An Eye on Optics

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Lesson Focus

The goal of this lesson is to provide students with an open-ended opportunity to explore and work with the materials, make and share observations, and build a foundational understanding of the relationship between gelatin shapes and light. Open-ended exploration encourages creativity and problem solving useful to meet the final challenge of designing a lens system to improve vision.

Age Levels

10 – 14

Objectives

Introduce students to:

- Light
- Lenses
- Assistive vision technologies

Anticipated Learner Outcomes

Students will be able to:

- Understand and apply knowledge of properties of light, lens shape to solve a problem related to human vision
- Use Lab Equipment (lights, lenses etc.) to design a solution to a problem
- Apply the scientific method and collect data to draw conclusions from evidence
- Develop and document a repeatable process

Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel/visiblelight_solarsystem/telescopesrev1.shtml

Optional Writing Activity

- What other applications do lenses have in our world?

For Teachers:
Teacher Resources

◆ **Time needed for Unit**
- ✦ Six 45-60 minute class periods

◆ **Materials**
Kits that include activity materials can be found at**:**
http://store.laserclassroom.com/gelatin-optics/

Introduction
- ✦ Student Worksheet 1: KWL Chart – SAVE for use again in Activity 5
- ✦ Normal, hyperopic and myopic eye diagrams/hand out
- ✦ Pair of eyeglasses

Activity 1
- Prepared Gelatin slabs (see recipe below)
- Set of Light Blox (http://store.laserclassroom.com/light-blox/) OR Laser Blox (http://store.laserclassroom.com/laser-blox/)
- Set of circular cookie cutters
- Plastic knife
- Student Worksheet #2: Materials and Experimental Set-up

Activity 2
- Prepared Gelatin shapes
  - o Molded convex lenses
  - o Molded concave lenses
  - o Square of gelatin (~ 3" X 3")
  - o Circle of Gelatin (~3" diameter)
- Set of Light Blox (http://store.laserclassroom.com/light-blox/) OR Laser Blox (http://store.laserclassroom.com/laser-blox/)
- Student Worksheet #3: Ray Tracing

Activity 3
- 1 Prepared Gelatin slab per team
- 1 Set of circular cookie cutters per team
- 1 Plastic knife per team

Activity 4
- 1 Prepared Gelatin slab per team
- 1 Set of circular cookie cutters per team
- 1 Plastic knife per team

Activity 5
- 1 Prepared Gelatin slab per team
- 1 Set of circular cookie cutters per team
- 1 Plastic knife per team
- Student Worksheet # 1

Activity 6

- 1 Prepared Gelatin slab per team
- 1 Set of circular cookie cutters per team
- 1 Plastic knife per team
- Eye Template
- KWL Chart for reference

Gelatin recipe:

The following recipe makes enough gel for about six large disks:

- 4 cups water
- 8 envelops of Knox Original Gelatin
- 1 container with dimensions of 9” x 7” x 2”

Boil water. Mix 4 cups of boiling water to 8 envelopes (or a ratio of 1:2 water to gelatin) of Knox Original Gelatin. For activity #2, pour mixture into lens mold trays.
For all other activities, pour mixture into container such that the depth of the liquid is at least 0.75 inches. Set gelatin in a refrigerator overnight to solidify.

Introducing the Challenge

1 Period (45-60 min)

Summary

This unit concludes with a design challenge, an open-ended project that encourages students to ask questions, take initiative, and think creatively. Engineering and design challenges provide context and meaning for employing the scientific process, developing technical knowledge and skills, and success in modern society.

To introduce this Design Challenge, students are presented with the goal of designing a system of lenses to improve the sight of a patient, students identify what they know and need to about the optics of lenses and the human eye to meet the challenge.

Background Skills and Knowledge

- Path of light from source (or object) to eyes (Optional Activity: Classroom Cave) http://laserclassroom.com/products/classroom-cave/
- Path of light into the Human Eye: Retina and focal point
- Optional Activity - Experiment with your own vision http://content.teachengineering.org/content/clem_/lessons/clem_waves_lessons/clem_waves_lesson05_worksheet.pdf

Set up for Activity

Set the stage for a brainstorming session about the structure and function of lenses and the human eye.

Hold up a pair of eyeglasses.

Ask volunteers to explain how glasses work to improve vision. Let students draw their ideas on the white board if it helps them express themselves more completely.

Explain to the class that this unit ends with a design challenge. Explain that pairs of students will design a system of lenses to improve vision for a patient. Explain that they will receive a model of a patient's eye, similar to the handout below, and will be tasked with designing a set of lenses to improve the patients' vision.

Explain that teams will need to explain their design decisions based on data they collect while designing and testing lenses.

Have a Class Discussion - ask students:

- How do eyeglasses work?
- How do glasses combine with the eye to improve vision?
- Are their different types of glasses? If so, how do they differ and why?
- How do you think doctors figure out what type of lens will improve vision?

Facilitating the Lesson

Project the images of a normal eye, a hyperopic, and a myopic eye on the screen and/or distribute a handout to teams with these images.

As a class, examine and discuss the differences between the images. Help students understand and note the following:

- Identify and understand basic functions the structures of the eye shown in the drawing

- Lens of the eye is identical throughout
- Distance from the lens to the retina is different from eye to eye
- Retina is located in the same place for all eyes
- Shape of each eye as a whole is different

Distribute the scenario challenge and Student Worksheet #1, KWL chart to students.
As a class, read and review the scenario.
Allow students complete the KWL in pairs.

