NASA Spotlite Interactive Lesson

Interactions of Light
Grades 5-8

Image Credit: NASA/Goddard Space Flight Center Conceptual Image Lab

Teacher Packet

NASA Spotlite Interactive Lesson

Science for students by students

This NASA eClips™ Spotlite Interactive Lesson supports existing curriculum and should be used as one of many strategies to build students' understandings of science content. The goal of this 5E lesson is to address a science misconception. Through watching a student-produced video (Engage), completing activities (Explore), explaining relevant concepts while applying new vocabulary collectively using a Frayer Model (Explain), and applying new information (Extend/ Elaborate), students will develop an understanding of the science content and how to correct the science misconception.

This PDF document should be downloaded to use the interactive features. The hyperlinks included in this document open PDFs or webpages and may perform differently based on the device being used. Links may have to be cut and pasted into a web browser to open.

Try using Adobe Acrobat Reader and Flash Player for optimal performance of all interactive features included in this guide. An accompanying student packet is located on the NASA eClips™ Website.

What are NASA Spotlites?

NASA Spotlites are 90-120 second student-produced video segments that address common science misconceptions as determined by reputable assessment sources such as the National Assessment of Educational Progress (NAEP), Progress (NAEP), National Science Foundation (NSF) Factual Knowledge Questions, and the Misconceptions-Oriented Standards-based Assessment Resources for Teachers (MOSART).

NASA Spotlites are designed to increase scientific literacy in a standards-based classroom. By producing Spotlite videos, students gain production experience, as well as deepen their understanding of science content. Approved NASA Spotlites can be found at the NASA eClips website.
https://nasaeclips.arc.nasa.gov/

Animated 5E Instructional Model

NASA eClips™ Guides use the 5E constructivist model developed by Biological Sciences Curriculum Study. Constructivism is an educational philosophy that promotes student-centered learning where, students build their own understanding of new ideas. The 5E instructional model consists of five stages for teaching and learning: Engage, Explore, Explain, Extend (or Elaborate), and Evaluate.

Lesson Information

Science Misconception
Light is unaffected as it passes through transparent materials.

Standards
Next Generation Science Standards
1-PS4.B: Electromagnetic Radiation
- Some materials allow light to pass through them, others allow only some light through and others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam.

MS-PS4.B Electromagnetic Radiation
- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light.
- The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends.

Objective
In this lesson, students will address the common misconception that light is unaffected as it passes through transparent materials. As the students develop their understanding of the interaction of light with matter through explore activities, they will learn new vocabulary that applies to new concepts. Students will apply the vocabulary as they explain how light interacts with different materials.

Time Frame
Between two and three 45-minute class periods:
Day 1 - Engage and Explore
Day 2 - Explain and Elaborate/Extend
Day 3 – Evaluate

This icon identifies the suggested directions and information to read to students.

Remind students to save responses. Suggested steps:
Under "file" choose "save as."
Type your name in front of the document name.
Choose "save."

Materials
Assessment
•Per student: copy of pretest and posttest
Frayer Model Activity
•Per classroom: chart paper for posting final vocabulary definitions
•Per small group: copy of a digital Frayer Model (alternatively, this can be printed)
Explore
•Per group: clear plastic cup, water, pencil, penny, tall paper/plastic opaque cup, prism, flashlight or penlight, baggie or wax paper

Safety
Review digital citizenship before students use online resources. Make sure to warn students against shining the laser pointer, flashlight or penlight in anyone's eyes.

Background Information
When light strikes any form of matter, it can be absorbed, redirected, reflected (bounced back), or allowed to pass through objects. It turns out that light is absorbed and re-radiated in all of those processes, including reflection, but an understanding of absorption and re-radiation of light is not essential for addressing the current misconception.

