Combining Forces

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Learning Objectives

• Define net force.
• Calculate the net force acting on an object and determine the direction it will move.

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 1.1. 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 1.2. 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 1.3 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 1.4, 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 1.5? If the book moves, in which direction will it move?

References

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