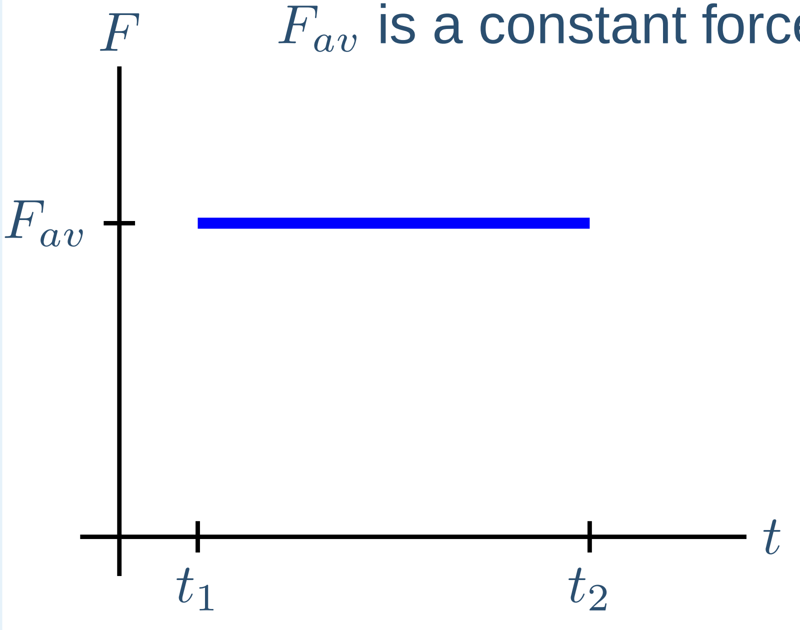
F_{av} is a constant force



Impulse-Momentum Theorem

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

F_{av} is a constant force

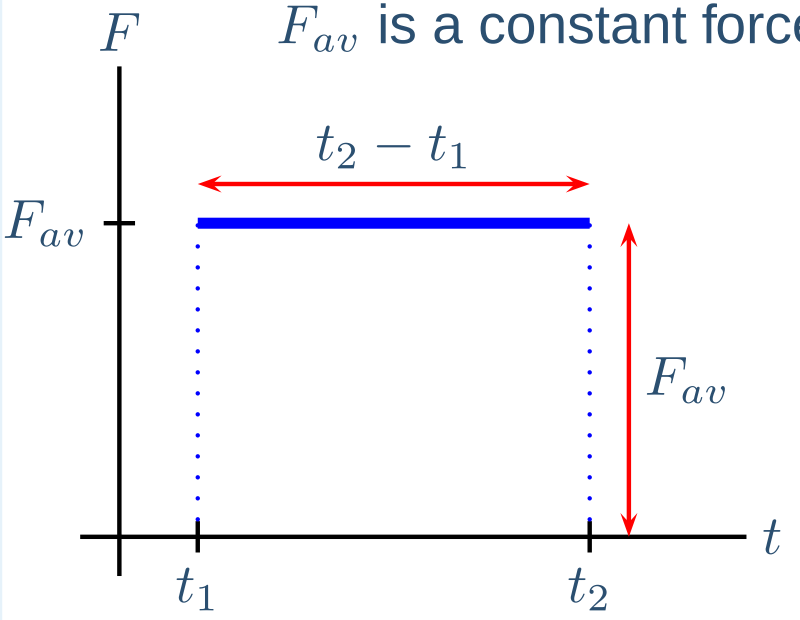


$$J = F_{av}\Delta t = F_{av}\left(t_2 - t_1\right)$$

Impulse-Momentum Theorem

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

F_{av} is a constant force

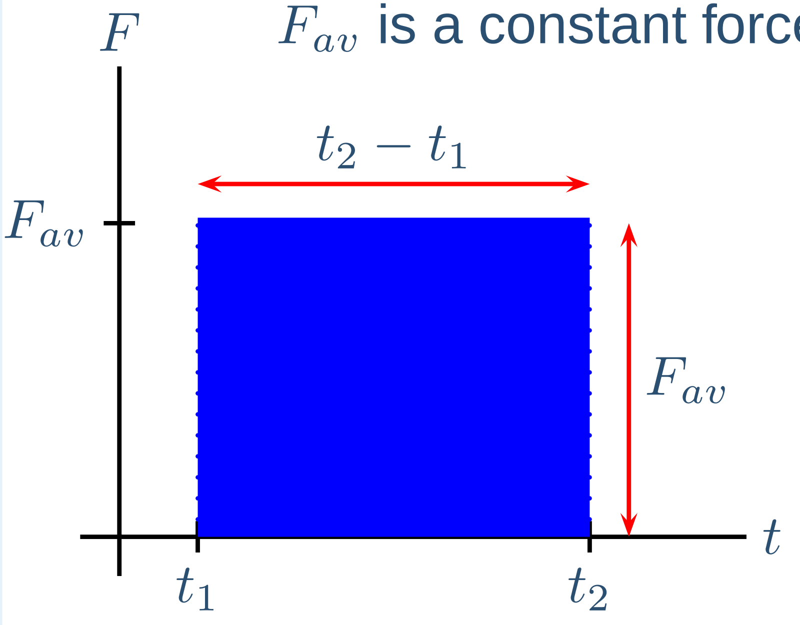


$$J = F_{av}\Delta t = F_{av}\left(t_2 - t_1\right)$$

Impulse-Momentum Theorem

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

F_{av} is a constant force

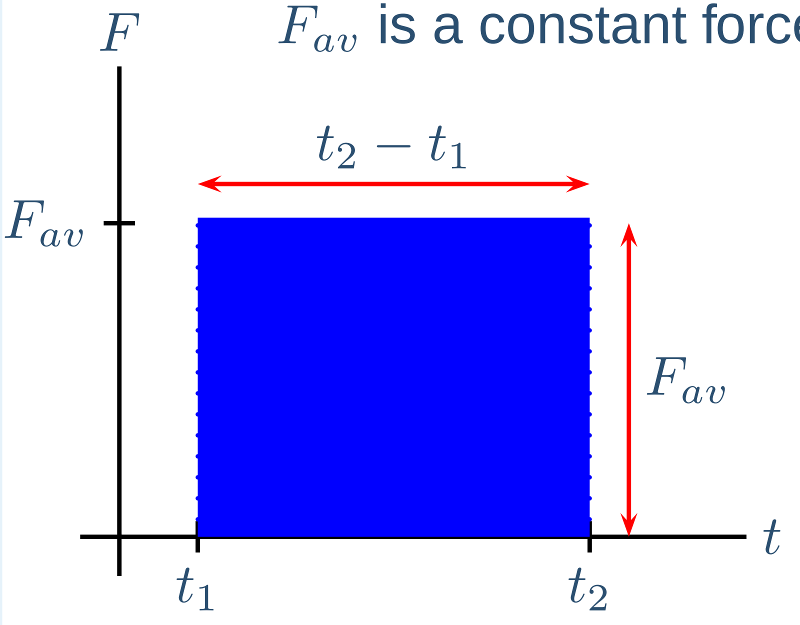


$$J = F_{av}\Delta t = F_{av}\left(t_2 - t_1\right)$$

Impulse-Momentum Theorem

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

F_{av} is a constant force



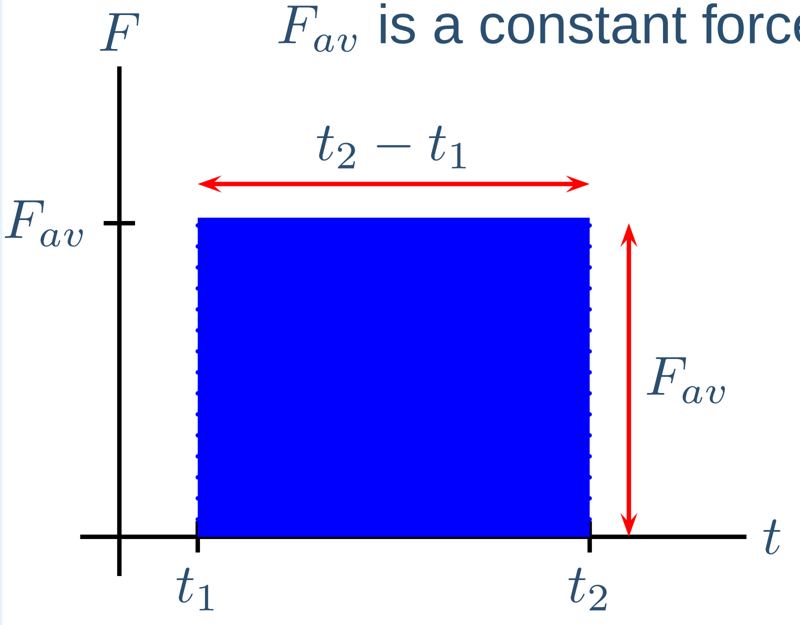
$$J = F_{av}\Delta t = F_{av}\left(t_2 - t_1\right)$$

