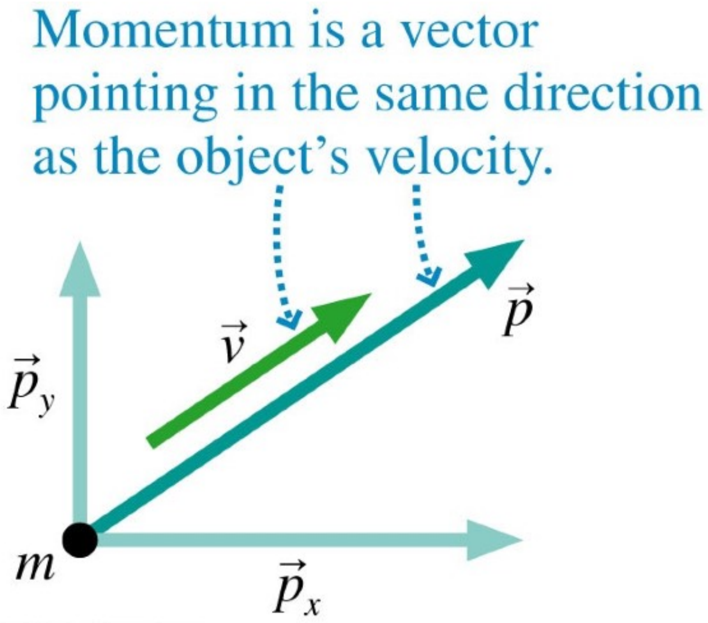
Momentum

- The product of an object's mass and velocity <u>vector</u> is its momentum

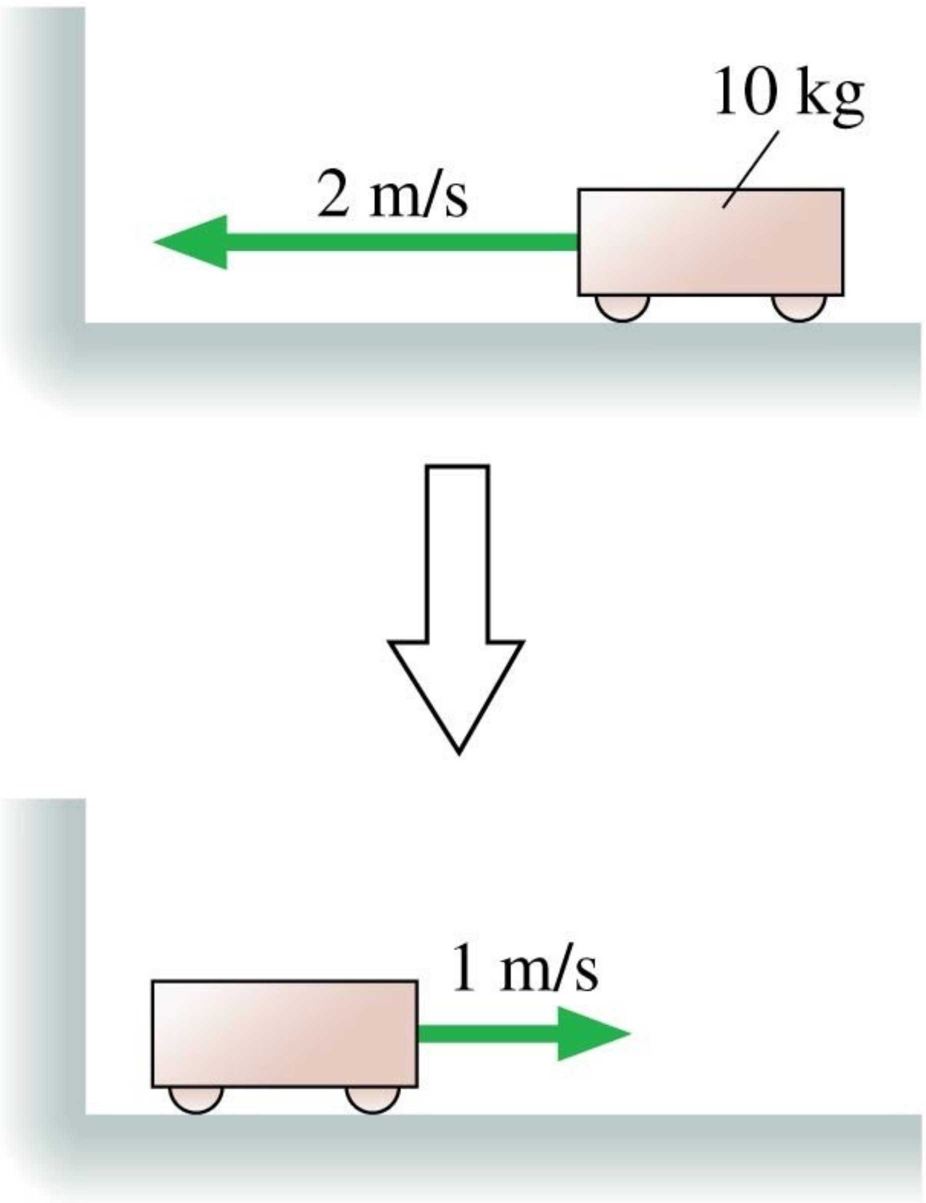
$$\text{momentum } = \vec{p} = m\vec{v}$$



Question #40

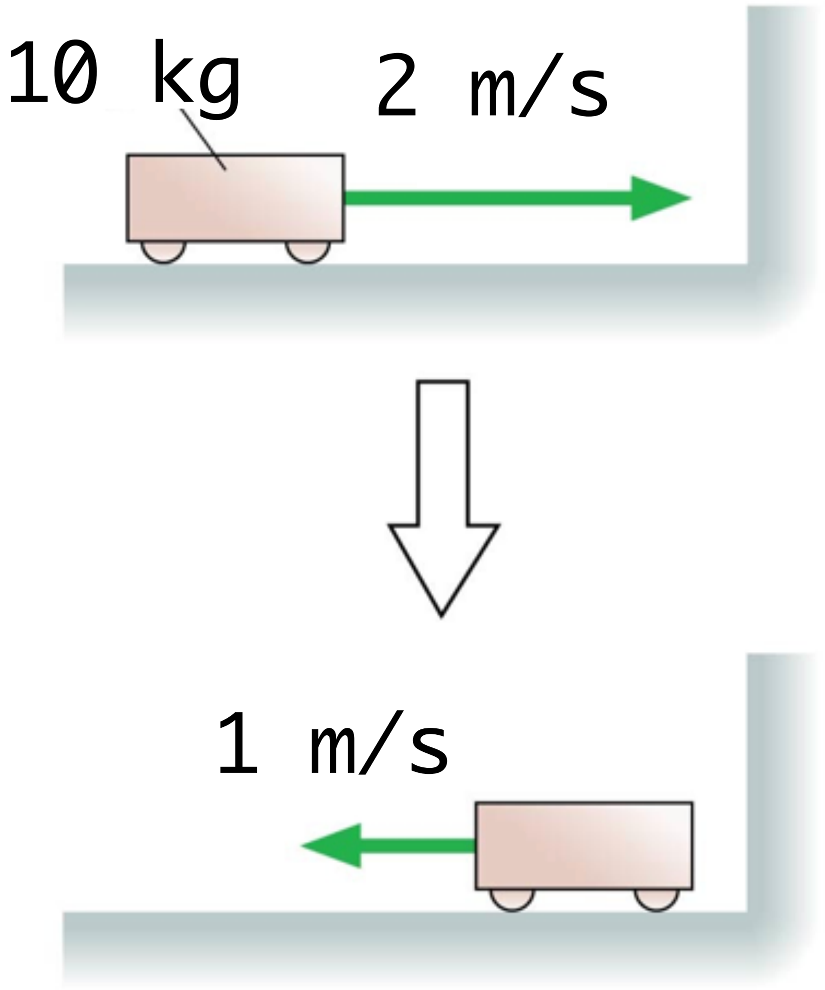
The cart's <u>change</u> of momentum Δp_x is

