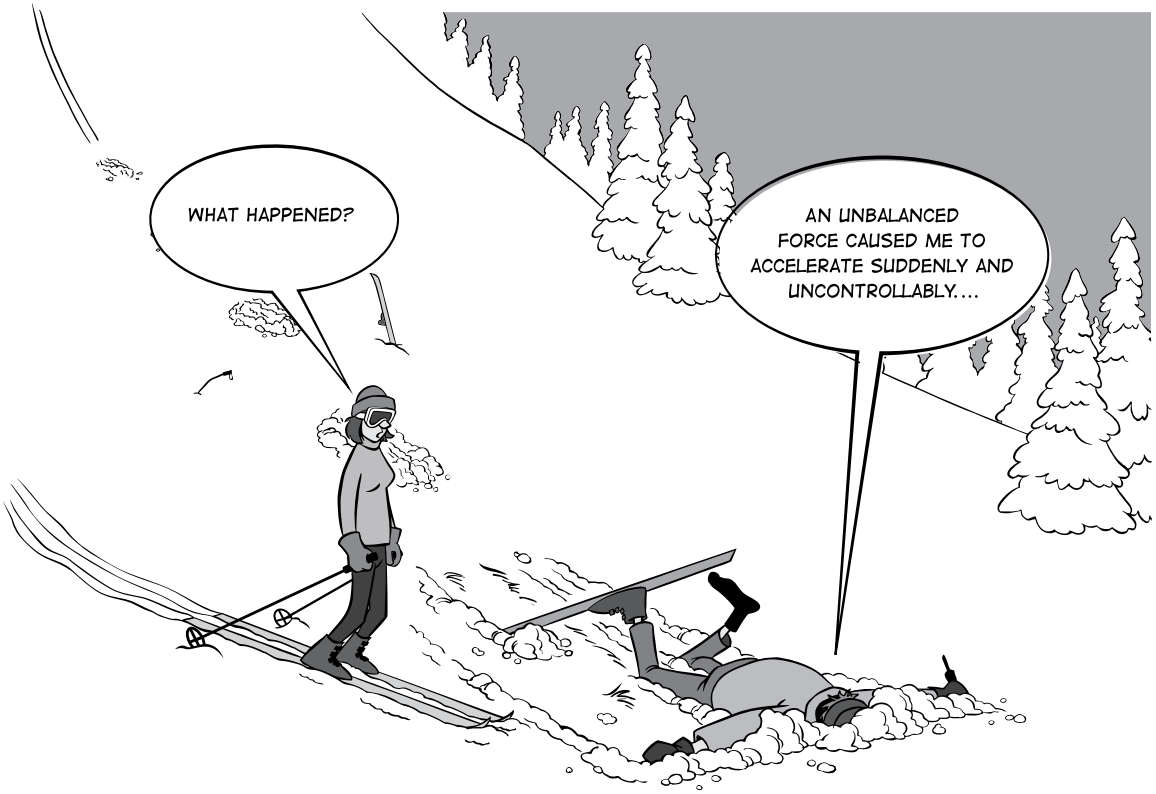
Chapter 6

Net or Unbalanced Forces



Teacher Guide to 6.1/6.2

Changes in Motion and What Causes Them

Objectives: The students will be able to explain that the changes in motion referred to in Newton's first law are actually changes in velocity or accelerations. The students will be able to define unbalanced forces and be able to explain that only unbalanced forces cause changes in velocity.

Process Skills Addressed: Observing, inferring

National Science Education Standards Addressed: Content standard B: Position and motion of objects; Motions and forces

Position in the Learning Cycle: *Explore/Explain*. This brief activity and explanation clarify that the changes in motion we've been talking about are changes in velocity, and explains that unbalanced, or net, forces are what cause changes in velocity. There will be no specific elaboration activity for these concepts, as the students will be applying the concepts for the next several activities.

