Forces
Lesson 4a: Can a Surface Push on a Moving Object?

Grade 3	**Length of lesson:** 45 minutes	**Placement of lesson in unit:** 4a 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:** What force makes a moving object slow down and eventually stop?
Main learning goal: When bumps on the surfaces of two objects push against one another, they create a force called *friction*. Friction is the reason moving objects on Earth slow down and eventually stop.		
Science content storyline: The toy car in our investigation traveled different distances over three different surfaces. Tiny bumps on these surfaces pushed against the bumps on the surface of the car's wheels, creating a force called *friction* that acted in the opposite direction of the car's motion. The pushing force of friction caused the car to slow down and eventually stop. In a world without friction, such as outer space, objects in motion would keep moving forever in a straight line.		
Ideal student response to the focus question: When bumps on the surfaces of two objects push against each other, it creates a force called *friction* that we can't see. This force pushes in the opposite direction of an object's motion and makes the object slow down and eventually stop.		

Preparation

Materials Needed

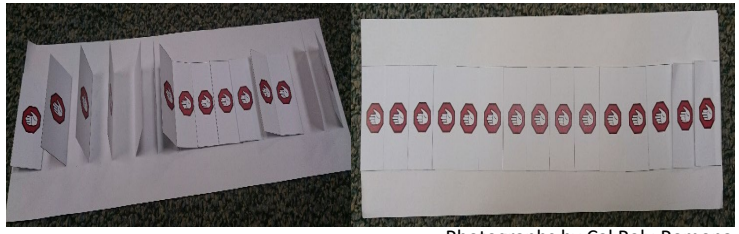
- Science notebooks
- Chart paper and markers
- Class data table on chart paper (or displayed on a document reader) (from lesson 3b)
- Hand lens (magnifying glass) (2 per team)
- Tape (for assembling hand-strip model)
- *Ramp setup from lesson 3b (for class demonstration):*
  - Wood strip (for ramp)
  - 1–2 wood blocks to support the ramp
  - Toy car (from lesson 2b)
  - Hand strip (1 for class demonstration)
- *Materials for surface investigation (1 set per team):*
  - Toy car (from lesson 2b)
  - Strip of tile with strip of sandpaper on opposite side (from lesson 3b)
  - Strip of carpet (from lesson 3b)
  - Meter stick

Student Handouts and Teacher Masters

- 4.1 Hand Strip (Teacher Master)

Ahead of Time

- Review section 3 (Friction) in the content background document.
- **ELL support:** Prepare visual references (e.g., a word wall) for Tier 2 and Tier 3 words in the lesson plan, such as *friction*, *force*, *gravity*, *motion*, *pull*, *push*, and *twist*.
- Cut apart the hand-strip squares from handout 4.1. Center and tape the bottom of each square onto a sheet of plain paper (see images below) and continue taping until the sheet is filled.
- Assemble the ramp setup and hand strip for the class demonstration.



