

2.6: Newton's Third Law

Explain the motion of objects using Newton's third law.

We have spent much of this lesson discussing forces and how they affect motion. Newton's second law of motion is a very important scientific concept that explains the motion of objects very well. Newton also explained a relationship between the agent and the object of a force. Newton's third law of motion states that for every action force there is an equal and opposite reaction force.

Think back to our definition of what a force is: an interaction between two objects that results in a push or a pull. One object (called the agent of the force) does the pushing or pulling, and the other object (referred to as the object of the force) is being pushed or pulled. Newton discovered that the agent and object of any force are interchangeable. This means that the one you choose as the agent and the one you choose as the object of the force, the box pushes on you with 35 N of force, just in the opposite direction. The interaction between two objects is the same, but the direction of the resulting force is opposite.

Forces always come in pairs called action-reaction pairs. In the above example, the action-reaction pair was you pushing the box and the box pushing you. Notice that the two objects are the same and the contact interaction is the same. Only the direction is different. In the case of you pushing the box, you were the agent and the box was the object. For the box pushing back on you, you were the



Fig. 2.21: Newton's third law

object and the box was the agent. Identifying action-reaction pairs of forces is really easy to do if you remember two little details:

- 1. The two objects involved are the same. The object of one force is the agent of the other and vice versa (i.e., you pushing the box and the box pushing on you).
- 2. The sizes of the pairs of forces are the same, but the direction is exactly opposite. (It does not matter if there is constant velocity or acceleration: paired forces are always equal and opposite.)

This third law sometimes causes confusion. How can an object accelerate if there is always an equal force pushing back? The answer to this question takes a little thinking, but once you understand it, it really is not very difficult. Objects accelerate because of forces acting on them. So to understand the motion of any object, you consider the forces that act on that object. You do not consider any forces that that object exerts on anything else, just the ones acting on the object. For example, a horse pulls forward on a cart. The action-reaction pair to this force is the cart pulling backward on the horse. The cart will accelerate if the force of the horse pulling forward is greater than the force of friction between the cart and the ground pulling backward. If you examine a free-body diagram, you can see that you only draw those forces that act on the cart.

Newton's third law is often used to explain how rockets propel astronauts into space. Basically, a rocket engine is a contained explosion that propels gas out the back end. Consider the force of the rocket pushing the gas (exhaust) out the back to be one force. The action-reaction pair to



Fig. 2.22: Newton's third law (second example)

this force is the force of the exhaust pushing forward on the rocket. It requires a great deal of force to propel rockets into space—to overcome the downward pull of Earth's gravity.