Forces
Lesson 3a: Slowing Down and Stopping

Grade 3	**Length of lesson:** 45 minutes	**Placement of lesson in unit:** 3a 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:** Why do moving objects slow down and eventually stop?
Main learning goal: Moving objects slow down and stop at different distances on different surfaces.		
Science content storyline: All moving objects on Earth eventually slow down and stop. The surface an object moves over determines how long it will take for the object to stop. Objects take longer to slow down and stop on smooth surfaces, but they slow down and stop more quickly on rough surfaces.		
Ideal student response to the focus question: The surface an object moves over or through has something to do with the object slowing down and stopping. Objects pushed with the same force travel farther over smooth surfaces than over bumpy surfaces.		

Preparation

Materials Needed

- Science notebooks
- Chart paper and markers
- *For surface demonstration:*
  - Wood strip (for ramp)
  - 1–2 wood blocks to support the ramp
  - Toy car (from lesson 2b)
  - Strip of carpet (4 ft long)
  - Strip of tile (4 ft long) with smooth surface (or 4 individual tiles)
  - Strip of sandpaper (4 ft long; glued to underside of tile)
  - Meter stick

Student Handouts

- 3.1 Does the Surface Matter? (Page 1 only) (1 per student)

Ahead of Time

- Read section 3 (Friction) in the content background document.
- **ELL support:** Identify Tier 2 and Tier 3 words in the lesson plan to review in advance with ELL students and prepare visual references (e.g., a word wall).
- Glue the sandpaper to the underside of the strip of tile.
- Assemble the necessary materials to set up a demonstration ramp on a tabletop (see Materials Needed). Practice setting the car at the top of the ramp and letting it go without applying force so that gravity pulls it down the ramp. Perform a trial run and resolve any problems with the setup. The tabletop will be the only "surface" used in the demo, but prepare samples of the three surfaces to show students what they'll be working with in the actual investigation.

Lesson 3a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
10 min	**Link to previous lesson:** The teacher reviews what arrows represent about the forces acting on an object. Then students describe how they would use arrows to represent the forces acting on a soccer ball.	• The forces acting on an object have a strength and direction that can be represented using arrows of various lengths and directions.
2 min	**Lesson focus question:** The teacher reviews the unit central questions, *What makes something start to move? What makes something stop moving or change direction?* Then the teacher introduces the focus question, *Why do moving objects slow down and eventually stop?*	
7 min	**Setup for activity:** Students consider what makes a kicked soccer ball eventually stop moving.	
15 min	**Activity:** Students predict what would happen if they rolled a soccer ball and a toy car over three different surfaces. They consider how this relates to objects slowing down and eventually stopping.	• An object rolling over a rough surface doesn't travel as far as when it rolls over a smooth surface.
5 min	**Follow-up to activity:** Students share their ideas and predictions with a partner about whether a toy car will travel the same distance over three different surfaces.	• Differences in surface texture must have something to do with variations in the distance an object moves when the same force is acting on it.
5 min	**Synthesize/summarize today's lesson:** The teacher reviews the focus question. Then students revise the statements they completed earlier about what makes a kicked soccer ball slow down and eventually stop.	
1 min	**Link to next lesson:** The teacher announces that in the next lesson, students will test their predictions by collecting data on a toy car rolling over three different surfaces.	

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10 min	**Link to Previous Lesson** **Synopsis:** The teacher reviews what arrows represent about the forces acting on an object. Then students describe how they would use arrows to represent the forces acting on a soccer ball. **Main science idea(s):** • The forces acting on an object have a strength and direction that can be represented using arrows of various lengths and directions.	Link science ideas to other science ideas. Summarize key science ideas.	**Show slides 1 and 2.** In our last two lessons, we learned how scientists use arrows to represent the forces acting on an object in a diagram. What two things does an arrow show about a force? Right! An arrow shows *both* the strength and the direction of a force acting on an object. The direction of an arrow represents the direction of the force, and the length of an arrow shows the strength of the force. A short arrow represents a small or weak force; a medium-length arrow represents a medium-strength force; and a long arrow represents a big or strong force. **NOTE TO TEACHER:** *If students need a visual reminder of arrow lengths and their corresponding strengths, you might draw and label short, medium-length, and long arrows as you review these concepts.* **Show slide 3 (without animation).** This slide shows players kicking a soccer ball down the field toward a goal.	It shows the strength and direction of a force.	

