SIEMENS STEM DAY | Science Technology Engineering Math

SIEMENS STEM DAY ACTIVITY

PERCEPTION DECEPTION

REAL-WORLD SCIENCE TOPICS

- An exploration of how the human eye works
- An exploration of how visual perception is affected by various optical illusions

ADDRESSES NGSS

LEVEL OF DIFFICULTY

2

GRADE RANGE

3–5

OVERVIEW

In this activity, students will gain an understanding of the structure of the human eye and analyze and classify optical illusions.

TOPIC

Optical illusions

OBJECTIVE

Students will gain an understanding of how visual perception works by analyzing various optical illusions and by classifying them based on the type of visual perception responsible for creating the illusion.

MATERIALS NEEDED FOR PAIRS OF STUDENTS:

- ruler
- scissors
- note cards or other pieces of paper that can be used to cover up parts of optical illusion one copy of each image

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TEACHER PREPARATION

Decide on the specific optical illusions you will use. Make sure that you have selected at least one of each type as described below. Providing two or three examples of each type will help make it easier for students to recognize characteristics of each type.

Make copies of each image for students so that there is one image for each pair of students. In some cases, colored images will be needed. For others, black and white images will suffice.

NGSS THREE-DIMENSIONS

Science and Engineering Practices	Disciplinary Core Idea	Crosscutting Concepts
Engaging in Argument from Evidence Construct an argument with evidence, data, and/or a model.	**LS1.A: Structure and Function** Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.	**Systems and System Models** A system can be described in terms of its components and their interactions.

1. **Warm-up Activity:** open the class by telling students that they are going to learn about how the human eye works and then be introduced to several different types of **optical illusions**. First, show a diagram or physical model of the human eye such as this one, identifying the major parts and their functions. In particular, guide students to appreciate the differing functions of rods and cones. Explain that the eye works in much the same way that a camera does. When light enters the eye through the lens, the lens inverts the light so that images picked up by the retina are also inverted (upside-down). Ask, "Why do we see the world as right-side up?" The answer is that the human brain processes the image sent to it by the retina via the optic nerve and interprets the signal in such a way that we can understand it (right- side up). Then explain that the study of optical illusions is really a study of how the eye and brain work together to help us understand our world.

   Explain that a good example of the way that the eyes and brain work together occurs whenever we encounter an optical illusion. Ask students what the word **sensation** means. Ask students what the word **perception** means. Help students make these definitions by showing a few classic optical illusions, such as the faces/vase illusion or the duck/rabbit illusion, both of which can be found at: http://www.123opticalillusions.com. Such classic optical illusions should illustrate that the same image can be perceived (interpreted) in more than one way. Ask students which organ—eye or brain—is used for sensation. Which organ is used for perception?

   Impress on students that research in the area of human perception is quite challenging and that even now not a lot is known about how the brain is able to perceive and interpret information brought to it from the sensory organs. Emphasize that research into why we are deceived by optical illusions, like other areas of science, is a process of gathering information in order to answer fundamental questions.

2. Have students work in groups of two. Distribute the Perception Deception handout and materials to each student pair and allow them to work at their desks.

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3. Have students follow the sequence in the Student Handout to observe and analyze examples of optical illusions.

   Illusion 1: Provide at least one geometric illusion, such as the illusion in which two lines appear to be different lengths because of the different directions of the arrows at the ends. This illusion and some other good examples can be found at http://faculty.washington.edu/chudler/chvision.html.

   Which line appears to be longer than the other one?

   Measure the length of each line and record the results in your handout.

   Illusion 2: Provide at least one color illusion such as the "Hearts of Four Colors" illusion, which can be found at http://www.psy.ritsumei.ac.jp/~akitaoka/color12e.html.

   How many different colors appear in this image?
   Use scissors to cut out a portion of each image containing only the color of the heart. This will allow you to "screen out" all other background colors behind or in front of the hearts. When you compare all of these slivers of paper, how many colors do you observe?

