Lab Handout

Lab 21. Light and Information Transfer

How Does the Type of Material Affect the Amount of Light That Is Lost When Light Waves Travel Down a Tube?

Introduction

Starting in the late 1940s, scientists and mathematicians began conducting experiments that led to a new field of study that today we call information theory. Scientists and mathematicians who conduct research in the field of information theory focus on answering a few important questions. The first of these questions is, how can we transfer information from one place to another? By information transfer, scientists and mathematicians mean how information is shared between people and things. For example, you might have watched a sporting event over the weekend and know who won the game, while your friend was unable to watch and does not know who won. If you tell your friend who won, that is transferring information from you to your friend. Although not a new question (humans have been transferring information for thousands of years), the formal study of this question is quite new. Telephones, fax machines, and even the internet grew out of this type of research. Furthermore, many of the cables that you connect to your TV or computer serve the purpose of transferring information from someplace else to your TV or computer.

A second question that scientist and mathematicians who study information theory ask is, what are the advantages and disadvantages to transferring information in different ways? For example, the oldest ways to transfer information from one person to another person is by talking to that person. The advantages of this type of information transfer are that (1) it happens very quickly and (2) you know who sent the message because you can see him or her in front of you. The disadvantage is that the message does not last very long. Another way to transfer information is by writing a letter. The advantage of the letter is that it lasts a long time. The disadvantage of the letter is that it also takes a long time to mail a letter to a friend.

Related to the question about the advantages and disadvantages of information transfer is the question, how can we get a message to another person in the least amount of time possible? Scientists who study physics (another branch of science) have determined that light moves faster than anything else in the universe. Information scientists used this finding to answer their question about transmitting a message as fast as possible. If light is the fastest thing in the universe, then maybe light can be used to transfer information.

Another question that information scientists ask about information transfer is, how can we limit the loss of information when transferring it from one place to another? Information scientists have determined that all messages lose some information between being sent and being received. Sometimes this is not a problem; for example, if you write a letter to a friend, the letter will not transfer information about whether you wrote it while sitting inside or wrote it while sitting outside (unless you say so in the letter). Other times,

however, loss of information is a problem. If you have ever heard static while you talked to another person on the phone, this is an example of information loss.

Your Task

Use what you know about light, tracking energy and matter, and the relationship between structure and function to design and carry out an investigation that will allow you to determine how much light is lost when it shines down different types of tubing. This will allow you to make a recommendation about what type of materials we should use for transferring information with light. It is also important to recognize that many of the cables we use to transfer information are able to bend, so that we can get the cables to go in whatever direction we want. To complete this task, you will need to test how much light makes it from one end of a tube to the other end, when the tube has a 45° bend in the middle.

The guiding question of this investigation is, **How does the type of material affect the amount of light that is lost when light waves travel down a tube?**

Materials

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

- Light source
- Light sensor with interface
- Electrical tape
- Fiber optic tubing
- Amber rubber tubing
- Red vacuum and pressure tubing
- Tygon laboratory tubing
- Protractor
- 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 light source, because it can get hot and burn skin.
3. Use only GFCI-protected electrical receptacles for the lamp power source.
4. Do not shine a laser pointer at anyone's eyes or face.
5. Lightbulbs are made of glass. Be careful handling them. If they break, clean them up immediately and place in a broken glass box.
6. 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 light that is lost when it shines down a tube. 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 before you begin.

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

- How will you determine how much light enters the tube?
- How will you determine how much light exits the tube?

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)?
- Are there different ways you can measure the amount of light transferred?
- 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 amount of light lost?
- 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

- the importance of tracking how energy and matter move into, out of, and within systems;
- the relationship between structure and function in nature;
- science as a culture and how it influences the work of scientists; and
- the importance of imagination and creativity in science.

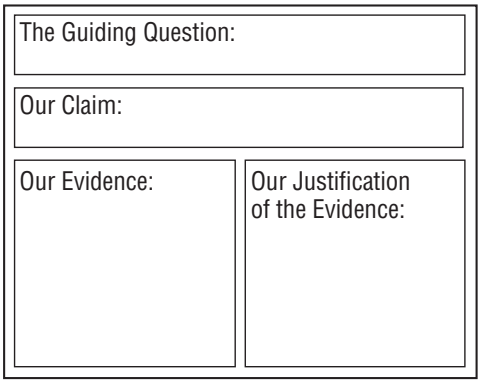
Initial Argument

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 L21.1.

FIGURE L21.1

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!