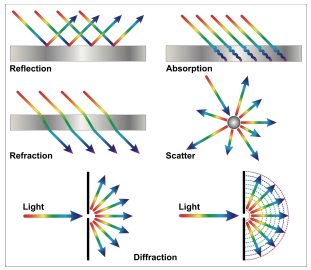


image credit: FouadA.Saad, Shutterstock

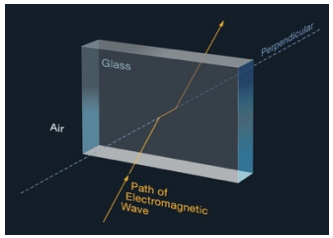


image credit: NASA Science

•The density, or the amount of material in a certain space, affects how the light ray is refracted.
•Light rays bend, or change direction, whenever they travel from one substance or medium to another. This bending is known as refraction.
•Matter through which visible light is easily transmitted is said to be transparent.
•Matter that does not transmit any light is said to be opaque.
•Translucent matter transmits light but also scatters the light as it passes through the matter.

Target Vocabulary
light, refract, reflect, absorb, transmit, transparent, medium

Engage

Pre-assessment

Probe for students' prior knowledge using the pre-assessments.
1. Pretest items are located on page 13. Student packets contain a pretest.
2. Essential question
3. Discussion questions

Essential Question

What happens to light when it passes from air through a transparent substance like water?

Today's Lesson

In this lesson you will learn about the characteristics of light. The activities you will participate in will let you explore and develop an understanding of what light does in different substances and why. Using interactive Frayer Models, you will learn key vocabulary that will help you explain how light interacts with different types of materials.

What do you already know about how light behaves?

True or False

Light is unaffected as it passes through transparent materials.

Select the best choice.
This statement is TRUE.
This statement is FALSE.

NASA Spotlite Video

Next, you will watch a clip of a video about light. As you watch the video, identify a misconception about light. **Make sure to warn students against shining the laser pointer, flashlight or penlight in anyone's eyes.

NASA Spotlite: Interactions of Light - Engage Segment

NASA eClips Website Link:
NASA eClips YouTube link: https://youtu.be/1QDXApMlwKM

Class Discussion

Use these questions to lead the class in a discussion.

1. What did you observe about how light interacts with objects from watching the video?

2. Recreate Jimmy and Timmy's demonstration. What were your results? Were they the same as those of Jimmy and Timmy?

Explore

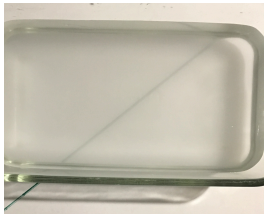
Explore Activities

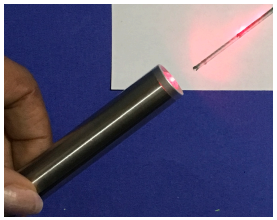
Next, you will complete activities to learn what light does in different substances and why. Record all observations in your science notebook. *Make sure to warn students against shining the laser pointer, flashlight or penlight in anyone's eyes.*

Set up stations for each activity. Review instructions and safety rules for each station. Allow students time to rotate through stations and record observations.

Activity 1 - Light Beam in Water

1. Shine a laser pointer or narrow beam from a flashlight through a clear pan of water that has coffee creamer dissolved in it. Try shining the light through the pan at different locations.
2. Record your observations.
3. Draw a diagonal line on a sheet of paper and place it under the pan of water.
4. Line up the laser pointer with the diagonal line.
5. Record your observations.





Activity2 - Pencil in Water

1. Observe the pencil and notice that it is straight.
2. Place the pencil in the empty clear plastic cup and record observations.
3. Pour water into the cup until it is ¾ full.
4. Looking from the side of the glass, focus on the pencil where the water and air meet. Record observations.
5. Remove the pencil from the cup and record observations.

Activity 3 - Penny in Water

1. Place a penny in the middle bottom of a non-see-through cup. Hold it in place with a small piece tape.
2. Stand in a place where you can see inside the cup but can't quite see the penny in the bottom of the cup. The top of the cup will block the penny.
3. While standing in the same place, have someone start to fill the cup up slowly with water. Make observations about what you can see as water is being added.

Activity 4 - Wax Paper and Water

1. Place a piece of wax paper (or a baggie) over the printed text from a worksheet, newspaper or magazine.
2. Put a single drop of water on top of the wax paper. Move the paper around on top of the printed text and record your observations.
3. Experiment with different sized drops of water. How does this affect the size of the letters?

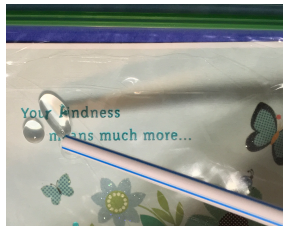


Image credit: Niyal, Shutterstock.com

Think-Pair-Share

1. How did the activities demonstrate that something happens when light travels through transparent materials?
2. Which of these activities are most like Jimmy and Timmy's demonstration?