Impulse is the area under the curve

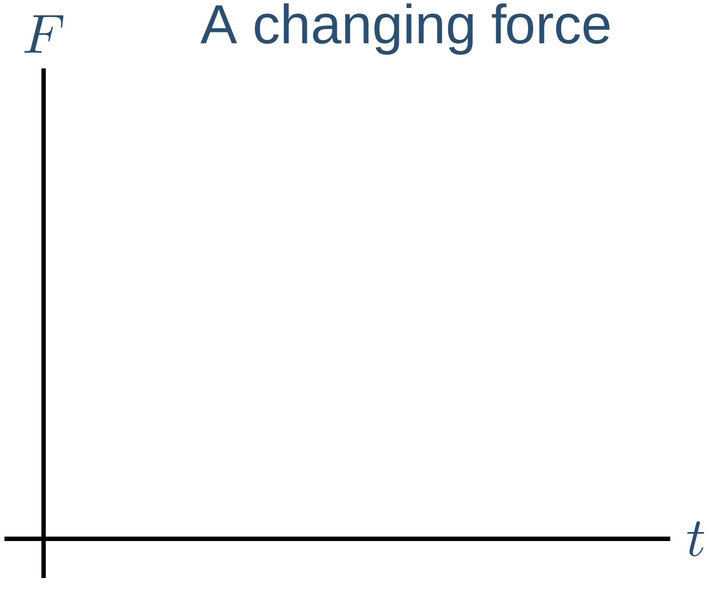
Impulse-Momentum Theorem

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

F_{av} is a constant force



A changing force



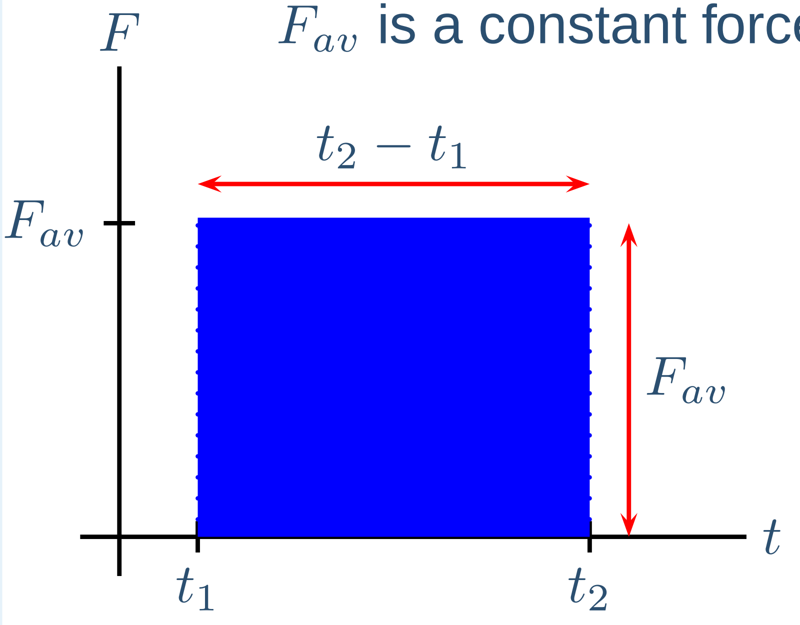
$$J = F_{av} \Delta t = F_{av} (t_2 - t_1)$$

Impulse is the area under the curve

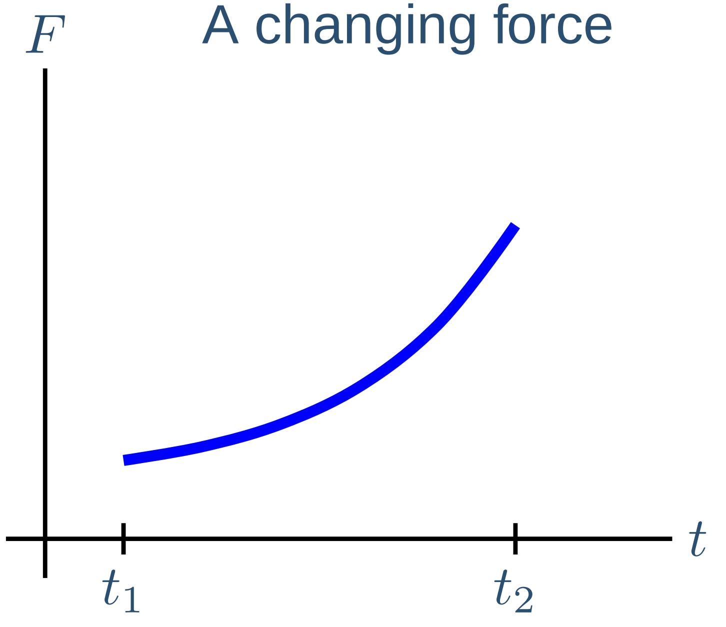
Impulse-Momentum Theorem

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

F_{av} is a constant force



A changing force

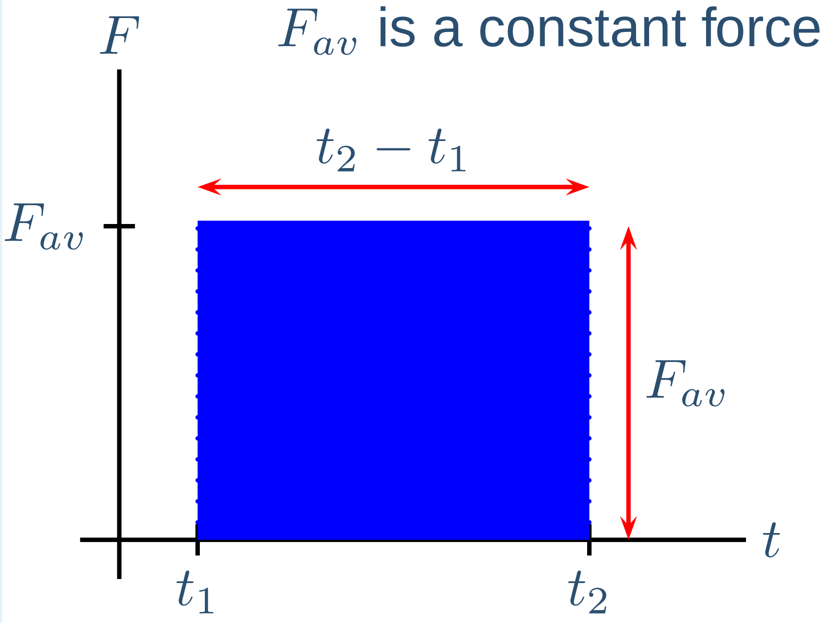


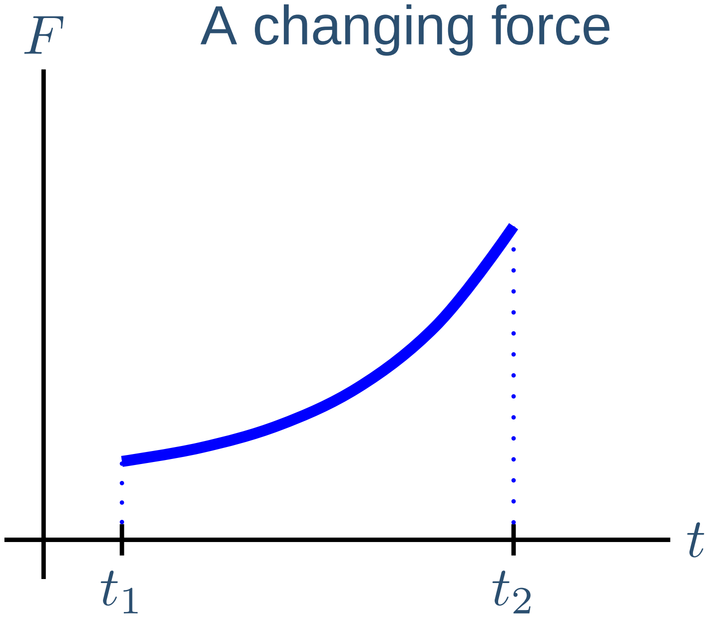
$$J = F_{av}\Delta t = F_{av}\left(t_2 - t_1\right)$$

Impulse is the area under the curve

Impulse-Momentum Theorem

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





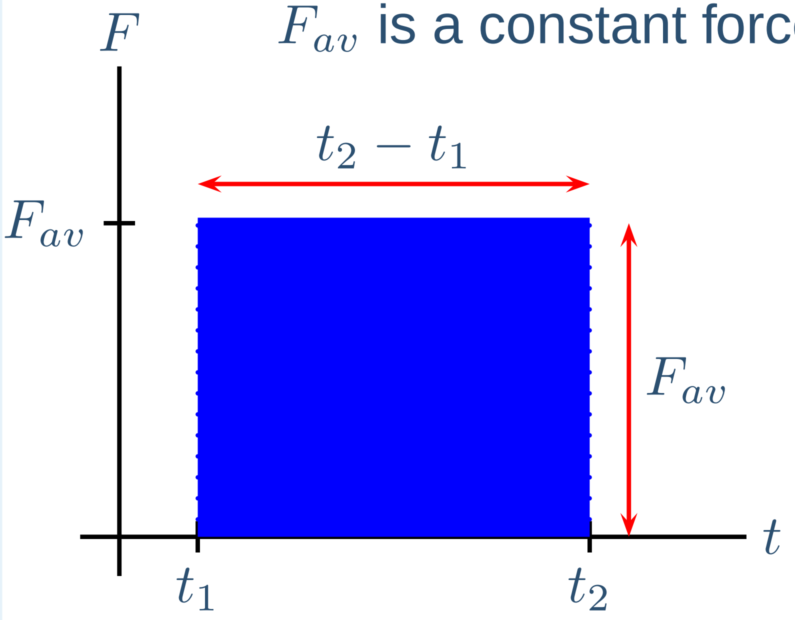
$$J = F_{av}\Delta t = F_{av}\left(t_2 - t_1\right)$$