   Illusion 3: Provide at least one brightness and contrast illusion such as the "Four Cans" illusion, which can be found at http://www.psy.ritsumei.ac.jp/~akitaoka/light3e.html.

   How many different shades of gray appear in this image? use scissors to cut paper into pieces or shapes that will allow you to "screen out" the background colors behind the shapes. Now how many shades of gray do you observe?

   Illusion 4: Provide at least one size-constancy illusion such as the "equal circles" illusion, which can be found in Figure 17 at http://www.visualillusion.net/Chap04/Page04.php.

   Which circle appears to have a larger diameter than the other one? Measure the diameter of each circle and record the results in your handout.

   Illusion 5: Provide at least one three-dimensional interpretation illusion such as the "Necker Cube" illusion, which can be found at http://www.michaelbach.de/ot/sze_Necker/index.html.

   If this cube were solid, which face of the cube would be visible to you—the top or the bottom? Look steadily at the cube for several seconds. Is there another way to see it? Explain.

   Illusion 6: Provide at least one apparent-motion illusion such as the "rotating Snakes" illusion, which can be found at http://www.ritsumei.ac.jp/~akitaoka/index-e.html.

   What happens to the other wheels when you focus on just one of the wheels? Is this a real phenomenon, or a perception? Explain.

4. Note: Some types of geometric and three-dimensional interpretation illusions may present a visual paradox and thus will not lend themselves to be "disproven" by any method of objective measurement. In such cases, instruct students to instead describe the nature of the visual paradox.

5. **Wrap-up Activity**: Lead the class in a discussion comparing students' perceptions of each optical illusion. Ask: Did everyone perceive each illusion the same way? Sometimes, differences in physiology or cultural background cause some people not to be "fooled" by certain optical illusions. How did students prove that each illusion was just that—an illusion? Did they use different methods? How does the way we look at an image affect how we perceive the image? How does the context of the image affect how we perceive the image? Have students brainstorm some other ways that our perceptions can

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be affected by context or the relative positions of objects. Examples include words that have different meanings, depending on context, the way that the senses of smell and taste interact, the way that an aftertaste of one food can affect the way another food tastes, or the way that the Doppler effect changes the pitch of a sound being emitted by an object that is either traveling toward or away from the observer.

PERCEPTION DECEPTION EXTENSION ACTIVITY

To extend this activity, students can use the principles they learned to create their own simple optical illusions or use the Internet to find other examples of optical illusions that fit the categories used in the main activity. You may also want them to find and classify various animated optical illusions that can be found on the Internet. You may want to extend the main activity by adding extra optical illusion examples, or, if practical, by using a computer lab to include animated illusions. In addition, students may want to research further into the psychological and physiological causes of optical illusions.

How does the human eye work?

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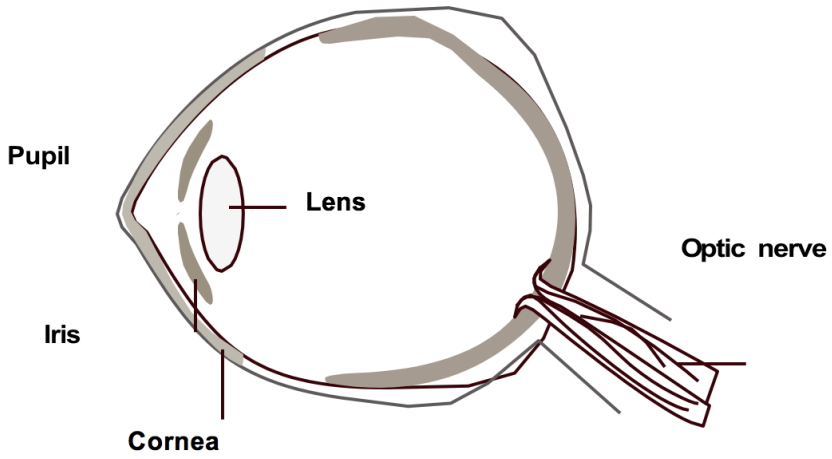
The human eye is one of the most sensitive sensory organs in the animal kingdom. The diagram below shows the main parts of the human eye. The **cornea**, which is the transparent outer covering, is the first part of the eye that light passes through. The **iris** is made of a circular arrangement of tiny muscles that expand or contract to control the amount of light that enters the eye. The **pupil** is the black hole in the center of the iris that becomes larger or smaller due to the action of the iris. Next, light passes through the lens, which is the eye's primary mechanism for focusing light on the retina. The retina consists of about 1 billion light-sensitive cells called rods and cones. **Rods** are primarily responsible for detecting extremely low levels of light, but do not detect color, nor do they detect the edges of objects very well. **Cones** are primarily responsible for detecting color and the edges of objects, but they must have adequate light to do so. When light strikes a rod or a cone cell, the cell generates a nerve impulse that travels to the **optic nerve** and then to the brain. The brain then interprets the signals as visual images.



