Forces
Lesson 2a: How Can We Represent a Force?

Grade 3	**Length of lesson:** 45 minutes	**Placement of lesson in unit:** 2a of 6 two-part lessons on forces
Unit central questions: What makes something start to move? What makes something stop moving or change direction?		**Lesson focus question:** How can we draw the forces pushing or pulling an object when we can't see them?
Main learning goal: The forces acting on an object have a strength and direction that can be represented using arrows of various lengths and directions.		
Science content storyline: Arrows can be used to represent the strength and direction of the forces acting on an object. The direction of an arrow represents the direction of the force, and the length of an arrow represents the strength of the force.		
Ideal student response to the focus question: Arrows can represent the strength and direction of the forces acting on an object. A longer arrow means a bigger, stronger force. A shorter arrow means a smaller, weaker force. The direction of an arrow shows the direction of the force. Arrows pointing in opposite directions represent forces pushing or pulling an object in opposite directions.		

Preparation

Materials Needed • Science notebooks • Chart paper and markers • Rolling cart (from lesson 1a) • 3 foam-board arrows of different lengths (1 long, 1 medium, and 1 short)	**Ahead of Time** • Review the content background document, particularly the discussion of vectors (arrows) in sections 4 and 5. • **ELL support:** Display key science terms on a word wall or ensure that a key-word dictionary is available for students to refer to throughout the lesson. Highlight the terms *force*, *motion*, *movement*, *gravity*, *push*, *pull*, and *twist* • If you haven't already done so, look through students' science notebooks and identify between three and five drawings from the end of lesson 1b that show different ways of representing motion or force. Typical examples include wavy lines, arrows, or streaks. You'll display these sample drawings during the activity setup.

Lesson 2a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
7 min	**Link to previous lesson:** The teacher engages students in a review of key science ideas from previous lessons.	• An object starts to move when it's pushed, pulled, or dropped, or when it falls. These actions are called *forces*. Forces happen only when there's an interaction between two objects. Usually two objects have to touch for something to move, but gravity is a special type of force that pulls an object toward Earth without requiring it to touch the ground.
1 min	**Lesson focus question:** The teacher introduces the focus question, *How can we draw the forces pushing or pulling an object when we can't see them?*	
10 min	**Setup for activity:** The teacher shares several student drawings from the previous lesson that show different ways of representing motion or force.	
15 min	**Activity:** Students use foam arrows of various lengths to represent the strength and direction of a force that causes a cart to move.	• The forces acting on objects have a strength and direction that can be represented using arrows of various lengths and directions. • The direction of an arrow represents the direction of the force, and the length of an arrow represents the relative strength of the force.
8 min	**Follow-up to activity:** The teacher draws diagrams using arrows to represent different forces acting on a cart. Students look for patterns in the diagrams and describe and/or demonstrate the force acting on the cart in each diagram.	• The forces acting on objects have a strength and direction that can be represented in a diagram using arrows of various lengths and directions.
3 min	**Synthesize/summarize today's lesson:** The teacher summarizes key science ideas from the lesson.	• A *force* is a push or pull that involves an interaction between two objects and changes an object's motion. • Arrows can be used to represent the strength and direction of forces acting on objects.
1 min	**Link to next lesson:** The teacher foreshadows the next lesson by asking students what would happen if multiple forces act on an object.	

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7 min	**Link to Previous Lesson** **Synopsis:** The teacher engages students in a review of key science ideas from previous lessons. **Main science idea(s):** • An object starts to move when it's pushed, pulled, or dropped, or when it falls. These actions are called *forces*. Forces happen only when there's an interaction between two objects. Usually two objects have to touch for something to move, but gravity is a special type of force that pulls an object toward Earth without requiring it to touch the ground.	Link science ideas to other science ideas. Highlight key science ideas and focus question throughout.	**Show slides 1 and 2.** How did you answer the focus question from lesson 1, *What makes something start to move?* What did we call those actions that cause something to move? Good examples! **Show slide 3.** Sometimes scientists use words in different ways from how we use them in everyday language. The word *force* is like that. I might say my mother *forced* me to wear this outfit today, or someone's joke *forced* me to laugh out loud. But in science, a *force* is a push or pull between two objects that causes	Something starts to move when it's pushed, pulled, or dropped, or when it falls. Forces.	Can you give us an example from the previous lessons of a force acting on an object? What was exerting the force, and what moved?

