COMPUTER GRAPHICS AND MULTIMEDIA

Unit-6: Color Model

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Today's Lecture

- Color Fundamentals
- Color Models

Color Model

Color Fundamentals

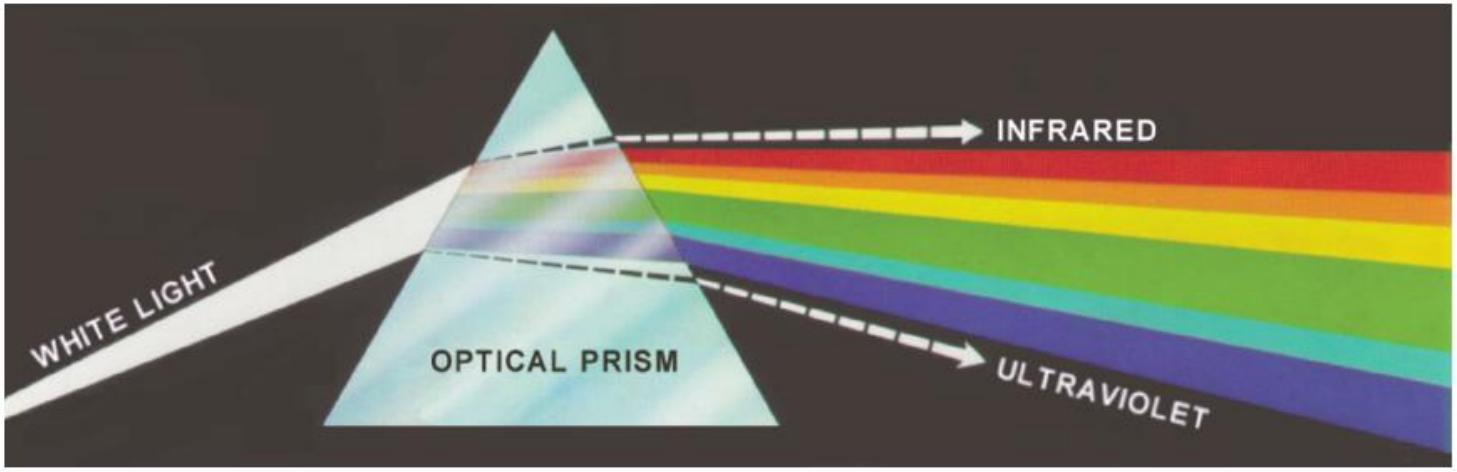


FIGURE 6.1 Color spectrum seen by passing white light through a prism. (Courtesy of the General Electric Co., Lamp Business Division.)

Color Model

Color Fundamentals

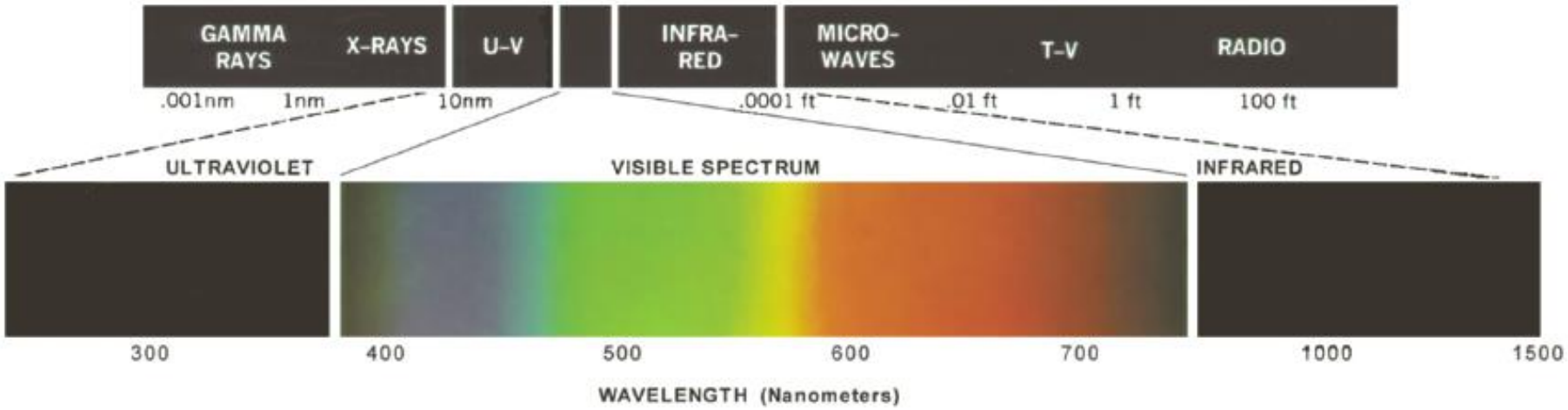


FIGURE 6.2 Wavelengths comprising the visible range of the electromagnetic spectrum. (Courtesy of the General Electric Co., Lamp Business Division.)

Color Model

Color Fundamentals

- 6 to 7 million cones in the human eye can be divided into three principal sensing categories, corresponding roughly to red, green, and blue.
- 65%: red 33%: green 2%: blue (blue cones are the most sensitive)

