



Learning Set 1

What Makes Things Move?

The biologists on the island have a problem. They must *move* a heavy crate up to the top of the cliff. It is probably obvious to you at this point that machines can help move things. However, you may not know how they do this. Before you can begin to understand how machines move things, you need to understand why things move. What causes something to move from one location to another?

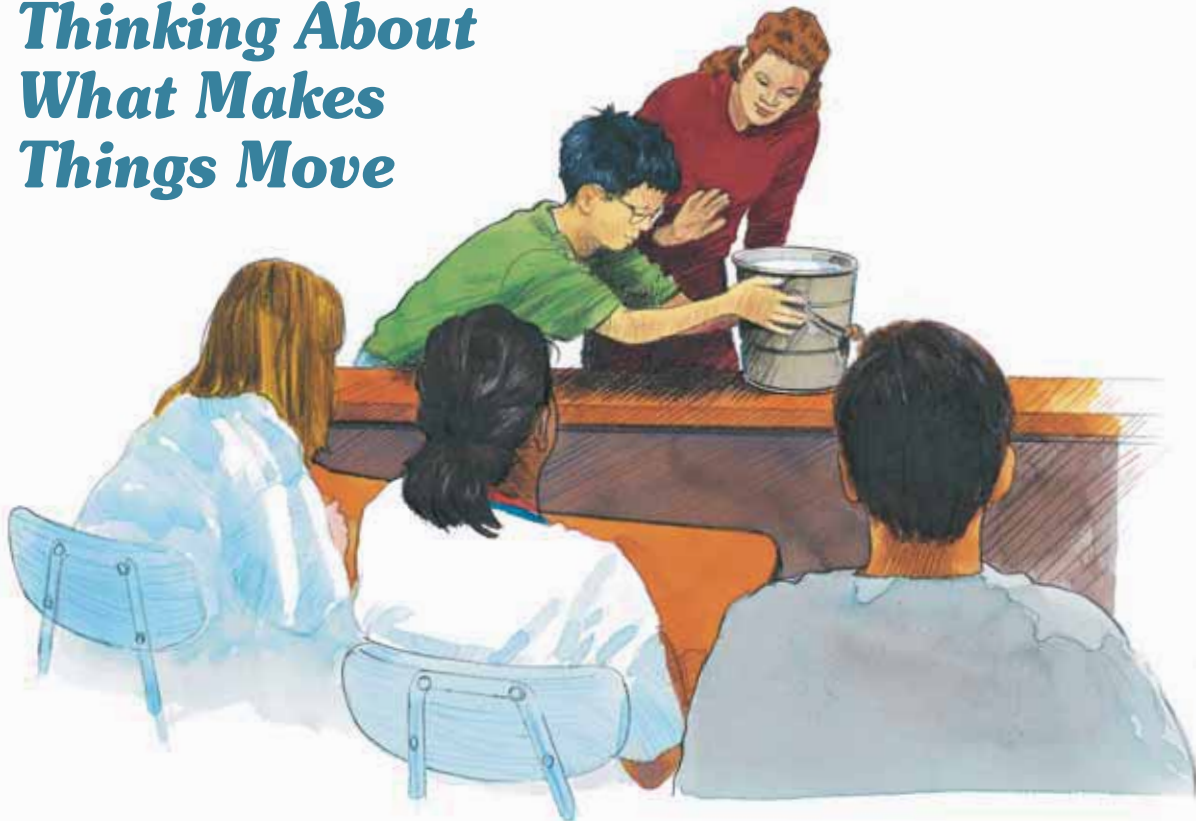
To answer the *Big Question*, you need to break it down into smaller questions. In this *Learning Set*, you are going to answer the question: *What makes things move?* Answering this question is the first step toward achieving the challenge and answering the *Big Question*: *How do machines help move large, heavy objects?*



What enables you to lift a backpack and carry it forward?

1.1 Understand the Question

Thinking About What Makes Things Move



The question for this *Learning Set* is *What makes things move?* You see things move all the time. Soccer balls get kicked, papers get shuffled, leaves get blown, and chairs get pushed. To answer the question about what makes things move, think about what you already know about making things move. Also, think about what you do not know or are unsure about.

You will observe a class demonstration about pushing, pulling, and moving a heavy bucket. Then you will begin to understand more about how and why objects can move.

Demonstration

Your teacher will demonstrate three different pushes and pulls on a heavy bucket. Your teacher will repeat the demonstration three times. Each time, the push and pull on the bucket will be greater. Observe how the bucket's motion changes with each push and pull. Record your observations.