a. –20 kg m/s.
b. 10 kg m/s.
c. 0 kg m/s.
d. 30 kg m/s.
e. -10 kg m/s.



Question #41

The cart's <u>change</u> of momentum Δp_x is



a. -20 kg m/s.
b. -10 kg m/s.
c. 30 kg m/s.
d. 10 kg m/s.
e. -30 kg m/s.

Question #42

You and your friend drop eggs from a very high distance. Your egg hits the surface of the asphalt. Your friend's egg lands in an enormous box of packing peanuts.

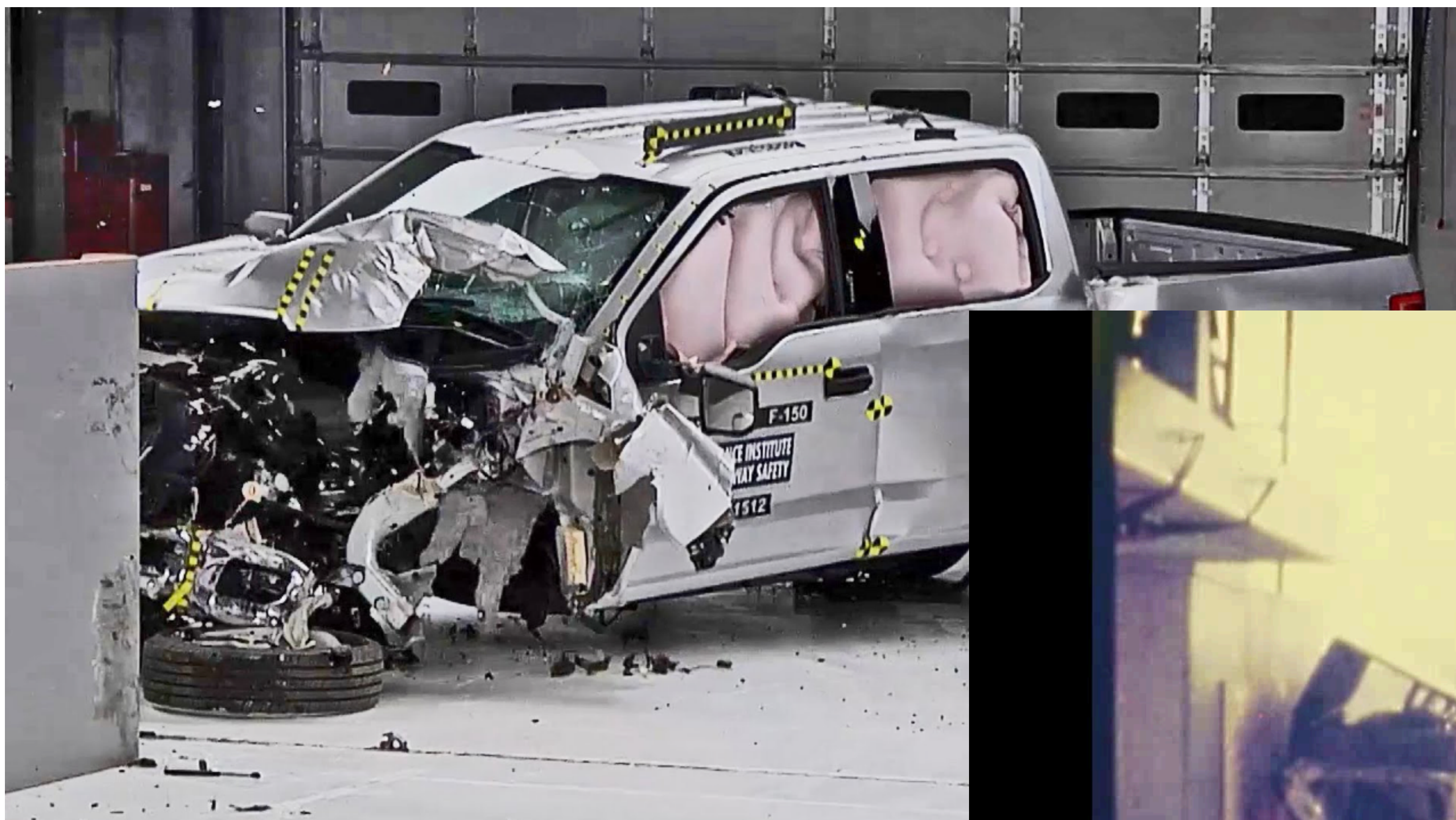
Which of the three quantities listed below are **<u>the same</u>** for the two scenarios?