Color Model

Color Fundamentals

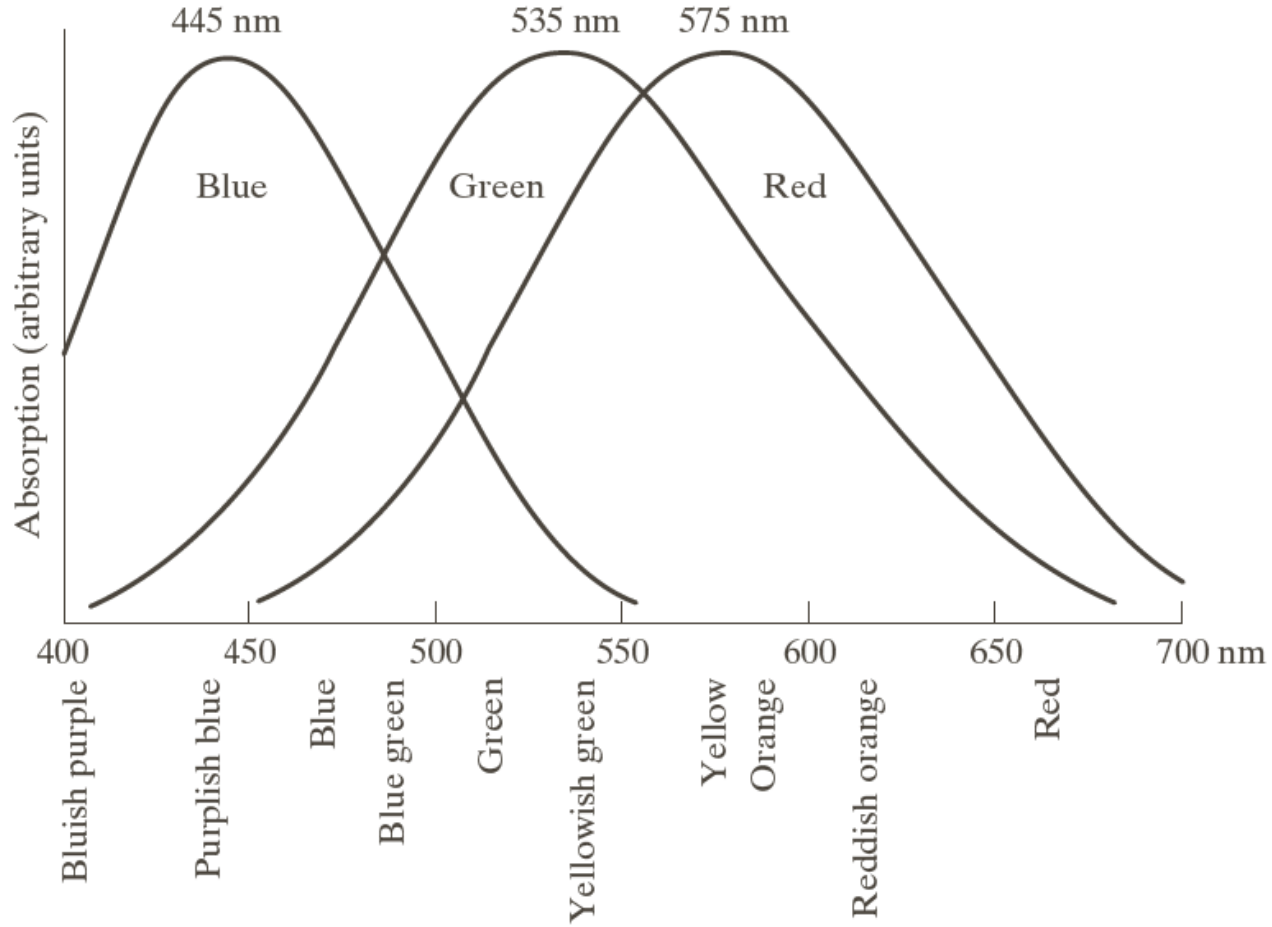
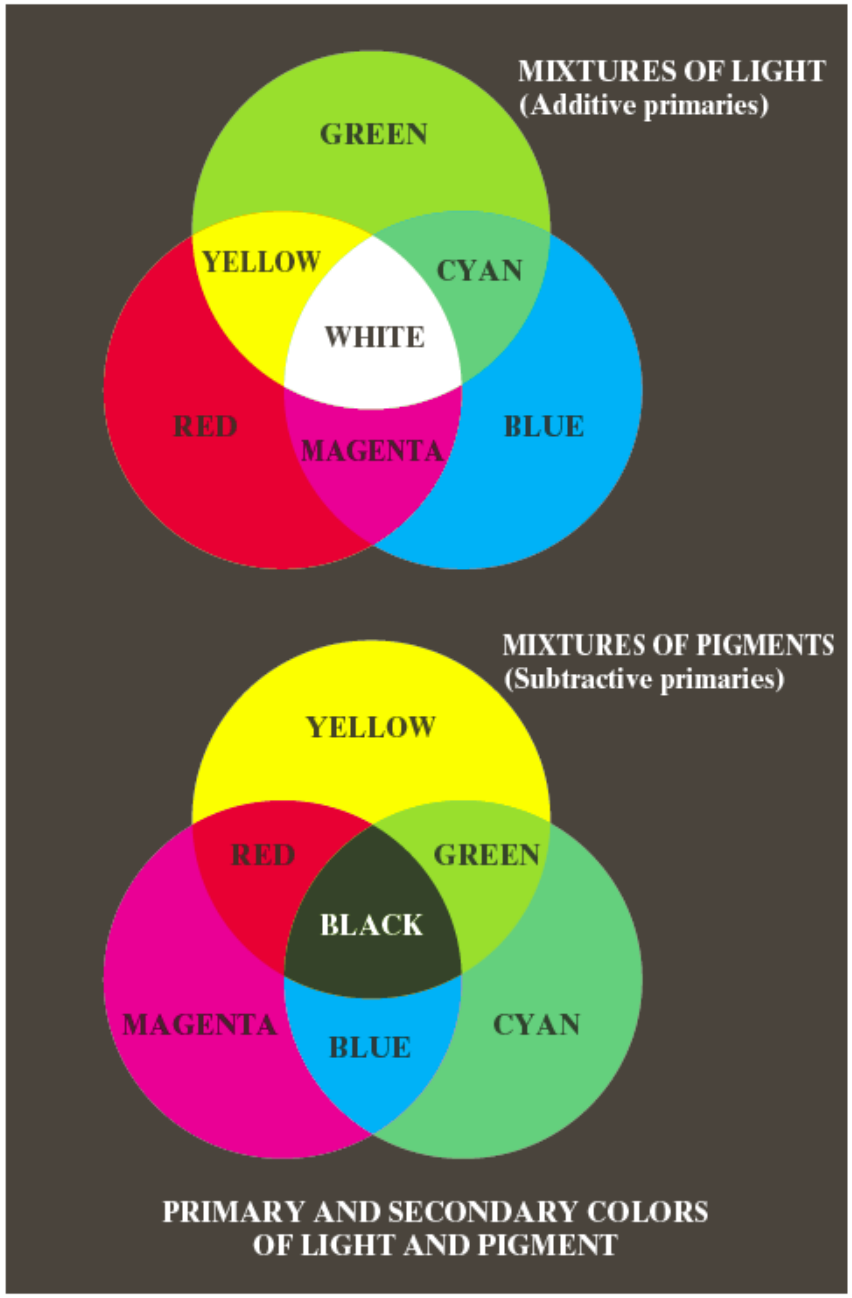


FIGURE 6.3
Absorption of light by the red, green, and blue cones in the human eye as a function of wavelength.



a
b

FIGURE 6.4
Primary and secondary colors of light and pigments. (Courtesy of the General Electric Co., Lamp Business Division.)

Color Model

Color Fundamentals

- The characteristics generally used to distinguish one color from another are brightness, hue, and saturation

Brightness: the achromatic notion of intensity.

Hue: dominant wavelength in a mixture of light waves, represents dominant color as perceived by an observer.

Saturation: relative purity or the amount of white light mixed with its hue.