Conference

force: a push or a pull resulting from an object's interaction with another object.

So far, you have been talking about pushes and pulls. Your teacher pushed and pulled the bucket, the machines at the construction site pushed and pulled things, and in the dead-lift activity, you lifted the mass using thread. In each case, something needed to be pushed or pulled. When scientists talk about pushes and pulls, they use the word **force**. Scientists define forces as pushes and pulls.

You are now going to hold a conference with your classmates about the forces on the bucket and how the forces changed the bucket's motion. While you are discussing your ideas, make sure you use the word "force" when you talk about pushes and pulls.

During the demonstration, you may have discovered a few things you already know about what makes things move. You probably also discovered that there are things you do not know yet. You are going to think of what you would like to investigate that might help you answer the question: *What makes things move?*

Develop two questions that might help you understand how objects move and what causes this motion. When you write your questions, keep in mind that your questions should

- be interesting to you;
- require several resources to answer;
- relate to the *Big Question* and the crate-lift problem and;
- require collecting and using data.

Make sure your question is not simply a yes/no question or one you can answer in one sentence.

When you have completed your two questions, meet with your group. Share all the questions with one another. Carefully consider each question and decide if it meets the criteria for a good question. With your group, rewrite the questions that do not meet the criteria. Choose the two most interesting questions to share with the class. Give your teacher the rest of the questions so they might be used later.

Update the *Project Board*

You will now share your group's two questions with your class. Be prepared to support your questions with the criteria on the previous page. Your teacher will help you with the criteria if needed. Then your teacher will add your questions to the *Project Board*. Throughout this *Learning Set*, you will work to answer some of these questions.

Later in this *Learning Set*, you will conduct some investigations and use models to understand how forces work together on an object. The investigations will require you to make careful observations and record all your results. The *Project Board* can help you to organize your ideas as you answer the *Big Question*.

How do machines help move large, heavy objects?				
What do we think we know?	What do we need to investigate?	What are we learning?	What is our evidence?	What does it mean for the challenge or question?

1.2 Read

How Do Pushes and Pulls Relate to Force?

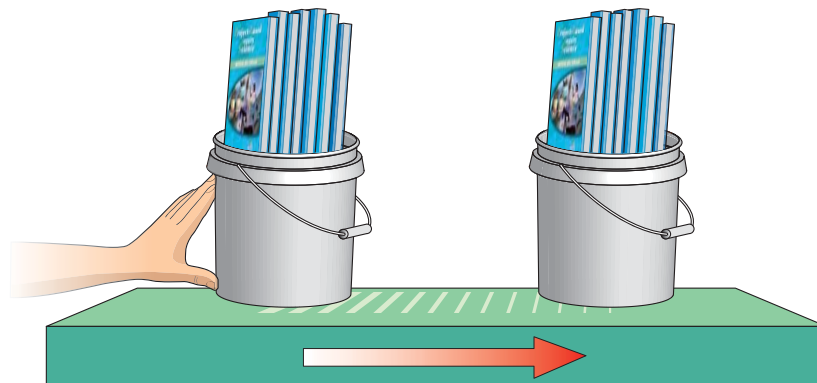


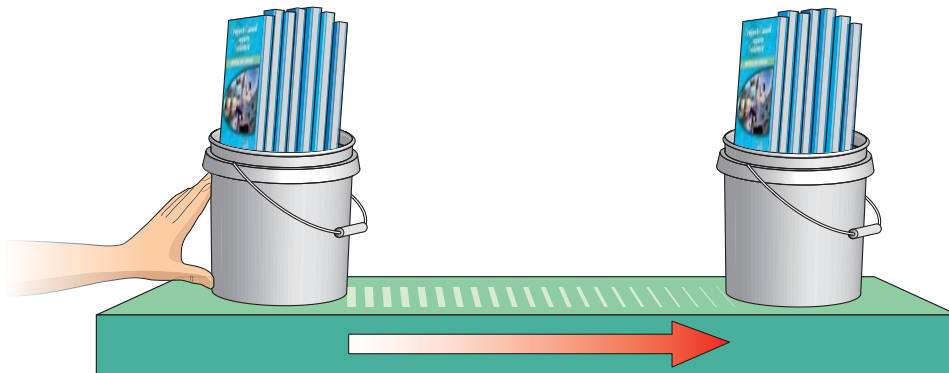
A force is being applied as the basketball player pushes down on the ball to bounce it.

A force is a push or pull. You apply a force to make an object move. There are many examples of things that you move in everyday life. Some of these examples include lifting a book to put it on the table, closing a door, dribbling a basketball, and lifting a trash bag to take out the garbage. To do each of these things, you have to apply a force. You push or pull something.