Impulse is the area under the curve

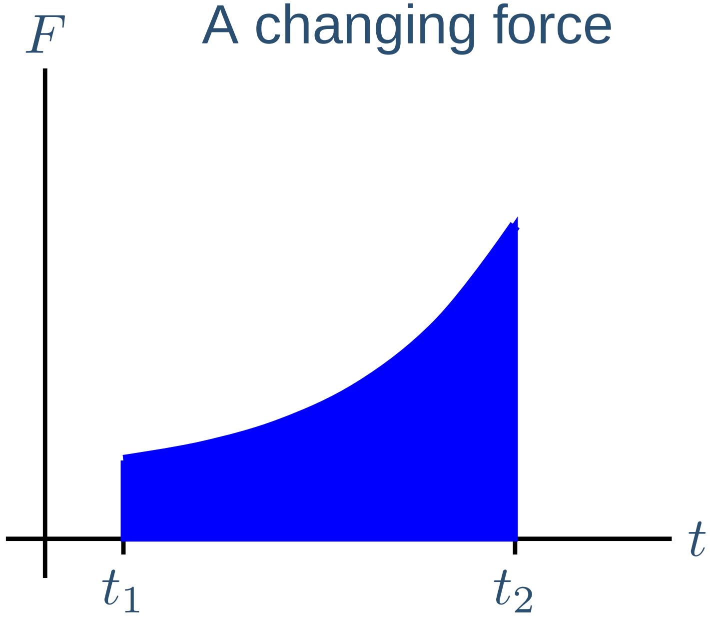
Impulse-Momentum Theorem

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

F_{av} is a constant force



A changing force

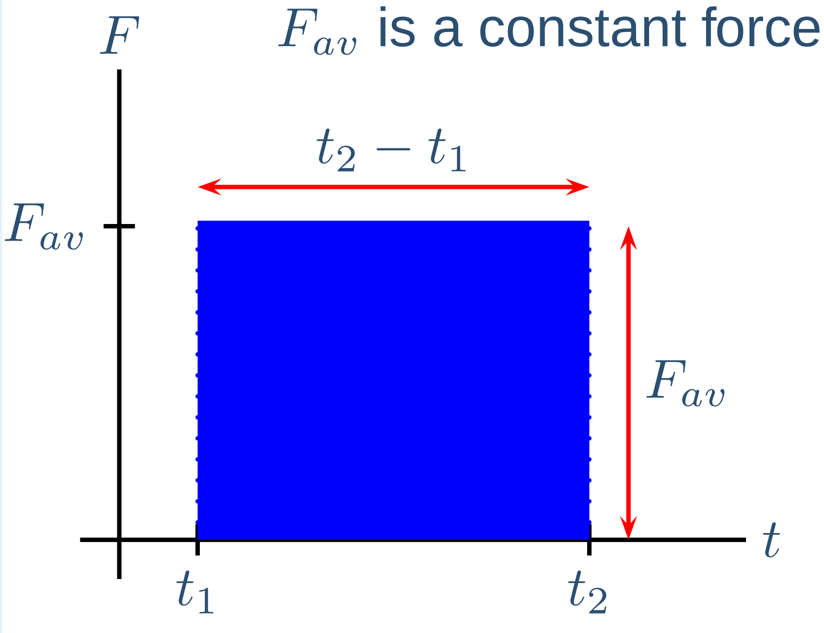


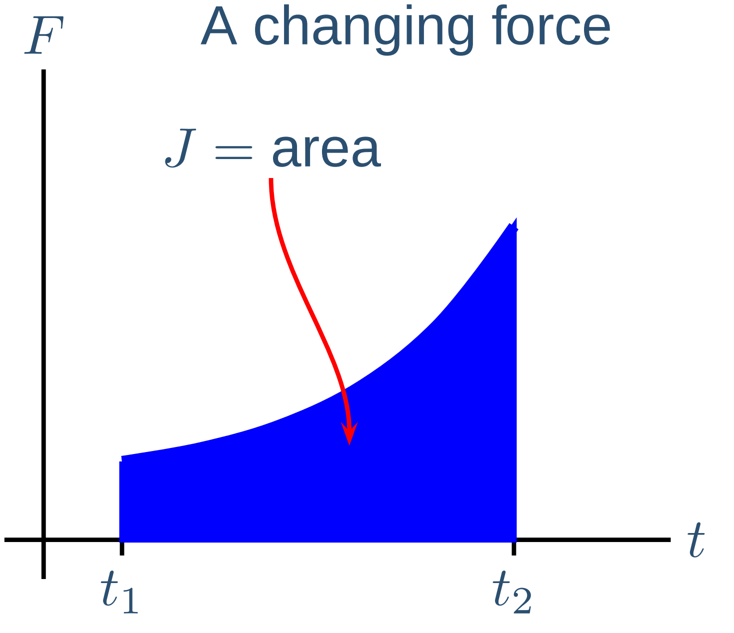
$$J = F_{av}\Delta t = F_{av}\left(t_2 - t_1\right)$$

Impulse is the area under the curve

Impulse-Momentum Theorem

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





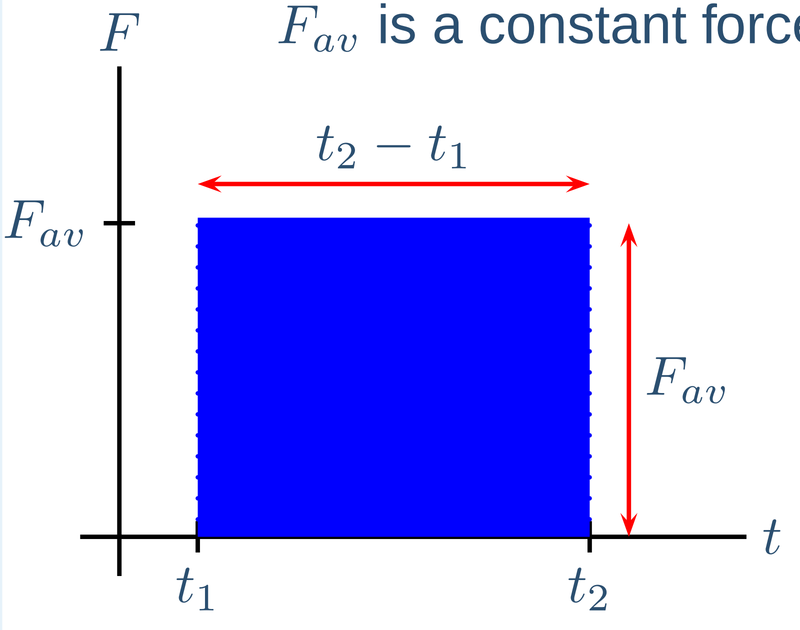
$$J = F_{av}\Delta t = F_{av}\left(t_2 - t_1\right)$$

Impulse is the area under the curve

Impulse-Momentum Theorem

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

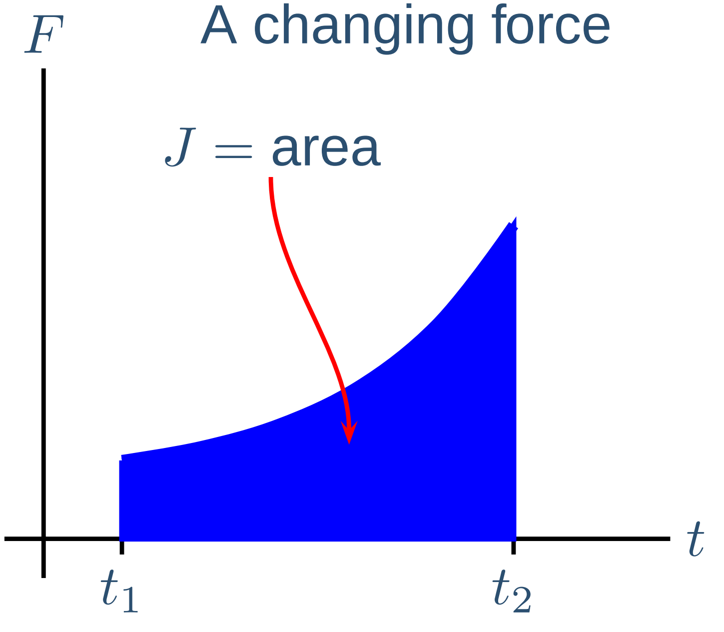
F_{av} is a constant force



$$J = F_{av}\Delta t = F_{av}\left(t_2 - t_1\right)$$

Impulse is the area under the curve

A changing force

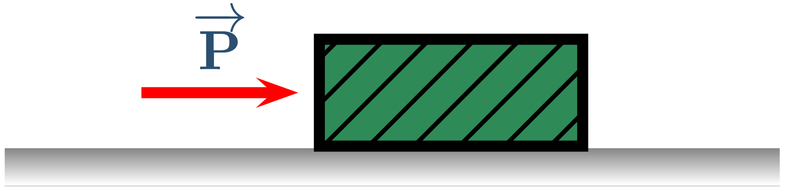


It can be shown that $\boxed{J = \Delta p}$ still!

Variable Force Exercise

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

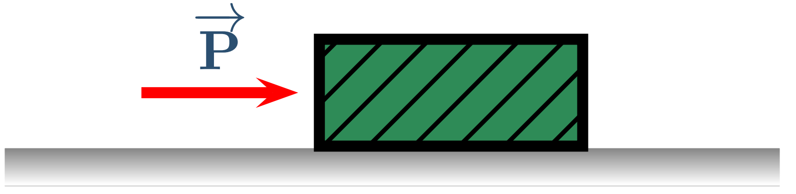
A $5\,kg$ block is sitting on a horizontal, frictionless floor. The force shown is applied to the block for $1\,s$. What impulse is imparted?

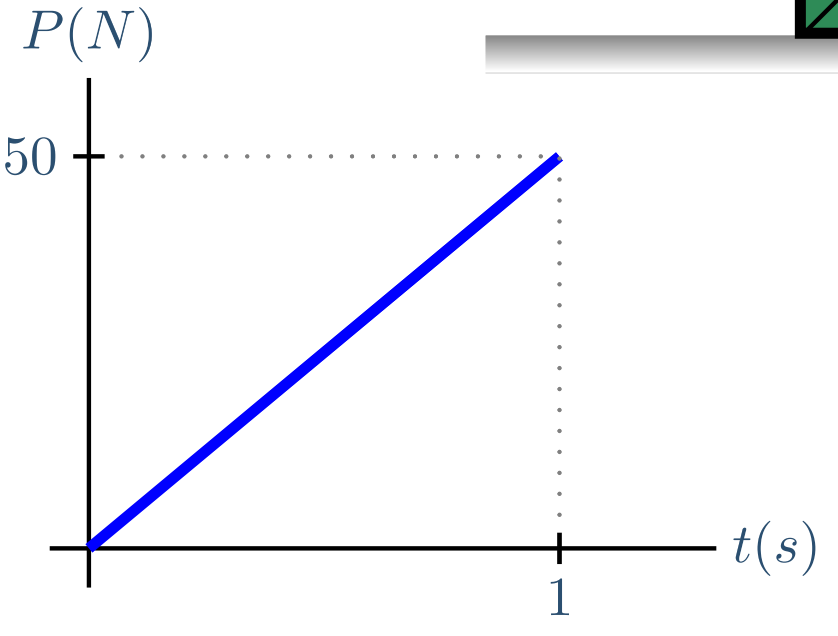


Variable Force Exercise

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?