Color Model

Color Fundamentals

- Tristimulus

  Red, green, and blue are denoted X, Y, and Z, respectively. A color is defined by its trichromatic coefficients, defined as

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

$$z = \frac{Z}{X + Y + Z}$$

Color Model

CIE Chromaticity Diagram

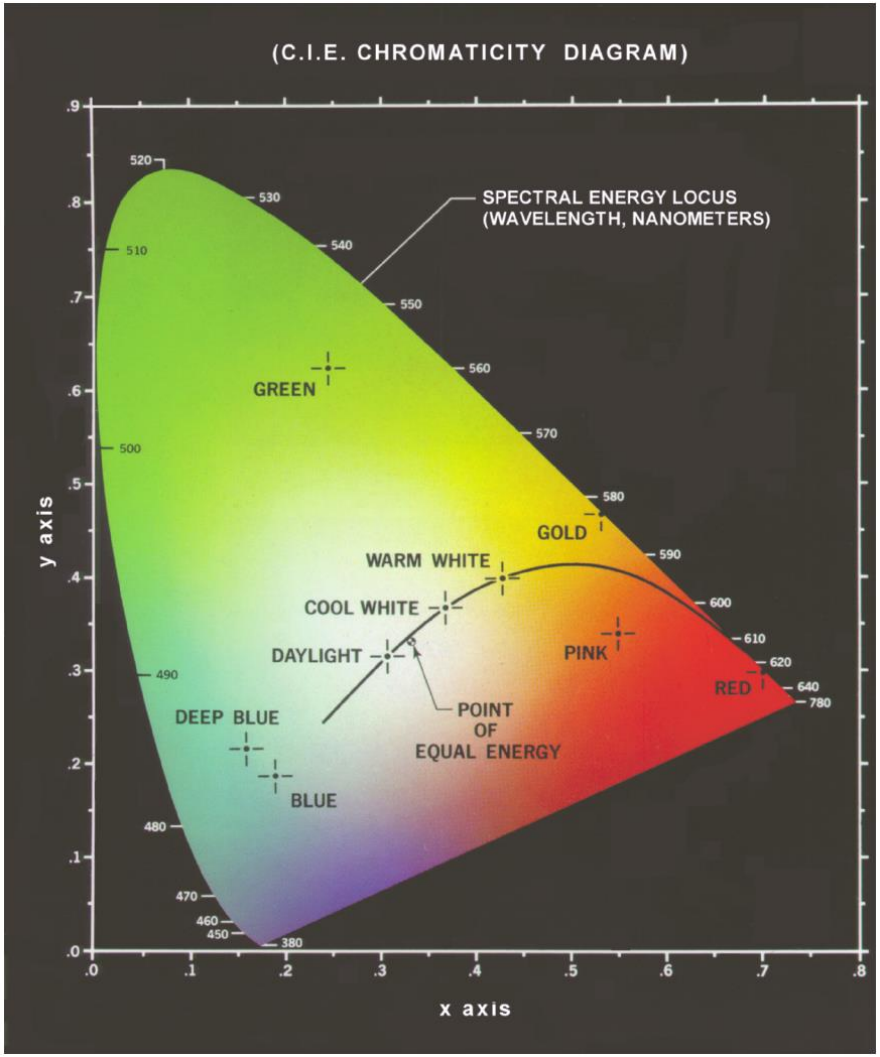


FIGURE 6.5 Chromaticity diagram. (Courtesy of the General Electric Co., Lamp Business Division.)

It shows color composition as a function of x (red) and y (green)

Color Model

RGB Color Model

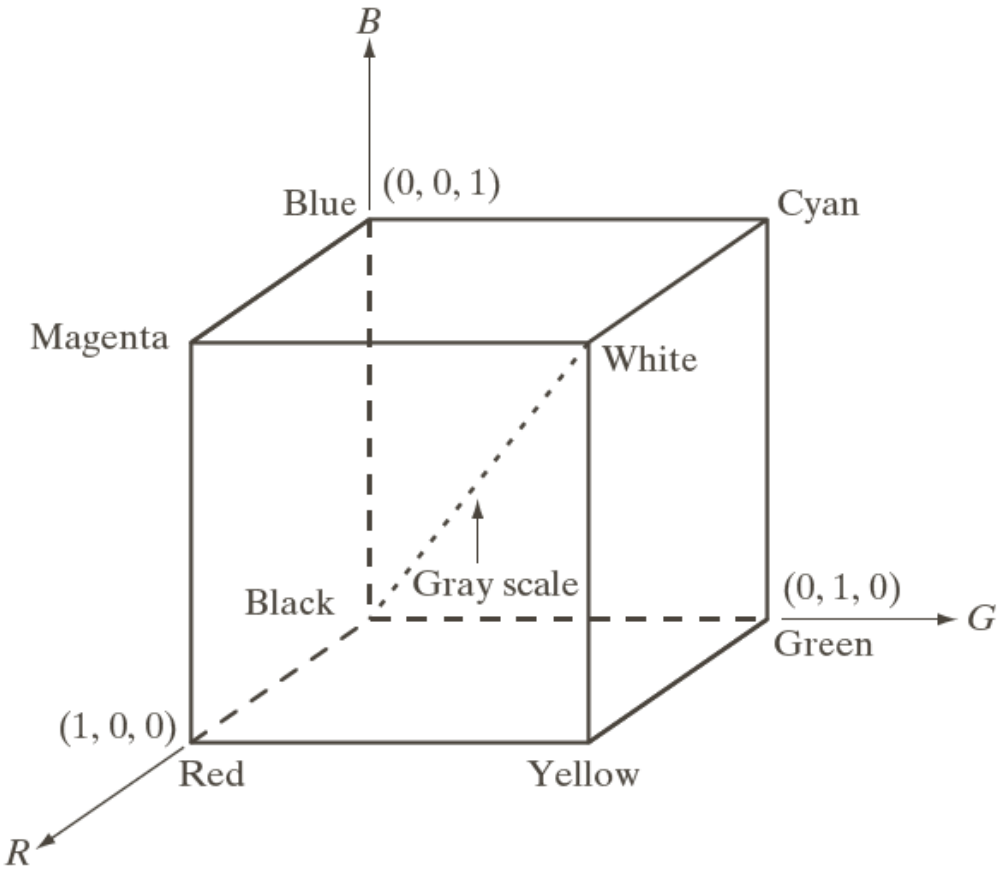


FIGURE 6.7 Schematic of the RGB color cube. Points along the main diagonal have gray values, from black at the origin to white at point (1, 1, 1).

