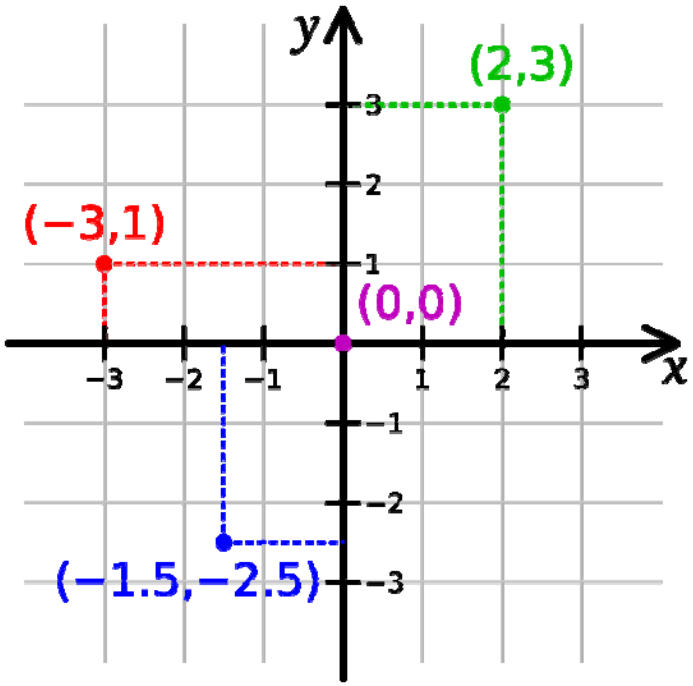
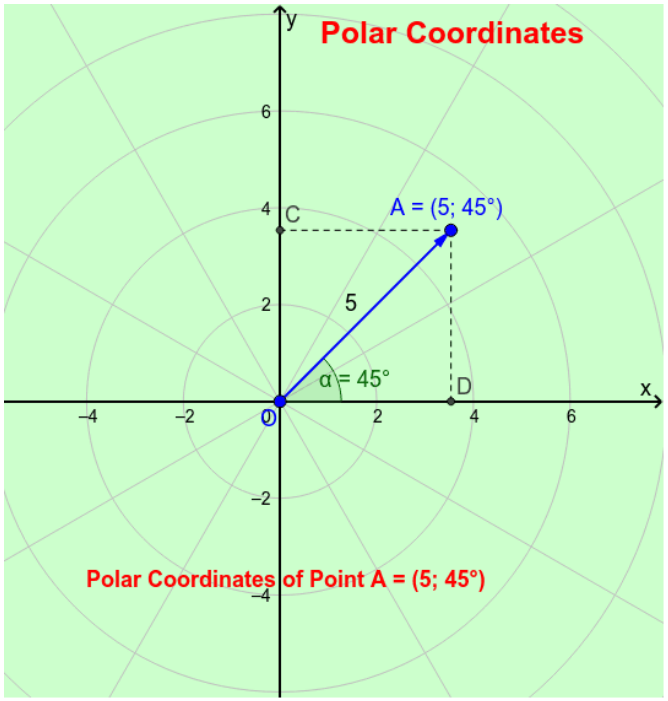
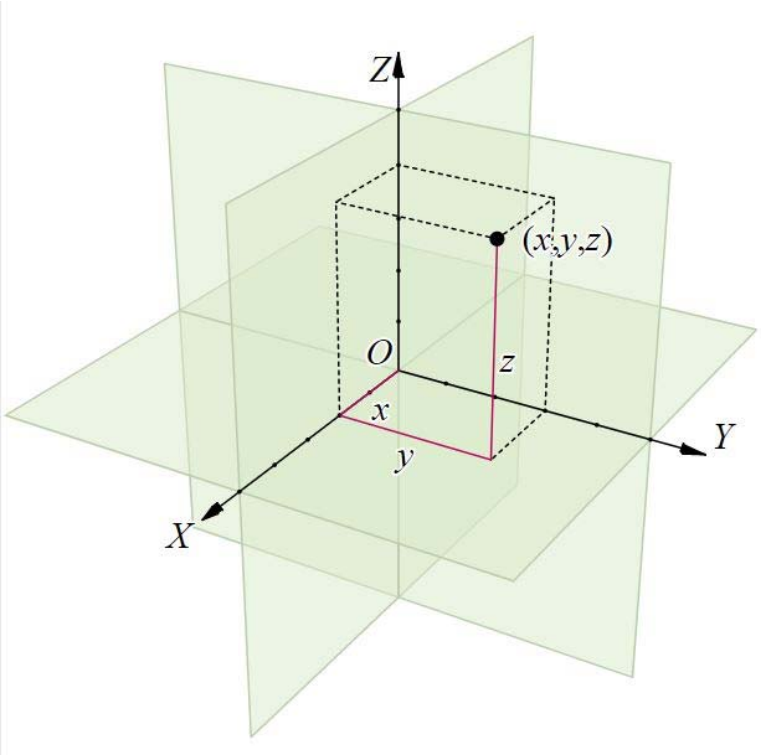
Color