Summary and Reflection
As a class, review the scenario and ask volunteers to share from their KWL graphic organizers, and assess students' understanding of the Design Challenge.

Ask students questions such as:
- How, in your own words, would you describe the design challenge you have been given?
- What do you think you need to know to design a system of lenses to improve vision?
- What do you already understand about the human eye and vision that will help you meet this challenge?
- What do you already understand about the nature of lenses that will help you meet this challenge?
- What do you think you need to learn to meet the design challenge?

Activity 1: Explore with light and gelatin

1 Period (45-60 min)

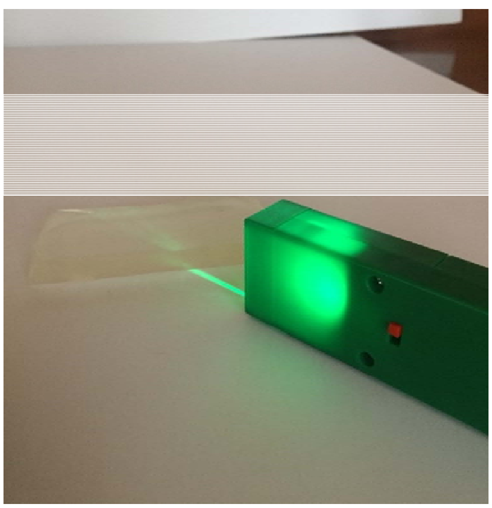
Summary

The goal of this lesson is for students to find and document the most effective way to observe and record the path of light as it leaves the light source and passes through and then out of the gelatin. Students will have an open-ended opportunity to explore and work with the materials, make and share observations, and build a foundational understanding of the relationship between gelatin shapes and light. This open-ended exploration encourages creativity and problem solving useful to meet the final challenge of designing a lens system to improve vision.

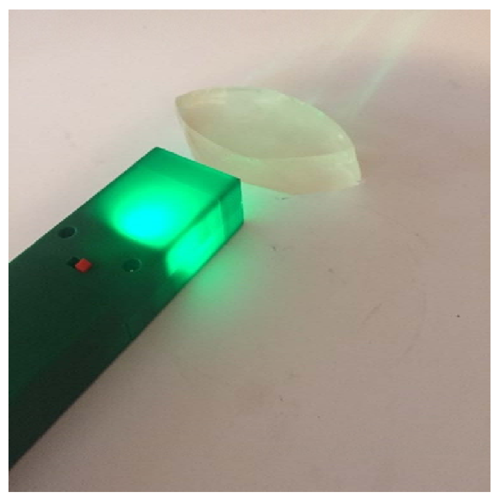
Learning Outcomes

As a result of this activity students will be able to

- Orient gelatin and lights to observe the path of light as it passes from the light source through a piece of gelatin
- Describe and document the path of light as it passes through gelatin
    - o With gelatin laid flat on the table
    - o With the gelatin is NOT laid flat on the table
    - o 1 beam with Light Blox sitting on its wider side
    - o 1 beam with Light Blox sitting on it's narrower side
    - o 3 beams at once



CORRECT Orientation



INCORRECT Orientation

Prior Knowledge and Skills

Prior to beginning Activity 1

- *students should have an understanding of the Design Challenge at the end of this Unit. See "Introduction – Design Challenge", above.*
- Introduce the overarching goal for the exploration activity: To find and document the most effective way to observe and record the path of light as it leaves the light source and passes through and then out of the gelatin.

Demonstrate/model how to measure and record the following:

- Show students a set of materials and demonstrate how to use cookie cutters and the plastic knife to create various shaped pieces of gelatin.
- Show students how to manipulate the shapes such that they shine the lights through each surface.
- Show students the two different ways to orient the lights passing through the gelatin

Facilitating the Activity

Encourage creativity, exploration, and documentation

- Model exploring and experimenting with the materials:

- Hand out the Student Worksheet #2 and model how to Record Observations: Demonstrate how to document:
    - o The size and shape of their piece of gelatin
    - o The orientation of the gelatin and the light(s)
    - o The entire path of the beam of light starting as it leaves the Light Blox as it passes through and then out of the gelatin

- Create teams and distribute resources. Make sure each team has access a “slab of gelatin” for cutting, cookie cutters, plastic knife, Light Blox (or other light source) , a sheet of paper, and recording materials.

- Dim the lights if safe and possible

- Circulate throughout the classroom to observe teams as students prepare and organize their equipment.

- Circulate throughout the room observing as students work. As teams work, observe their efforts to shine Light Blox through the gelatin, help individuals or teams that struggle with equipment management and set-up.

- As appropriate, engage students in discussion about their activities. Ask students open-ended questions about their effort to arrange equipment, cut shapes, orient lights, record what they observe, and how they make sense of their observations.

- If appropriate, halt class to share the work of one or more teams with other teams. Use such interruptions to highlight positive examples of exploration including but not limited to: creative design, methods to align lights, gelatin and screen, record keeping, and teamwork.

Throughout the period remind students to keep detailed records of their work to which they will refer it in the follow-up discussion.

Summarize and Reflect

Bring closure to the activity, encourage teams to share their work, and draw conclusions about the results.

- As a class discuss students’ findings
    - How best to orient gelatin and lights to observe the path of the light as it passes through the gelatin

- How the shape of the gelatin impacts the path of the light as it passes through the gelatin
- Recall that in the future you will design a system of lenses to improve human vision. What did you do and learn today that applies to this challenge?
- As a class, agree on a procedure for tracing the path of light as it leaves the light source, passes through the gelatin and then out of the gelatin.

What's going on? Refraction definition and reference to more information. Optional: Kinesthetic Refraction Activity
http://laserclassroom.com/products/kinesthetic-model-refraction/

Activity 2: Experiment with Lens Shape

1 Period (45-60 min)

Summary

Students use the scientific process to uncover the **qualitative** relationship between light and the shape (concave, convex, square, circle) of a lens.

Learning Outcomes

As a result of this activity students will be able to:

Record the path of a single beam of light as it passes from the light source through a one side of a lens to the other side of a piece of gelatin; and draw conclusions about how light travels through a piece of gelatin with a

- Flat/straight surface
- Curved surface
- Describe, demonstrate and record the path of light as it passes through both a convex and concave lens (using 3 lights)
- Identify and define: concave lens, convex lens incident ray, refracted ray

Prior Knowledge & Skills

Review at the beginning of the activity:

- How to orient gelatin and lights (from previous activity)
- How to record the path of light as it passes through gelatin (from previous activity)

Set up for the Activity

Set up 4 stations

1. 3 Light Blox and circle of gelatin
2. 3 Light Blox and square of gelatin
3. 3 lights and a molded convex lens
4. 3 lights and a molded concave lens

Prior to beginning the experiment: Explain the Scientific Process

- Encourage the systematic study of light and lenses. At each station have students document their observations, with a drawing, including appropriate labels (incident and refracted rays, concave or convex lens)
- The difference between independent and dependent variables
- Which variables are the independent and dependent variables at each station
  The dependent variable is lens shape – concave or convex
- Additional steps in the scientific process that you expect students to follow from stating a hypothesis to drawing conclusions.
- SCIENTIFIC PROCESS: https://nces.ed.gov/nceskids/help/user_guide/graph/variables.asp

Demonstrate/model how to measure and record the following:

- The position and distance from the light sources to the lens
- What happens to the path of light as the dependent variable, (the shape of the lens), changes.
- The behavior of light as it passes through a lens
- Review vocabulary as you demonstrate
  - Incident ray
  - Refracted ray
  - Concave lens
  - Convex lens
  - Focal Point

Facilitate the activity

- Hand out Student Worksheet #3
- Explain that in this activity students will use the scientific process to make more organized and concrete analyses of the effect of different types of lenses on the behavior of light. Explain to students that they will rotate through four stations. Explain that at each station they will pass light through one type of lens and record the behavior of the beams of light as they pass through the lenses.
- Instruct students to observe and record with drawings and labels, their observations at each station:
    - o Light Source
    - o Incident Ray
    - o Refracted Ray
    - o Concave lens
    - o Convex lens
    - o Focal point ***(no need to introduce focal length at this point, or discuss the relationship between focal point and vision unless it comes up)***
    - o Notes, conclusions, other observations
- Divide students into pairs. Assign pairs to stations.
- Set expectations for time spent at each station and number of arrangements of the lights and the lens you expect students to measure and record at each station.
- Circulate throughout the room as teams work to observe their efforts. Help teams to set-up their equipment, identify the dependent and independent variables, and to measure, record, and draw their results.
- As appropriate, discuss with students their experimental set-up, their methods of measuring the position of the light, the angle of the beam of light entering and passing through the lens, and which variables they will keep constant when they move to the next station and the next lens.
- If opportunity arises to highlight student efforts, hold a class discussion about some of the observations you have made. Have students explain to their peers their experimental set-up, methods for measuring and recording results, and plans to keep their work consistent from station to station.
- Keep an eye on the time. Give students enough time to rearrange and measure their lights at least two or three times before moving to another station.
- Give a “pre-warning” about 5 minutes before students should rotate to the next station. Tell them to complete their work at the current station.
- With 1-2 minutes remaining, have students clean up and restore the station to the way it was when they found it (or better). If time permits, rotate to another station. If not, explain students will pick-up where they left off the next period.

Summarize and Reflect

Bring closure to the activity, encourage teams to share their work, and draw conclusions about the results.

- Discuss and share results and conclusions as a class
    - o Square vs. circle
    - o Concave lenses produce a focal point in front of the lens
    - o Convex lenses produce a focal point in back of the lens
    - o The distance from the center of the lens to the focal point is called the focal length
    - o Address vocabulary

Activity 3: Create your own lenses - Design and Document

1 Period (45-60 min)

Summary

Students engage in directed exploration and use what they have learned so far, to document a process for how to reliably create/design concave and convex lenses of different sizes (widths).

Learning Outcomes

As a result of this activity students will be able to:

- Describe, demonstrate and record how to cut both a concave and a convex lens out of gelatin with a circle cookie cutter.
- Draw conclusions from evidence about how the path of light behaves when a *dependent variable (lens shape, size, distance from light source)* changes.

Prior to the activity, introduce, discuss or review

- Concave and convex lenses
- How to document a repeatable process. http://www.wikihow.com/Document-a-Process

Facilitate the Activity

We strongly suggest that you take this class period to allow students a set amount of time (15-20 minutes) to struggle after you've shown them the shapes they are to create and given them their materials, rather than show students explicitly how to create the shapes. Once they have figured out how to create both a concave and a convex lens, they will document the process they used.

