1.4 Read

What Are Balanced and Unbalanced Forces?

In the last section, you experienced pushing and pulling with equal and unequal forces on an object. In some of the situations, you noticed that the mass did not move. In other situations, the mass moved. Your explanation and class discussion helped you understand what makes objects move. In this reading, you will learn more about the forces on an object when the motion of an object does not change. This is when forces are **balanced**. When the motion of an object changes, the forces are **unbalanced**.

balanced forces: forces that are equal in size and opposite in direction. Balanced forces do not result in any change in motion.

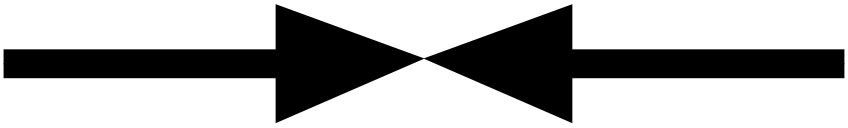
unbalanced forces: forces applied to an object in opposite directions that are not equal in size. Unbalanced forces result in a change in motion.

friction: the force that opposes the motion or tendency toward motion of two objects that are in contact.

Balanced Forces

Balanced forces are equal in size and opposite in direction. When forces are balanced, there is no change in motion. In one of your situations in the last section, you pushed or pulled on an object from opposite directions but with the same force. You observed that the object did not move. When the forces on an object are equal and in opposite directions, the forces are balanced, and there is no change in motion.

Remember when the heavy bucket in your classroom was pushed lightly? It was standing still, or at rest. Although a force was applied to it, the bucket remained at rest. Its motion did not change. The forces acting on the bucket were balanced. It was pushed in one direction, but a different force, called **friction**, pushed back in the opposite direction. The two forces were equal in size and opposite in direction, so they cancelled out each other, and no motion occurred.

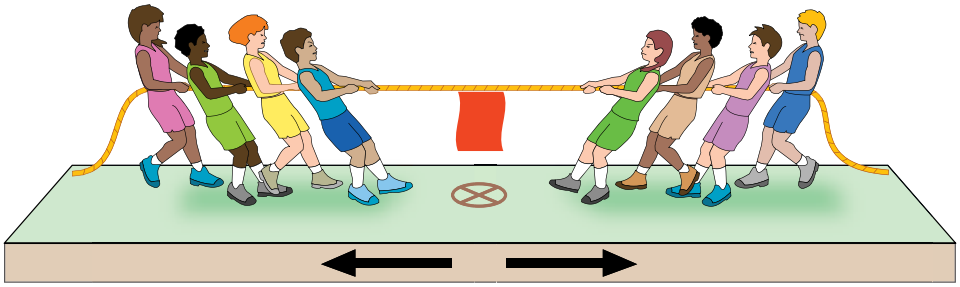


In one investigation, you applied balanced forces to a heavy object. You pushed on the object with the same amount of force from opposite sides. The force probes measured the amount of force you applied on each side. You saw that the forces were the same. You also pulled on the object with

the same amount of force in opposite directions. The force probes showed that the forces were equal. In both cases, you observed that the motion of the object did not change. It stayed at rest and did not move.

Another example of balanced forces can be seen in the game tug-of-war. In this game, the same number of people hold onto each end of a rope. A flag is tied to the center of the rope. Each team pulls on the rope and tries to move the flag to its side.

Imagine you are playing tug-of-war with your friends. Your team starts by pulling really hard, with all its strength. But the other team is also pulling with an equal amount of force and in the opposite direction. The flag in the middle of the rope does not move. The flag does not move because the force your team is pulling with is equal to the force applied by the other team but in the opposite direction. The forces are in opposite directions. The forces on the rope are balanced. When the forces are balanced, the flag in the center of the rope will not move. To win the game, one team must apply more force than the other.



Children playing tug-of-war

Gravity

In *Situation 1* in the previous section, you observed a mass on top of the table. The force diagram for this situation shows the force of gravity pulling on the mass and the table pushing back on the mass. The arrows are the same size, showing that the forces are the same size. The arrows also show that the forces are acting in opposite directions. Because the forces are the same size and acting in opposite directions, the forces are balanced. There is no change in motion for the object.

When you lifted the mass in the air in *Situation 7*, you had to use some force. Then you had to maintain that force to keep the mass in the air. You may have felt you were just holding the object, but you were applying

a *pulling force* upward. The mass did not change its motion because there was an equal pulling force working opposite your force, pulling the mass down. The downward force is **gravity**.

Gravity is the force that pulls everything towards Earth. When an object is being held in the air, the force holding it up must balance the force of gravity pulling it down. To hold a bag of groceries, you must pull up with a force equal to the downward force of gravity.

In the first situation in the last section, you observed a mass as it sat on the table. You probably noted that without any forces being applied to it, the mass didn't move. You could have watched the mass for hours, but as long as there were no further pushes or pulls on the mass, it would not have moved. The forces on the mass were balanced, and there was no change in motion.

