Optics I

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Links to the folder with today’s materials

November 2024 Optics I Workshop

Please rename yourself

First name

College or High school

Country

Eugenia University USA

Materials

A completely dark room

A frosted bulb (a regular LED bulb connected to a power supply or a wall)

A laser pointer

Water spray bottle with water

Aluminum foil

A straight stick (a meter stick will work)

A transparent rectangular container with water

A mirror and a protractor

A coin

What we will do today

Today we focus on how students construct the following ideas through the ISLE process:

I. What is needed for us to see objects?
II. How does light travel in air?
III. What models do we use when we study light?
IV. How do extended objects emit light?
V. How does light travel when it encounters a different medium?

Idea1: What is needed for us to see objects?

Need to know

https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-22-1-6

OALG 22.1.1 (homework)

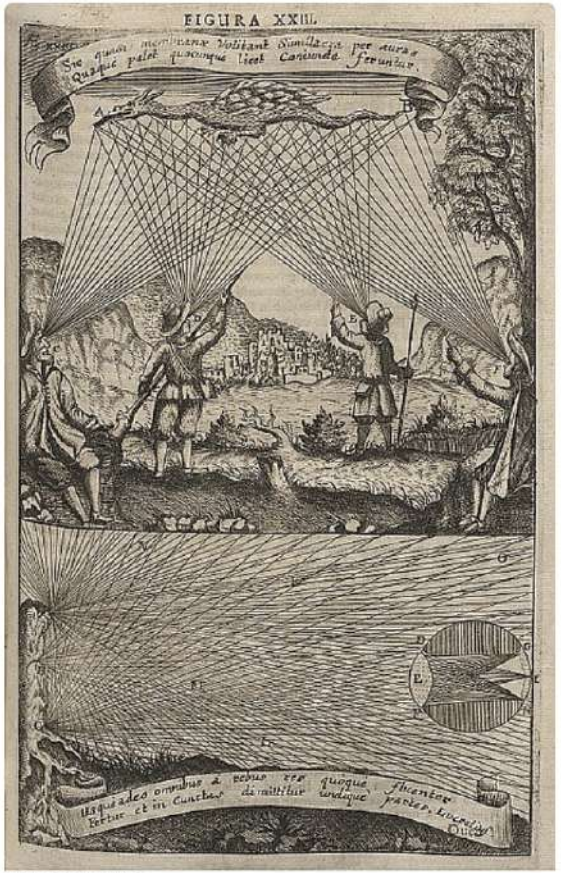
OALG 22.1.1 Observe and explain

Go into a room that is completely isolated from all external light sources—natural and artificial. Turn off the internal lights and wait in the dark room for several minutes. Record your observations and propose an explanation.

Historical model of how we can physically see with our eyes

The eye has been the subject of conflicting interpretations since antiquity. Many ancient physicians and philosophers believed in the idea of the active eye. Plato, for instance, wrote in the fourth century B. C. that light emanated from the eye, seizing objects with its rays. More metaphorically, Aristotle's disciple, Theophrastus, wrote that the eye had "the fire within." In saying this, he departed from the ideas of his teacher, since Aristotle was among the first to reject the extramission theory of vision. "In general, it is unreasonable to suppose that seeing occurs by something issuing from the eye," he declared. Aristotle advocated for a theory of intromission by which the eye received rays rather than directed them outward.

Source:
http://web.stanford.edu/class/history13/earlysciencelab/body/eyespages/eye.html



Quelle: Deutsche Fotothek

Illustration from System der visuellen Wahrnehmung beim Menschen (1687) depicting emission theory.

Idea II: How does light travel in air?
Idea III: What models do we use when we study light?

TEAM 1 - OALG 22.1.2

OALG 22.1.2 Observe and explain

Equipment: laser pointer and a spray bottle or chalk dust.
Take a laser pointer and point it at a wall. Can you see the beam of light it sends or only the shiny spot on the wall?

a. What path did the light follow to reach the wall? You can find it by trial and error - by trying to block the light with a small piece of paper at several locations along its path to the wall, or by using the water spray bottle.

b. What can you say about the path of the light from the laser to the wall? Represent that light path by a long line with an arrow, called a ray. A ray is not real; it is just a way to show the direction that light is traveling.

c. Explain why the water droplets (or chalk dust) makes it possible to see the light beam that was previously not visible.

d. Discuss the conditions needed for us to see something.

Video alternate if you can't find the equipment:
https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-experiment-video-51

TEAM 2 - OALG 22.1.2

OALG 22.1.2 Observe and explain

Equipment: laser pointer and a spray bottle or chalk dust.
Take a laser pointer and point it at a wall. Can you see the beam of light it sends or only the shiny spot on the wall?

a. What path did the light follow to reach the wall? You can find it by trial and error - by trying to block the light with a small piece of paper at several locations along its path to the wall, or by using the water spray bottle.

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d. Discuss the conditions needed for us to see something.

Video alternate if you can't find the equipment:
https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-experiment-video-51

What did we learn? and What is missing?

Time for telling

We see objects when light bounces off them.

Laser beam travels in a straight line in air.

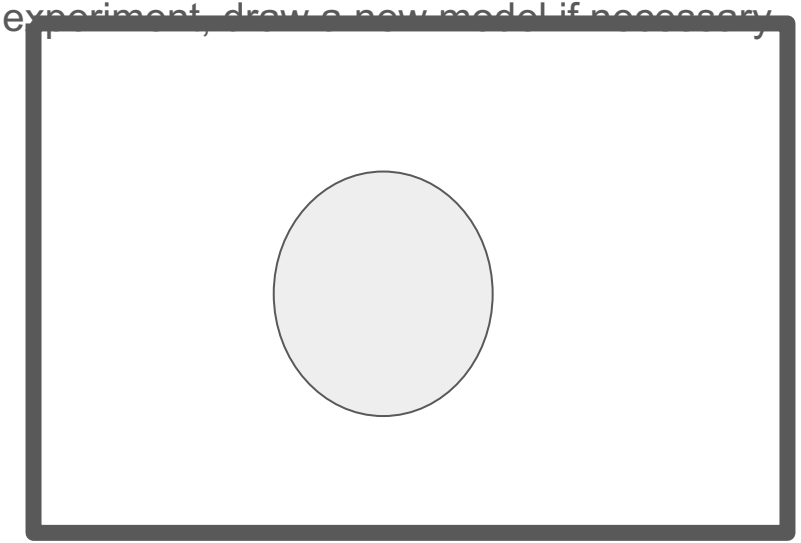
Light ray is a model of how light travels - straight line with an arrow

Idea IV: How do extended objects emit light?

Modified OALG 22.1.3

Place a powered, frosted light bulb on a table in the center of a dark room and observe that the walls are almost uniformly lit. https://youtu.be/mx8JQBxqBMk

Draw a ray diagram in your notes that illustrates how the frosted bulb (shown below with the walls and the ceiling) lights the room. Then think of an experiment that you can conduct to test your hypothesis. If you have the materials, run the experiment and report the outcome. After the experiment, draw a new model if necessary.



