

Talk to Me: Using Light to Communicate

Making the Connection
Women in Engineering Programs &
Advocates Network (WEPAN) Project
Funded by Lucent Technologies Foundation

Communication

Grades 5 & 6 (suggested)

1. This activity explores the process of using the properties of light to create a communication system.
2. This activity has students assuming the role of an engineer by designing and testing a method to use light to convey information.
3. This activity has a resource page that provides background information.

Objective

The goal is for students to understand how their knowledge of the properties of light enables them to design a method of communication. Communication is a basic human need. Since the beginning of time, humans have been developing new communication methods. Initially, communication occurred only between two humans in the same place. Today, technology allows humans and machines to communicate from millions of miles apart. One of the ways this is possible is through a great engineering feat -- fiber optic technology. Using light generated by lasers that is reflected along glass fibers, fiber optic cables transmit a massive amount of information in a single second.

Skills & Standards

- Identify a problem that emanates from the need for shelter, storage, or convenience.
- Identify relevant design features for building a prototype of a solution to a given problem.
- Identify materials used to accomplish a design task based on a specific property.

Activity Outline

Materials required per group:

-Flashlight
-Aluminum foil (approx. 4 feet)
-Tape measure or yardstick
-Paper towel or toilet paper
cardboard inserts
-Cardboard
-Construction paper
-Masking tape
-Scissors
-Assorted materials for building:
index cards, straws, Popsicle
sticks, toothpicks, additional
reflective materials such as
small mirrors, pieces of metal

Overview of Presentation

Briefly explain engineering. (See Presenter's Guide for more detail.)

Engineers use scientific information to design and create useful things. In designing and creating, the engineer goes through a problem solving process in which both the math and science are important components.

Introduce the activity to the students.

Have a general discussion about how people receive and give out information. How do you know when to stop your car? How do you know when it's time for lunch? What senses do you use to receive information?

Begin the activity.

Before doing the activity, present the 'problem' and 'who wants to know'.

Do the activity.

Break the class into groups of 2 or 3 students. Have them focus on two of the major components needed for a light based communication system: a method of coding information and a device to manipulate light.

Reflect on the activity.

After the activity is completed spend time discussing what was discovered and learned. Look at the existing fiber optic technology in comparison with the devices they created. What factors limit the effectiveness of both? What role do materials play?

Career Connection

Discuss what types of jobs including engineering are involved with designing, testing, and developing communication systems. Asking 'Who can help you solve the problem' may get students to think about the type of people who would know.

Time frame:

Part 1: 15 to 20 minutes

Part 2: 35 to 45 minutes

Activity: A Communication System – Software and Hardware

This activity has students designing their own communication system. Students will design both a series of light commands as well as the physical device that will transmit their commands. The activity has been developed based on a traditional engineering design process which pose key questions – all identified in boldface type, that help the students approach the problem as engineers.

PART 1: A Means To Communicate

1. Discuss as a class different methods of communication. What methods employ sounds? Light or visual cues? Touch? Explore what senses are used in communicating with these methods?

What's the problem? You and some friends will be exploring a large cave with many twists, turns and tunnels. As you explore you discover that the echoes make it very difficult to understand what the leader is saying. Devise a method using your flashlight to communicate the 6 commands the leader shouts to direct the exploration

2. Have the groups work to develop a system for communicating the 6 commands on Activity Sheet 1 only using a flashlight.
3. Monitor the progress of the groups. You may want to suggest a series of short and long flashes to groups who are stuck on an idea
4. Spend a few minutes discussing how each group devised its signaling process. What were the major obstacles? What were the important factors to consider?

PART 2: Curving Your Communication

Who wants to know? As your team travels deeper and deeper into the cave, the narrow, curving tunnels make it impossible for the last person to see the flashlight signals. Build a device that the leader could shine a flashlight into that would allow the last person to see the signals.

How can you help solve the problem? Use your knowledge of materials that change the direction of light to construct your device.

1. Discuss what experiences the students have had with light. What materials affect where light shines? Mirrors? Pieces of glass?
2. Have the students follow the instructions on Activity Sheet 2 to construct a device that will allow their flashlight signals to be seen around twists and curves.
3. Monitor students' progress. Encourage students who are having difficulty to experiment with the foil to see how it effects the light.
4. Lead a discussion on how effective this particular method of communication is. How could these methods be used in the real world? What materials would be best to use? What properties of these materials make them a good choice?
5. Present the materials and methods used in a real world application such as fiber optic technology that utilize the principles of Part 1 and Part 2.

Will your suggestion(s) work? Is your design feasible? What problems do you notice? Which parts of the communication process would you replace with a machine or computer?

