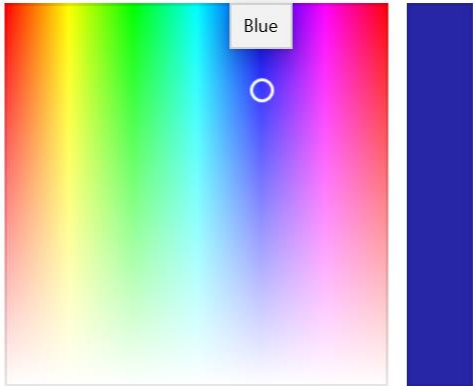


Color Model of Light

Additive Color

Pick a background color



A color picker interface. At the top, a rainbow gradient bar is shown with a white circle labeled 'Blue' indicating the selected color. To the right of the gradient bar is a vertical blue bar. Below the gradient bar is a horizontal slider with a black knob positioned towards the right end. Below the slider is a 'Less ^' link. At the bottom, there are three input fields for HSV values: '241' for Hue, '77' for Saturation, and '65' for Value. To the right of these fields is a text box containing the hex code '#2726A6'. At the very bottom are 'Done' and 'Cancel' buttons.

Blue

Less ^

HSV ▾

#2726A6

241 Hue

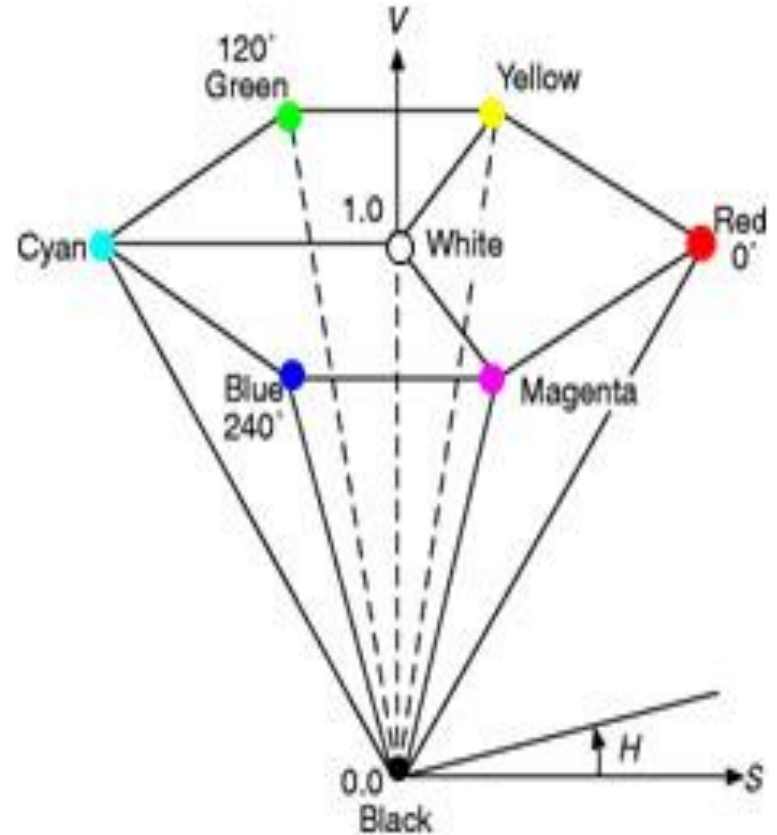
77 Saturation

65 Value

Done Cancel

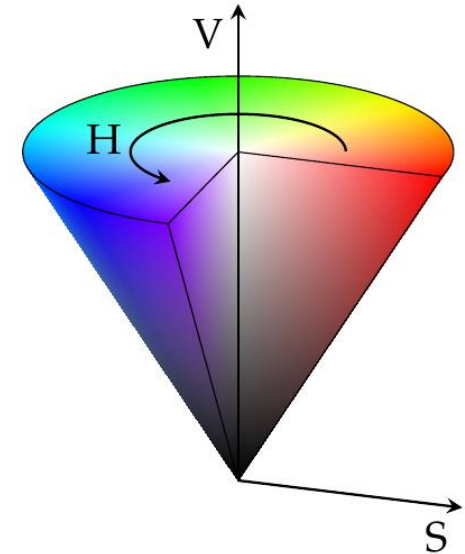
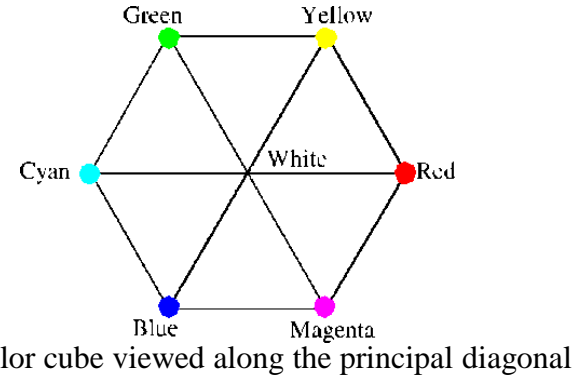
The HSV Color Model

- ▶ **H**ue, **S**aturation, **V**alue (Brightness)
- ▶ HSV-space invented by Alvy Ray Smith—described in his 1978 SIGGRAPH paper, *Color Gamut Transformation Pairs*.