Color Model

RGB Color Model

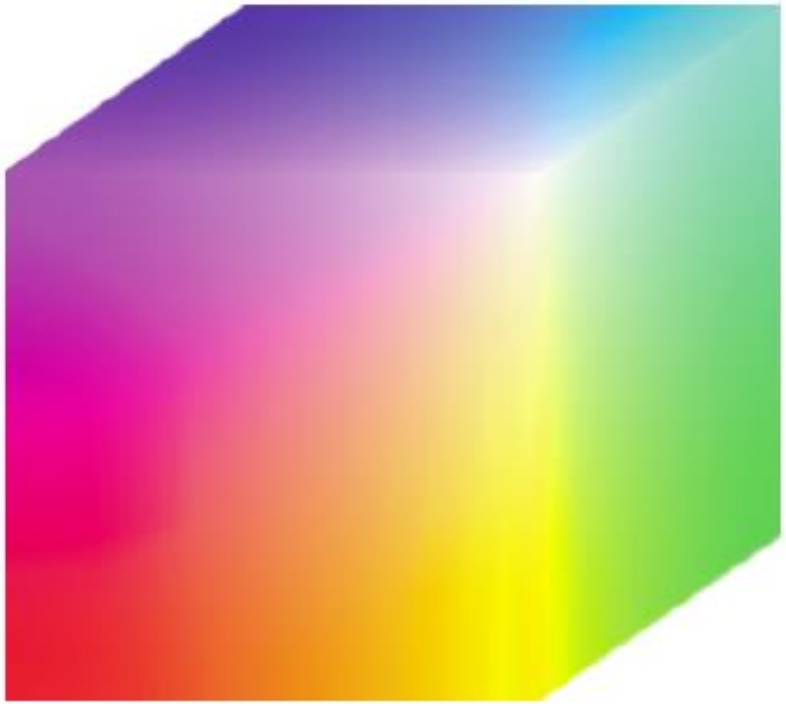


FIGURE 6.8 RGB 24-bit color cube.

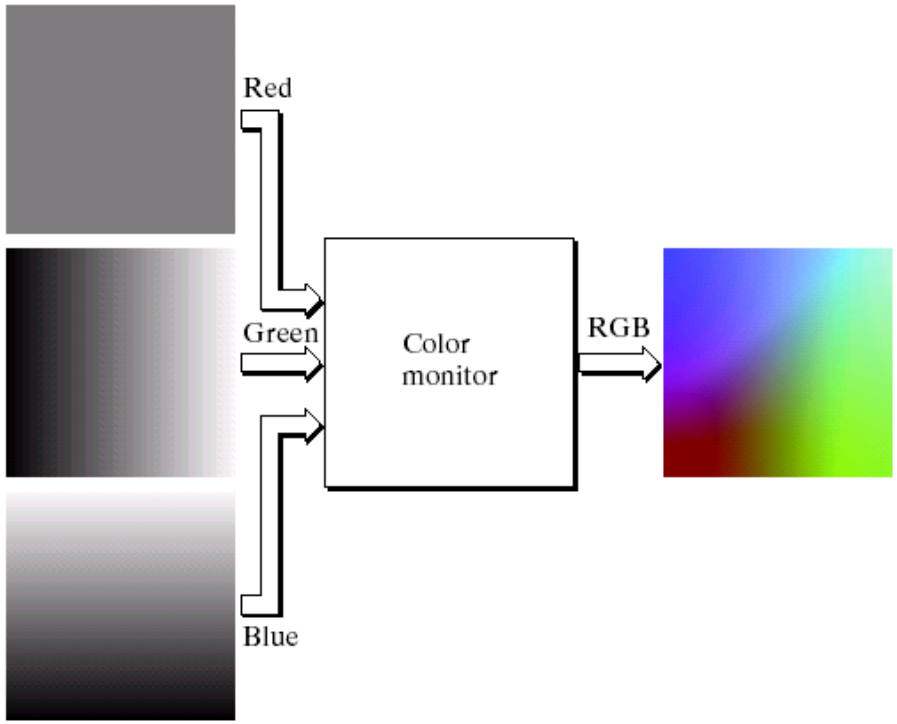
The total number of colors in a 24-bit RGB image is $(2^8)^3$ = 16,777,216

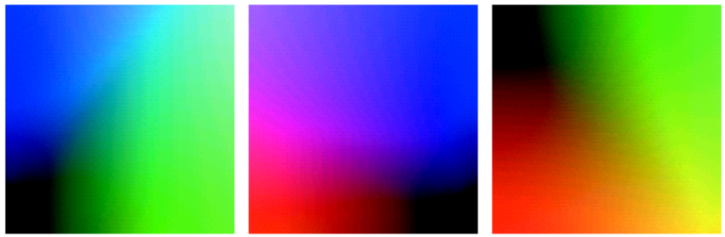
Color Model

RGB Color Model

a
b

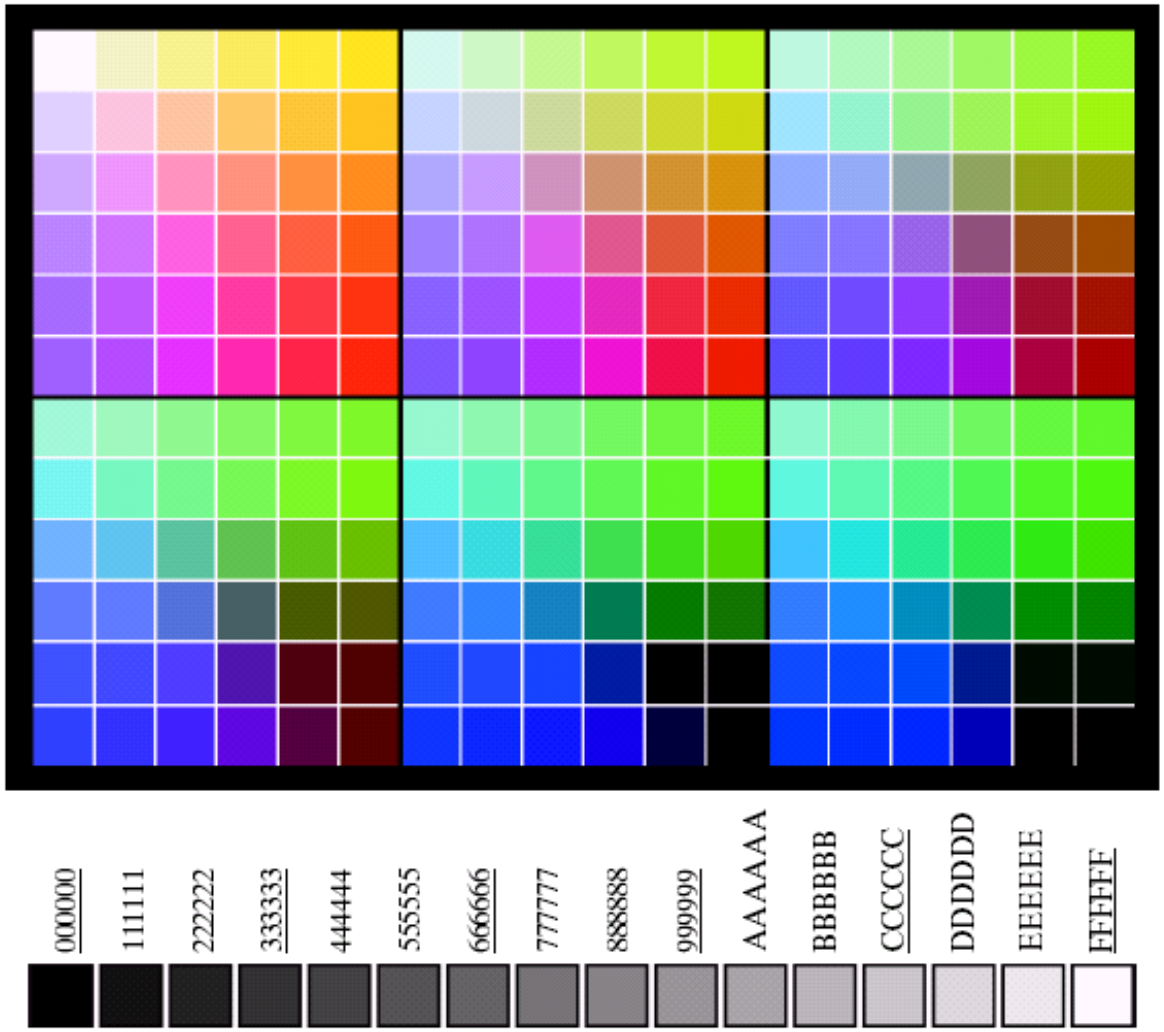
FIGURE 6.9
(a) Generating the RGB image of the cross-sectional color plane (127, G, B).
(b) The three hidden surface planes in the color cube of Fig. 6.8.