Relevant Pages in *Force and Motion Stop Faking It!* Book: All of Chapter 1; Chapter 2, pages 17–21

Suggested Group Size: whole class and individual

Materials: Per class: 1 large beach ball, Swiss exercise ball, or similar movable object

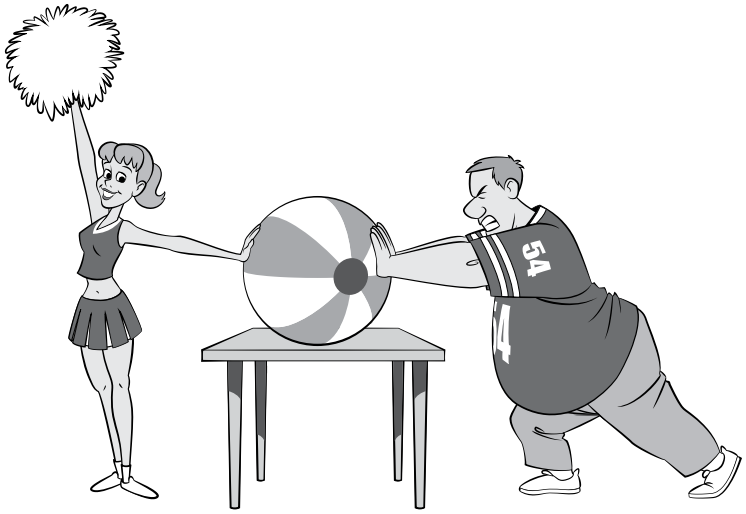
Approximate Time: 30 minutes

Procedure:

1. **Place a large ball in front of the class.** Ask for two student volunteers, and have each push equally hard on the ball in opposite directions. You'll know they're pushing equally hard when the ball doesn't go anywhere even though the students are pushing.

Teacher Guide to 6.1/6.2

Changes in Motion and What Causes Them



2. **Ask the class,** "Are Wally and Ophelia[1] pushing on the ball? (yes) Are they exerting forces on the ball? (yes) Then why isn't the ball changing its motion? We've learned that forces cause objects to change their motion, but the ball is staying put. What's going on?" (The class should realize that the two students are somehow "canceling each other" or "working against each other.")
3. With the students still pushing on the ball, **add your own push** to assist one of the students. Make sure the other student doesn't push harder in order to keep the ball at rest. The ball should begin moving.
4. **Ask the students why the ball changed its motion.** Hopefully you'll get answers that you upset the balance or added an "extra" push. Help the students understand that in order to change the motion of an object, you have to have an unbalanced force, which means ignoring any forces that cancel one another and just focusing on the force that's left over (in this case, the force you provided).
5. **Have the students read the passage Changes in Motion and What Causes Them.**
6. **Discuss the reading with the class.** When dealing with the fact that changes in motion are changes in velocity, it will probably help to remind the class, using materials as necessary, of the way they changed velocity in the activity Changing Motion. The words "change in motion" tend to make people think of speeding up or slowing down, but changes in direction are also changes in motion. Therefore,

[1] Just a suggestion, but if the students aren't named Wally and Ophelia, you might want to alter the wording of this question.

all the discussions regarding changes in motion in Newton's first law are really discussions about changes in velocity. And changes in velocity have a special name—acceleration. When discussing the terms *unbalanced force* and *net force*, it's up to you which term you wish to emphasize. Both terms are used by scientists, but sometimes it's easiest for students to use just one of the terms.

Be aware that this activity and this reading will not indelibly stamp in the students' brains the concept that unbalanced forces cause changes in velocity, which are also called *accelerations*. You will have to remind the students of these ideas throughout the other activities in the book. Get used to repeating, and having the students repeat, that the compact way to state Newton's first law is that unbalanced forces cause accelerations. Try to avoid from this point on saying that forces cause accelerations, because only unbalanced forces cause accelerations. Now click your heels together three times and repeat, "Unbalanced forces cause accelerations, unbalanced forces cause accelerations, unbalanced forces cause accelerations…."[2]

