# Multimedia Communication (SW-416)

## COLOR CONCEPTS

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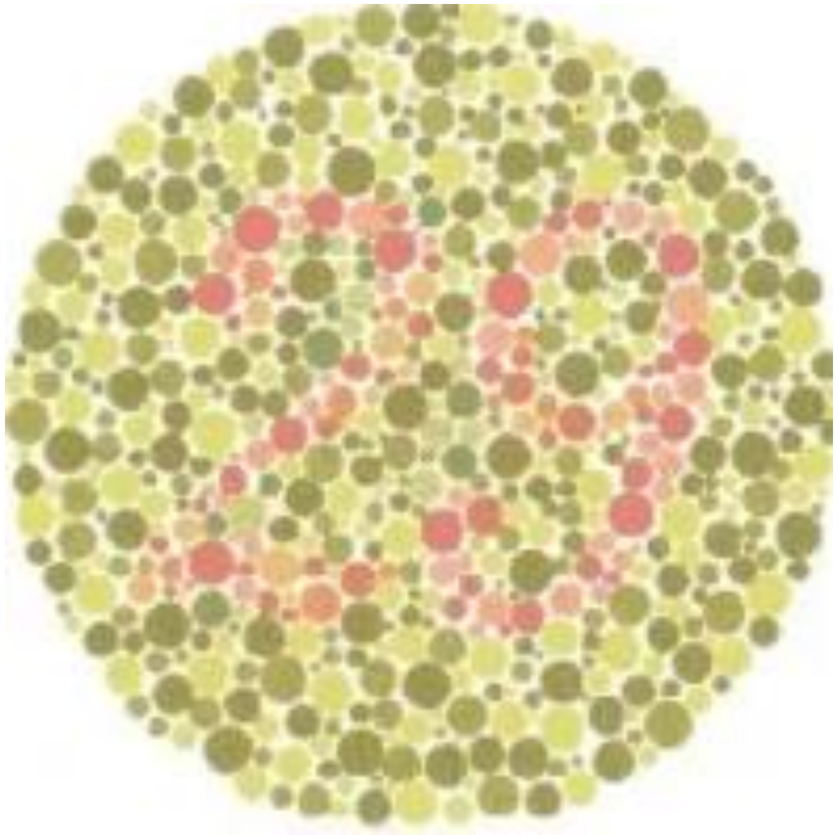
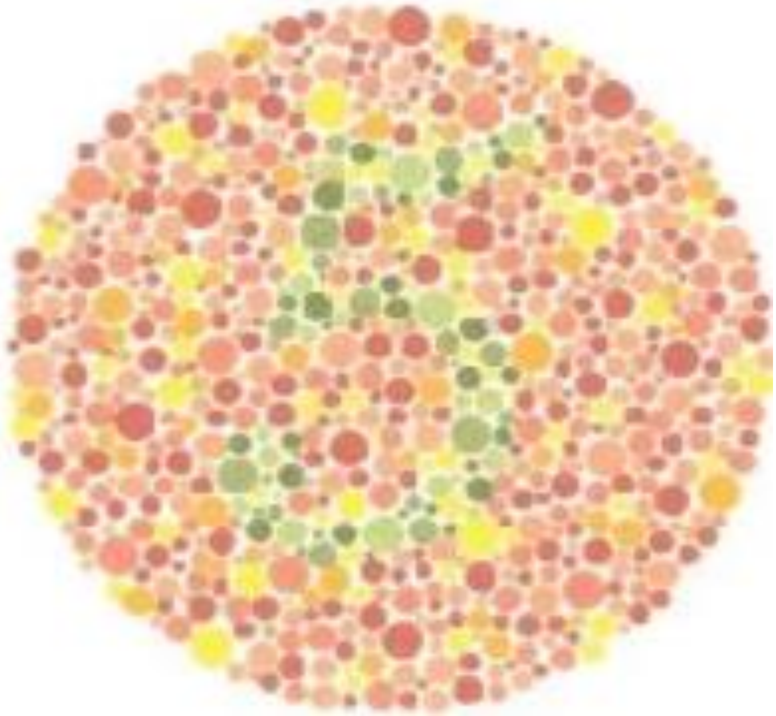
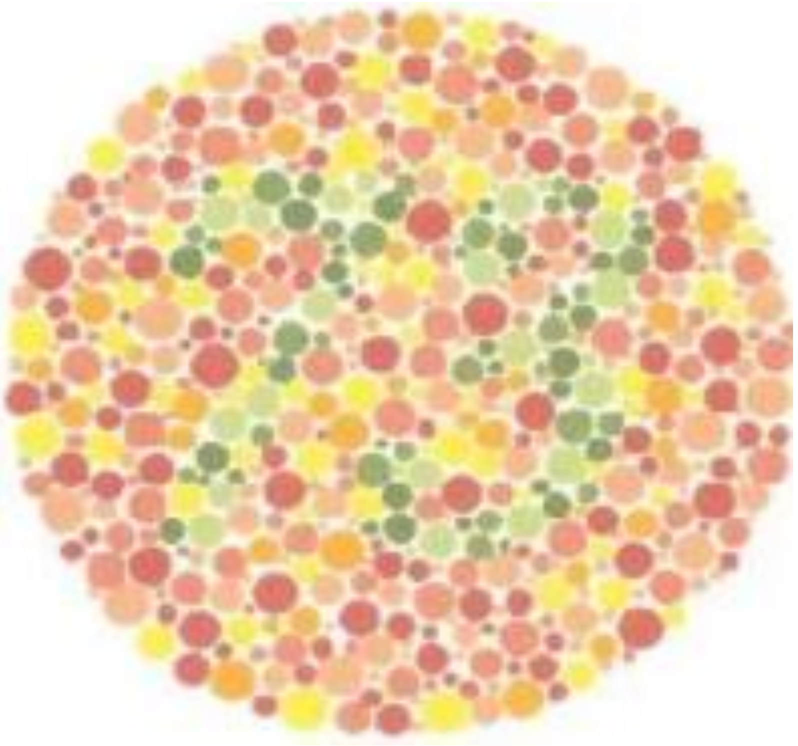
Everyone should be able to see the number 12 in this image.



The number pictured above is 29. Most individuals with normal color vision will see this number.