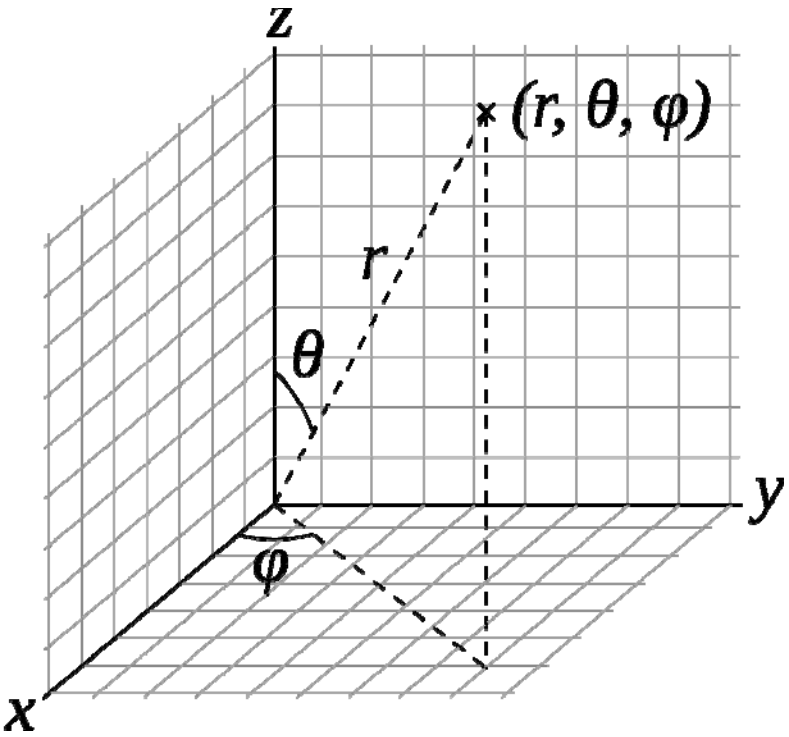
Degrees of Freedom – 2 Dimensions





Degrees of Freedom – 3 Dimensions

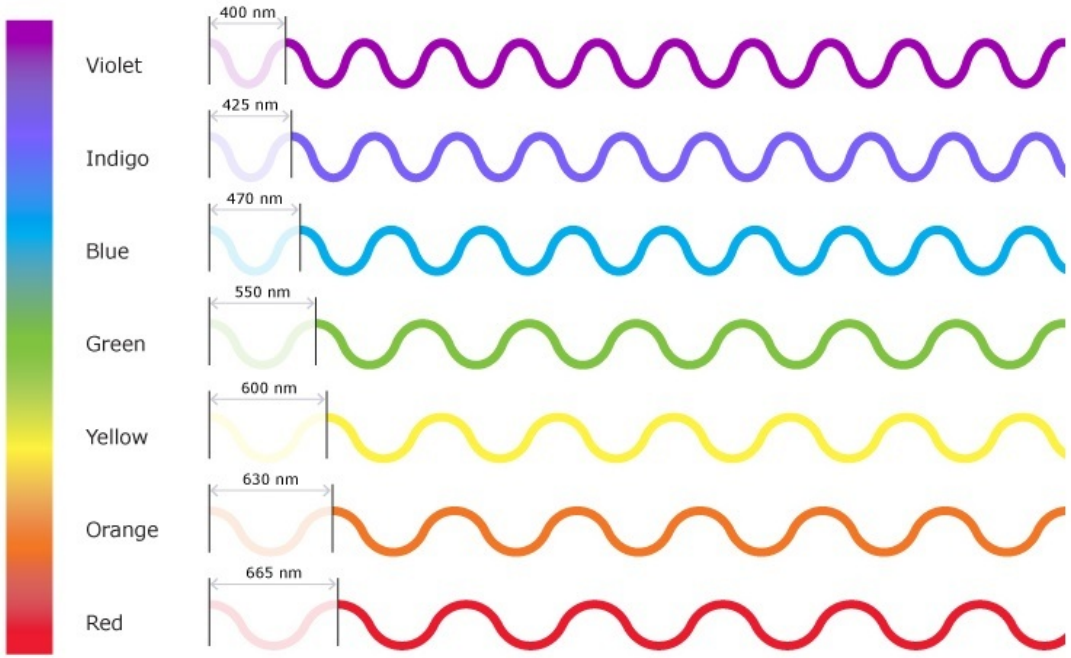




Degree of Freedom

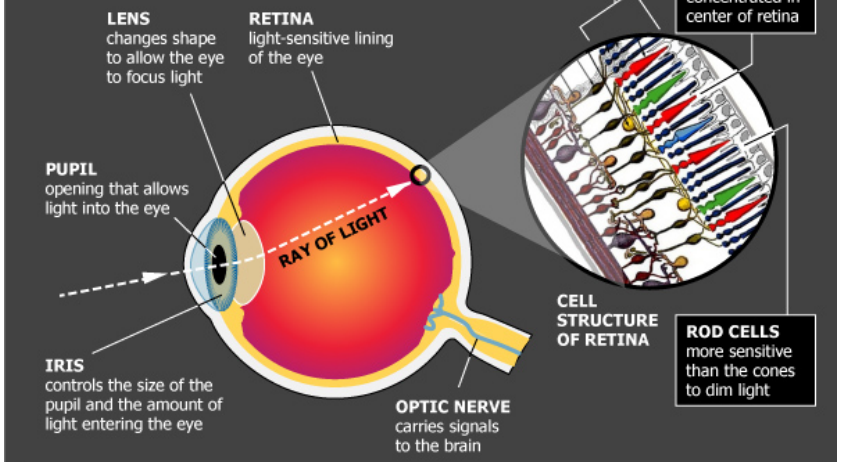
- 2 dimensions: 2 degrees of freedom
- 3 dimensions: 3 degrees of freedom
- Color: 3 degrees of freedom
- Degrees of Freedom is independent of the Representation

The Physics of Color



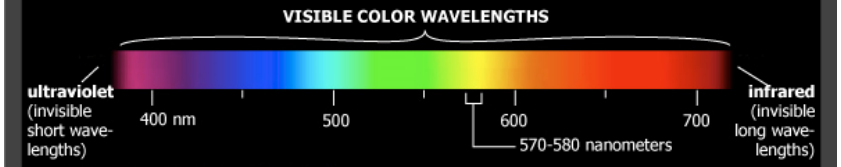
How the Eye Sees in Color