This challenge lays the foundation for understanding something basic, but not intuitive about these kinds of lenses – that they are derived from circles; and the more advanced understanding of the math that describes the properties of lenses relies on that understanding. This simple hands-on activity gives students an experiential, intuitive experience of the relationship between concave/convex lenses and circles.

- Introduce the challenge for today: Document a process for how to cut a convex and a concave lens
    - o Concave: 2 -3 different sizes
    - o Convex: 2-3 different sizes
- Give each pair of students a set of round cookie cutters and a ~9" X 7" slab of gelatin.
- Allow 15-20 minutes for teams of students to experiment with cutting out lens shapes, focusing on documenting a repeatable and reliable process for using round cookie cutters to design concave and convex lenses.
- Circulate throughout the room as teams work to observe their efforts. Help teams to set-up their equipment if necessary.

Summarize and Reflect

- Stop students after 15-20 minutes to hold a class discussion about students' work. Have students explain to their peers their experimental set-up, and methods for documenting the process.
- As a class, write up (document) the process based on students' findings and input.

Activity 4: Experiment with Lens Size (width)

1 Period (45-60 min)

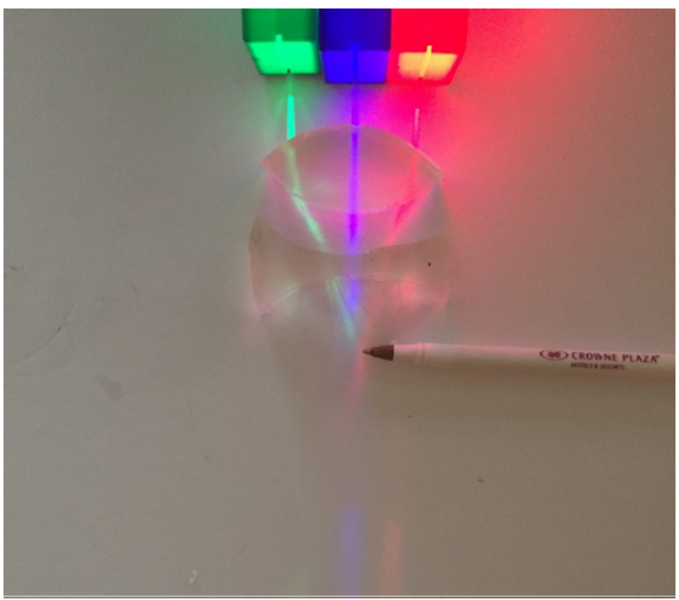
Summary

Using the process documented in the last class period, students engage in the scientific process to collect and record data and reach a conclusion about the impact of the dependent variable (width of lens) on the focal length. *This is qualitative. The focal length gets longer or shorter, for example.*

Understanding how the size (width) of the lens and the distance from the light source to the lens impacts focal length will help students to design a system of lenses to improve vision when they engage the final challenge.

Students will:

- Design:
  - Concave: 2 -3 different widths
  - Convex: 2-3 different widths
- Record: Beam path AND approximate focal length
  - Concave lenses: 2 -3 different widths
  - Convex lenses: 2-3 different widths
- Conclude the qualitative relationship between the width of a lens and the focal length
- Terminology and concepts:
  - Light Source
  - Focal Length – how does changing the width of the lens impact focal length?



Prior to the activity, introduce, discuss or review

- The difference between independent and dependent variables
- Which variables are the independent and dependent variables in today's activity –
  - The width of the lens AND distance of light source from the lens are the dependent variables that impact the result: focal length

- The definition of focal length and ***briefly***, its relationship to vision.
  - The light source = the object (light bouncing from the object into the eye)
  - The light that enters the eye needs to focus directly on the retina for a clear image to form.
- If you prefer to introduce more math or go into focal length in more detail, Khan Academy offers excellent overview for your reference:
  - Convex: https://www.khanacademy.org/science/physics/geometric-optics/lenses/v/convex-lenses
  - Concave: https://www.khanacademy.org/science/physics/geometric-optics/lenses/v/concave-lenses

Demonstrate/model how to observe, measure and record

- How to determine the approximate focal length of both a concave and a convex lens
- What happens to the behavior (path) of light as the dependent variable, (the width of the lens), changes.
- Review or introduce vocabulary as you demonstrate
  - Incident ray
  - Refracted ray
  - Concave lens
  - Convex lens
  - Focal Length

Facilitate the Activity:

Encourage systematic experimentation with light and lenses

- Introduce the goal of the activity for today:
  - Collect data and draw conclusions about the impact of the size (width) of the lens on the focal length
  - Collect data and draw conclusions about the impact of the distance from the light source to the lens on the focal length
- Give each pair of students a set of materials:
  - Set of round cookie cutters
  - 9” X 13” slab of gelatin
  - Set of three Light Blox
- Give students instructions to
  - Design 3 ***convex*** lenses with varying widths
  - Measure and record the width of each lens and it’s corresponding focal length
- Give students instructions to
  - Design 3 ***concave*** lenses with varying widths
  - Measure and record the width of each lens and it’s corresponding focal length
- Give students instructions to
  - Measure and record how the focal length changes as the distance between the light source and the lens changes.
- Once teams have recorded their measurements and observations draw the activity to a close.
- Give students time to wrap up their work, completing data tables and drawings as needed.
- Set time aside to clean up.

Summary and Reflection

Ask teams to share their results. Hold a class discussion in which teams/individuals explain what they did, what they observed, and what sense they make of the results. Depending upon your approach you may want to use one of several active learning strategies or invite volunteers to draw or demonstrate their work at the front of the class.