Photographs by Cal Poly Pomona

Lesson 4a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
10 min	**Link to previous lesson:** The teacher reviews science ideas about forces from previous lessons and links these ideas to the unit central questions, *What makes something start to move? What makes something stop moving or change direction?*	• A *force* is a push, pull, twist, or drop that causes an object at rest to start moving. • In our investigation, a toy car rolling over the three different surfaces stopped at different distances even though the force (gravity) that caused the car to start moving was always the same. • Variations in surface texture (the roughness or smoothness of a surface) caused the car to stop at different distances on each surface.
2 min	**Lesson focus question:** The teacher introduces the focus question, *What force makes a moving object slow down and eventually stop?*	
6 min	**Setup for activity:** Students analyze patterns in the class data from the previous lesson and consider whether forces have anything to do with making an object slow down and stop.	• The three surfaces in our investigation weren't the same. The carpet was very rough, the tile was very smooth, and the sandpaper was in between. Variations in the texture of each surface affected how far the car rolled before it stopped, even though the force of gravity that caused the car to start moving was always the same.
10 min	**Activity:** The teacher introduces a hand-strip model to demonstrate the surface forces that push in the opposite direction of an object's motion, causing the object to slow down and eventually stop.	• When an object moves over a surface, the surface exerts a pushing force in the opposite direction of the object's motion, causing the object to slow down and eventually stop.
10 min	**Follow-up to activity:** Working in teams, students use a hand lens to examine the three surfaces (carpet, sandpaper, and tile) and compare them with the hand strip. They also examine the car's wheels and compare them with the three surfaces. Then students record their observations on a data table.	• When the toy car rolls over each of the three surfaces, tiny bumps on each surface push against tiny bumps on the car's wheels, creating a force that acts in the opposite direction of the car's motion. The bigger the bumps on a surface, such as the carpet, the greater the force pushing in the opposite direction of the car's motion.
6 min	**Synthesize/summarize today's lesson:** Students share the observations they recorded on their data tables, comparing the three surfaces with the hand-strip model. Then the teacher relates the discussion to the focus question.	• As the toy car rolls over a surface, bumps on the surface push against bumps on the car's wheels, creating a force that acts in the opposite direction of the car's motion. The bigger the bumps on a surface, such as the carpet, the greater the force pushing in the opposite direction of the car's motion.
1 min	**Link to next lesson:** The teacher foreshadows the next lesson in which students will learn the name of the force that causes a moving object to slow down and eventually stop.	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
10 min	**Link to Previous Lesson** **Synopsis:** The teacher reviews science ideas about forces from previous lessons and links these ideas to the unit central questions, *What makes something start to move? What makes something stop moving or change direction?* **Main science idea(s):** • A *force* is a push, pull, twist, or drop that causes an object at rest to start moving. • In our investigation, a toy car rolling over the three different surfaces stopped at different distances even though the force (gravity) that caused the car to start moving was always the same. • Variations in surface texture (the roughness or smoothness of a surface) caused the car to stop at different distances on each surface.	Link science ideas to other science ideas.	**Show slide 1.** At the end of our last lesson, I gave you a homework assignment to ask your family the final question on our handout: *If forces make an object start to move, do they also have something to do with making an object stop?* Who would like to share how your family members answered this question? **NOTE TO TEACHER:** *Spend a few minutes discussing the results of the family interviews students conducted at home after the previous lesson.* **Show slide 2.** Let's review what we've learned so far about forces. **ELL support:** Make sure visual and language resources are available for ELL students to use. Who can give me a good definition of the word *force*? Who can give me an example of a force that's acting on an object?	A *force* is a push, pull, twist, or drop that makes an object start to move. Pushing someone while playing tag.	Can anyone give

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
					me another example?
			What does a force cause an object to do?	A force causes an object to start moving.	
			Who can give me a good definition of *gravity*?	*Gravity* pulls things toward the ground.	
			Who can give me an example of gravity causing something to move?	Dropping a pencil.	Tell me more about dropping a pencil and gravity?
				Gravity pulls the pencil down to the floor.	So is gravity a force?
				Gravity is the pull of Earth, and a pull is a force.	
			Show slide 3.		
			Now let's think about our investigation with the toy car and the three surfaces in the previous lesson.		
			What force made the toy car start to move?	When we had the car at the top of the ramp, gravity pulled	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
				on the car, but it didn't go straight down to the ground because the ramp was in the way. The ramp made the car start moving. No, gravity pulled the car down.	Say more about the ramp. Did the ramp push or pull the car?
			We let the car roll down the ramp and over the three surfaces many times, didn't we? It rolled over the carpet three times, it rolled over the tile three times, and it rolled over the sandpaper three times. Was the force that made the car start moving the same or different each time the car went down the ramp and rolled over one of the three surfaces?	The force had to be the same. Well, the car was the same, and the ramp was the same. Nothing changed that would make the pull of gravity different.	Why do you say it had to be the same? What do others think? Do you

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
					agree or disagree? Do you have anything to add?
			Why do you think it's important to make sure the force that's acting on the car is the same every time?	I think the force that started the car moving could have been different if someone pushed the car down the ramp instead of just setting it there and letting gravity pull it. If you pushed the car sometimes and didn't push it sometimes, and the force was different, then the trials wouldn't be fair.	What do you mean by "the trials wouldn't be fair"?
				Well, if you gave the car a push at the beginning, it would go farther than if you just set it down.	Does everyone agree? Anyone want to add to that idea?
			Show slide 4. In this unit on forces, we've been talking about two central questions: *What makes*		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		Summarize key science ideas.	*something start to move?* and *What makes something stop moving or change direction?* **Turn and Talk:** Pair up with an elbow partner and summarize what you've learned so far about forces that can help us answer these questions. Think about the sentence you completed last time: *I think forces [do/do not] have something to do with making an object stop moving because _____.* **Whole-class discussion:** What have you learned about forces that can help us answer our unit central questions? **ELL support:** Encourage students to respond to one another's ideas and share epistemic authority for what they're learning.	A force can start something moving or make something slow down, speed up, or stop moving. For a force to work, two things usually need to touch, like your hand and the toy car.	Say more about "start something moving." What starts something moving? Talk more about the car. What do

