# COLOR MODELS

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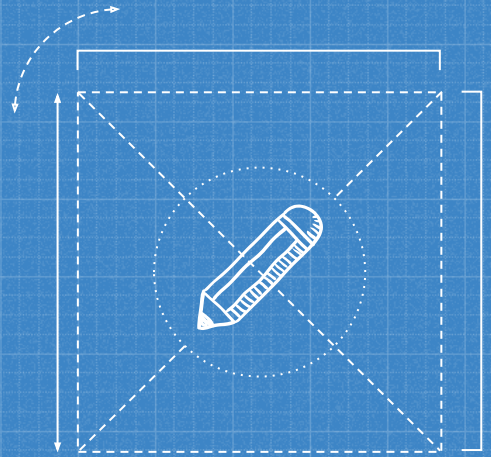
# Topics:

- Color Models:
  - RGB Color Model
  - CMY Color Model
  - YIQ Color Model
  - HSV Color Model

# Color Models

Color models provide a standard way to specify a particular color, by defining a 3D coordinate system, and a subspace that contains all constructible colors within a particular model. Any color that can be specified using a model will correspond to a single point within the subspace it defines.

Each color model is oriented towards either specific hardware (RGB,CMY,YIQ), or image processing applications (HSI).

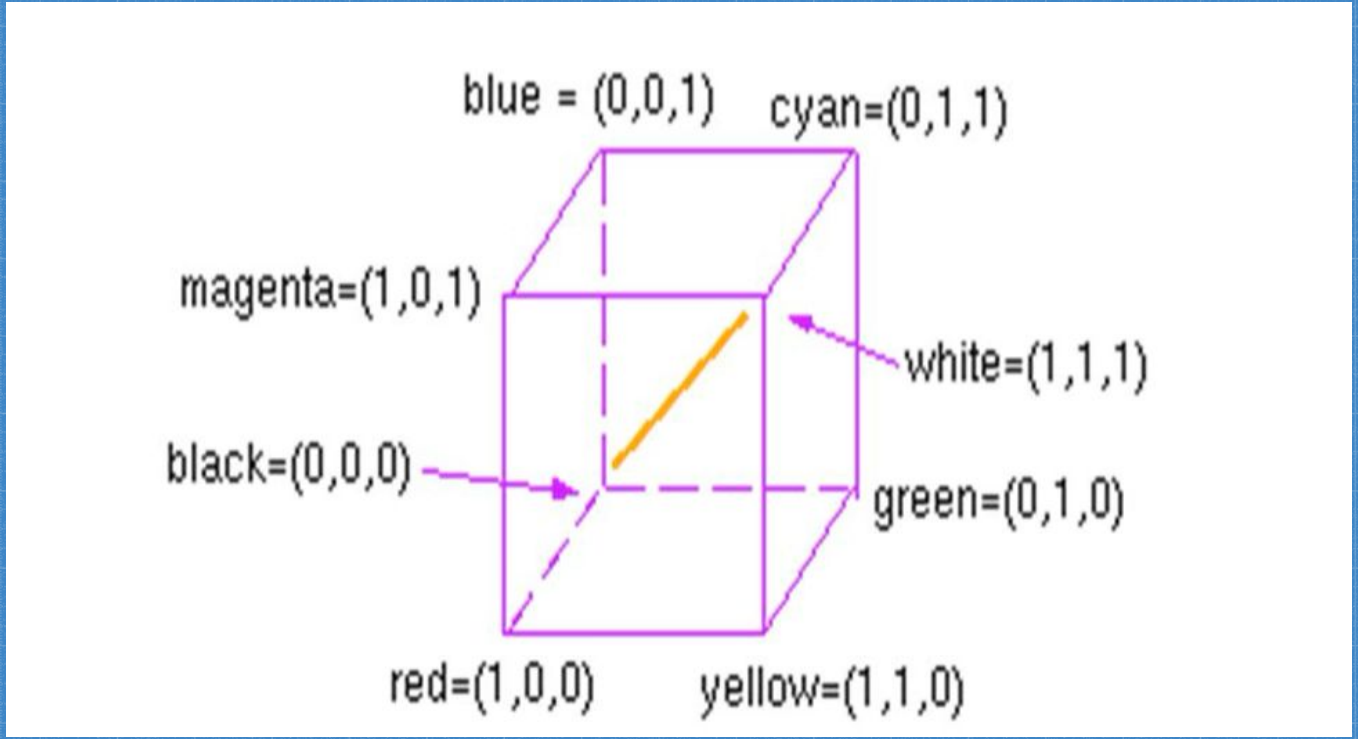


# RGB COLOR MODEL

# RGB Color Model

The additive color model used for computer graphics is represented by the RGB color cube, where R, G, and B represent the colors produced by red, green and blue phosphorus, respectively.