TEAM 1 - Modified OALG 22.1.3

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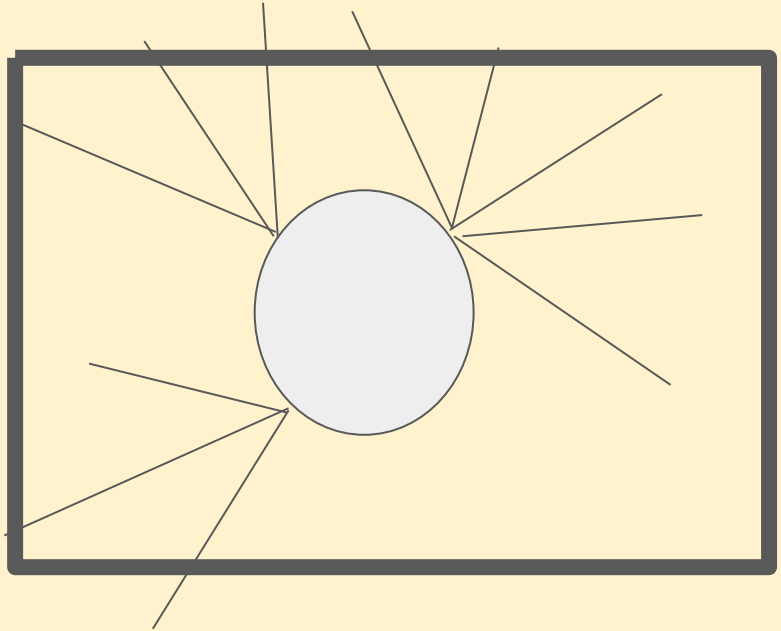
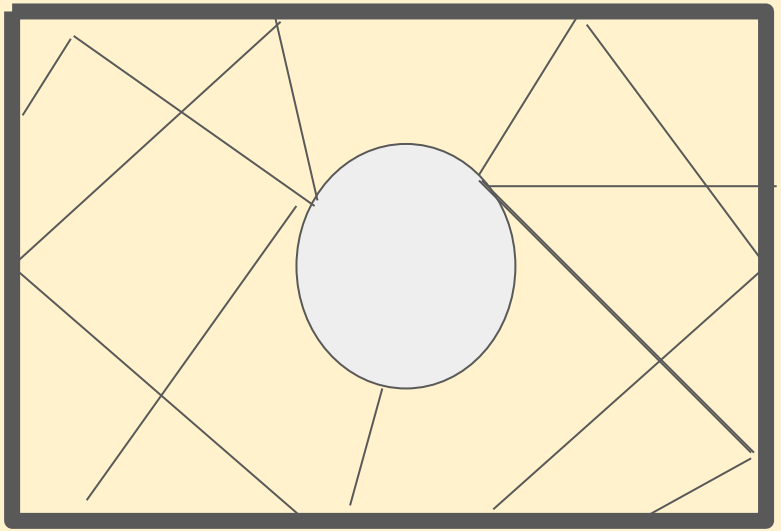


TEAM 2 - Modified OALG 22.1.3

Place a powered, frosted light bulb on a table in the center of a dark room and observe that the walls are almost uniformly lit. Draw a ray diagram in your notes that illustrates how the frosted bulb (shown below with the walls and the ceiling) lights the room. Then think of an experiment that you can conduct to test your hypothesis. If you have the materials, run the experiment and report the outcome. After the experiment, draw a new model if necessary.



Variation with more scaffolding ALG 22.1.3

Tovi (a.) and Jaeline (b.) draw two ray diagrams to try to model how a light bulb's light can reach the walls and the ceiling in the room.

a. b.

a. Compare and contrast the two diagrams. Consider how each point of the bulb emits light according to each diagram.

b. Design an experiment to test which of the diagrams represents the way a light bulb emits light—does each point emit one ray, or does each point emit rays in all directions? Describe the experiment with a picture and write a prediction of the outcome of the experiment based on each diagram.

c. Perform the experiment and decide which diagram led to the prediction that did not match the outcome. Which diagram will you use to represent how each point of the bulb emits light?

OALG 22.1.3 part d

d. Watch two experiments at https://mediaplayer.pearsoncmg.com/assets/_frames.true/secs-experiment-video-52. Which model predicts their outcomes? Draw ray diagrams to support your answer.

What did we learn? and what is missing?