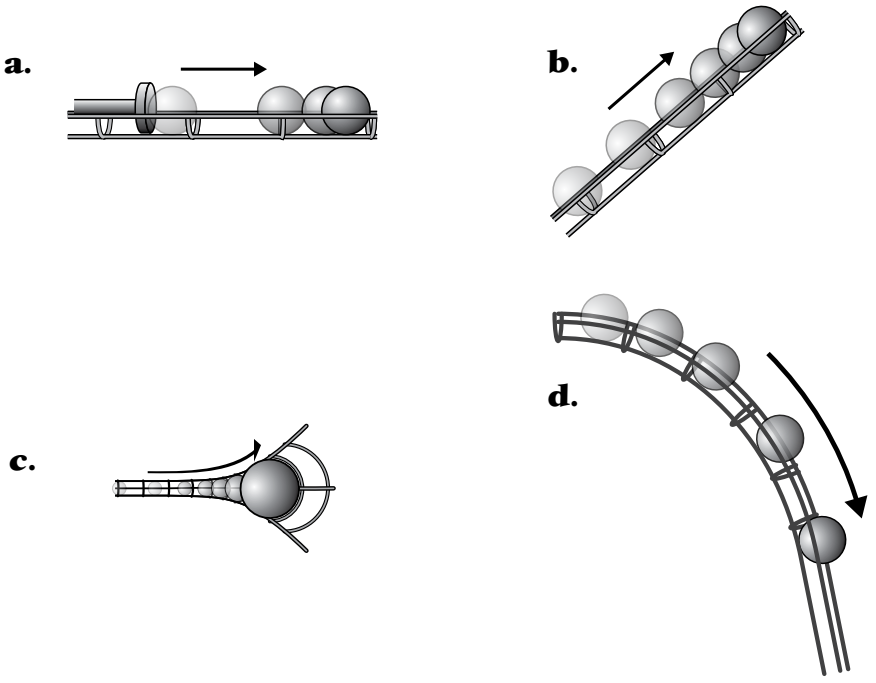
[2] You will find physicists and physics educators who will argue that unbalanced forces do not, in fact, cause accelerations, but rather that the two occur simultaneously. We'll stick with the commonsense version here, though, and say that unbalanced forces are the cause of objects accelerating.

Student Activity 6.1/6.2

Changes in Motion and What Causes Them

In learning about Newton's first law, we talked about changes in motion. Things tend to keep doing what they're doing unless forces cause them to change their motion. But what exactly does "changes in motion" mean? How can an object change its motion? Take a look at the drawings in Figure 1 and decide which ones show a change in motion.

Figure 1

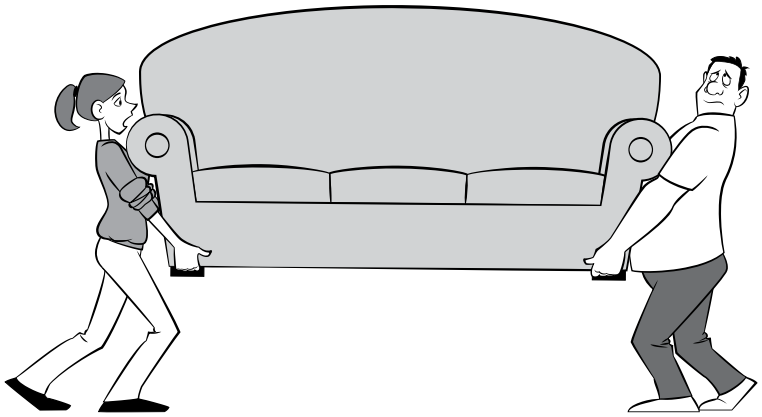


What did you decide? If you said that all the drawings show changes in motion, then you got it right. An object that starts at rest and speeds up is changing its motion. An object that slows down is changing its motion. An object that changes its direction is changing its motion. Think back to the activity Changing Motion and the reading Acceleration, and you should realize that all the changes in motion shown in Figure 1 are changes in velocity. And we have a name for changes in velocity. They're called **accelerations**. So, all of the changes in motion we dealt with in Newton's first law are accelerations.

With Newton's first law, you also learned that changes in motion, or accelerations, happen when you exert forces on objects. But the forces that change motion, or cause things to accelerate, are special kinds of forces. In the demonstration in front of your class, you found out that you can exert forces

on objects without them changing their motion. For example, if you push equally hard on opposite sides of a couch, in opposite directions, the couch isn't going to change its motion.

