Forces
Lesson 2: Representing Forces

Grade: 3	**Length of lesson:** 60 minutes	**Placement of lesson:** 2 of 6 lessons in the Forces lesson series.
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 cannot see a push or a pull?
Main learning goal: Forces acting on an object have a strength and a direction that can be represented by arrows of various lengths and directions.		
Science content storyline: A force between two objects can be represented by an arrow. The direction of the arrow shows the direction of the force. The length of the arrow shows the strength of the force.		
Ideal student response to the Focus Question: Arrows can represent the strength and direction of a force. A longer arrow means a stronger force. A shorter arrow means a weaker force. Arrows pointing in opposite directions mean forces are pushing or pulling in opposite directions.		

Note to teacher: In the lesson plans for this module, anticipated student responses indicate ideas that students might have related to the elicit question posed. Some of these ideas are scientifically correct, but others represent misconceptions. Inaccurate ideas are indicated with italics. Notice that these inaccurate student ideas are not "corrected" by the teacher. Sometimes the teacher uses the opportunity to ask questions to push student thinking and make connections to science ideas developed during classroom activities. Other times, teachers should keep track of these ideas and return to them as the lessons progress to address these ideas.

Preparation

MATERIALS NEEDED	AHEAD OF TIME
Teacher Masters: • Lesson 2 powerpoint **Student Handouts:** • 2.1 Master: What are the Forces? **Other Materials:** **1 per class** • Cart • Foam board arrows of different sizes to demonstrate forces **1 per pair:** • Toy Car • 6 small arrows (tag board)	• Review the information about ***forces and motion*** in the Content Background document. • • ***Between lesson 1 and lesson 2, look through the students' science notebook to identify different ways that students represented either motion or force in their drawings. Typical examples might be wavy lines or arrows or streaks. Select 3-5 examples to show the class in the set-up to today's activity.***

Lesson 1 General Outline

Time	Phase of lesson	How the Science Content Storyline Develops
8 min	**Link to previous lesson:** Teacher reviews the lesson 1 focus question, *What makes something start to move?*	An object moves when it is pushed, pulled or dropped. These actions are called forces. Forces don't just happen with one object by itself, a force is an interaction between two objects. Usually those two objects are touching, but the force of gravity pulls objects toward Earth even when that object is not touching the ground.
5 min	**Lesson Focus Question:** The teacher introduces the lesson focus question: *How can we draw the forces pushing or pulling an object when we cannot see a push or a pull?*	
7 min	**Set up for Activity 1:** Several drawings from students' science notebooks from lesson 1 are shared on the document camera or smart board to see how students represented a force acting on an object.	
20 min	**Activity 1:** Students use arrows to represent forces causing a cart to start to move and to stop.	• Forces have a both a strength and a direction that can be represented by arrows. • The length of the arrow represents the relative strength of the force. • Arrows pointing in different directions show that forces are acting in different directions. • If more than one force acts on an object, you can predict its motion by adding or subtracting the length of the arrows.
13 min	**Follow-up to Activity 1:** Students practice drawing arrows to represent forces on a worksheet.	
5 min	**Synthesize/Summarize:** Students summarize how arrows can represent forces.	Arrows can be used to show the direction and strength of the force(s) acting on an object.
2 min	**Link to Next Lesson:** If forces make an object start to move, why do objects eventually stop moving?	

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8 min	**Link to previous ideas** Synopsis: Students review the key science ideas from Lesson 1. Main science ideas: An object moves when it is pushed, pulled or dropped. These actions are called forces. Forces don't just happen with one object by itself, a force is an interaction between two objects. Usually those two objects are touching, but the force of gravity pulls objects toward Earth even when that object is not touching the Earth.	Highlight key science ideas throughout.	Who can tell me how you would answer yesterday's focus question, *What makes something start to move, change direction or stop?* What did we call those actions that result in motion, does anyone remember? That's good. You want to remember that word. Sometimes scientist use words in ways that are different from how we use the word in everyday language. The word force is like that. I might say my mother forced me to wear this outfit today, or John's joke forced me to laugh out loud. **In science a force is a push or pull between two objects.** Most of the time, two things touch to exert a force, but we had one example yesterday where there was a pull when two objects didn't touch. Does anyone remember what force we saw yesterday that can push or pull even without objects touching? *If students need a prompt, have them recall the ball dropping from the table. What caused the ball to change the direction of its motion?* *If students blew on an object to make it move without touching it, be sure that they recognize that even though they didn't touch the ball, the air pushed the ball. The air exerted the force.*	Something moves when it is pushed, pulled or if it drops or falls. We said that is a force. Gravity is a force that pulls everything toward the ground. Gravity is a pull. The force of gravity makes you fall. It is what makes you go down a hill on a bike, or down the slide at the playground. When you throw a ball up in the air it is gravity that pulls it back to Earth.	Can you give me an example from lesson 1 of the forces acting on an object? What was exerting a force and what was moving? Do you think gravity would be a push or a pull? Can you think of other examples of the force of gravity pulling on something?

