Chapter Six: Newton's Laws of Motion

- 6.1 Newton's First Law
- 6.2 Newton's Second Law
- 6.3 Newton's Third Law and Momentum

Chapter 6.3 Learning Goals

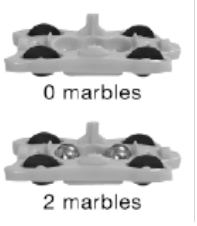
- Describe action-reaction force pairs.
- Explain what happens when objects collide in terms of Newton's third law.
- Apply the law of conservation of momentum when describing the motion of colliding objects.

Investigation 6B

Newton's Third Law

- **Key Question:**

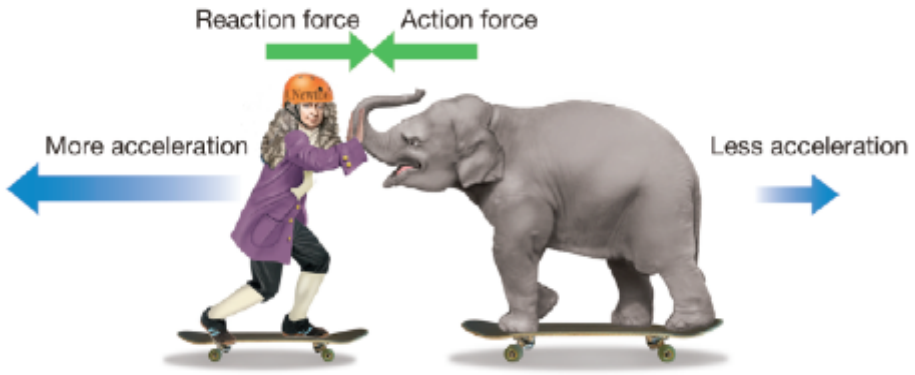
  What happens when equal and opposite forces are exerted on a pair of Energy Cars?



6.3 Newton's Third Law

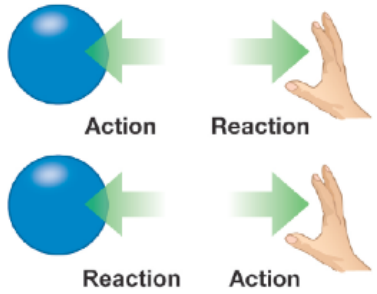
- **Newton's Third Law (action-reaction) applies when a force is placed on any object, such as a basketball.**

Newton's Third Law and Momentum



6.3 The Third Law: Action/Reaction

- Newton's Third Law states that every action force creates a reaction force that is equal in strength and opposite in direction.
- There can never be a single force, alone, without its action-reaction partner.

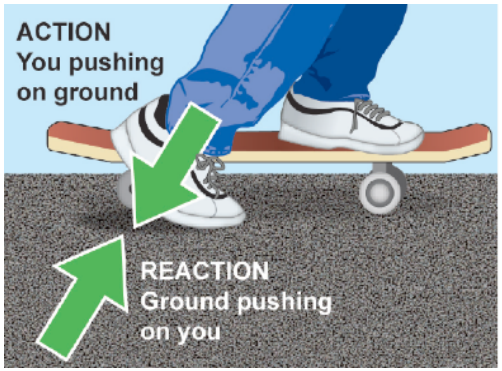


6.3 The Third Law: Action/Reaction

One force acts on the ball, and the other force acts on the hand.

- It doesn't matter which force you call the action and which the reaction.
- The forces do not cancel because we can only cancel forces acting on the same object.

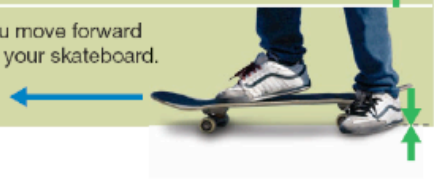
6.3 Action and reaction



- When sorting out action and reaction forces it is helpful to examine or draw diagrams.

The action force is on the _____, and the reaction force is on the _____.

Action Reaction Guidlines

Guidelines for Action-Reaction Forces	Examples
Both are always there whenever any force appears.	Your foot pushes (action) and the ground pushes back (reaction). 
They always have the exact same strength.	The force arrows are the same length. 
They always act in opposite directions.	The force arrows point in opposite directions.
They always act on different objects.	Your foot and the ground. 
Both are real forces and can cause changes in motion.	You move forward on your skateboard. 

