Section 2.12: Newton's Third Law of Motion

Newton's Third Law is of called Newton's Law of Action and Reaction. It states that for each action force there is an equal but opposite reaction. In other words,

If Object A exerts a force on Object B
then
Object B exerts an equal but opposite force on Object A

Mathematically: $\mathbf{F_{AB} = - F_{BA}}$ $\mathbf{(F_{A\ on\ B} = - F_{B\ on\ A})}$

There are two important things to point out:

(1) the minus sign indicates that the <u>directions are opposite</u>.

(2) there are two objects and the so-called "action" and "reaction" forces <u>act on different objects</u> (namely each other).

It does not matter which force is called the action force and which force is called the reaction force. **What is important is that neither force can exist without the other. For every action force there must be and equal but opposite reaction force.** In other words, in every interaction, the forces always occur in pairs.

Examples

1 You interact with the floor when you walk. You push backward on the floor and the floor simultaneously pushes you forward. $F_{YF} = - F_{FY}$

2 The tires of a car interact with the road to produce the car's motion. The tires push backward against the road and the road simultaneously pushes forward on the tires. $F_{TR} = - F_{RT}$

3 When swimming, you interact with the water. You push backward on the water and the water pushes you forward. $F_{YW} = - F_{WY}$

Notice that the interactions in the above examples depend on friction. For example, a person trying to walk on ice, where the friction is minimal, may not be able to exert an action force against the ice. Without the action force, there cannot be a reaction force, and thus no resulting forward motion. It is these reaction forces, those acting in the direction of our resulting accelerations that account for our motion in these cases.

Newton's Third Law states that for every action there is an equal but opposite reaction which means that forces always act in pairs. If this is the case, why do object move?

Recipe for Identifying Action-Reaction Forces

Identify the interacting objects A and B. If the action force is A on B then the reaction force is B on A.

Examples

1. Identify the action and reaction forces in the following situations and draw a FBD for each object.

   A You are supporting a 5 N force on your outstretched hand.

   B A falling rock

   C Picking up a bowling ball. Why does the bowling ball move upward?

D A father pulls his daughter on a toboggan. Why does the toboggan move?

2 Mary and Jane both want to dance with John. Mary pulls on one of his arms with 50 N and Jane pulls on his other arm in the opposite direction with a force of 50 N. Do these forces make an action-reaction pair? Explain.

3 A boy roes his boat toward the wharf and when he is a couple of feet from the wharf, he attempts to leap to shore. Explain, with reference to Newton's Second and Third Law, why he may fall into the river.

4 A skater standing at the side of a skating rink pushes against the boards and glides of in the other direction. Explain with reference to Newton's Second and Third Law.