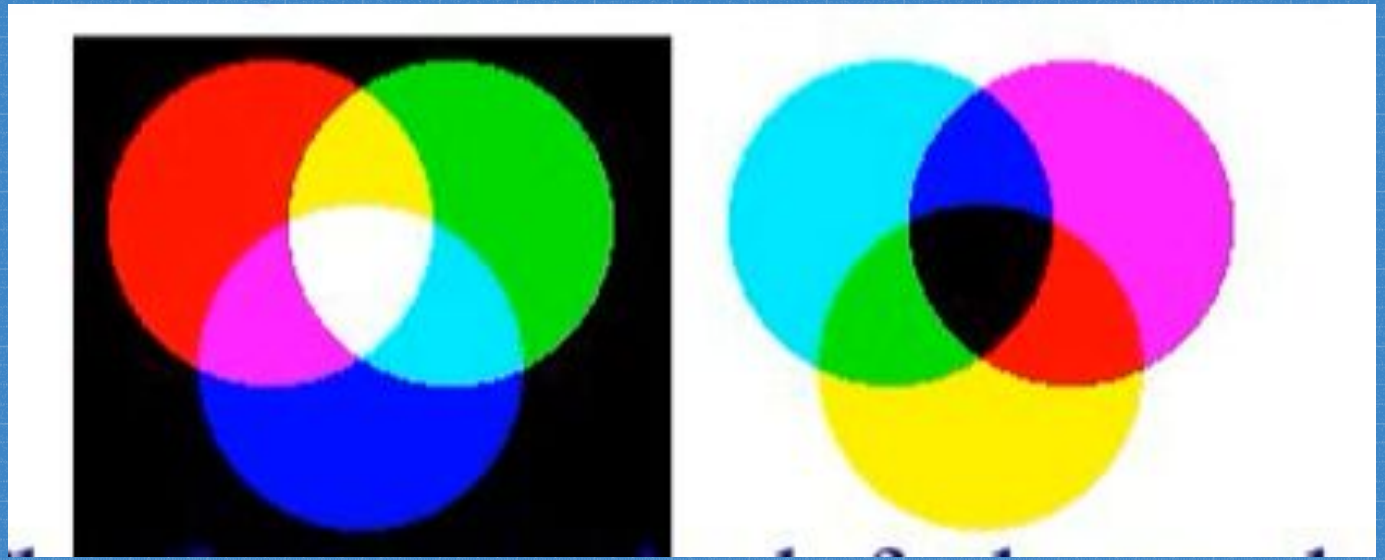
# RGB Color Model



# RGB Color Model

This is an additive model, i.e. the colors present in the light add to form new colors, and is appropriate for the mixing of colored light for example.

# RGB Color Model



# RGB Color Model

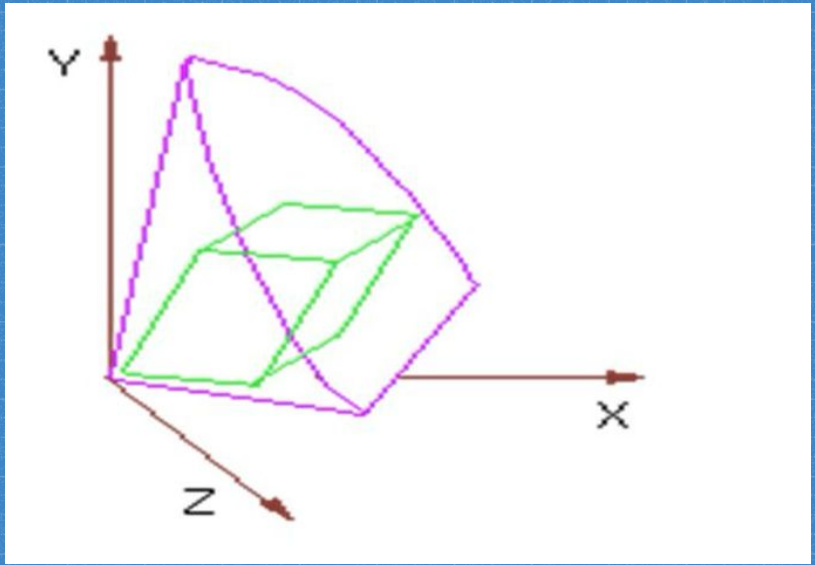
The figure on the left shows the additive mixing of red, green and blue primaries to form the three secondary colors yellow (red + green), cyan (blue + green) and magenta (red + blue), and white ((red + green + blue).