- ▶ Hexcone subset of cylindrical (polar) coordinate system
- ▶ Single hexcone HSV color model.
The cross-section at $V = 1$ contains the RGB model's $R = 1, G = 1, B = 1$



The HSV Color Model

- ▶ Colors on $V = 1$ plane are not equally bright perceptually
- ▶ Complementary colors 180° opposite (Hue = 0 to 360°)
- ▶ Saturation measured relative to color gamut represented by mathematical HSV model which is subset of the perceptually-based chromaticity diagram for a given value (Color Button in TV):
- ▶ Top of HSV hexcone is projection seen by looking along principal diagonal of RGB color
- ▶ RGB subcubes are plane of constant V
- ▶ Note: linear path RGB \neq linear path in HSV! (has consequences for interpolation/animation)



The HSV Color Model

► RGB to HSV conversion

$$C_{max} = \max(R, G, B);$$

$$\Delta = C_{max} - \min(R, G, B);$$

$$V = C_{max};$$

$$\text{if } (V == 0)\{$$

$$S = 0;$$

$$\}$$
$$\text{else } \{$$

$$S = \Delta / C_{max};$$

$$\}$$
$$\text{if } (S == 0)\{$$
$$H = \text{undefined};$$
$$\}$$
$$\text{else } \{$$
$$\text{if } (C_{max} == R)\{$$