- Using student results, including drawings and data tables, compare the difference between passing a light though each type of lens.
- As a class discuss questions such as:
  - What happens to the focal length as the width of the lens increases or decreases?
  - Is it the same for concave as for convex?
  - Do the results differ with the distance from the light to the lens?
  - What did you learn about convex and concave lenses that will help you with the final challenge?
- As a class discuss the outcomes of the experiment. Questions to address include but are not limited to:
  - How does the focal point change as the lens becomes smaller/larger?
  - What evidence supports these conclusions?
  - How do the results differ between concave and convex lenses?
  - How does understanding the relationship between lens shape and size and focal point help with the final challenge of designing a lens system to improve vision?
  - If students made a prediction about focal point and lens size, how did their prediction compare to the results? Were any results surprising?
  - In the final activity you will be challenged to create a system of lenses designed to improve vision. What did you learn about lenses and focal point that will help you meet the challenge?
  - Recall the images of the eye (normal, near, and far sighted). On which part of the diagram would you want the light to focus?

Activity 5: Experiment with 2 lens systems

1 Period (45-60 min)

Summary
As their final activity in preparation for the Design Challenge, students explore the behavior of light as it passes through various combinations of lens pairs. In the final challenge, students receive a diagram of a patient's eye. One lens in the system will represent the lens found in the eye. Students will need to design one or more gelatin lenses to correct or improve the vision of their patient. The combination of lenses and their alignment need to focus light on the retina in the diagram of the patient's eye.

Fill out the last part of the KWL chart FIRST.

Learning outcomes
As a result of this lesson, students will be able to:

- Describe, demonstrate and record the impact of a system of two lenses on the path of light and focal length
    - o 2 convex lenses
    - o 2 concave lenses
    - o 1 concave and 1 convex lens
- Describe the role of lenses in various instruments used to enhance vision or focus images
    - o Camera
    - o Telescope
    - o Microscope
    - o Magnifying glass
- Describe the role of lenses in human vision
    - o The human eye contains a convex lens
    - o Clear human vision relies on the ability to focus light specifically on the retina
    - o Myopia and hyperopia as common vision problems
- Predict how various lenses might enhance human vision when myopia or hyperopia are present.

OPTIONAL MATH
https://www.khanacademy.org/science/physics/geometric-optics/lenses/v/multiple-lens-systems

Set the stage for experimenting with multiple lenses.

As a class, make a list of various instruments that use two or more lenses. If students suggest that the eye combined with eyeglasses is a lens system, explain that in the final lesson they will specifically address this combination. For now focus on instruments such s telescopes, microscopes, and binoculars.

Ask students to explain how they think the various instruments work and the relationships between the lenses and the lenses and light.

Explain that in this activity students will explore combinations of lenses on the behavior of light. Explain that they will pass a beam of light through two lenses to observe and record the results.

As a class discuss the many variables in the experiment, which to change, and which to keep the same. Some variables students should recognize include:

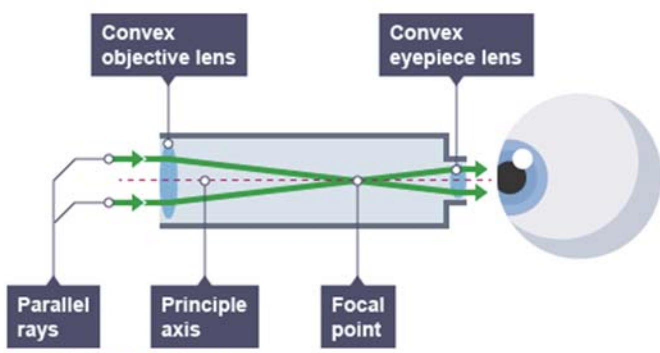
- Distance between lenses
- Combination of lens types to create pairs of lenses
- Position and distance of light source to lenses

Facilitate the Activity

Explain that in this activity students need to keep careful records of their work. Depending on the time available, have all teams work with all combinations of lenses or break the class into "expert groups" and assign them the responsibility of reporting back to the class on the system they explored.

Teams should experiment with all or some of the following lens combinations:
Convex + Convex
Concave + Concave
Convex + Concave

- Fill out the last part of the KWL chart FIRST
- Have students plan their experiment, draw their set-up, and make a data table in which to record results. Alternatively, draw the equipment set-up on the board and distribute a data table to each team.
- Once teams demonstrate an appropriate plan for their experiments provide them with gelatin and tools.
- Make sure that students explore the effect of lens combinations AND the effect of changing the distance between lenses.
    - Draw attention to the effects of different lens combinations on the behavior of light.
    - Draw attention to the effects of changing the distance between lenses on the behavior of light.
- Circulate throughout the room to observe students. As appropriate engage teams in a discussion of their experimental procedures, measurements, observations, and results. Help them to connect their methods to their outcomes.
- (Optional) Have students create "ray diagrams" for lenses such as the one shown here.



A simple optical telescope

Summary and Reflection

Bring closure to the experiments students performed. As a class, review the behavior of light as it passes through various pairs of lenses and the effect of changing the distance between pairs of lenses.

