

# Light and Filters

## Overview

### Prerequisite Skills:

- This activity is an introduction to light, colors, and filters. It does not require any particular prior knowledge.

### Learning Goals:

- Describe the color of light that is able to pass through different color filters.
- Identify the primary colors of light.
- Identify the colors a person would perceive when primary colors are combined.

### Key questions:

- What happens to light of a particular color when it goes through a filter?
- How do we perceive the combination of lights of different colors?

### Materials:

- Computers/tablets for each student or pair of students
- PhET *Color Vision* simulation:  
[https://phet.colorado.edu/sims/html/color-vision/latest/color-vision\\_en.html](https://phet.colorado.edu/sims/html/color-vision/latest/color-vision_en.html)
- Light and Filters–Pre-Lab Activity - (1 per students)
- Light and Filters Activity Sheet - (1 per student)



Notes about the **materials in the student worksheet**: In this activity, the cellophane can be replaced by colored gelatin (such as JELL-O). Check more about this activity at: <https://www.compadre.org/Precollege/items/detail.cfm?ID=14335>

### Estimated Time:

2 sessions, one per experiment. Approximately 50 minutes per session.

## Light, colors, and filters

### Session 1, Experiment #1 Light and Filters

#### Pre-Lab

15 minutes

Students may have preconceptions about how light of different colors interacts with filters. Some of them may not be in accordance with observations.

At the beginning of the activity it is okay for students to have those ideas. Support students to identify their prior ideas with the **Pre-Lab** activity. These are some common students' prior knowledge related with the topic that may be found in the #1 prediction-table:

- Students generally think that filters add or combine light. Therefore, in their predictions it will likely be evident that many students believe that in the case of white light source and a red filter after, the outcome is that the person sees the color red, because of the addition of the colors white and red.
- Similarly, in their prediction of the experiment with two filters (red and blue) or for the question with the blue light source and red filter, the students will believe that the light that a person would observe is purple, since they believe that the mixture of the color blue and red is purple, just like in the case of pigments.

Another common idea that students may have is to think that the mixture of light of different colors (additive synthesis) behaves the same way as the mixing of color pigments (subtractive synthesis). This idea is probed using question # 2 of the activities.

**Important:** Other naïve prior ideas that students may have regarding light and color (Flores et al., 2014) are listed below. These ideas will not necessarily be evident in the initial ideas section, but are important to consider when tackling the topic:

- The color of an object is one of its intrinsic properties, therefore, the color is not affected by light.
- The human eye emits light, allowing it to see objects.
- An object is seen if it is illuminated, it is not necessary for light to pass from the object to the eye.
- The eyes need daylight to see.
- The object is seen only if it emits light.

Open play time	7-10 minutes
<i>Teacher will...</i>	<i>Students will...</i>
<ul style="list-style-type: none"> <li>● Distribute the <b>activity sheet</b>. Ask students to work in pairs.</li> <li>● Encourage students to take a few minutes to explore the <i>Color Vision</i> simulation.</li> <li>● Ask students to complete their explorations of activity #1, and allow them to share their observations with other teams.</li> <li>● <b>Circulate the room</b> and ask students:               <ol style="list-style-type: none"> <li>1. What is the simulation about?</li> <li>2. How does the "Filter color" button work? What is it for?</li> </ol> </li> </ul> <p>After the open play a group discussion is recommended to make sure the students figured out how to use the whole</p>	<ul style="list-style-type: none"> <li>● Make and write predictions on activity #1 before the sim exploration.</li> <li>● Begin by openly playing around with the simulation for about 5 minutes.</li> <li>● Figure out how to use the simulation and find the controls.</li> <li>● Answer to the teacher's informal questions.</li> </ul>

