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Session Plan

In this session plan, I present an introduction to optics. This could be used in a high school or undergraduate physics class or in an undergraduate optics class. This lesson introduces both basic concepts in optics and basic components of optical systems. Optics are very expensive to purchase and therefore most students are not given the opportunity to learn optics in an inquiry way. Instead, students are shown ray tracing diagrams and have textbooks that describe what different optical components do. In this session plan, I aim to allow students to try out different optical components to understand concepts in optics. Because optics are pricey, in this lesson students will use optics made out of gelatin that the teacher will make ahead of time. In addition, this lesson presents connections with real life optics, thus trying to make the students aware that optics are a part of their everyday life as well as a part of modern science.

The optics lesson plan incorporates all four stages of the learning cycle. The invitation to optics is presented as a pre-write with broad questions. In this pre-write, the students are asked to make connections with their experiences by asking them how they use optics in their everyday life. In addition, the pre-write aims to uncover the students' knowledge of the subject by asking: What questions do you have about light and optics?

Five different optics concepts are presented in this session plan. Throughout these concepts different stages of the learning cycle are used. Some of the concepts are introduced using the exploration stage of the learning cycle. The five optics concepts are presented using the concept introduction stage of the learning cycle. Some of the concepts presented include the application stage. The entire session ends with the application stage. The lesson concludes by asking the students to use some of the vocabulary they have learned and to apply what they have learned to a common everyday item (eyeglasses) and to other branches of science.

Questioning strategies are used throughout the session. The warm-up uses broad questions. The warm-up is also used to uncover misconceptions by asking what the students want to know about light and optics. Broad questions are used throughout the session and especially in the final application stage to get the students to make connections with optics and the real world. Focused questions are used in this session to emphasize new vocabulary. For example, the students are asked to explain the difference between convergence and divergence. During the concept introduction, questions are used to guide the students through the optics hands-on inquiries. Questions are presented several times throughout the session on worksheets.

Assessment is carried out by both questioning and by worksheets. The worksheets help to guide the students and often ask the students to predict an outcome and then to test their predictions.

The parts of the session that I will present in our class are the pre-write, concept 1: Reflection versus Refraction, and Concept 3: Convergence and Divergence.

Introduction to Optics

1) Goal

Understand fundamental concepts in optics by exploring the use of basic optical components (lenses, filters, light, lasers, and mirrors).

2) Materials

- Circle cookie cutter
- Sharp knife
- Knox gelatin
- Petri dishes
- Watch glasses
- Rulers (1 per group)
- Laser pointers (1 per group)
- Mirrors (3 per group)
- Flashlights (1 per group)
- Food coloring (red, blue, yellow)
- Paper with typed words (different size fonts)
- Blank white paper

3) Pre-lesson Preparation for the teacher

a) Prepare gelatin

i) All gelatin should be made using 1/3 of the water suggested on the packet to make it stiffer and should be Knox brand which is less sticky and is colorless. The gelatin will need to be left in a refrigerator to harden for at least 4 hours.

b) Plano-concave and plano-convex lenses

i) To make plano-convex lenses, pour gelatin into a watch glass. To make plano-concave lenses, pour the gelatin into a Petri dish. Then add a watch glass on top of it, convex side to the gelatin.

ii) Allow the gelatin to harden in a refrigerator.

iii) Remove the watch glasses and Petri dishes from the gelatin.

c) Concave and Convex lenses

i) Make the gelatin in a deep square shaped tub.

ii) After the gelatin has hardened, use the cookie cutter and knife to cut out both concave and convex lenses about 1" high and to cut out 1" squares of gelatin (see photo below). (Each group will need 1 of each).

d) Colored Filters

i) Pour liquid gelatin into three different bowls. Add a few drops of food coloring (red, yellow, blue) into each bowl. Only 1 color per bowl!

ii) Pour the colored gelatin into Petri dishes. Each group will need 1 Petri dish of each color.

iii) Once the gelatin has hardened, remove the gelatin from the Petri dishes.

4) *Invitation*: Warm-up: (to be completed prior to lesson)

- How do you use optics in your everyday life?
- What questions do you have about light and optics?

5) Class Rules

a) We are going to be using laser pointers today. Do not stare into the lasers or shine them into anyone's eyes.

b) You will be working in groups. The teacher will assign you to a group.