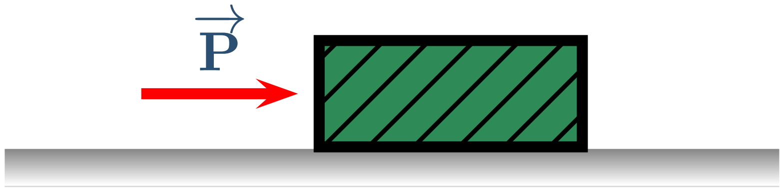


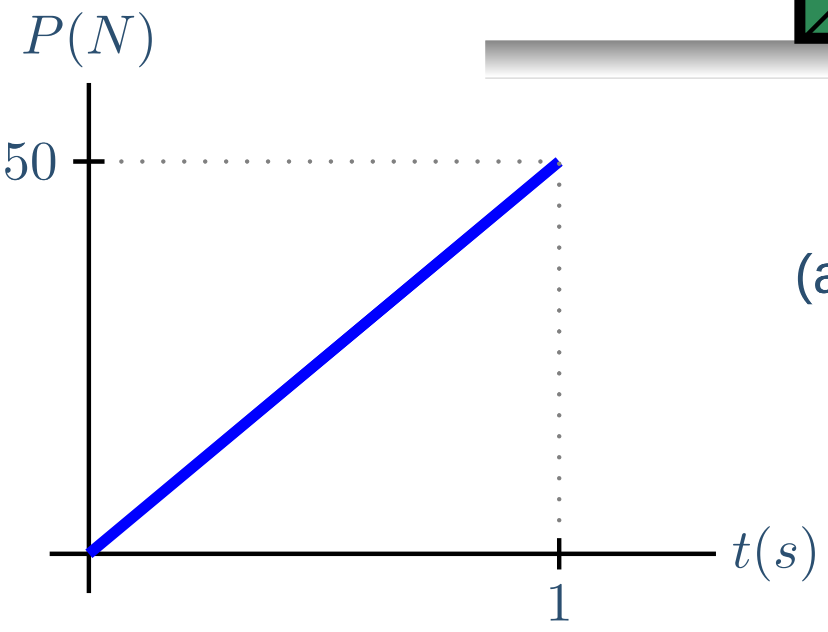


Variable Force Exercise

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?



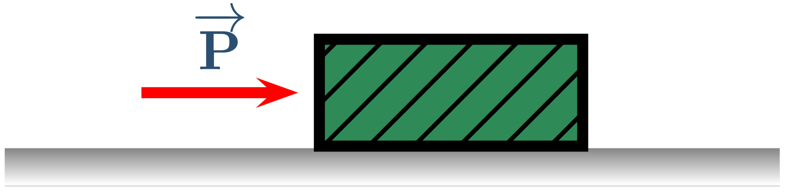


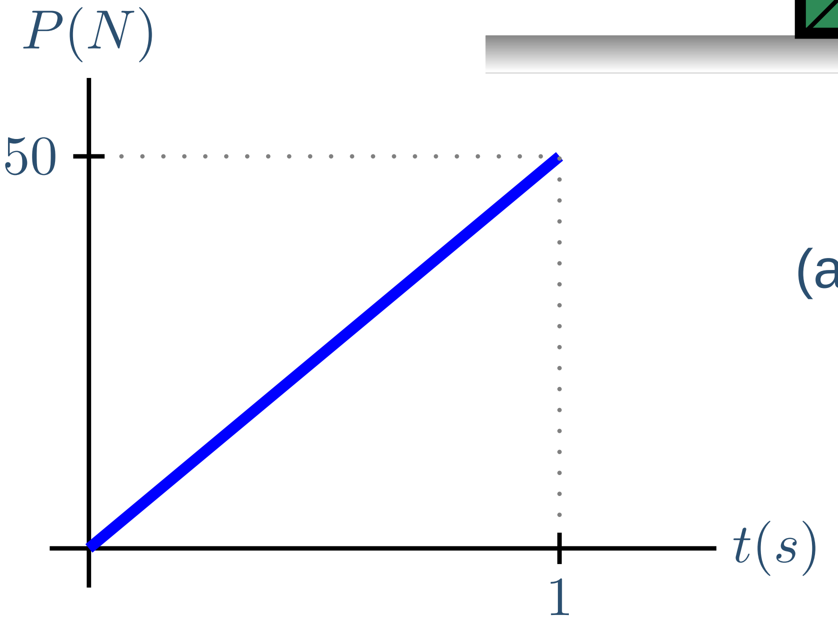
(a) $0\,kg \cdot m/s$

Variable Force Exercise

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?