What causes optical illusions?

The reasons we experience different kinds of optical illusions have been debated for more than 200 years. Much of the debate and research has been aimed at determining the roles that the eye and the brain play in producing optical illusions. Does the structure and function of the eye cause the illusion, or is it the result of how the brain interprets sensory input from the eye, or some combination of both? Perhaps different types of optical illusions are caused by different interactions of the brain and the eye. Although few definitive answers have been found, research continues. Scientists hope that finding the answers will help us understand the nature of perception and treat patients with certain types of brain damage.

One promising area of research centers on movements of the eyes. The eye contains a complex system of muscles and ligaments that help it move in a variety of ways in order to focus on and track objects within the field of view. Many of these motions are obvious, such as following a moving object while keeping the head still, or moving the head while keeping the eyes directed toward a stationary object. other motions are less obvious such as the tiny, imperceptible movements of the eye called microsaccades. Microsaccades are important because they allow the retina to "refresh" its view of the world. Without the constant shifting of the scene caused by microsaccades, the images produced by the retina tend to fade out if the field of view remains fixed for a significant amount of time. recent research has shown a direct link between the changing frequencies of microsaccades and the occurrence of apparent-motion illusions (described below). Thus, for this type of optical illusion, the evidence strongly suggests that the illusion is brought about by the eye, and not the brain. Other types of optical illusions, however, are thought to be strongly influenced by cognitive and cultural factors.

What are the classes of different types of optical illusions?

Although there are several different ways to classify optical illusions, some of the more common categories include: brightness and contrast, color, geometric, size constancy, three-dimensional interpretation, and apparent motion. The table below describes each briefly.

Type of Optical Illusion	Description
Brightness and contrast illusions	The observer perceives dots or lines where none exists due to the juxtaposition of light and dark shapes.
Color illusions	The observer incorrectly perceives colors due to the presence of other color contexts present in the image.
Afterimage illusions	After staring at a colored image for several seconds, the observer sees the same image in a complementary color on a blank screen where no image exists.
Geometric illusions	The observer perceives distortions in lines or shapes as a result of the geometric context present in other portions of the image.
Size-constancy illusions	The observer incorrectly perceives relative sizes of two images based on cues provided by other images present.
Three-dimensional interpretation illusions	The observer perceives an object projected into three-dimensional space in multiple ways.
Apparent-motion illusions	The observer perceives motion in a static image.

In addition, many of these same types of illusions also exist as animations. Two reference sources for both static and animated optical illusions are listed below. The first site listed has a large inventory of optical illusion images that can be downloaded and printed for this activity. This site also references a book that offers useful information and explanations related to this topic.

http://www.ritsumei.ac.jp/kic/~akitaoka/index-e.html
http://www.michaelbach.de/ot/

