Forces

Carson has been riding a scooter for almost as long as he can remember. As you can see, he’s really good at it. He can even do tricks in the air. It takes a lot of practice to be able to control a scooter like this. Carson automatically applies just the right forces to control his scooter.

Defining Force

Force is defined as a push or pull acting on an object. There are several fundamental forces in the universe, including the force of gravity, electromagnetic force, and weak and strong nuclear forces. When it comes to the motion of everyday objects, however, the forces of interest include mainly gravity, friction, and applied force. Applied force is force that a person or thing applies to an object.

Q: What forces act on Carson’s scooter?

A: Gravity, friction, and applied forces all act on Carson’s scooter. Gravity keeps pulling both Carson and the scooter toward the ground. Friction between the wheels of the scooter and the ground prevent the scooter from sliding but also slow it down. In addition, Carson applies forces to his scooter to control its speed and direction.

Force and Motion

Forces cause all motions. Every time the motion of an object changes, it’s because a force has been applied to it. Force can cause a stationary object to start moving or a moving object to change its speed or direction or both. A change in the speed or direction of an object is called acceleration.

How much an object accelerates when a force is applied to it depends not only on the strength of the force but also on the object’s mass. For example, a heavier scooter would be harder to accelerate. Carson would have to push with more force to start it moving and move it faster.
Q: What units do you think are used to measure force?

A: The SI unit for force is the Newton (N). A Newton is the force needed to cause a mass of 1 kilogram to accelerate at 1 m/s², so a Newton equals 1 kg • m/s². The Newton was named for the scientist Sir Isaac Newton, who is famous for his laws of motion and gravity.

Force as a Vector

Force is a vector, or a measure that has both size and direction. For example, Carson pushes on the ground in the opposite direction that the scooter moves, so that’s the direction of the force he is applies. He can give the scooter a strong push or a weak push. That’s the size of the force. Like other vectors, a force can be represented with an arrow. You can see some examples in the Figure below. The length of each arrow represents the strength of the force, and the way the arrow points represents the direction of the force.

Q: How could you use arrows to represent the forces that start Colton’s scooter moving?

A: Colton pushes against the ground behind him (to the right in the Figure right). The ground pushes back with equal force to the left, causing the scooter to move in that direction. Force arrows A and B in example 2 in the Figure above) could represent these forces.

Summary

- Force is defined as a push or pull acting on an object. Forces include gravity, friction, and applied force.
- Force causes changes in the speed or direction of motion. These changes are called acceleration.
- The SI unit for force is the Newton (N).
- Force is a vector because it has both size and direction. Like other vectors, it can be represented by an arrow.

Review

1. What is force?

2. Relate force and motion.

3. What forces control the motion of everyday objects?

4. Identify and define the SI unit for force.
Combining Forces

It’s boys against girls in this friendly tug of war. The two teams are pulling the rope in opposite directions. Which team do you think will win? It depends on which side pulls on the rope with the greatest force. As this example shows, more than one force may act on an object at the same time. Would it surprise you to learn that at least two different forces are acting on you as you read this article? Can you guess what they are?

Pulling Down and Pushing Up

One force acting on you—and all the other objects on Earth—is gravity. Look at the physics book in the Figure below. Gravity pulls the book downward with a force of 20 Newtons. Why doesn’t the book fall to the ground? The table pushes upward on the book with the same amount of force. The combined force, or net force, acting on the book is 0 Newtons. That’s because upward and downward forces are balanced, so they cancel out.

Forces Acting in Opposite Directions

In general, whenever forces act on an object in opposite directions—like the book on the table—the net force is equal to the difference between the two forces. In other words, one force is subtracted from the other to calculate the net force. If the opposing forces are equal, or balanced, the net force is zero, as it is for the book. That’s why the book doesn’t fall to the ground but instead remains resting on the table. However, if the opposing forces are unbalanced, the net force is greater than zero, although it will be less than either of the individual forces. In this case, the object will move in the same direction as the net force.

Look at the dogs playing tug-of-war in the Figure below. The dogs are pulling the rope in opposite directions, but one dog is pulling with more force than the other. The net force acting on the rope is 2 Newtons to the right, so the rope will move to the right.

Q: The boys in the Figure above are about to kick the soccer ball in opposite directions. What will be the net force on the ball? In which direction will the ball move?

A: The net force on the ball will be 50 N to the left (125 N – 75 N = 50 N), so the ball will move to the left.
Forces Acting in the Same Direction

If two forces act on an object in the same direction, the net force is equal to the sum of the two forces. This always results in a stronger force than either of the individual forces alone. In the Figure below, after the man on the left picks up the couch, he will push the couch to the right with a force of 25 Newtons, and the man on the right will pull the couch to the right with a force of 20 Newtons. The net force on the couch is 45 Newtons to the right, so that’s the way the couch will move.

Summary

- The net force acting on an object is the combination of all of the individual forces acting on it.
- If two forces act on an object in opposite directions, the net force is the difference between the two forces. In this case, the net force is always greater than or equal to zero but less than either of the individual forces.
- If two forces act on an object in the same direction, the net force is the sum of the two forces. In this case, the net force is always greater than either of the individual forces.

Review

1. What is the net force acting on an object?

2. If an object has two forces acting on it, how can the net force equal 0?

3. Under what conditions does the net force acting on an object equal the sum of the individual forces?

4. What is the net force on the book in the Figure below? If the book moves, in which direction will it move?
Net Force Worksheet

The force resulting from all the combined forces is called the net force. Calculate the net force for the following boxes. Be sure to indicate if the direction of the force (left or right) for each problem.

1. **4 N**
   - Net Force:

2. **7 N**
   - Net Force:

3. **4 N**
   - Net Force:

4. **6 N**
   - Net Force:

5. **8 N**
   - Net Force:

6. **4 N**
   - Net Force:

7. **3 N**
   - Net Force:

8. **2 N**
   - Net Force:

9. **6 N**
   - Net Force:

10. **7 N**
    - Net Force: