IMHOTEP'S LEGACY ACADEMY

9.7 Telescopes: More Than Meets the Eye

Grade 9 Activity Plan

Reviews and Updates

9.7 Telescopes: More Than Meets the Eye

Objectives:

1. To compare the propagation of light through air to the propagation of light through water.
2. To understand incident and refracted rays, and calculate the refractive index of an acrylic block.
3. To understand how different lenses manipulate and focus light, and apply this knowledge to build a telescope.

Key words/concepts: properties of visible light, lens, refraction, refractive index, vacuum, light (luminescent and incandescent) focal length, focal point/plane, magnification, rays, and beams

Curriculum outcomes: 209-3.

Take-home product: a telescope

Segment	Details
African Proverb and Cultural Relevance (5 min.)	"Knowledge is like a garden; if it is not cultivated it cannot be harvested." **Ghana**
Pre-Test (10 min.)	Have students observe the distortion as they look at a pencil in a beaker filled with water. Ask thought provoking questions on students' observation.
Background (10 min.)	Introduce the topic of refraction and associated concepts such as light in a vacuum, lenses, refractive indices, etc., using as many real life examples as possible.
Activity 1 (25 min.)	Illustrate the rectilinear propagation of light and refractive indices.
Activity 2 (30 min.)	Ensure that students are able to identify different types of lenses, and encourage them to apply their knowledge in making their telescopes.
Post-test (10 min.)	Encourage students to spot objects in the room that cannot be seen with the normal eye. The winner is the one who finds things others cannot see even with their periscopes

Suggested interpretation of proverb: if one does not apply the knowledge one acquires, it is of no use; knowledge put into practise exposes one to even more knowledge. Motivate students to always apply acquired knowledge, and in the activity, the application of their knowledge will help them see things at distances that cannot be seen by the ordinary eye.

Cultural Relevance

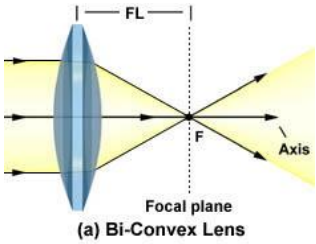
Name: Benjamin Benneker
Position: Mathematician, Inventor, Surveyor, Philosopher and Abolitionist

The word telescope was derived from the Greek word tele "far" and skope "to look or see". This was an instrument used most often by Benjamin Banneker. An African American who was born in 1731 in Maryland, US (died in 1806). As a young boy he spent many of his nights staring at skies and that's how his nickname came about "the stargazer". He was also a Mathematician, Inventor, Surveyor, Philosopher, and an Abolitionist who fought against the system that kept his people in bondage.

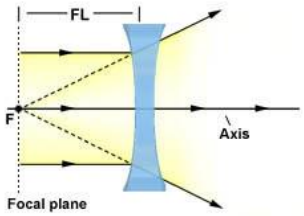
Background Information

Light is a range of frequencies of electromagnetic waves that stimulates the retina of the eye. Light is also a particles which is why is can travel through a **vacuum.** Packets of light are called **photons**.

Refraction is the process of light bending when it passes through a different medium.
A **lens** is a transparent substance with curved edges that bends/refracts light.
A **convex lens** bends the light towards a single point called the **focal point**. This is a **converging** lens.
A **concave lens** bends the light rays away from each other. This is a **diverging** len
The **focal point** of the converging lens is the point where the light rays converge. The focal point of the diverging lens is also known as the **intersection point** s.. This is where the light rays originally intersected.



(a) Bi-Convex Lens



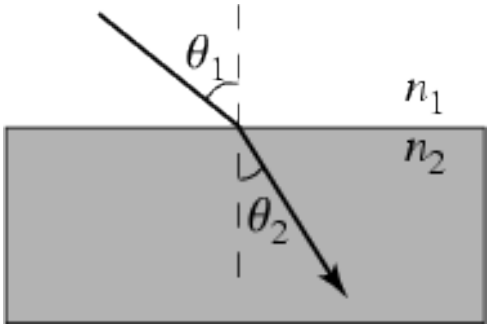
(b) Bi-Concave Lens

Figure 1

The **focal length** is the distance from the center of the lens to the focal point

The amount of refraction is determined by the type of substance the light passes through and the angle at which it hits the substance.
This can be seen in **Snell's law**.

$$n_1 \sin\theta_1 = n_2 \sin\theta_2,$$



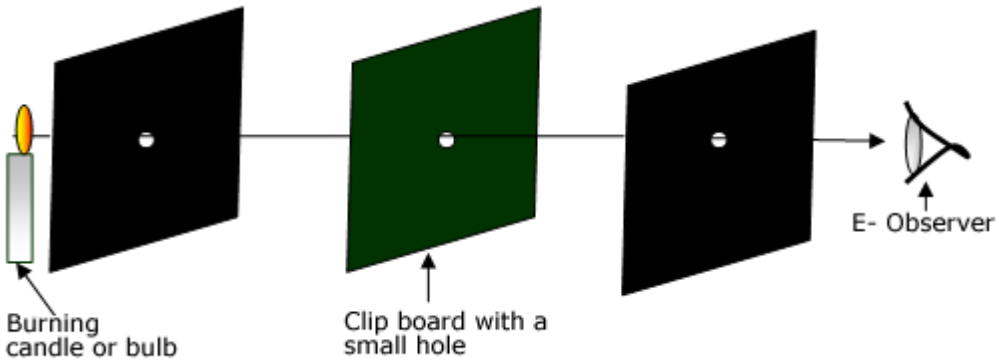
Activity 1a: Rectilinear propagation of Light

Purpose: To compare the propagation of light through air to the propagation of light through water.