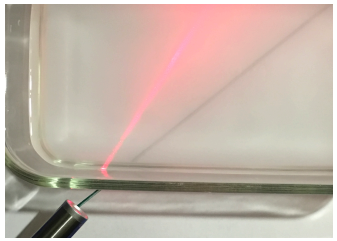
Explain

Let's compare answers.

Activity 1

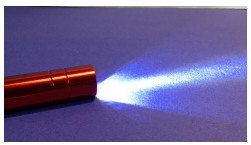
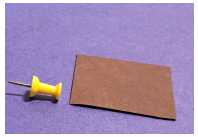
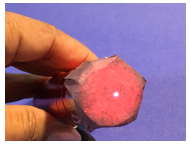
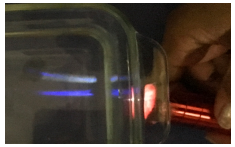
When light travels from one medium or material to another, it doesn't just keep going in a straight line. You know that because you saw it take place. When you shone a narrow flashlight beam or a laser pointer so it went from air to water (with creamer mixed in), you saw the light bend. And if you were observant, you saw that the light bent again when it exited the water and went back into the air.

[NOTE: You might have also noticed that not all of the light travels on through the water. Some of it reflects off at a different angle. For now, we'll just focus on the light that travels through the water.]



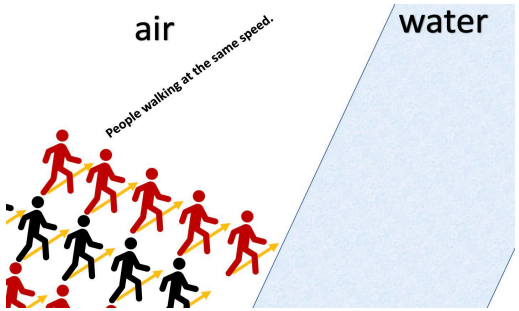
Teacher Tip:

Convert a flashlight if a laser pointer is not available. Use a pushpin to make a hole in the middle of a piece of opaque paper. Tape the paper over the light.

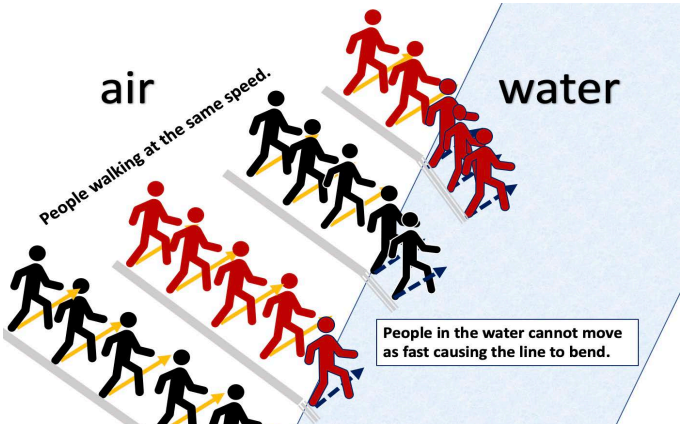
Why does light do that? You can do a simple activity with your classmates that explains why.

Place a long strip of tape (masking tape, electrical tape, or duct tape) on the floor of your classroom. Label one side of the tape "air" and the other side of the tape "water," as shown in the diagram below.



Then have five or more students line up side by side and approach the tape from the "air" side. Tell students to march slower after crossing the tape.

Hopefully, you noticed that the line of students changed direction. Well, that's pretty much what happens to light. Light slows down when it travels through denser (more compact) materials. The reason it slows down is that the light gets absorbed by the molecules in the denser material and then re-radiated.



This absorption and re-radiation takes time, and that means light travels slower in denser materials.

Try repeating this activity, but label the "air" side as "water," and vice versa. Now, when a student reaches the "air" side, the student should speed up instead of slow down. Do you get a different result?

Why did we use a long line of students to represent light? Because one way of representing light is as a series of waves. One horizontal line of students represents one part of these waves. Later in this section, we'll represent light as a series of arrows traveling in a straight line. It turns out there are several different ways to model what light is.

