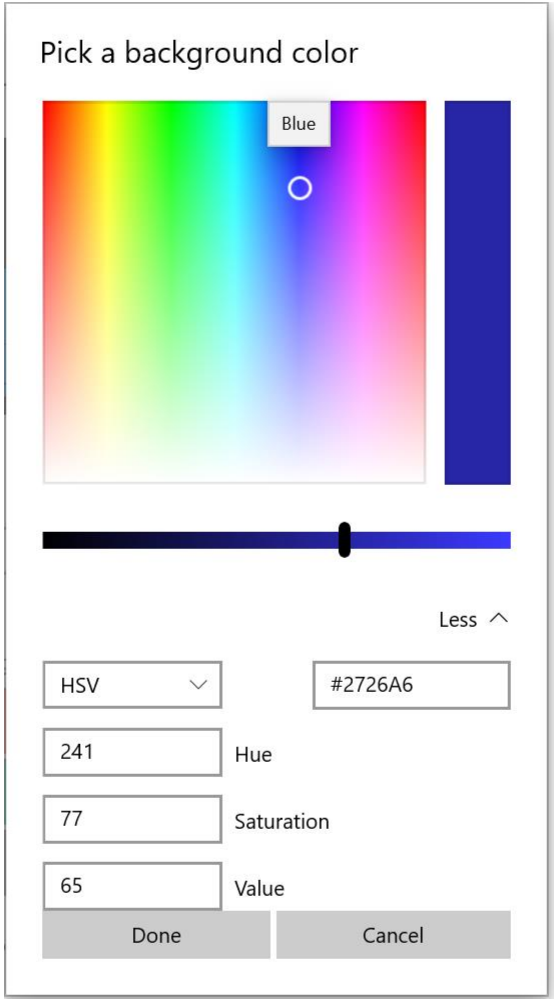
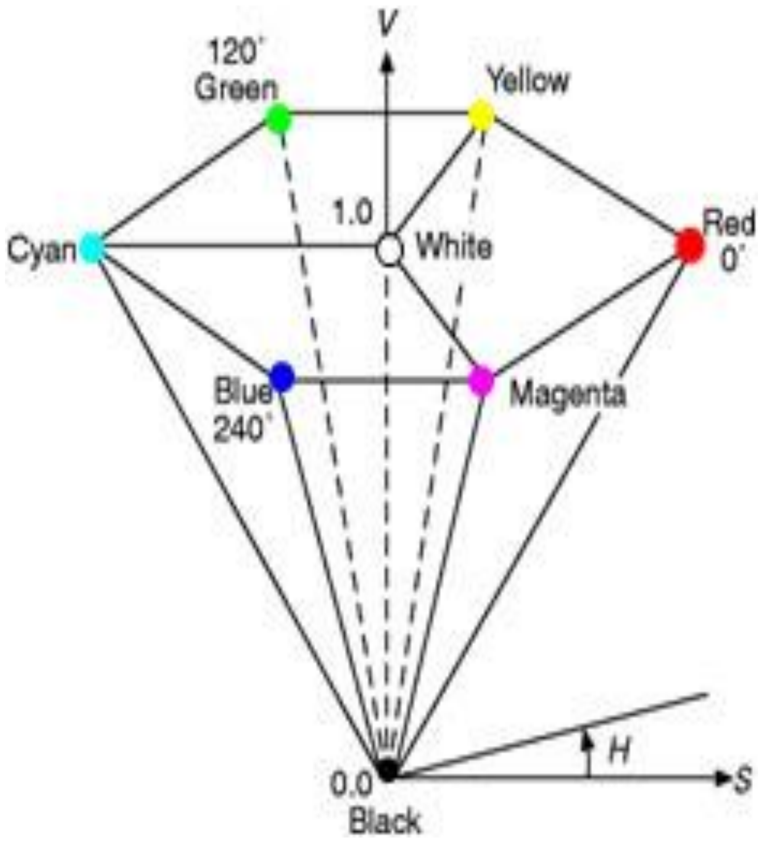
Color Model of Light

