Impulse - Momentum Change Theorem

Lesson Notes

Learning Outcomes

- What does impulse mean?
- What does impulse do?
- What does the impulse-momentum change theorem tell us about collisions and explosions?

The BIG Idea

- The **impulse-momentum change theorem** is the first of two *accounting methods* that we will learn in this Tutorial Series that help us to analyze collisions and explosions.
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What is Impulse?

A collision force will always cause an object to change its velocity - to speed up, to slow down, or to change direction.

Consider the task of stopping a football player:
It takes a combination of force and time to bring the player's momentum to 0.

This combination of force and time is referred to as **impulse**. Mathematically, impulse is …

Impulse = Force • Time

Unit on impulse: Newton•second (abbreviated N•s).

What Does Impulse Do?

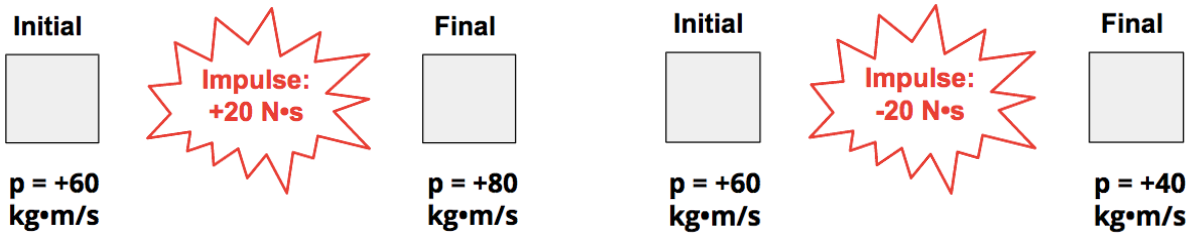
During a collision, a force acts upon an object for a given amount of time to cause a change in momentum. That is, an **impulse** causes a **momentum change**.

And the impulse is equal to the momentum change.

Impulse = Momentum Change

$$\underbrace{F \cdot \Delta t}_{\text{Impulse}} = \underbrace{m \cdot \Delta v}_{\text{Momentum Change}}$$

Impulse is a means of transferring momentum, adding it to an object or removing it from an object.



Many Ways to Get the Same Impulse

How do you stop an 80-kg football player moving at 10 m/s?

Momentum Change = m•Δv = (80 kg)•(-10 m/s) = -800 kg•m/s

You must apply an **impulse of -800 N•s** to stop the player! That impulse can come from many combinations of force and time.

ΔMomentum	Impulse	Force	Time
-800 kg•m/s	-800 N•s	-800 N	1.0 s
-800 kg•m/s	-800 N•s	-80 N	10.0 s
-800 kg•m/s	-800 N•s	-8000 N	0.10 s
-800 kg•m/s	-800 N•s	-80 000 N	0.010 s

Hit-and-Stick vs. Rebounding Collisions

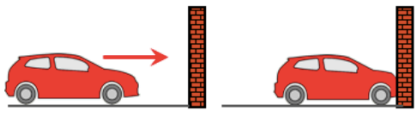
The momentum change of an object is always calculated as …

Final momentum - Initial Momentum

… or simply as m•Δv where the Δv is Final Velocity - Initial Velocity

Hit-and-Stick Collision

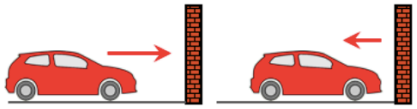
A 1000-kg moving at 10 m/s hits a wall and comes to a stop.



Δv = -10 m/s
Δp = Impulse = -10 000 N•s

Rebounding Collision

A 1000-kg moving at 10 m/s hits a wall and rebounds a -5 m/s.



Δv = -15 m/s
Δp = Impulse = -15 000 N•s

Larger Impulse!!