Unit Map 2010-2011

Department of Defense Education Activity
Science, Middle School / Integrated Science I /
Grade 6 (Middle School)
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Unit: **Unit 5 Properties of Light** (Week 12, 4 Weeks)

Stage 1: Desired Results

Unit Overview

Occurrences in students' everyday environment can be the starting point for having them investigate some of the ways **light** interacts with materials. Starting with mirrors, students can explore what happens to reflections of their faces and generate questions that are the basis for an extended inquiry. After some initial explorations with mirrors, a more systematic experimentation begins. Visual representations of the behavior of **light** are introduced by means of the concept of the **light** ray. To take students further in their investigation and to provide a context for getting at properties other than reflection, other materials are introduced. These can be translucent, opaque, and transparent materials. Building on what students have learned about reflection of mirrors, they compare and contrast what happens with these different materials. Drawing on these experiences, students' conceptions about how **light** interacts with opaque and translucent materials can be challenged. Further investigation is carried out with curved reflective surfaces, providing an opportunity to apply what was experienced in the previous activities.

New materials are introduced to move students to the exploration and investigation of a different **light** phenomenon. Working with bottles, containers, and specially shaped plastic lenses, students can discover and develop understandings about how **light** is diffracted by different materials. Practical applications of this property can be further developed from these experiences.

Grade 6 Quarter 2 Essay

Primary Standards

Science, Grade 6 , S1 Scientific Inquiry
The student demonstrates abilities necessary to do scientific inquiry and an understanding about scientific inquiry; that is, the student:

- S1a: develops research questions that can be answered through scientific investigations.
- S1b: accesses, evaluates and uses information from a variety of reliable sources.
- S1c: designs, conducts, and records scientific investigations following the general procedures of scientific inquiry.
- S1d: applies appropriate tools and techniques to systematically collect, record, analyze, interpret and present data.
- S1e: develops logical descriptions, explanations, predictions, and models using evidence.
- S1f: recognizes and analyzes interpretations, conclusions, and predictions based upon alternative evidence and explanations.
- S1g: communicates scientific procedures, explanations, and conclusions using

appropriate scientific language and mathematics.

Science, Grade 6 , S5 Physical Science
S5c: investigates how radiant energy (light) interacts with matter.

- S5c1. demonstrates through investigations that **light** can be reflected, transmitted, and/or absorbed when it strikes an object.
- S5c2. Explores how transmitted **light** is refracted to different degrees by a variety of materials.
- S5c3. groups materials based on physical properties that affect the behavior of **light** (e.g., transparent, translucent, opaque, absorbent, reflective materials).
- S5c4. investigates and explains that an object can be seen when **light** waves emitted or reflected by it enter the eye.

Essential Understandings & Guiding Questions	**Key Concepts & Skills**
Essential understandings are conceptual knowledge students should develop throughout the unit. The sample guiding questions frame the teaching and learning, pointing toward key issues and ideas, and suggest meaningful and provocative inquiry into content. The behavior of **light** depends on the physical properties of the material with which it interacts. • How does **light** behave when it strikes a flat object? • How do different kinds of materials affect the behavior of **light**? • In what way is **light** reflected off of curved surfaces the same or different from **light** reflected off a flat surfaces? • What happens when **light** travels through two curved surfaces? 2. An object can be seen when **light** rays emitted or reflected by it enter the eye. • How does the reflection of **light** allow us to see objects?	By the end of the unit, students should be able to: • Explain that **light** travels in a straight line. • Draw diagrams of how **light** rays reflect off of flat and curved surfaces. • Use a protractor to measure the angle of incidence and the angle of reflection. • Verify that the angle of incidence is equal to the angle of reflection. • Distinguish between reflection, refraction, and scattering. • Describe how the path of **light** changes as it travels from one medium into another. • Explain that an object can be seen when **light** waves emitted or reflected by it enter the eye.

Stage 2: Assessment Evidence

Sample Assessments

To assess student knowledge of the essential understandings, teachers should create assessments which require students to do the following, with examples of sample assessment questions that can be used or adapted to serve their students more successfully listed below in paper clipped links:

Assessment Evidence:
• Creates a physical model to illustrate how **light** travels in straight lines. [EU #1]
• Groups materials based on physical properties that affect the behavior of **light**. [EU #1]

• Distinguishes between reflection and refraction using a protractor to measure the angles. [EU #1]
• Describes, using a diagram, how the eye detects objects. [EU #2]
• Applies their understanding of the behavior of **light** (reflection, refraction, and scattering) to make predictions about how **light** will behave in new situations. [EU #1]

Sample Assessments:
The following examples of assessment items can be used during this unit. Teachers may adapt these to serve their students more successfully.