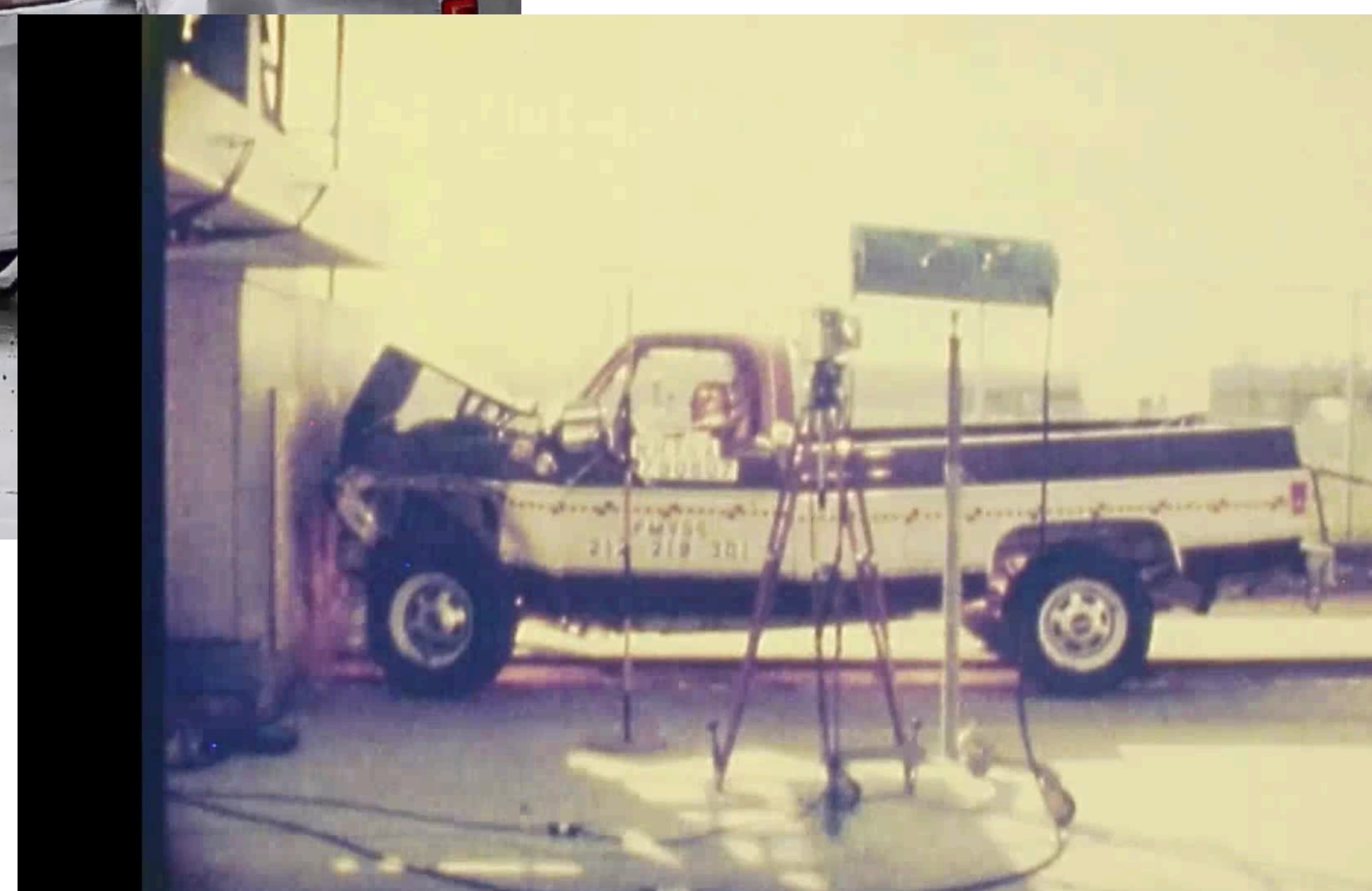
a) 3 only
b) 1 and 2
c) 1 and 3
d) 2 only
e) 1 only

1. Peak force on egg
2. collision time
3. change in momentum

Question #43

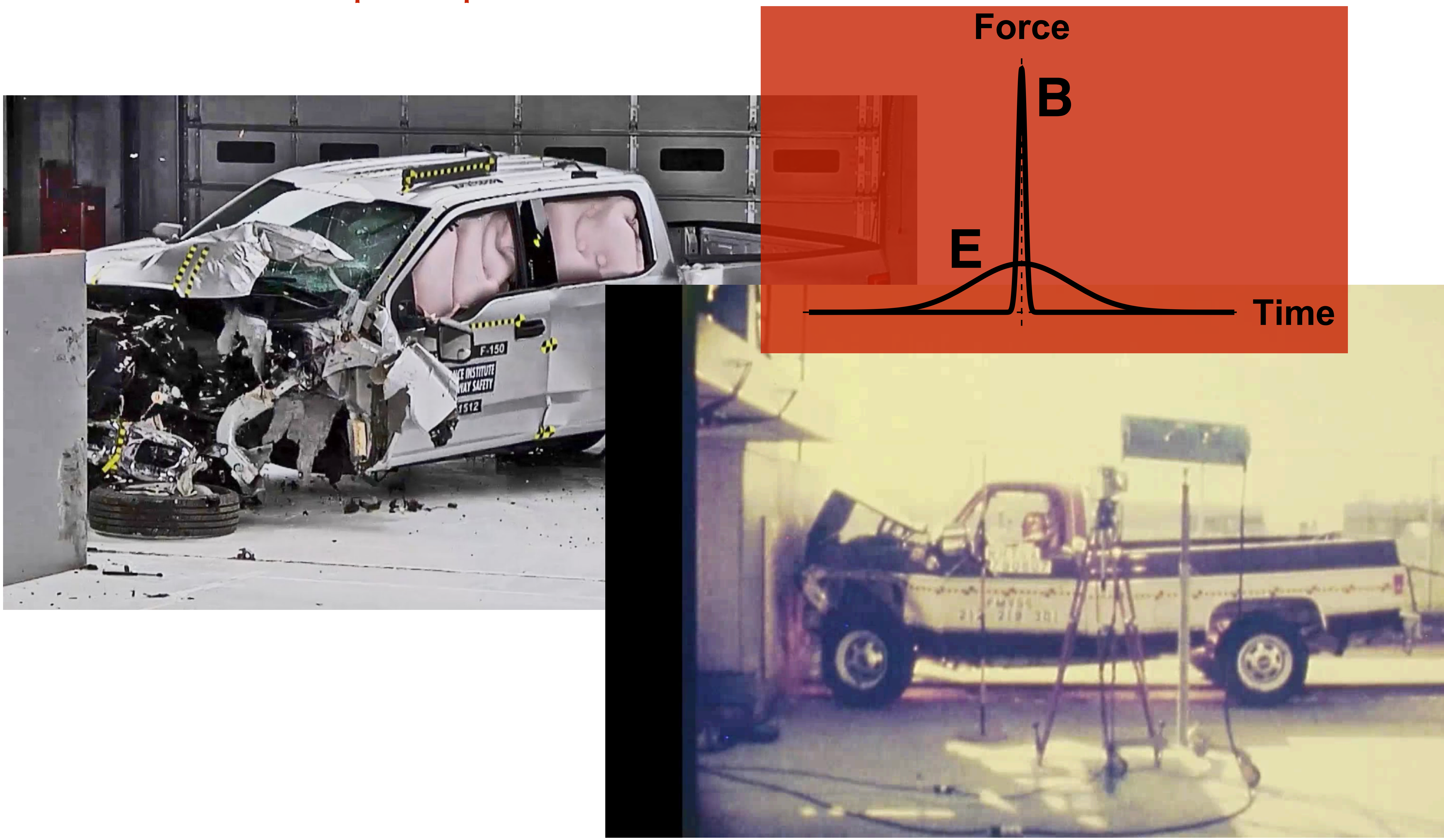
We are living in the 21st century. Why can't we design a car that does not get demolished in a wreck? Don't we have stronger materials?