Suggested format: make students form groups of two.

Item	Quantity (10 students)
Bristol board	3
Masking tape	1
Candle sticks	5
Hole punch	1
Beaker	1
Pencil	1

Note: Bristol board should be cut into squares of equal sizes about 15cmx15cm, 3 squares for each group of student. Each 3-card-collection should be perforated.



http://www.elateafrica.org/elate/physics/propagation/method1.png

Procedure:

1. Cut Bristol board to 6 (two for each card) pieces of dimensions 2cm x 8cm.
2. Fold them; make stands out of the pieces by slitting them in the middle.
3. Make the square cards stand about 15cm apart such that the holes are in line with each other.
4. Light a candle, place it at one end and look through the hole on square at the other end. Observe.
5. Nudge any of the squares to the left or right to observe the obstruction.

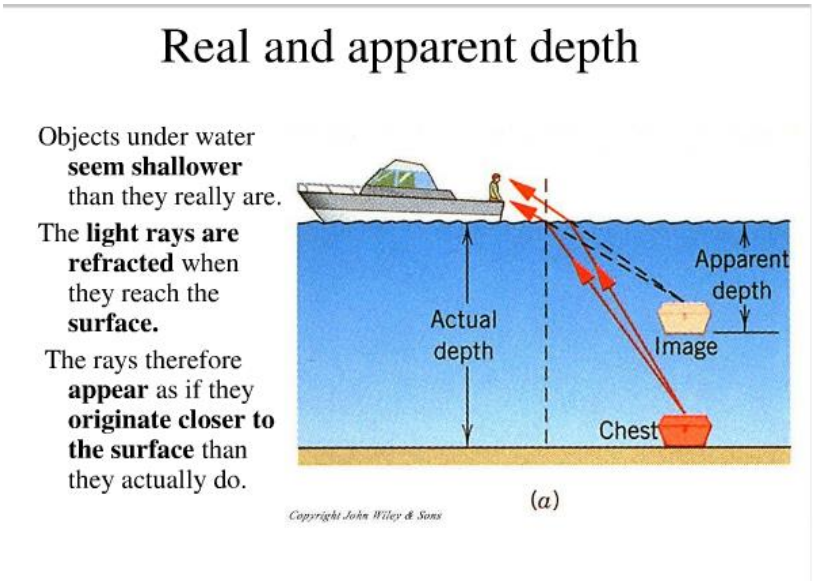
6. Fill a beaker with water.
7. Drop a pencil in the beaker at an angle.
8. Observe how the pencil looks bent. Hypothesize with students why this is happening.

Activity 1b: Refraction and Refractive Indices

Source: http://www.youtube.com/watch?v=plZocHWpFhk

Purpose: To understand incident and refracted rays and calculate the refractive index of an acrylic block

Suggested format: assemble all students; show them the diagram and Youtube video below; ask them to find the refractive index of the glass/acrylic block and allow them to share responsibilities.



The above image was culled from
http://www.slideshare.net/kwarne/grade-10-light

Item	Quantity (one setup only)
Acrylic block	1
Laser pointer	1
Pencil	1
White cardboard	1
Ruler	1
Protractor	1

Procedure:

1. Cut the white card board into two.
2. Set up the acrylic block on one half of the card board as shown in the video above.
3. Trace the outline of the block and turn the laser pointer on so it goes through the block. Mark where the laser meets the block, and leaves it.
4. Draw a normal at the incident end using the protractor.
5. Measure the angles incidence and refraction, and proceed to calculating the refractive index.

Activity 2: Knowing Your Lenses and Building a Telescope

Purpose: To understand how different lenses manipulate and focus light, and apply this knowledge to build a telescope

Suggested format: make student form groups of two, but encourage them to come up with individual opinions and discuss them with each other as each student would build their own telescope.

> *Note: It is recommended that mentor creates a telescope beforehand and do all cutting of gaskets and boards for students.*

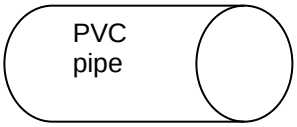
Item	**Quantity (10 Students)**
Large Diameter Biconvex Lens (7.5 cm D)	10
Small Diameter Biconcave Lens (3.8 cm D)	10
Small Diameter Biconvex Lens (3.8 cm D)	10
Plastic Ruler (12 inch)	10
Cardboard (for gaskets holding Lenses) 10cm x 10cm piece	20
Black Bristol board (Stiff Card Paper large Sheets)	4
PVC piping of similar diameter to large lens (~9cm)	10 feet
Masking Tape	2 rolls
Glue	2 bottles

Procedure:

1. Hand out a biconvex lens and a biconcave lens to each student (while they are still in groups), help them discover, observe and discuss the features of the lenses as they fill out the tables below. Bring everyone together to discuss the findings.