Sample Assessment 5.1: Selected Multiple Choice Item from MOSART 2007 on refraction.

Sample Assessment 5.2: Selected Multiple Choice Item from National Assessment of Educational Progress (NAEP) on the pathway of **light** that allows the eyes to see objects.

Sample Assessment 5.3: Selected Multiple
G6_Q2_SampleAssessment_5-1_111607new
G6_Q2_SampleAssessment_5-2_111107
G6_Q2_SampleAssessment_5-3_111107

Stage 3: Learning Resources

Learning Resources

Examples of possible learning resources including model learning activities that support the essential understandings for this unit.

1. Zubrowski, B., Mirrors: Finding Out About the Properties of **Light**. (Available from Kelvin, spring 2008)
2. ARIES: Exploring **Light** and Color—Filters, Lenses and Cameras, Charlesbridge Publishing, 2000.
3. Seeing the **Light**: Optics in Nature, Photography, Color, Vision and Holography, by Falk, D., Brill, D., and Stork, D. 1986, John Wiley, New York. Chapters 2 and 3 provide careful descriptions of how cameras and mirrors function using many illustrations. A useful reference book for gaining an understanding of a variety of optical instruments and other visual objects.
4. PSSC textbook: Chapter 12 and 13. D.C. Heath. Boston, 1960, A careful and extended examination of shadows, reflections in mirrors, and lenses.
5. Mirror, Mirror: A History of the Human Love Affair with Reflection by Mark Pendergrast, Basic Books, 2003. A non-technical account of artists and scientists explorations of mirrors and their use in scientific investigations
6. The Shadow Club: The Greatest Mystery in the Universe-Shadow-and the Thinkers Who Unlocked Their Secrets by Roberto Casati, Knopf, 2003. A non-technical historical account of artists' and scientists' gradual understandings of the relationship between **light** and shadows. Includes some of the mathematical implications of shadows.
7. This physics tutorial provides good explanations and diagrams about the behavior of **light**. http://www.glenbrook.k12.il.us/gbssci/phys/Class/usage.html
8. Chapter 23: **Light**, Mirrors, and Lenses. Glencoe Science: Level Green, 2003. pp. 662-689.
9. DoDEA Science Teachers Summer Workshop (2007) Optics II: Plane Mirrors, Concave Mirrors, Convex Mirrors.

In addition, the following Learning Activities provide sample lessons for this unit:

Learning Activity 5.1: Reflections in Two Mirrors. Zubrowski, Bernie, Mirrors: Finding Out About the Properties of **Light**, (Available from Kelvin, spring 2008)

Learning Activity 5.2: Exploration 9: Mirrors and **Light** Beams. ARIES: Exploring **Light** and Color—Filters, Lenses and Cameras, Charlesbridge Publishing, 2000.

Learning Activity 5.3: Exploration 6: Looking at Shiny Surfaces. ARIES: Exploring **Light** and Color—Filters, Lenses and Cameras, Charlesbridge Publishing, 2000.

Learning Activity 5.4: Reflections in a Curved Mirror. Zubrowski, Bernie, Mirrors: Finding Out About the Properties of **Light**, (Available from Kelvin, spring 2008).

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G6_Q2_LearningActivity_5-2_111107
G6_Q2_LearningActivity_5-3_113007
G6_Q2_LearningActivity_5-4_113007

<< Previous Year

UNIT 5: Properties of Light

Synopsis

Essential Understandings:

- The behavior of light depends on the physical properties of the material with which it interacts.
- An object can be seen when light rays emitted or reflected by it enter the eye.

Part 1: Exploring reflection with flat mirrors (reflection of faces)
The reflection of light is encountered daily by students in a variety of situations. Students begin this unit by recalling their experiences with mirrors and other reflecting surfaces and environments. They first identify objects inside a home or school in which they can see their reflections; then they consider where they can see their reflections outdoors. Students may note reflections in mirrors and spoons, in the windows of homes and glass buildings, on the surface of the calm waters of ponds, or from large shiny objects such as automobiles. Students describe how reflected images appear and compare reflections on each of these objects/surfaces.

To begin to explore the path of reflected light, students investigate ways to produce multiple or "weird" images of their faces using flat mirrors. They find different ways to position two or more planar mirrors to see multiple images of a face, half of a face, hundreds of faces, an upside-down face, and a split face (face with no nose). Students draw how they arranged the mirrors and their own face in each scenario. They generate questions and ideas about how these effects happen; students discuss, "How do we see these multiple or skewed images? Where does each image that we see 'come from'?"