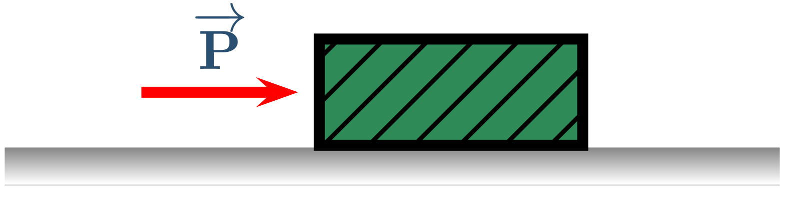
(a) $0\,kg \cdot m/s$

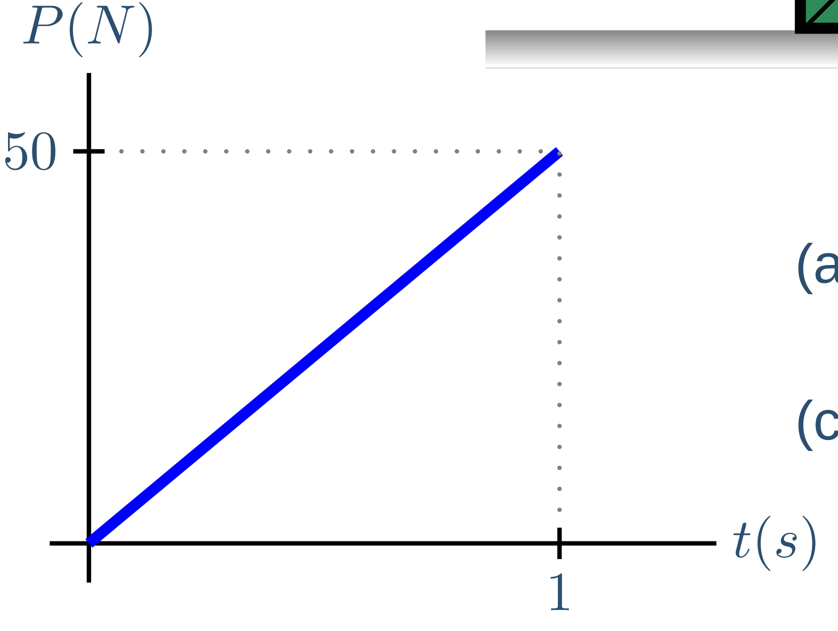
(b) $25\,kg \cdot m/s$

Variable Force Exercise

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

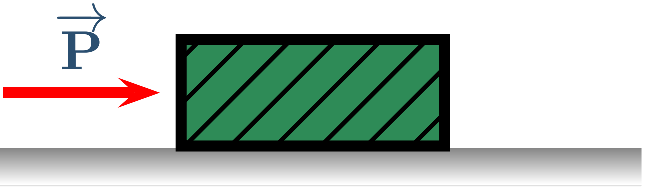
(b) $25\,kg \cdot m/s$

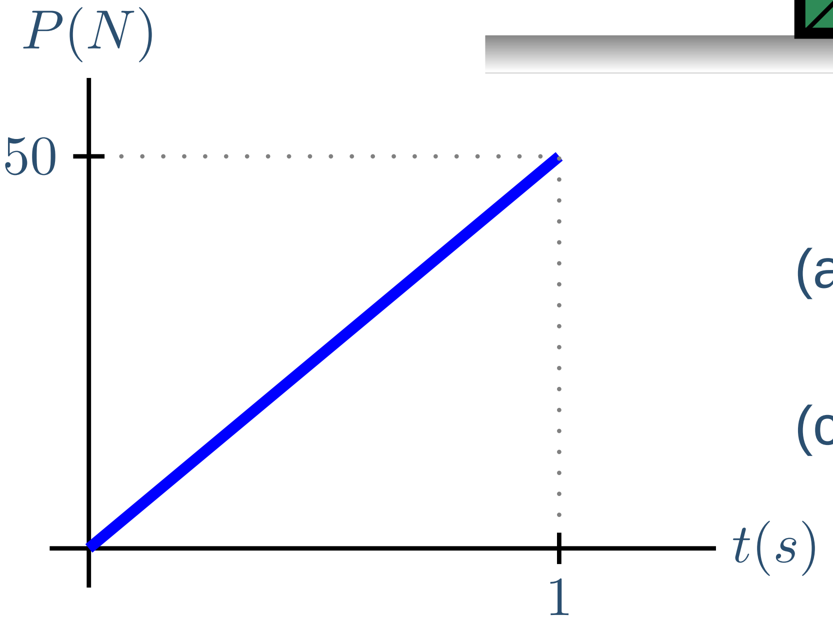
(c) $50\,kg \cdot m/s$

Variable Force Exercise

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

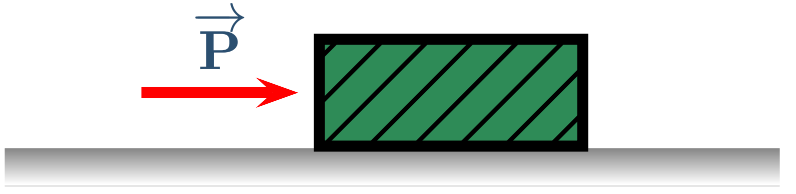
(c) $50\,kg \cdot m/s$

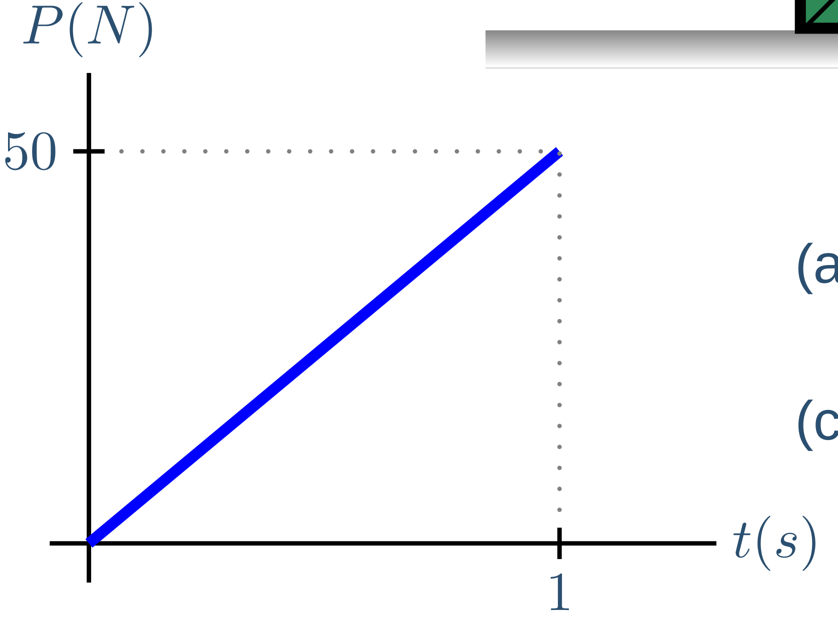
(d) $75\,kg \cdot m/s$

Variable Force Exercise

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

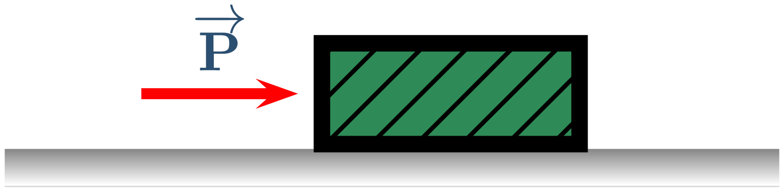
(d) $75\,kg \cdot m/s$

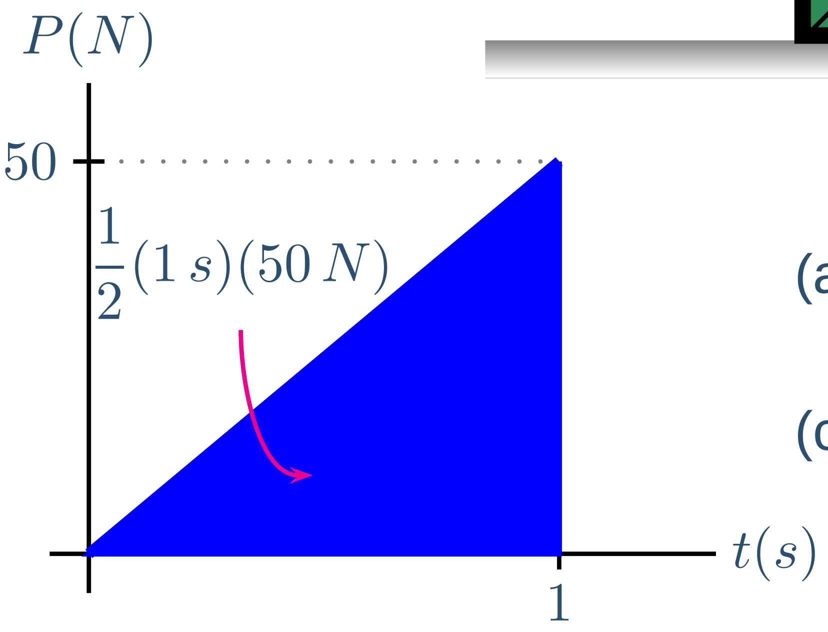
(e) $100\,kg \cdot m/s$

Variable Force Exercise

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

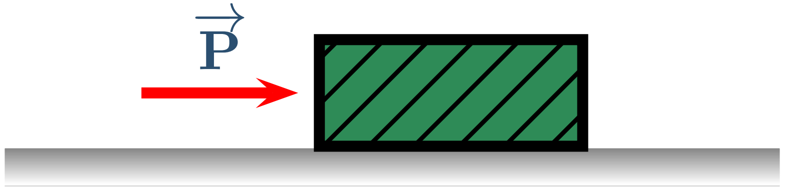
(d) $75\,kg \cdot m/s$

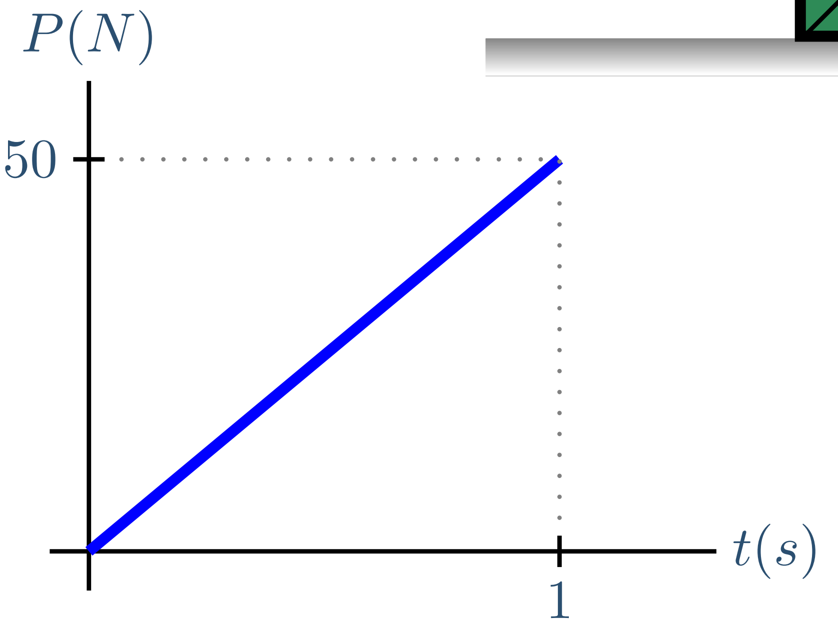
(e) $100\,kg \cdot m/s$

Variable Force Exercise II

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, how fast is it going after $1\,s$?

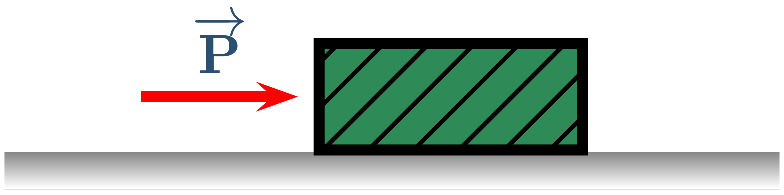


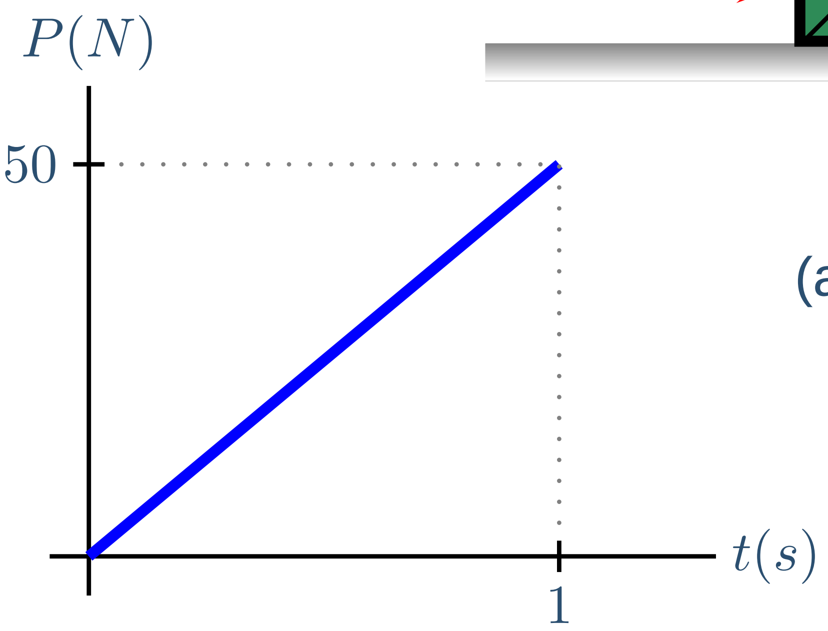


Variable Force Exercise II

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, how fast is it going after $1\,s$?