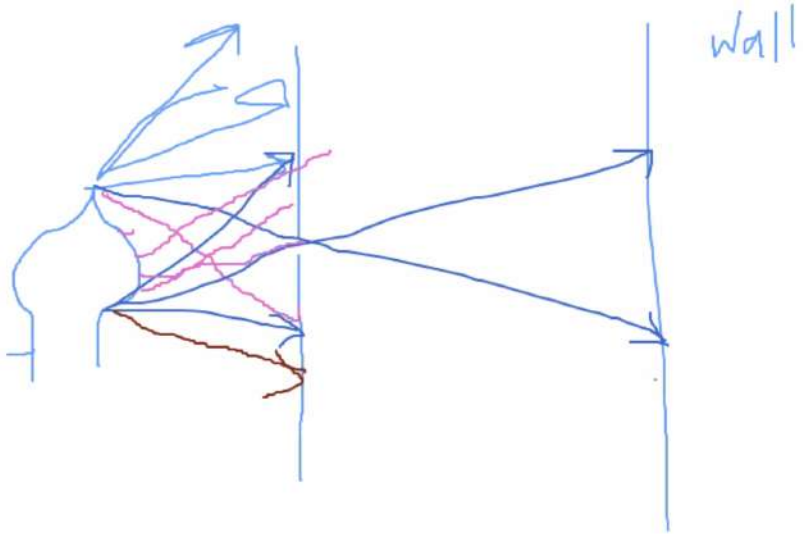
Connection to the Need to know

In extended light sources each point emits multiple rays

What happens when light reaches the wall?

Return to the Need to Know OALG 22.1.4 (All together)

In the “Need to know” we put a candle on a table and placed a piece of thin cardboard between the candle and a nearby wall. Draw a ray diagram to predict what we should see on the wall if you make a tiny hole in the cardboard.



Return to the Need to Know OALG 22.1.4 (All together)

Then light the candle and turn off the room lights to observe the outcome of the experiment(s). If you do not have the equipment, use the video at https://mediaplayer.pearsoncmg.com/assets/_frames.true/sci-OALG-22-1-6. Make sure that you examine the image on the screen carefully. The candle flame is narrow on top and wide at the bottom. What do you see on the screen?

Then revise your diagram if necessary.

Idea V: How does light travel when it encounters a different medium?

All together

OALG Chapter 22 Final.docx

Activity OALG 22.2.1

Team 1

OALG 22.2.2 Test your idea

Imagine that you have two vertical mirrors on a flat surface so that their faces make a right angle. Use any of the relationships that you found in Activity 22.2.1 to draw a ray diagram to predict what will happen to a laser beam incident on one of the mirrors. Once you made the prediction, watch the following video http://islephysics.net/pt3/experiment.php?topicid=12&exptid=176 and decide whether your prediction matched the outcome. If it did not, how do you need to revise the ray diagram?

Team 2

OALG 22.2.2 Test your idea

Imagine that you have two vertical mirrors on a flat surface so that their faces make a right angle. Use any of the relationships that you found in Activity 22.2.1 to draw a ray diagram to predict what will happen to a laser beam incident on one of the mirrors. Once you made the prediction, watch the following video http://islephysics.net/pt3/experiment.php?topicid=12&exptid=176 and decide whether your prediction matched the outcome. If it did not, how do you need to revise the ray diagram?

All together

In Activity 22.1.2 you learned that you only see an object if emitted or reflected light travels from the object to your eye. In Activity 22.2.1 you learned that when a laser beam is reflected off a smooth surface, the incident beam and the reflected beam are at the same angles relative to a line perpendicular to the surface. Imagine that a laser beam hits a wall. If you stand at any place in the room, you see a bright spot on the wall where the laser beam hits it. How can you reconcile these two phenomena? *Hint:* Examine the surface of the wall and compare it to the mirror.

Team 1

Watch the experiment in video
https://youtu.be/6kvb89hLZLQ There you see a mirror with its right side scratched and the left side smooth. In the first part of the experiment a source of light shines on the mirror perpendicular to its surface. In the second part of the experiment the light shines at an angle so that the reflection is seen on the wall.
(a) Describe carefully what you observe in both experiments.