# RGB Color Model

The figure on the right shows the three subtractive primaries, and their pairwise combinations to form red, green and blue, and finally black by subtracting all three primaries from white.

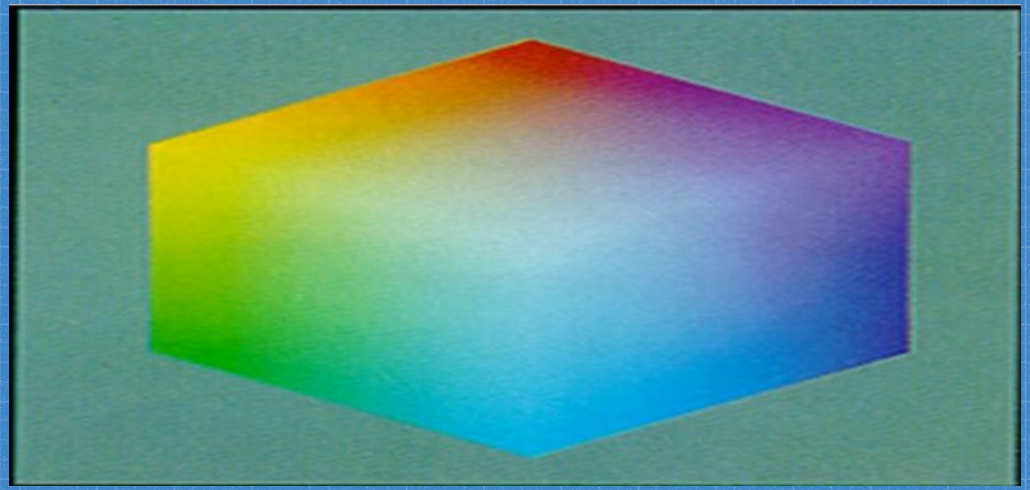
# The RGB Color Cube

The color cube sits within the CIE XYZ color space as follows.