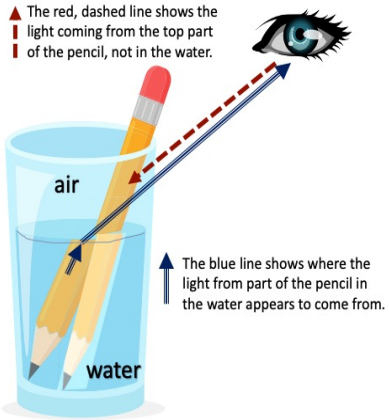
When light bends as it travels from one material or substance to another, we call that "refraction."

Explain

Activity 2

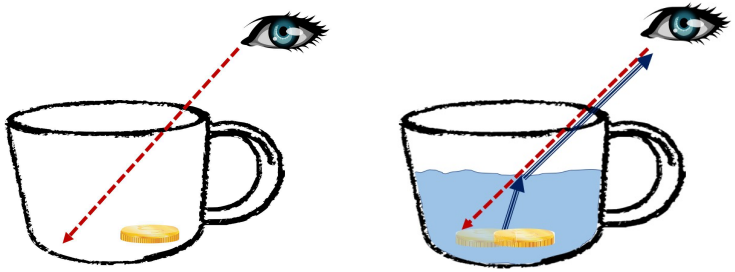
When you added the water to the cup the pencil appears to be broken into two pieces, but once you remove the pencil you see that it isn't really broken at all. When we look at a pencil outside of the water, light from the pencil travels through the air and straight to the eye.

The drawing shows what's going on when there is water in the cup. The solid arrows show the actual path taken by the light from the pencil as it reaches your eye. Notice that the light bends when it travels from water to air. The dotted arrow shows where the light from the pencil appears to be coming from. So your eyes are fooled into seeing a broken pencil.



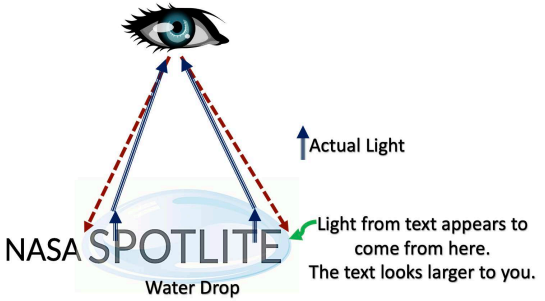
Activity 3

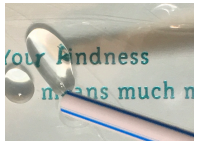
You should have been able to see the penny at the bottom of the opaque cup as soon as you had enough water in the cup. Once again, this is due to light bending as it travels from water into air. The next drawing shows what the light from the penny actually does, and where it appears to be coming from according to the viewer.

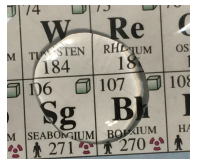


Activity 4

As in the first activity, light refracts (or bends or changes direction) as it travels from water into air. The next drawing shows what is going on. Again, the dotted lines show where the light from the printed text appears to be coming from. The text looks larger than it actually is. Did you know this is how glasses work? The lens will bend the light and make images get bigger or smaller, depending on the prescription. Notice in this drawing that the straight up light arrow does not hit the interface perpendicularly because the water drop is curved.







In the Spotlite video the glass is empty. Why does the light bend? Because the light still travels to and from a denser substance (glass) to and from a less dense substance (air). All the bending takes place at the sides of the glass vase. If you're really clever, you can figure out why the vase being curved increases the amount of bending.

Explain

Vocabulary Development

It's almost impossible to learn science concepts without also learning vocabulary words. Those vocabulary words help people discuss science concepts, so they're important. However, knowing vocabulary words is not the same as understanding science concepts. This section is designed to help your students do more than memorize definitions as they connect the vocabulary to the science concepts that they have explored.

1. Place the word "refraction" in the center of the graphic organizer. (See page 11 for a fillable Frayer Model. Student packets contain a fillable Frayer Model.) Facilitate a discussion with students exploring why this word is key vocabulary to this study.
2. Ask students to brainstorm characteristics of "refraction" and add responses to the area with the corresponding heading on the graphic organizer.
3. Ask students to continue their exploration as they research the topic using a variety of resources including their textbook and notes.
4. Next, ask students to add examples and non-examples in the Frayer Model. Emphasize the higher-level thinking skill of comparing and contrasting.