Think about the heavy-bucket demonstration. At the beginning of the demonstration, the bucket was sitting on the table. It was not moving. Scientists would say the bucket was *at rest*. When your teacher pushed and pulled the bucket very lightly, applying a small force, the bucket did not move. A force was applied, but it was not enough to make the bucket move. When your teacher applied a little more force, the bucket moved. Finally, your teacher applied a much larger force, and the bucket moved more.

In these demonstrations, a force was applied to move the heavy bucket. The bucket's motion was affected differently by greater amounts of force. With a small force, the motion did not change. The bucket stayed at rest. With more force, the bucket moved.





Forces can change motion. You need to apply forces to make things move and to make things stop moving. If a cart is moving across the floor, a force was needed to start it moving, and a force is needed to make the cart stop moving.

Forces are also needed to change direction. When you want an object to turn, you have to push or pull the object in the direction you want it to turn.

A force is needed to get an object moving, to change the direction an object is moving in, to slow down an object, and to stop an object from moving. In other words, a force is needed to change the speed and/or direction of an object. For example, riding a skateboard is all about using forces. To start riding a skateboard and build up speed, the rider pushes off the ground with one foot. To change direction or turn a corner, the rider applies a force by pushing down more on one side of the board.

To start riding a skateboard and build up speed, the rider pushes off the ground with one foot. To change direction or turn a corner, the rider applies a force by pushing down more on one side of the board. A common way to slow down or stop a skateboard is to press down on the tail, or back, of the board until it drags on the pavement.



Moving a skateboard

to stop the skateboard	apply a force to the skateboard.
to speed up the skateboard	apply a force to the skateboard.
to change the skateboard's direction	apply a force to one side of the skateboard.

To change the speed or direction of an object, a force must be applied to the object.

Moving objects do not have any force of their own. Forces are a result of interactions between two objects. This interaction requires contact. For example, imagine you are catching a baseball. As the ball is moving through the air, it is interacting with Earth (that is, pulling it down toward it) and it is interacting with the air (that pushes against it). When the ball lands in your glove, the ball applies a force to your glove. You can feel it. Your glove also applies a force to the ball. This force slows down the ball and makes it stop moving. Neither the ball nor the glove had a force by itself. The force acts when the two objects interact. In this example, a force acts when the ball hits the glove.

**Stop and Think**

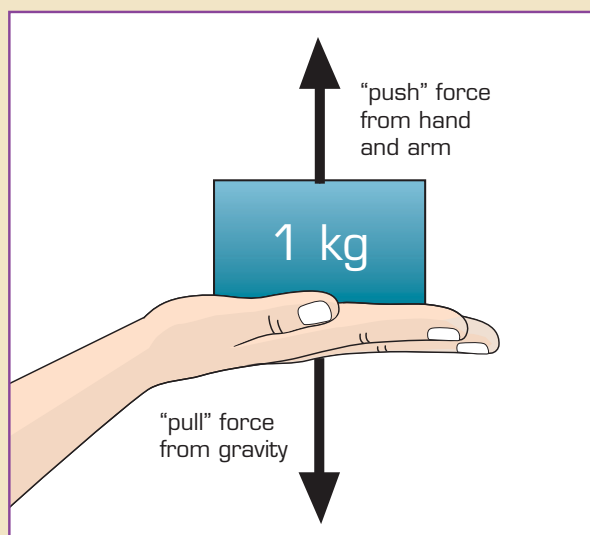
1. Give two examples of something you pushed or pulled today. Use different examples than those in the reading.
2. Compare the amount of force used to move the bucket with how much the bucket moved in each part of the demonstration.
3. When pushing the heavy bucket, what two objects interacted? Draw a picture of pushing the bucket. Make sure your picture includes all the objects that are interacting and the forces on the objects.

Force Diagrams

You drew a picture of the heavy bucket being pushed. You might have found it difficult to include in your picture all the information about forces. When scientists want to show the forces that are acting on an object, they use force diagrams.

Force diagrams provide a simple way to show the forces acting on an object. Instead of drawing the object, scientists simplify the object. Usually, the object will be shown as a square or other simple shape. Scientists then use arrows to show forces acting on the object. The direction of the arrow shows the direction of the force. You would show a push to the right with an arrow pointing to the right. The length of the arrow shows the size of the force. If two forces were the same size, the arrows would be the same length. If one force were twice as big as another, that arrow would be two times longer.

An example of a force diagram is shown below. The arrows are equal in length because the forces on the object are equal. The forces are acting in opposite directions, so they are pointing in opposite directions. One force is pushing up, and the other force is pulling down.