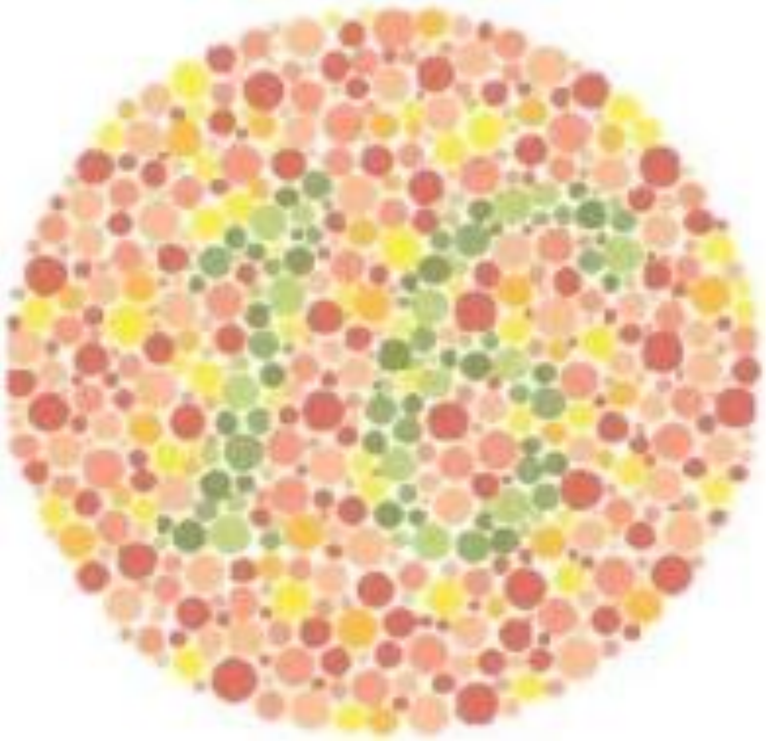


**The number pictured above is 5**
**Most color blind people won't**
**see this number clearly.**



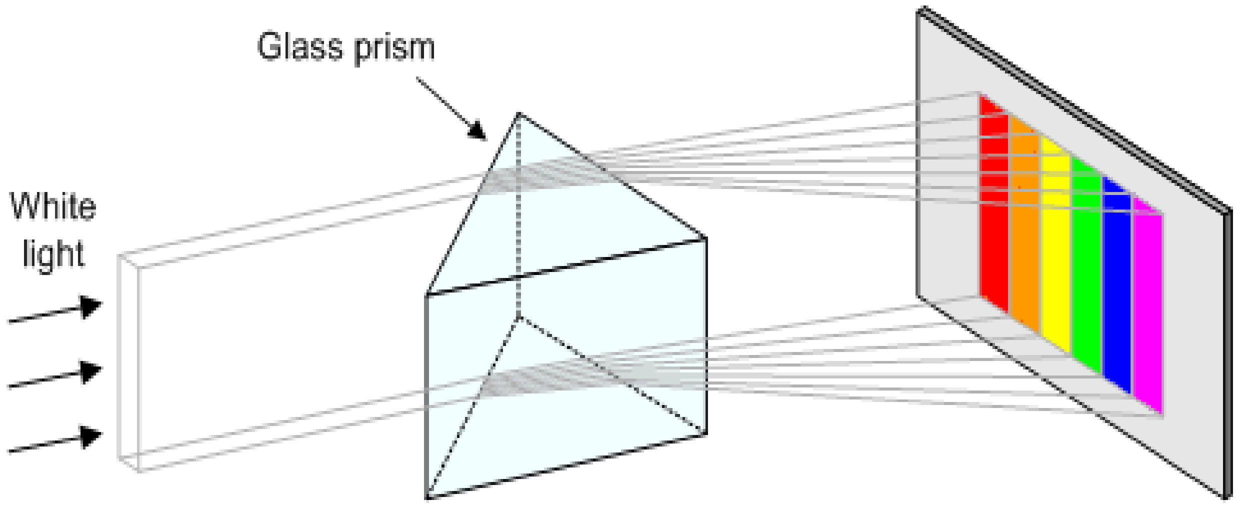
**The number pictured above is 73.**
**Most color blind people won't see this**
**number clearly.**

**The number pictured below is 16.**
**Most color blind people won't see**
**this number clearly.**



# Color and the Human Eye

- Light is an electromagnetic wave
- White light contains all the colors of a rainbow.

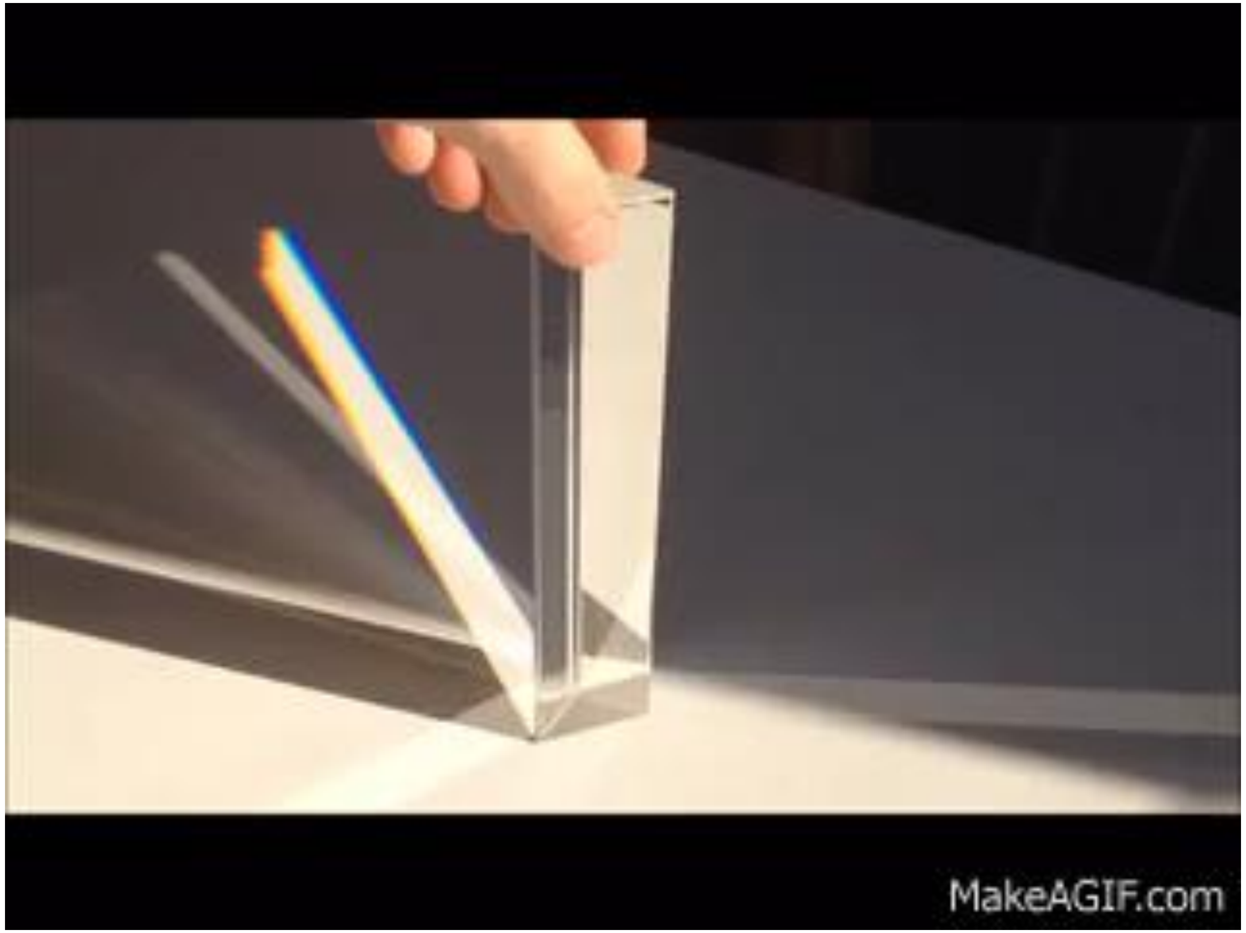


Newton's experiment for splitting white light into a spectrum

- Sensor: **Eye**
  - Most sensitive to red (R), green (G), and blue (B)
- Processor: **Brain**
  - R, G, B
  - Because the eye's receptors are sensitive to red, green and blue light, by adjusting combinations of these three primary colors the eye and brain will interpolate the combinations of colors in between.

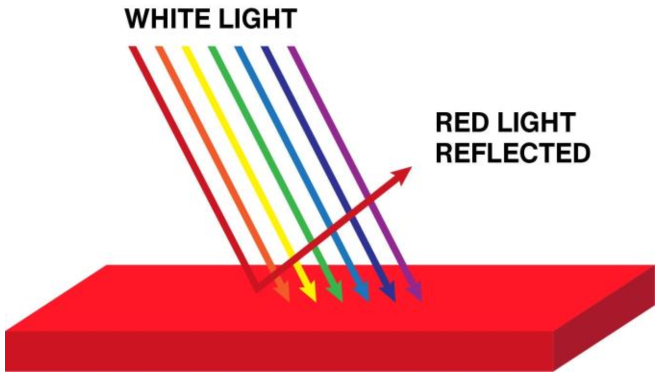
# Color and the Human Eye

- Red, green and blue are the additive primary colors of the color spectrum. Combining balanced amounts of red, green and blue lights also produces pure white.
- By varying the amount of red, green and blue light, all of the colors in the visible spectrum can be produced.



# Color and the Human Eye

- The human eye and brain together translate light into color. Light receptors within the eye transmit messages to the brain, which produces the familiar sensations of color.
- Newton observed that color is not inherent in objects. Rather, the surface of an object reflects some colors and absorbs all the others. We perceive only the reflected colors.

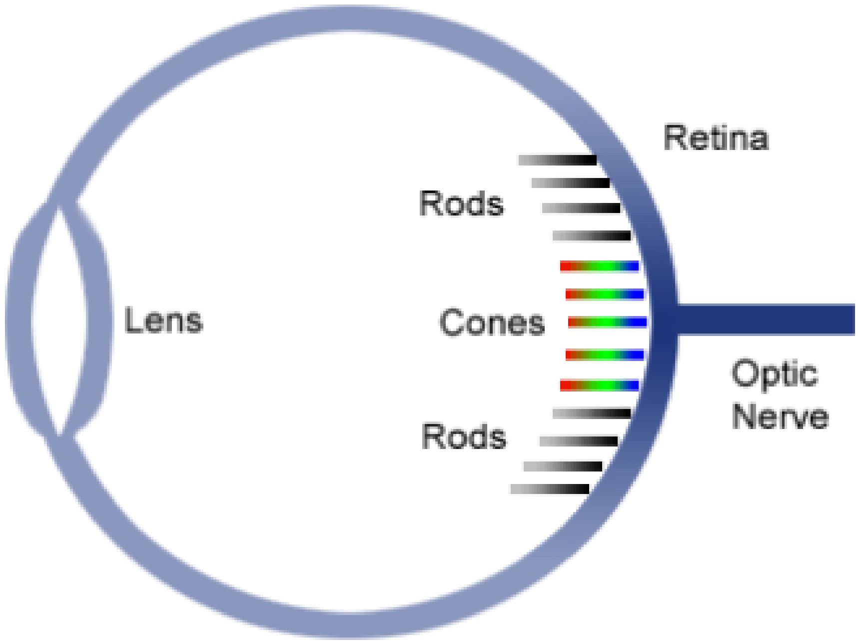



- **Thus, red is not "in" an apple.**
- The surface of the apple is reflecting the wavelengths we see as red and absorbing all the rest.
- ***An object appears white when it reflects all wavelengths and black when it absorbs them all.***

# How do we see color?

- Light travels into the eye and to the retina, located on the back of the eye.
- The retina is covered with millions of light receptive cells called rods and cones.
- When these cells detect light, they send signals to the brain.

- Most people have three kinds of cone cells, and every color stimulates more than one cone.
  - The proportions of R, G, B cones are 40:20:1
- Their combined response produces a unique signal for each color, and millions of different colors can be distinguished this way.
- These cells, working in combination with connecting nerve cells, give the brain enough information to interpret and name colors.



# How do we see color?

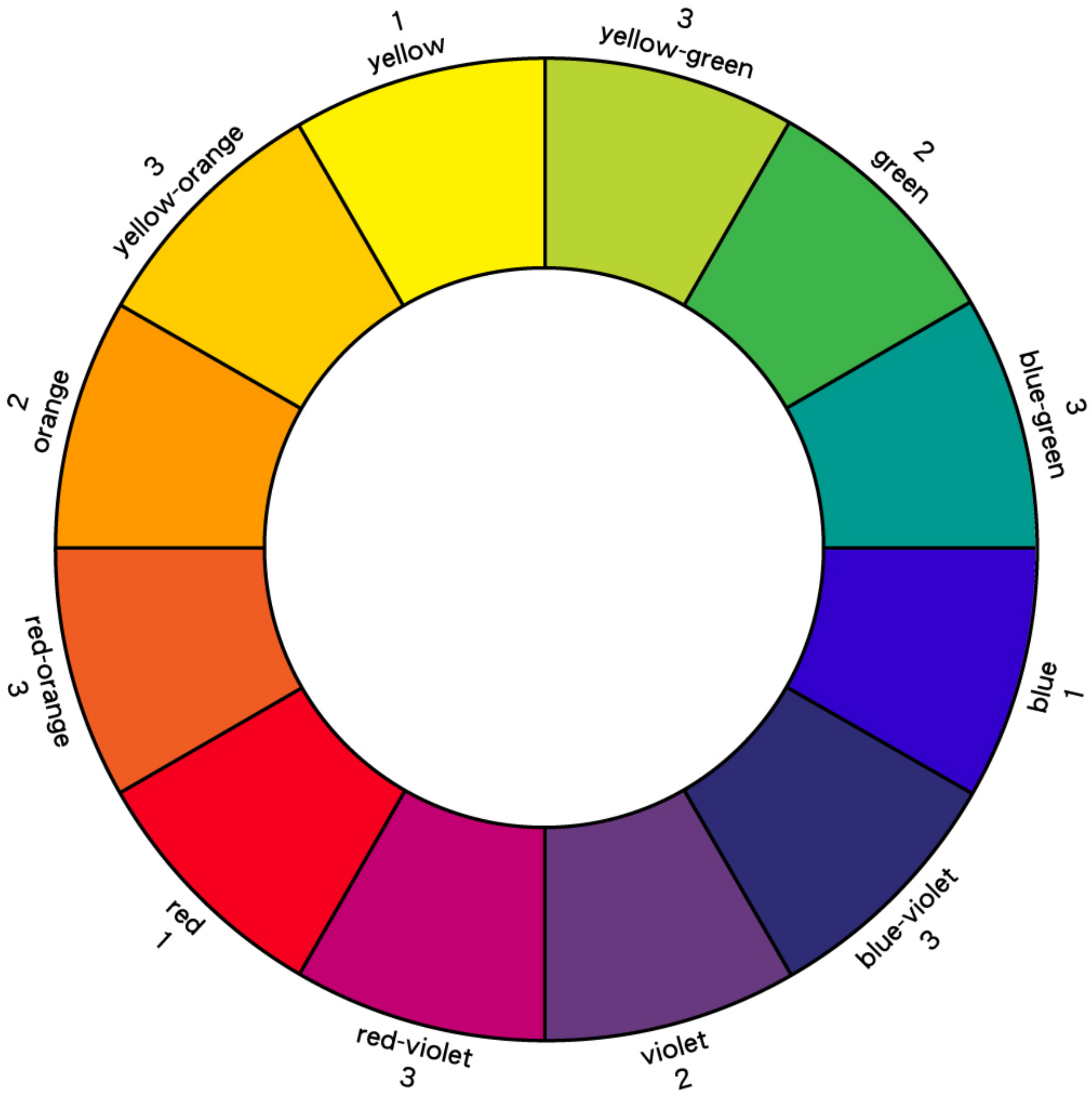
- **Rods** are most highly concentrated around the edge of the retina. There are over 120 million of them in each eye.
- Rods transmit mostly **black and white** information to the brain. As rods are more sensitive to dim light than cones, you lose most color vision in dusky light and your peripheral vision is less colorful.
  - It is the rods that help your eyes adjust when you enter a darkened room.
- **Cones** are concentrated in the middle of the retina, with fewer on the periphery.
- Six million cones in each eye transmit the higher levels of light intensity that create the sensation of color and visual sharpness. There are three types of cone-shaped cells, each sensitive to the long, medium or short wavelengths of light.
  - These cells, working in combination with connecting nerve cells, give the brain enough information to interpret and name colors.

# Color

- Color is a vital component of multimedia and computer graphics.
- Picking the right color and combinations of colors for your project can involve many tries until you feel the result is right.
- Color is a very general term used to describe every hue, tint, tone, or shade we can see.
- An artist creates a color painting by mixing color pigments with white and black pigments to form the various shades, tints, and tones in the scene.

# Color
## **Hue**

- Hue refers to the dominant color family.
- Hues are origin of the colors we can see.
- Primary and Secondary colors (Yellow, Orange, Red, Violet, Blue, and Green) are considered hues; however, tertiary colors (mixed colors where neither color is dominant) would also be considered hues.