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			something to move. Most of the time, two things have to touch to exert a force that causes motion, but last time, we learned about a force that doesn't require two objects to touch. Does anyone remember what that force is called? How did we define *gravity*? What examples of gravity did we come up with in our last two lessons? **NOTE TO TEACHER:** *If students need prompting to recall an example of gravity from the previous lessons, ask them what happened to the toy car or the pencil when it rolled off the table. What caused the car or pencil to change direction and fall to the ground?* **ELL support:** Draw or demonstrate for ELL students what happens before and after the toy car or pencil reaches the edge of the table.	Gravity! *Gravity* is a force that pulls everything toward the ground. No, gravity only pulls on objects. The force of gravity makes things fall to the ground. Gravity makes you go down a hill on a bike or down a slide at the playground. When you throw a ball up in the air,	Does gravity push things too? Can you think of other examples of gravity pulling on something?

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		Link science ideas to other science ideas.	**Show slide 4.** So let's add gravity to our list of key science ideas: • In science, a *force* is a push or pull between two objects that causes motion. • In most cases, two objects must touch to exert a force that causes motion. • *Gravity* is a special type of force that pulls an object toward Earth without requiring it to touch the ground.	gravity pulls it back to Earth.	
1 min	**Lesson Focus Question** **Synopsis:** The teacher introduces the focus question, *How can we draw the forces pushing or pulling an object when we can't see them?*	Set the purpose with a focus question or goal statement.	**Show slide 5.** In this lesson, we'll continue thinking about forces that cause an object to move. Our focus question is *How can we draw the forces pushing or pulling an object when we can't see them?* Write this question in your science notebooks and draw a box around it. **NOTE TO TEACHER:** *Write the focus question on the board for students to see and refer to throughout the lesson.*		

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		Highlight key science ideas and focus question throughout.	Scientists often use diagrams to share their ideas about forces with others. Diagrams help them explain things they can't see but have evidence for, such as forces. That's what we'll do during today's investigation. **ELL support:** To help ELL students visualize what they're being asked to do, provide two or three sample diagrams that scientists use to explain the concept of forces.		
10 min	**Setup for Activity** **Synopsis:** The teacher shares several student drawings from the previous lesson that show different ways of representing motion or force.	Make explicit links between science ideas and activities **before** the activity.	In our last lesson, you drew diagrams of objects and labeled the forces that made them move. Take a moment to locate those drawings in your notebooks. **Show slide 6 (first question only).** **Turn and Talk:** Share your drawings with an elbow partner and answer each question on the slide. After everyone has finished answering the first question for your drawings, I'll show the next one. **ELL support:** Have ELL students pair up with a shared-language partner for this activity.		

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			NOTE TO TEACHER: *Reveal the questions on the slide one at a time. Don't reveal the next question until partners have finished answering the previous question for each of their drawings.* *During the pairs work, inform the students whose drawings you selected as examples that you'd like to share their drawings with the class and will need to collect them immediately following the Turn and Talk.* **Show slide 7.** **Whole-class discussion:** I've selected a few drawings to talk about. As you look at each drawing, think about the questions on the slide: • Can you see a force in the drawing? • What part of the drawing tells you that a force is acting on an object? • How is the force represented in the drawing? For example, are lines, arrows, or something else used to show the force? • What object is exerting a force on another object? • Is the force pushing or pulling the object? How can you tell? • Does the drawing show the		

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			direction and strength of the force? Let's hear your observations!	*Sample 1:* In this picture, I see wavy lines that show the ball rolling, but I don't see the hand that pushed the ball. The hand provided the force, but it isn't in the picture. Yes, it's moving forward. *Sample 2:* In this picture, there are streaky lines that show the paddleball moving. No, but the lines	Say more about the hand pushing the ball. From the picture, can you tell what direction the ball is going? Do the lines show how hard the ball was hit? Can you tell the amount of force used to hit the ball?