How does light behave when it strikes a flat object?

Part 2: More systematic experimentation of reflection
Next, students investigate the reflection of a beam of light in a more controlled manner and answer some of the questions generated in Part 1. Using a flashlight with a very small bulb or a laser pointer, students map how light is reflected off a mirror surface. If using a flashlight, a comb placed between the light source and the mirror can be used to produce an array of beams. This array of beams (or the beam of a laser pointer) provides a way of introducing the concept of a light ray—which is a visual and conceptual representation of what happens to light.

As they experiment with the light beam striking the mirror at a number of different angles, students notice that there is a relationship between the way a light beam hits a mirror and the way it bounces off. Here students can use a protractor to measure the angles and find that the angle of incidence (the angle at which the beam hits the mirror) is equal to the angle of reflection (the angle at which the beam reflects off the mirror). They apply this quantitative relationship to a number of different situations in which they position mirrors so that a light source hits a target (e.g., a mirror maze game, finding a person around a barrier, designing a periscope).

How do different kinds of materials affect the behavior of light?

Part 3: Exploring and experimenting with transparent sheets of plastic using flashlights and laser pointers

Students move on to exploring what happens when a light beam strikes materials other than mirrors, such as different kinds of opaque materials, transparent sheets of plastic, and translucent pieces of plastic. They repeat their investigations from Part 2 with these different materials and consider: "How does the reflection or reflections with these materials differ from flat mirrors?" Students observe that they can re-create many of the effects they achieved with the flat mirrors, but the images are much more faint. Through these explorations, students learn that transparent materials reflect *and* transmit light and that some materials that are opaque do not transmit or scatter the light.

In what way is light reflected off of curved surfaces the same or different from light reflected off a flat surface?

Part 4: Exploring and experimenting with curved surfaces

Students now apply their new understanding about the behavior of light to explore curved surfaces. Beginning with the curved surfaces of spoons or the side of a drinking glass, students investigate what happens to their images as they look at both the convex and concave surfaces. Next they use a comb with the light source to explore how light is reflected off of curved surfaces. Once again they consider the relationship between the way light beams hits a surface and the way they bounce off. Students draw diagrams to describe how they think the light rays are behaving.

What happens when light travels through two curved surfaces?

Since the surfaces of the spoon and drinking glass are static, students can try using a flexible sheet of plastic, such as Mylar, to change the curvature of the surface. They notice that a small change in the surface can result in large changes in the images. Students again draw diagrams to describe the behavior of the light beams and compare them with their earlier diagrams. These drawings help students realize that when light hits a curved surface, it either spreads out or is concentrated.

Part 5: Exploring with containers and lens-shaped materials (refraction)

How does the reflection of light allow us to see objects?

Students explore how light behaves using objects, such as bottles and other kinds of transparent containers, which simulate lenses. They apply what they have learned about single curved surfaces and make predictions about how light will behave as it passes through one curved surface and then another. Using a light source, students explore the path of the light as it enters one side of the bottle or container and leaves the other. These explorations and investigations provide the context for discovering and discussing the property of refraction.

Part 6: Exploring in a systematic manner what happens with containers and lens-shaped materials

Further explorations can be carried out by having students explore what happens when water is put in these different containers. These explorations and experiments provide the experiences for going further with the property of refraction. They also help students make a connection to their lives outside the classroom since lenses are used in cameras and eyeglasses. At this point, students may have their own questions about the behavior of light and can design their own investigations based on these questions.

Part 7: Vision

So far, students have explored how light behaves as it is reflected from both flat and curved shiny surfaces. They now apply what they know about reflection to how they see objects. Using the diagrams that they generated from their earlier explorations, students add a diagram of an eye and determine how the reflected light from an object, such as a mirror or a spoon, enters the eye. They trace the pathway of the reflected light from the object to the eye.

Prerequisite knowledge

This is the first time since grade 1 that students explore the behavior of light. Since it is doubtful that students will be able to draw upon their experiences from this early grade, the unit assumes no prerequisite knowledge and begins with the fundamental properties of light and then delves into light's behavior.

