LAB 18

Lab Handout

Lab 18. Elastic and Inelastic Collisions: Which Properties of a System Are Conserved During a Collision?

Introduction

Physics is the scientific study of time, space, and matter. Some branches of physics, such as cosmology, investigate questions regarding the entire universe (e.g., how old is it, how did it begin). Most branches of physics, however, investigate questions related to smaller scales and systems. When studying a system, a physicist will identify the system and then ask questions about (1) the matter contained in that system, (2) the interactions between matter contained in the system, and (3) how the matter moves in the system. When doing this, the physicist ignores any influences from outside the system during the investigation, while recognizing that those influences are still there. For example, when studying acceleration of an object in free fall due to gravity, a physicist might ignore the influence of air resistance when its effects are less than the uncertainty in the measurements. Systems come in all sizes. Astronomers study systems as large as galaxies. Chemists study systems that can be as small as a few atoms.

Scientists have identified several laws of conservation that are the same across all systems. A conservation law states that some property of an isolated system is the same before and after some specific interaction takes place within that system. The properties of each object in the system, however, do not need to be the same before and after the interaction in order for some property of the system to stay the same. For example, the law of conservation of energy indicates that the total amount of energy in a system stays the same before and after any interaction that takes place between one or more components of that system. To illustrate what the conservation of energy means, consider what happens when a person places a hot metal spoon into a cold cup of water. When the hot metal spoon is placed into the cup, some heat energy will transfer from the spoon into the water, but the total amount of energy of the system remains constant because the energy that transferred from the spoon into the water is still a part of the system. The transfer of energy caused the temperature of the water to increase and the temperature of the metal to decrease but the total amount of energy in the system did not change, so energy is conserved within the system.

When studying the interactions between two or more objects in a system, physicists often try to identify which properties are conserved during the interaction. In the example of putting a hot metal spoon into cold water, energy is conserved but temperature is not. Another type of interaction that physicists often study is a collision. Collisions are a common experience, from billiard balls colliding on a pool table to an asteroid hitting a planet, or, as shown in Figure L18.1, a collision between two cars.

There are a number of properties that could be conserved during a collision. Some examples include acceleration, velocity, force, energy, and momentum. There are likely other

properties that might also be conserved during a collision. In this investigation, you will have an opportunity to determine which properties of a system are conserved during a two-car collision.

FIGURE L18.1

A collision between two vehicles

Your Task

Use what you know about momentum, velocity, acceleration, the conservation of energy and matter, and systems and system models to design and carry out an investigation that will allow you to understand what happens to the different properties of a two-car system before and after a collision.

The guiding question of this investigation is, ***Which properties of a system are conserved during a collision?***

Materials

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

- Safety glasses or goggles (required)
- Dynamics carts
- Dynamics track
- Bumper kit for the carts
- Video camera
- Computer or tablet with video analysis software
- Electronic or triple beam balance
- Mass set
- Stopwatches
- Ruler

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. Keep fingers and toes out of the way of moving objects.
3. Wash hands with soap and water after completing the lab.

Investigation Proposal Required? ☐ Yes ☐ No

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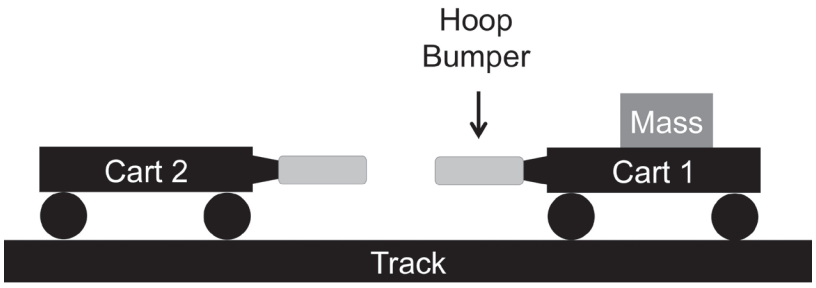
Getting Started

To answer the guiding question you will need to design and carry out two experiments. Figure L18.2 shows how you can set up two carts on a track to examine changes in the velocity, acceleration, and position of each cart before and after a collision. You can also change the nature of the collision by changing the bumpers on the carts. You can use a hoop bumper to make the carts bounce apart after they collide or a Velcro or magnet bumper to make them stick together. To measure changes in velocity, acceleration, and the position of the two carts at the same time, you will need to use a video camera and video analysis software. Before you can design your two experiments, however, you must first determine what type of data you need to collect, how you will collect it, and how you will analyze it.

FIGURE L18.2

One way to measure the velocity, acceleration, or position of a moving object before and after a collision



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

- What are the boundaries and components of the system under study?
- How do the components of the system interact?
- What properties of the system might be conserved?
- What properties of the system are directly measurable?
- What properties of the system will you need to calculate from other measurements?
- What types of collisions will you need to model?
- How can you track how matter and energy flows into, out of, or within this system?
- What will be the independent variable and the dependent variable for each experiment?

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

- What other factors will you need to control during each experiment?
- Which quantities are vectors, and which quantities are scalars?
- What scale or scales should you use when you take your measurements?
- 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 and organize the data you collect?

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

- How will you determine if a property has been conserved during a collision?
- What type of calculations will you need to make?
- What types of comparison will be useful for you to make?
- How could you use mathematics to describe a relationship between variables?
- What type of table or graph could you create to help make sense of your data?

Connections to the Nature of Scientific Knowledge and Scientific Inquiry

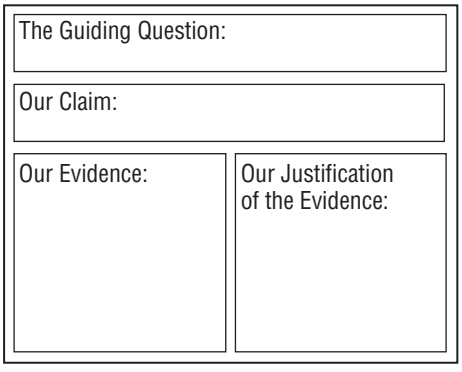
As you work through your investigation, you may want to consider

- the difference between laws and theories 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 L18.3.

FIGURE L18.3
Argument presentation on a whiteboard



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Argumentation Session

The argumentation session allows all of the groups to share their arguments. One or two members 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 other arguments. This is similar to what scientists do when they propose, support, evaluate, and refine new ideas during a poster session at a conference. If you are presenting your group's argument, your goal is to share your ideas and answer questions. You should also keep a record of the critiques and suggestions made by your classmates so you can use this feedback to make your initial argument stronger. You can keep track of specific critiques and suggestions for improvement that your classmates mention in the space below.

Critiques about our initial argument and suggestions for improvement:

If you are critiquing your classmates' arguments, your goal is to look for mistakes in their arguments and offer suggestions for improvement so these mistakes can be fixed. You should look for ways you to make your initial argument stronger by looking for things that the other groups did well. You can keep track of interesting ideas that you see and hear during the argumentation in the space below. You can also use this space to keep track of any questions that you will need to discuss with your team.

Interesting ideas from other groups or questions to take back to my group:

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 best argument possible.

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 or valid!