IMAGE PROCESSING USING PYTHON

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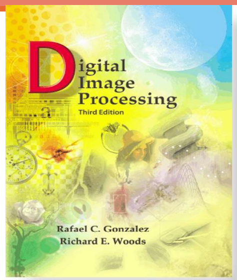
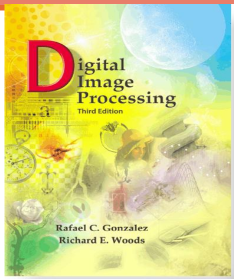


Syllabus

- ❑ Fundamentals of Image Processing:
  - Introduction
  - Fundamental steps in image processing
  - Image sampling, Quantization, Resolution
  - Elements of image processing system
  - Applications of Digital image processing

- ❑ Color fundamentals, Color image formats and conversion.



Contents

- Introduction
- Color models and Conversion

Introduction

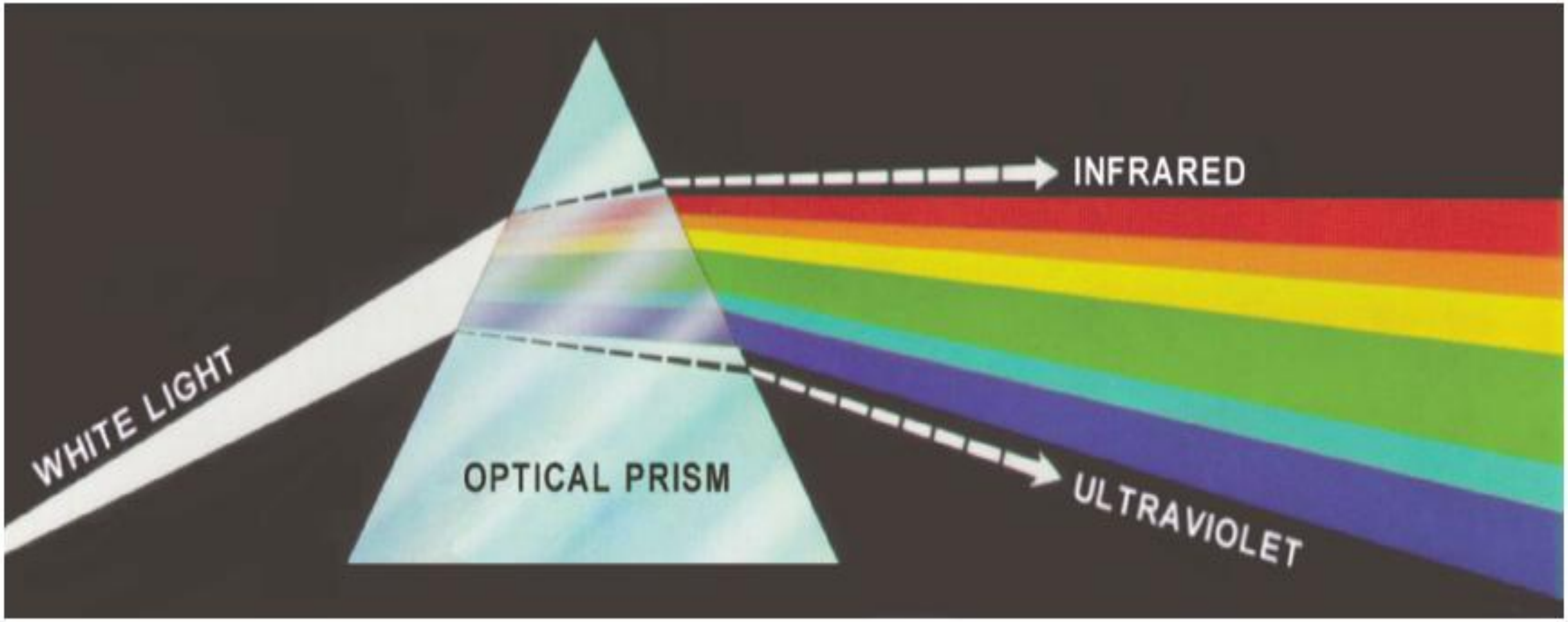


FIGURE 1 Color spectrum seen by passing white light through a prism.

