Intro Physics
Spring 2021

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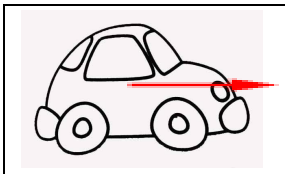
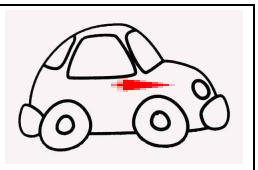
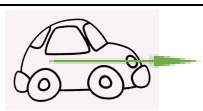
Linear Momentum and its Conservation

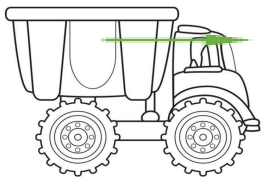


Fast-moving car



Slow-moving car





Truck and car moving with the same speed

1. Defining momentum

- Momentum: *inertia in motion*.

Magnitude:

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Example 1: Can a small sports car ever have the same momentum as a large sport-utility vehicle with three times the sports car's mass? Explain.

Example 2: The magnitude of the momentum of an object is $64\ kg{\cdot}m/s$. *If the velocity of the object is doubled, what would be the magnitude of the momentum of the object?*

Example 3: Cart A has a mass of 2 kg and a speed of 3m/s. Cart B has a mass of 3 kg and a speed of 2 m/s. Compared to the inertia and magnitude of momentum of cart A, cart B has:

a. *The same inertia and a smaller magnitude in momentum.*
b. *The same inertia and the same magnitude in momentum.*
c. *Greater inertia and a smaller magnitude in momentum.*
d. *Greater inertia and the same magnitude in momentum.*

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2. Conservation of momentum

An **isolated** system is one in which the only (significant) forces are those between the objects in the system. The sum of all these "internal" forces within the system will be zero because of Newton's third law.

Law of conservation of momentum:

The total momentum of an isolated system of objects remains constant.

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Example 4:

BEFORE	**AFTER**
Granny : $m_A = 80\ kg$ and $v_A = 6\ m/s$ Grandson: $m_B = 27\ kg$ and $v_B = 0\ m/s$ 	Granny : $m_A = 80\ kg$ and $v' = ?$ Grandson: $m_B = 27\ kg$ and $v' = ?$ 

Calculate velocity v' after collision:

Your mission:

Show that momentum can be conserved by using the track, the two carts, motion detector(s) and the Lab Quest Mini.

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3. Explosion vs Collision (some reading…)

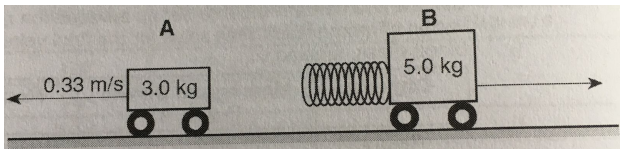
a. Explosion

An explosion results when an object is broken up into two or more pieces.

Example 5:

In the diagram below, you can see two toy cars that were initially at rest on a horizontal, frictionless surface and being pushed together when a compressed spring attached to one of the toy cars is released.

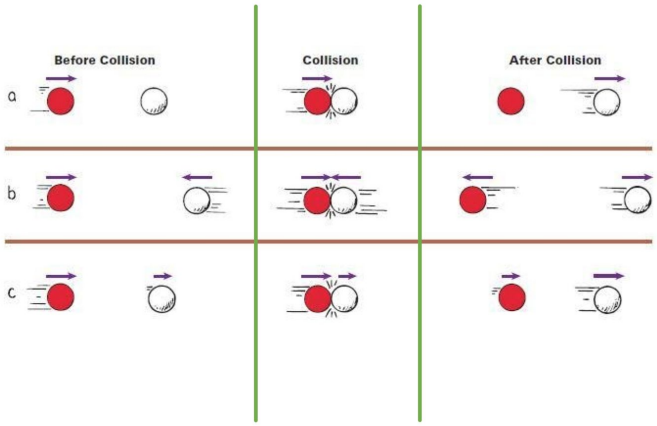
If the speed of Toy Car A is 0.33 m/s after the spring is released, what is the approximate speed of Toy Car B after the spring is released?



b. Collision

A collision is an event in which two (or more) objects approach and interact strongly for a brief period of time.

- **Elastic collision:**



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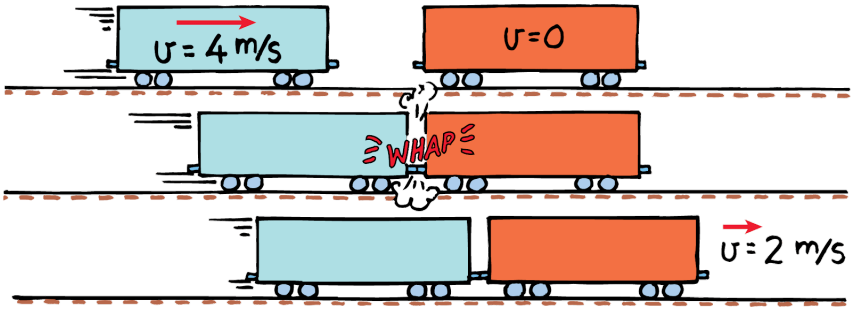
When a moving billiard ball collides head-on with a ball at rest, the first ball comes to rest and the second ball moves away with a velocity equal to the initial velocity of the first ball. We see that momentum is transferred from the first to the second ball.

When objects collide **without being permanently deformed** and **without generating heat**, the collision is said to be an elastic collision.

In each situation above (a, b or c), you can note that the sum of momentum vectors (purple arrow) is the same **before** and **after** each collision.

- **Inelastic collision:**

An inelastic collision occurs whenever colliding objects become tangled or couple together.



Suppose that the freight cars below are of equal mass m. The momentum of the freight car on the left is shared with the freight car on the right.

- **Collision and Kinetic Energy**

For perfect elastic collisions, the kinetic energy after the collision will be equal to the kinetic energy before the collision.

For inelastic collision, some of the kinetic energy will be transformed into thermal energy. As a result, the total energy will be conserved, but the kinetic energy will be lost during the collisions that are not perfectly elastic.