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5 min	**Focus Question** Synopsis: The teacher introduces the lesson focus question: *How can we show in a drawing the forces on an object?*	Set the purpose with a focus question.	Today we're going to continue to think about forces that cause motion. As scientists we want to be able to show other people what we're thinking, so scientists often use diagrams to explain their ideas to others. Scientists also try to put things they cannot see in their diagrams. Today's focus question asks, *How can we draw the forces pushing or pulling an object when we cannot see a push or a pull?* Write that question on the top of a new page in your science notebook. Draw a box around the question.		
7 min	**Set up for Activity 1** Synopsis: Several drawings from students' science notebooks from lesson 1 are shared on the document camera or smartboard to see how students represented a force acting on an object. Main science ideas:		Take a minute to look back at the drawing you made in your science notebook at the end of Lesson 1. How did you represent a force in your drawing? Can you see it? Can you tell if it is a push or a pull? Can you tell how strong the force is? *Show slide 4 of the Lesson 2 ppt. This slide is animated to allow you to introduce the questions one at a time. Have students turn and talk as they look at their diagrams to answer each question separately.* *Prior to this lesson, look through the students' science notebooks to identify different ways that students represented force or motion. (See Ahead of Time on page 1 of the lesson plan.)* I looked through your science notebooks and pulled out a couple that I would like to	In Jackson's picture I see wavy lines that show the ball was	In the picture, can you tell what direction the ball was going?

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			share with you. As we look at these drawings, try to figure out if the drawing shows a force. If so, how did you know it was a force by looking at it.	rolling, but I don't see the hand that pushed it. In Gloria's picture there are streaky lines that show the paddle ball moving. Trevor used arrows to show which way the ball was moving.	Do you know how hard the ball was pushed? Can you tell the strength of the force by the lines on Gloria's picture, whether she hit the ball hard or soft? Can you tell from the picture that the ball went one direction and then another?
20 min	**Activity 1** Synopsis: Students use arrows to represent forces acting on a cart causing it to. A number line on the floor shows differences in relative motion of different pushes to help students represent the strength of the force. Main science ideas: • Forces have a both a strength and a direction that can be represented by arrows. • The relative length of the arrow represents the relative strength of the force. • Arrows pointing in different directions		*Pass out one Hot Wheel car to each pair of students.* With your partner, I want you to exert a small force. Then exert a medium force on the car and then a strong force on the car. While you do, think about these questions: *(Show slide 5 of the lesson 2 ppt)* • What was different when you used a small, medium and strong force on the toy car? • How do you think you could show the ***direction*** of the force on the toy car in a diagram? • How do you think you could show the ***strength*** of the force in a diagram? Set your toy car on the corner of the desk, and let's try the same thing with our cart. We'll come back to the toy car in a minute. Use self-control not to touch it until I tell	The car went farther when we pushed harder. The car went faster when we pushed harder. If you gave the car a stronger force it went farther and faster. If you gave it a softer push it went slow and	Is that the only thing that was different about the motion of the cars when you pushed harder and softer? Who can compare the motion of the car when it was pushed with stronger and weaker forces?

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	show that forces are acting in different directions. • If more than one force acts on an object, you can predict its motion by adding or subtracting the lengths of the arrows.		you to. Scientists like to be able to communicate something about the forces between two objects to other scientists in their drawings and diagrams. Their diagrams can sometimes help them figure out what caused different motions to occur. In this activity we're going to learn to represent a force in a diagram just like scientists do. Yesterday, I had a volunteer use a force to make the cart move. Who wants to volunteer for that job today? Please exert a force the cart. *Student should give it a push.* What direction did the cart move? How might you demonstrate that direction in a picture? Okay. How would I know how strong the force was that pushed the cart? Any ideas? (*accept all answers*)	not as far. The cart moved toward the door. I could show what direction he went with an arrow. I could put wavy lines behind the cart to show it was moving. I could make the wavy lines longer for more movement.	

