Lab Handout

Lab 9. Mass and Motion

How Do Changes in the Mass of an Object Affect Its Motion?

Introduction

The motion of an object depends on all the different forces that are acting on the object, how strong those different forces are, and how much mass the object has. Changing the number of forces acting on an object, the direction of those forces, or the strength of the forces will have an effect on the object's motion. But what happens if you apply all the same forces to two different objects, one with a small mass and one with a larger mass?

The amount of mass of an object is a measure of the amount of matter in that object. Objects with more mass have more weight (a measure of the force of gravity) because there is a stronger attraction between the object and Earth due to gravity. Motorcycles are lightweight vehicles, about 250 kg, with strong engines that help them travel at high speeds (see Figure L9.1). How might the speed of a motorcycle change if it is carrying one rider or two riders? In this example the strength of the engine doesn't change, but the total mass of the motorcycle and riders increases. It is important for scientists and engineers to understand the relationship between the forces applied to an object and the mass of that object so that they can predict the object's motion.

FIGURE L9.1

Motorcycles are lightweight, but their engines generate a lot of force.

Your Task

Use what you know about forces, stability and change, and patterns to design and conduct an investigation that will allow you to describe the motion of a cart (e.g., does it speed up, slow down, or travel at a constant speed) and how its motion is affected by changing the mass of the cart while keeping the pulling force the same.

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

Materials

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

- Pull cart
- Pull car track or flat table
- Pulley
- Pulley clamp
- Cart masses
- 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, masses, 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.

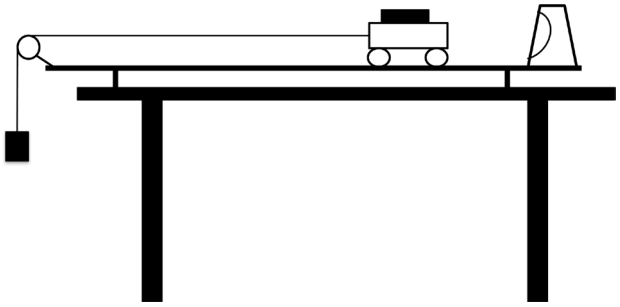
Investigation Proposal Required? ☐ Yes ☐ No

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 L9.2 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.

FIGURE L9.2

Setting up the motion sensor, cart, pulley, and masses



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

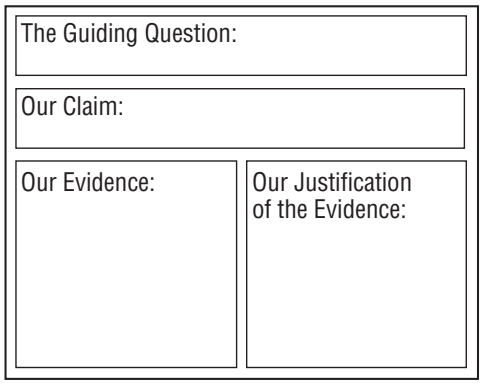
- how scientists often look for patterns in nature and attempt to understand the underlying cause of these patterns,
- the importance of understanding what makes a system stable or unstable and what controls rates of change within a system,
- the differences between observations and inferences in science, and
- the difference between data and evidence 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 L9.3.

FIGURE L9.3

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!