Solving Problems

- A woman with a weight of 500 newtons is sitting on a chair.
- Describe one action-reaction pair of forces in this situation.

Action:
Sitting on a chair

6.3 Collisions

- Newton's third law tells us that any time two objects hit each other, they exert equal and opposite forces on each other.
- The effect of the force is not always the same.

6.3 Momentum

- Momentum is the mass of a object times its velocity.
- The units for momentum are kilogram-meter per second (kg·m/s).

MOMENTUM

Momentum (kg-m/sec) — $P = mv$ — ***Mass*** (kg), ***Velocity*** (m/sec)

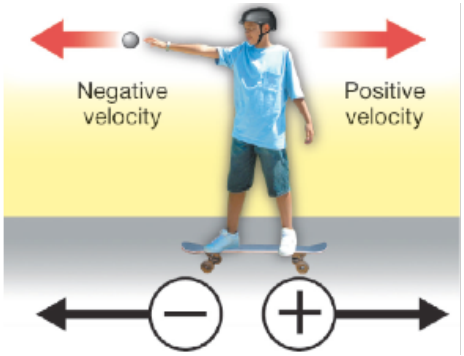
Solving Problems: Conservation of Momentum

MOMENTUM

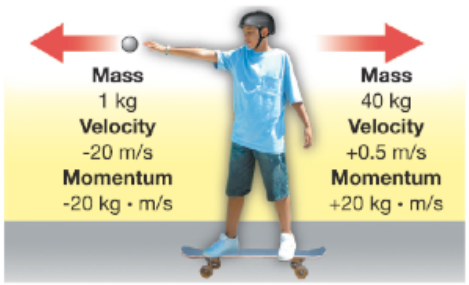
Momentum (kg-m/sec) $P = mv$ ***Mass*** (kg), ***Velocity*** (m/sec)

6.3 Momentum

- The law of conservation of momentum states that as long as the interacting objects are not influenced by outside forces (like friction) the total amount of momentum is constant or does not change.



6.3 Momentum



We use positive and negative numbers to show opposite directions.

- The result of a skateboarder throwing a 1-kg ball at a speed of -20 m/sec is that he and the skateboard with a total mass of 40 kg move backward at a speed of +0.5 m/sec (if you ignore friction).

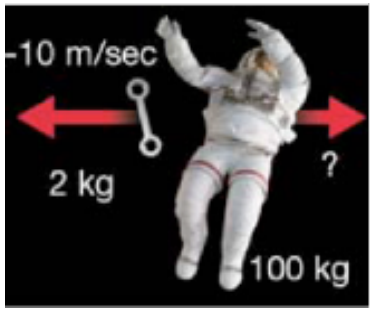
6.3 Collisions

- When a large truck hits a small car, the forces are equal.
- The small car experiences a much greater change in velocity much more rapidly than the big truck.

Which vehicle ends up with more damage?

Solving Problems

- If an astronaut in space were to drop a 2-kilogram wrench at a speed of 10 m/s, the astronaut would move backward at what speed?
- The astronaut's mass is 100 kilograms.



Solving Problems

1. **Looking for:**
   - … the velocity of the astronaut (backward)
2. **Given**
   - …velocity$_1$ = 10 m/s; mass$_1$= 2 kg;
   - …mass$_2$ = 100 kg;
3. **Relationships:**
   - $m_1v_1 = m_2v_2$
4. **Solution**
   - Draw a free body diagram.

Solving Problems

4. Solution

- The momentum of the wrench and the astronaut also add up to zero AFTER the wrench is thrown.
- $[2\ \text{kg} \times (-10\ \text{m/s})] + [(100\ \text{kg}) \times v_2] = 0$; $v_2 = +20 \div 100 = +0.2\ \text{m/s}$
- The astronaut moves backward at a velocity of +0.2 m/s to the right.

CAREER ▸▸ CONNECTION

Forensic Engineering

- Human bodies are not designed to handle the impact of crashing into a stationary object after traveling through space at the speed of a car.

- The study of how vehicles move before, during, and after a collision is called vehicular kinematics.