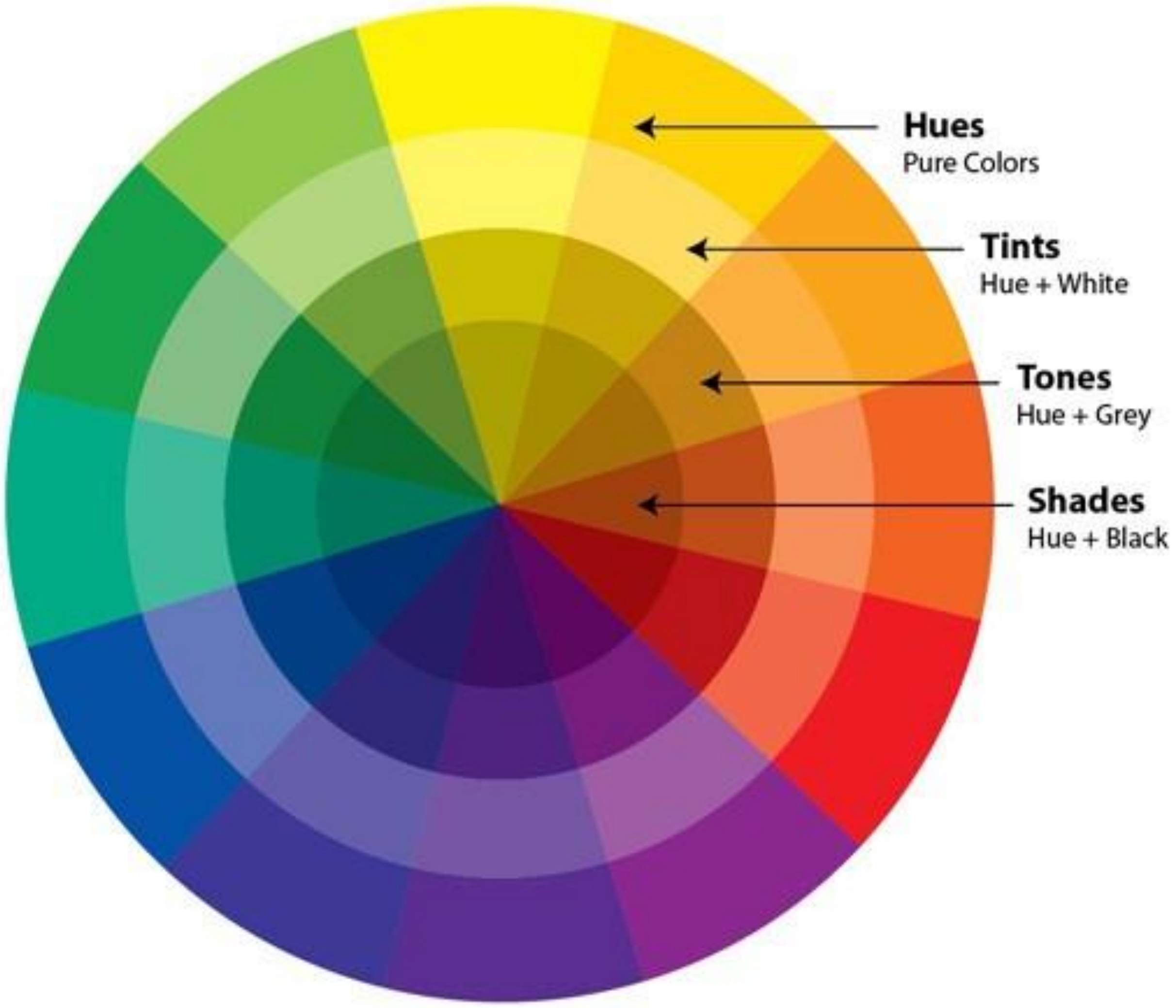
# Color
## Tint and Tone

- Tint refers to any hue or mixture of pure colors to which white is added.
- Pastel colors are generally tinted colors.
- Tinted color remains the same color, but it is paler than the original. When mixing a tint, always begin with white paint and gradually mix in small amounts of color until you’ve achieved the tint you want.

- Tone is a hue or mixture of pure colors to which only pure gray is added (equal amounts of black and white). Adding gray to a color will make the intensity much duller. Beware of mixing too much gray into a hue as it can become over-dulled and virtually impossible to restore the brilliance.

# Color
## Shade

- Shade is a hue or mixture of pure colors to which only black is added.
- It contains no white or gray.
- Shade darkens the color, but the hue remains the same.
- When mixing a shade, begin with the color itself then add black one drop at a time.



# Color

- **Tints**
  Obtained by adding white pigment to original color.

- **Shades**
  Obtained by adding black pigment to produce different shades.

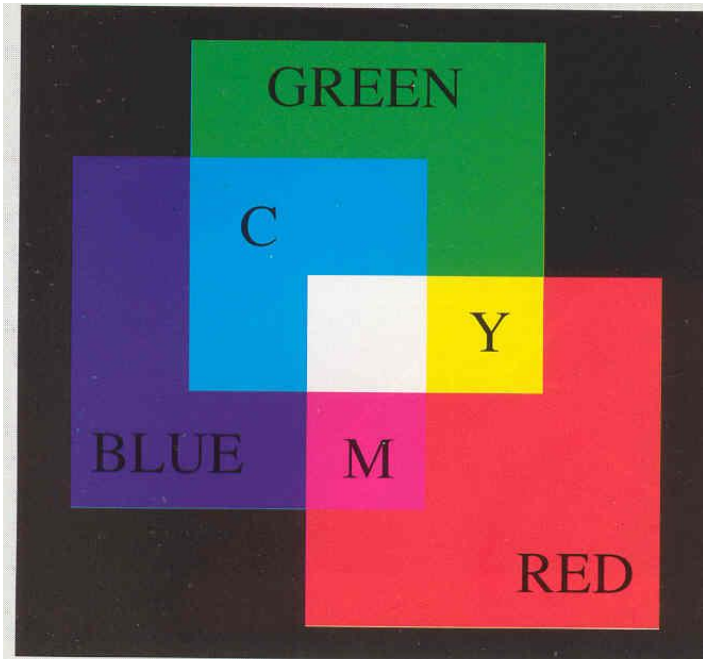
- **Tones**
  Obtained by adding both white and black pigments.

# Color Models

- A color model is a method for explaining properties and behavior of color within some particular context.
- No single color model can explain all aspects of color, so we make use of different models to describe different perceived characteristics of color.
- Graphics packages providing color palettes to a user often employ two or more color models.
- One model provides an intuitive color interface for the user, and other describe the color components for the output devices.
- The color of a pixel on your computer monitor is typically expressed as an amount of red, green, and blue.