Who can help you solve the problem? What type of information or knowledge is needed to understand communication systems? Computer scientists as well as computer and electrical engineers helped to devise the codes that are encoded in the light pulses. Computer and electrical engineers are also involved in designing the cables used for fiber optics.

Engineering Summary: Finish with a discussion about how students approached the problem like engineers.

Activity Resource Page

Background Information for Activity Leader

Optics is the domain of physical science that studies light and how it behaves. Scientists (particularly physicists) examine how light behaves when it encounters different materials. There are four different possibilities that can happen when light encounters a material.

1. **Transmission:** The light can pass through the material with little or no change.
2. **Absorption:** Light can be absorbed by the material it encounters. Wood absorbs visible light.
3. **Reflection:** Light is not absorbed by the material but instead bounces off the material in a uniform fashion. Metals reflect well.
4. **Scattering:** Light is partially reflected off a surface that is rough so that it reflects at all sorts of angles. Paper is rough so it scatters light.

Scientists also research and develop materials that make use of the properties of light.

Light is used for communication in many ways. In the past, it was one of the methods people used to communicate across distances. Lights placed in towers or ships and switched on and off in a pattern could communicate information across distances before the advent of telephones and the Internet. As devices like phones, television, and Internet connections have grown in popularity, the volume of information that needs to be transmitted from place to place has grown.

Engineers have taken the knowledge of light and the way it interacts with materials and applied it to create new ways of communicating. Fiber optics is one of the newer solutions that has been developed to accommodate the increasing amount of information. Fiber optic cables work on the principle of total internal reflection. Imagine you had a pipe that was a perfect mirror inside. If you turned on a flashlight at one end, a friend several miles away could see the light at the other end, regardless of how many twists and turns were in the pipe. The light would reflect off the sides until it reached the end of the pipe.

Fiber optic cables are effectively tiny strands of mirrored pipe. However, a traditional mirrored surface is not the optimal material to use to make a cable. Therefore, fiber optics cable is made of tiny strands of very pure glass fiber. The glass fiber is then clad with several layers of plastic. Coating the glass creates an effective mirror. (See Figure 1 on Information Sheet 1) You can observe a similar effect if you put a piece of black paper behind a glass and shine a flashlight on it. (See Figure 2 on Information Sheet 1.)

Lasers are used as the light source to send information via fiber optic cables. Information is translated into digital codes. The laser then pulses on and off to transmit the information through the fiber. At the other end of the fiber a receiver with the light detector translates the code back into usable information. Lasers can send information incredibly fast. The information in a whole set of encyclopedias can be sent in under a second. Different color lasers are used to send multiple pieces of information at the same time on one strand of fiber optic cable.

The distance fiber optic cables can carry light is limited by the quality and manufacturing of the materials used. At present time, the cables can only carry information about 60 miles before there is danger of the information being compromised. Therefore, in a fiber optic network there are stations every 60 miles or so which receive the pulses being transmitted and relay them to the next segment of cable. This, however, is a greater distance than other methods of communication.

Fiber optic technology also has applications outside of communications. It is used extensively in the field of medicine to develop instruments for viewing internal organs. Industry, similar to medicine, uses fiber optic technology to create tools to inspect the interior of products.

Activity Resource Page

Questions to Ask

As you go through this activity with the students you should encourage them to think about what they know about light and how it works. What are some other ways light could be used to solve a problem or meet a need?

Additional questions:

Q: What other kinds of technologies use light?

A: There are many other connections between light and technology. Light exists in many different forms. The discovery of these different forms and their properties has led to a myriad of new technologies. The discovery of X-rays (very high frequency light that can penetrate many solid materials) provided the basis for the medical technology of X-rays. Infrared light (invisible to the naked eye) is used in many wireless devices ranging from TV remotes to toys and robots.

Q: What are the advantages of fiber optic technology?

A: Many of the exciting communication methods have limitations that fiber optics overcomes. Traditional transmission through copper wires (pulses of electricity are sent in binary form) is

much more limited in distance and can be disrupted by electromagnetic interference. Microwave communication sends electromagnetic waves through the air from tower to tower. This requires that the towers have open spaces between them. Fiber optics cables are not susceptible to electromagnetic interference. Because different colored lasers can be used to send multiple signals, they can transmit much more information than other cabling. Similar to traditional wiring, fiber optics can be run anywhere eliminating the need for open spaces.

Q: Why haven't all cables been replaced with fiber optic ones?

A: Changing existing cabling to fiber optic fibers is a costly procedure and in many situations doesn't offer immediate benefits. Most of the backbone of the communications system (large cables that run from city to city) have been changed to fiber optics. However, the cables that run from your local communication center to your house still use existing copper wire technology as the demand for the high speed and large bandwidth fiber optics provides isn't in high demand at this time.