Misconceptions

The Nature of Light

Research (Driver, Squires, Rushworth, & Wood-Robinson, 1994) suggests that middle school students believe that:

- Light is associated only with a source or its effects. Light is not considered to exist independently in space; hence, light is not conceived of as "traveling."
- Light from a bulb only extends outward a certain distance, and then stops. How far it extends depends on the brightness of the bulb.
- The mirror image of an object is located on the surface of the mirror. The image is often thought of as a picture on a flat surface. Light reflects from a shiny surface in an arbitrary manner. Light shines on a

translucent material and illuminates it so it can be seen. Light does not travel from the translucent material to the eye

Vision

Because students have difficulty with the notion of light travel, many students struggle to understand the scientific conception of vision. The scientific theory of vision is that our eyes detect the light that is reflected and scattered from the object. Some students have a problem understanding that light travels from objects into the eyes. A novice understanding of how we see is usually expressed in this manner: "The light brightens or illuminates the object, and people's eyes "focus on" the object itself (Andersen, 1990). Closely related to this "misconception" is that "eyes see objects directly." Students do not "depict any light traveling from the object to the eye"; they think that the light "simply illuminates the object so that it can be seen" (Driver et al., 1994). "We see, not by light being reflected to our eyes, but by looking" (Driver et. al., 1994). This leads students to mistakenly believe that they can see in total darkness.

To believe the scientific concept of vision, students need to believe that light reflects off opaque objects (not just mirrors) and scatters. But a main misconception is that light is reflected from smooth mirror surfaces but not from non-shiny surfaces. During the explorations with mirrors students can observe how light is reflected. Since smooth mirrors have been treated with a special material, reflection readily occurs and students can readily accept the reflection. Reflection off of non-shiny surfaces for the student is less apparent. Students have problems differentiating between reflection and scattering. While students are exploring with the transparent sheets of plastic and translucent materials, teachers may want to introduce the concept of scattering and to challenge students' understandings of what they are seeing. When they shine light on several successive sheets of transparent plastic, students can observe that the light passes through as well as is reflected back. When a laser pointer is shined on translucent materials, scattering of the light can be observed.

Abu Ali al-Hasan, born in Iraq in the 10th century, destroyed the theory that light emerges from the eye merely by looking into the sun. It hurt. Clearly the rays were going into the eye, not out. He proposed that objects we see in our minds are reproductions of real objects: a mountain is reproduced point for point on the eye's lens, only in tiny form.

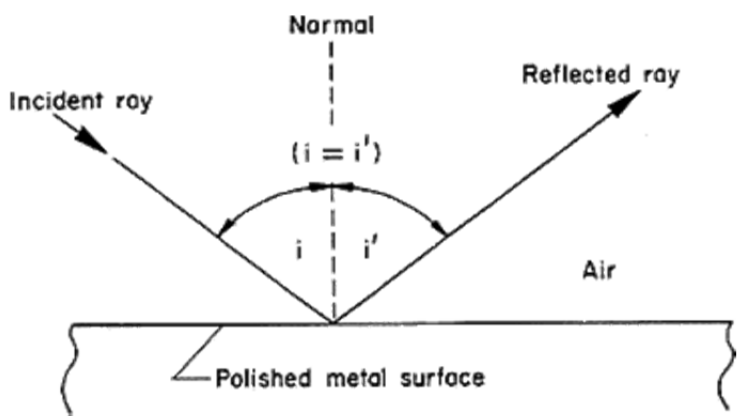
Foundational teacher content knowledge

Light energy travels in straight lines and is described as traveling as a ray or rays. Light rays are useful because they can represent how images are formed or how light is bent as it moves through materials. A material through which light passes, such as glass or water, is referred to as a medium. Light rays can be reflected, scattered, refracted, and/or absorbed, depending upon the media through which it is traveling.

Light is a phenomenon that is so much a part of our everyday lives that we generally don't examine how it interacts with materials. Some of the properties of light can be brought to our attention by considering the following situation. If you are walking down a city street past some office buildings when the sun is about to set, you can observe several properties of light. Looking at the glass windows of the buildings you can see *reflections* of other buildings. Sometimes these images are distorted. If the building is of a shiny metal, there are reflections of light but usually not images of nearby structures. If the material of the building is black or dark material, there are no images or reflections unless the material is highly polished stone. As the sun goes down over the horizon, there is still light, suggesting that somehow the atmosphere has *bent* the light. When it starts to grow darker, the interior of the buildings becomes more visible. The lights on in the offices appear to be brighter. This indicates that the glass of the windows lets light travel in both directions (i.e., windows *transmit* light). If we enter a hotel lobby that happened to have chandeliers and an aquarium, another property of light becomes apparent. The glass pieces hanging from the chandelier appear to *bend* the light. Looking closely at fish in the aquarium is an occasion to observe another curious phenomenon. When looking at a fish from the side, the fish seems to be in one place in the aquarium, but while looking from the top, it appears to be in a slightly different position. Also, plants near the corners of the aquarium look to be distorted. In these occurrences, light is *diffracted* both by the glass and the water. During the summer the black asphalt of the street will be hot, indicating that it has *absorbed* sunlight during the day.