6) Concept 1: Reflection versus Refraction

a) Background information for the teacher:

i) Reflection is the change in direction of light as it bounces off an opaque material, like a mirror.

ii) Refraction is the bending of light as it passes into a transparent material. To bend, light must strike a surface at an angle. Refraction is caused by the change in speed experienced by the light when it changes medium.

b) *Exploration*

i) Divide the class into groups. (2-3 students per group)

ii) Tell the class that their group will have 3 minutes to come up with a list of things that reflect and refract light. They can be optical components or everyday items.

iii) Give each group a worksheet

iv) After 3 minutes, ask the class to name things that reflect and refract light and write them on the board.

c) *Concept Introduction*

i) Give each group a laser pointer and a gelatin cube.

ii) First we will investigate refraction. Using your Refraction vs. Reflection worksheet, put the gelatin cube in the printed square. Now use your laser pointer to see what happens when the laser beam enters the gelatin at the three different angles marked.

iii) Now we will investigate reflection. Hand out three mirrors to each group. Challenge the group to find ways to shine the laser beam into one mirror and have it reflect off the other two mirrors and shine into the gelatin cube.

d) *Application*: Wrap-up

i) Assessment: Ask the students:

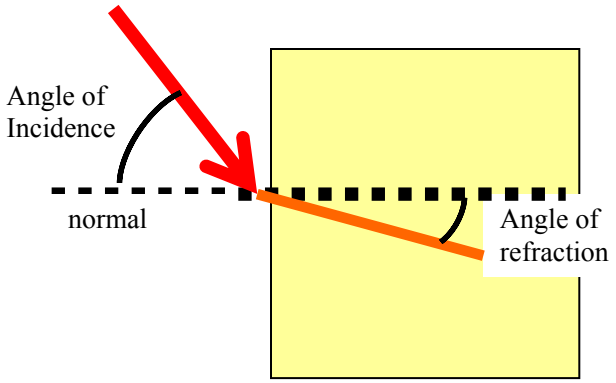
(1) What does refraction mean?

(2) What do you think is happening to the laser light when it hits the gelatin?

(3) What does reflection mean?

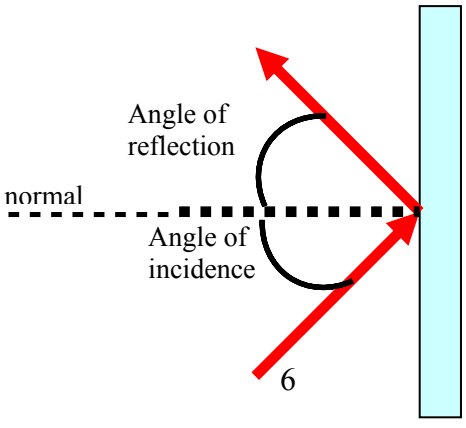
ii) Discussion of concepts

(1) The teacher should now draw on the board a gelatin cube. The teacher will then explain the angle of incidence & angle of refraction.



(1) The teacher will explain to the students: If light passes from a medium in which it travels slowly into a medium in which it travels faster, then the light will refract away from the normal. If light passes from a medium in which it travels fast into a medium in which it travels slower, then the light will refract towards the normal. And then ask: Which one happened with the gelatin?

(2) The teacher draws a mirror on the board a mirror. The teacher will then explain the angle of reflection. (The law of reflection states that when a ray of light reflects off a surface, the angle of incidence is equal to the angle of reflection.)

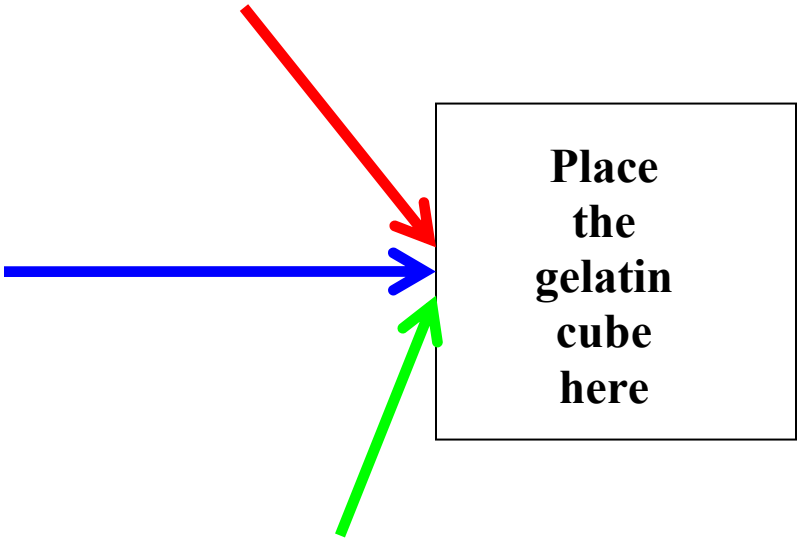


Refraction vs. Reflection Group Worksheet

(1) Make a list of things that you think reflect light and refract light.