TIPS

Involve local experts to enhance the activity. Contact the engineering school at a local university, WEPAN at www.WEPAN.org or the Society of Women Engineers at www.SWE.org.

Vocabulary Words

Expanding the Activity

- 1) Students could use colored plastic wrap or cellophane and multiple flashlights and devise a different communication system.
- 2) Groups could devise plans for setting up a communication system using everyone's device.

Potential Safety Issues

Institute a handling policy for flashlights to avoid damage or misuse.

Additional References

[Http://www.howstuff works.com](http://www.howstuffworks.com)
<http://www.britannica.com>
<http://www.science.org.au/nova>
http://www-dse.doc.ic.ac.uk/~nd/surprise_97/journal/vol4/sm27/intro.html

Extensions for Advanced Students

If students are more advanced they could explore more of the optical principles involved with light and its interaction with matter.

Activity Sheet 1

You and some friends will be exploring a large cave with many twists, turns and tunnels. As you explore you discover that the echoes make it very difficult to understand what the leader is saying. Devise a method using your flashlight to communicate the 6 commands the leader shouts to direct the exploration

<u>Commands</u>	<u>Flashlight Signals</u>
Go Forward	
Go Backward	
Turn Right	
Turn Left	
Stop	
Emergency	

Test and practice your communication system by having each member of the group take turns sending the signal with the flashlight and viewing the signals.

Activity Sheet 2

As your team travels deeper and deeper into the cave, the narrow, curving tunnels make it impossible for the last person to see the flashlight signals. Build a device that the leader could shine a flashlight into that would allow the last person to see the signals.

Materials:

- -Aluminum foil and other reflective materials
- -Cardboard
- -Construction paper
- -Masking tape
- -Scissors
- Tape measures or yardsticks
- -Assortment materials for building: index cards, straws, mirrors, Popsicle sticks, toothpicks etc...

Your device must be at least 2 feet from end to end and be able to accommodate at least one bend or curve.

Testing your design:

1. Every person in the group should take a turn sending and receiving the sample signals
2. The Sender should select one of the following sets of signals to send
 - A. Turn Right, Turn Left, Go Back
 - B. Go Back, Turn Right, Emergency
 - C. Go Forward, Turn Left, Go Forward
 - D. Go Forward, Turn Right, Stop
3. The Receiver should write down which set of signals was sent
4. Track the success of the group using the table below.

SENDER	SIGNAL SET SENT	RECEIVER	SIGNAL SET RECEIVED

A manufacturer has bought the rights to produce your device. What materials would you recommend they use to create the device?

Information Sheet 1

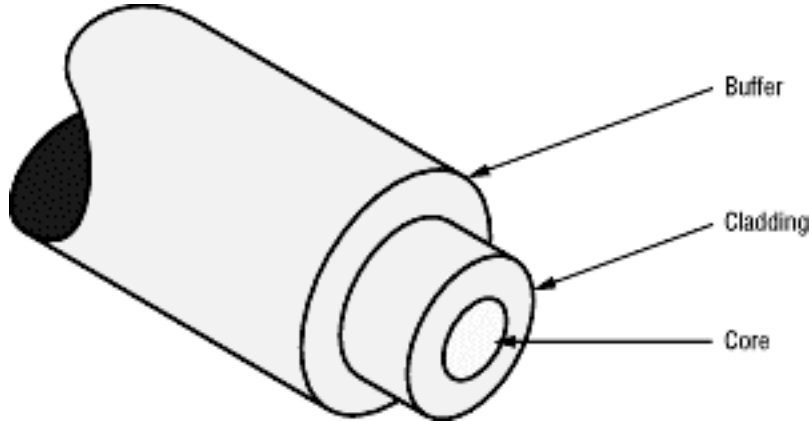


Figure 1: A cross section of a fiber optic cable

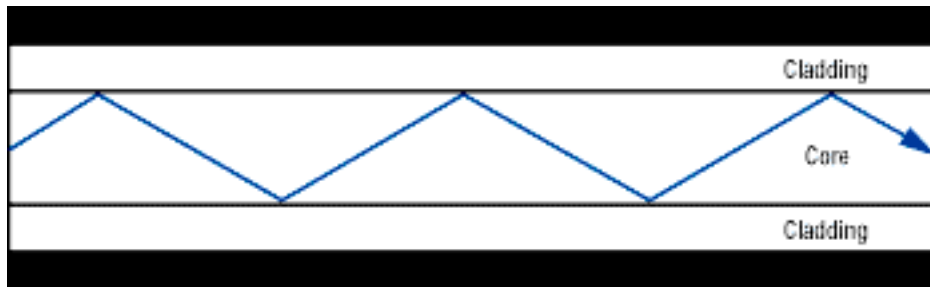


Figure 2: The behavior of light inside a fiber optic cable