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			Thank you for sharing your ideas!	We think the force of the carpet made the car stop moving. The carpet seemed to pull on the car, but the tile just let the car keep going.	you think made it stop moving? Interesting. What do you mean by "the force of the carpet"?
2 min	**Lesson Focus Question** **Synopsis:** The teacher introduces the focus question, *What force makes a moving object slow down and eventually stop?*	Set the purpose with a focus question or goal statement.	**Show slide 5.** Today's focus question is similar to our previous focus question: *What force makes a moving object slow down and eventually stop?* Can anyone tell me what new science word has been added? Yes, our new focus question includes the science idea of force. 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 refer to throughout the lesson.*	Force!	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			In our next two lessons, we'll continue thinking about why moving objects slow down and stop, and we'll try to figure out what causes this to happen.		
6 min	**Setup for Activity** **Synopsis:** Students analyze patterns in the class data from the previous lesson and consider whether forces have anything to do with making an object slow down and stop. **Main science idea(s):** • The three surfaces in our investigation weren't the same. The carpet was very rough, the tile was very smooth, and the sandpaper was in between. Variations in the texture of each surface affected how far the car rolled before it stopped, even though the force of gravity that caused the car to start moving was always the same.	Make explicit links between science ideas and activities **before** the activity. Engage students in analyzing and	**Show slide 6.** To answer today's focus question, we need to look again at our class data table showing the results of our surface investigation. **NOTE TO TEACHER:** *Display the chart from the previous lesson showing the class data. You may also want to display the table on a document reader.* What pattern did we identify in our class data? Thank you for this summary! **Show slide 7 (first question only).** **NOTE TO TEACHER:** *Reveal one question at a time during the discussion.* Now let's analyze our class data based on what we observed in our investigation.	The car rolled the greatest distance on the tile, a middle distance on the sandpaper, and the least distance on the carpet.	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		interpreting data and observations.	Why do you think the car traveled different distances over the three surfaces?	Because the tile was really smooth, but the carpet was really soft. *[Inaccurate]*	So the surfaces were different? Why did that matter?
				Well, the smooth surface doesn't grab the car at all. The car glides right along. But the soft surface sort of grabs the car and won't let it go very far. *[Misconception]*	What do you think it is about the carpet that grabbed the car?
				The different pieces of yarn stick up and stop the car. *[Misconception]*	Who would like to add to these ideas?
				The surfaces felt different. The tile was smooth, but the sandpaper was bumpy.	
			What do you think the bumpiness of the surface had to do with the distance the car rolled before it stopped?	It's just like when we	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
				were talking about the ball in our other lesson. If you roll it over the playground surface, it bumps into all sorts of rocks and holes, and whatever it bumps into makes it go slower or not go in a straight line.	So you think that bumps on the surface made the car slow down? Is that the same for the carpet?
				Yes. I don't think it matters if the carpet is hard or soft. It has bumps that the car has to roll over. Those bumps make the car slow down and stop.	
			OK. Based on our data, do we all agree that an object will move farther on a smooth surface than it will on a rough surface? **ELL support:** Have ELL students add the adjectives *smooth* and *rough* to their key-word dictionaries or some other resource for future use.	Yes!	
			Does everyone agree that forces have		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			something to do with making objects slow down and eventually stop?		
10 min	**Activity** **Synopsis:** The teacher introduces a hand-strip model to demonstrate the surface forces that push in the opposite direction of an object's motion, causing the object to slow down and eventually stop. **Main science idea(s):** • When an object moves over a surface, the surface exerts a pushing force in the opposite direction of the object's motion, causing the object to slow down and eventually stop.	Select content representations and models matched to the learning goal and engage students in their use. Ask questions	In today's investigation, we're going to use our ramp setup again, but this time, we'll use a "hand strip" as our surface and see what happens when the toy car rolls over it. **NOTE TO TEACHER:** *Show students the hand strip you assembled from handout 4.1.* **Show slide 8.** Describe the surface of the hand strip. How is the hand strip *like* or *not like* the three surfaces in our investigation? What do you think will happen when the	It has little hands on it that look like stop signs. Each hand kind of sticks up. It looks like the hands on our handout in lesson 2 when we drew the arrows. It seems like the hand strip is mostly like the carpet. It has things sticking up.	Does anyone have anything to add? Does anyone have other ideas?

