Forces
Lesson 5a: Describing Multiple Forces

Grade 3	**Length of lesson:** 50 minutes	**Placement of lesson in unit:** 5a of 6 two-part lessons on forces
Unit central questions: What makes something start to move? What makes something change direction or stop moving?		**Lesson focus question:** What happens if more than one force pushes or pulls an object?
Main learning goal: If two forces of *equal* strength are pushing or pulling an object in opposite directions, the object won't move. If forces of *unequal* strength are pushing or pulling an object in opposite directions, the object will move in the direction of the stronger force.		
Science content storyline: We can predict whether an object will move by figuring out the direction and strength (size) of the forces pushing or pulling it. If a student tries to push a heavy file cabinet across a carpet, the push exerts a force on the cabinet, and the frictional force between the carpet and the bottom of the cabinet pushes back in the opposite direction. If the student's push is equal to the opposing push of friction, the cabinet won't move. If the student's push is greater, or stronger, than the push of friction, the cabinet will move in the direction of the student's push. Smoother surfaces like tiles, have smaller bumps that push against other surfaces with less force, so the student would be able to push the cabinet across tiles more easily than across a carpet. In this case, the student would apply much more force than the frictional force of the tiles pushing in the opposite direction. In summary, if two forces of *equal* strength are pushing or pulling on an object in opposite directions, the object will remain at rest. If forces of *unequal* strength are pushing or pulling an object in opposite directions, the object will move in the direction of the stronger force.		
Ideal student response to the focus question: More than one force can push or pull an object at the same time. If forces of the same size (equal strength) are pushing or pulling an object in opposite directions, the object won't move. But if forces of different sizes (unequal strength) are pushing or pulling the object in opposite directions, the object will move in the direction of the stronger force.		

Preparation

Materials Needed	**Ahead of Time**
• Science notebooks • Chart paper and markers • 6 foam-board arrows of different lengths (2 short, 2 medium, and 2 long) (1 set from lesson 2a) • File cabinet or some other heavy object in the classroom • 2 hand strips (1 from lesson 4a) • **Optional:** rolling cart (from lesson 1a)	• Review section 4 (Net Forces) in the content background document. • Assemble another hand-strip model in addition to the hand strip from lesson 4a.
Student Handouts • 4.2 Friction (1 per student) (from lesson 4b) • 5.1 Describe the Forces (Part 1 only) (1 per student)	

Lesson 5a General Outline

Time	Phase of Lesson	How the Science Content Storyline Develops
10 min	**Link to previous lesson:** The teacher engages students in a review of key science ideas about friction.	• *Friction* is a force created when bumps on the surfaces of two objects push against one another. Friction is what causes moving objects to slow down and eventually stop.
1 min	**Lesson focus question:** The teacher introduces the focus question, *What happens if more than one force pushes or pulls an object?*	
5 min	**Setup for activity:** Students consider the forces acting on a heavy file cabinet and attempt to explain why the cabinet doesn't move when a girl pushes on it.	
20 min	**Activity:** Students describe and illustrate what happens when multiple forces act on a file cabinet in three different scenarios.	• When tiny bumps on the surfaces of two objects push against one another, a force called *friction* is created that causes a moving object to slow down and stop. These bumps can also exert a force strong enough to result in no motion at all. • Reducing the weight of an object reduces the force of friction, since the bumps on the surfaces of two objects don't push against one another quite as strongly. • Smoother surfaces have smaller bumps that don't exert as much force. So when an object moves over a smoother surface, the force of friction is also reduced.
10 min	**Follow-up to activity:** Students share their ideas about the equal and unequal forces acting on the file cabinet in the three scenarios. The teacher uses the hand strips to demonstrate friction in each scenario.	• More than one force can push or pull an object at the same time. • If forces of *equal* strength are pushing or pulling an object in opposite directions, the object won't move. • If forces of *unequal* strength are pushing or pulling an object in opposite directions, the object will move in the direction of the stronger force.
3 min	**Synthesize/summarize today's lesson:** The teacher summarizes key science ideas from the lesson.	
1 min	**Link to next lesson:** The teacher foreshadows the next lesson in which students continue exploring what happens if more than one force acts on an object and how gravity can be involved.	

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10 min	**Link to Previous Lesson** **Synopsis:** The teacher engages students in a review of key science ideas about friction. **Main science idea(s):** • Friction is a force created when bumps on the surfaces of two objects push against one another. Friction is what causes moving objects to slow down and eventually stop.	Link science ideas to other science ideas.	**Show slides 1 and 2.** In our last lesson, we added *friction* to our word wall. What is friction and how does it work? Let's think for a moment about the bumps on a surface that push back against a moving object. What did we learn from our reading on friction last time? Are there bumps anywhere else besides the surface the object moves across?	Friction means that bumps on the surfaces of two objects push back against each other when something is moving. Friction causes something to slow down and stop moving because of the push from the surface that the object is moving across. There are bumps on the bottom of the	How do the bumps, or friction, affect the motion of an object?

