Infrared Investigations

Provided by TryEngineering - www.tryengineering.org

Lesson Focus
Lesson focuses on how infrared technology is used by engineers creating equipment and system for a variety of industries. Teams of students explore the application of infrared in remote controls, test materials that encourage or prevent infrared transmission, and develop systems that allow transmission of infrared in restricted environments.

Lesson Synopsis
The Infrared Investigations lesson explores how engineers have to test components or systems within a product to make sure it meets customer needs. Students explore infrared and products or systems in which engineers have integrated infrared technology. Student teams are given a challenge of testing the limitations of infrared in a standard television remote control to devise a way to point infrared around a corner or between two rooms.

Age Levels
8-18.

Objectives

- Learn about infrared technology.
- Learn about how engineers incorporate different technologies in product and system designs.
- Learn about teamwork and working in groups.

Anticipated Learner Outcomes
As a result of this activity, students should develop an understanding of:

- infrared light and technology
- engineering product development and testing
- problem solving
- teamwork

Lesson Activities

Students learn how infrared technology has been integrated into products and systems serving most industries. Student teams test the limitations of infrared using a television remote control and devise a plan for adapting infrared to work around a corner or between two rooms. Teams test their plan, troubleshoot, evaluate their own work and that of other students, and present to the class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Worksheets (attached)
- Student Resource Sheets (attached)

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- TryEngineering (www.tryengineering.org)
- NASA Infrared (http://imagers.gsfc.nasa.gov/ems/infrared.html)
- Our Infrared World Photo Gallery (http://coolcosmos.ipac.caltech.edu/image_galleries/our_ir_world_gallery.html)
- Herschel & His Discovery of Infrared (http://coolcosmos.ipac.caltech.edu/cosmic_classroom/classroom_activities/herschel_bio.html)
- ITEA Standards for Technological Literacy (www.iteaconnect.org/TAA)
- National Science Education Standards (www.nsta.org/publications/nses.aspx)

Recommended Reading

- Engineering Tomorrow: Today's Technology Experts Envision the Next Century (ISBN: 0780353625)
- Engineering Science (ISBN: 0750652594)
- Visual Science and Engineering (ISBN: 0824791851)

Optional Writing Activity

- Write an essay or a paragraph about how heat imaging techniques using infrared technology have helped human rescue operations.

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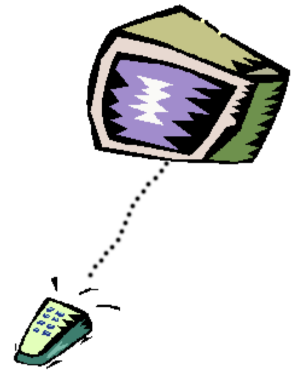
For Teachers:
Teacher Resource

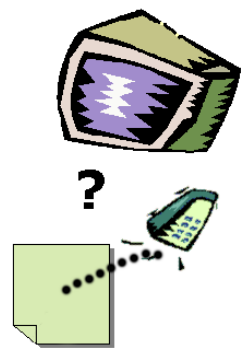


◆ **Lesson Goal**

Students learn how infrared technology has been integrated into products and systems serving most industries. Student teams test the limitations of infrared using a television remote control and devise a plan for adapting infrared to work around a corner or between two rooms. Teams test their plan, troubleshoot, evaluate their own work and that of other students, and present to the class.

◆ **Lesson Objectives**

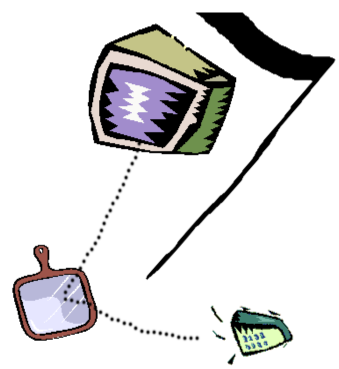
- Learn about infrared technology.
- Learn about how engineers incorporate different technologies in product and system designs.
- Learn about teamwork and working in groups.



◆ **Materials**

- Student Resource Sheet
- Student Worksheets
- Remote Control and Television
- One set of materials for each group of students:
  - Black paper, white paper, aluminum foil sheets (smooth), several small mirrors, flashlight, plastic wrap, plastic bag, clear plastic, other materials for testing beam, clear cup, water, food coloring, milk or other liquids.