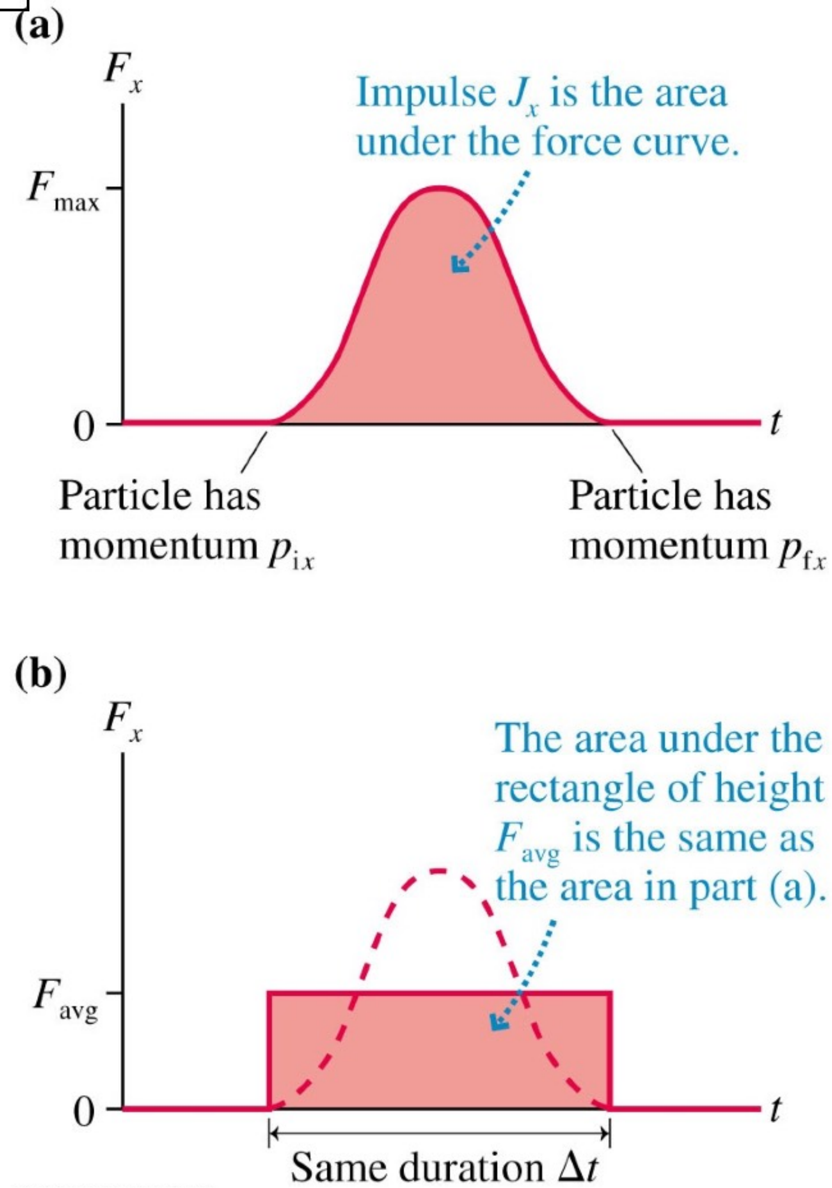
Question #43

Which force vs. time graph corresponds to the crash involving the modern ford pickup?



Impulse

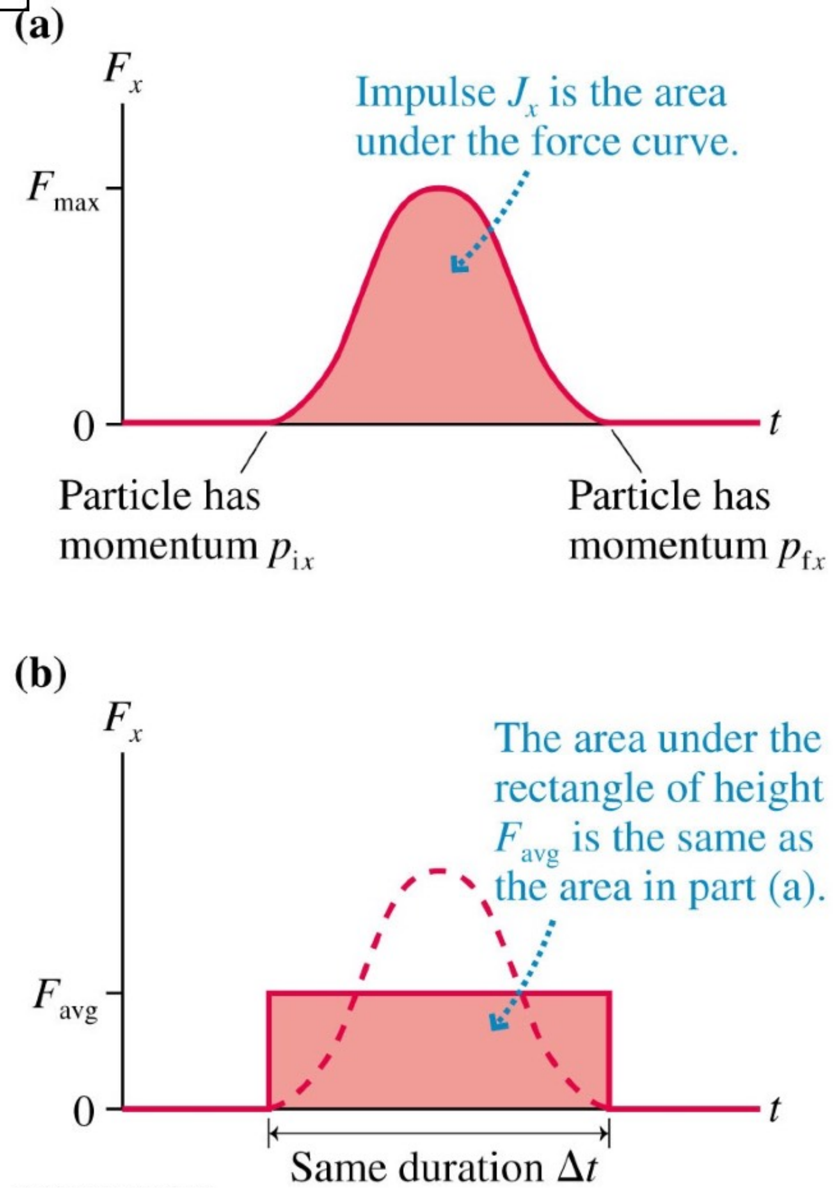
Newton's second law can be formulated in terms of momentum rather than acceleration



Impulse

Newton's second law can be formulated in terms of momentum rather than acceleration

$$\vec{F} = m\vec{a} = m\frac{d\vec{v}}{dt} = \frac{d(m\vec{v})}{dt} = \frac{d\vec{p}}{dt}$$