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			Great discussion! Now let's investigate how scientists represent the forces that make objects move.	show the paddle pushing the ball. *Sample 3:* This drawing used arrows to show which direction the paddleball was moving. It moved down and then back up.	Tell us more about the ball's motion in this drawing.
15 min	**Activity** **Synopsis:** Students use foam arrows of various lengths to represent the strength and direction of a force that causes a cart to move. **Main science idea(s):** • The forces acting on objects have a strength and direction that can be represented using arrows of various lengths and directions.	Make explicit links between science ideas and activities **during** the activity. Highlight key science ideas and focus question throughout. Select content representations and models matched to the	I mentioned earlier that scientists often use drawings and diagrams to share their ideas about the force involved when two objects interact. These diagrams help them explain things they can't see but have evidence for. Diagrams can also help them figure out what causes objects to move in different ways. In this investigation, you'll represent the forces in different diagrams just like scientists do. **Show slide 8.**		

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	• The direction of an arrow represents the direction of the force, and the length of an arrow represents the relative strength of the force.	learning goal and engage students in their use.	In our first lesson, I asked several volunteers to show us what might make this cart move. Let's have another volunteer come up and exert a pushing force on the cart. When our volunteer pushed the cart, in what direction did it move? How could we show in a drawing or diagram the direction of the force (or push) on the cart? **NOTE TO TEACHER:** *Record student ideas on chart paper during this discussion.* Good idea! An arrow shows a clear direction, doesn't it? How could we show in a diagram the strength of the force? Was it a small, weak push or a big, strong push? Any ideas? **NOTE TO TEACHER:** *As students brainstorm possibilities, accept all ideas without correcting inaccuracies.*	It moved toward the door. We could put wavy lines behind the cart to show that it's moving. We could show the direction of the push with an arrow. We could color the arrow very dark to show a strong push.	Any other ideas to show the direction the cart moves?

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				We could draw a really long, thick arrow to show a strong force and a shorter, thin arrow to show a weaker force.	Any other ideas to show the strength of the push or force?
		Highlight key science ideas and focus question throughout.	These are all great ideas! Scientists use arrows to show both the direction and strength of a force, so we'll use them too. For the next part of our investigation, I'll need two new volunteers. **NOTE TO TEACHER:** *Have Student 1 push the cart and Student 2 use different-sized foam arrows to show the strength and direction of the force used to push the cart.* **Student 1,** when I give you the signal, give the cart a small push to make it move. **Student 2**, watch carefully what happens when the cart is pushed and		

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			think about how you'd use the arrows to show *both* the strength and the direction of the force used to move the cart. OK, **Student 1**, go ahead and push the cart. **Student 2**, select an arrow to show the *strength* and *direction* of the force that caused the cart to move. **Show slide 9.** What did you notice about the arrow Student 2 chose to represent the *strength* of the force? What does the length of the arrow mean? How did Student 2 show the *direction* of the force that made the cart move?	The arrow was really short. It means the force of the push was really small. The cart moved toward the door, and the arrow points toward the	Show me a thumbs-up if you agree. Show me a thumbs-down if you disagree.

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		Summarize key science ideas.	**Show slide 10.** Very good! Arrows show *both* the strength and the direction of a force. The direction of the arrow shows the direction of the force, and the length of the arrow shows how strong the force is. A shorter arrow represents a smaller, weaker force, and a longer arrow represents a larger, stronger force. Now let's use our arrows to show how different forces move the cart in different directions with different strengths. **ELL support:** Review with ELL students words that describe the strength of a force (large, medium, small) and discuss the different ways these words are used when describing physical objects (scientific language vs. everyday language). This was done well with the word *force*. **NOTE TO TEACHER:** *Designate two new volunteers for this part of the investigation. Ask Student 1 to exert a*	door. So that's the direction of the force.	Does anyone want to add to this idea?