2. This should have them thinking about how they will make their telescope. Encourage students to ask any questions they may have about the effects of lenses. They should feel comfortable about the features of each type of lens and what they can see when they look through two lenses at once.

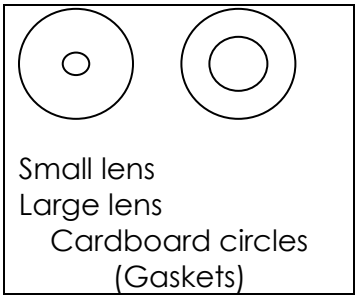
3. Use a black PVC pipe as the tube for the telescope. This will need to be cut to length before arriving at the school to do the activity. Use the sketches below to further aid with assembling a telescope.



Observations:

Single Lens	Lens 1	Lens 2	
Biconcave or Biconvex?			
Diameter			
Focal Length			
Comment on the image of a far away object (size, orientation, clarity)			
Comment on the image of a nearby object (size, orientation, clarity)			
Combining Lenses		Lens 1 as Objective	Lens 2 as Objective
Comment on the image of a far away object (size, orientation, clarity)			
Comment on the image of a nearby object (size, orientation, clarity)			

4. Cut two pieces of cardboard to fit the inner diameter of the pipe.



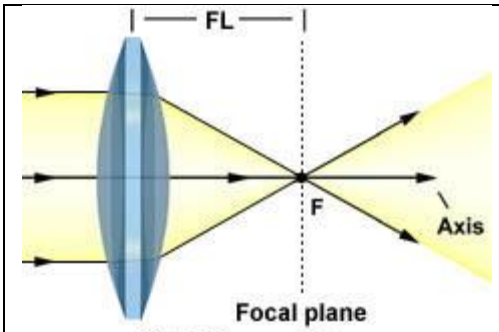
5. Now cut the center of each circle; one should be the circumference of the large lens, the other piece of cardboard should have an inner circle the circumference of the small lens.

6. Roll some stiff black paper (Bristol board) to fit in the PVC pipe and tape it into shape. (This should be the end holding the gasket and smaller lens, but you can let the students figure that out themselves).This Bristol board will function as the sliding portion of the telescope, also called the drawtube. This allows the telescope to be adjusted to find the focal point.

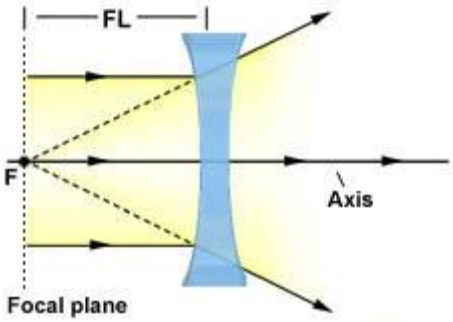
7. Glue the gaskets in place. Again, the smaller lens and gasket should be glued to the end of the Bristol board. The larger lens and its appropriate gasket should be glued to the end of the PVC pipe.

These diagrams of a telescope show the black Bristol board is rolled to fit inside the PVC pipe. The view on the left shows the gasket and larger lens are glued in the end of the PVC pipe. The view on the right shows the smaller gasket and lens are glued in the end of the Bristol board. The Bristol board tube is inserted (but not glued or taped) so it can still slide in and out of the PVC pipe to adjust the focal point of the telescope.

A more curved lens will have a shorter focal length and will be a more powerful lens.



(a) Bi-Convex Lens



(b) Bi-Concave Lens

Figure 1

Convex	Concave
Parallel lines of light enter from the left side of the biconvex lens. The rays of light are bent at a greater angle around the edges than through the middle (the rays through the middle are barely affected). "F" signifies the focal point. The focal length is the distance from the middle of the lens to the focal point. Convex lens always has a positive focal length.	Parallel lines of light enter the biconcave lens. As light leaves the lens, it is bent significantly more at the edges than the centre. Imagine this light continuing to travel around the globe; these rays would not reconvene until they were behind the lens (where they started). "F" in the diagram is the focal point. The focal length would have a negative measurement.

Useful links:

- http://amasci.com/amateur/teles.html
- http://www.life.illinois.edu/boast1/sciencelessons/telescopes.htm
- http://www.globio.org/glossopedia/article.aspx?art_id=50
  Simple information about fibre optics.
- http://micro.magnet.fsu.edu/optics/lightandcolor/lenses.html
  The images of convex and concave lenses in the lesson plan are taken from this site. It also outlines different types of more complex lenses
- http://www.physicsclassroom.com/class/refrn/u14l5a.cfm
  This page explains how prisms can be combined to form convex and concave lenses. It uses most terms explained in the lesson plan. Note: the terms converging and diverging lenses are used instead of concave and convex