simulation, especially the beam / photon control, and to switch between monochromatic light and white light.	
<b>Gathering data and interpreting the evidence</b>	<b>15-20 minutes</b>
<i>Teacher will...</i>	<i>Students will...</i>
<ul style="list-style-type: none"> <li>● Encourage students to begin working on #2-4 on the activity worksheet in pairs, but writing in their own worksheets. Try to give them at least 5 minutes where <b>the teacher is silent</b> before probing/aiding.</li> <li>● <b>Circulate the room</b> to be available for questions and ask probing/pushing questions, such as: <ol style="list-style-type: none"> <li>1. What happens to white light when it passes through a filter?</li> <li>2. What happens when the filter and bulb have similar colors?</li> <li>3. What happens when you select light and the photon option? What does it mean?</li> <li>4. In which different ways can you make the person see the color red / blue?</li> </ol> </li> <li>● In questions # 3 and # 4, students are asked to use the simulation to complete the table and then to compare their answers with the predictions they made in activity # 1 of the opening ideas.</li> <li>● In question # 4 asks students to use flashlights and filters (cellophane). They should observe that with a white flashlight and different colors of the cellophane filters the same outcome that was observed in the simulation is reproduced. Ideally, when two or more filters of different colors are placed in front of the flashlight, no light should pass through, as it is equivalent to the situation presented in the simulation where you have the light source of one color and a filter of another. But in this case, cellophane is not a perfect filter, and students may see a small amount of colored light passing through the filters. It will, however, not be in the color combination they expect (such as purple if they use the filter red and blue). To that extent, it is expected that the experiment will still help students with some evidence that shows that</li> </ul>	<ul style="list-style-type: none"> <li>● Complete #2-4 on the activity worksheet.</li> <li>● Answer the teachers' questions.</li> <li>● Ask questions or ask for help as needed.</li> <li>● After answering, they share their answers with other teams.</li> <li>● Do activity #4 with light bulbs and cellophane.</li> </ul>

<p>filters subtract elements of light and do not add to it. Filters allow only light of the same color as the filters themselves to pass through them.</p> <ul style="list-style-type: none"> <li>● Ask students to briefly share what their thoughts and impressions of the simulation are; what questions do they have; what did they write down for question #2 of the activity worksheet and discuss any of the questions above.</li> </ul>	
<p><b>Discussion and Summary</b></p>	<p><b>10-15 minutes</b></p>
<p><i>Teacher will...</i></p>	<p><i>Students will...</i></p>
<ul style="list-style-type: none"> <li>● Encourage students to begin working on question #5 of the activity worksheet.</li> <li>● <b>Facilitate a class discussion</b> to bridge an understanding between predictions on the initial ideas' activity and tables in activities #3 and #4. Ask the students whether the answers are different and why.</li> <li>● At the end of the discussion the teacher can ask quick questions that serve as feedback to learning such as:       <ol style="list-style-type: none"> <li>1. Which concept from those seen in the lesson was most difficult to you?</li> <li>2. What are the key concepts in today's activity?</li> <li>3. What else would you like to know about today's topic?</li> </ol> </li> </ul>	<ul style="list-style-type: none"> <li>● Complete question #5 of the activity sheet.</li> <li>● Answer questions and question the answers: students should be able to determine if they agree/disagree with others' claims and justify their own responses.</li> </ul>

## Session 2, Experiment #2 Color Combination

### Pre-Lab

15 minutes

This activity is a complementary session to the previous activity “**Experiment # 1 light and Filters**”. This brainstorming activity is expected to take place after the session has been completed.

In question # 1, students are expected to predict that the numbers that they will be able to see with each filter are the white ones and those that correspond to the color of the filter. They will be surprised to see that number 5, 6 and 7, can also be seen with some of the filters. Allow your students to share their answers to question # 2.

### Open play time

7-10 minutes

*Teacher will...*

*Students will...*

- Continue working on the **activity sheet**. Ask students to work in pairs.
- Encourage students to take a few minutes to explore the *Color Vision - RGB bulbs* window of the simulation.
- **Circulate the room** and ask students:
  1. What is this simulation window about?
  2. How can you get yellow light?