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			The red and blue circles represent the players, the yellow circle is the ball, and the dotted line is the path the ball travels down the field. What arrows would you draw to represent the forces acting on the soccer ball as it moves down the field and passes from one player to the next? Give me a thumbs-up when you have these arrows in mind. **Show slide 4.** **NOTE TO TEACHER:** *Toggle between the slides 4 and 5 so that students can see the soccer image as they discuss the following questions. Alternatively, display the image on a document reader or smart board.* What arrows would you draw to represent the forces necessary to score a goal? **Turn and Talk:** Now turn to an elbow partner and describe the arrows you'd draw to represent these forces. As you and your partner discuss your ideas, think about the questions on the slide: • What object is being pushed or		

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			pulled? • What object is exerting a force? • What is the direction of each arrow that represents a force acting on an object? • What is the length of each arrow? • What does the length of each arrow represent? **Show slide 5.** **Whole-class discussion:** Who would like to come to the board and draw an arrow representing the first force exerted on the ball that makes it start to move? Can you tell us about your drawing? **ELL support:** It may be helpful for ELL students to see visual representations of the Tier 2 and Tier 3 words used in this discussion. **NOTE TO TEACHER:** *During this discussion, use the slide animation to show the arrows as students describe them. If possible, have students draw the arrows and labels directly on the board.* *Emphasize that the player's foot exerts a force on the soccer ball **only** while both objects are in contact. So the arrow should be directly over the point of contact between the foot and the ball. It*	I drew a long arrow from the first kicker to the second player. *[Misconception: Extending the long arrow from one player to another implies that a constant force is being exerted on the ball.]* The arrow represents the force of the first kick.	Why did you draw the arrow there? What does the arrow represent?

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		Engage students in communicating in scientific ways.	*should **not** extend the entire distance the ball travels. An arrow the same length as the distance the ball travels might lead to the misconception that a force continues acting on the ball as long as the ball is moving.* *If time allows, ask students to describe the forces acting on the ball as it moves down the field. Based on their soccer or kickball experience, they might describe different actions, such as stopping and starting, slowing down, and changing direction. See examples in column 5.* *During this discussion, encourage other students to agree or disagree, question or challenge the description, or add on.*	The arrow is pointing from the first player to the second player to show the direction of the force. The size of the force is pretty big because the ball went pretty far. The force is acting on the ball the whole time until the ball stops. *[Inaccurate]* The foot and the ball	Based on the long arrow you drew, what can you tell me about the size and direction of the force acting on the ball? Where or how, exactly, is this force occurring? In lesson 1 we talked about the idea that most forces occur when two objects are touching. What two objects are touching for the force to occur in your diagram?

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				are touching.	
				I could draw it over the first player instead of from one player to the other player.	How might you draw your arrow so it shows that the force is occurring only where the ball and the foot are touching?
			Does anyone else have something to add about the forces acting on the soccer ball?	I think the first force acting on the ball is the first soccer player's foot pushing the ball to the second soccer player.	How would you draw that arrow? How long should it be? In what direction should the arrow point? What motion results from that

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					action? Do you think the ball would speed up, slow down, change direction, or stop?
				I think the second force is the second soccer player kicking the ball in a different direction.	
					How would you draw that arrow? How long should it be?
					In what direction should the arrow point?
					What two objects interact to move the ball in a different direction?
				I'd draw an arrow pointing toward the goal and make that arrow longer because the soccer ball looks like it's going faster.	
			Now who would like to come up and draw another force acting on the soccer		

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			ball that results in a goal? **NOTE TO TEACHER:** *Students might observe that the goal net exerts a force that stops the ball's motion. The arrow representing this force would point in the opposite direction of the ball's motion.* You've done a fantastic job showing both the strength and direction of the forces acting on the soccer ball!		
2 min	**Lesson Focus Question** **Synopsis:** The teacher reviews the unit central questions, *What makes something start to move? What makes something stop moving or change direction?* Then the teacher introduces the focus question, *Why do moving objects slow down and eventually stop?*	Set the purpose with a focus question or	**Show slide 6.** Let's review our unit central questions, *What makes something move? What makes something stop moving or change direction?* For the past few days, we've been thinking about the first question and exploring forces that push, pull, or twist an object to make it start moving. Today we'll begin thinking about the second question and investigate what makes an object stop moving. **Show slide 7.** Our focus question for this lesson is *Why do moving objects slow down and eventually stop?*		

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		goal statement.	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.*		
7 min	**Setup for Activity** **Synopsis:** Students consider what makes a kicked soccer ball eventually stop moving.	Make explicit links between science ideas and activities **before** the activity.	We just described the forces acting on a soccer ball to score a goal. But what makes a soccer ball stop moving? If you were out on the playground and kicked a ball as hard as you could, what do you think would happen?	The ball would keep going forever. The ball would stop eventually. Nothing keeps going forever. It would depend on how hard the ball was kicked. Just like the toy car, the	Have you seen that happen on the playground? Does the ball keep going and never stop? What do you mean by "eventually"? How far do you think the ball would go before it stopped?