Things that Reflect Light	Things that Refract Light

(2) **Put your laser pointer on a colored line.**



What happens to the laser light when it enters the gelatin if

- **the laser light starts on the red line?**
- **the laser light starts on the blue line?**
- **the laser light starts on the green line?**

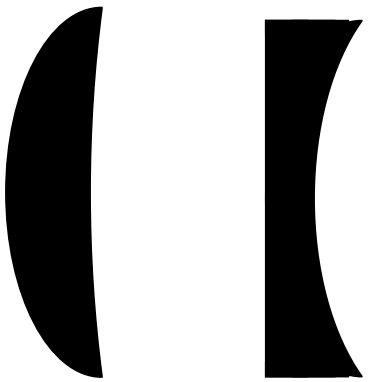
7) **Concept 2: Magnification and Demagnification**

a. Exploration

i. The teacher will draw the 2 shapes shown below on the board.

ii. Identify to the class which one is plano-convex and which one is plano-concave.

iii. Tell the students that an easy way to remember is the concave shape is like a cave.



iv. Ask the class to predict which one will act as a magnifier and which will act as a demagnifier. Take a vote, tally it up, and write it on the board.

b. Concept Introduction

i. Tell the students you will now give each group one of each type of lens (gelatin lenses) and a piece of paper with typed words. They will now need to figure out which lens magnifies and which one demagnifies.

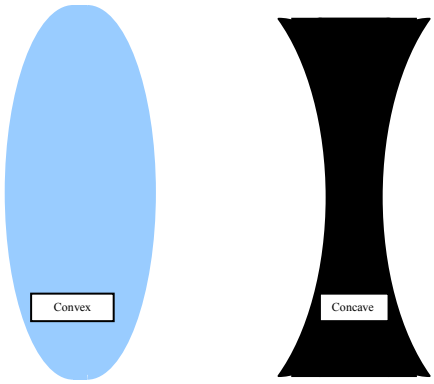
ii. Now ask the class to say which one acts as a magnifier and which acts as a demagnifier. Again, tally up the votes and write it on the board.

iii. Ask the students again which lens is plano-concave and which is plano-convex to make sure that they know the vocabulary.

8) **Concept 3: Convergence and Divergence**

a. Concept Introduction:

i. Tell the students they will work in their groups to predict what will happen to light traveling through a concave and a convex lens. (Note to teacher: here are drawings of the two types!)



ii. Give each group a worksheet.

iii. Give each group a gelatin concave lens and a gelatin convex lens.

iv. Tell the students to put the lenses flat on the paper. Then use the laser pointer to shine light through the lenses. This works best if the room is darkened.

v. Tell the students to complete the observations section of the worksheet.

b. *Application:* Discussion:

i. What does convergence mean?

ii. What does divergence mean?

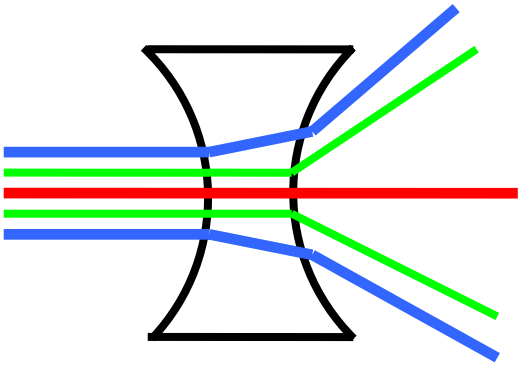
iii. Which lens made the light converge?

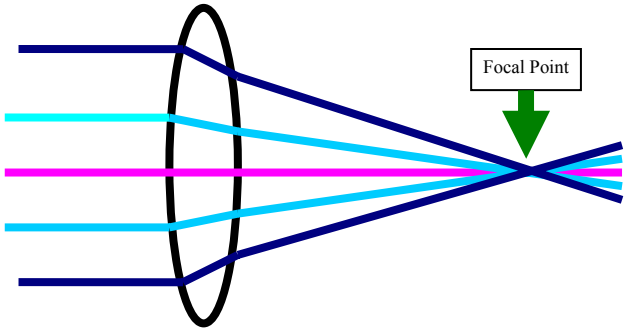
iv. What is the point where all the rays converged to called?

v. Which lens made the light diverge?

vi. How does refraction of light explain how a lens works?

vii. The teacher should now draw the lenses on the board and draw the optical rays to show what the lenses do to the light. (example drawings are shown below)



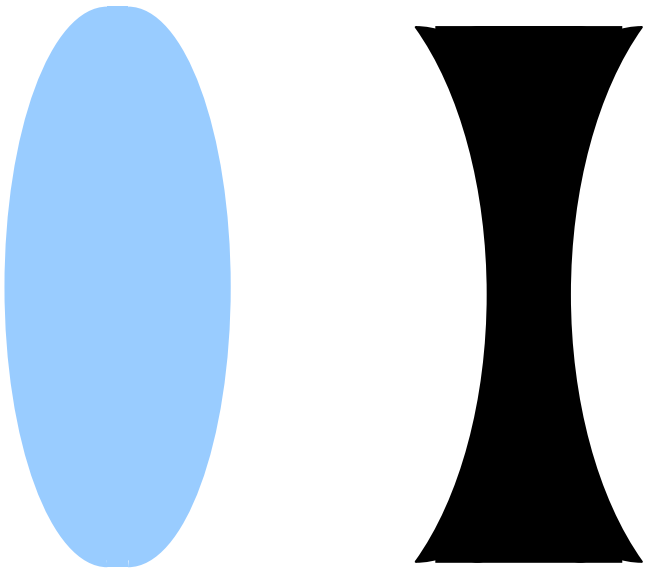


Convergence and Divergence Worksheet

My Predictions:

What do you think will happen when light passes through the concave lens?