Stop and Think

Redraw your picture of the heavy bucket as a force diagram. Remember to indicate the direction and size of the forces.



What's the Point?

Forces cause objects to change motion. Forces can change the speed of an object, slowing it down or making it speed up. Forces can also change the direction of an object, and make objects turn. A small push or pull might not be enough to make an object change its speed or its direction. It might be necessary to apply a lot of force to an object to make it change its motion.

Previously, you discussed the idea of lifting the crate from the beach to the top of the cliff. This *lift* could be a push or a pull, depending upon how you build your machine. You will have to apply a force to move the crate. In the next section, you will learn more about the nature of that force.



Locomotives provide the force needed to move train cars.

Locomotives usually pull the train from the front.

Other times, locomotives are used to push the train.

1.3 Investigate

How Do Forces Affect Motion?

In this *Learning Set*, you have been thinking about forces and motion. You now know that forces are pushes and pulls that act when two objects interact. Forces can be large or small. Next you will investigate the effect of various forces on the motion of a heavy object. You will use a science instrument called a *force probe* to measure the amount of force applied to the object when it is pushed or pulled.

In order to answer the question *What makes things move?* you are going to explore what happens in seven different situations. Each group will be assigned to do two of the explorations, and then, in an *Investigation Expo*, the groups will report to the class what they have observed. In each situation, a different force will be applied to a heavy object. For each situation, you will predict if the probes will measure the same or different amounts of force and record your prediction.

A prediction is an educated guess based on what you know. You should not record only what you think will happen, but you should also record your reason for why you think it will happen.

Next, you will observe what actually happens and draw a diagram of your observations.

Finally, you will compare what you observed with what you predicted. When everyone has finished, you will share your observations with your class. Your class will work together to develop a statement describing the relationship between forces and motion.



A force probe is an instrument used to measure the amount of force applied to an object.

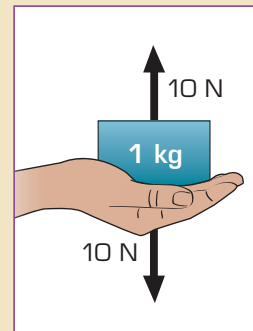
newton: a unit used to measure force.

Materials

- 1-kg mass
- 2 force probes
- Datalogger or CBL technology

Measuring Force

In this investigation, you will be using force probes to measure the amount of force that is applied to an object. A force probe is a measuring device similar to a spring scale used to determine the mass of things. The probe measures the amount of force applied using a unit called a **newton**. A newton (N) is a measure of force in the same way that a meter is a measure of distance and a second is a measure of time. If you are holding a mass of 1 kg (2.2 lbs), you are applying an upward force of about 10 N on the mass.



Procedure

1. Situation 1

In this situation, you will not push on the mass. Read the directions carefully

- Place a mass on your table.
- Predict how the motion of the mass will change if it is not touched. Record your prediction. You also need to record your reasons for making this prediction.
- Observe the mass for a short time and record your observation. Include a diagram to show the forces acting on the mass. Record your data on a *Demonstration Notes* page.
- Compare your observations with your predictions. How would you explain what happened in this situation?

2. Situation 2

In this situation, you will be pushing on the mass with equal force from opposite sides. Read the directions carefully. Use the force diagram to help you.

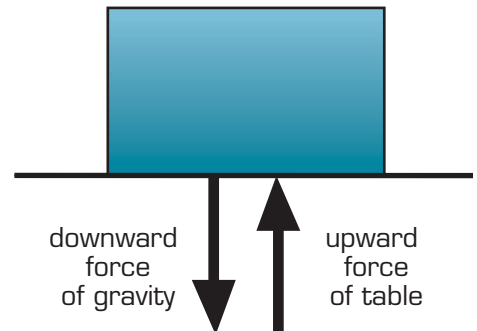
Demonstration Notes

1.3.1

Name: _____ Date: _____

Demonstration	Predict	Observe	Compare
#1 Describe the event here			
#2 Describe the event here			
#3 Describe the event here			
#4 Describe the event here			