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				object too, like on the wheels of the toy car.	
			Good! We learned that there are bumps on both surfaces, didn't we? **NOTE TO TEACHER:** *If necessary, have students reread the section on bumps in handout 4.2 (Friction).* Who can give us an example of friction from your everyday life? **ELL support:** To get the conversation going, offer an example from your home life to give ELL students an idea of what you're looking for. Encourage ELL students to respond to one another's ideas during this discussion. Note any confusing and/or surprising ideas that might form the basis of a future science talk. **NOTE TO TEACHER:** *Allow plenty of time for this discussion to prepare students for today's investigation. The more clearly they can articulate their understandings of friction as bumps on the surfaces of two objects pushing against one another, the more success they'll have during the investigation.*	If I wear tennis shoes, I don't slide around on the floor because of the friction. But if I'm wearing socks, I slide around a lot. Well, tennis shoes are sticky on the bottom, so they have a lot of friction. But socks are smooth on the bottom, so there isn't a lot of friction, and I can move more easily.	Tell us more about friction in your example.
		Ask questions to probe	*Ask probe and challenge questions to help students link and compare their examples with the hand-strip model, the essay on*		How do these examples compare with our hand-strip model?

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		student ideas and predictions. Ask questions to challenge student thinking. Engage students in making connections by synthesizing and summarizing key science ideas.	*friction, or the investigation of the three surfaces. Challenge students to use the word* friction *in their examples.*	I guess the bottom of the tennis shoes would be more bumpy like the hand-strip model because of the tread, but the socks would be less bumpy because the surface is smoother. The tennis shoes would have more bumps like the grass in our reading. The socks would be more slippery like the floor. The tennis shoes have more friction than the socks, so I can't slide around on the floor in the tennis shoes, but I	How do these examples compare with the examples of the grass and the floor in our reading on friction? Can you compare these examples using the word *friction* instead of *bumps*?

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				can in the socks. I wouldn't be able to slide around in either the tennis shoes or the socks because the carpet has a lot more bumps.	What would happen if you were on carpet instead of a smooth floor? How would that affect your ability to slide around in your stocking feet? What would be different about the friction?
1 min	**Lesson Focus Question** **Synopsis:** The teacher introduces the focus question, *What happens if more than one force pushes or pulls an object?*	Set the purpose with a focus question or goal statement.	**Show slide 3.** Today's focus question is *What happens if more than one force pushes or pulls an object?* 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.*		

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			As we think about this question during today's investigation, keep in mind that one of the forces might be friction.		
5 min	**Setup for Activity** **Synopsis:** Students consider the forces acting on a heavy file cabinet and attempt to explain why the cabinet doesn't move when a girl pushes on it.	Make explicit links between science ideas and activities **before** the activity.	**Show slide 4.** Consider this scenario: A student is trying to move a heavy file cabinet across a carpeted classroom floor. She pushes as hard as she can, but the cabinet doesn't budge. Why do you think the cabinet won't move? Could forces have something to do with it? If so, how? **Turn and Talk (2 min):** Discuss these questions with an elbow partner and share your ideas. Think about the forces that are acting on the file cabinet and see if you can explain why the cabinet doesn't move. **ELL support:** Have ELL students pair up with shared-language classmates for this discussion. **Whole-class discussion:** Let's hear some of your ideas. Why do you think the file cabinet doesn't move? How might forces be involved? **NOTE TO TEACHER:** *If students are*	We think the cabinet doesn't move because it's too heavy.	Are you saying

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			struggling to explain why the cabinet doesn't move, remind them of the demonstration in lesson 2 when two students pulled a rolling cart with equal force at the same time, but in opposite directions. As needed, perform the cart demonstration again so that students can visualize the forces involved. *Relate the cart to the file cabinet by asking students to describe the equal but opposite forces acting on the cabinet that keep it from moving. What force is pushing in the opposite direction of the force the girl is using on the cabinet?*	Yes. Something lighter would move. We think the cabinet doesn't move because it's flat on the bottom. Yes. We think that if the cabinet had wheels, it would move. We think the cabinet doesn't move because a force must be pushing against it in the opposite direction—just like what happened with the cart.	that if the file cabinet wasn't so heavy, it would move if the girl pushed it? Are you saying that the surface of the file cabinet has something to do with the cabinet not moving when it touches the floor? What do you think that opposite force