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			medium force on the cart and then have Student 2 select appropriate arrows to represent the direction and strength of the force. Then repeat the process, asking Student 1 to exert a large force and having Student 2 select appropriate arrows to represent the direction and strength of the force. *Alternatively, hold up an arrow and ask different volunteers to exert a pushing or pulling force on the cart that matches the direction and strength the arrow represents.* *Make sure volunteers hold the arrows at the point of contact between the two objects that interact—the student and the cart—to represent the direction and strength of the force acting on the cart.* ***Remind students that the force acts on the cart only when the two objects (the student and the cart) are actually touching.***		
8 min	**Follow-Up to Activity** **Synopsis:** The teacher draws diagrams using arrows to represent different forces acting on a cart. Students look for patterns in the diagrams	Highlight key science ideas and focus question throughout. Make explicit	**Show slide 11.** Today's focus question is *How can we draw the forces pushing or pulling an object when we can't see them?* So let's think about how we might use diagrams to represent the forces acting		

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	and describe and/or demonstrate the force acting on the cart in each diagram. **Main science idea(s):** • The forces acting on objects have a strength and direction that can be represented in a diagram using arrows of various lengths and directions.	links between science ideas and activities **after** the activity. Engage students in analyzing and interpreting data and observations.	on the cart. In a moment, I'll draw a series of diagrams on chart paper. Each diagram will show a figure representing the cart and an arrow representing a force that's acting on the cart. After drawing the diagram, I'll ask a volunteer to use the cart to demonstrate the direction and strength of the force that's acting on it. **Show slide 12.** **Turn and Talk:** Look carefully at each diagram and demonstration. Then turn to an elbow partner and describe the force that the arrow represents in each diagram. Think about the questions on the slide: • What is the *direction* of the force? • How *strong* is the force acting on the cart? • How do you know? **NOTE TO TEACHER:** *Draw the first diagram on chart paper and ask a volunteer to use the cart to demonstrate the strength and direction of the force that the arrow represents.* Does the arrow in the diagram represent		

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			the direction and strength of the force you observed when our volunteer pushed the cart? Why or why not? **NOTE TO TEACHER:** *Draw a few more diagrams on chart paper and have different volunteers demonstrate the force acting on the cart. Change the length and direction of the arrows so students will recognize that they represent both the strength and direction of a force. Ask them to describe the force as a push or a pull and make sure they understand that their hands are the objects exerting the force on the cart.* *If time allows, invite students to record the diagrams in their science notebooks, using labels to indicate the strength and direction of the force (arrow) and whether it represents a push or a pull.* *This investigation will prepare students for the next lesson when they're asked to describe multiple forces acting on an object.*	I agree with the direction, but I thought the arrow showed a stronger force than *[Student 1]* used. This force is a push because your hand would push the cart to get it to move in this direction. *[Student 1]* provided the force.	Show us how strong you think the force should have been. Do we all agree? Are there other ideas? Is this force a push or a pull? How do you know? Could it be a pull? Can someone demonstrate this? What object is exerting the force on the cart to make it move?

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				A hand exerted the force on the cart.	What body part exerted the force? Yes, good. We need to be specific about the object that touches the target object and exerts a force.
3 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** The teacher summarizes key science ideas from the lesson. **Main science idea(s):** • A *force* is a push or pull that involves an interaction between two objects and changes an object's motion. • Arrows can be used to represent the strength and direction of forces acting on objects.	Summarize key science ideas.	**Show slides 13 and 14.** Let's summarize what we've learned so far about forces. First, we know that a *force* is a push or pull between two objects that causes something to move. In most cases, two objects must be touching to exert a force that causes an object to move. One exception is the force of gravity that pulls an object toward Earth without requiring the object to touch the ground. Scientists use arrows to show the *strength* and *direction* of a force. The direction of an arrow represents the direction of the force, and the length of the arrow represents how strong the force is. Shorter arrows represent smaller, weaker forces, and longer		

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			arrows represent larger, stronger forces. We'll continue using these key science ideas throughout this unit.		
1 min	**Link to Next Lesson** **Synopsis:** The teacher foreshadows the next lesson by asking students what would happen if multiple forces act on an object.	Link science ideas to other science ideas.	**Show slide 15.** Today we investigated what happens when a force acts on an object like a cart. But what happens if more than one force acts on an object at the same time? In what direction would the object move, or would it move at all? How would we use arrows to represent more than one force acting on an object? We'll explore these questions next time.		