3M Young Scientist Lab

Classroom Activity | Grades 3-5

Don't Slip

GUIDING QUESTION

What is friction and how does the type of surfaces affect the force of friction?

LEARNING OBJECTIVES

Students will be able to:

- manipulate and read a spring scale.
- collect data regarding the force of friction.
- identify friction as a force that slows motion between two surfaces.
- construct a graph showing the amount of friction vs. type of surface.
- propose a model to explain how friction works.

OVERVIEW

Friction is a common and pervasive force that students experience every day. And yet, little thought is given to the nature and uses of friction. In this lesson students will investigate frictional forces between a block of wood and 3M™ Sandpaper. They will measure, record, and graph the force needed to move the block of wood across various grades of 3M™ Sandpaper using either spring scales or rubber bands. In addition to the grade of 3M™ Sandpaper, other variables could be considered.

Students can extend their investigation into friction at home in the form of a demonstration, short activity, problem to solve, or research to conduct.

NEXT GENERATION SCIENCE STANDARDS

- PS2.A: Forces and Motion
    - Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes

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in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3-PS2-1)

- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitured, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2)

- PS2.B: Types of Interactions
  - Objects in contact exert forces on each other. (3-PS2-1).
- ETS1.B: Developing Possible Solutions
  - Research on a problem should be carried out before beginning to design a solution. Testing a solution involves investigating how well it performs under a range of likely conditions. (3-5-ETS1-2)
  - At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. (3-5-ETS1-2)
- ETS1.C: Optimizing the Design Solution
  - Different solutions need to be tested in order to determine which of them solves the problem, given the criteria and constraints. (3-5-ETS1-3)(secondary to 3-PS4-3)

LESSON TIME FRAME

Two Sessions:

- One 20-minute session to engage students
- One 50-minute session for students to demonstrate the activity and carry out the investigation

BACKGROUND INFORMATION

Friction is one of the fundamental forces of nature. Friction affects us in countless ways throughout our daily lives. Friction can be commonly defined as a measure of the resistance felt when sliding one surface over another. The term 'measure' in this definition hints at the fact that as a force, friction has a magnitude or size that can vary which will be the focus in this lesson. The amount of friction between two surfaces depends on a number of factors: type of surface, amount of surface area contact, the force that presses the two surfaces together, and the presence or absence of any lubricating substance between the two surfaces to name a few. In this lesson, lubrication will not be considered but your students could certainly investigate this as an extension.

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A note about grit: grit is a reference to the number of abrasive particles per square inch (psi). Fewer particles psi will tend to be larger particles (suitable for rough sanding). More particles will tend to be smaller (suitable for medium or fine sanding). In addition, different minerals can be used to form the abrasive particles (silicon and garnet are two examples). While the investigation as written will only use one kind of 3M™ Sandpaper to limit that variable, an extension of the investigation can include testing different grits and abrasives.

MATERIALS

Teacher Materials/Prep

- Block of wood
- Spring scale*
- Demonstration table or desk
- 9" x 11" sheet of 3M™ Sandpaper
- Print out copies of:
  - Friction Data Collection Student Capture Sheet
  - Home Connections (for students to take home)
- Print copies and cut out

Materials per Student Group

- Block of wood
- Spring scale*
- Surface (desktop, table, floor)
- 9"x 11" sheets of 3M™ Sandpaper of different grit (fine, medium, coarse)
- Objects to serve as weights to place on the block of wood (batteries, sets of washers, bags of sand, lightweight books)
- Paper or student journals
- One copy of Friction Data Collection Student Capture Sheet
- Optional – magnifying glasses or 50 – 100x microscopes to more closely observe the surfaces

*If spring scales are not available, use rubber bands along with metric rulers to measure the stretch of the rubber bands. It is not essential to measure in standard units (Newtons, grams or pounds). A relative value (e.g. stretching to the 5cm mark or the 10cm mark) is sufficient. Cutting a #33 size rubber band will make the rubber band twice as long, allowing it to stretch further with less force. It can be fastened to the block with masking tape. See the figure on the last page.

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CLASSROOM ACTIVITY

Day 1

Engage

1. Ask students if they've ever slipped on ice or a slippery floor before. In a brief discussion about this, see if students can contrast this slipping with what normally occurs when we walk on a surface like a floor when we don't slip. Can students articulate that normally there is friction between our shoes and the floor and so we are able to push off from the floor to move our bodies forward?
2. Ask students to push themselves back in their chairs (if they are indeed sitting in chairs) and imagine the friction between the feet of the chair and the floor and how this experience would feel if they were doing this on a very slippery surface such as ice.
3. Have students shove a book or binder across their desk and let it stop moving on its own accord. Discuss how friction acts to slow down and finally stop the book/binder.
4. Ask students for other examples of friction at work. Use this opportunity to probe for student conceptions about friction.