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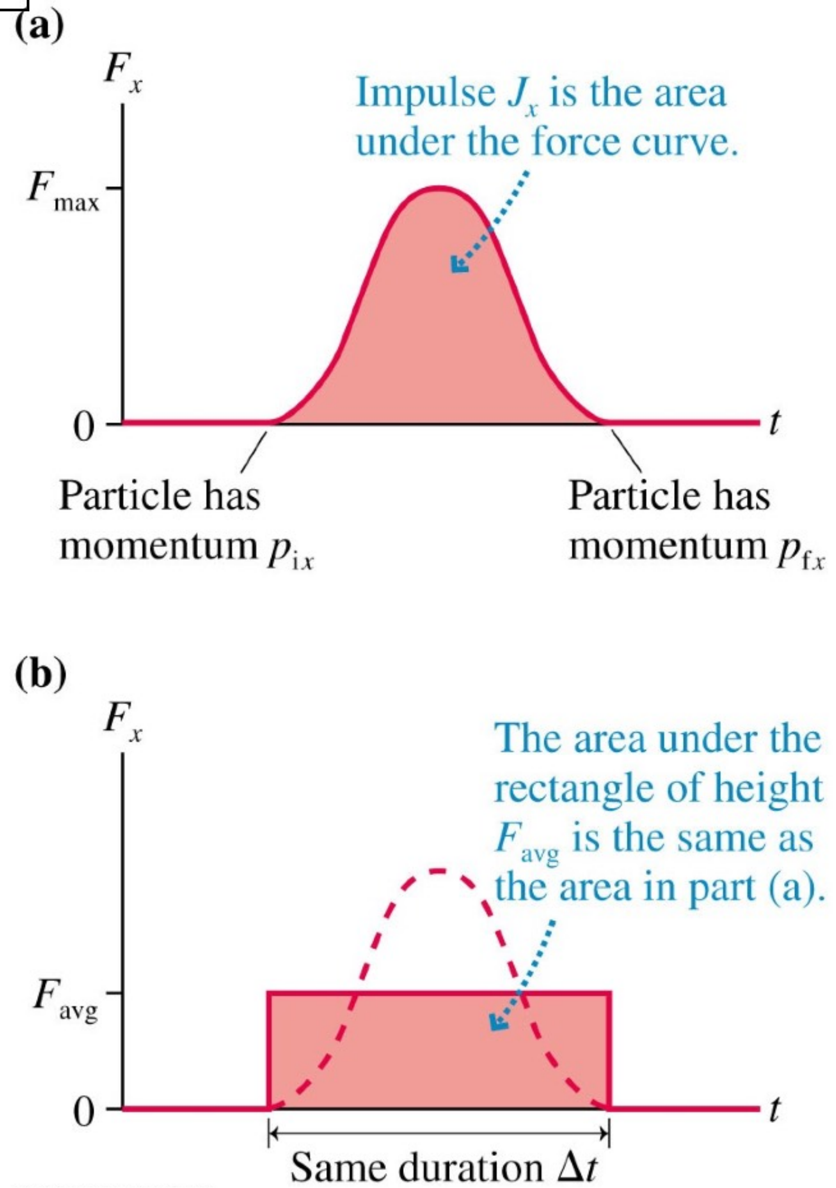
$$\vec{F} = m\vec{a} = m\frac{d\vec{v}}{dt} = \frac{d(m\vec{v})}{dt} = \frac{d\vec{p}}{dt}$$

$$\Delta p_x = p_{fx} - p_{ix} = \int_{t_i}^{t_f} F_x(t)\, dt$$



Impulse

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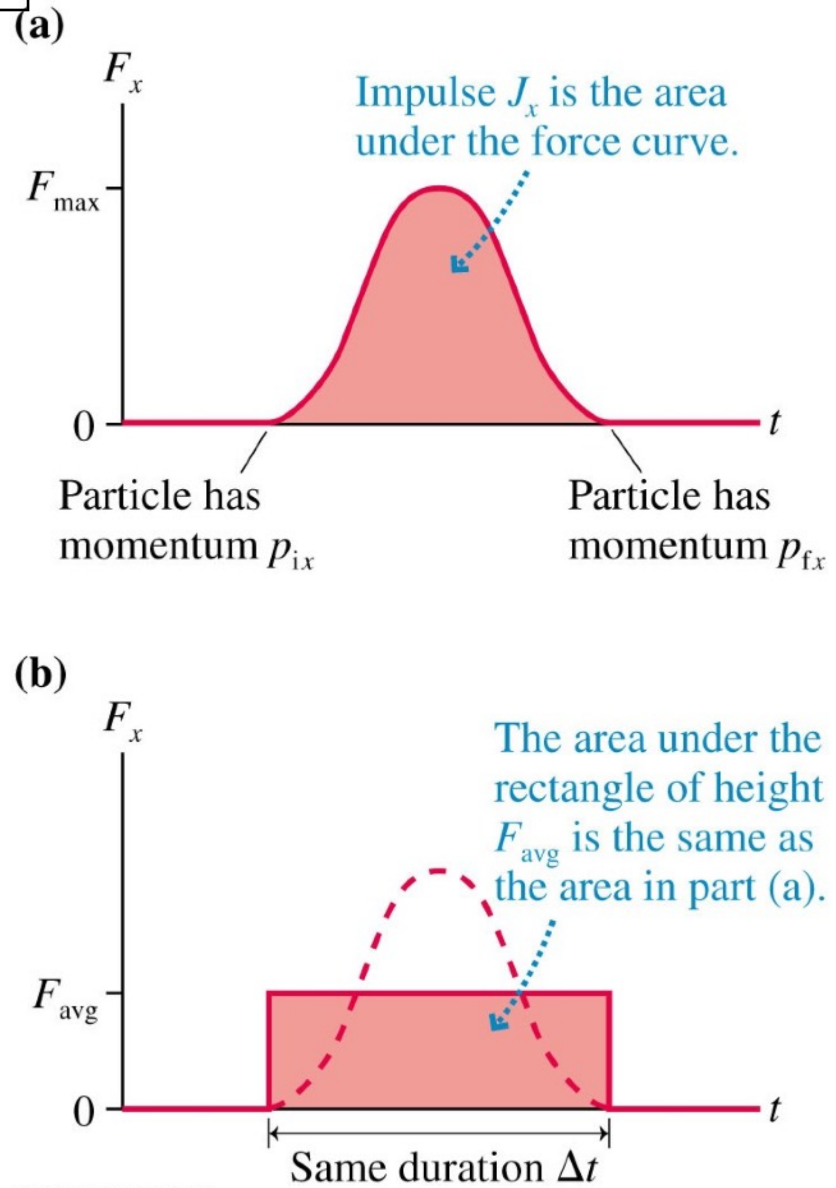
$$\Delta p_x = p_{\mathrm{f}x} - p_{\mathrm{i}x} = \int_{t_\mathrm{i}}^{t_\mathrm{f}} F_x(t)\, dt$$