- If needed, allow students time to review and complete work from the previous step in the lesson before presenting.
- Have teams share their results. Encourage students to refer to drawings and data to explain their observations and conclusions.
- As a class, discuss questions such as:
  - What happens to the focal point as you move one lens closer to or further from the other? Does it depend on which combination of lenses you are using?
  - What happens to the focal point of two convex lenses
  - What happens to the focal point of two concave lenses?
  - What happens to various combinations of different lenses?
  - How does working with two (or more) lenses apply to the final challenge of designing a system of lenses to improve a patient's vision?
  - Which combinations of lenses do you think will improve vision for a nearsighted patient?
  - Which combination of lenses do you think will improve vision for a farsighted patient?

OPTIONAL

- Experiment with additional combinations of lenses.
- Research designs of various instruments that use lenses like telescopes, lasers, microscopes, and binoculars.

The Challenge:
Design a 2-lens system to correct a vision problem

1 Period (45-60 min)

Summary
This activity is focused on taking students through a process to create a lens system that corrects a vision problem. The goal of the activity lesson is not to design the perfect lens, but to understand what goes into solving a problem with the engineering process. Allow plenty of time and some structured boundaries to allow discovery to motivate exploration!

Materials and Equipment

1. Set of Light Blox
2. Set of Molded Lenses – one concave and one convex
3. Slab of gelatin
4. Plastic knife
5. Cookie Cutters
6. Eye Template
7. Completed KWL Chart

Prior Knowledge & Skills

1. Light travels in a straight line until it strikes an object or travels from one medium to another
2. Everything we see is the result of light entering our eyes; most of that light is reflected
3. When light passes from one medium to another (ie: through a lens), the light is bent or refracted
4. The shape and material of the lens effects how the light bends
5. The eye contains a lens that focus' light on the retina. Clear vision depends on the ability of the eye's lens to bend the light that enters the eye so that the image forms specifically on the retina

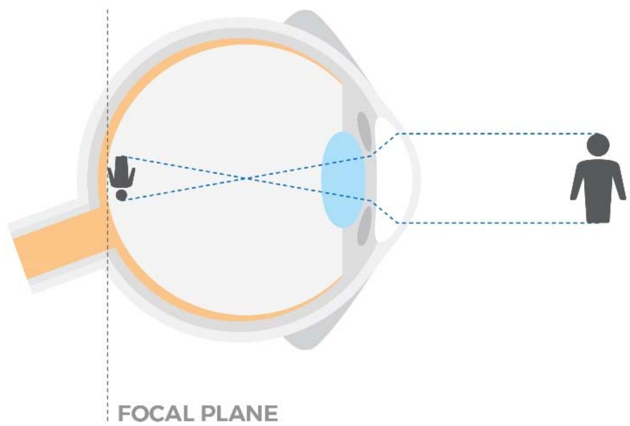
Facilitate the Activity:

1. Review and refer to students' KWL chart
2. Hand out one set of Light Blox with the slit caps ON, and two molded gelatin lenses (one convex and one concave) to each group of 3 students.
3. Show students how to turn on the lights and give them 3-5 minutes to explore how the light moves through the lenses.
4. Hand out the template of an eye with "normal" vision. Have students place the molded convex lens "in" the eye to see that the light comes to a focal point ON the retina. Seeing clearly depends on the focal point landing in a specific place in the eye, called a retina.
5. Next, have students place the molded convex lens on the template of a hyperopic eye that needs vision correction because the light lands in the wrong spot. Notice where the focal point is. This does not create good vision!

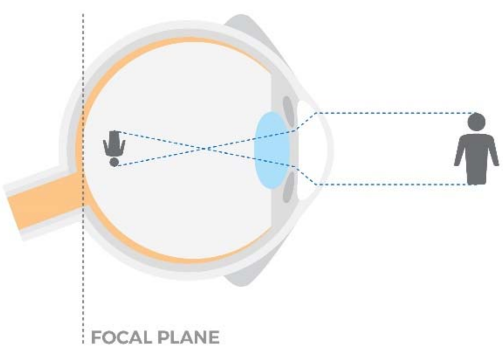
6. Ask them to define the problem and speculate a solution... What might “move” the focal point to another location. At this point, allow students some time with both the concave and the convex lenses together so that they can discover that the concave lens moves the focal point.
7. Next, give each group a square (~ 4” X 8”) of prepared, double strength plain gelatin and 3 round cookie cutters of various diameters.
8. Explain that with this gelatin, they will create a SECOND lens, to correct the vision problem. The materials and tools available to them are the gelatin, knife and cookie cutters!
9. Ask students first to practice creating concave and convex lenses with their cookie cutters and gelatin.
10. Next ask students to construct lenses using cookie cutters, the plastic knife and gelatin, that will correct the vision problems demonstrated on the templates.
11. As students create, test and improve their lens design, they are engaging in the essentials of the engineering process using lenses and light.
12. The goal is to allow students to understand that light can be manipulated with lenses -- and that by doing this, they can solve problems. It will be challenging to get the lens just right. For more advanced students, you can introduce focal length, radius of curvature and index of refraction as mathematical methods of creating solutions rather than the “trial and error” approach that they are using.