The force diagram for the first situation showed two force arrows, one down and one up, both the same size. These arrows represent the forces acting on the object. The downward force shows the force of gravity. The upward force is the force of the table on the mass.

gravity: A pull between two objects, for example, between an object and Earth.

Friction

Remember when your teacher lightly pushed the heavy bucket? It was at rest on top of the table, and it remained at rest when it was pushed lightly. Although a force was applied to it, the bucket remained at rest. Its motion did not change. The forces acting on the bucket were balanced. The push acted on the bucket in one direction, but another force acted on the bucket in the opposite direction. The force that acted against the push was friction.

Friction is a force that opposes the motion or tendency toward motion of two objects that are in contact with one another. In the case of the heavy bucket, there was friction between the bucket and the surface it was sitting on.

Friction was the force opposing the motion of the bucket. It balanced out the small force that was applied to the bucket. To move the bucket, you had to apply a force strong enough to overcome the force of friction.

Friction acts to resist motion. When you push on the bucket, friction acts to keep the bucket from moving.

Unbalanced Forces

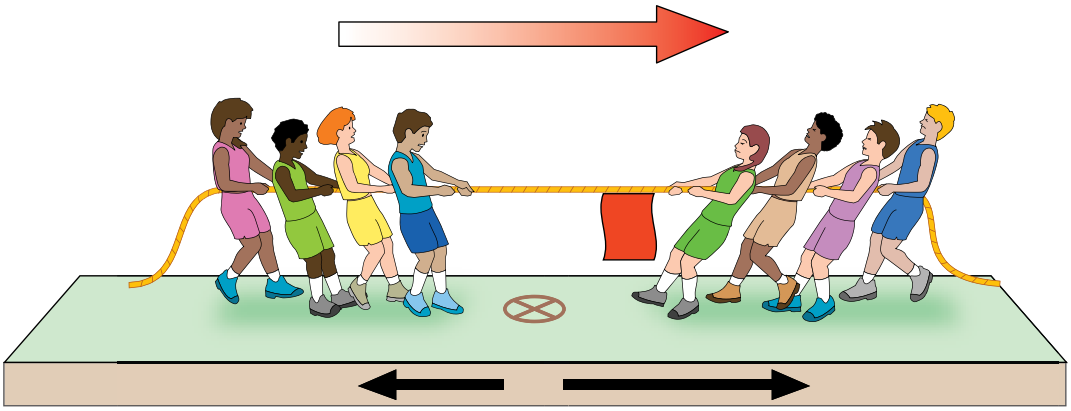
When forces on an object are balanced, there is no change in speed or direction. So what do you need to do to move something? If something starts to move, it must be because unbalanced forces are acting on it.

To have unbalanced forces means that the force applied in one direction is greater than the force applied in the opposite direction. When unbalanced forces are acting on an object, there is a change in speed and/or direction.

When you pushed lightly on the bucket in the class demonstration, it did not move. It moved only when you pushed on it hard enough. To move the bucket, the force you applied had to be greater than the friction force acting in the opposite direction. One force (pushing) had to be greater than the other force (friction) before the bucket would move. When one force is greater than another, the forces are not balanced, they are unbalanced.

By applying an unbalanced force, you can change the motion of an object. Unbalanced forces can make an object at rest start moving, make a moving object stop, or change the direction and speed of the object.

Think back to the game of tug-of-war. At the start of the game, both teams pulled equally hard on opposite ends of the rope. The two teams pulled with balanced forces. The flag in the middle of the rope did not move.

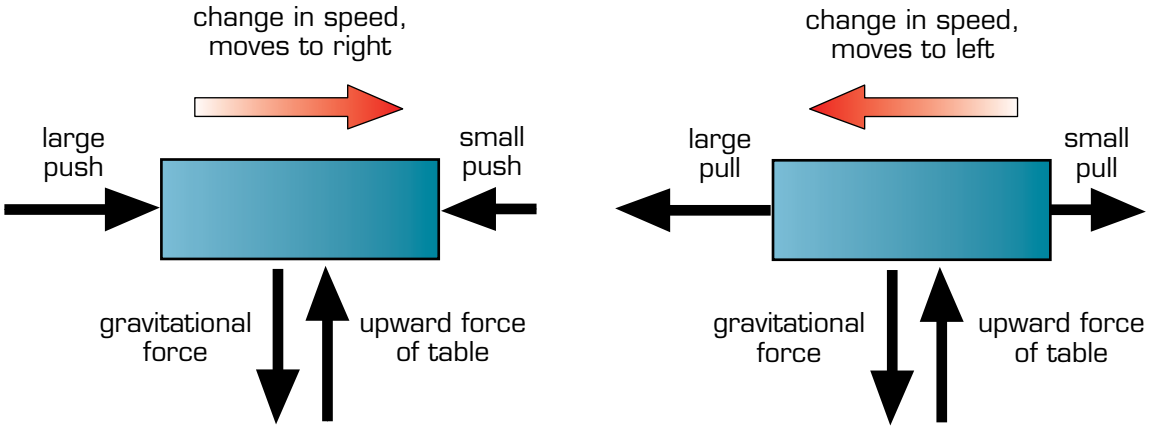


For a team to win a game of tug-of-war, it must pull with greater force than the other team.