Additive Color



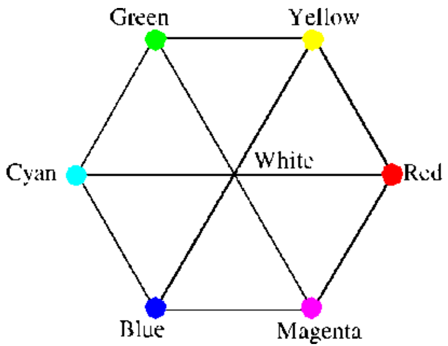
The HSV Color Model

- Hue, Saturation, Value (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

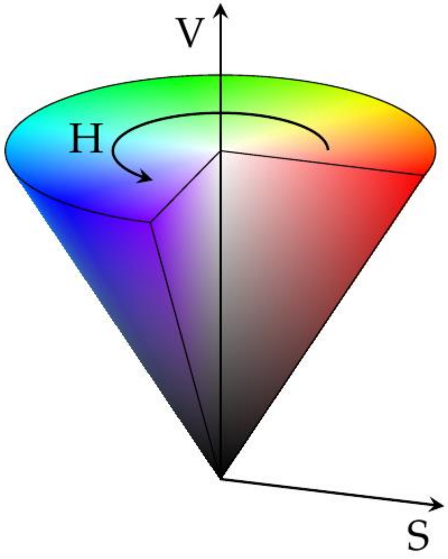


The HSV Color Model

- Colors on V = 1 plane are not equally bright perceptually
- Complementary colors 180° opposite (Hue = 0 to 360^0)
- 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 ≠ linear path in HSV! (has consequences for interpolation/animation)



RGB color cube viewed along the principal diagonal



The HSV Color Model

- RGB to HSV conversion

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

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

$V = C_{max};$

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

$\quad S = 0;$

$\}$

$else\ \{$

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

$\}$

$if\ (S == 0)\{$

$\quad H = undefined;$

$\}$

$else\ \{$

$\quad if\ (C_{max} == R)\{$

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

$\quad \}$

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

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

$\quad \}$

$\quad else\ \{$

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

$\quad \}$

$\}$

The HSV Color Model

- HSV to RGB conversion

$$C_1 = V \times S$$

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

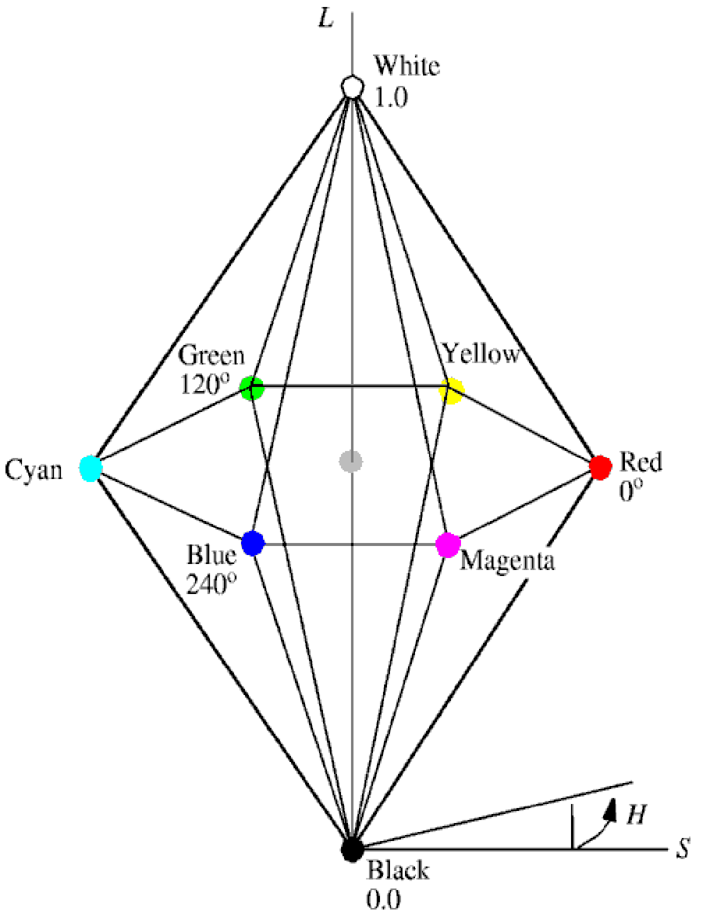
$$(R', G', B') = \begin{cases} (C_1, C_2, 0), & 0^\circ < H < 60^\circ \\ (C_2, C_1, 0), & 60^\circ < H < 120^\circ \\ (0, C_1, C_2), & 120^\circ < H < 180^\circ \\ (0, C_2, C_1), & 180^\circ < H < 240^\circ \\ (C_2, 0, C_1), & 240^\circ < H < 300^\circ \\ (C_1, 0, C_2), & 300^\circ < H < 360^\circ \end{cases}$$

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

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

The HLS Color Model

- Hue, Lightness, Saturation
- 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

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

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

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

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

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

$\quad S = 0;$

$\}$

$else\ \{$

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

$\}$

$if\ (S == 0)\{$

$\quad H = undefined;$

$\}$

$else\ \{$

$\quad if\ (C_{max} == R)\{$

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

$\quad \}$

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

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

$\quad \}$

$\quad else\ \{$

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

$\quad \}$

$\}$

The HLS Color Model

HSL to RGB conversion formula

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

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

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

$$m = L - C/2$$

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

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