KEY VOCABULARY

cornea: the clear, outer layer of the eye through which light enters the eye
iris: a circular group of tiny muscles that expand or contract to control the amount of light that enters the lens
pupil: the black hole in the center of the iris that becomes larger or smaller due to the action of the iris
retina: the thin layer of light-sensitive cells at the back of the eye that receive light that has been focused by the lens and that convert light into nerve impulses that are sent to the brain
rods: light-sensitive cells of the retina that are extremely sensitive to light, but cannot detect color or edges very
well cones: light-sensitive cells of the retina that can detect colors and edges very well, but do not function under low-light conditions
optical illusion: a phenomenon that occurs when the visual perception of an object or event is different from its objective reality
sensation: the process by which an external stimulus is received by the brain through nerve impulses from a sensory organ
perception: the awareness and interpretation of sensory information
cognitive: relating to the use of learning and reasoning in interpreting and analyzing perceptions
microsaccades: small movements of the eye that help the viewer fixate on and continue to see a single image for a long period of time
optic nerve: the major nerve connecting sensory cells in the retina to the brain
vitreous humor: gelatinous substance that fills the space between the lens and the retina of the eye

With your partner, examine each optical illusion. For each illusion, describe to your partner what you see. Have your partner describe what they see. Then follow the directions below to answer specific questions about that optical illusion before moving on to the next one.

Illusion 1:
Which line appears to be longer than the other one?

Measure the length of each line and record the results below.

Illusion 2:
How many different colors appear in this image?

Use scissors to cut paper into pieces or shapes that will allow you to “screen out” the background colors behind the shapes. Now how many colors do you observe?

Illusion 3:
How many different shades of gray appear in this image?

Use scissors to cut paper into pieces or shapes that will allow you to "screen out" the background colors behind the shapes. Now how many shades of gray do you observe?

Illusion 4:
Which circle appears to have a larger diameter than the other one?

Measure the diameter of each circle and record the results below.

Illusion 5:
If this cube were solid, which face of the cube would be visible to you—the top or the bottom?

Look steadily at the cube for several seconds. Is there another way to see it? Explain.

Illusion 6:

What happens to the other wheels when you focus on just one of the wheels?

Is this a real phenomenon or a perception? Explain.

PERCEPTION DECEPTION | BACKGROUND INFORMATION

TEACHER KEY

With your partner, examine each optical illusion. For each illusion, describe to your partner what you see. Have your partner describe what they see. Then follow the directions below to answer specific questions about that optical illusion before moving on to the next one.

Illusion 1:

Which line appears to be longer than the other one?

[Sample answer: The line with the arrows pointing outward appears to be longer.]

Measure the length of each line and record the results below.

[Sample answer: Both lines were 5 cm long.]

Illusion 2:

How many different colors appear in this image?

[Sample answer: This image appears to be made of four different colors.]

Use scissors to cut paper into pieces or shapes that will allow you to "screen out" the background colors behind the shapes. Now how many colors do you observe?

[Sample answer: The image is actually made with three colors. The hearts were all the same color.]

Illusion 3:

How many different shades of gray appear in this image?

[Sample answer: Each cylinder is a different shade of gray, so there are four different shades of gray in the picture.]

Use scissors to cut paper into pieces or shapes that will allow you to "screen out" the background colors behind the shapes. Now how many shades of gray do you observe?

[Sample answer: Each cylinder is the same shade of gray.]

Illusion 4:

Which circle appears to have a larger diameter than the other one?

[Sample answer: The circle within the ring of small circles appears to be smaller than the one surrounded by the larger circles.]

Measure the diameter of each circle and record the results below.

[Sample answer: Each of the central circles has a diameter of 2 cm.]

Illusion 5:

If this cube were solid, which face of the cube would be visible to you—the top or the bottom?

[Sample answer: The top of the cube would not be visible because it appears to be tilted up.]

Look steadily at the cube for several seconds. Is there another way to see it? Explain.

[Sample answer: Yes, if you look at it long enough, it seems to switch so that the top would be visible and the bottom would be hidden.]

Illusion 6:

What happens to the other wheels when you focus on just one of the wheels?

[Sample answer: The wheels surrounding it seem to spin.]

Is this a real phenomenon or a perception? Explain.

[Sample answer: This must be an optical illusion because when you look at any particular spot on the paper, that spot does not move. So, the movement is only a perception and is not what is really happening.]