Lab Handout

Lab 8. Force and Motion

How Do Changes in Pulling Force Affect the Motion of an Object?

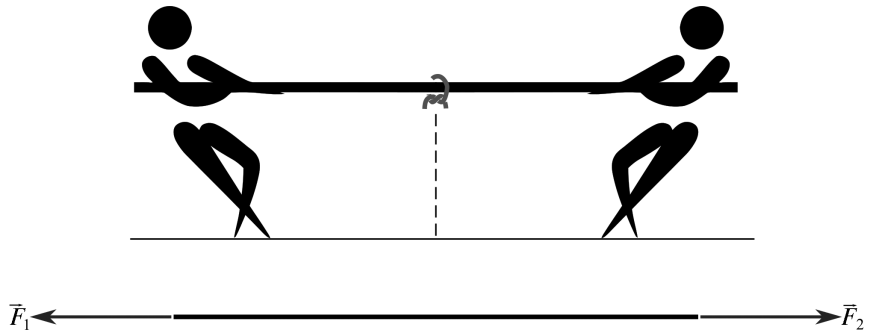
Introduction

A force can be described simply as a push or pull that acts on an object. For example, when you push or pull on a doorknob, you are applying a force that moves the door. In addition to a push or a pull, forces can be described as contact or non-contact. Pushing a box across the floor is an example of a contact force; the force to move the box is being applied by your hands, which are in contact with the box. However, non-contact forces can act on objects without having to actually touch the object. For example, a magnet can push or pull another magnet without the two ever touching each other. Similarly, gravity is a non-contact force that pulls objects closer together, such as when something falls toward Earth.

When you apply a force to an object, that object often will move. Sometimes, however, when you apply a force to an object it doesn't move. It is relatively easy to apply enough force to slide a box across the floor, but it is much more difficult to push a car down the road. The motion of an object is determined by the strength of the force applied to move it, the weight of the object, and any other forces that might be acting to move the object in a different direction. Consider a game of tug-of-war (see Figure L8.1): if both people pull with equal strength, then the rope doesn't move, but if one person pulls harder, the rope moves in that direction.

FIGURE L8.1

In a game of tug-of-war, the overall movement of the rope is based on the strength of the pull in both directions.



Isaac Newton (1642–1727) was a physicist who studied the motion of objects. He is perhaps most well known for the laws of motion he developed after extensive observation of the planets in our solar system. Newton described that (1) a stationary object will remain stationary unless an external force acts on it, (2) the change in an object's motion is

proportional to the force acting on it, and (3) every force has an equal and opposite force. The motion of an object is the result of all the different forces that are pushing or pulling on that object. When all the forces are acting in the same direction, the object will move in that direction. If all the forces acting on an object are balanced, then the object either will not move or will move with a constant speed. When there are forces acting in different directions on the same object but they are not the same strength, then the forces are unbalanced; the object will move, but how it moves (e.g., fast, slow, constant speed, speeds up, or slows down) depends on the relationship of all the forces acting on the object.

Your Task

Use what you know about forces, systems, and stability and change to design and carry out an investigation that will allow you to predict how different pulling forces (hanging weights) influence the motion of a cart (e.g., does it speed up, slow down, or travel at a constant speed).

The guiding question of this investigation is, **How do changes in pulling force affect the motion of an object?**

Materials

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

- Pull cart
- Pull car track or flat table
- Pulley
- Pulley clamp
- String
- Hanging weights
- Meterstick
- Electronic or triple beam balance
- Motion sensor with interface
- Safety glasses or goggles

Safety Precautions

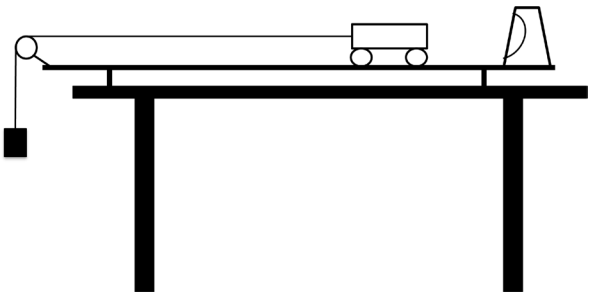
Follow all normal lab safety rules. In addition, take the following safety precautions:

1. Wear sanitized safety glasses or goggles during lab setup, hands-on activity, and takedown.
2. Use caution when working with the moving pulleys, cart, and weights.
3. Keep your fingers and toes out of the way of the moving objects.
4. Wash hands with soap and water after completing the lab activity.

Investigation Proposal Required? ☐ Yes ☐ No

FIGURE L8.2

Setting up the motion sensor, cart, and pulley



Getting Started

To answer the guiding question, you will need to plan an investigation to measure the motion of a cart as it is pulled across the tabletop. Figure L8.2 shows how you can set up the cart and motion sensor to collect your data; however, 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:

- What information do you need to describe the motion of the cart?
- What information or measurements do you need to calculate the speed of the cart?

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:

- What type of calculations will you need to make?
- What type of table or graph could you create to help make sense of your data?
- How will you determine the effect of different pulling forces on the cart's motion?

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

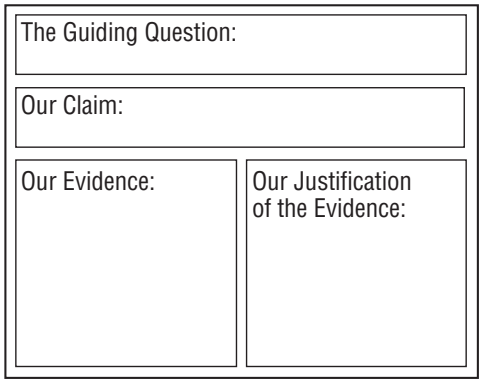
- how scientists often need to understand and define systems under study and that making a model is a tool for developing a better understanding of natural phenomena in science,
- the importance of understanding what makes a system stable or unstable and what controls rates of change within a system,
- how scientists use different types of methods to answer different types of questions, and
- the nature and role of experiments within 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 L8.3.

FIGURE L8.3

Argument presentation on a whiteboard



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!