Teacher Resource:
Eye Diagrams

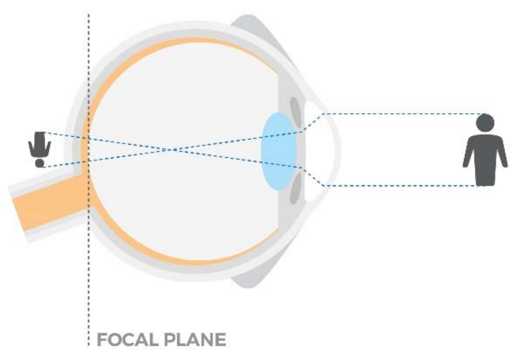
NORMAL VISION

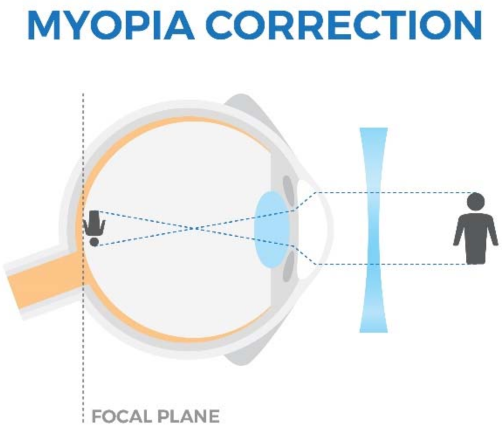


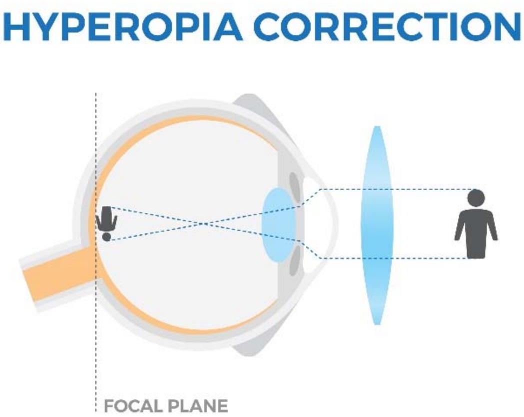
MYOPIA



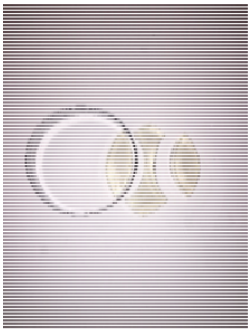
HYPEROPIA



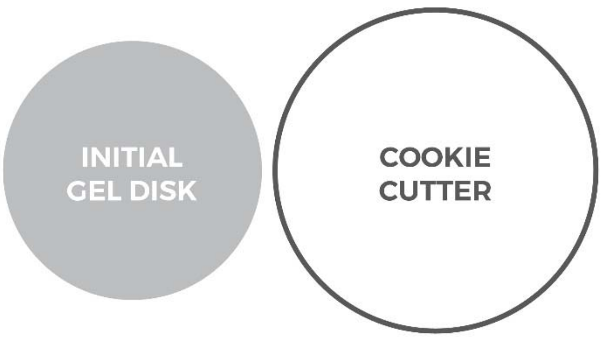

MYOPIA CORRECTION
FOCAL PLANE


HYPEROPIA CORRECTION
FOCAL PLANE

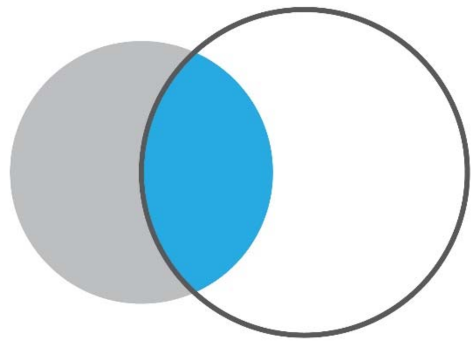
Teacher Resource:
How to cut out Gel Lenses



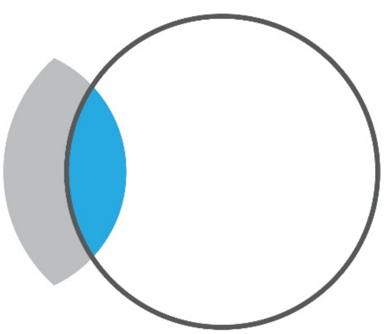
STEP 1 Use a cookie cutter and a disk of gel to make successively smaller lenses.



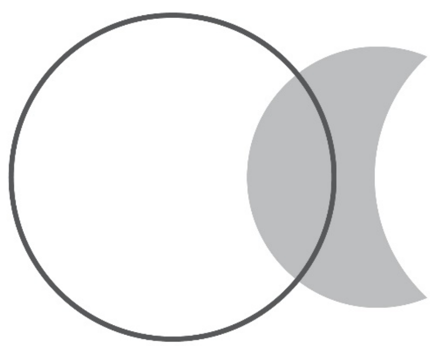
STEP 2 Cut the gel disk to make a large convex lens. Save the rest of the gel to create the concave lens.



STEP 3 Cut the large lens to make a smaller convex lens.



STEP 4 Cut the gel you saved earlier to create a large concave lens.



An Eye on Optics

Student Worksheet #1:KWL Chart

Student Name **Date**

Nurses, doctors, and engineers work together to design and build eyeglasses and other tools that improve vision. In this challenge you will design a system of lenses to improve a patient's vision.

What do you need to know about the human eye and lenses to help improve someone's vision?