Day 2

Explain

1. If you have spring scales available, present one and show students what one does and how it works as an instrument to measure weight and force. If not, show them a rubber band and demonstrate how it resists being stretched when you pull on it in opposite directions with both thumbs. The more force you use, the farther it stretches so if students are going to use rubber bands, they can assign a number to the size of this force by measuring how much the rubber band has stretched using a ruler. Tell students that they are going to measure the size (called magnitude) of forces in this lesson by using either a spring scale or a rubber band and ruler.

***Teacher Note:** See How to Measure the Stretch of a Rubber Band handout below for more detailed instructions on this.

2. Push on a block of wood resting on a table with your finger, noting out loud that you can feel some resistance (which we call the force of friction) between the wood and the table as you push. Next, bring out a spring scale (or rubber band), attach it to the block and begin to pull the block across a table or desk looking at the scale so you can call out a value. (The force needed to start the block moving will be greater than the force to keep it moving slowly at a constant speed. Mention this fact to students and instruct them to take their force readings after the block is moving, not just before it starts moving.)

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3. Bring out a piece of 3M™ Sandpaper and tape it to the table you are using. Place the block of wood on top of the 3M™ Sandpaper and begin to push it with your finger. Before you do, ask students to predict (and possibly explain) if they think there will be any difference in the amount of force necessary to push the block on the 3M™ Sandpaper vs. on the table. Encourage discussion and let the discussion lead into your instructions to students to begin their own investigation of frictional forces.

Explore

1. Group students according to the quantity of materials you have available.
2. Distribute materials and give each group one copy of the Friction Data Collection student capture sheet.
3. Let each group first meet together to plan how they want to investigate the following prompt: "What factors affect how hard it is to push or pull a block of wood across a surface?"
4. Either meet with each group individually or ask that each group draft a written plan to show you proposing what the group would like to do in their investigation. Once you are satisfied the groups are prepared to carry out a well-designed investigation, including plans to collect data. Assist as necessary, checking that each group is collecting and recording appropriate and accurate data and probing to help students develop a deeper understanding of friction.
5. Once groups have collected their data and cleaned up their materials, allow them to meet and discuss and graph their results and develop conclusions. Assist with the graphing as needed. The type of data collected might dictate the type of graphical display used.

Extend

1. Begin a discussion with students about the mechanism of how friction works on a microscopic scale. Let students gather again in their groups to come up with a model of the interaction of the block of wood with the 3M™ Sandpaper at a very small scale. Then let each group share their model with the class and if it seems appropriate, try to blend the various models together into one coherent explanation using a labeled diagram. (A typical model or understanding of the mechanism of friction includes two surfaces with very small bumps and ridges that catch each other as the surfaces are moved past each other.) The individual grains of grit on 3M™ Sandpaper are visible enough (physically and conceptually) to make 3M™ Sandpaper a good material to use to develop this model. With this model in mind, students should be able to go on to explain any differences in results they observed of the force needed to move the block vs. the different grades of 3M™ Sandpaper.

***Teacher Note:** Depending on grade level- you may need to lead this part of the activity and complete it in more of a whole-group setting.

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Evaluate

***Teacher Note:** Have students answer the following questions on a piece of paper or in their science journal.

1. How would you describe how a spring scale works to someone who had never used one before?
2. Explain what friction is and how you could detect it.
3. If you shove a box across three different floors with exactly the same amount of force and it slides the same distance on each floor, what can you infer about the friction between the box and the different floors?
4. How would you revise the following statement to make it more accurate? "Friction works because microscopic peaks and ridges easily glide over one other as the surfaces are moved past each other."

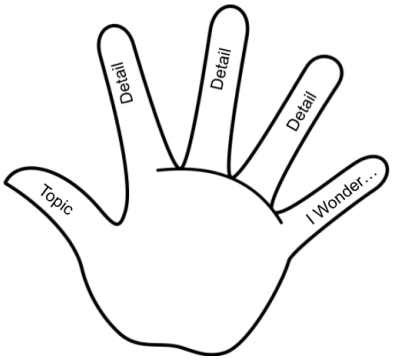
Teacher Scoring Key for Evaluate

1. When you pull on something with a spring scale, the spring inside stretches and gets longer. The harder you pull, the longer the spring gets. If you measure how much the spring stretches, you can assign a specific number to that particular amount of force.
2. Friction is force that you can feel and measure when two surfaces rub against each other. You can detect it by observing that moving things tend to slow down when one surface moves against another.
3. All other things being equal, you could infer that the different floors all have the same amount of friction between the box and the floor.
4. You could say: "Friction works because microscopic peaks and ridges make it difficult for the two surfaces to move past each other."