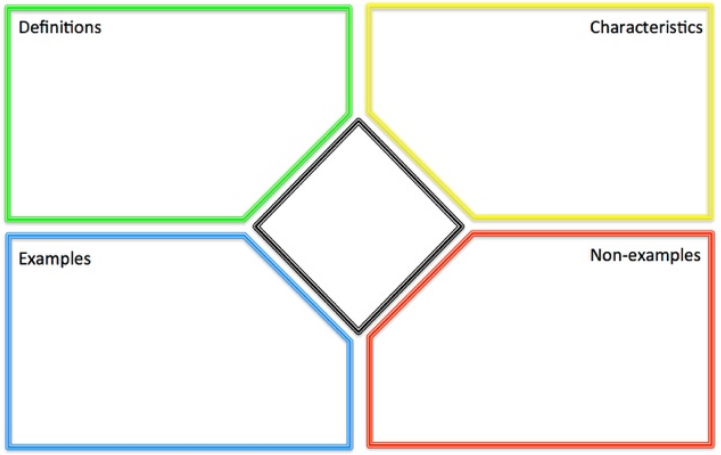
How are the examples alike/different than the non-examples?

5. Using the information provided, ask students to develop their own definition of the word "refraction" that is clear and concise. An example is in the Answer Key section of this document (page 15).
6. After completing the example together, assign a new vocabulary word to each group of students to work on collaboratively.

Now complete a new Frayer Model with your group using your assigned word and fill in the graphic organizer. We will share some as a class.

Frayer Model for Vocabulary Development

Use the graphic organizer to write definitions, characteristics, examples and non-examples for a vocabulary word. You can include drawings, graphics, and diagrams.



7. Groups will share their Frayer Models and lead discussions to check for understanding of each vocabulary word. Refer to definitions in the Resources section (page 12).
8. Compile and post final definitions so all students have access for later reference.

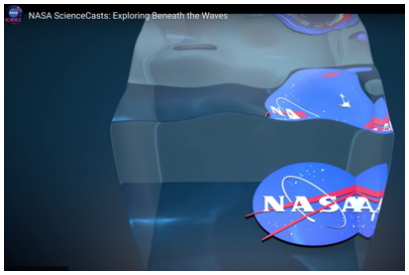
You will review key vocabulary. Pay attention to how your definitions compare.

Elaborate

It is important for the students to explain what's going on by applying what they have learned. It is not unusual for students to have a bit of difficulty with elaborate activities. Student are not used to doing "novel" activities and being asked to apply what they know.

NASA CONNECTION

Exploring Beneath the Waves
Excerpt from NASA ScienceCasts
https://go.nasa.gov/3qvtxDj



Oceans cover over 70% percent of Earth's surface and profoundly influence our planet's atmosphere, weather, and climate. However, uncovering the many secrets hidden beneath the ocean's waves presents unique challenges for researchers, and requires specific technology to observe what humans can't see.

NASA technologists are developing sensors that can improve measurements of Earth's oceans, creating new instruments to study aspects of our home planet we haven't before been able to research.

Imaging what's below the ocean surface requires the development a new instrument capable of improving the information available to scientists. Ved Chirayath, a scientist at NASA's Ames Research Center says, "Images of objects under the surface are distorted in several ways, making it difficult to gather reliable data about them."

Why are the images of objects under the surface distorted?

Elaborate Activity

Prisms

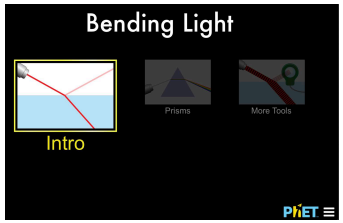
Light traveling through prisms not only involves the bending of light, but also involves something that is tangential to the main idea of the lesson. At that point, explain to students that different colors of light bend different amounts.

You have explored and explained how transparent materials can bend light. Investigate bending light using prisms. Play with prisms of different shapes and make rainbows. Record all observations in your science notebook.