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		Highlight key science ideas and focus question throughout.	Does everyone agree that the ball would eventually stop? Give me a thumbs-up if you agree and a thumbs-down if you don't. Today's focus question asks us to figure out why moving objects slow down and eventually stop. Why does everything in motion eventually stop unless something keeps pushing or pulling it? **Show slide 8.** Let's think about another scenario: If you kick a soccer ball on a field, why do you think the ball will eventually stop? **Turn and Talk (2 min):** Briefly discuss this question with an elbow partner and come up with your best ideas and explanations. **ELL support:** Have ELL students pair up with shared-language partners for this discussion. **Whole-class share-out:** Let's hear some of your ideas. Why do you think a soccer ball will eventually stop after you kick	harder it's pushed or kicked, the farther it will go before it stops.	

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			it? **NOTE TO TEACHER:** *Keep this discussion brief. As students share their ideas, record them on chart paper to revisit later. Encourage students to participate in the discussion by agreeing, disagreeing, asking questions, or adding on. If they need prompting, direct their attention to the sentence starters on the CSW poster (e.g., "I'd like to piggyback on what X is saying"; "I have a question for Y"; "I disagree with Z because ....").* You've come up with some interesting ideas about why a soccer ball eventually stops after it's kicked. **Show slide 9.** Summarize your ideas by completing	I don't know why it stops. I just know it does. I think the force just runs out. If you kick the ball, it will keep going until the force runs out. *[Inaccurate]* I think a force is like energy. You have energy, and then you get tired and stop. So the soccer ball has energy at first, but then it gets tired and stops. *[Inaccurate]*	Can you think of anything that doesn't eventually stop? What do you mean by "runs out"? Where does the force go? Does it run out like gas in a car? Do you think a soccer ball really "gets tired"?

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			this sentence in your science notebooks: *I think the soccer ball I kick on a field will eventually stop because _____.*		
15 min	**Activity** **Synopsis:** Students predict what would happen if they rolled a soccer ball and a toy car over three different surfaces. They consider how this relates to objects slowing down and eventually stopping. **Main science idea(s):** • An object rolling over a rough surface doesn't travel as far as when it rolls over a smooth surface.	Make explicit links between science ideas and activities **during** the activity. Ask questions to elicit student ideas and predictions.	**Show slide 10.** Now let's think about this scenario: Some students went outside and rolled a soccer ball over three different surfaces. First, they rolled the ball across a grassy field. Then they measured how far the ball rolled before it stopped. Next, the students rolled the same soccer ball over the blacktop on their school playground. They tried to push the ball with exactly the same force they used the first time. Then they measured how far the ball rolled before it stopped. Finally, the students rolled the ball over the tile floor in one of the school hallways, trying again to use exactly the same force. Then they measured how far the ball rolled before it stopped. Do you think the ball traveled the same distance on all three surfaces before it came to a stop? Why or why not? **Turn and Talk (2 min):** Share your ideas and predictions with an elbow partner. Explain your reasoning using		

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			the ideas we talked about earlier and evidence from any experiences you've had. **Whole-class discussion:** So do you think the ball traveled the same distance over the grass, the blacktop, and the hallway tile before it stopped? Why or why not?  Listen to students' ideas. What's visible about student thinking?	I think the ball rolled the same distance if the students pushed it with the same force each time. *[Inaccurate]* I think the ball rolled farther in the hallway than on the grass. It wouldn't go as far on the grass.	Why do you think so? Can you provide any evidence for your ideas based on your experiences? Why do you think the ball wouldn't go as far on grass? Can you provide any evidence for your ideas based

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		Select content representations and models matched to the learning goal and engage students in their use.	You'll have an opportunity to test your ideas in our next lesson as we investigate what happens when another object moves over three different surfaces. To prepare for our investigation, you'll predict what you think is likely to happen. **Show slide 11.** First, let's go over the setup you'll be using for this investigation. Each team will have a ramp, a toy car, and three different surfaces for the car to travel across. You'll place a meter stick along the strip of material at the bottom of the ramp to measure the distance the car travels over each surface. As you can see on this slide, one of the surfaces the car will travel across is carpet. The other two surfaces are tile and sandpaper. **NOTE TO TEACHER:** *You should already have assembled a ramp setup to demonstrate for students. Placing the setup on a tabletop will ensure that everyone will be able to see. For the actual investigation, students will set up*		on your experiences?

