

## Lab Handout

# Lab 12. Unbalanced Forces

## How Does Surface Area Influence Friction and the Motion of an Object?

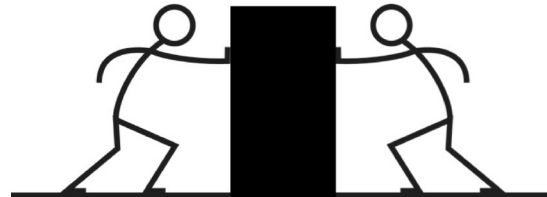
### Introduction

The motion of an object is determined by the combination of all the forces acting on that object. Those forces may come in the form of a simple push or pull that result from contact forces, such as pushing a box with your hand, or non-contact forces, such as gravity pulling an object toward Earth. When forces are acting on an object from the same direction, the influence of each force is added together. Think of two people pushing a box across the floor. If they push from the same side, the forces acting on the box are unbalanced, meaning that there is more force on one side of the box than the other. When the forces acting on the box are unbalanced, the box moves in the direction of that force. However, if the two people stand on opposite sides of the box and push again, their forces are working against each other (see Figure L12.1). One person is trying to push the box to the right and the other person is trying to push the box to the left. In this case, their forces are balanced and cancel each other out. When the forces acting on an object are balanced, the motion of the object does not change.

When two people push on a box in opposite directions, it's easy to see that there are opposing forces acting on the box, but sometimes there are opposing forces acting on an object that are less obvious. If you give a book a push and let it slide across a table, it will eventually come to a stop. The book stops because there is an opposite force acting on it, just like the person pushing on the opposite side of the box. The force that causes the book to come to a stop is called friction. Friction is a force that occurs when two surfaces are in contact with each other. The force of friction always works on an object in a direction that is opposite of the motion of the object. Therefore, friction is always trying to slow an object down or keep an object from moving. Trying to slide a heavy object is often difficult due to friction. Placing a heavy object on a cart with wheels can make it easier to move. The amount of friction is greatly reduced by the wheels, so it is easier to move the heavy object.

The amount of friction between two objects depends on several factors. One important factor is the specific surfaces involved. The amount of friction between two objects as they slide past one another depends on the specific surfaces that are rubbing against each other. For example, a cardboard box sliding on a wooden floor has a different amount of friction than the same cardboard box sliding on a carpet floor. Different combinations of surface materials will result in different amounts of friction. Another factor that influences the

**FIGURE L12.1** \_\_\_\_\_  
**Two people pushing on opposite sides of a box**



amount of friction is the weight of the object that is moving. The heavier the object, the more friction there will be that opposes the motion of the object.

Reducing friction is often an important goal when there is work to be done. There are many different ways that someone can try to reduce the amount of friction when moving an object. One strategy is to change the surface that an object is sliding on. For example, there is very little friction between ice and other materials, therefore objects slide over ice very easily. Another strategy for reducing the amount of friction when trying to slide an object would be reducing the mass of the object; then there would be less force between the moving object and the surface it is sliding on. A third strategy would be to change the shape of the object and change the amount of contact between the two surfaces that are rubbing together. For example, instead of sliding two separate boxes side by side, perhaps stacking them one on top of the other would reduce the amount of friction and make them easier to move.

## Your Task

Use what you know about forces and motion, patterns, and stability and change to design and carry out an investigation that will allow you to test how changing the amount of surface area between two objects influences the amount of friction between the objects and how changing the amount of surface area influences the motion of the object.

The guiding question of this investigation is, **How does surface area influence friction and the motion of an object?**

## Materials

You may use any of the following materials during your investigation:

- Friction block set
- 20 N spring scale
- 10 N spring scale
- 5 N spring scale
- Mass set
- Meterstick
- Stopwatch
- Safety glasses or goggles

## Safety Precautions

Follow all normal lab safety rules. In addition, take the following safety precautions:

1. Wear sanitized safety glasses or goggles during lab setup, hands-on activity, and takedown.
2. Wash hands with soap and water after completing the lab activity.