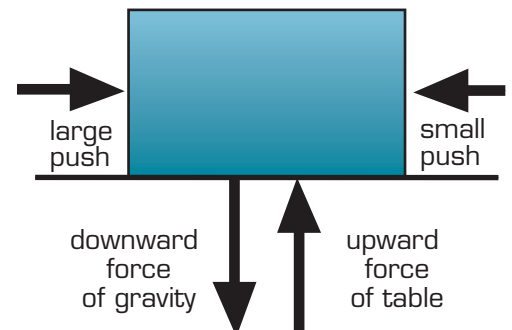
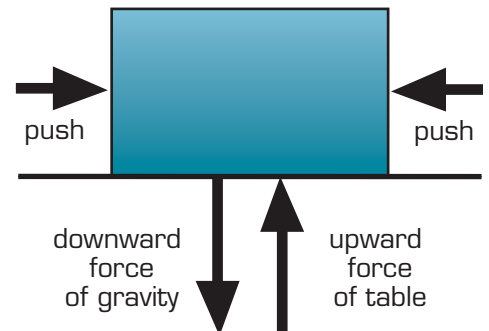
- The mass is at rest on the table. Make a prediction about the motion of the mass. What do you think the change in motion will be if you push on the mass, equally, from opposite sides? Justify your prediction. Record your prediction and what you know that supports it.
- Attach the force probes to the mass as shown in the photo at the beginning of this Unit. Push on the mass and use the force-probe readings to be sure you are pushing with equal force.
- Observe the motion of the mass. Record your observations. Use arrows on your diagram to show any motion of the mass.
- Compare your observations with your predictions. How would you explain what happened in this situation?



3. Situation 3

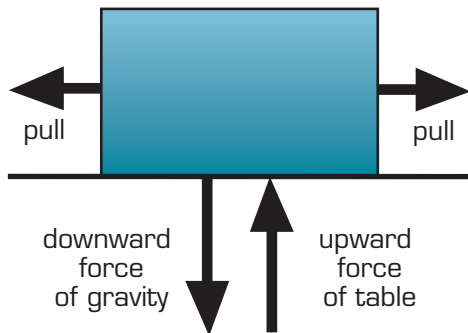
In this situation, you will be pushing on the mass with different forces from opposite sides of the mass. Read the directions carefully. Use the force diagram to help you.

- The mass is at rest on the table. Make a prediction about the motion of the mass. What do you think the change in motion will be if you push with more force from the left side of the mass? Justify your prediction. Record your prediction and what you know that supports it.
- Attach the force probes to the mass as shown in the photo at the beginning of the Unit. Push on the mass, and use the force-probe readings to make sure you are pushing with different forces.
- Observe the motion of the mass. Record your observations. Use arrows on your diagram to show any motion of the mass.
- Compare your observations with your predictions. How would you explain what happened in this situation?



4. Situation 4

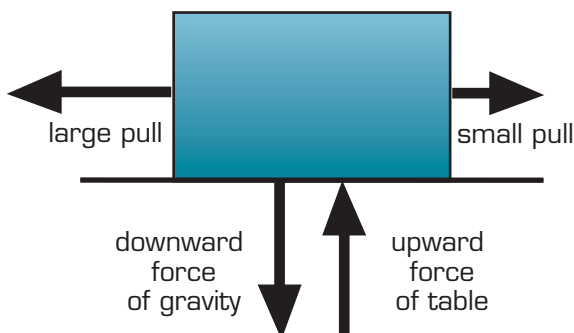
In this situation, you will be pulling on the mass with the same force from opposite sides of the mass. Read the directions carefully. Use the force diagram to help you.



- a) The mass is at rest on the table. Make a prediction about the motion of the mass. What do you think the change in motion will be if you pull on the mass, equally, from opposite sides? Justify your prediction. Record your prediction and what you know that supports it.
- b) Attach the force probes to the mass as shown in the photo at the beginning of this Unit. Pull on the mass and use the force-probe readings to make sure you are pulling with equal force.
- c) Observe the motion of the mass. Record your observations. Use arrows on your diagram to show any motion of the mass.
- d) Compare your observations with your predictions. How would you explain what happened in this situation?

5. Situation 5

In this situation, you will be pulling on the mass with different amounts of force from opposite sides of the mass. Read the directions carefully, and use the force diagram to help you.



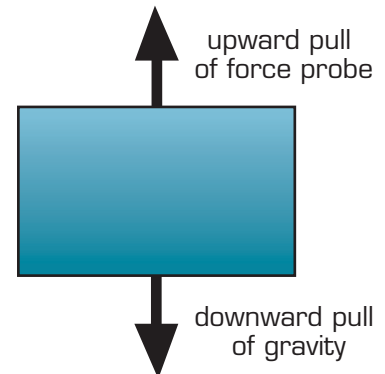
- a) The mass is at rest on the table. Make a prediction about the motion of the mass. What do you think the change in motion will be if you pull on the mass with different forces, from opposite sides? Justify your prediction. Record your prediction and what you know that supports it.
- b) Attach the force probes to the mass as shown in the photo at the beginning of this Unit. Pull on the mass and use the force-probe readings to make sure you are pulling with unequal forces.
- c) Observe the motion of the mass. Record your observations. Use arrows on your diagram to show any motion of the mass.