- Begin by freely exploring the other screen of the simulation for about 5 minutes.
- Figure out how to use the simulation and find the controls.
- Answer the teacher's informal questions.
- Write their answers and thoughts about question #1 for the second experiment in the activity worksheet.

### Gathering data and interpreting the evidence

15-20 minutes

*Teacher will...*

*Students will...*

- Encourage students to begin working on #4-5 on the activity worksheet in pairs, but writing in their own worksheets. Try to give them at least 5 minutes where **the teacher is silent** before probing/aiding.

This activity will help students see how the full range of known colors of light is generated from red, blue, and green. Students will notice that some colors like brown are difficult to create.

- In question # 5 students are asked to give an idea of how to reproduce the results observed with the simulation, but using cellophane. One idea is to use flashlights and duct tape, as shown in the pictures. In order to combine colors (for example green and blue), several lamps are required (continuing with the example, a green, and a blue lamp).



- Complete #4-5 on the activity sheet.
- Answer the teacher’s questions.
- Ask questions or ask for help as needed.
- After answering, they share their answers with other teams.
- If possible, they’ll do activity #5 with light bulbs and cellophane paper.

**Discussion and Summary**

**10-15 minutes**

*Teacher will...*

*Students will...*

- Encourage students to begin working on #6-8 on the activity worksheet.
- **Facilitate a class discussion** to bridge an understanding between predictions and observations on the table in activity #1 in this section. Ask the students whether the answers are different and why.
- Remind students to cover their laptop screens with their worksheets so that they are not distracted. Use an established teaching strategy such as pulling name sticks, or small group discussions (print out or display questions and have groups talk to each other, and write down consensus for the “speaker” to share aloud with class). Use this strategy, for example, to discuss what students predict and observe in the activity with colored numbers, #1 in the *initial ideas* section for this experiment.
- You can also discuss how computers and televisions combine the three primary colors to form the images we see on screens using electronic systems.

With the interaction with the PhET simulation, both in the current session and in session 2, with both experiments, students are expected to discover that:

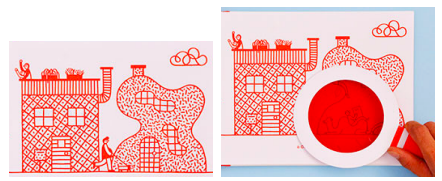
- The person sees the color of the light that reaches the eyes.
- If no light reaches your eyes, you see the color black.
- Filters only let through light that is of the same color as the filter.
- If the light is of a different color than the filter, then you will not see light or you will see the color black.
- White light through a red filter results in the person seeing red, because white light is the combination of many colors, and the filter prevents colors other than red from passing through.
- As a teacher you must facilitate a discussion that verifies these findings.
- At the end of the discussion, the teacher can ask quick questions that serve as feedback to learning, such as: Which concept from those seen in the lesson was most

- Complete #6-8 on the activity sheet.
- Answer questions and question the answers: students should be able to determine if they agree/disagree with others’ claims and justify their responses.

difficult to you? What are the key concepts in today's activity? What else would you like to know about today's topic?

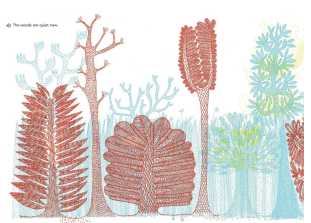
**Going forward...**

As a teacher, you can complement this activity with more applications of light filters. For example, numerous games make use of illustrations that display images in particular colors. They can be observed through red, blue, and green filters, revealing different drawings or secret messages. Examples of such drawings are shown below (each of the mentioned authors has a collection of books with this same theme of using filters to "see hidden images"). Students can also draw their own pictures.



**The Great Journey.**

Book by Agathe Demois.



**What's Hidden in the Woods?**

Book by Aina Bestard.



**Illuminature.** Book by Rachell Williams.

A tour through the book can be seen in this video:

<https://youtu.be/mgvt1vDySI8>