

Chapter 7 Newton's Third Law of Motion—Action and Reaction

Summary

THE BIG IDEA : For every force, there is an equal and opposite force.

7.1 Forces and Interactions

- ✓ A force is always part of a mutual action that involves another force.
 - A mutual action is an **interaction** between one thing and another.
 - An example of interaction occurs when a hammer exerts a force on a nail, and the nail exerts a force on the hammer.

7.2 Newton's Third Law

- ✓ Newton's third law states that whenever one object exerts a force on a second object, the second object exerts an equal and opposite force on the first object.
 - **Newton's third law** describes the relationship between two forces in an interaction. Newton's third law is often stated: "To every action there is always an equal opposing reaction."
 - In an interaction, one force is called the **action force**. The other force is called the **reaction force**. The action and reaction forces are equal in strength and opposite in direction.
 - When you walk on a floor, you push against the floor, and the floor simultaneously pushes against you.

7.3 Identifying Action and Reaction

- ✓ To identify a pair of action-reaction forces, first identify the interacting objects A and B, and if the action is A on B, the reaction is B on A.
 - When a boulder falls to Earth, the *action* is Earth exerting a force on the boulder, and the *reaction* is the boulder simultaneously exerting a force on Earth.
 - A rocket accelerates because the rocket pushes exhaust gas and the exhaust gas pushes on the rocket.

7.4 Action and Reaction on Different Masses

- ✓ A given force exerted on a small mass produces a greater acceleration than the same force exerted on a large mass.
 - Recall that Newton's second law states that acceleration is proportional to the net force and inversely proportional to the mass.
 - When a boulder falls toward Earth, Earth also moves toward the boulder. Because Earth has a huge mass, its acceleration toward the boulder is infinitesimally small. A rocket accelerates because it continually recoils from the exhaust gases ejected from its engine.

Chapter 7 Newton's Third Law of Motion—Action and Reaction**7.5 Defining Systems**

- ✓ **Action and reaction forces do not cancel each other when either of the forces is external to the system being considered.**
- Consider an imaginary system consisting of an orange sitting on a cart. An external force, provided by an apple pulling the cart, causes the system to accelerate in accord with Newton's second law.
 - The fact that the orange simultaneously exerts a force on the apple, which is external to the system, may affect the apple (another system), but not the orange. You can't cancel a force on the orange with a force on the apple.
 - Now consider a larger system, enclosing both the orange and the apple. The force pair is internal to the orange-apple system. Therefore these forces do not cancel each other.
 - A force external to the system, in this case friction, is needed for acceleration. When the apple pushes against the floor, the floor simultaneously pushes on the apple—an external force on the system—and the system accelerates.

7.6 The Horse–Cart Problem

- ✓ **If the horse in the horse–cart system pushes the ground with a greater force than it pulls on the cart, there is a net force on the horse, and the horse–cart system accelerates.**
- Imagine a horse that believes its pull on a cart carrying a farmer will be canceled by the opposite and equal pull by the cart on the horse, thus making acceleration impossible.
 - From the farmer's point of view, the net force on the cart, divided by the mass of the cart, will produce an acceleration.
 - In the system of the horse, the opposite reaction force by the cart on the horse restrains the horse. The horse moves forward by interacting with the ground. When the horse pushes backward on the ground, the ground simultaneously pushes forward on the horse.
 - In the horse–cart system as a whole, the pull of the horse on the cart and the reaction of the cart on the horse are forces that act and react within the system. They cancel and can be neglected. It is the outside reaction by the ground that pushes the system.

7.7 Action Equals Reaction

- ✓ **For every interaction between things, there is always a pair of oppositely directed forces that are equal in strength.**
- Suppose that, for some reason, you punch a wall. You cannot hit the wall any harder than the wall can hit you back.
 - Hold a sheet of paper in midair and tell your friends that the heavyweight champion of the world could not strike the paper with a force of 200 N (45 pounds). The paper is not capable of exerting a reaction force of 200 N, and you cannot have an action force without a reaction force.