Number System	Color Equivalents					
Hex	00	33	66	99	CC	FF
Decimal	0	51	102	153	204	255

TABLE 6.1
Valid values of each RGB component in a safe color.



a
b

FIGURE 6.10
(a) The 216 safe RGB colors. (b) All the grays in the 256-color RGB system (grays that are part of the safe color group are shown underlined).

Color Model

RGB Color Model

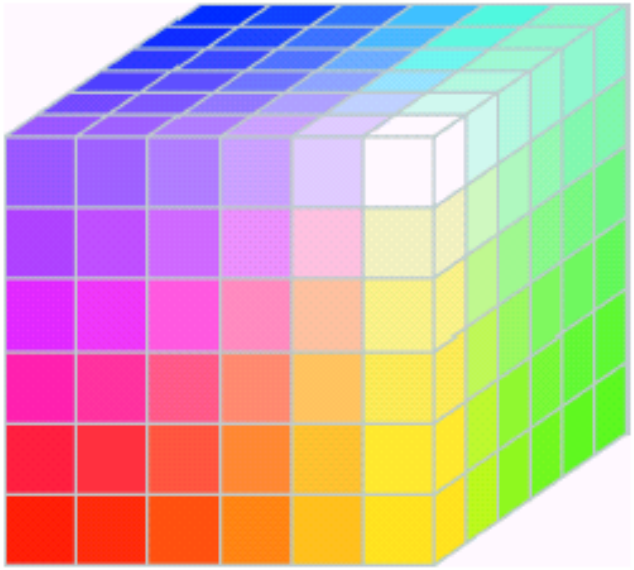


FIGURE 6.11 The RGB safe-color cube.

Color Model

The CMY and CMYK Color Models

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

- Equal amounts of the pigment primaries, cyan, magenta, and yellow should produce black. In practice, combining these colors for printing produces a muddy-looking black.

- To produce true black, the predominant color in printing, the fourth color, black, is added, giving rise to the CMYK color model.

CMY vs. CMYK

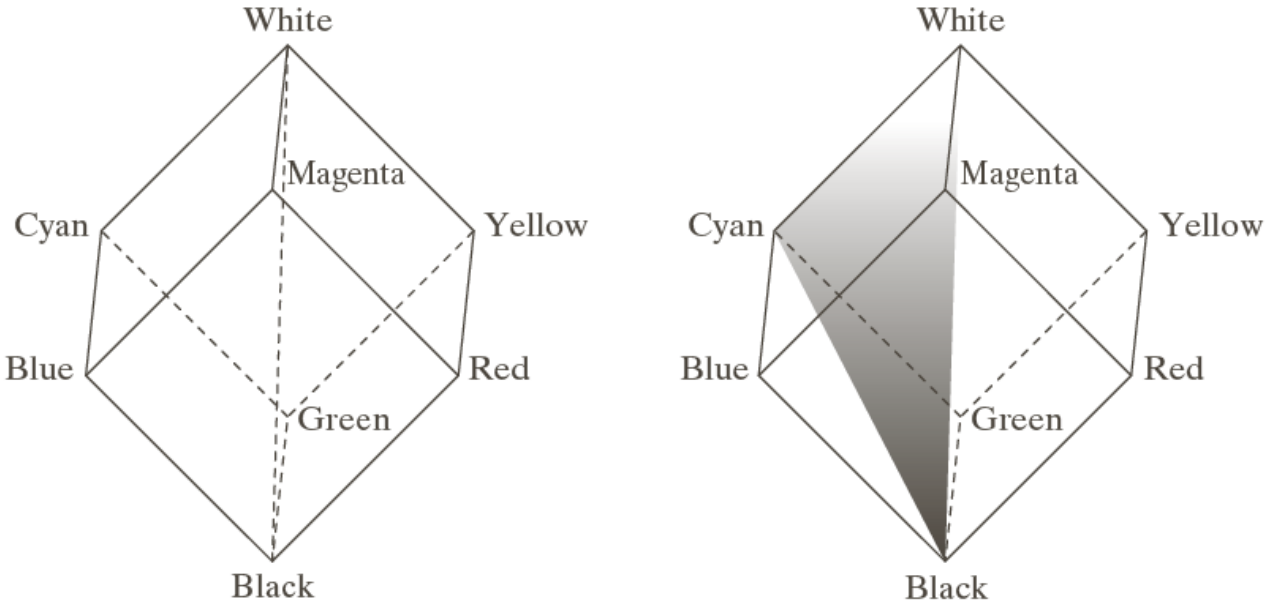
Color Model

HSI Color Model

- **Hue**: dominant wavelength in a mixture of light waves, represents dominant color as perceived by an observer.
- **Saturation**: relative purity or the amount of white light mixed with its hue.
- **Intensity**: the achromatic notion of **intensity**.