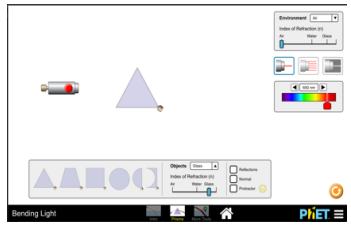
Shine a light source through a prism.
Explain:
What do you observe?
What colors do you see? In what order are the colors?
Where does the light enter and exit the prism?

Follow the directions for PhET website simulation.
https://phet.colorado.edu/en/simulation/bending-light

1.Go to the following Phet website (https://phet.colorado.edu) and search for Bending Light simulation. Start with Intro.



2.When the simulator window opens, you should notice a laser pointing at a 45° angle downwards to the right. Look to the right of the window for the two information boxes explaining the media shown on the screen. Set both to air.
3.Click on the RED button on the laser. Record what happens.
4.Change the bottom medium first to glass and then to water. Click on the RED button on the laser. Record what happens.



5.Switch to the prism simulation and investigate the interactions of light with prisms.
6. Discuss your observations.

Evaluate

Post-Assessment

Check students' understanding with these activities.
1. Identify misconception
2. Discussion questions
3. Vocabulary Review
4. Post test items are located on page 13. Student packets contain a posttest.

Identify Misconception

What is a common misconception people have about how light behaves and how can you correct this misconception?

Discussion Question(s

What happens to light when it travels from one substance or material to another?

NASA Spotlite Video

Carefully re-watch the NASA Spotlite video about light. Write an explanation, suitable for a classmate or for a younger student, of what's going on in the video.

NASA Spotlite:Timmy and Jimmy's Interactions with Light

NASA eClips Website Link:
NASA Spotlite YouTube Link: https://youtu.be/m4UiH0ZnvOc