The retina contains cells called rods and cones that are sensitive to different colors of light.



Why Bananas Appear Yellow

The full spectrum of light falls on the bananas, but only light with wavelengths of 570 to 580 nanometers, in other words "yellow" light, is bounced off. (A nanometer is one billionth of a meter.)

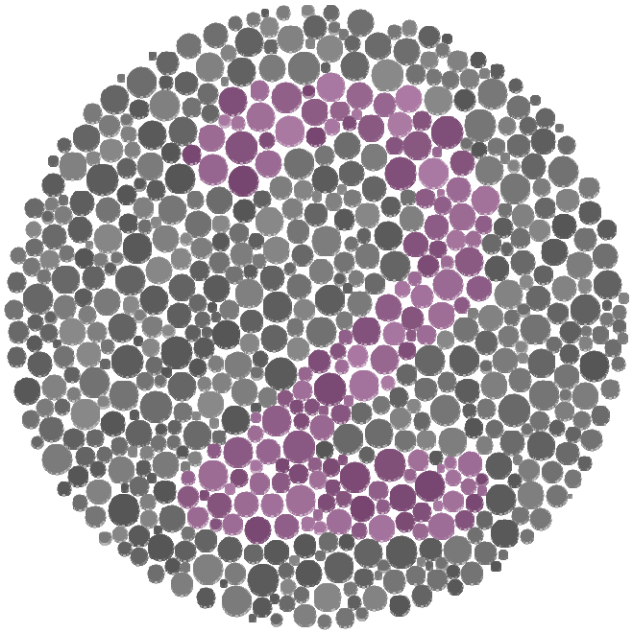


Yellow light reflected from the bananas stimulates the eye's cone cells to varying degrees. Nerve signals from the cones travel to the optical cortex of the brain for decoding.