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			Can we agree that forces might have something to do with why the cabinet in our scenario doesn't move? Do you think you could move a heavy file cabinet yourself? Let's find out!	I really don't know. Maybe gravity is pushing down on the cabinet while the girl is pushing sideways?	might be?
20 min	**Activity** **Synopsis:** Students describe and illustrate what happens when multiple forces act on a file cabinet in three different scenarios. **Main science idea(s):** • When tiny bumps on the surfaces of two objects push against one another, a force called *friction* is created that causes a moving object to slow down and stop. These bumps can also exert a force strong enough to result in no motion at all. • Reducing the weight of an object reduces the	Make explicit links between science ideas and activities **during** the activity. Select content representations and models matched to the learning goal and engage students in their use. Engage students in using and applying new	Today, we'll investigate the forces acting on a file cabinet in our own classroom. Then we'll describe these forces in three different scenarios. **NOTE TO TEACHER:** *Select a heavy object in the classroom that student won't be likely to move with a hard push. If you don't have a heavy file cabinet, you might use a heavy table stacked with books or another heavy object in the room.* So who wants to try moving this file cabinet *[or another heavy object]*? Be careful not to hurt yourself by pushing too hard or trying to lift the cabinet! **NOTE TO TEACHER:** *Monitor students*		

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	force of friction, since the bumps on the surfaces of two objects don't push against one another quite as strongly. • Smoother surfaces have smaller bumps that don't exert as much force. So when an object moves over a smoother surface, the force of friction is also reduced.	science ideas in a variety of ways and contexts.	*during the activity to make sure they don't hurt themselves as they try to push the cabinet. Caution them not to try lifting the cabinet.* **Show slide 5.** *[Student 1]* is obviously exerting a force on the cabinet, but it isn't moving. Can someone use a foam arrow to represent the pushing force that *[Student 1]* is exerting on the file cabinet? **NOTE TO TEACHER:** *Have a volunteer use a long foam arrow to represent the force the student is exerting on the file cabinet.* Because the file cabinet isn't moving, we know that a force of equal strength must be pushing on the file cabinet in the opposite direction, don't we? Think about the rolling cart and what happened when two students pulled it in opposite directions at the same time using the same force. What would be the direction and strength of the forces pushing on the cabinet? Use two arrows to show us what you think is happening.		

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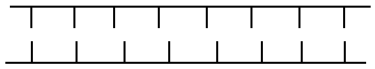
		Select content representations and models matched to the learning goal and engage students in their use.	**NOTE TO TEACHER:** *Have students use two arrows to show how they think multiple forces are pushing or pulling on the cabinet.* **Show slide 6.** In our last lesson, we used a hand strip to help us understand how the bumps on two surfaces push against one another, creating friction that makes an object slow down and eventually stop. Try to imagine the tiny bumps on the bottom surface of the file cabinet and on the surface of our classroom floor *[or carpet]*. How could we use our hand-strip model to show how the bumps on these surfaces interact or push against one another? **NOTE TO TEACHER:** *You'll need two hand strips for this demonstration. Have one student hold a hand strip facedown in the air, and a second student hold a hand strip faceup just below the first hand strip.*  Can you picture in your minds the tiny bumps on the surfaces of the file cabinet and the		

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			floor? **Show slide 7.** Do you think the weight of the file cabinet makes any difference in how the bumps interact or push against one another? When a few of you tried to push the heavy file cabinet across the floor, how do you think the bumps on the cabinet and the floor interacted or pushed against one another? Can someone describe this using the hand strips? **Show slide 8.** Now what do you think would happen if we tried pushing an empty file cabinet across the floor? How do you think the bumps on both surfaces would interact?	The bumps pushed against each other more closely, and that's why the cabinet didn't move. The hand strips get pushed closer together when the cabinet is heavy. The bumps wouldn't	Does anyone agree or disagree with these ideas? Do you have anything to add on?

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				push together as much if the cabinet was empty.	
			Can someone describe this using the hand strips?	The hand strips might be farther apart and barely touch if the cabinet is lighter.	Does anyone agree or disagree with these ideas? Do you have anything to add on?
			Do you think the cabinet will move if the bumps on both surfaces are barely touching?		
			Show slide 9.		
			How strong are the forces acting on the cabinet? Are they stronger if the bumps on both surfaces are pushing close together or if they're barely touching?	I think the forces are stronger if the bumps are pushing together more, and the forces are weaker if the bumps aren't touching as much.	
			Can someone demonstrate this using the hand strips?		