◆ **Procedure**



1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework.
2. Divide students into groups of 2-3 students, providing a set of materials per group.
3. Explain that students are going to test the limitations of infrared technology in a remote control by using various materials including plastic wrap, paper, foil, mirror, and other materials. Teams predict how the infrared will be impacted by attempting to reflect the beam off an object (such as foil or plastic wrap) back to the television, then test the objects, and evaluate their results.
4. Once they have completed the "research" phase, student teams may also be presented with the challenge of developing a system for turning on a television in another room, or around a wall or corner.
5. Student teams meet to develop a plan, write their plan, then test it, evaluate their results and present to the class.

◆ **Tips**

Students will need to use a mirror to redirect the infrared around the wall or corner; some success will result with aluminum foil, but only if it has not been crumpled.

◆ **Time Needed**

Two to three 45 minute sessions

Student Resource: Infrared and its Applications

◆ What is Infrared?

Infrared (IR) radiation is electromagnetic radiation of a wavelength longer than that of visible light, but shorter than that of radio waves. The name means "below red" (from the Latin infra, "below"), red being the color of visible light of longest wavelength. Infrared radiation spans three orders of magnitude and has wavelengths between approximately 750 nm and 1 mm.

The infrared portion of the spectrum has a number of technological uses, including target acquisition and tracking by the military; remote temperature sensing; short-ranged wireless communication; spectroscopy, and weather forecasting. Telescopes equipped with infrared sensors are used in infrared astronomy to penetrate dusty regions of space, such as molecular clouds; detect low temperature objects such as planets orbiting distant stars, and to view highly red-shifted objects from the early history of the universe.

At the atomic level, infrared energy elicits vibrational modes in a molecule through a change in the dipole moment, making it a useful frequency range for study of these energy states. Infrared spectroscopy is the examination of absorption and transmission of photons in the infrared energy range, based on their frequency and intensity.

◆ Infrared Applications in Engineering

Engineers incorporate infrared technology into a variety of equipment and systems used in many industries. The following are just a few examples.

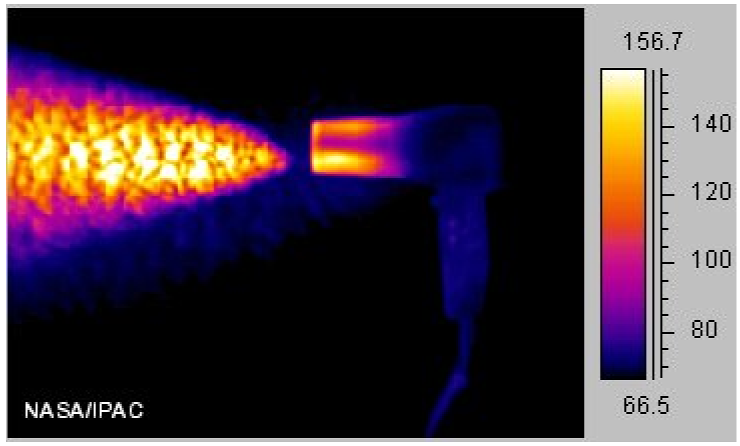
Night vision

Infrared is used in night-vision equipment when there is insufficient visible light to see an object. The radiation is detected and turned into an image on a screen, hotter objects showing up in different shades than cooler objects, enabling the police and military to acquire warm targets, such as human beings and automobiles.

Spectroscopy

Infrared radiation spectroscopy is the study of the composition of (usually) organic compounds, finding out a compound's structure and composition based on the percentage transmittance of IR radiation through a sample.

Weather Satellites

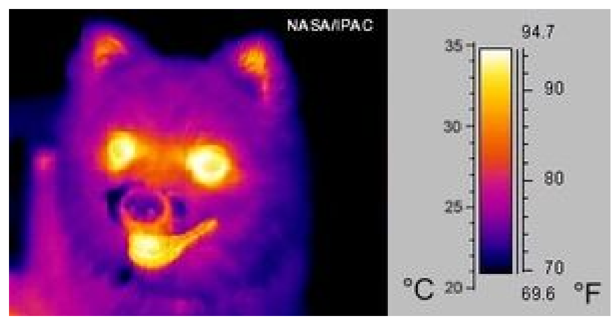


Weather satellites equipped with scanning radiometers produce thermal or infrared images which can then enable a trained analyst to determine cloud heights and types, to calculate land and surface water temperatures, and to locate ocean surface features.