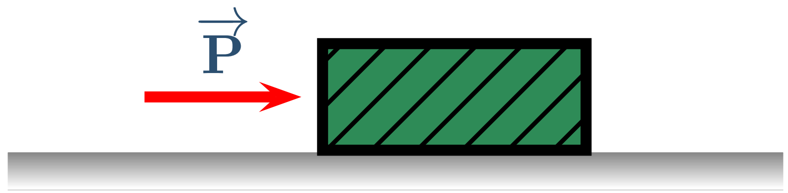


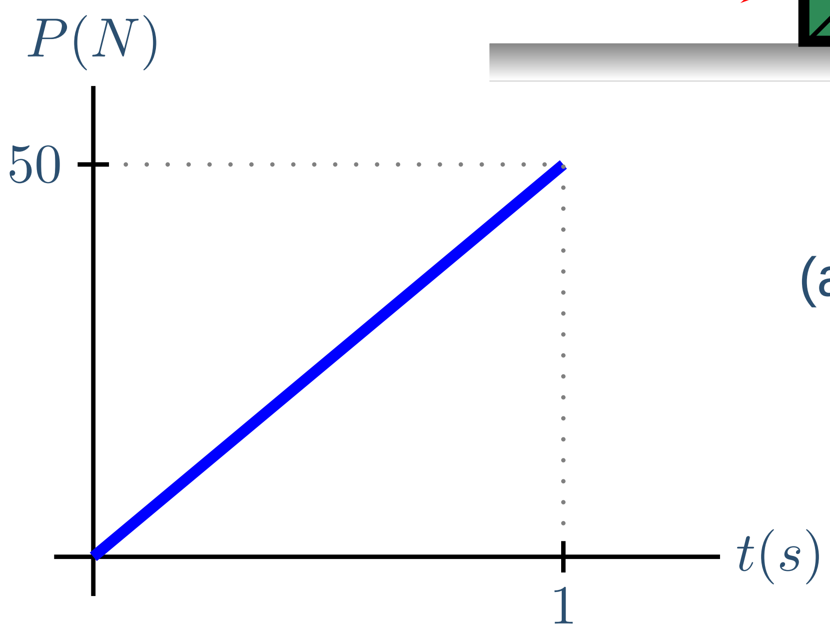
(a) $50\,m/s$

Variable Force Exercise II

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, how fast is it going after $1\,s$?





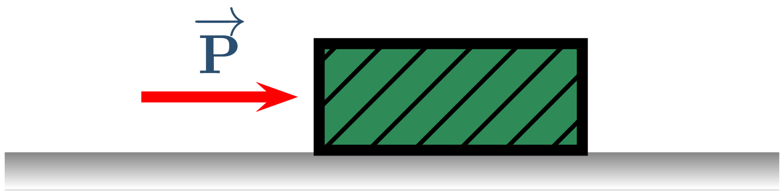
(a) $50\,m/s$

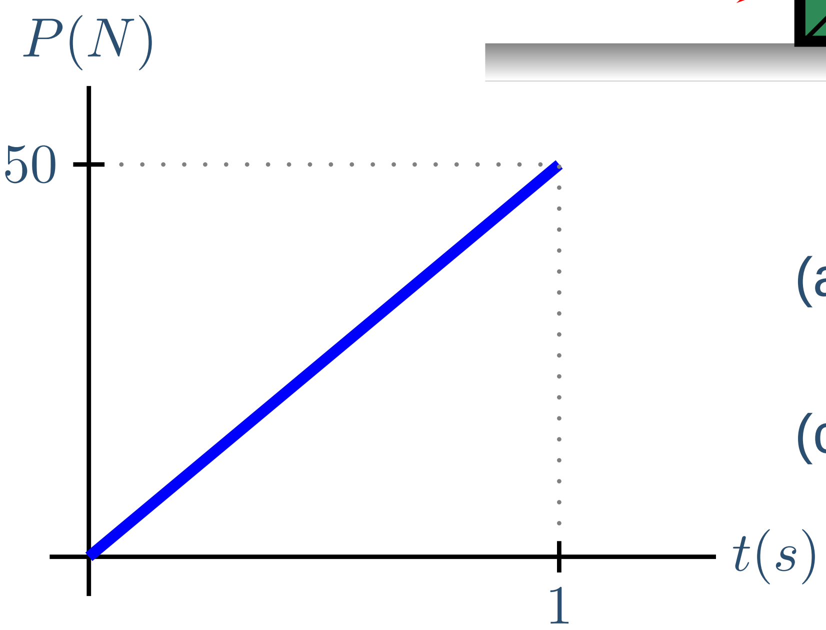
(b) $25\,m/s$

Variable Force Exercise II

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, how fast is it going after $1\,s$?