What do you think will happen when light passes through the convex lens?



My Observations: Use both words and drawings!

What happened when light passed through the concave lens?

What happened when light passed through the convex lens?

9. **Concept 4: Focal length**

    a. Concept Introduction:

        i. We just learned that a convex lens converges light to a point.

        ii. Now we will calculate the focal point of this lens.

        iii. Hand out the Focal Length worksheet and explain:

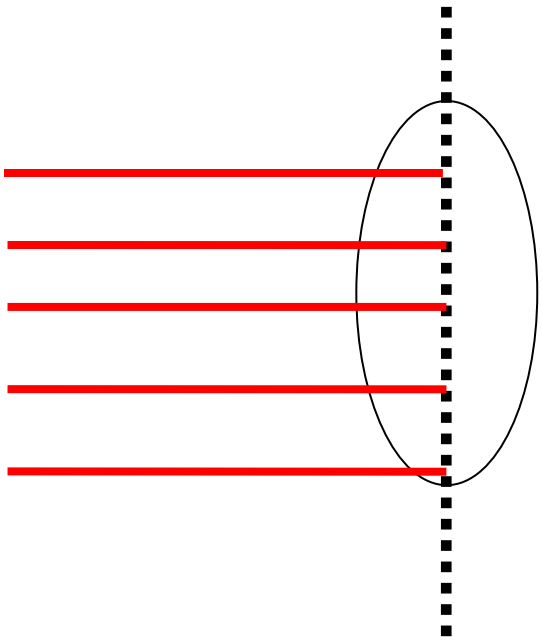
            1. Line the center of your lens up on the dashed line (put your lens on the lens that is drawn)

            2. Put the laser pointer on each drawn red line and shine it through the lens. Trace the beam on the right side of the lens, where the beam exits the lens.

            3. Do you see where the beams all meet? This is the focal point.

            4. Now measure from the dashed line to the focal point. This is the focal length!

Focal Length of a Convex Lens Worksheet



10. **Concept 5: Filtering and Absorption of Light**

    a. *Exploration*:

        i. Discussion Questions

            1. Why are filters needed in optics?
            2. Can you name places that we use filters in everyday life? (examples can include cameras, sunglasses, lighting, automobile lights)
            3. Will all light pass through a filter?
            4. Give each group three Petri dishes full of colored gelatin (red, blue, yellow) and a sheet of blank white paper.

        ii. Predictions:

            1. Give each group a worksheet.
            2. Tell each group that they must predict what color will be seen on the white paper using the filter or filters listed and a red laser pointer or a flashlight. Or if they think that all of the light will be absorbed, write absorbed.

    b. *Concept Introduction*:

        i. After the predictions have been made, give each group a red laser pointer and a flashlight.

        ii. Discussion:

            1. The teacher should draw the observation table from the worksheet on the board.
            2. Fill out the observation table on the board with input from the class.
            3. Ask the students to explain the results. Make sure to ask if there were any surprises!

Filtering and Absorption of Light

My Predictions

Predict the color of light that will be seen on the white paper using the filter or filters listed. Or if you think that all of the light will be absorbed, write absorbed.

Filter Color(s)	Red Laser Pointer	Flashlight
Blue		
Yellow		
Red		
Blue + Yellow		
Blue + Red		
Yellow + Red		

My Observations

Write down the color of light that you see on the white paper using the filter or filters listed. Or if all of the light is absorbed, write absorbed.

Filter Color(s)	Red Laser Pointer	Flashlight
Blue		
Yellow		
Red		
Blue + Yellow		
Blue + Red		
Yellow + Red		

11) *Application:* Wrap up discussion

Ask the students the following questions

- What are some components of optical systems?
- What kinds of things can we make with optics?
- How do you use optics in your everyday life?
- What kinds of things do we need optics for in space exploration (example: Hubble telescope, satellites)? For studying the ocean (example: fiber optics, photography)? For the medical field (example: LASIK, laser surgeries)?
- How do eye glasses work?
    - What kinds of lenses would someone need if they are near-sighted? Far-sighted? (correct answer: Near-sighted needs concave. Farsightedness needs convex.**)**