Space Applications

Astronomers observe objects in the infrared portion of the electromagnetic spectrum using optical components, including mirrors, lenses and solid state digital detectors.

Heating Applications



Infrared radiation is used in infrared saunas to heat the occupants, and to remove ice from the wings of aircraft (de-icing). It is also gaining popularity as a method of heating asphalt pavements in place during new construction or in repair of damaged asphalt. Infrared can be used in cooking and heating food as it heats only opaque, absorbent objects and not the air around them, if there are no particles in it.

Thermography Equipment

Infrared thermography is a non-contact, non-destructive test method that utilizes a thermal imager to detect, display and record thermal patterns and temperatures across the surface of an object. Thermography is widely used in law enforcement, firefighting, search and rescue, and medical and veterinary sciences.

Communications Devices

IR data transmission is also employed in short-range communication among computer peripherals and personal digital assistants. Remote controls and IrDA devices use infrared light-emitting diodes (LEDs) to emit infrared radiation which is focused by a plastic lens into a narrow beam. The remote works by using a low frequency light beam, so low that the human eye cannot see it. The beam is modulated, i.e. switched on and off, to encode the data. IR does not penetrate walls and so does not interfere with other devices in adjoining rooms. Infrared is the most common way for remote controls to command appliances.

Student Resource:
Engineering Advances in Remote Control

◆ Many Methods of Remote Control

The first remote intended to control a television was developed by Zenith Radio Corporation in the early 1950s. The "remote" was unofficially called "Lazy Bones" and was actually connected to the television set by a long wire. To improve the cumbersome setup, a wireless remote control called "Flashmatic" was developed in 1955 which worked by shining a beam of light onto a photoelectric cell. Unfortunately, the cells did not distinguish between light from the remote and light from other sources and the Flashmatic also required that the remote control be pointed very accurately at the receiver.

In 1956 the "Zenith Space Command" was developed. It was mechanical and used ultrasound to change the channel and volume. When the user pushed a button on the remote control it clicked and struck a bar. This explains why some people used to call remote controls the "clicker." Each bar emitted a different frequency and circuits in the television detected this noise. The invention of the transistor made possible cheaper electronic remotes that contained a piezoelectric crystal that was fed by an oscillating electric current at a frequency near or above the upper threshold of human hearing, though still audible to dogs. The receiver contained a microphone attached to a circuit that was tuned to the same frequency. Some problems with this method were that the receiver could be triggered accidentally by naturally occurring noises, and some people, especially young women, could hear the piercing ultrasonic signals. There was even a noted incident in which a toy xylophone changed the channels on these types of TVs since some of the overtones from the xylophone matched the remote's ultrasonic frequency.

In the late 1970s, most commercial remote controls had a limited number of functions, sometimes only four: next station, previous station, increase, or decrease volume. At the time BBC engineers began talks with one or two television manufacturers which led to early prototypes in around 1977-78 that could control a much larger number of functions. ITT was one of the companies involved, and later gave its name to the ITT protocol of infrared communication.

By the early 2000s, the number of consumer electronic devices in most homes greatly increased. According to the Consumer Electronics Association, an average American home has four remotes. To operate a home theater as many as five or six remotes may be required, including one for cable or satellite receiver, VCR or digital video recorder, DVD player, TV and audio amplifier.

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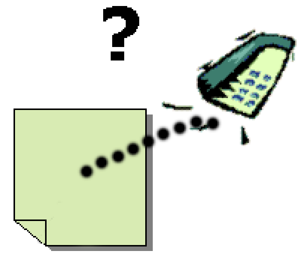
Student Worksheet: Engineering Research

You are a team of engineers who have been given the challenge of testing infrared technology to understand its limitations and devise a plan to operate a television from around a corner or in another room.

◆ Research and Prediction Phase

1. Review the various Student Reference Sheets to learn about infrared and its applications.
2. Working as a team of "engineers," discuss and make predictions about how different materials will impact the infrared. What would happen if you tried to bounce the infrared off of paper, foil or other materials to see if it still controls the television?