# RGB Color Model

Colors are Additive



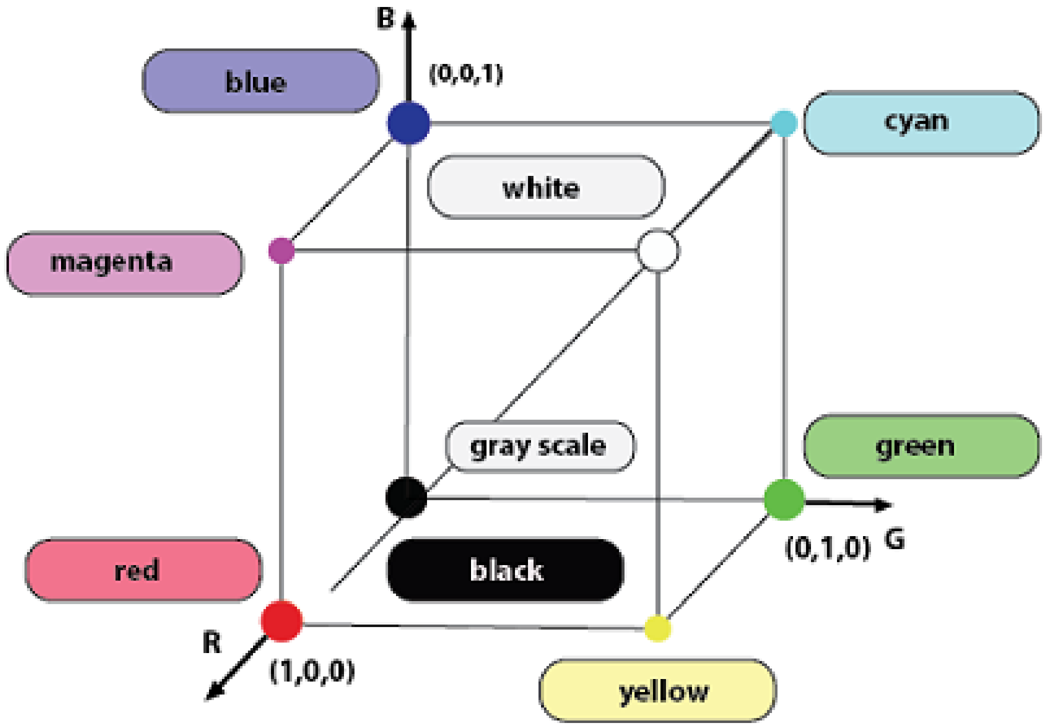

| R | G | B | Color |
|---|---|---|---|
| 0 | 0 | 0 | Black |
| 1 | 0 | 0 | Red |
| 0 | 1 | 0 | Green |
| 0 | 0 | 1 | Blue |
| 1 | 1 | 0 | Yellow |
| 1 | 0 | 1 | Magenta |
| 0 | 1 | 1 | Cyan |
| 1 | 1 | 1 | White |

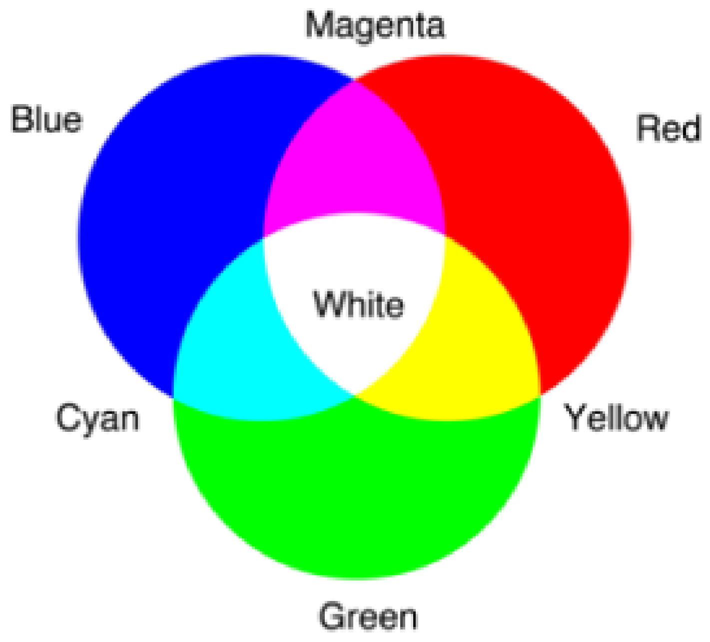
# Color Models
## RGB

- The RGB model is used when working with screen based designs.
- A value between 0 and 255 is assigned to each of the colors, Red, Green and Blue.
- So for example, if you wanted to create a purely blue color, Red would have a value of 0, Green would have a value of 0 and Blue would have a value of 255 (pure blue).
- To create black, Red, Green and Blue would each have a value of 0 and to create white, each would have a value of 255.
- RGB is known as an “additive” model.

# Color Models
# RGB

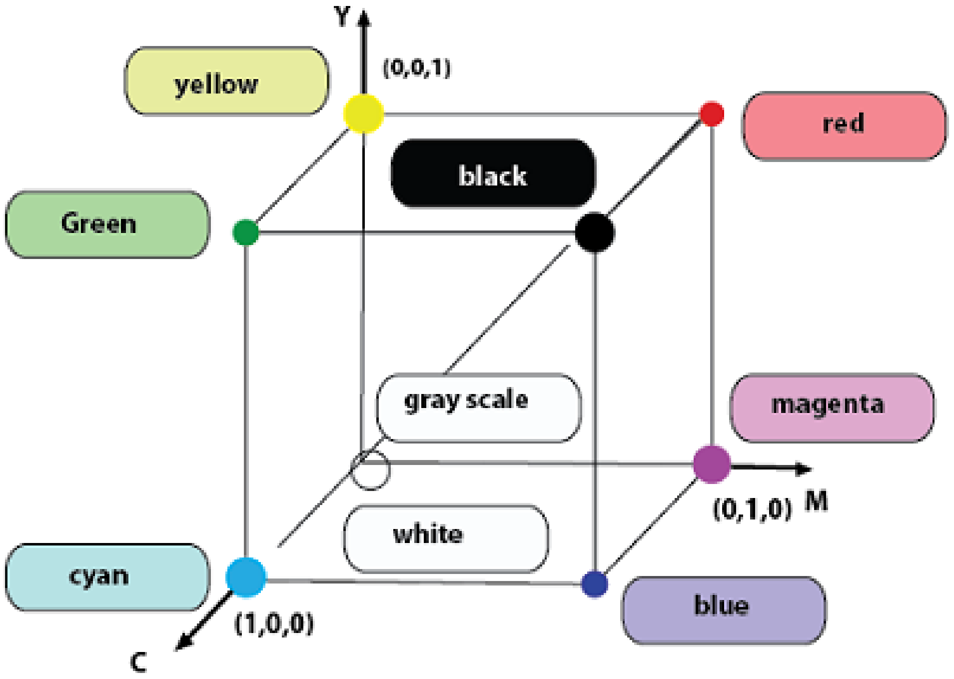
- The Additive color model uses a mixture of light to display colors. The perceived color depends on the transmission of light. It is used in digital media



# Color Models
## CMYK

- The CMYK or CMY model is used for **print work** and it describes colors based on their percentage of Cyan, Magenta, Yellow and Black.