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		to elicit student ideas and predictions.	toy car rolls over the hand strip? **Turn and Talk:** Discuss this question with an elbow partner and share your predictions and ideas. **Whole-class discussion:** So what do you think will happen when the car rolls over the hand strip? Let's test our predictions and see what happens! **NOTE TO TEACHER:** *Have students gather around the ramp setup and position themselves so they can see. Let the car run down the ramp and over the*	I think it will be just like on the carpet. The things sticking up will make the car slow down and stop. I think that the paper is soft, kind of like the carpet, and the car will just push it over. *[Inaccurate]* I think the paper will make the car stop on the first hand. It doesn't have enough force to push the paper down. *[Inaccurate]*	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		Make explicit links between science ideas and activities **during** the activity.	*hand strip at least two times so students see that the car stops about the same distance each time.* **Show slide 9.** Why do you think the car stopped? Use the words *force*, *push*, or *pull* in your explanations. **MISCONCEPTION NOTE:** *The idea that a moving object just runs out of force is a common student misconception. Objects don't* ***contain*** *a force, so they*	The car stopped because the hands on the strip pushed it. Each hand that pushed the car caused it to slow down a little bit. Eventually, it just stopped. Each time the car hit a hand, it slowed down. Each hand was a force that pushed on the car and made it slow down. I think the car stopped because it just ran out of force. Gravity pulled on it	Can someone add to these ideas? Can you use our science words in your description? What did the hands do to the car?

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			can't run out. Help students understand that a force is an ***interaction*** *between two objects. What makes the object start to move (e.g., a push, a kick)? What then makes an object slow down and stop (e.g., a push from the hands on the hand strip, or a push from the bumps on the sandpaper or carpet fibers)? Students will continue exploring the science ideas of forces as interactions between two objects in subsequent lessons.* Let's think about the idea of the car stopping because the hands on the strip pushed it. What is our science word for a push or pull?	only when it was at the top of the ramp. It didn't pull down anymore once the car got to the bottom. *[Misconception]* Well, it started with a certain amount of force, and it just quit after a while. *[Misconception]* A force. I think the car slowed down because the hand strip made a force that pushed against the car. The hand pushed in the opposite direction the car was moving.	You said the car "ran out of force." What do you mean by that? Can you use the word *force* to describe why the car slowed down? What direction was the hand strip pushing? What was the size of the force each
		Highlight key science ideas and focus question throughout.			

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			Great discussion! You may return to your seats now.	Each hand pushed with only a little force. It took a bunch of hands pushing to stop the car.	hand exerted on the car?
10 min	**Follow-Up to Activity** **Synopsis:** Working in teams, students use a hand lens to examine the three surfaces (carpet, sandpaper, and tile) and compare them with the hand strip. They also examine the car's wheels and compare them with the three surfaces. Then students record their observations on a data table. **Main science idea(s):** • When the toy car rolls over each of the three surfaces, tiny bumps on each surface push against tiny bumps on the car's wheels, creating a force that acts in the opposite	Make explicit links between science ideas and activities **after** the activity. Select content representations and models matched to the learning goal and engage students in their use.	Now let's revisit our class data and think about how the hand strip can help us explain why the car stopped at different distances on the three surfaces. For this activity, you'll work in teams to examine the three surfaces from the previous investigation. I'll give each team two hand lenses, or magnifying glasses, so you'll need to share. **NOTE TO TEACHER:** *Divide the class into teams and give each team two hand lenses, a toy car, and the surface strips of carpet, sandpaper, and tile. Make sure the class data table is displayed where everyone can see it.* **Show slide 10.** In your teams, take turns using the hand lenses to examine each surface closely. Observe any differences between the		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
	direction of the car's motion. The bigger the bumps on a surface, such as the carpet, the greater the force pushing in the opposite direction of the car's motion.		surfaces; then think about how each surface is like or not like the hand strip. Discuss the three questions on the slide with your teammates and record the answers in your science notebooks: 1. How is the *carpet* like or not like the hand strip? 2. How is the *sandpaper* like or not like the hand strip? 3. How is the *tile* like or not like the hand strip? **NOTE TO TEACHER:** *Make sure teams finish examining the surfaces and discussing the questions before displaying the next slide.* **Show slide 11.** Next, create a data table in your notebooks like the one on the slide and describe how each surface is like or not like the hand strip. **Individual work time.** **Show slide 12.** Now take turns using your hand lenses to examine the wheels of the toy car. Then talk about these questions with your teammates:		