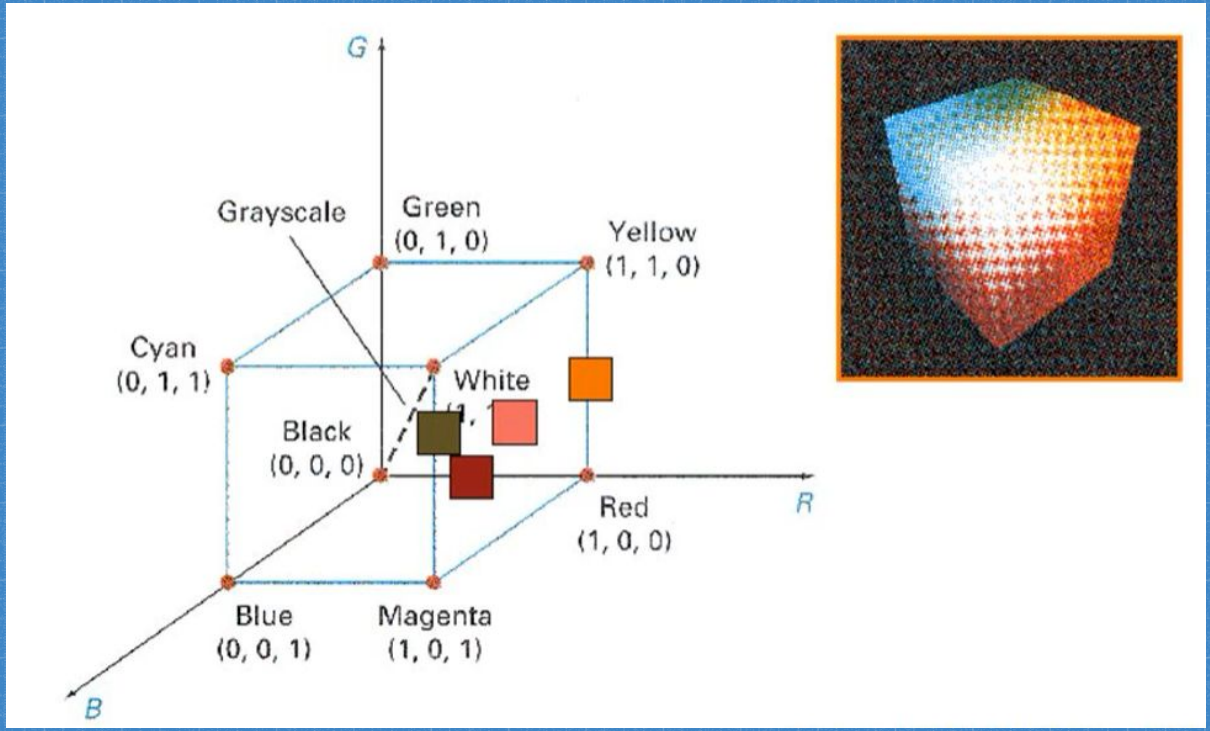


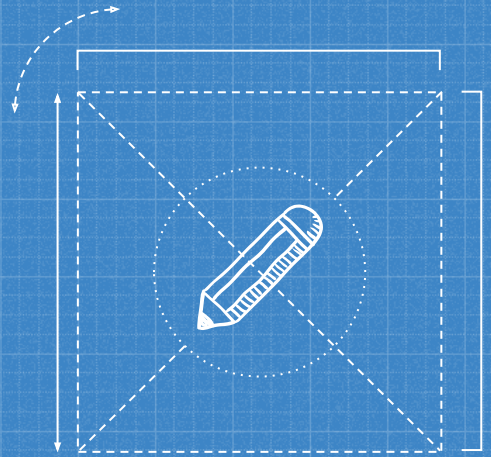
# RGB Color Model for CRT Displays

CRT displays have three phosphors (RGB) which produce a combination of wavelengths when excited with electrons.