$$\text{Impulse} = J_x \equiv \int_{t_i}^{t_f} F_x(t) dt$$



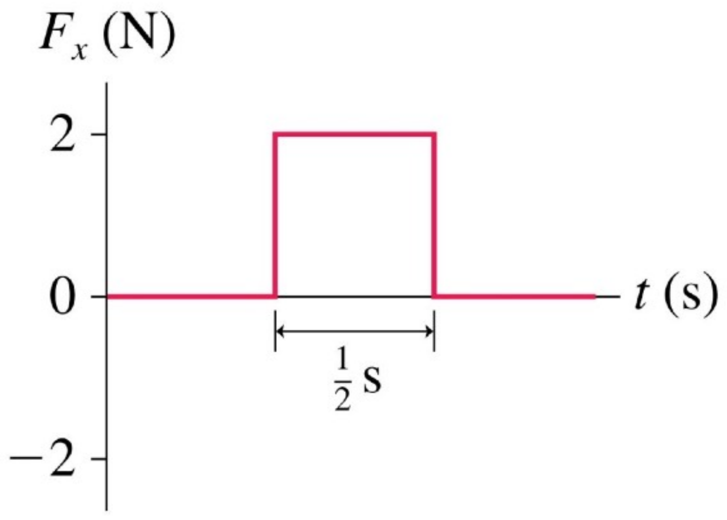
Impulse-momentum theorem

The impulse delivered to a particle is equal to the change in the particle's momentum

$$\Delta p_x = J_x \qquad \text{Impulse-momentum theorem}$$

Question #44

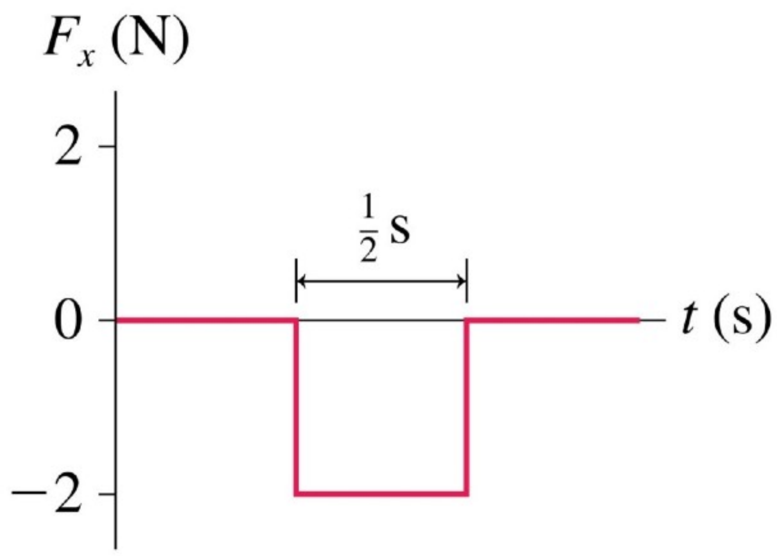
A 2.0 kg object moving to the right with speed 0.50 m/s experiences the force shown. What are the object's speed and direction after the force ends?



a. 0.50 m/s left.
b. At rest.
c. 0.50 m/s right.
d. 2.0 m/s right.
e. 1.0 m/s right.

Question #45

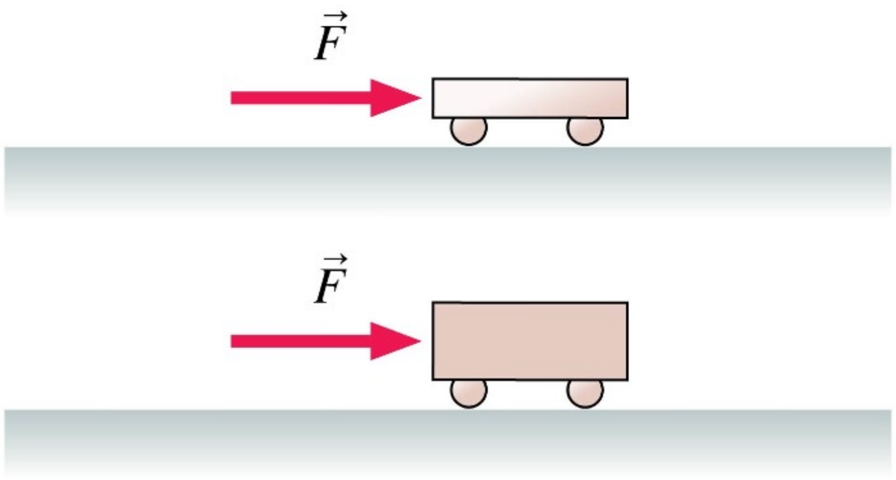
A 2.0 kg object moving to the right with speed 0.50 m/s experiences the force shown. What are the object's speed and direction after the force ends?



a. 0.50 m/s left.
b. At rest.
c. 0.50 m/s right.
d. 1.0 m/s right.
e. 2.0 m/s right.

Question #46

A light plastic cart and a heavy steel cart are both pushed with the same force for 1.0 s, starting from rest. After the force is removed, the momentum of the light plastic cart is ________ that of the heavy steel cart.



a. less than

b. greater than

c. equal to

d. Can't say. It depends on how big the force is.

Question #47

You awake in the night to find that your living room is on fire. Your one chance to save yourself is to throw something that will hit the back of your bedroom door and close it, giving you a few seconds to escape out the window. You happen to have both a sticky ball of clay and a super-bouncy Superball next to your bed, both the same size and same mass. You've only time to throw one. Which will it be? Your life depends on making the right choice!

B. It doesn't matter. Throw either.

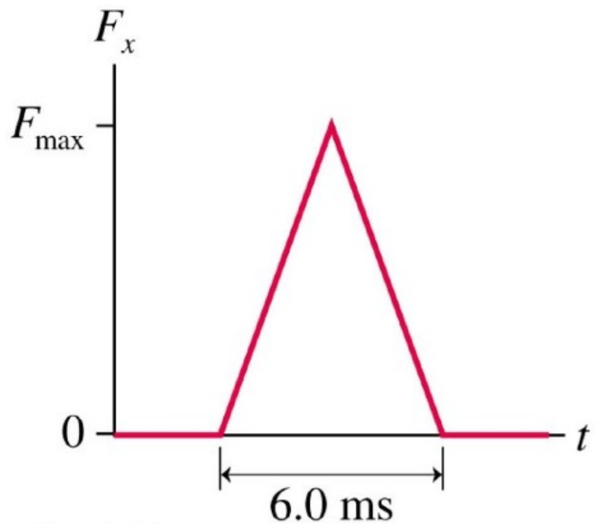
C. Throw the ball of clay.

D. Throw the Superball.

Happy/Sad Pendulum Demo

Throwing a baseball

A 150 g baseball is thrown with a speed of 20 m/s. It is hit straight back toward the pitcher at a speed of 40 m/s. The interaction force between the ball and the bat is shown in the figure below. What maximum force does the bat exert on the ball?