Figure 2



"I am going 'that' way."

The two movers in Figure 2 are both pushing on the couch, but their forces balance. What you need to change the motion of an object is an **unbalanced force**. An unbalanced force is also called a **net force**. No, that's not a force exerted by a net, but the force that's "left over" after considering the magnitude and direction of all the forces acting on an object. You might have heard your parents talk about "net income," which is the money they make after they've paid all their taxes. Net force and net income are similar.

So, another way of stating Newton's first law is this:

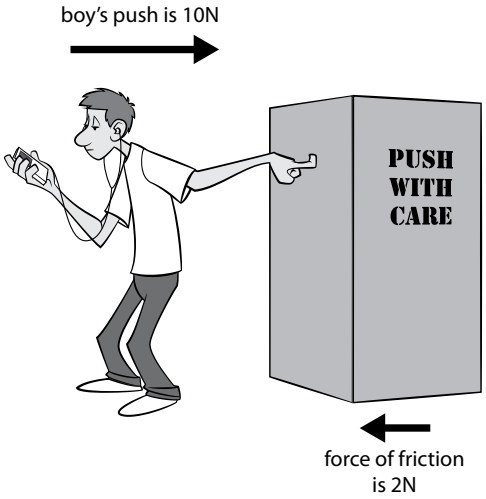
Unbalanced forces cause objects to accelerate.

When an object accelerates, it changes its velocity. That means a change in speed, a change in direction, or a change in both speed and direction. What causes objects to accelerate are unbalanced forces. Just because you are exerting a force on an object, that doesn't necessarily mean it will accelerate. You must exert an unbalanced force in order to accelerate (change the velocity of) an object.

Teacher Guide to 6.4

Evaluation

Answers to Student Activity 6.4



A box is sitting at rest on the floor. A boy pushes on this box with a force of 10 newtons (newtons are units of force, just as meters are units of distance). The frictional force between the box and the floor that opposes the boy's push is 2 newtons. Which of the following are true?

Because the boy's push is opposed by friction, the box will not move.

Answer: *Not true. As long as there is an unbalanced force, the box will accelerate.*

There is an unbalanced net force on the box, so it will accelerate.

Answer: *True.*

Objects at rest tend to stay at rest, so the box won't move because of its inertia.

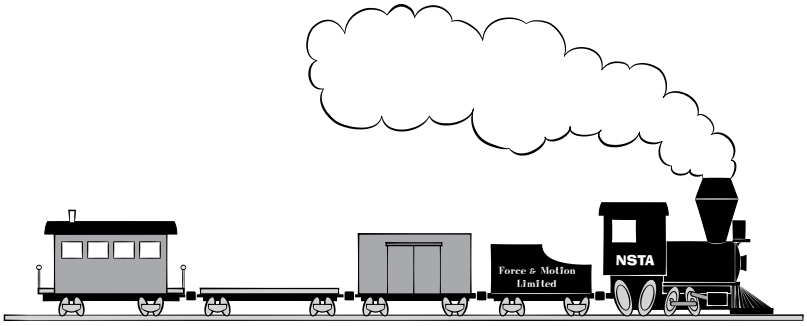
Answer: *Not true. Inertia is the tendency of an object to keep doing what it's doing, but an unbalanced force on any object will cause it to accelerate. Inertia is not a force that opposes other forces.*

The box has inertia that will resist the boy's push, so if the box's inertia is large enough, the box won't move.

Answer: *Not true. Inertia is not a force. It's common for people to think of inertia as a "resistance," and thus a force, but that's not the case.*

Teacher Guide to 6.4

Evaluation



A train is moving along a straight section of track at a constant speed. Which of the following statements about the train are true?

If the train is moving at constant speed, there must be no forces at all acting on the train.

Answer: *Not true. If the train is moving at a constant speed in a straight line, then it is not accelerating. That means that there is no unbalanced force acting on the train. There can be all sorts of forces acting on the train that cancel out.*

If the train is moving at a constant speed, then any forces that might be acting on the train must cancel out.