# The RGB Color Cube





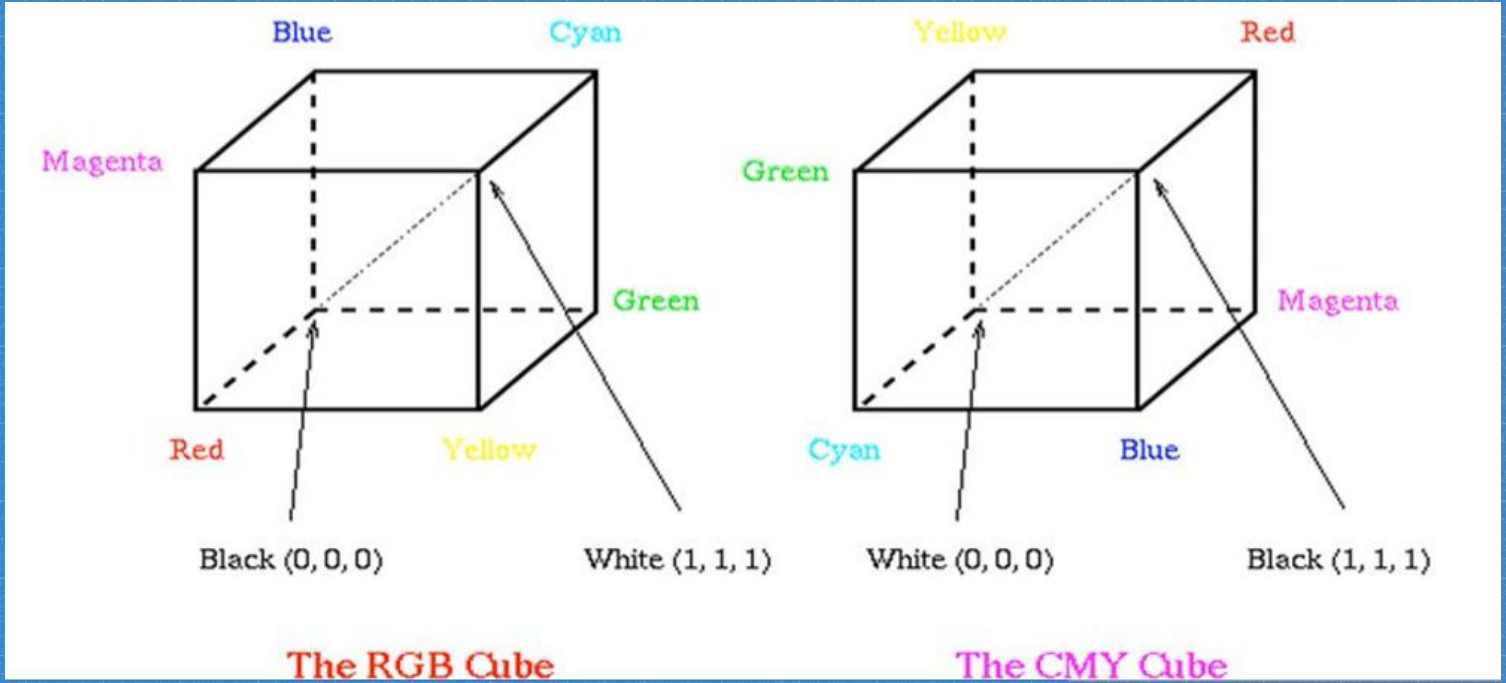
# CMY COLOR MODEL

# CMY Color Model

Cyan, Magenta, and Yellow (CMY) are complementary colors of RGB. They can be used as Subtractive Primaries.

CMY model is mostly used in printing devices where the color pigments on the paper absorb certain colors (e.g., no red light reflected from cyan ink).

# CMY Color Model



# Conversion between RGB and CMY

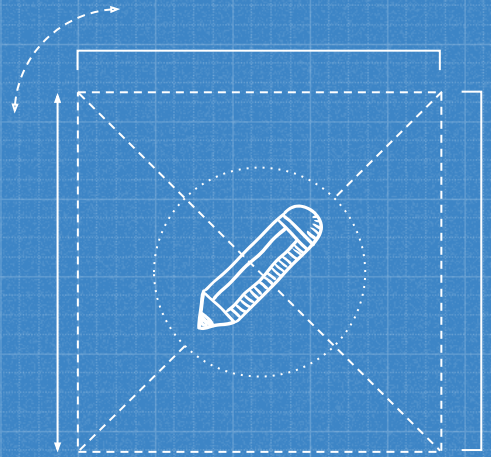
Convert White from (1, 1, 1) in RGB to (0, 0, 0) in CMY:

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

# Conversion between RGB and CMY

Sometimes, an alternative CMYK model (K stands for Black) is used in color printing (e.g., to produce darker black than simply mixing CMY).

K := min (C, M, Y), C := C - K, M := M - K, Y := Y - K.



# YIQ COLOR MODEL

# YIQ Color Model

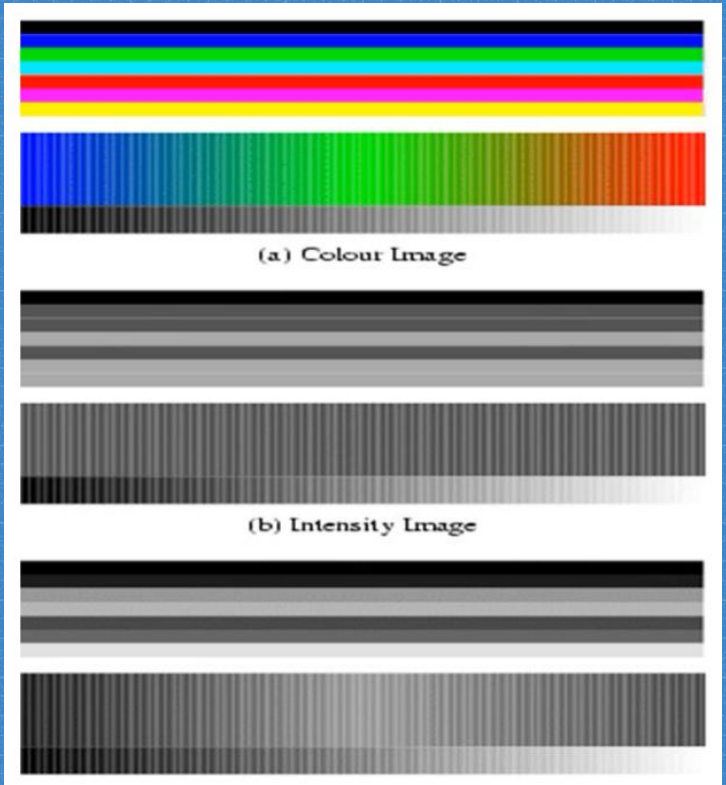
The YIQ (luminance-inphase-quadrature) model is a recoding of RGB for color television, and is a very important model for color image processing. The conversion from RGB to YIQ is given by:

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.30 & 0.59 & 0.11 \\ 0.60 & -0.28 & -0.32 \\ 0.21 & -0.52 & 0.31 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

# YIQ Color Model

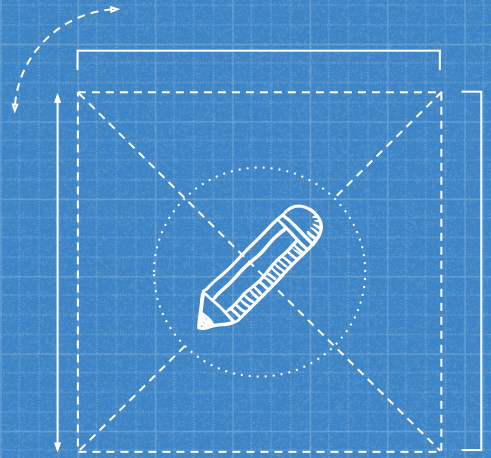
The luminance (Y) component contains all the information required for black and white television, and captures our perception of the relative brightness of particular colors. That we perceive green as much lighter than red, and red lighter than blue, is indicated by their respective weights of 0.587, and in the first row of the conversion matrix above. These weights should be used when converting a color image to greyscale if you want the perception of brightness to remain the same.

# YIQ Color Model



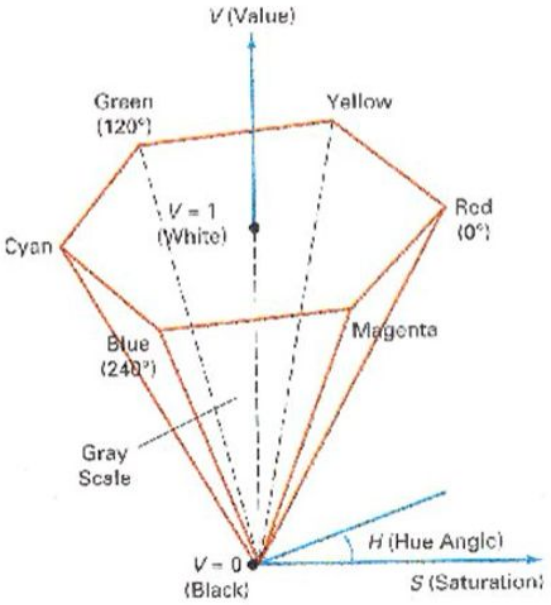
# YIQ Color Model

Figure: Image (a) shows a color test pattern, consisting of horizontal stripes of black, blue, green, cyan, red, magenta and yellow, a color ramp with constant intensity, maximal saturation, and hue changing linearly from red through green to blue, and a greyscale ramp from black to white. Image (b) shows the intensity for image (a). Note how much detail is lost. Image (c) shows the luminance. This third image accurately reflects the brightness variations perceived in the original image



# HSV COLOR MODEL

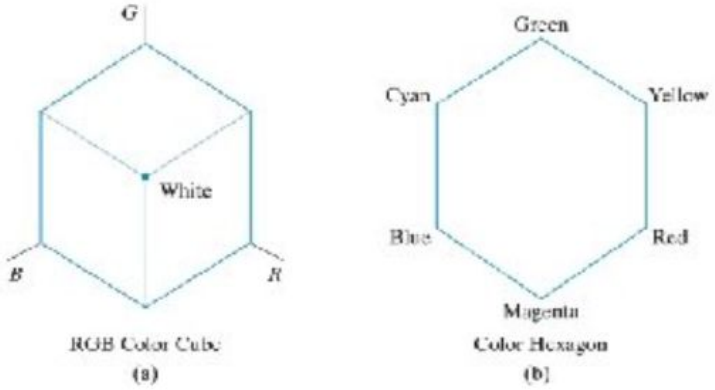
# HSV Color Model




| H | S | V | Color |
|---|---|---|---|
| 0 | 1.0 | 1.0 | Red |
| 120 | 1.0 | 1.0 | Green |
| 240 | 1.0 | 1.0 | Blue |
| * | 0.0 | 1.0 | White |
| * | 0.0 | 0.5 | Gray |
| * | * | 0.0 | Black |
| 60 | 1.0 | 1.0 | |
| 270 | 0.5 | 1.0 | |
| 270 | 0.0 | 0.7 | |