- d) Compare your observations with your predictions. How would you explain what happened in this situation?

6. Situation 6

In this situation, you pull up on the mass without removing it from the table. Read the directions carefully and use the force diagram to help you.

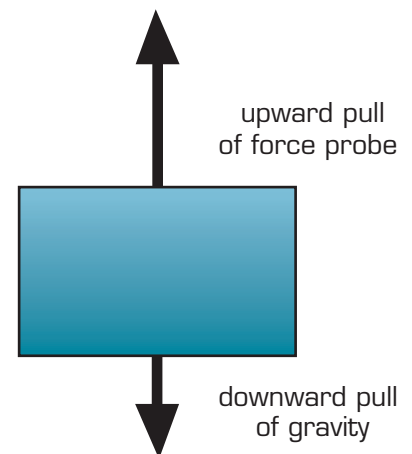
- a) The mass is at rest on the table. What do you think the change in motion will be if you pull up on the mass with the force probe without lifting it off the table? Justify your prediction. Record your prediction and what you know that supports it.
- b) Attach the force probe to the mass as shown in the photo on page 21. Pull on the mass as hard as you can without lifting it off the table.
- c) What is the reading on the force probe?
- d) Observe the motion of the mass. Record your observations. Use arrows on your diagram to show any motion of the mass.
- e) Compare your observations with your predictions. How would you explain what happened in this situation?



7. Situation 7

In this situation, you pull up on the mass and lift it from the table. Read the directions carefully, and use the force diagram to help you.

- a) The mass is at rest on the table. What do you think the change in motion will be if you pull up on the mass with the force probe and lift it off the table? Justify your prediction. Record your prediction and what you know that supports it.
- b) Attach the force probe to the mass as shown in the photo on page 21. Pull on the mass as needed to lift it off the table. Pull on the mass slowly so you can read the force on the probe.



- c) What is the reading on the force probe as the mass is lifted from the table?
- d) Observe the motion of the mass. Record your observations. Use arrows on your diagram to show any motion of the mass.
- e) Compare your observations with your predictions. How would you explain what happened in this situation?



Communicate

Investigation Expo

Each group has explored two different situations. Make a poster that briefly describes what you did in each exploration with your results and conclusions. Make sure your ideas are described clearly so the rest of your class can learn from your experiences. As you describe your understanding of the situations, be sure to use the scientific words you already know. Use the word *force* to describe the pushes and pulls on your object.

As you are listening to others' presentations, pay attention to how each of the situations is unique. Think about how the situations are different from the ones you explored. Note anything that surprises you.

Explain

Now that you have listened to everyone's description and ideas about their situations, you will create an explanation of the effect of various forces on how an object moves.

Recall that a good explanation has this structure:

- your claim
- your evidence
- your science knowledge
- a logical statement tying the claim to the science evidence

If you have created explanations before, you know that after scientists get results from an investigation, they make a claim based on what their evidence shows. A claim is a statement of what you understand

or a conclusion you have reached from an investigation. You will do the same thing now based on the results of your investigation into force and motion. Using a *Create Your Explanation* page, develop a statement declaring your claim.

Next, you will state your evidence. Describe the data that support your claim. You may want to include force diagrams to help you communicate this information.

Science knowledge is knowledge about how things work. This knowledge comes through reading, discussion, talking to an expert, or other experiences. You may include information that you read in this *Learning Set* or knowledge you have gained from other resources. Put this all together to write an explanation on your own. Do not worry if you cannot create a perfect explanation. Just work with the information you have for now. There will be opportunities for you to revisit and rewrite your explanation as you learn more.

Take turns sharing explanations with your group, and then work together to build a group explanation.

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.

What's the Point?

The forces acting on an object can change the way an object moves. Forces can make an object speed up, slow down, or change direction. The investigations in this section showed what happens to an object when different forces act on it. Your explanation helped describe how the forces acting on an object can change the object's motion.

Create Your Explanation
1.3.2 / 2.3.1 / 3.3.1

Name: _____ Date: _____

Use this page to explain the lesson of your recent investigations.

Write a brief summary of the results from your investigation. You will use this summary to help you write your Explanation.

Claim – a statement of what you understand or a conclusion that you have reached from an investigation or a set of investigations.

Evidence – data collected during investigations and trends in that data.