One more problem

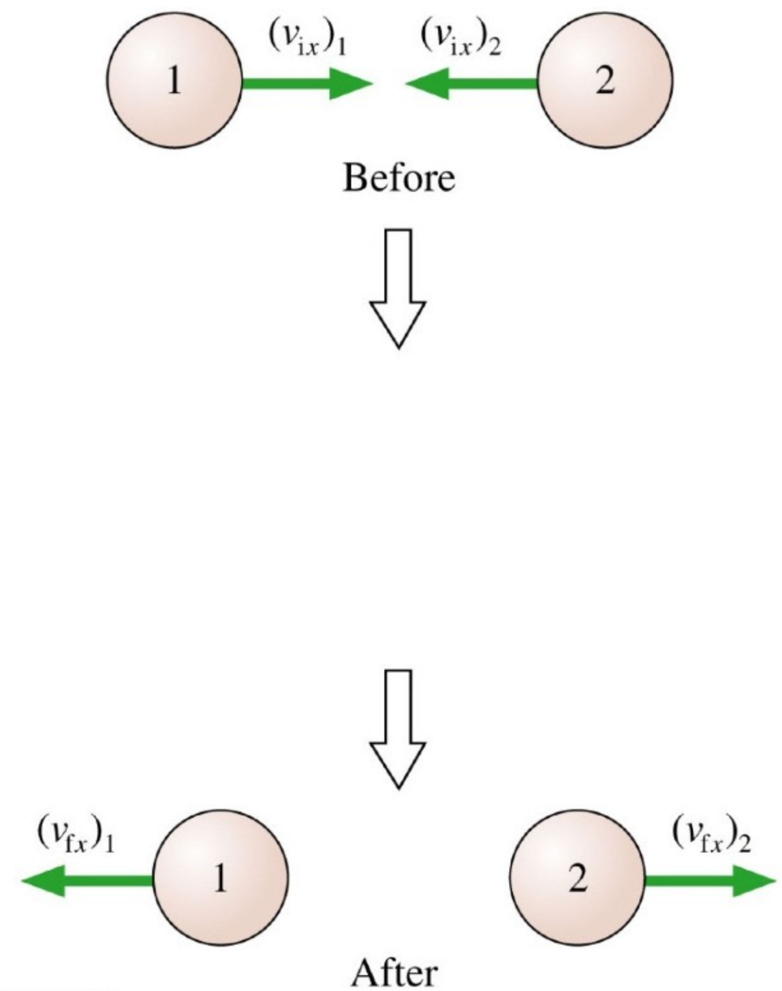
A sled slides along a horizontal surface on which the coefficient of kinetic friction is 0.25. Its velocity at point A is 8.0 m/s and its velocity at point B is 5.0 m/s. Use the impulse-momentum theorem to find how long the sled takes to travel from point A to point B.

Conservation of momentum

Question worth pondering: How does the impulse on ball 1 compare to the impulse on ball 2?

a) Impulse on ball 1 is greater than impulse on ball 2.
b) Impulse on ball 2 is greater than impulse on ball 1
c) Impulses are equal.

$$\text{Impulse} \;=\; J_x \equiv \int_{t_i}^{t_f} F_x(t)dt$$



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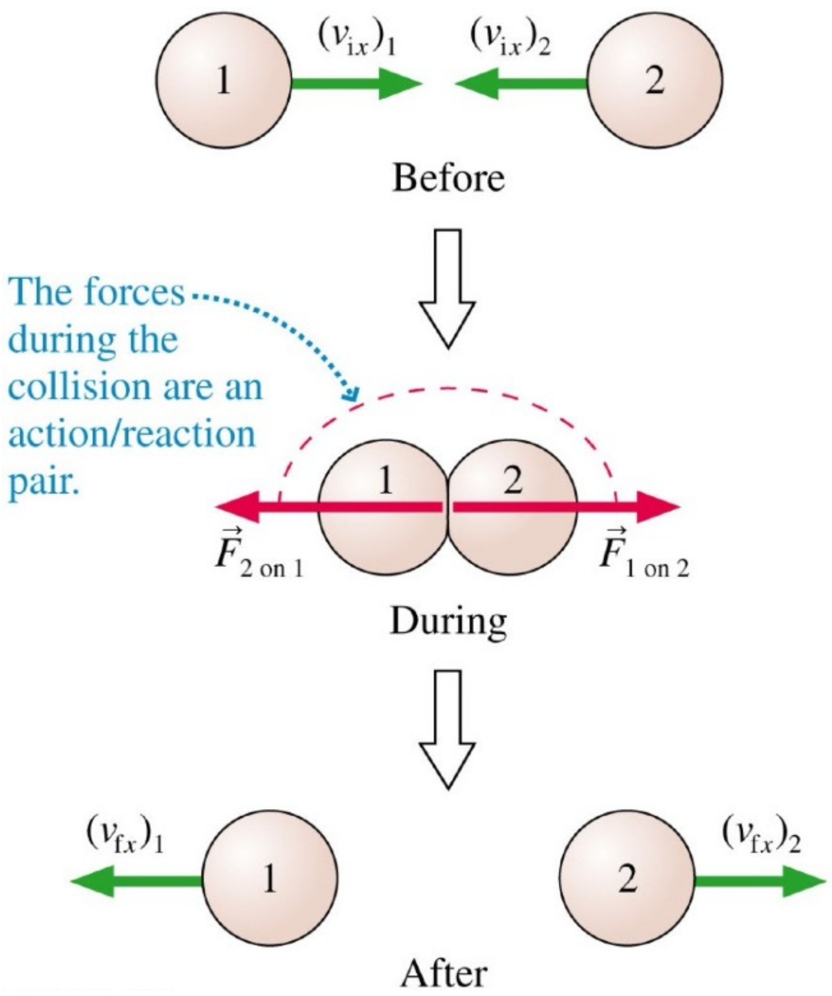

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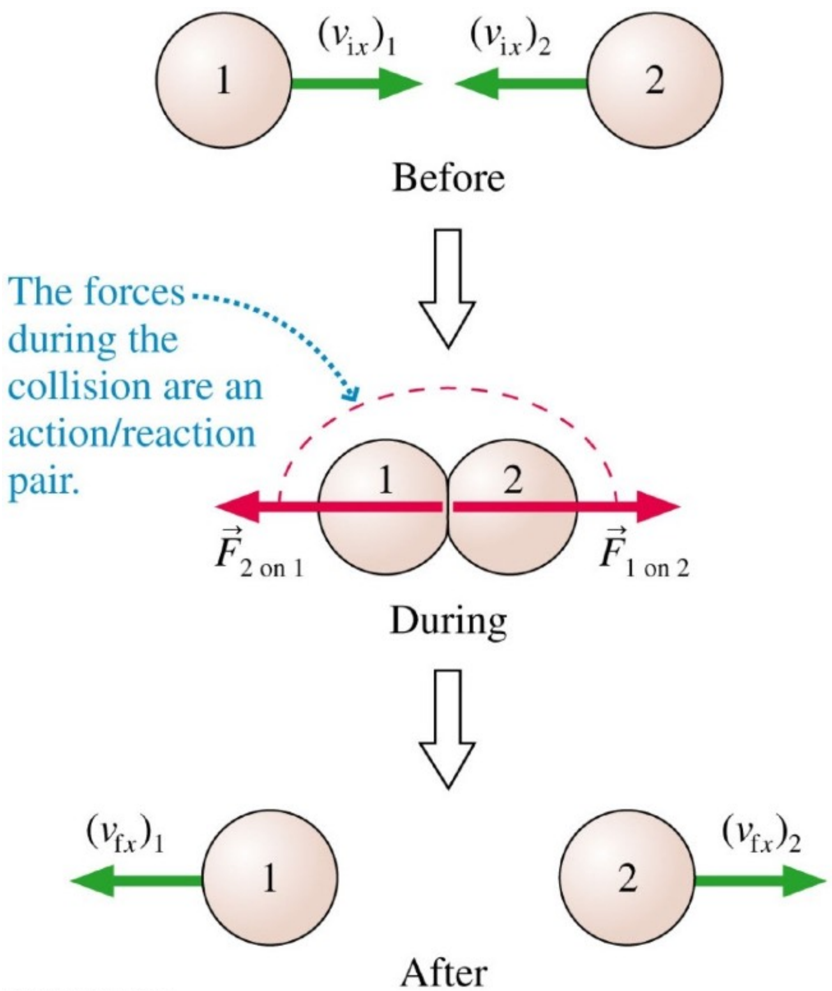