Material	**White Paper**	**Black Paper**	**Flat Foil**	**Crumpled Foil**	**Plastic Wrap**	**Your hand**	**CD**
Prediction							
Material	**Glass of Water**	**Glass of Milk**	**Glass of Colored Water**	**Black Electrical Tape**	**Other**	**Other**	**Other**
Prediction							

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Student Worksheet: Engineering Research (continued)

◆ Testing Phase

1. Test your teams' predictions about interference or extension of infrared by bouncing the infrared off of paper, foil or other materials to see if it still controls the television. Also test the effect of using a flashlight at a 90 degree angle and parallel with the beam to the television. Note your results below:

Material	**White Paper**	**Black Paper**	**Flat Foil**	**Crumpled Foil**	**Plastic Wrap**	**Your hand**	**CD**
Results							

Material	**Glass of Water**	**Glass of Milk**	**Glass of Colored Water**	**Black Electrical Tape**	**Other**	**Other**	**Other**
Results							

Notes:

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Student Worksheet: Evaluation

◆ Use this worksheet to evaluate your team's results:

1. What result surprised your team the most? Why?

2. Based on your research, if your engineering team was considering using infrared to control an underwater system, would you agree to incorporate infrared? Why? Why not?

What about in space? Why? Why not?

3. Why do you think engineers need to test components they are considering to incorporate in a new product or system?

4. Can you think of any other applications for which your engineering team thinks infrared controllers might be useful?

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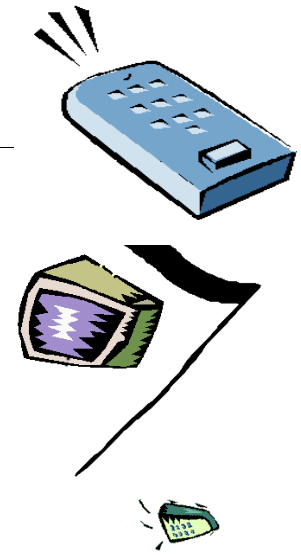
Student Worksheet: Engineering Challenge



You are a team of engineers who have been given the challenge to devise a plan to operate a television from an infrared remote control that is around a corner or in another room.

◆ Team Planning

1. Consider the results of your research and in the box below, devise a plan that you think will solve the engineering challenge. Make sure to make a list of all the materials you will require.

Materials You Need:

Student Worksheet: Engineering Challenge (continued)

◆ Testing Phase

1. Gather the equipment you predicted you would need, and test your teams' plan.

◆ Evaluate and Reflect

1. Did your plan work? If not, why not?

2. Did you find you needed to make changes to your plan in the testing phase? (either by changing the placement of items, or adding or removing materials?) If so, how did you need to change your plan to achieve your goal?

3. What systems that other team's developed did you think were particularly clever? Why?

4. Can you think of an application where a controller might need to be in a different room than the equipment it controls?

5. Meet as a team and consider what you'd like to see the next generation of remote controls be able to do. What engineering enhancements would be needed to make your ideas a reality?

For Teachers:
Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:
- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆National Science Education Standards Grades K-4 (ages 4 - 9)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop
- ✦ Abilities necessary to do scientific inquiry
- ✦ Understanding about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of
- ✦ Properties of objects and materials
- ✦ Position and motion of objects
- ✦ Light, heat, electricity, and magnetism

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop
- ✦ Abilities of technological design
- ✦ Understanding about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of
- ✦ Science and technology in local challenges

◆National Science Education Standards Grades 5-8 (ages 10 - 14)

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop
- ✦ Abilities necessary to do scientific inquiry
- ✦ Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of
- ✦ Transfer of energy

CONTENT STANDARD E: Science and Technology

As a result of activities in grades 5-8, all students should develop
- ✦ Abilities of technological design
- ✦ Understandings about science and technology

For Teachers:
Alignment to Curriculum Frameworks (continued)

◆**National Science Education Standards Grades 9-12 (ages 14-18)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- Structure and properties of matter
- Interactions of energy and matter

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local, national, and global challenges

◆**Next Generation Science Standards Grades 2-5 (Ages 7-11)**

Matter and its Interactions

- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3.Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆**Next Generation Science Standards Grades 6-8 (Ages 11-14)**

Waves and their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

- MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

For Teachers:
Alignment to Curriculum Frameworks (continued)

◆Standards for Technological Literacy - All Ages

The Nature of Technology

- Standard 1: Students will develop an understanding of the characteristics and scope of technology.
- Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

- Standard 7: Students will develop an understanding of the influence of technology on history.

Design

- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities for a Technological World

- Standard 11: Students will develop abilities to apply the design process.
- Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

- Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.