# HSV Color Model

- Interface for selecting colors often use a color model based on intuitive concepts rather than a set of primary colors
- The HSV parameters
  - Color parameters are hue (H), saturation (S) and value (V)
  - Derived by relating the HSV parameters to the direction in the RGB cube
  - Obtain a color hexagon by viewing the RGB cube along the diagonal from the white vertex to the origin

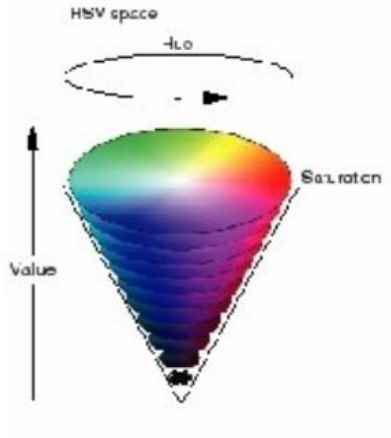


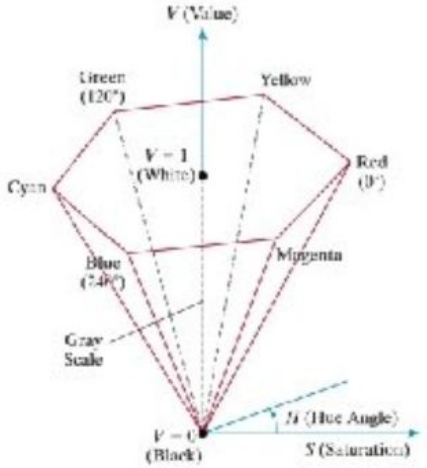

RGB Color Cube (a)

Color Hexagon (b)

# HSV Color Model

- The HSV hexcone
  - Hue is represented as an angle about the vertical axis ranging from 0 degree at red to 360 degree
  - Saturation parameter is used to designate the purity of a color
  - Value is measured along a vertical axis through center of hexcone



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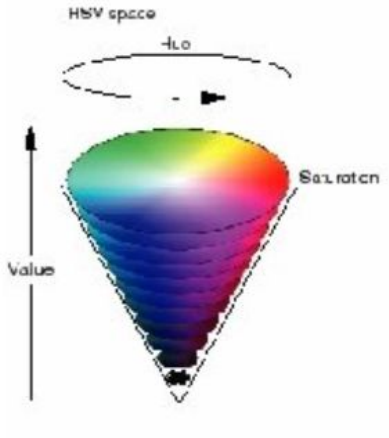
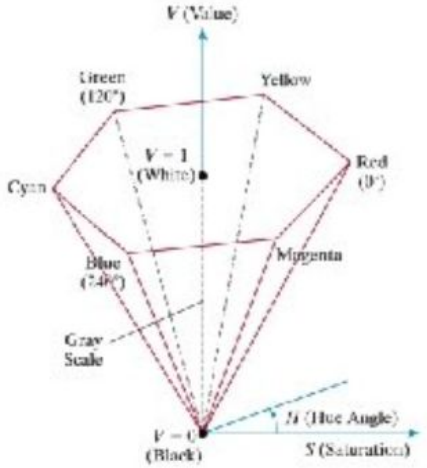
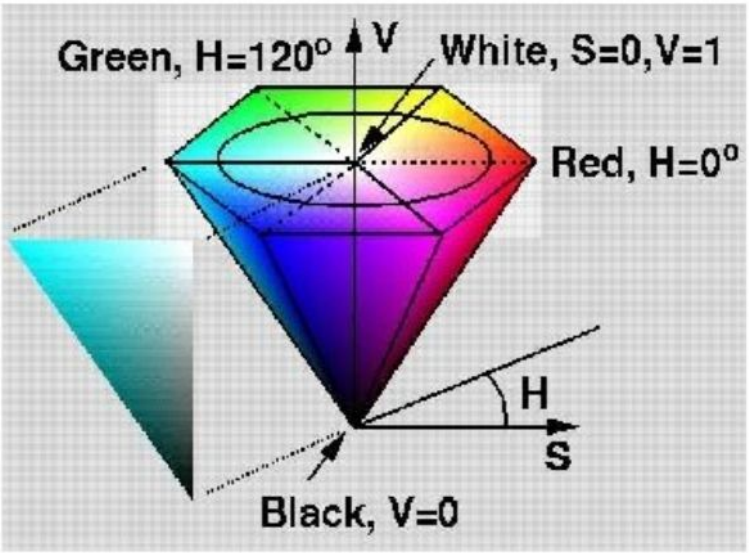