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		Select content representations and models matched to the learning goal and engage students in their use.	Scientists use arrows to show the direction and strength of a force. The direction of the arrow shows the direction of the force. The length of the arrow shows how strong the force is. Longer arrows mean bigger forces. Can I get two student volunteers? Student 1, please use a small force to make the cart move. Student 2, will you select an arrow and use it to show the strength and direction of the force that caused the cart to move? How did Student 2 show the strength and direction the small force that Student 1 used to make the cart move? *Repeat this process having students exert a medium and a large force and selecting appropriate arrows and holding them at the point of contact between the student and the cart to show the direction and strength of the force acting on it.* ***Remind students that the force is acting on the cart only when the two objects (student and cart) are touching.*** Now, what would we do if more than one force were acting on the cart at the same time? Can anyone imagine what that how could more than one force act on the cart at the same time?	Well, two students could push the cart at the same time. We would have to use two arrows to show two	

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			How might we represent that?	forces.	
			Student 1, why don't you pull the cart this time. Stand on one side of it and get ready to pull. Student 2, stand on the other side of the cart and get ready to pull in the opposite direction.		
			Which direction is the force exerted by student 1? How would we represent that force?	Student 1 is pulling toward the windows. We would show that with an arrow that points toward the window.	
			Which direction is the force exerted by student 2? How would we represent that force?	Student 2 is pulling toward the door. We would show that with an arrow pulling toward the door.	
			Now, what do you think will happen when student 1 and 2 pull?	It depends on how hard the two students pull!	
				Maybe the cart won't move at all.	
				Well, if they are the same amount of force pulling in opposite directions, it will just stay still.	If forces are being exerted on the cart, why wouldn't it move?
				The cart would move a little bit.	What do you think would happen if student 1 and student 2

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			Shall we try that out? First, Student 1 and Student 2, try to pull gently on the cart with the same amount of force. How will you know you were each pulling with the same amount of force? Can I have two more students come up to use the arrows and show me what's happening with the forces? Now let's try if Student 1 pushes with a gentle force and Student 2 pushes with a stronger force. What do you think might happen? Try to keep the force steady so we can see what happens. Could my volunteers now represent the two different strength forces with the arrows? *All the student volunteers can sit down.*	If the cart doesn't move, then we must be pulling with the same force. If the cart starts to move, then one of us is using more force than the other.	exert forces of different strengths on the cart?
13 min	**Follow-up Activity 1** Synopsis: Students work together with their team to complete Master 2.1, Representing		With your partner, let's try to do the same thing with our toy cars. *(Show lesson 2 ppt. slide 5. Pass out the baggies with arrows to represent small medium and large forces to each pair)*		

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	Forces. Main Science Ideas: Arrows can be used to show the direction and strength of the force(s) acting on an object.	Engage students in using and applying new science ideas in a variety of ways and contexts.	First, I want you and your partner to exert equal forces on the toy car. How would you know if the forces you exert are the same? Now, use the arrows in your bag to represent the forces acting on the toy car when they are equal. Next, you and your partner agree on who will push or pull the toy car with a small force and who will push or pull with a large force. Try that out, and then use arrows in your bag to represent the forces acting on the toy car when they are not equal. Now let's see if we can use these ideas to communicate ideas about forces in diagrams. *Pass out Master 2.1, What are the Forces.* Now that you've tried it with a real car, how would we represent those motions in a diagram? *Students draw arrows on the worksheet and write a sentence to describe the motion of the car with different strength forces pushing in opposite directions.*		
5 min	**Summarize/Synthesize** Synopsis: Students summarize how		I'd like you to turn to a partner to summarize what you learned today. Remember our focus question is, *How can we draw the forces pushing or pulling an*		

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	arrows can represent forces.	Engage students in making connections by synthesizing and summarizing key science ideas.	*object when we cannot see a push or a pull?* Talk to your partner to come up with your best answer to that question. Open your science notebook to your drawing and response to the Lesson 1 Focus Question. In this picture add arrows to represent the direction and strength of the forces acting on your object. Then turn to today's focus question and write a complete sentence that answers today's focus question. *(Show slide 7 of the Lesson 2 ppt.)*		
2 min	**Link to Next Lesson** Synopsis: If forces make an object start to move, why do objects eventually stop moving?		In the past 2 lessons, we've talked about how forces can make an object start to move. In tomorrow's lesson, we will explore what makes objects slow down and eventually stop.		

Embedded assessment task.

Listen to students' ideas. What's visible about student thinking?