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			the ramp on the floor. At the beginning of each trial, you'll place the car at the top of the ramp and let it go. Don't push the car; just set it *gently* at the top and let go, and it will start moving down the ramp. **NOTE TO TEACHER:** *Demonstrate how to gently set the car at the top of the ramp and let it go without applying force so that gravity will cause the car to roll down the ramp.* If you set the car at the top of the ramp, what force will cause the car to start moving down the ramp? Will gravity pull the car with the same force each time you gently set it on the ramp? If we perform this test 10 times, do you think the car will be traveling at about the same speed each time when it reaches the bottom of the ramp?	Gravity will pull down on the car. The ramp makes the car roll down at a slant instead of falling straight down. Yes, gravity should pull with about the same force each time.	

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			Are you ready to test your predictions? **NOTE TO TEACHER:** *Invite two or three students to gently set the car at the top of the ramp and let it go. Note the speed and distance the car travels across the table. As long as the car is placed in the same spot at the top of the ramp each time and isn't pushed, students should observe that gravity affects the car the same way each time, and the car should travel at approximately the same speed and distance.* In the actual investigation, you'll collect data on how far the car travels over the carpet, the tile, and the sandpaper after it rolls down the ramp. **NOTE TO TEACHER:** *Pass around samples of the three different surfaces and allow students to touch and examine them. Then distribute page 1 of handout 3.1 (Does the Surface Matter?) and walk students through step 1 of the assignment.* **Show slide 12.** Today we'll work on step 1 of the handout. First, you'll read the information about the investigation at the top of the handout, and then write down		

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			your predictions about the toy car and explain your reasoning. The questions you'll answer are *Do you think the car will travel the same distance over all three surfaces?* and *Why do you think this will or won't happen?* As you write your predictions and explanations on the handout, keep in mind our previous discussion about the soccer ball rolling over the grass, the blacktop, and the hallway tile. Also think about our focus question, *Why do moving objects slow down and eventually stop?* **ELL support:** Allow ELLs students to pair up with a shared-language partner and discuss their predictions before writing them on the handout. Students also benefit from engaging in multiple modes of expression. One possibility is to have them draw a diagram of their predictions.		
		Ask questions to elicit student ideas and predictions. Highlight key science ideas and focus question throughout.			
5 min	**Follow-Up to Activity** **Synopsis:** Students share their ideas and predictions with a partner about whether a toy car will travel the same distance over	Make explicit links between science ideas and activities **after** the	**Show slide 13.** **Turn and Talk:** Share your predictions with an elbow partner and make sure to include your reasoning! You can revise your answers on the		

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	three different surfaces. **Main science idea(s):** • Differences in surface texture must have something to do with variations in the distance an object moves when the same force is acting on it.	activity. Engage students in constructing explanations and arguments.	handout if you think your partner has a better idea or prediction. Don't erase your original ideas. Just *lightly* cross through them so you can still read them. Then write your new ideas underneath or on the back of the handout in a different-colored pencil or pen. **NOTE TO TEACHER:** *Encourage students to listen carefully to their partners' ideas and be willing to revise their own predictions if their partners' ideas are better or stronger. Instruct students to write their new ideas in a different color and lightly cross through their original ideas so they can still read them.* **Whole-class share-out:** Let's hear a few of your predictions and explanations. **NOTE TO TEACHER:** *As students share their predictions, record their ideas on chart paper for comparison with the ideas they express following the investigation.*		
5 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** The teacher reviews the focus question. Then students revise the statements they completed earlier about what makes a	Highlight key science ideas and focus question throughout.	**Show slide 14.** The focus question we've been pondering in this lesson is *Why do moving objects slow down and eventually stop?*		

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	kicked soccer ball slow down and eventually stop.	Engage students in making connections by synthesizing and summarizing key science ideas.	As we explored this question today, you came up with some interesting ideas about why a kicked soccer ball eventually stops. To summarize your ideas, you completed this sentence: *I think the soccer ball I kick on a field will eventually stop because _____.* Find this sentence in your science notebooks and revise it based on the ideas we explored today. Don't erase your original ideas. Just lightly cross them out so you can still read them and then write any new ideas underneath your answer using a different-colored pencil or pen. Be prepared to share your ideas and explanations with the class at the beginning of our next lesson.		
1 min	**Link to Next Lesson** **Synopsis:** The teacher announces that in the next lesson, students will test their predictions by collecting data on a toy car rolling over three different surfaces.	Make explicit links between science ideas and activities.	**Show slide 15.** Today we predicted whether a toy car rolling down a ramp will travel the same distance over three different surfaces. Next time, we'll test our predictions and collect some data to help us figure out		

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			why moving objects slow down and stop. Do you think your predictions will match what actually happens? Stay tuned!		