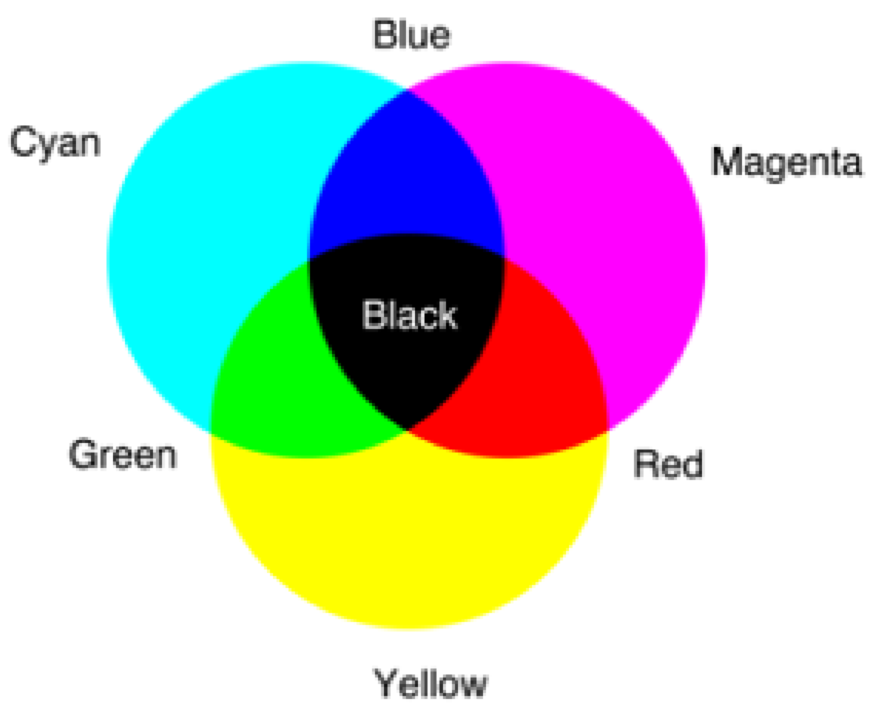


# Color Models
## CMYK

- These four colors are used by commercial printers and bureaus and you may also find that your home color printer uses these colors too.
- These four colors are needed to reproduce full color artwork in magazines, books and brochures.
- C, M, Y do not mix to form real black: Muddy brown.
  - Black ink is in fact cheaper than mixing colored inks.
- By combining Cyan, Magenta, Yellow and Black on paper in varying percentages, the illusion of lots of colors is created.

# CMYK Color Model

Colors are Subtractive




| C | M | Y | Color |
|---|---|---|---|
| 0 | 0 | 0 | White |
| 1 | 0 | 0 | Cyan |
| 0 | 1 | 0 | Magenta |
| 0 | 0 | 1 | Yellow |
| 1 | 1 | 0 | Blue |
| 1 | 0 | 1 | Green |
| 0 | 1 | 1 | Red |
| 1 | 1 | 1 | Black |

# Color Models
## CMYK

- In the CMY model, point (1, 1, 1) represents black. The origin represents white light.
- Equal amounts of each of the primary colors produce grays, along the main diagonal of the cube.
- Conversion from a CMY color representation to an RGB representation with the matrix transformation:

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} C \\ M \\ Y \end{bmatrix}$$

- The conversion from an RGB representation to a CMY representation with the matrix transformation:

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

# Color Models
## HSV

- Unlike RGB and CMYK, which use primary colors, HSV is closer to how humans perceive color.
- It has three components: hue, saturation, and value.
- This color space describes colors (hue) in terms of their tone (saturation or amount of gray) and their brightness value.
- Some color pickers, like the one in Adobe Photoshop, use the acronym HSB, which substitutes the term "brightness" for "value," but HSV and HSB refer to the same color model.

# Color Models
## **HSV**

- **Hue:** a specific color

- **Saturation:** It is the intensity of a hue from grey. At maximum saturation a color would contain no grey at all. At minimum saturation, a color would contain mostly grey.

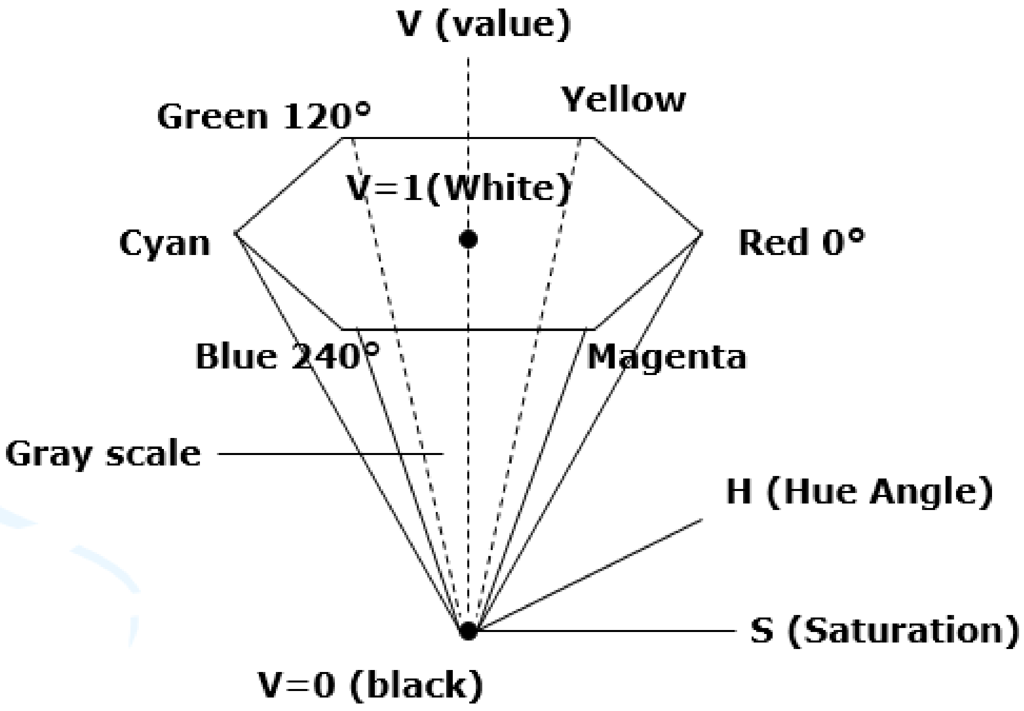

- **Brightness** refers to how much white, or black, is contained within a color.

# Color Models
## HSV

- To give a color specification, a user selects a spectral color and the amounts of white and black that are to be added to obtain different shades, tints, and tones.
- For most graphics applications, 128 hues, 8 saturation levels, and 15 value settings are sufficient.
    - With this range of parameters in the HSV color model, 15,384 colors would be available to a user, and the system would need 14 bits of color storage per pixel.