Color Model

HSI Color Model

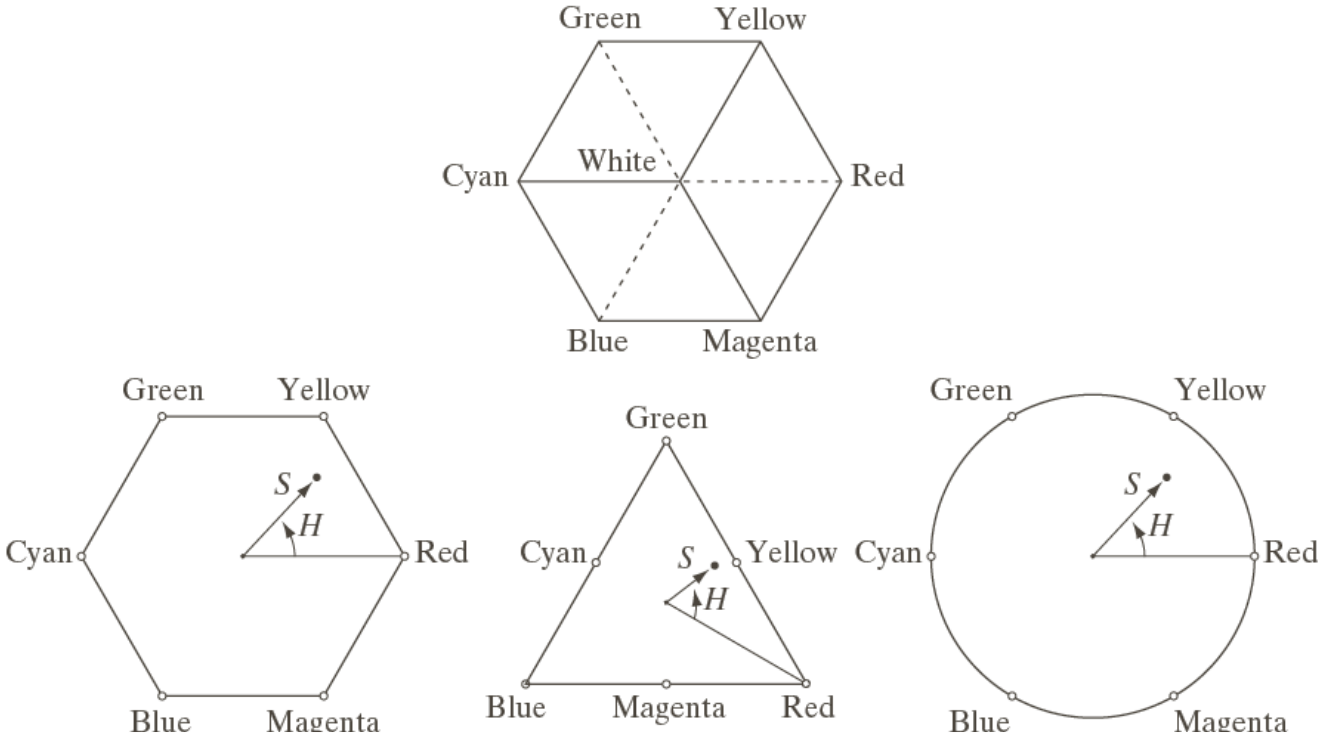


a b

FIGURE 6.12 Conceptual relationships between the RGB and HSI color models.

Color Model

HSI Color Model



a
b c d

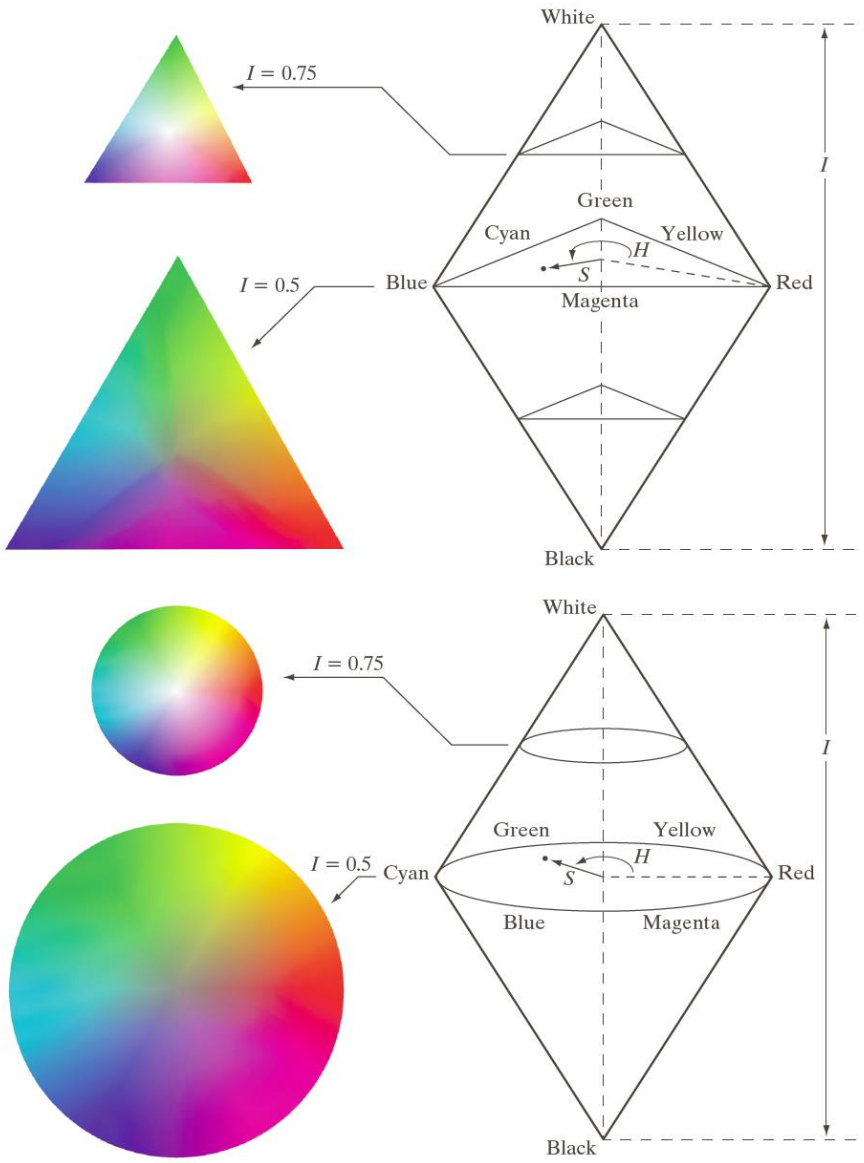
FIGURE 6.13 Hue and saturation in the HSI color model. The dot is an arbitrary color point. The angle from the red axis gives the hue, and the length of the vector is the saturation. The intensity of all colors in any of these planes is given by the position of the plane on the vertical intensity axis.