(b) Explain your observations.

The scratched part of the mirror scatters light in all directions compared to unscratched part of the mirror, the latter observes the specular law

Team 2

Watch the experiment in video
https://youtu.be/6kvb89hLZLQ There you see a mirror with its right side scratched and the left side smooth. In the first part of the experiment a source of light shines on the mirror perpendicular to its surface. In the second part of the experiment the light shines at an angle so that the reflection is seen on the wall.

(a) Describe carefully what you observe in both experiments.
In the first experiment the scratched part od the mirror is brighter
In the second experiment there is a shadow on the wall on one part of the bright spot. We suppose that scratch part makes shadow.

(b) Explain your observations.
In the first experiment, the scratched part reflects the light in all directions, so we can perceive the light coming to our eyes, the flat part of the mirror is dark.

All together OALG 22.3.1

OALG Chapter 22 Final.docx

Team 1 OALG 22.3.2

Team 2 OALG 22.3.2

Team 1 OALG 22.3.4

Team 2 OALG 22.3.4

Team 1

In video https://youtu.be/PXShvpZUQ2E you see how difficult it is to reach an object under water with a stick, but the laser beam does it without any problem. Explain why it is easy to do it with the laser beam but difficult or impossible with a stick.

Team 2

In video https://youtu.be/PXShvpZUQ2E you see how difficult it is to reach an object under water with a stick, but the laser beam does it without any problem. Explain why it is easy to do it with the laser beam but difficult or impossible with a stick.

The stick can not bend. It follows the same path as light (reflected from the coin) in the air but not in the water.

All together
Back to idea III: Models of light

OALG 22.7.1 Explain

In the previous activities you found that light reflects and refracts (bends) as it travels between different media. One explanation that scientists formulated hundreds of years ago to explain this observed phenomenon was a “particle-bullet model” of light. They thought that an object that radiates light emits tiny particles, like little bullets, that travel in all directions. Use this model to explain the following.

a. How does light travel in straight lines in the same medium?