$$H = \left(\frac{G-B}{\Delta} \times 60 \right) \bmod 360;$$

$$\}$$
$$\text{else if } (C_{max} == G)\{$$

$$H = \left(\frac{B-R}{\Delta} \times 60 \right) + 120;$$

$$\}$$
$$\text{else } \{$$

$$H = \left(\frac{R-G}{\Delta} \times 60 \right) + 240;$$

$$\}$$
$$\}$$

The HSV Color Model

► HSV to RGB conversion

$$C_1 = V \cdot S$$

$$C_2 = C_1 \cdot \left(1 - \left|\frac{H}{60^\circ} \bmod 2 - 1\right|\right)$$

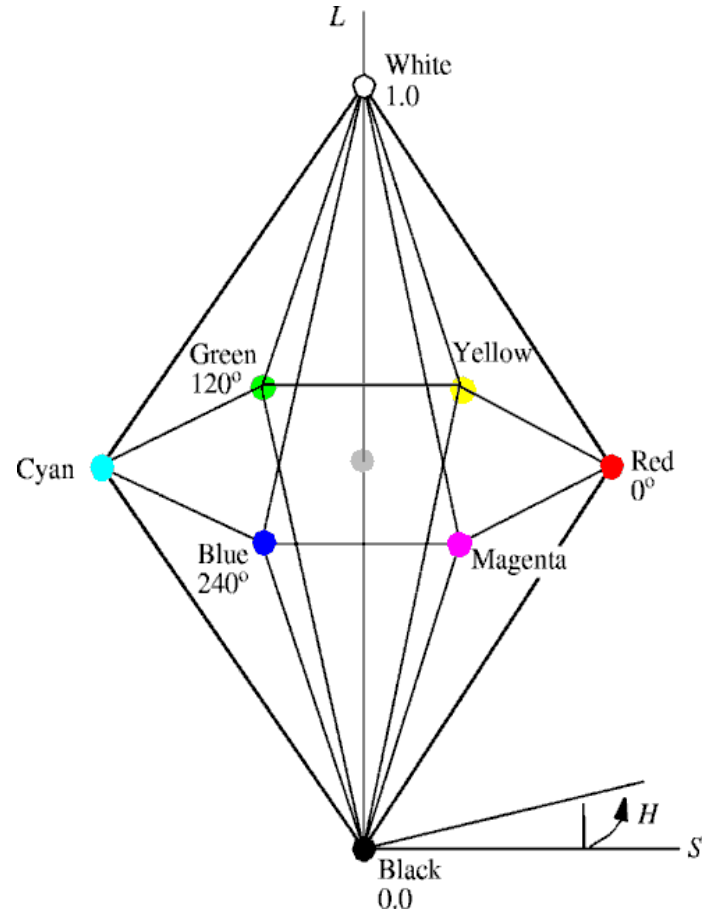
$$(R', G', B') = \begin{cases} (C_1, C_2, 0), & 0^\circ < H < 60^\circ \\ (C_2, C_1, 0), & 60^\circ < H < 120^\circ \\ (0, C_1, C_2), & 120^\circ < H < 180^\circ \\ (0, C_2, C_1), & 180^\circ < H < 240^\circ \\ (C_2, 0, C_1), & 240^\circ < H < 300^\circ \\ (C_1, 0, C_2), & 300^\circ < H < 360^\circ \end{cases}$$

$$C_{min} = V - C_1$$

$$(R, G, B) = (R' + C_{min}, G' + C_{min}, B' + C_{min})$$

The HLS Color Model

- ▶ **H**ue, **L**ightness, **S**aturation
- ▶ Double-hexcone subset of XYZ space
- ▶ Maximally saturated hues are at $S = 1$, $L = 0.5$
- ▶ Conceptually easier for some people to view white as a point



The HLS Color Model

► RGB to HLS conversion

$$C_{max} = \max(R, G, B);$$

$$C_{min} = \min(R, G, B);$$

$$\Delta = C_{max} - C_{min};$$

$$L = (C_{max} + C_{min})/2;$$

$$\text{if } (L == 0)\{$$

$$S = 0;$$

$$\}$$
$$\text{else } \{$$

$$S = \frac{\Delta}{1 - |2L - 1|};$$

$$\}$$
$$\text{if } (S == 0)\{$$
$$H = \text{undefined};$$
$$\}$$
$$\text{else } \{$$
$$\text{if } (C_{max} == R)\{$$

$$H = \left(\frac{G - B}{\Delta} \times 60 \right) \bmod 360;$$

$$\}$$
$$\text{else if } (C_{max} == G)\{$$

$$H = \left(\frac{B - R}{\Delta} \times 60 \right) + 120;$$

$$\}$$
$$\text{else } \{$$

$$H = \left(\frac{R - G}{\Delta} \times 60 \right) + 240;$$

$$\}$$
$$\}$$

The HLS Color Model

HSL to RGB conversion formula

When $0 \leq H < 360$, $0 \leq S \leq 1$ and $0 \leq L \leq 1$:

$$C = (1 - |2L - 1|) \times S$$

$$X = C \times (1 - |(H / 60^\circ) \bmod 2 - 1|)$$

$$m = L - C/2$$

$$(R', G', B') = \begin{cases} (C, X, 0) & , 0^\circ \leq H < 60^\circ \\ (X, C, 0) & , 60^\circ \leq H < 120^\circ \\ (0, C, X) & , 120^\circ \leq H < 180^\circ \\ (0, X, C) & , 180^\circ \leq H < 240^\circ \\ (X, 0, C) & , 240^\circ \leq H < 300^\circ \\ (C, 0, X) & , 300^\circ \leq H < 360^\circ \end{cases}$$

$$(R, G, B) = ((R' + m) \times 255, (G' + m) \times 255, (B' + m) \times 255)$$