Conservation Law

$$(p_{fx})_1 + (p_{fx})_2 = (p_{ix})_1 + (p_{ix})_2$$

Conservation of momentum

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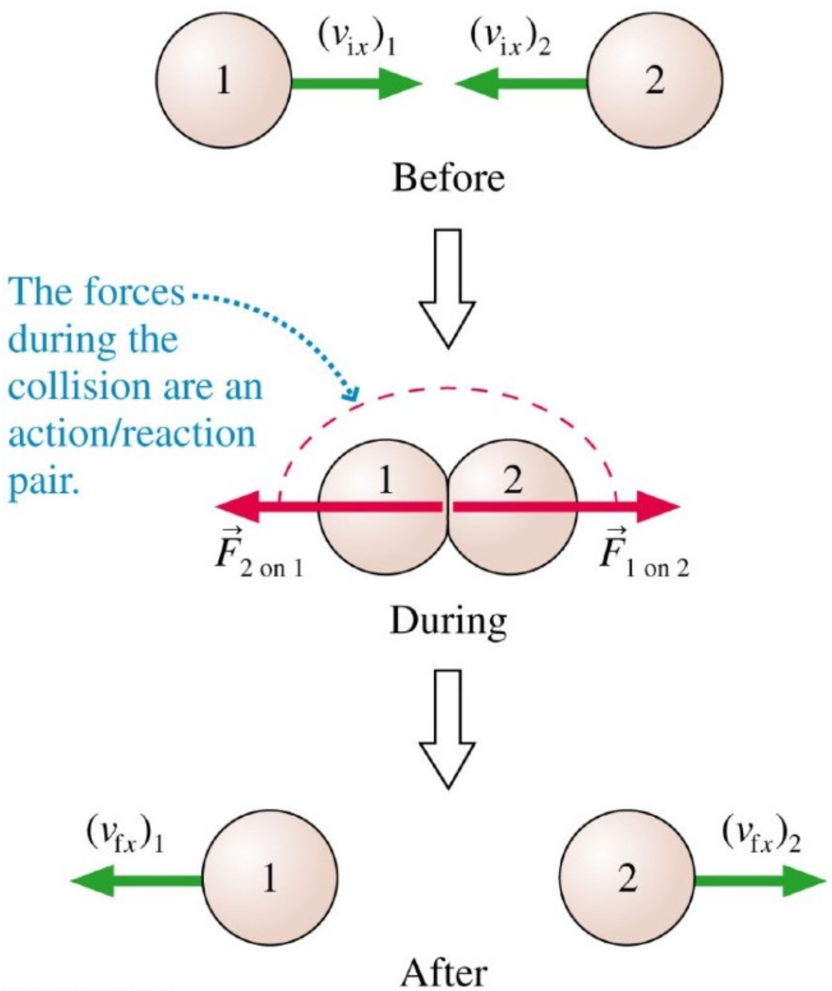


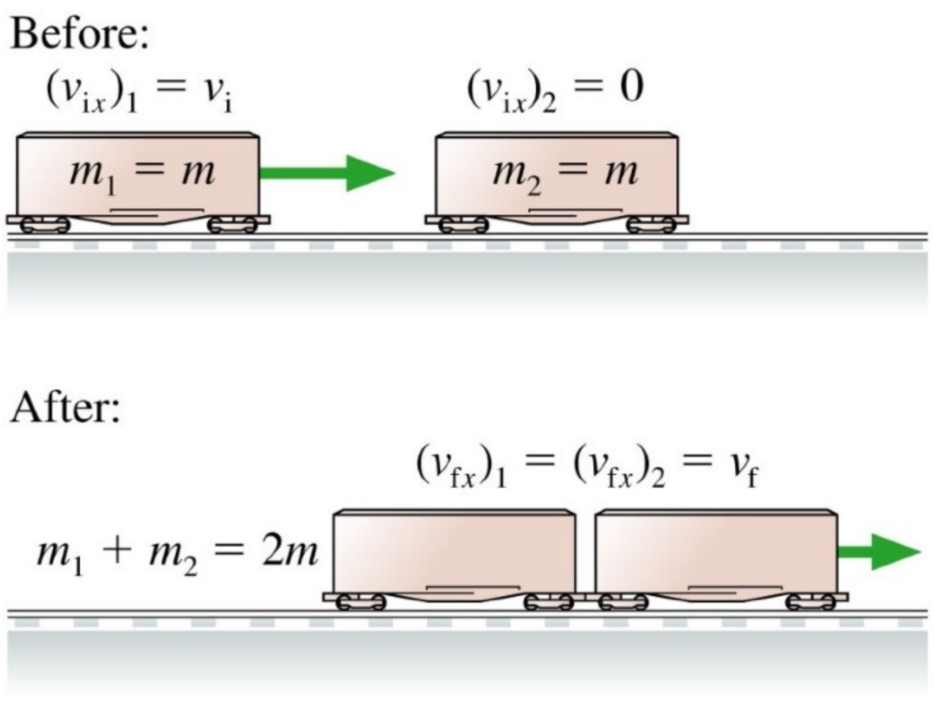
Conservation Law

$$(p_{fx})_1 + (p_{fx})_2 = (p_{ix})_1 + (p_{ix})_2$$

http://serc.carleton.edu/dmvideos/videos.html

Example

A train car moves to the right with initial speed vi. It collides with a stationary train car of equal mass. After the collision the two cars are stuck together. What is the train cars' final velocity?



$$m_1 v_{1f} + m_2 v_{2f} = m_1 v_{1i} + m_2 v_{2i}$$

$$2mv_f = mv_i + 0$$

$$v_f = \frac{1}{2} v_i$$