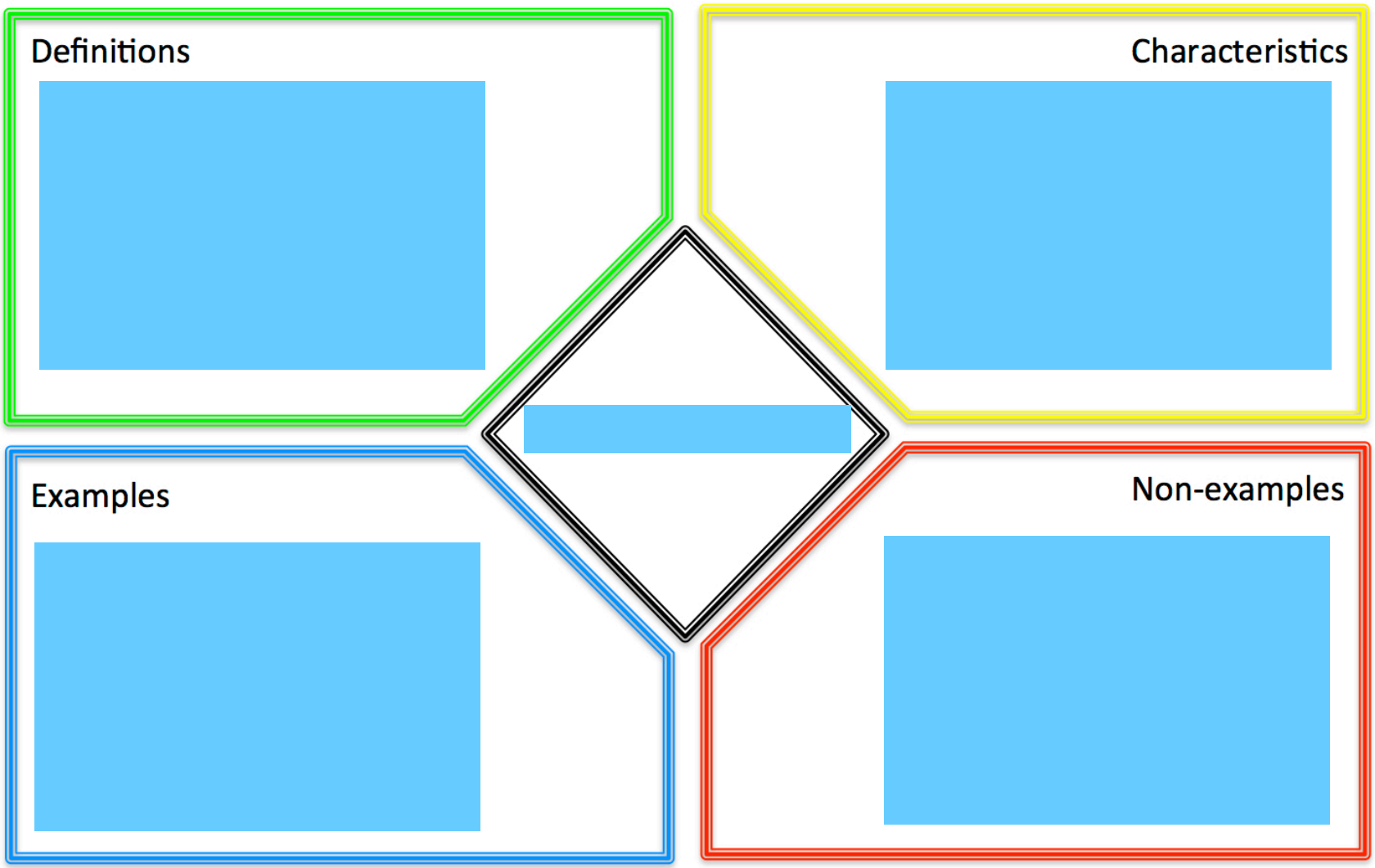
Vocabulary Review

Using your new vocabulary words and illustrations, explain what happens to light when it travels from one substance or material to another.

Resources

Frayer Model for Vocabulary Development

Use the graphic organizer to write definitions, characteristics, examples and non-examples for a vocabulary word. You can include drawings, graphics, and diagrams.



Resources

Vocabulary Words

light - Light is a form of energy that allows us to see objects. Light can be absorbed, transmitted, reflected and refracted.

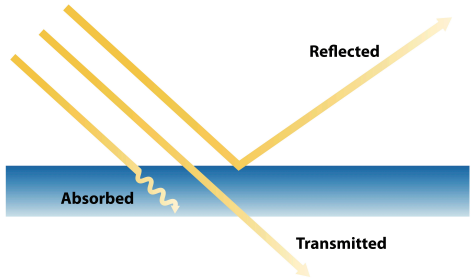


Image credit: OSweetNature, Shutterstock.com

reflect - Reflected light is light that is absorbed and then re-radiated off in a new direction.

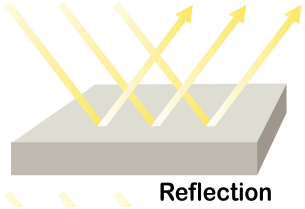


Image credit: VectorMine, Shutterstock.com

refract - When light is refracted it is bent. Light refracts when it passes from one material to another.

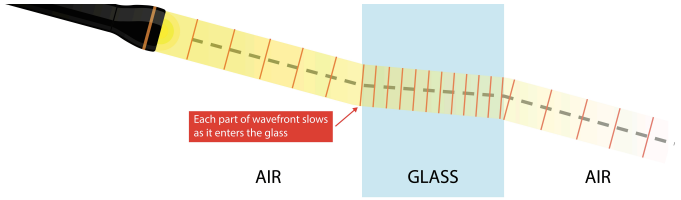


Image credit: Nasky, Shutterstock.com

transmit - When referring to light, transmit or transmission is when light passes through an object. Transmitted light interacts with the molecules of the object, which is one reason the light slows down when it is transmitted.

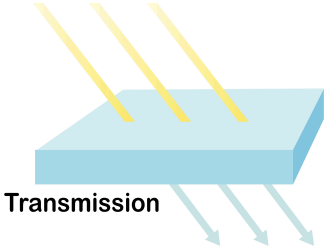


Image credit: OSweetNature, Shutterstock.com

transparent - Transparent describes a substance through which light is able to pass.

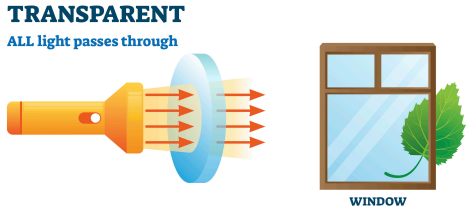


Image credit: OSweetNature, Shutterstock.com

Resources

NASA Spotlite Interactions of Light Interactive
Lesson Pretest / Posttest

Read each question and select the best choice.