Science knowledge – knowledge about how things work. You may have learned this through reading, talking to an expert, discussion, or other experiences.

Write your Explanation using the **Claim**, **Evidence**, and **Science knowledge**.



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.

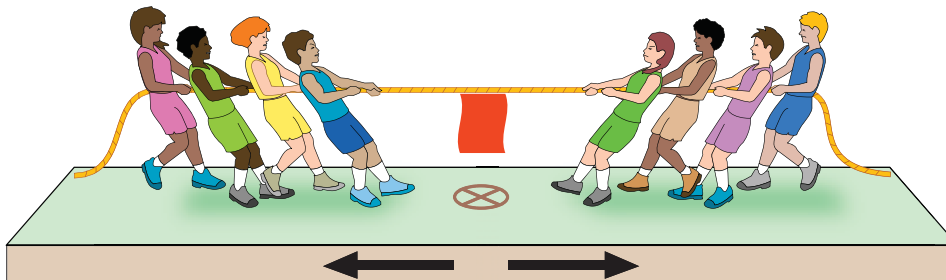


In one investigation, you applied balanced forces to a heavy object. You pushed on the object with the same amount of force from opposite sides. The force probes measured the amount of force you applied on each side. You saw that the forces were the same. You also pulled on the object with

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

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

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.

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.

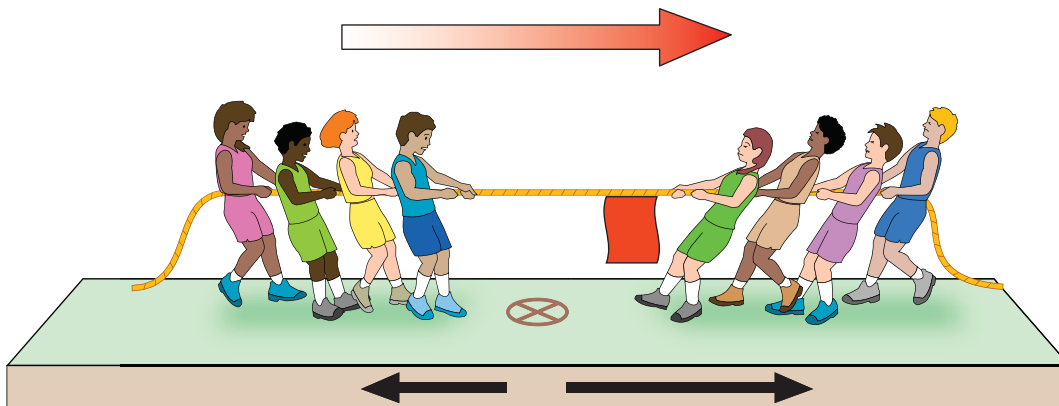
To have unbalanced forces means that the force applied in one direction is greater than the force applied in the opposite direction. When unbalanced forces are acting on an object, there is a change in speed and/or direction.

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.





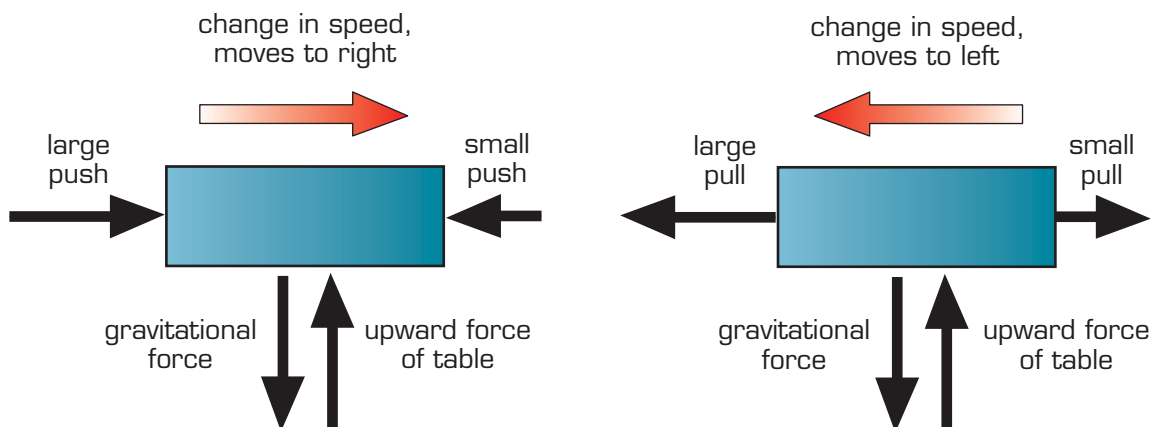
For a team to win a game of tug-of-war, it must pull with greater force than the other team.