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			• What do you notice about the wheels? Are they smooth or bumpy? • Are the wheels more like the carpet, the sandpaper, or the tile? Why do you think so? Make notes about the wheels below your data table. We'll talk more about this in our next lesson.		
6 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** Students share the observations they recorded on their data tables, comparing the three surfaces with the hand-strip model. Then the teacher relates the discussion to the focus question. **Main science idea(s):** • As the toy car rolls over a surface, bumps on the surface push against bumps on the car's wheels, creating a force that acts in the opposite direction of	Engage students in making connections by synthesizing and summarizing key science ideas.	**Show slide 13.** Let's share the observations you recorded on your data tables. How did you describe the similarities and differences between the surfaces and the hand strip? **NOTE TO TEACHER:** *If possible, project a few team data tables on a document reader. If the data is incomplete, have students share their observations and ideas verbally. Keep this discussion brief, since students will focus on these ideas in the next lesson as well.* How is the *carpet* like or not like the hand strip?	The carpet is like the hand strip because it	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
	the car's motion. The bigger the bumps on a surface, such as the carpet, the greater the force pushing in the opposite direction of the car's motion.		How is the *sandpaper* like or not like the hand strip? How is the *tile* like or not like the hand strip? **Show slide 14.** Can we agree that the carpet is most like the hand strip?	has a lot of pieces sticking up. The carpet isn't smooth; it's rough and bumpy. The hand strip is made of paper, and the carpet is made of yarn or string. The sandpaper is bumpy too, but not as bumpy as the carpet. The sandpaper doesn't have anything sticking up like on the hand strip. I don't think the tile is like the hand strip at all! They're both squares! The tile doesn't stick up like the hand strip.	

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
			What would you say is the main difference between the carpet and the tile when you compare it with the hand strip? Why do you think the car travels the shortest distance over both the carpet and the hand strip? What does this have to do with our science idea of force? **NOTE TO TEACHER:** *If time allows, have students discuss these questions with a partner before sharing their ideas with the class. Also encourage students to compare the hand strip and tile strip and ask these questions: Does something also push back on the car as it rolls across the smooth tile? Will the car roll forever on the tile? (They already know the car will travel farther on tile.) What will eventually make the car slow down and stop, even on a smooth surface?* *If students observe that the wheels of the toy car are also bumpy and wonder whether the bumps might have something to do with the car slowing down and stopping, just make a note of their ideas for now. This idea will be the focus of the next lesson when friction is introduced.*	Yes! Like the hand strip, the carpet has a lot of hands pushing back on the car, but the tile doesn't have as many hands or bumps pushing back. The car travels a shorter distance on the carpet because a lot of hands are pushing back against it. The hand strip shows how each hand pushes back on the car to slow it down, so the carpet must do that too. The carpet pushes more on the car, so it has more force to make the car slow down.	Can you use the science idea of force in your description? Can anyone add to this idea?

Time	Phase of Lesson and How the Science Content Storyline Develops	STeLLA Strategy	Teacher Talk and Questions	Anticipated Student Responses	Possible Probe/Challenge Questions
		Highlight key science ideas and focus question throughout.	**ELL support:** Encourage students to respond to one another's ideas. It may be beneficial if ELL students pair up for this discussion so they have more opportunities to share their ideas. **Show slide 15.** You're doing some very good thinking about our focus question, *What force makes a moving object slow down and eventually stop?* I hope the hand-strip model will help you think about how a surface pushes against a moving object to make it slow down and eventually stop. We'll learn more about this in the next lesson.	We know that a force is a push or pull, so the hand strip shows us that the surface can push back somehow. The same thing happens with the carpet.	
1 min	**Link to Next Lesson** **Synopsis:** The teacher foreshadows the next lesson in which students will learn the name of the force that causes a moving object to slow down and eventually stop.	Link science ideas to other science ideas.	**Show slide 16.** Scientists use a special word to describe the force that makes a moving object slow down and eventually stop. We'll find out what that word is next time! Are you curious?		