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			NOTE TO TEACHER: *To represent the forces acting on the heavy file cabinet, students should place the two hand strips closer together, with the hands touching and intertwining. To represent the forces acting on the lighter file cabinet, students should allow more space between the hand strips so that only the tips are touching.* **Show slide 10.**  ***Embedded Assessment Task*** Next, we'll investigate the forces acting on a file cabinet in three different scenarios. Complete all of the tasks for each scenario on the handout and then share your drawings and explanations with an elbow partner. Make sure to include in your explanations the science ideas we've been learning about. **NOTE TO TEACHER:** *Distribute handout 5.1 (Describe the Forces: Part 1). Have students complete the tasks on the handout independently and then share their drawings and explanations with an elbow partner.* *Review the scenarios on the handout and instruct students to follow the directions carefully. Students' explanations should be based on their understandings of forces and the science ideas they've been learning about.*		

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			Students may find it difficult to explain the forces acting on the file cabinet, so it might be helpful to work through the first scenario as a class. Then have students complete the next two scenarios individually or in pairs, using the first scenario as a model. *In the first scenario, the arrows students draw to represent the forces acting on the file cabinet should be the same length/size and face in opposite directions.* *Make sure students complete all of the tasks as they work through each scenario on the handout. (Students will complete part 2 of the handout in the next lesson.)* **ELL support:** Preview the handout with ELL students. Read through the scenarios and direction and make sure students know what to do.		
10 min	**Follow-Up to Activity** **Synopsis:** Students share their ideas about the equal and unequal forces acting on the file cabinet in the three scenarios. The teacher uses the hand strips to demonstrate friction in each scenario.	Engage students in constructing explanations and arguments. Engage	**Show slide 11.** Let's have a volunteer come up and talk us through your drawings and explanations for each scenario on the handout. Listen carefully as your classmate shares and be prepared to agree or disagree, ask questions, or add on.		

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	Main science idea(s): • More than one force can push or pull an object at the same time. • If forces of *equal* strength are pushing or pulling an object in opposite directions, the object won't move. • If forces of *unequal* strength are pushing or pulling an object in opposite directions, the object will move in the direction of the stronger force.	students in communicating in scientific ways. Make explicit links between science ideas and activities **after** the activity. Ask questions to probe student ideas and predictions. Ask questions to challenge student thinking.	As we share our ideas, think about how the force of friction is involved in each scenario. **NOTE TO TEACHER:** *Select a volunteer to display her or his handout on the document reader and describe the bumps and arrows added to the picture in each scenario. Ask questions to probe and challenge student thinking. Direct students to listen carefully to their classmate's explanations and consider whether the ideas make sense. Encourage them to agree or disagree, ask clarifying questions, or add on to the ideas. As time allows, invite other students to share their drawings and explanations.* *During the presentations, use the hand strips to help students visualize the bumps on the surfaces exerting a frictional force on one another. In the first scenario, the bumps exert a strong force on one another (i.e., there is a lot of friction), and in the other two scenarios, the force of friction isn't as strong, so the student can move the file cabinet more easily.* *After this discussion, ask students whether any of their ideas about the forces acting on the cabinet have changed. If possible, give them time to revise their drawings and explanations on the handout so they're scientifically accurate. They'll need to refer to their drawings at the beginning of the next*		

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			lesson.		
3 min	**Synthesize/Summarize Today's Lesson** **Synopsis:** The teacher summarizes key science ideas from the lesson. **Main science idea(s):** • More than one force can push or pull an object at the same time. • If forces of *equal* strength are pushing or pulling an object in opposite directions, the object won't move. • If forces of *unequal* strength are pushing or pulling an object in opposite directions, the object will move in the direction of the stronger force.	Highlight key science ideas and focus question throughout. Summarize key science ideas.	**Show slide 12.** Today we've been thinking about the focus question, *What happens if more than one force pushes or pulls an object?* **Show slides 13 and 14.** Let's review what we've learned so far about forces and motion: • A *force* is a push or pull that makes an object start to move. • Forces have a strength and direction that can be represented using arrows of different lengths and directions. • *Friction* is a force that's created when tiny bumps on the surfaces of two objects push against one another. • The pushing force of friction makes a moving object slow down and eventually stop. • More than one force can push or pull an object at the same time. One of those forces can be friction. • If forces of *equal* strength are pushing or pulling an object in opposite directions, the object won't move. • If forces of *unequal* strength are pushing or pulling an object in opposite directions, the object will		

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			move in the direction of the stronger force.		
1 min	**Link to Next Lesson** **Synopsis:** The teacher foreshadows the next lesson in which students continue exploring what happens when if than one force acts on an object and how gravity can be involved.	Link science ideas to other science ideas.	**Show slide 15.** In our next lesson, we'll continue exploring what happens when multiple forces act on an object. We'll also think about how gravity can be involved. Here's a question to think about tonight: *Are any forces acting on a pencil that's lying still on a table?* We'll talk about your ideas next time!		