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

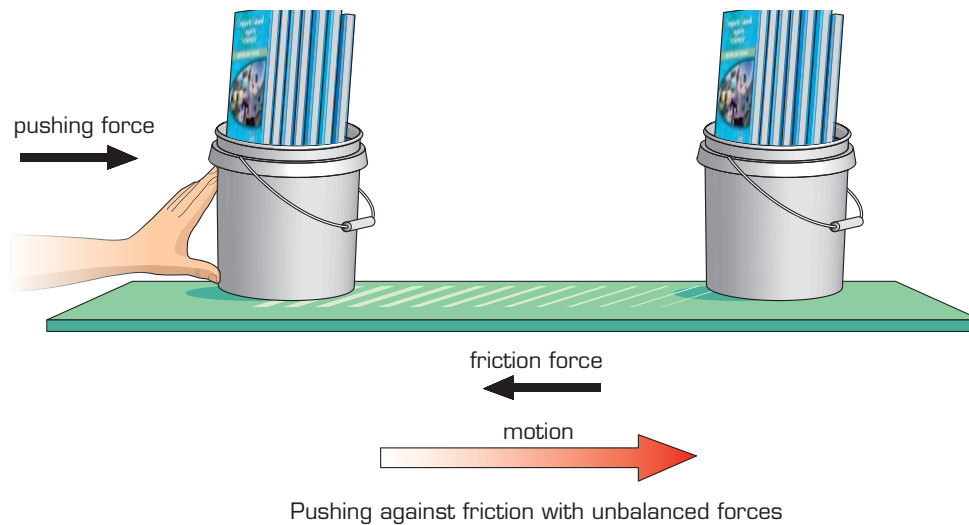
move in the direction of the greater force. That direction was toward the stronger team, so they won.

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.



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.



Learning Set 1

Back to the Big Question

How do machines help move large, heavy objects?

Think back to the construction site or video you saw at the beginning of this Unit. You and your classmates discussed what each of the different types of machines might be used for. Large objects, such as heavy metal beams, large piles of bricks, and big piles of dirt, are difficult to move. That is because there are large forces of gravity and friction acting on them. It is not possible for people to move such heavy objects by themselves. A machine is able to apply a larger force than a person can. The machine can apply a force greater than the force of gravity or friction on the large, heavy object. Since the applied force is greater, there are unbalanced forces acting on the object. The object's motion changes. This is why people use machines to help move big things.

Machines can be designed to move specific objects. For example, a bulldozer is designed to push dirt from one place to another, so it applies an unbalanced force along the ground. A backhoe is designed to dig holes, so it applies unbalanced forces downward to scoop up the dirt and then upward to lift it out of the hole. Smaller machines are designed the same way. A hammer, for instance, is designed to push a nail through wood. It applies a large unbalanced force to the head of the nail. A pair of scissors applies an unbalanced force to a very small point on a piece of paper, allowing the scissors to cut.



To move the nail into the wood a hammer applies a large, unbalanced force on the top of a nail.

Explore

In this Unit, you determined the number of threads required to lift the mass to the top of the cliff. Maybe you found that it requires six or seven threads to avoid having the threads break. You could make the argument that each of these threads represents a certain amount of upward-lifting force. You had to design a situation where the forces were unbalanced in the upward direction.

If you used six or seven threads, each thread would represent a unit of force, and the force of gravity must be equal to about five or six threads. You do not, however, measure force in *threads*. You measure force in newtons. Small forces can be measured with a device known as a *spring scale*.

Get a spring scale, a loop of thread, and the mass you used before. Attach the mass and the thread to the spring scale. Measure

- the amount of force required to lift the mass, and
- the amount of force the thread can handle just before it snaps.

These two numbers will be very important to you when you design your machine to help the biologists, Enrique, Susan, and Tanika. The measurement of the mass will tell you how much force is pulling down on the mass.

You discovered during this *Learning Set* that the biologists need to use an unbalanced upward force to lift the crate up the cliff. You and your group have to do the same thing to the mass. Remember though, you only can use only one single thread to apply the force to the mass. The difference between the force needed to lift the mass and the force at which the thread broke shows you how much force you will need to lift the mass. The machine you design will help supply that force.

In the next few *Learning Sets* you will investigate how a machine might help you make up the difference between these two force measurements.

Update the *Project Board*

Your teacher may have your class return to your *Project Board* to update any questions or ideas you have posted. You now can post some information in the *What are we learning?* column. Be sure to give the evidence you collected to support what you say you have discovered about forces and how objects move.