REFLECTION

Students will reflect on their learning by completing the Five Finger Summary. Print off the Five Finger Summary Resource, cut them up, and distribute one to each student. Alternatively, students may trace their hand on a piece of paper or in their science journal.

Students will fill in each finger as shown below:



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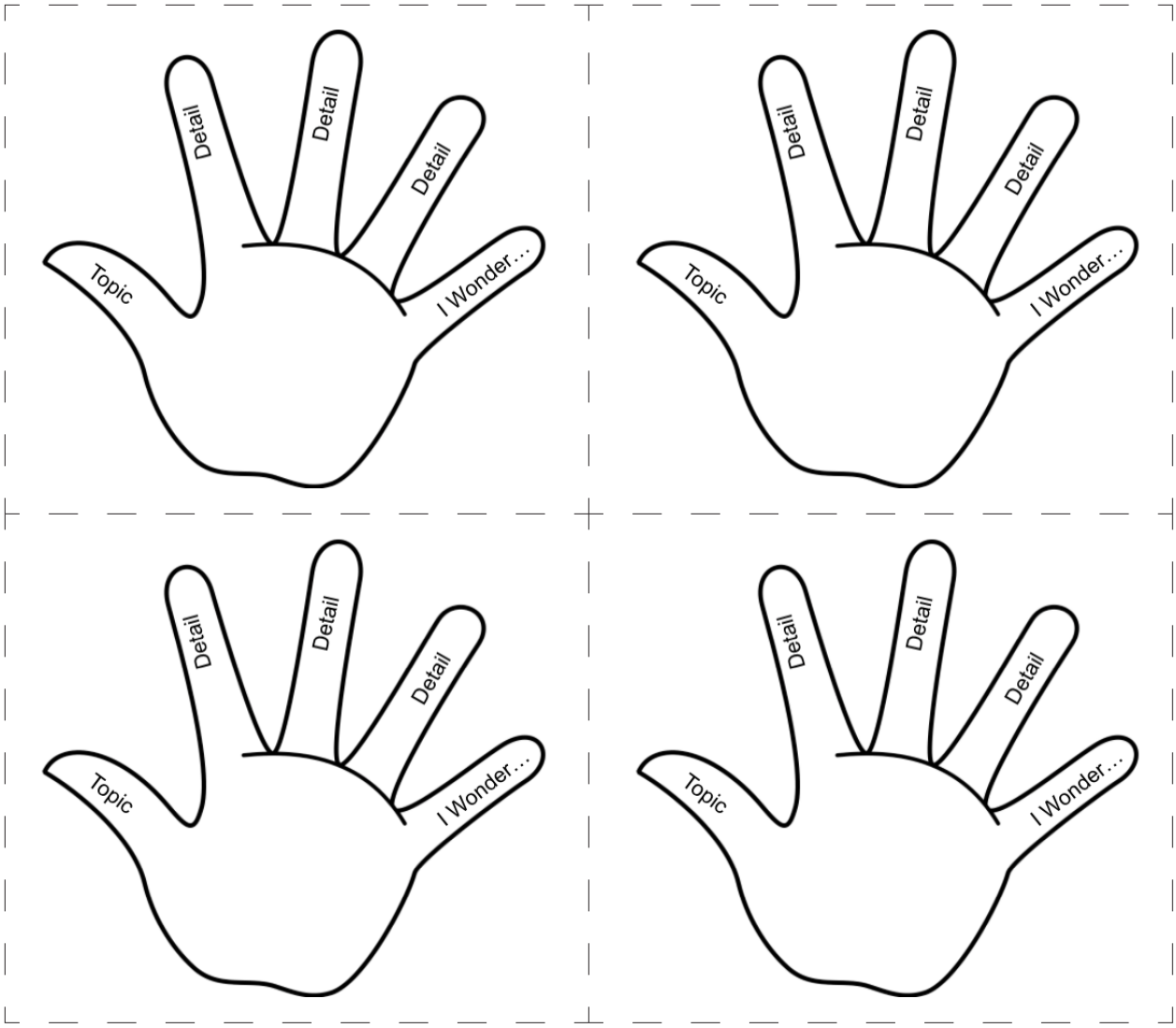
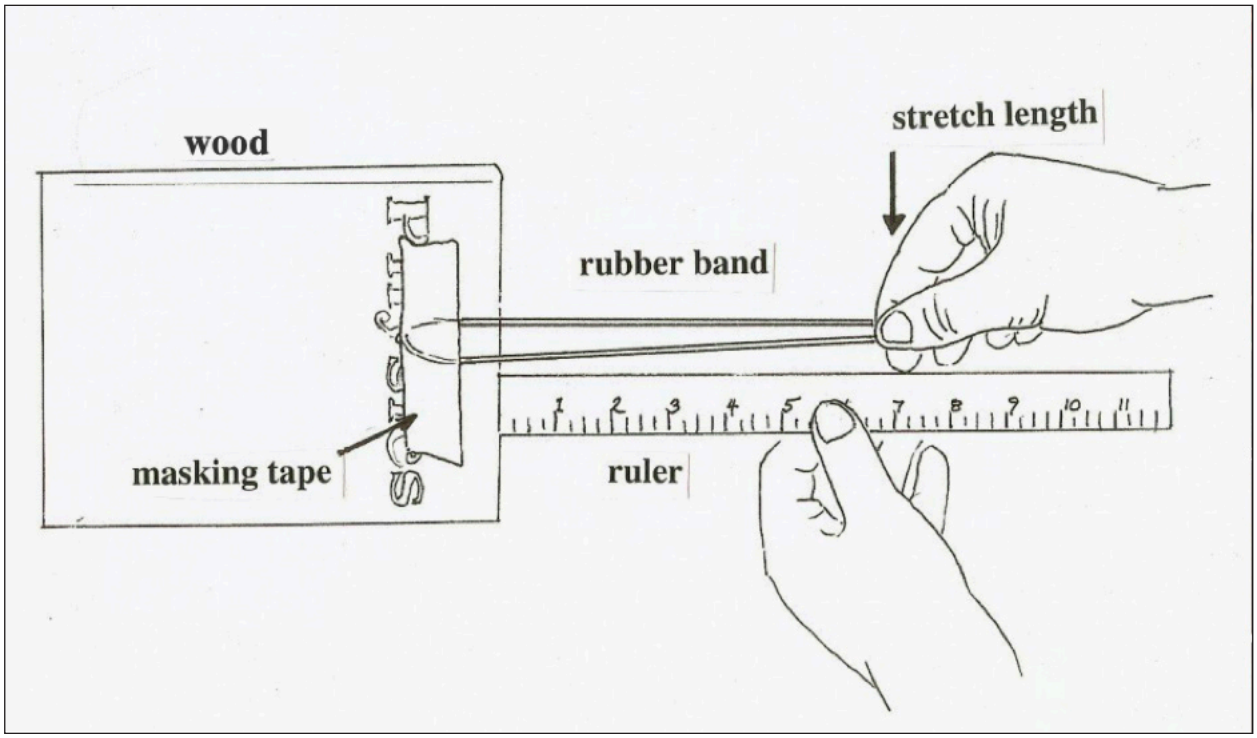
FRICTION DATA COLLECTION