(a) $50\,m/s$

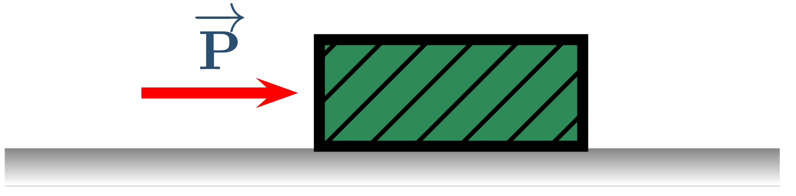
(b) $25\,m/s$

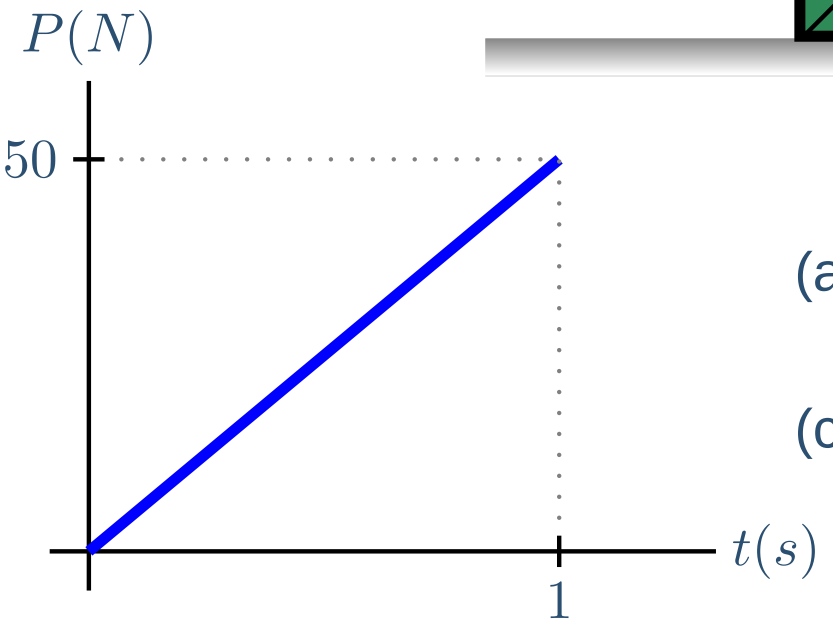
(c) $10\,m/s$

Variable Force Exercise II

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

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





(a) $50\,m/s$

(b) $25\,m/s$

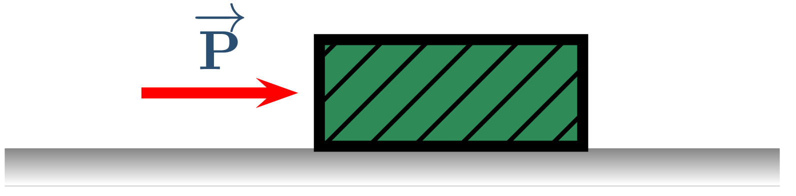
(c) $10\,m/s$

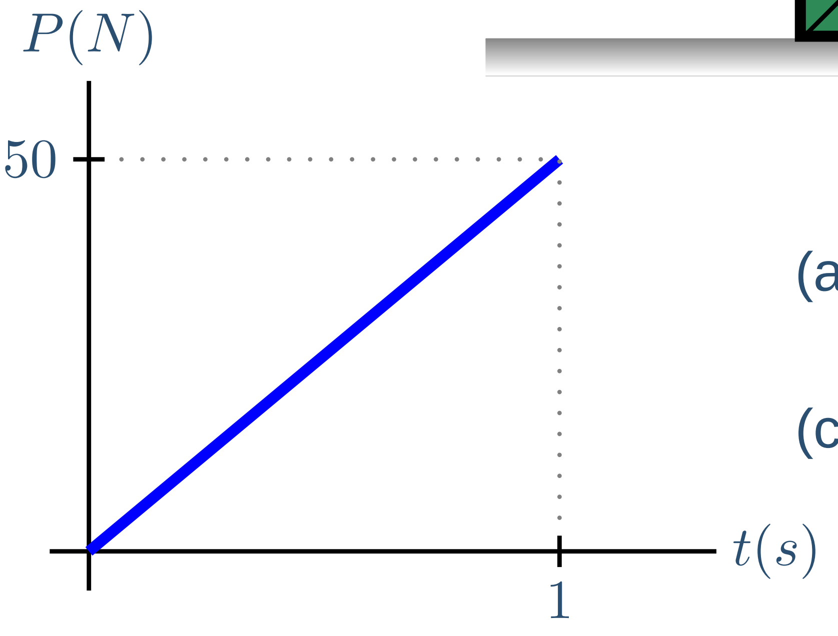
(d) $5\,m/s$

Variable Force Exercise II

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

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





(a) $50\,m/s$

(b) $25\,m/s$

(c) $10\,m/s$

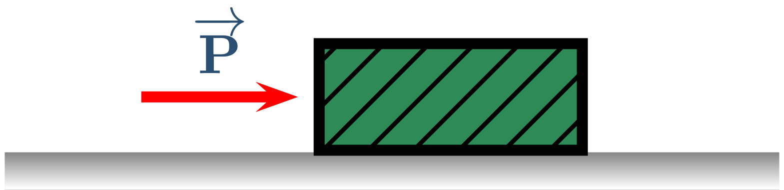
(d) $5\,m/s$

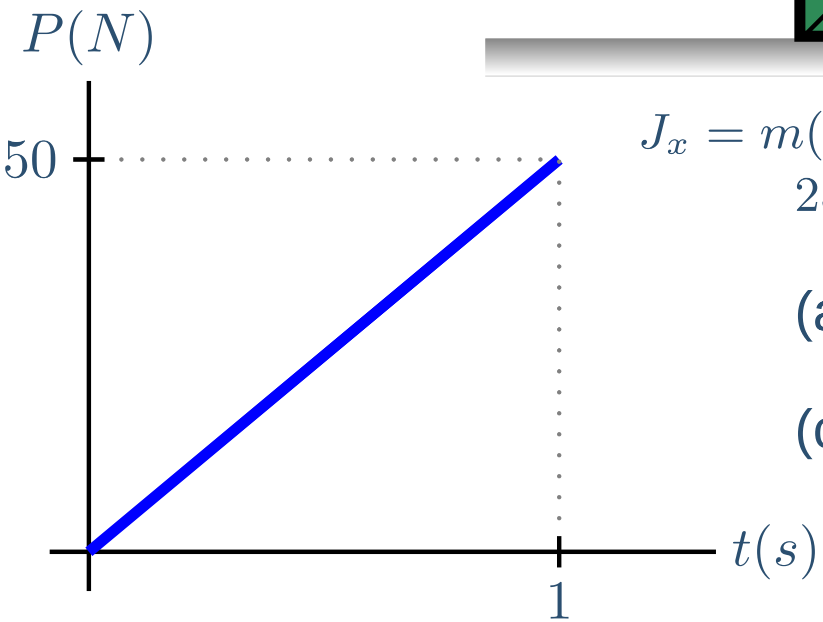
(e) $0\,m/s$

Variable Force Exercise II

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

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





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

(a) $50\,m/s$

(b) $25\,m/s$

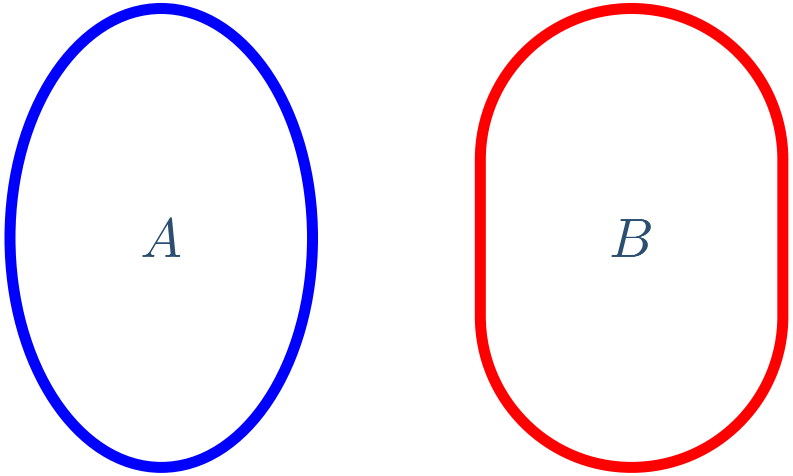
(c) $10\,m/s$

(d) $5\,m/s$

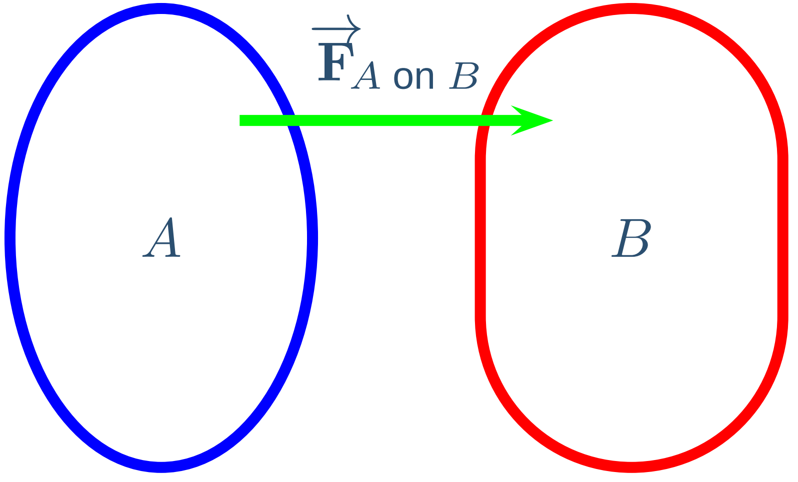
(e) $0\,m/s$

Conservation of Momentum

Conservation of Momentum

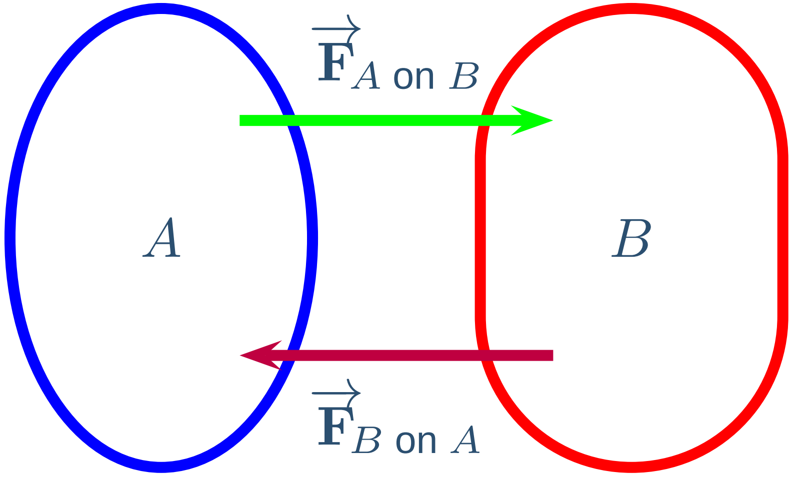


Conservation of Momentum



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

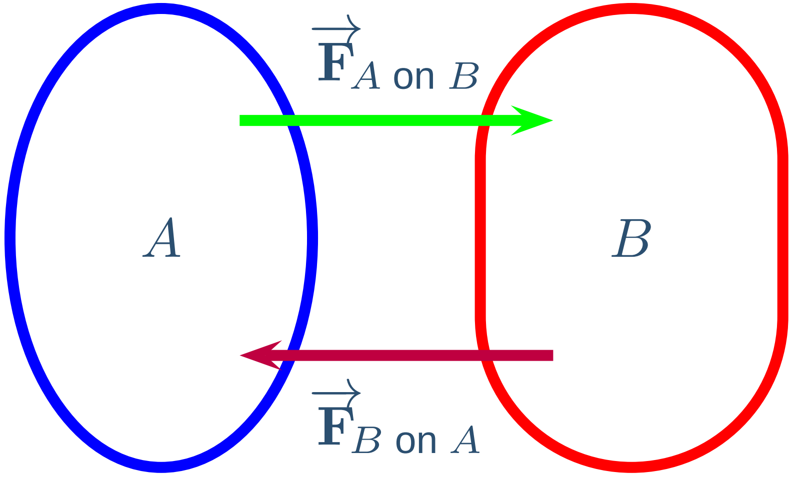
Conservation of Momentum



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

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

Conservation of Momentum

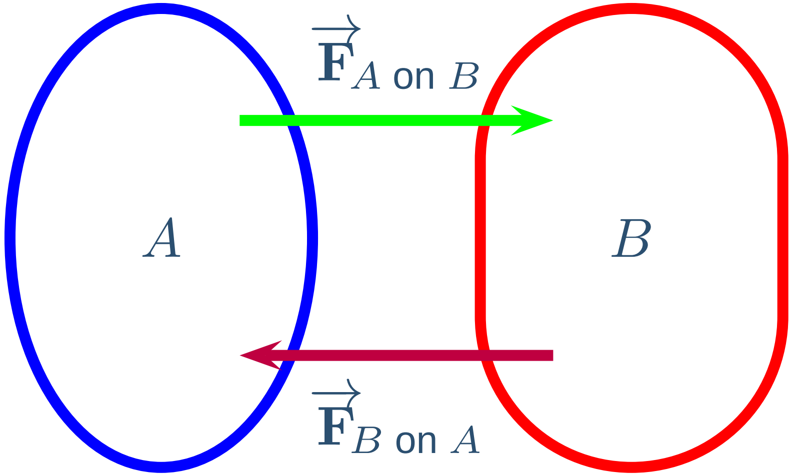


$\overrightarrow{\mathbf{F}}_{A \text{ on } B} =$ Force on B due to A

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



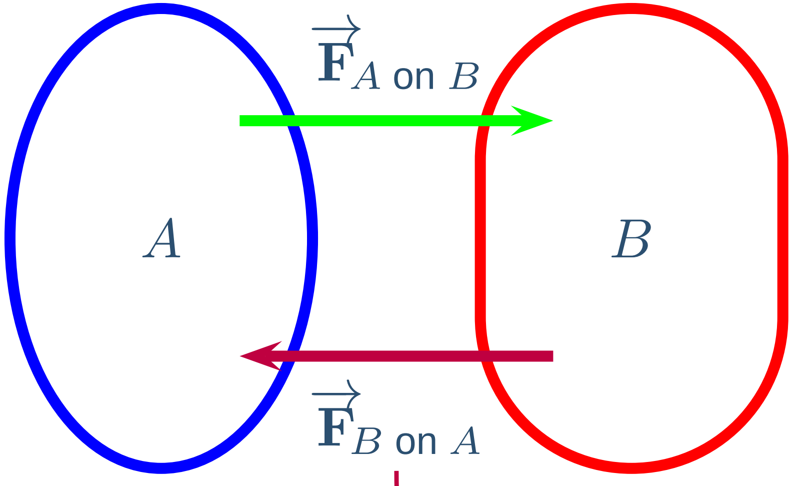
$\overrightarrow{\mathbf{F}}_{A \text{ on } B} =$ Force on B due to A