1. When the sun's light rays slow down and bend as they leave air and enter water, they are:

Select the best answer.
A. deflected
B. reflected
C. refracted
D. dispersed

2. Which of the following is an example of refraction?

Select the best answer.
A. Light being absorbed by a plant.
B. Light bouncing off a mirror.
C. Light bending as it passes through a prism.
D. Light being blocked by a solid object.

3. Which of the following does not describe an interaction of light when it strikes an object?

Select the best answer.
A. It scatters.
B. It is transmitted.
C. It gets absorbed.
D. It changes from energy to matter.

4. Objects that block light are:

Select the best answer.
A. transparent
B. opaque
C. translucent
D. clear

5. Which of the following items is translucent?

Select the best answer.
A. frosted glass
B. clean window
C. windshield
D. mirror

6. The stem of the flower under the water appears larger than the portion that is above the water. This occurs when light is bent or:

Select the best answer.
A. deflected
B. refracted
C. reflected
D. blocked

7. Light bends when it goes from one transparent material to another because:

Select the best answer.
A. It speeds up in denser materials.
B. It slows down in denser materials.
C. Light doesn't bend in this instance.
D. Most light gets absorbed when entering the material.

8. When light travels from one medium to another, such as from air into water, it:

Select the best answer.
A. changes direction.
B. keeps moving in a straight line.
C. does not reflect back into the air.
D. scatters and gets absorbed by water.

Answer Key

NASA Spotlite Interactions of Light
Interactive Lesson Pretest / Posttest

Read each question and select the best choice.

1. When the sun's light rays slow down and bend as they leave air and enter water, they are:

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C. **refracted** ***
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B. Light bouncing off a mirror.
C. **Light bending as it passes through a prism.** ***
D. Light being blocked by a solid object.

3. Which of the following does **NOT** describe an interaction of light when it strikes an object?

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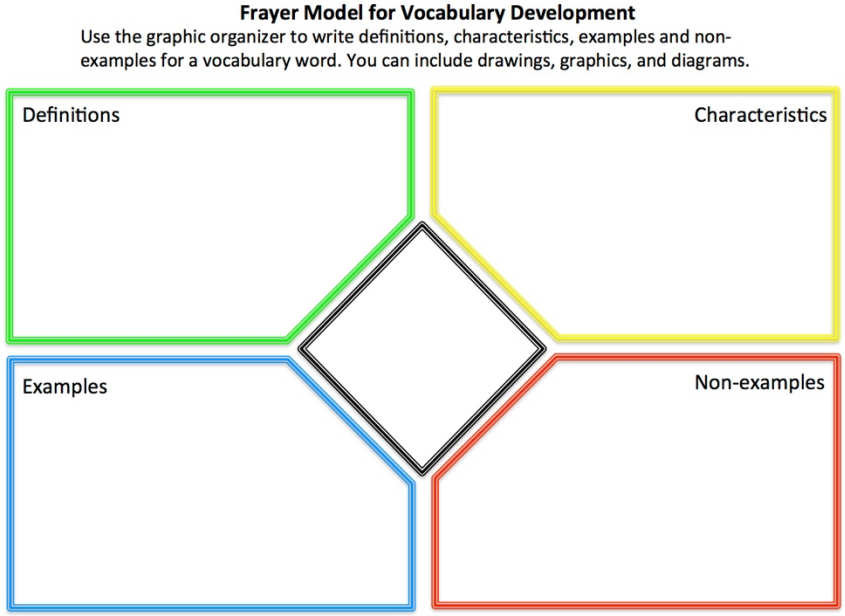

Word
Refraction

Characteristics
-Light changes speed as it enters a different medium
-Light bends a different amount as it enters a different medium

Examples
-light moving from air into water making a pencil appear to be bent where the air and water meet

Non-examples
-absorption
-reflection
-transmission

Definition
Refraction is the bending of light as it passes from one material to another. Reflected light is light that is absorbed and then re-radiated off in a new direction.

Product Information

This product has been developed by the National Institute of Aerospace's Center for Integrative STEM Education.

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