Use the KWL graphic organizer below to list what you know, want to know and learned to design eyeglasses to improve someone's vision

What I **Know** about Eyes and Lenses	What I **Want** to Know about Eyes and Lenses	What I **Learned** about Eyes and Lenses

An Eye on Optics

Student Worksheet 2:Materials and Experimental Set-up

Student Name **Date**

To complete the design challenge at the end of this unit, you will need ot know how to orient gelatin and lights to observe the path of light as it passes from the light source through a piece of gelatin

Using words and/or drawings, describe and document the path of light as it passes through gelatin:

- With gelatin laid flat on the table
- With the gelatin is NOT laid flat on the table
- 1 beam with Light Blox sitting on its wider side
- 1 beam with Light Blox sitting on it's narrower side
- 3 beams at once

An Eye on Optics

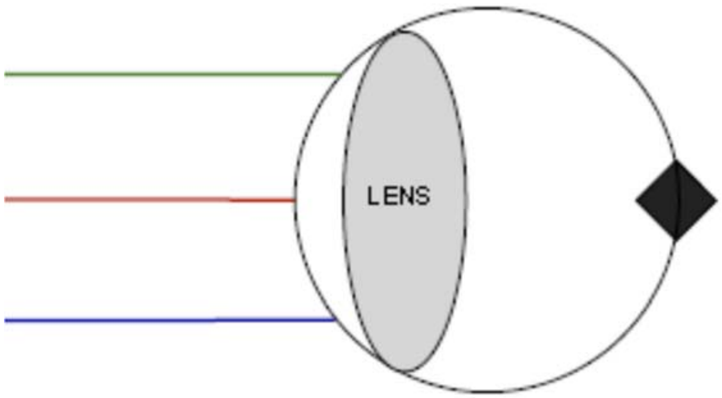
Student Worksheet 3: Ray Tracing

Using words and drawings, record the path of a single beam of light as it passes from the light source through a one side of a lens to the other side of a piece of gelatin; and draw conclusions about how light travels through a piece of gelatin with a

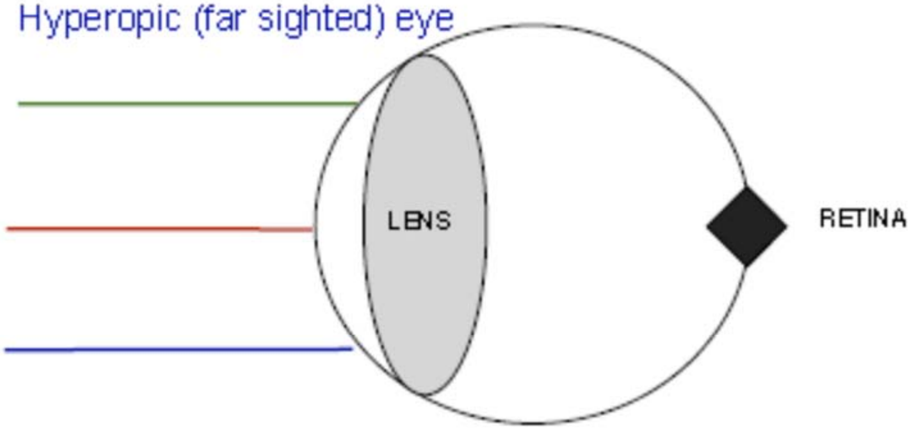
- Flat/straight surface
- Curved surface
- Describe, demonstrate and record the path of light as it passes through both a convex and concave lens (using 3 lights)
- Identify and define: concave lens, convex lens incident ray, refracted ray

Student Worksheet 4: Eye Template

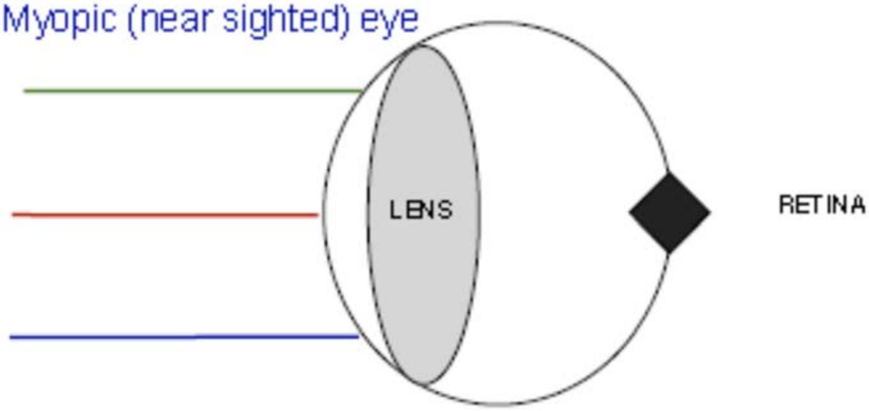
Normal Eye



Hyperopic (far sighted) eye



Myopic (near sighted) eye



An Eye on Optics

Teacher Resource:
Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the Computer Science Teachers Association K-12 Computer Science Standards, the U.S. Common Core State Standards for Mathematics, and if applicable also to the National Council of Teachers of Mathematics' Principles and Standards for School Mathematics, the International Technology Education Association's Standards for Technological Literacy, and the U.S. National Science Education Standards which were produced by the National Research Council.

Disciplinary Core Ideas

- PS4.B: Electromagnetic Radiation
  - The path of light 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 between media. (MS-PS4-2)
- ETS1.A: Defining and delimiting Engineering Problems
  - The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (MS-ETS1-1)
- ETS1.B: Developing Possible Solutions
  - A solution needs to be tested, and then modified on the basis of the test results in order to improve it. MS-ETS-4)

Science and Engineering Practices

- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)
- Develop and use a model to describe phenomena (MS-PS4-2)
- Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)

Crosscutting Concepts

- Structure and Function
  - Structures can be designed to serve particular functions by taking into account properties of different materials and how materials can be shaped and used (MS-PSR-2)
  - Structures can be designed to serve particular functions