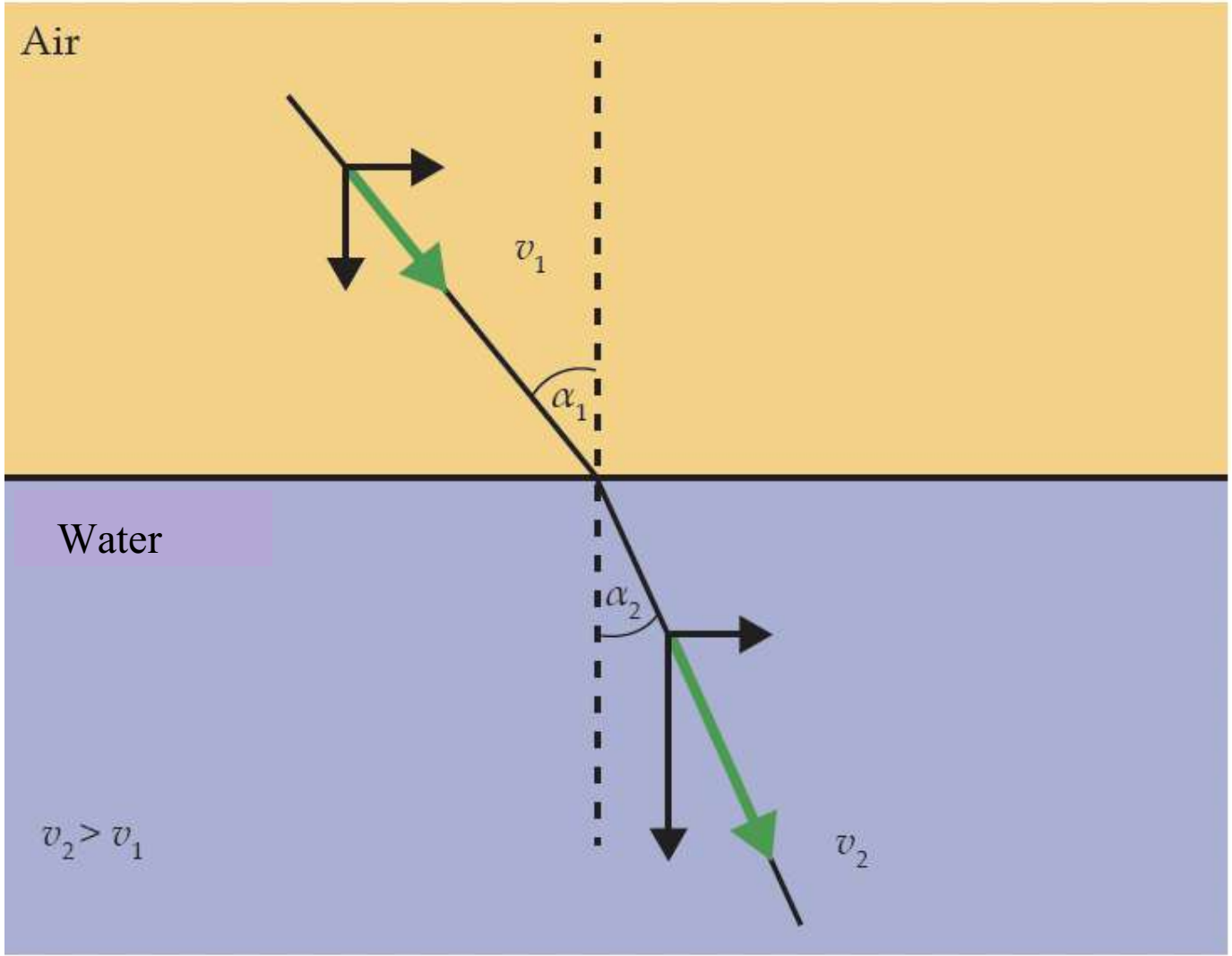
b. How does light form shadows if it encounters obstacles?

c. How does the angle of incidence equal the angle of reflection?

d. How does light bend when passing from one medium into another, different medium?

e. Light bends toward the normal line when it travels from air into any other medium. What do you need to assume about the components of velocity parallel to the surface and perpendicular to the surface of a light particle as it passes from air to the second medium?

How does particle model of light explain refraction?



Team 1 prediction

Length of the box shorter in water than in air

40 cm in air. Less in water

Team 2 prediction

The distance should be larger for the measurement in the air, and it should be shorter for the measurement in the water because the “bullets” travel faster in the water.

