**Color Vision**

**I. Introduction**

Visible light is a form of electromagnetic (EM) radiation, as are radio waves, infrared radiation, ultraviolet radiation, X-rays and microwaves.  Generally, visible light is defined as the wavelengths that are visible to most human eyes.

EM radiation is transmitted in waves or particles at different wavelengths and frequencies. This broad range of wavelengths is known as the [electromagnetic spectrum](https://www.livescience.com/38169-electromagnetism.html). That spectrum is typically divided into seven regions in order of decreasing wavelength and increasing energy and frequency. The common designations are radio waves, microwaves, infrared (IR), visible light, ultraviolet (UV), X-rays and gamma-rays.

Visible light falls in the range of the EM spectrum between infrared (IR) and ultraviolet (UV). It has frequencies of about 4 × 1014 to 8 × 1014 cycles per second, or hertz (Hz) and wavelengths of about 740 nanometers (nm) or 2.9 × 10−5 inches, to 380 nm (1.5 × 10−5 inches).

Perhaps the most important characteristic of visible light is color. Color is both an inherent property of light and an artifact of the human eye. Objects don't "have" color. Rather, they give off light that "appears" to be a color. In other words, color exists only in the mind of the beholder.

Our eyes contain specialized cells, called cones, that act as receivers tuned to the wavelengths of this narrow band of the EM spectrum. Light at the lower end of the visible spectrum, having a longer wavelength, about 740 nm, is seen as red; light in the middle of the spectrum is seen as green; and light at the upper end of the spectrum, with a wavelength of about 380 nm, is seen as violet. All other colors that we perceive are mixtures of these colors.

**II. Procedure**

1. Go to the following website :

<https://phet.colorado.edu/en/simulation/color-vision> .

2. Choose the application labeled **Color Vision**.

3. Click on “Run Now!”. Then open the JNLP file.

**Part I – Use the RGB Bulbs Tab**

1.Each light has a color gradient. For the best results, slide the bar to the very top of

each color. **Each color should be observed individually** for this first part. To stop

the color, return the bar to the black location.

What color is seen when the red light is on?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What color is seen when the green light is on?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What color is seen when the blue light is on?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. For the next part we will investigate the effects of mixing two colors. Before you

begin each part **be sure to make a hypothesis.**

What color *do you think* the man will see when **red and green** are mixed

together?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Turn on the red and green, both to the very top of the color scale. What does the

man *actually see*?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Experiment with the degree of color. While doing this, make sure that both

colors are in equal locations on the scale. What colors are observed? Do they

still fit into the same color family as the color observed in ‘b’?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Keep the red light on (to the top red location), and turn off the green. We will be

looking at red and blue next.

What color *do you think* the man will see when **red and blue** are mixed

together?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Turn on the red and blue, both to the very top of the color scale. What does the

man *actually see*?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Experiment with the degree of color. While doing this, make sure that both

colors are in equal locations on the scale. What colors are observed? Do they

still fit into the same color family as the color observed in ‘b’?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. Keep the blue light on (to the top blue location), and turn off the red. We will be

looking at green and blue next.

What color *do you think* the man will see when **green and blue** are mixed

together?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Turn on the green and blue, both to the very top of the color scale. What does the

man *actually see*?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Experiment with the degree of color. While doing this, make sure that both

colors are in equal locations on the scale. What colors are observed? Do they

still fit into the same color family as the color observed in ‘b’?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. Now we will be looking at mixing all three colors.

What color *do you think the man* will see when **red, green and blue** are all

mixed together?

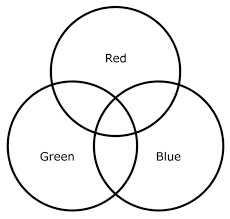
\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Turn on all three colors, all to the very top of the color scale. What does the man

*actually see*?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Fill in the color diagram below. Provide the appropriate colors that you observed when each was mixed. You may use colored pencils if you wish. Otherwise, take a screen-shot of your observations and paste the picture over the color diagram.



**Part II – Use the Single Bulb Tab**

1.Set the simulation to the following: **bulb type** – ‘white’, **beam** – ‘photons’, and **filter**

**color** – ‘off’.

What is coming out of the bulb?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What color light does the man see?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. Set the simulation to the following: **bulb type** – ‘white’, **beam** – ‘solid’, and **filter**

**color** – ‘off’.

What is coming out of the bulb?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What color light does the man see?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Set the simulation to the following: **bulb type** – ‘white’, **beam** – ‘photons’, and **filter**

**color** – ‘on’.

Choose any filter color. Record the color \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

What is coming out of the bulb before the filter (in the area just in front of the filter)?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What is coming out after the filter?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What color light does the man see?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Choose another filter color. Record the color \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.  
  
 What is coming out of the bulb before the filter (in the area just in front of the filter)?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What is coming out after the filter?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What color light does the man see?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What is the filter doing?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. Set the simulation to the following: **bulb type** – ‘white’, **beam** – ‘solid, and **filter**

**color** – ‘on’.

Choose any filter color. Record the color \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

What is coming out of the bulb before the filter (in the area just in front of the filter)?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What is coming out after the filter?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What color light does the man see?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Choose another filter color. Record the color \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

What is coming out of the bulb before the filter (in the area just in front of the filter)?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What is coming out after the filter?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What color light does the man see?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

What are the differences between question 3 (photon setting) and question 4

(solid setting)?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
  
 What are the similarities between question 3 (photon setting) and question 4

(solid setting)?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. Set the simulation to the following: **bulb type** – ‘monochromatic, **beam** – ‘solid, and

**filter color** – ‘on’.

Select a bulb color and a filter color that are **different**. Record the colors chosen

below. What does the man see?

**Bulb Color: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
 Filter Color: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
   
 Color seen by the man: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** Select a bulb color and a filter color that are the **same**. Record the colors chosen

below. What does the man see?

**Bulb Color: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_  
 Filter Color: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**  
  **Color seen by the man: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

What is the filter doing?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. In this activity light was represented in 2 ways – as a photon or as a solid. What

explanation can you provide for the nature of light?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_