After a while, one team begins to tire and it pulls with less force. The other team becomes excited and pulls with even more force. Soon, the tired team is moving in the direction that the stronger team is pulling. The flag moves, and stronger team wins!

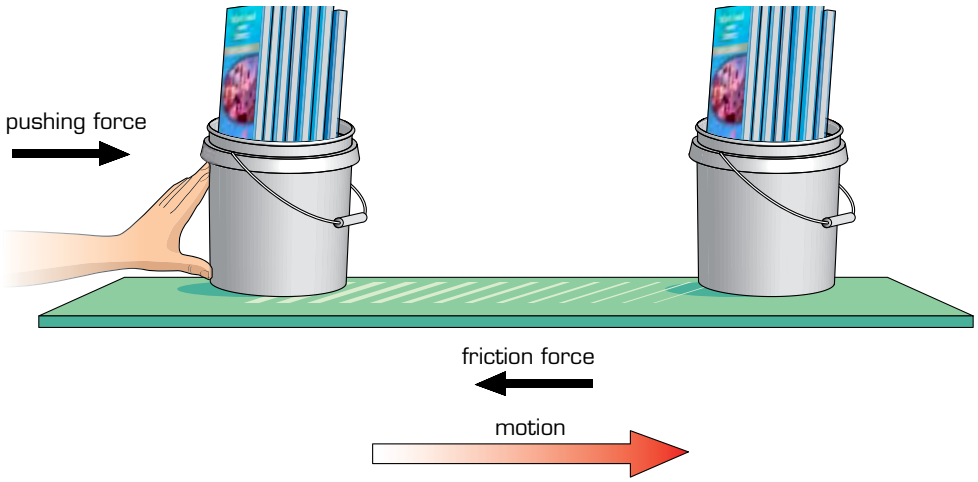
What happened during the game? The flag in the middle of the rope moved toward the stronger team, because there were unbalanced forces acting on the rope. The force applied by the stronger team was greater than the force applied by the tired team. When the forces became unbalanced, the flag started to move in the direction of the greater force. That direction was toward the stronger team, so they won.

In one of your situations, you pushed on an object unequally and in opposite directions. In this situation, the forces were unbalanced. The object moved across the table in the direction of the smaller force. You also pulled on the object with different amounts of force and in opposite directions. The object moved in the direction of the greater pulling force. You drew diagrams for each situation. Your diagrams may look something like the ones shown.



In these diagrams, the arrows represent the direction of the forces you applied to the object. The arrows are different sizes because you pushed and

pulled on the object with different amounts of force. When the object moves across the table, the arrows above the object show the direction of the motion. The object moved because you applied unbalanced forces.



Pushing against friction with unbalanced forces

A similar situation occurred when your teacher pushed the heavy bucket. With a small push, the bucket did not move. The friction force balanced the small pushing force. When a larger force was applied, the bucket moved. The pushing force was now greater than the friction force. Since the forces were unbalanced, the bucket moved.

Stop and Think

1. Suppose you were pushing on a heavy bucket of stones with 100 N of force and it did not move. How many newtons of force would be balancing the force you were applying?
2. You need to push a very heavy rock. You push and push, but the rock doesn't move. Draw a force diagram that shows how the forces work as you are pushing on the rock.
3. A strong adult pulls a desk to the right. At the same time, a small child pulls the desk to the left. Draw a force diagram of this situation. What direction will the desk move? Why do you think it will move in that direction?
4. When an apple falls from a tree, forces must be acting on it. Draw a force diagram, and describe how the forces act on the apple to make it fall.

Revise Your Explanation

Look at the explanation you have created so far for how forces affect the motion of an object. Work with your group to revise your explanation to include any new information you now have. Your revised explanation should include information about balanced and unbalanced forces.

Make sure when you revise one part of your explanation that the whole explanation still makes sense. If you think an additional claim and explanation are needed based on your investigations, then spend time in your group working on that, too. Use a new *Create Your Explanation* page for each explanation you develop.

Communicate

Share Your Explanation

Your class will meet to discuss each group's explanation. Your teacher will guide the class toward selecting or creating an explanation that everyone thinks best explains the relationship between force and motion, and includes information about balanced and unbalanced forces.

What's the Point?

Forces acting on an object may be balanced or unbalanced. When the forces acting on an object have equal strength and act in opposite directions, they are balanced. These forces cancel out one another, and the motion of the object they are acting on remains unchanged.

When the forces acting on an object are unbalanced, they do not cancel out one another. An unbalanced force acting on an object results in the object's motion changing. The object may change its speed (speed up or slow down), or it may change its direction.

Friction is a force that resists the motion or the tendency toward motion between two objects in contact with each other.

Gravity is a force that pulls objects toward one another. For example, Earth pulls all objects toward it.