Reflection occurs when light "bounces" off objects. How much light is reflected depends upon the surface that the light hits and how even the surface is. If the surface is smooth and flat, the light will "bounce" off it at equal angles. That is why a flat mirror reflects a good likeness of the object being reflected.

To represent what happens to light as it reflects off of a surface, one or more light rays are used. Reflection involves two rays—an incoming or *incident ray* and an outgoing or *reflected ray*. In the figure below, a single line illustrates a light ray reflected from the surface. The two rays are at identical angles but on opposite sides of the *normal*, which is an imaginary line (dashed) at a right angle to the mirror located at the point where the rays meet.

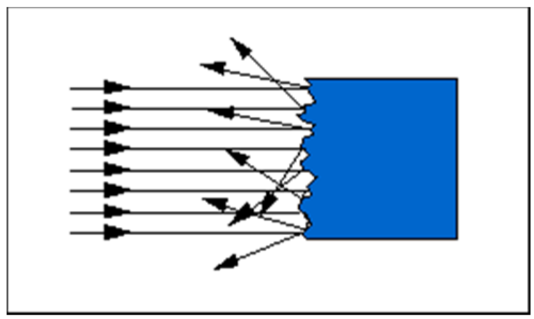


The *angle of incidence* (i) is the angle at which light strikes the object and the *angle of reflection* (i') is the angle at which light reflects off the object.

While the reflection of light is often discussed using a billiards ball analogy, it is better to describe light ray reflection as the turning back or bending of the ray when it encounters the edge of a medium.

If light strikes a rough surface, the light scatters. Almost all objects scatter light, which means they reflect the light that illuminates them in all directions. Below is an example of how light scatters.

Random reflection on a rough surface.

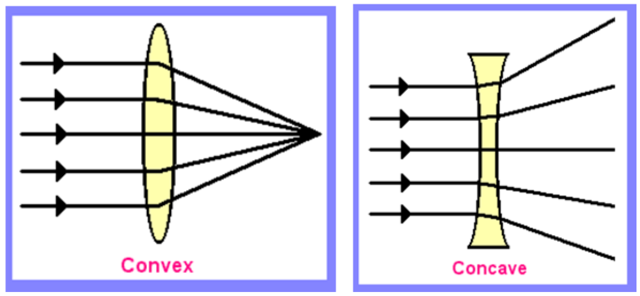


When light travels through one medium (e.g., air), it travels in a straight line. When light passes from one medium into a second medium, the light path bends. This is called *refraction*. Refraction occurs only at the boundary between two media. Once the light has crossed the boundary, it continues to travel in a straight line; however, now the direction of that line is different than it was in the former medium.

This visual distortion is witnessed if you look at a pencil submerged in a glass half-filled with water. As you observe part of a pencil above the water line through the side of the glass, light travels directly from the pencil to your eye. Because the light starts and finishes in air, the refraction into and out of the glass causes little deviation in the light's path. As you look at the portion of the pencil below the water, light travels from water to glass to air. This light ray changes media and refracts. As a result, the image of the pencil appears to be broken. These visual distortions are explained by the refraction of light.

Refraction also occurs if the surface of an object is curved, as with a lens. Notice the paths of light of the convex and concave lenses shown below.

Drawing of light rays being bent by glass.



These types of representations, where lines with arrows function as a way of modeling what happens to light as it encounters different kinds of materials, are called *geometrical optics*.

When we say we see an object, it is generally understood that the object is just present to us. The scientific theory of vision is that our eyes detect the light that is reflected and scattered from the object. The main function of the eye is to convert light from the outside world into electrical nerve impulses. These impulses then travel to the part of the brain responsible for vision, where they are interpreted as a visual scene. In the eye, light traverses through the tear film, cornea, anterior chamber, pupil, lens, and vitreous to the retina, which sends the nerve impulses through the optic nerve to the brain.

References

Andersen, B. (1990). Pupil's conception of matter and its transformations (age 12-16). *Studies in Science Education*, *18*, 53-85.

Driver, R., Squire, A., Rushworth, P., & Wood-Robinson, V. (1994). *Making sense of secondary science: Research into children's ideas.* New York, NY: Routledge.