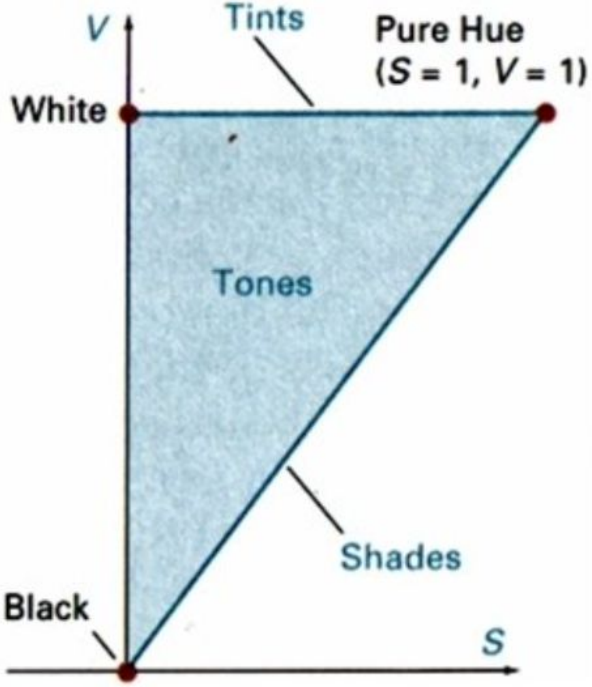



# HSV Color Model Hexagon



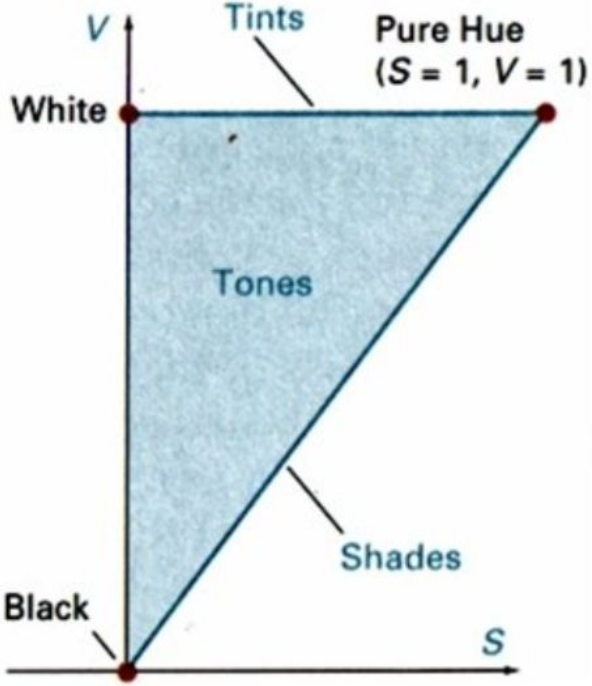

- Color components:
  - Hue (H) ∈ [0°, 360°]
  - Saturation (S) ∈ [0, 1]
  - Value (V) ∈ [0, 1]

# HSV Color Definition




- Color definition
  - Select hue, S=1, V=1
  - Add black pigments, i.e., decrease V
  - Add white pigments, i.e., decrease S
- Cross section of the HSV hexcone showing regions for shades, tints, and tones

# HSV Color Definition

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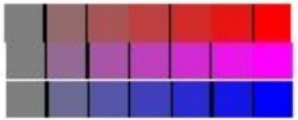
- Cross section of the HSV hexcone showing regions for shades, tints, and tones

# HSV

- Hue is the most obvious characteristic of a color
- Chroma is the purity of a color
  - High chroma colors look rich and full
  - Low chroma colors look dull and grayish
  - Sometimes chroma is called saturation



- Value is the lightness or darkness of a color
  - Sometimes light colors are called tints, and
  - Dark colors are called shades

# Thanks!