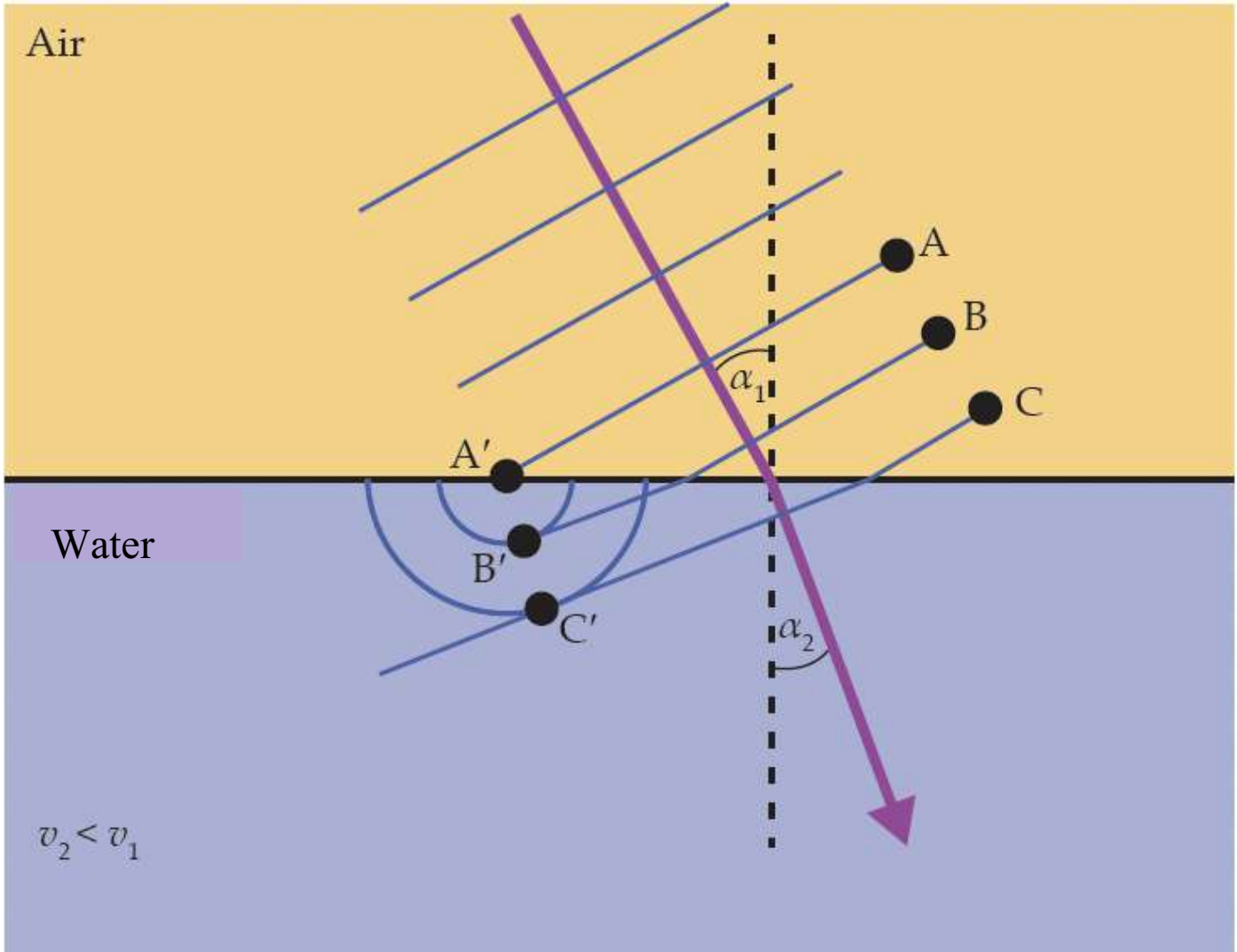
Team 1

Observe the experiment at https://youtu.be/mcCMGmb2tik and explain what is happening. Then, use the data in the experiment to compare qualitatively and quantitatively the speed of light in air and in plexiglass.

Team 2

Observe the experiment at https://youtu.be/mcCMGmb2tik and explain what is happening. Then, use the data in the experiment to compare qualitatively and quantitatively the speed of light in air and in plexiglass.

How does the wave model of light explain refraction?



What did you learn today and how did you learn it?

I have never incorporated an experiment that refutes the hypothesis on purpose. It is a wonderful experience as we build understanding of the power finding what doesn't work is just as important as finding what doesn't.

The importance of calling ideas coming from students' intuition as 'wild ideas'.

These new experiments are very exciting. Hoping for using them very soon in classroom activities.

The emphasis of staying away from having students make predictions as guesses based on their intuition, but rather have them make a hypothesis that can tested and disproved.

I learned that laser distance meter can be used to measure speed of light in transparent media and this is a simple and affordable way to bring optical physics into classroom and home. I learned how students can rule out corpuscular nature of light.

I liked the new part on diffuse light that is linked to students difficulties. We can always improve.

Never paid so much attention that is so important for students to be clear with fact that one point of the source emits multiple rays of light.