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



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

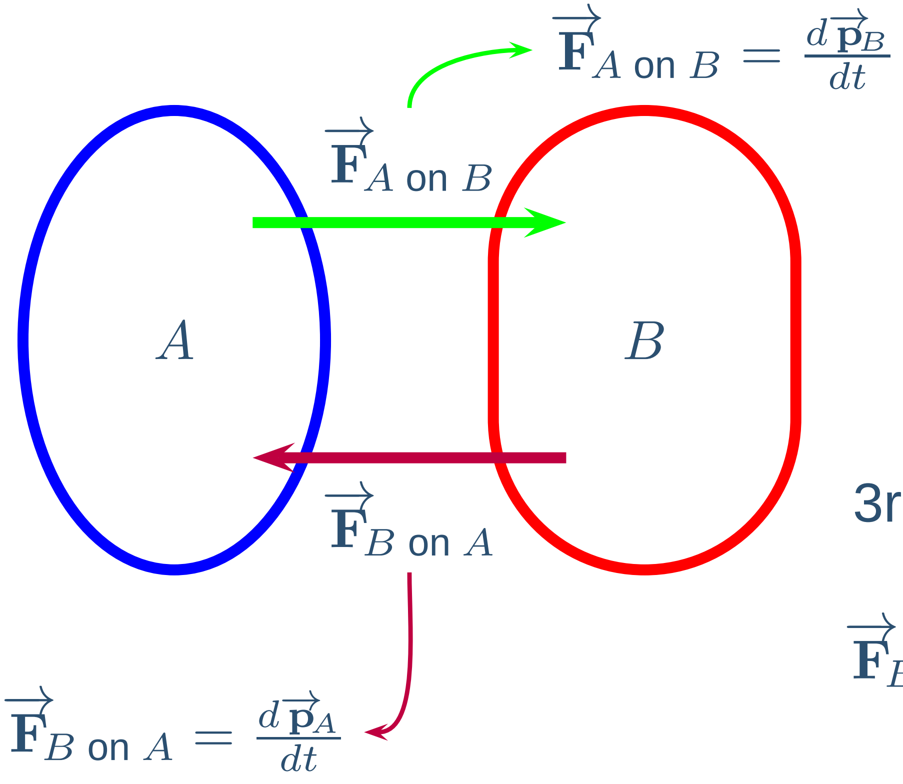
$\overrightarrow{\mathbf{F}}_{A \text{ on } B}$ = Force on B due to A

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



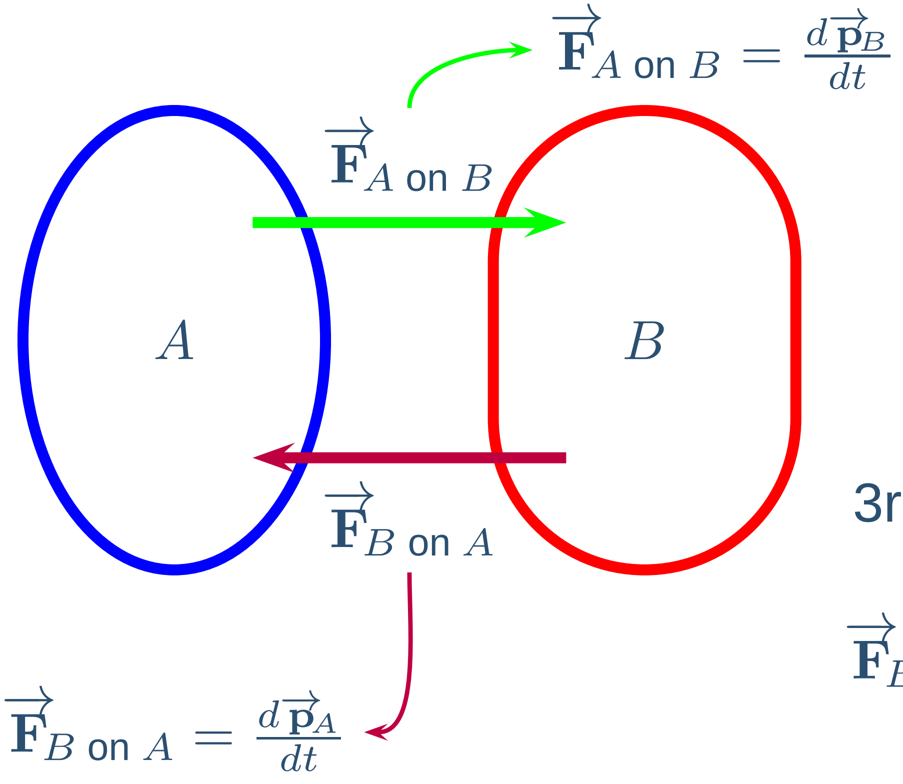
$\overrightarrow{\mathbf{F}}_{A \text{ on } B} =$ Force on B due to A

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



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

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

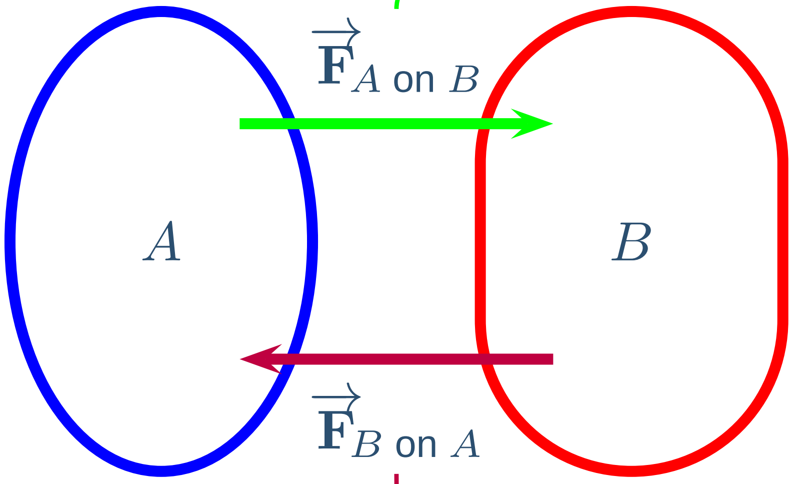
3rd Law: $\vec{\mathbf{F}}_{B \text{ on } A} = -\vec{\mathbf{F}}_{A \text{ on } B}$

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

$$\frac{d\vec{\mathbf{p}}_A}{dt} + \frac{d\vec{\mathbf{p}}_B}{dt} = 0$$

Conservation of Momentum

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



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

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

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

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

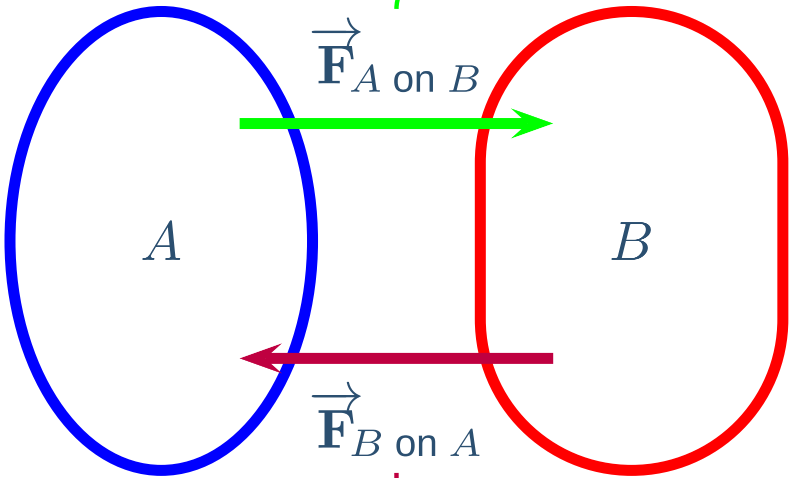
$$\overrightarrow{\mathbf{F}}_{B \text{ on } A} = \frac{d\overrightarrow{\mathbf{p}}_A}{dt}$$

$$\frac{d\overrightarrow{\mathbf{p}}_A}{dt} + \frac{d\overrightarrow{\mathbf{p}}_B}{dt} = 0$$

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

Conservation of Momentum

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



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

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

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

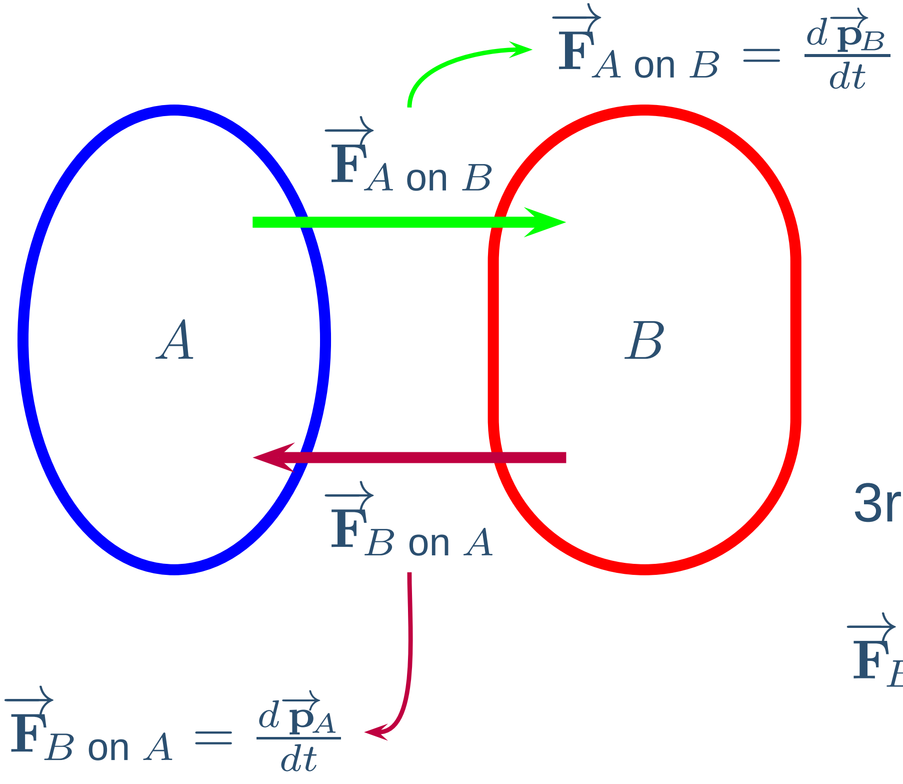
3rd Law: $\overrightarrow{\mathbf{F}}_{B\text{ on }A} = -\overrightarrow{\mathbf{F}}_{A\text{ on }B}$

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

$$\frac{d\overrightarrow{\mathbf{p}}_A}{dt} + \frac{d\overrightarrow{\mathbf{p}}_B}{dt} = 0$$

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

Conservation of Momentum



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

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

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

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

$$\frac{d\overrightarrow{\mathbf{p}}_A}{dt} + \frac{d\overrightarrow{\mathbf{p}}_B}{dt} = 0$$

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

The *total* momentum can't change