SOURCE: NATIONAL LIBRARY OF MEDICINE, PHOTOS8.COM

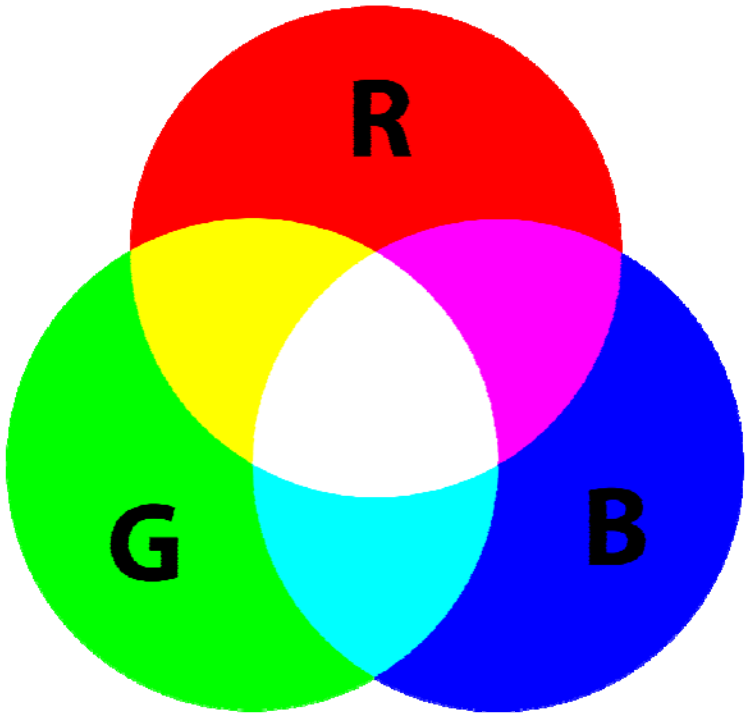
Graphic by Karl Tate Life's Little Mysteries

Color Blindness



- https://enchroma.com/pages/color-blind-test

How are colors produced: Additive - RGB



RGB Color Values

Color name	RGB triplet	Color
Red	(255, 0, 0)	
Lime	(0, 255, 0)	
Blue	(0, 0, 255)	
White	(255, 255, 255)	
Black	(0, 0, 0)	
Gray	(128, 128, 128)	
Fuchsia	(255, 0, 255)	
Yellow	(255, 255, 0)	
Aqua	(0, 255, 255)	
Silver	(192, 192, 192)	
Maroon	(128, 0, 0)	
Olive	(128, 128, 0)	
Green	(0, 128, 0)	
Teal	(0, 128, 128)	
Navy	(0, 0, 128)	
Purple	(128, 0, 128)	

- 3 degrees of freedom
- 255 x 255 x 255 = 3 bytes = 16K colors

Bit Depth	Max # of Colors	Storage Required per Pixel
1	2	1 bit (1/8 byte)
2	4	2 bits (1/4 byte)
4	16	4 bits (1/2 byte)
8	256	1 bytes
16	65,536	2 bytes
24	16,777,216	3 bytes
32	4,294,967,296	4 bytes

How are colors produced: Subtractive - CMYK

How to create colors with CMYK?

Combine values of the primary colors **cyan**, **magenta**, **yellow** – and **black**.

Each of the colors are calculated in percentages – from 0 to 100%.

C:	100	0	0	0	0
M:	0	100	0	0	0
Y:	0	0	100	0	0
K:	0	0	0	100	0

Color

- 3 degrees of freedom
- RGB – additive – screens
- CMY (K) – subtractive – printers
  - CMY is all that is needed
  - K added for cost since most images are black & white
  - Difficult to produce black with precisely C = M = Y

Conversion from RGB to CMYK

- If the RGB values are all 0 then the CMY values are all 0 and the K value is 1
- Otherwise use the following formulas:

$$w = \max(r/255, g/255, b/255)$$
$$c = (w - (r/255))/w$$
$$m = (w - (g/255))/w$$
$$y = (w - (b/255))/w$$
$$k = 1 - w$$

If the values are negative take the absolute value.

- The CYMK format represents colors on a scale from 0.0 to 1.0