Color Model

HSI Color Model

a
b

FIGURE 6.14 The HSI color model based on (a) triangular and (b) circular color planes. The triangles and circles are perpendicular to the vertical intensity axis.



Color Model

Converting Colors from RGB to HSI

- Given an image in RGB color format, the H component of each RGB pixel is obtained using the equation

$$H = \begin{cases} \theta & \text{if } B \le G \\ 360 - \theta & \text{if } B > G \end{cases}$$

$$\theta = \cos^{-1}\left\{ \frac{\frac{1}{2}\left[(R-G)+(R-B)\right]}{\left[(R-G)^2+(R-B)(G-B)\right]^{1/2}} \right\}$$

Color Model

Converting Colors from RGB to HSI

- Given an image in RGB color format, the saturation component is given by

$$S = 1 - \frac{3}{(R+G+B)}\left[\min(R,G,B)\right]$$

Color Model

Converting Colors from RGB to HSI

- Given an image in RGB color format, the intensity component is given by

$$I = \frac{1}{3}(R + G + B)$$

Color Model

Converting Colors from HSI to RGB

RG sector $(0^\circ \le H < 120^\circ)$

$$B = I(1 - S)$$

$$R = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

and

$$G = 3I - (R + B)$$

Color Model

Converting Colors from HSI to RGB

RG sector $(120^\circ \le H < 240^\circ)$

$$H = H - 120^\circ$$

$$R = I(1 - S)$$

$$G = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

and

$$B = 3I - (R + G)$$

Color Model

Converting Colors from HSI to RGB

RG sector $(240^\circ \le H \le 360^\circ)$

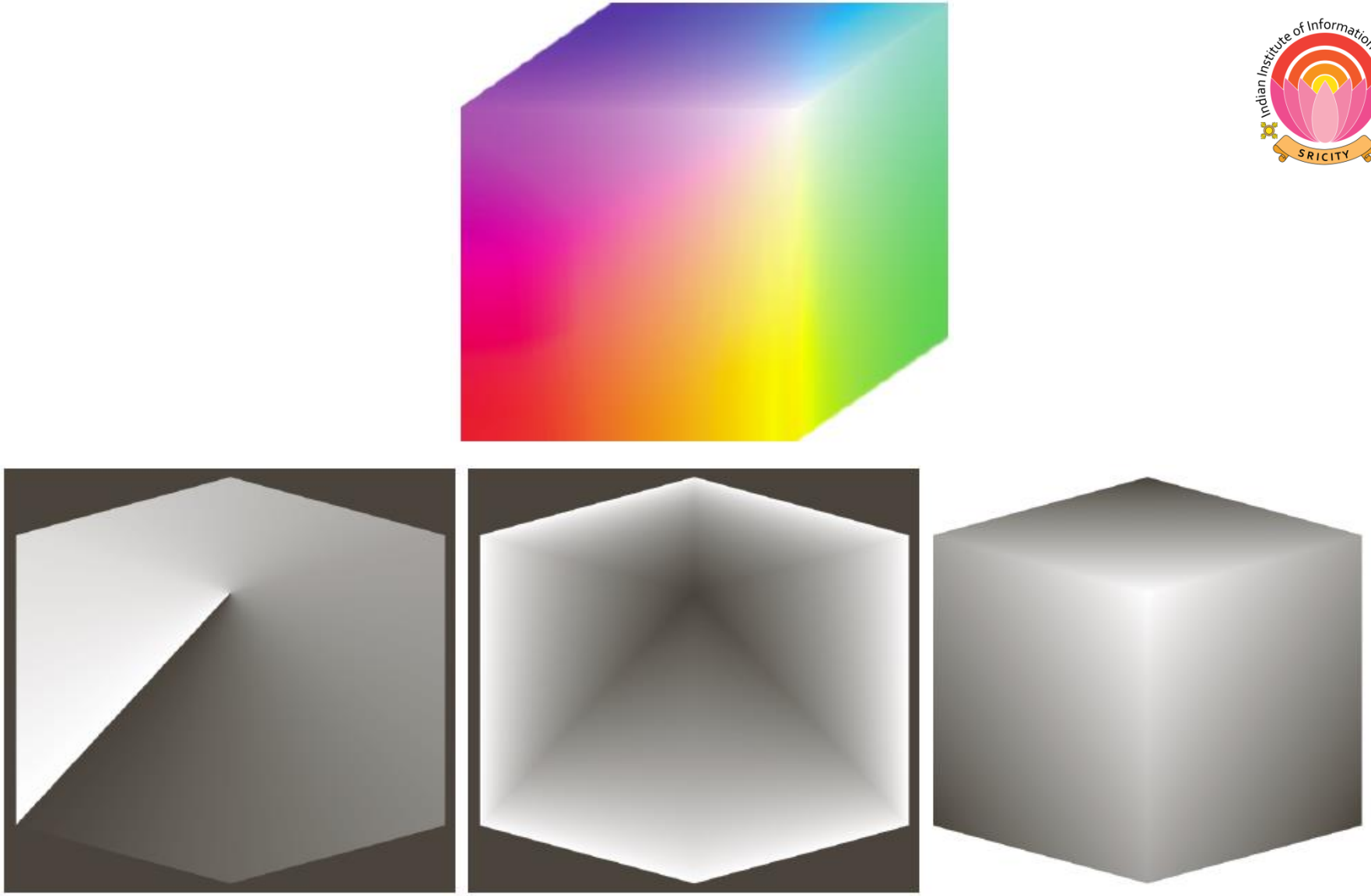
$$H = H - 240^\circ$$

$$G = I(1 - S)$$

$$B = I\left[1 + \frac{S\cos H}{\cos(60^\circ - H)}\right]$$

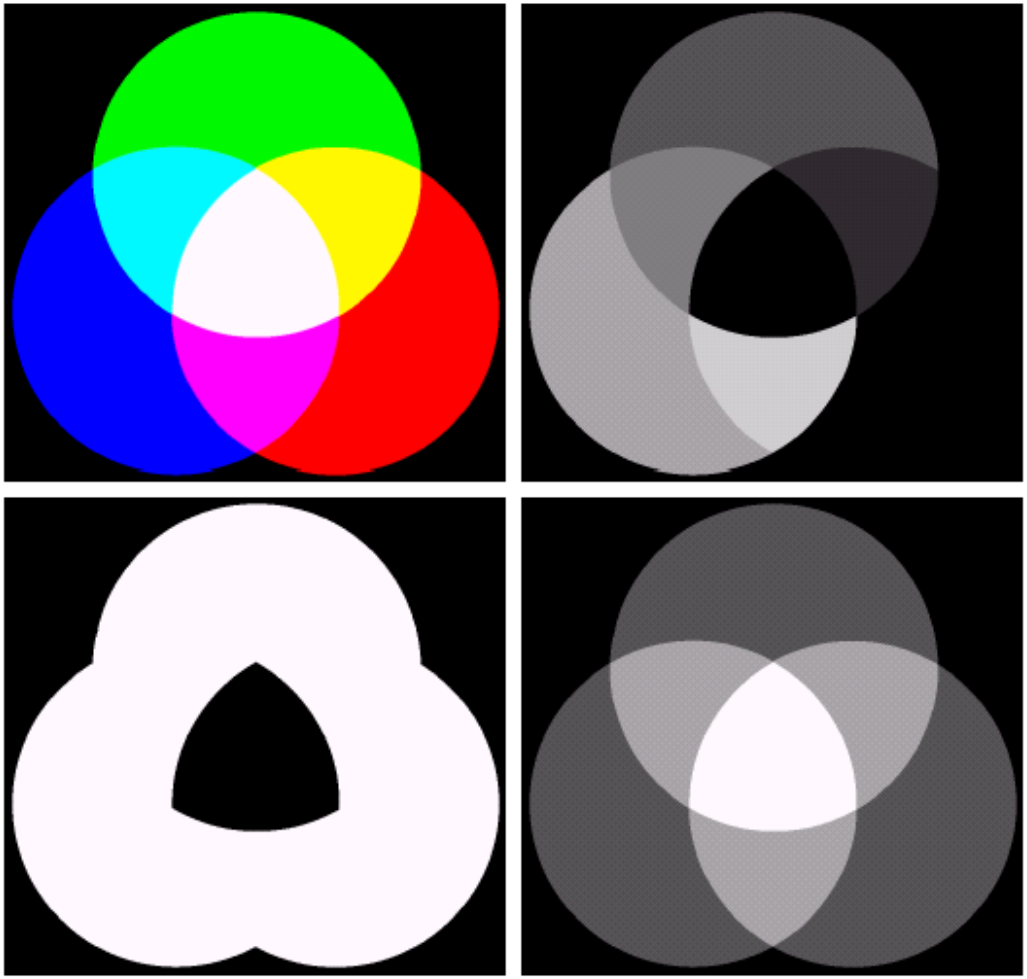
and

$$R = 3I - (G + B)$$



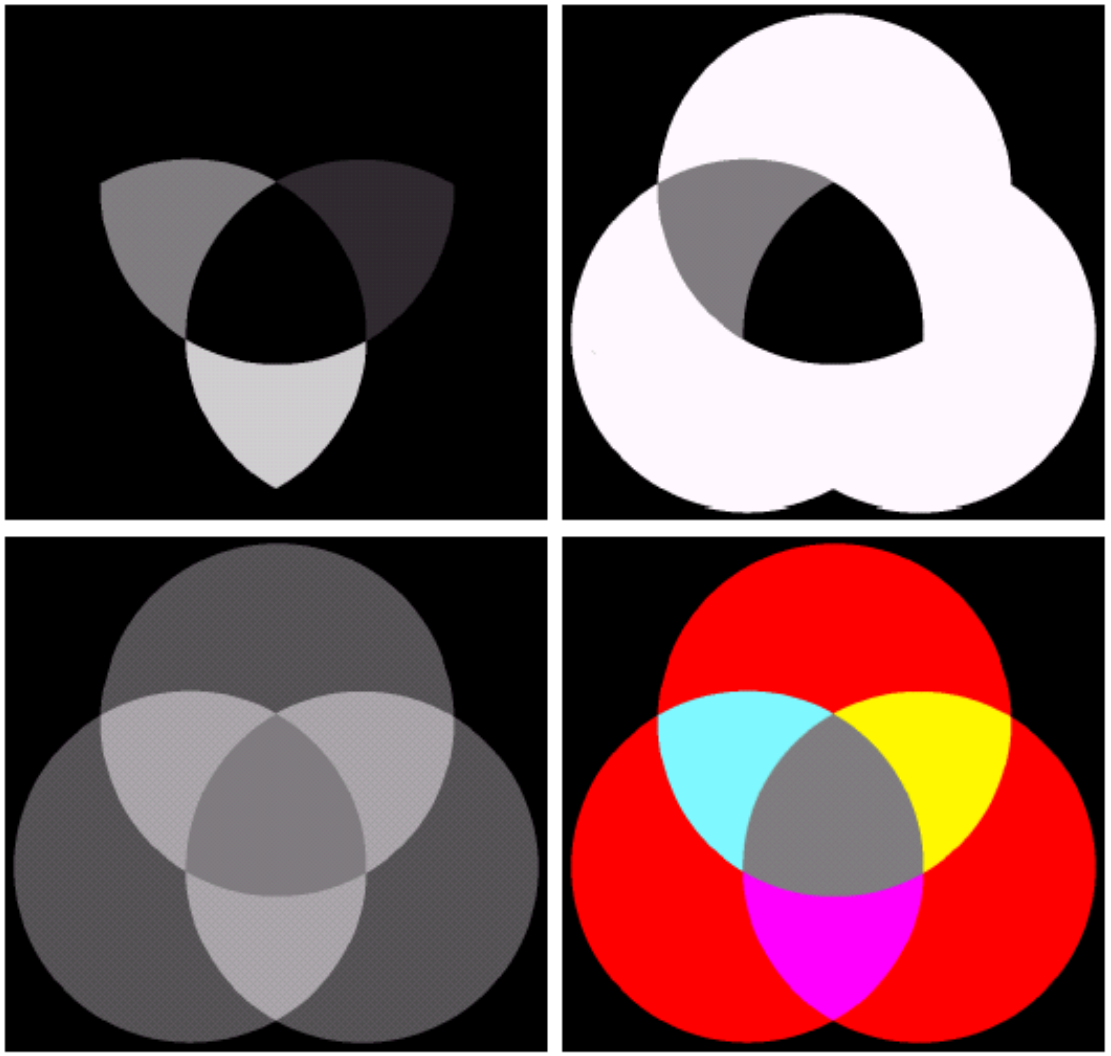
a b c

FIGURE 6.15 HSI components of the image in Fig. 6.8. (a) Hue, (b) saturation, and (c) intensity images.



a b
c d

FIGURE 6.16 (a) RGB image and the components of its corresponding HSI image: (b) hue, (c) saturation, and (d) intensity.



a b
c d

FIGURE 6.17 (a)–(c) Modified HSI component images. (d) Resulting RGB image. (See Fig. 6.16 for the original HSI images.)