Answer: *True, but only because the train is moving in a straight line. If it were rounding a curve, then it would be accelerating, and there would be an unbalanced force acting on it.*

There must be an unbalanced force acting on the train to keep it moving at a constant speed.

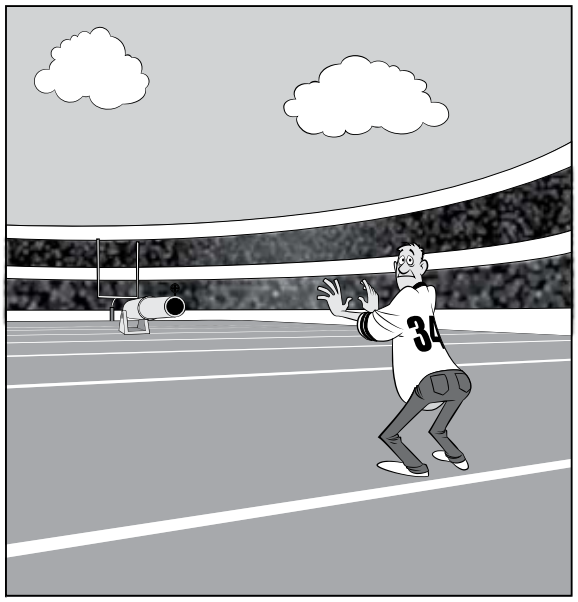
Answer: *Not true. A train moving at a constant speed in a straight line is not accelerating. Therefore, the unbalanced force acting on it is zero. Unbalanced forces cause things to accelerate. Of course, there must be a continued force on the train (from the tracks, actually) that matches the friction force in order for the unbalanced force to be zero. This answer addresses the fact that one must consider all forces acting on an object, not just certain ones.*

The train must have a force acting on it larger than the train's inertia in order to keep moving.

Answer: *Not true. Inertia is not a force.*

Evaluation

Teacher Guide to 6.4



At halftime of a pro football game, the local team has a contest in which a machine shoots out a football and a chosen fan has to catch the football. Which of the following statements is true regarding this situation?

The football comes to rest in the receiver's hands because the natural tendency of any object is to come to rest.

Answer: *This would be true if you were Aristotle. According to Newton, though, the natural tendency of an object is to keep doing what it's doing. The unbalanced force exerted on the football by the receiver is what causes it to come to rest.*

There is never an unbalanced force on the football. It's going to do what it's going to do because of Newton's first law.

Answer: *Not true. The football is accelerating all the time, changing both speed and direction. This acceleration means there is an unbalanced force acting. For most of its motion, the unbalanced force is due to a combination of the force of gravity and the force of air friction.*

The force exerted on the football by the machine stays with the football, propelling it to the receiver.

Answer: *Not true. The machine exerts a force on the football only while the football is in contact with the machine. Forces do not "stay with" objects. This is a common misconception for students, and one that doesn't go away easily.*

Teacher Guide to 6.4

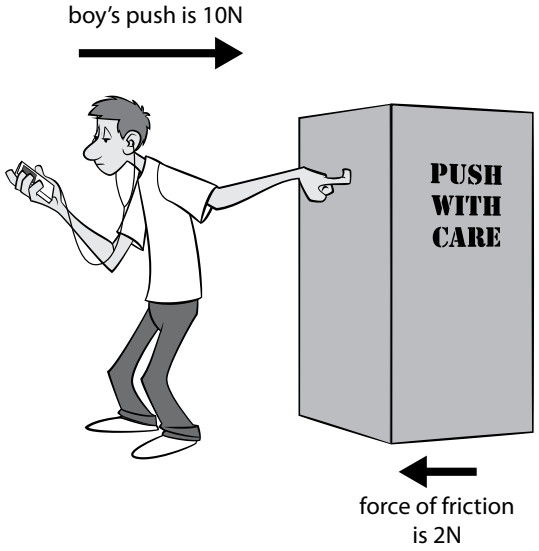
Evaluation

Once the football leaves the machine, the fact that it keeps moving toward the receiver is an indication that the ball has inertia.