**Investigation Proposal Required?**    Yes       No

## Getting Started

To answer the guiding question, you will need to design and conduct an investigation to measure the amount of friction between the friction block and the surface of your table and test how changes in the amount of surface area influence the motion of the block. To accomplish this task, you must determine what type of data you need to collect, how you will collect it, and how you will analyze it.

To determine *what type of data you need to collect*, think about the following questions:

- How will you determine the force due to friction?
- What information or measurements will you need to record?
- How will you determine the surface area of the block?
- Will you test different surface combinations?

To determine *how you will collect your data*, think about the following questions:

- What equipment will you need to collect the data you need?
- How will you make sure that your data are of high quality (i.e., how will you reduce error)?
- How will you keep track of the data you collect?
- How will you organize your data?

To determine *how you will analyze your data*, think about the following questions:

- How will you determine the influence of surface area on friction and motion of the block?
- What type of table or graph could you create to help make sense of your data?

## Connections to Crosscutting Concepts, the Nature of Science, and the Nature of Scientific Inquiry

As you work through your investigation, be sure to think about

- why it is important to understand patterns and their causes,
- the importance of understanding stability and change within systems,
- the difference between observations and inferences, and
- the role of different methods in science.

## Initial Argument

Once your group has finished collecting and analyzing your data, your group will need to develop an initial argument. Your initial argument needs to include a *claim*, *evidence* to support your claim, and a *justification* of the evidence. The claim is your group's answer to the guiding question. The evidence is an analysis and interpretation of your data. Finally,

the justification of the evidence is why your group thinks the evidence matters. The justification of the evidence is important because scientists can use different kinds of evidence to support their claims. Your group will create your initial argument on a whiteboard. Your whiteboard should include all the information shown in Figure L12.2.

**FIGURE L12.2**

### Argument presentation on a whiteboard

The Guiding Question:	
Our Claim:	
Our Evidence:	Our Justification of the Evidence:

## Argumentation Session

The argumentation session allows all of the groups to share their arguments. One member of each group will stay at the lab station to share that group's argument, while the other members of the group go to the other lab stations to listen to and critique the arguments developed by their classmates. This is similar to how scientists present their arguments to other scientists at conferences. If you are responsible for critiquing

your classmates' arguments, your goal is to look for mistakes so these mistakes can be fixed and they can make their argument better. The argumentation session is also a good time to think about ways you can make your initial argument better. Scientists must share and critique arguments like this to develop new ideas.

To critique an argument, you might need more information than what is included on the whiteboard. You will therefore need to ask the presenter lots of questions. Here are some good questions to ask:

- How did you collect your data? Why did you use that method? Why did you collect those data?
- What did you do to make sure the data you collected are reliable? What did you do to decrease measurement error?
- How did your group analyze the data? Why did you decide to do it that way? Did you check your calculations?
- Is that the only way to interpret the results of your analysis? How do you know that your interpretation of your analysis is appropriate?
- Why did your group decide to present your evidence in that way?
- What other claims did your group discuss before you decided on that one? Why did your group abandon those alternative ideas?

- How confident are you that your claim is valid? What could you do to increase your confidence?

Once the argumentation session is complete, you will have a chance to meet with your group and revise your initial argument. Your group might need to gather more data or design a way to test one or more alternative claims as part of this process. Remember, your goal at this stage of the investigation is to develop the most acceptable and valid answer to the research question!

## **Report**

Once you have completed your research, you will need to prepare an *investigation report* that consists of three sections. Each section should provide an answer to the following questions:

1. What question were you trying to answer and why?
2. What did you do to answer your question and why?
3. What is your argument?

Your report should answer these questions in two pages or less. This report must be typed, and any diagrams, figures, or tables should be embedded into the document. Be sure to write in a persuasive style; you are trying to convince others that your claim is acceptable and valid!