Prompt: What factors affect how hard it is to push or pull a block of wood across a surface?	
Our Plan: How are you going to carry out your investigation?	
Data Collected: Record the data from your investigation.	
Graph: Use the data you collected in your investigation to create a graph.	Draw your graph on the back of this paper.

FIVE FINGER SUMMARY



HOW TO MEASURE THE STRETCH OF A RUBBER BAND



HOME CONNECTIONS

Parent/Guardian Background Information:

Friction is one of the four fundamental forces of nature. Friction affects us in countless ways throughout our daily lives. Friction can be commonly defined as a measure of the resistance felt when sliding one surface over another. As a force, the amount or strength of friction can be measured and expressed as a number. The amount of friction between two surfaces depends on a number of factors: type of surface, amount of surface area contact, the force that presses the two surfaces together, and the presence or absence of any lubricating substance between the two surfaces, to name a few.

Activities to do with your young scientist:

1. Demonstration: if your student has investigated friction, ask them to demonstrate and explain friction to you using common objects and materials found around the house. For example, your student could drag their backpack across a table, push a heavy box along the floor, or carefully pull a kitchen drawer out (comparing the force necessary to pull out different drawers.)
2. Short activity: your student and you could compare how hard it is to pull a heavy backpack or other object across different surfaces in the home: wood floor, carpet, tile, lawn, etc. And by using the idea of measuring force by measuring the stretch of a rubber band with a ruler, you can begin to collect some numerical data. (Something lighter than a backpack would have to be used for this unless a heavy-duty bungee cord was used.)
3. Problem to solve: If you had a slippery rug in the house that was a safety hazard for a long time, what ideas can your student come up with to make the rug less slippery?
4. Research: You and your student could research adhesives such as tapes and glues to develop a better understanding of how they work. What is the history of Scotch Brand Tape? How many different kinds of Scotch Brand tapes and glues are there and what does each one do?
5. Explore: If you have different grits of 3M™ Sandpaper available in your home, try comparing how differently heavy objects can move across the surfaces. You may wish to demonstrate how differently those 3M™ Sandpaper types work on wood. Use the 3M site to view the hundreds of different kinds of abrasives available.