Answer: *True. Inertia is the tendency for an object to keep doing what it's doing. Inertia does not cause the ball to keep moving, though. Inertia doesn't cause anything. It's just a property of an object.*

Evaluation

Student Activity 6.4



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Student Activity 6.4

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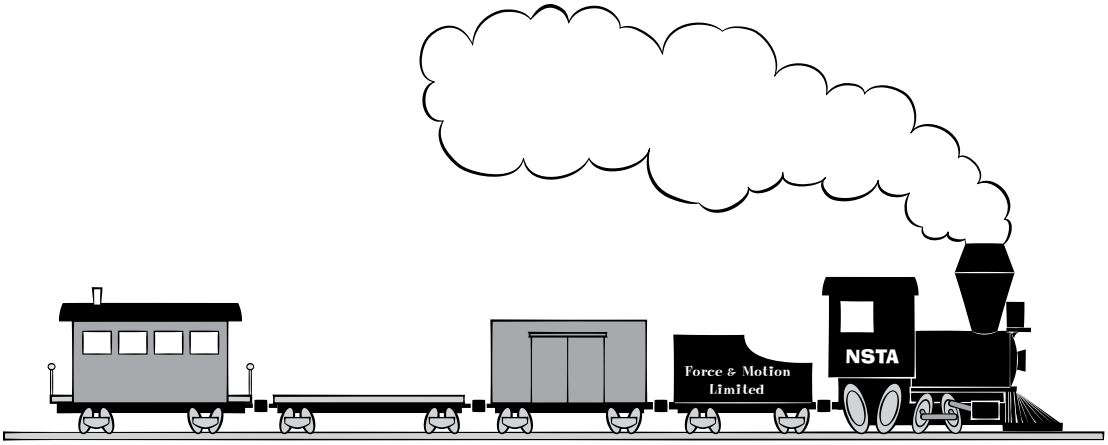

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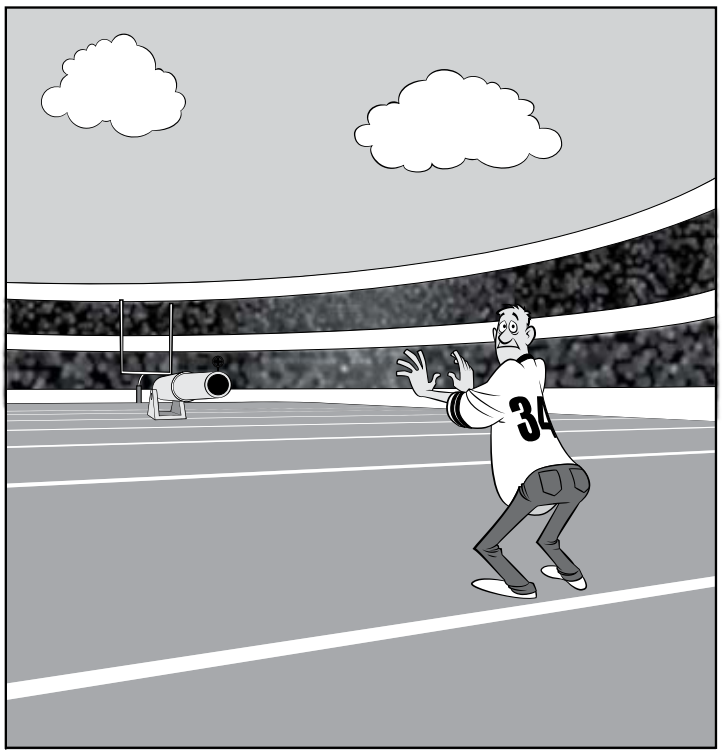
- The train must have a force acting on it larger than the train's inertia in order to keep moving.

Evaluation

Student Activity 6.4



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- The force exerted on the football by the machine stays with the football, propelling it to the receiver.
- Once the football leaves the machine, the fact that it keeps moving toward the receiver is an indication that the ball has inertia.