# Color Models
## HSV

*Hue* is the color portion of the model (number - 0 to 360°)
**Red** falls between 0 and 60 degrees.
**Yellow** falls between 61 and 120 degrees.
**Green** falls between 121 and 180 degrees.
**Cyan** falls between 181 and 240 degrees.
**Blue** falls between 241 and 300 degrees.
**Magenta** falls between 301 and 360 degrees.

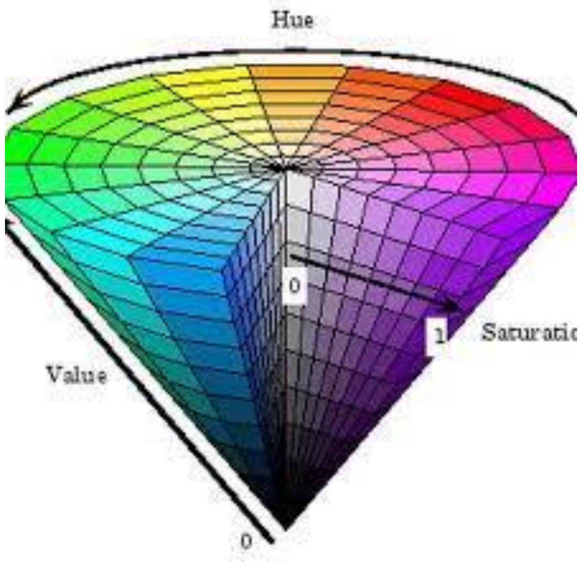



Saturation describes the amount of gray in a particular color, from 0 to 100 percent. Reducing this component toward zero introduces more gray and produces a faded effect. Sometimes, saturation appears as a range from 0 to 1, where 0 is gray, and 1 is a primary color.

Value works in conjunction with saturation and describes the brightness or intensity of the color, from 0 to 100 percent, where 0 is completely black, and 100 is the brightest and reveals the most color.

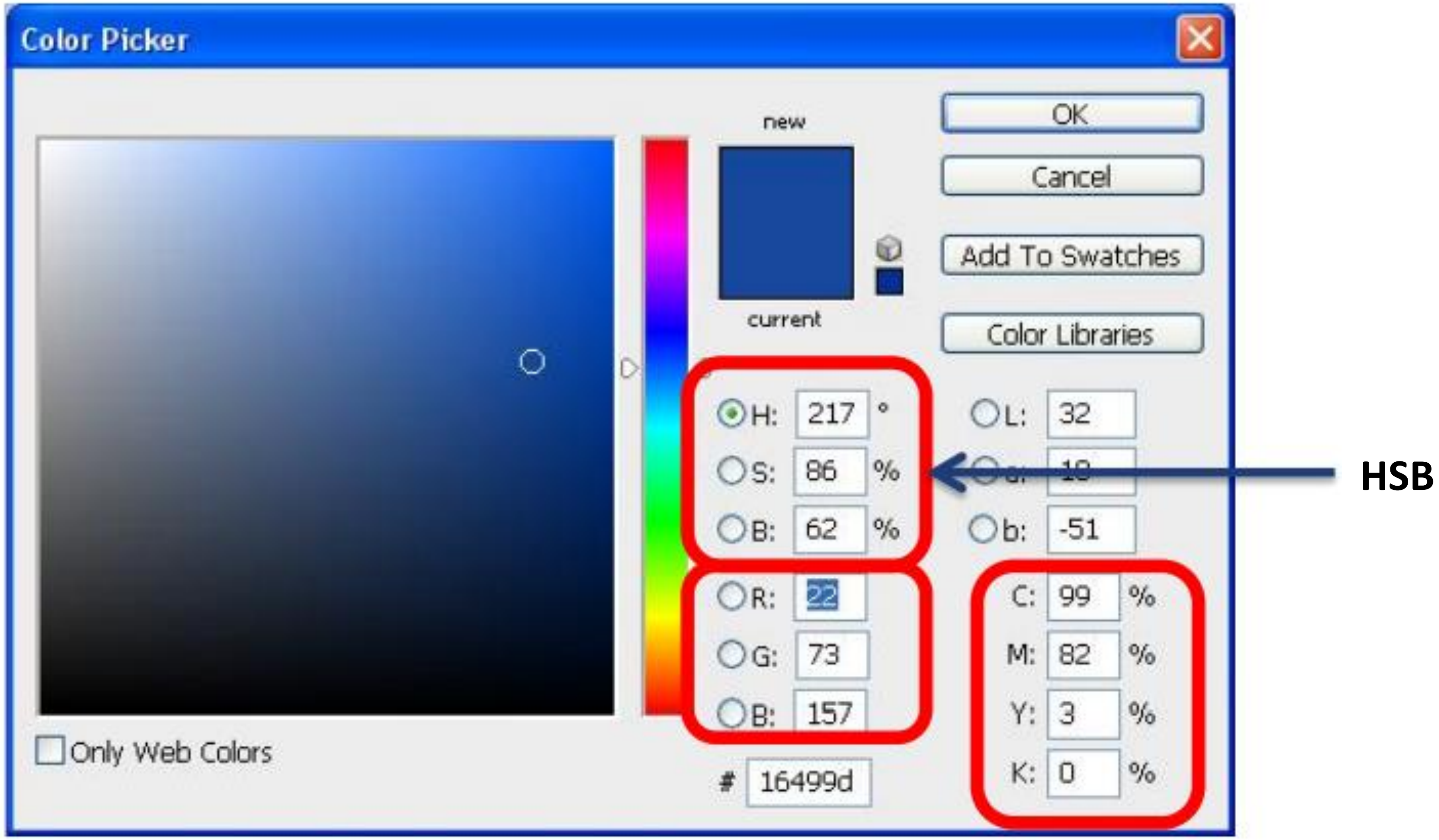
# Color Models
## HSV - Uses

- Designers use the HSV color model when selecting colors for paint or ink because HSV better represents how people relate to colors than the RGB color model does.
- The HSV color wheel also contributes to high-quality graphics. Although less well-known than its RGB and CMYK cousins, the HSV approach is available in many high-end image editing software programs.




- Selecting an HSV color begins with picking one of the available hues and then adjusting the shade and brightness values.

# Color Models
## HSV - Uses



# Color Models
## **HSV - Uses**