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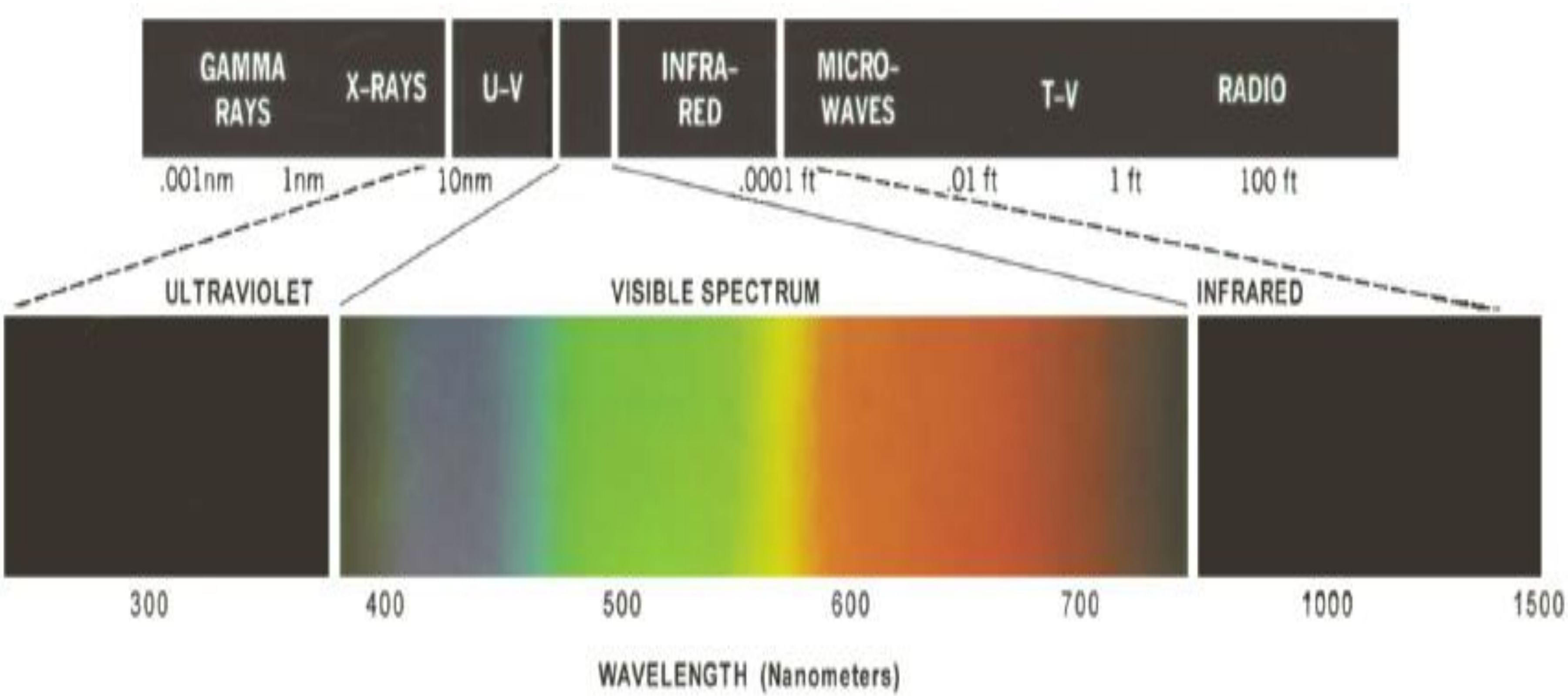
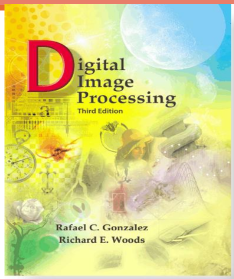


FIGURE 2 Wavelengths comprising the visible range of the electromagnetic spectrum.



Light

The colors that humans perceive in an object are determined by the nature of the light reflected from the object.

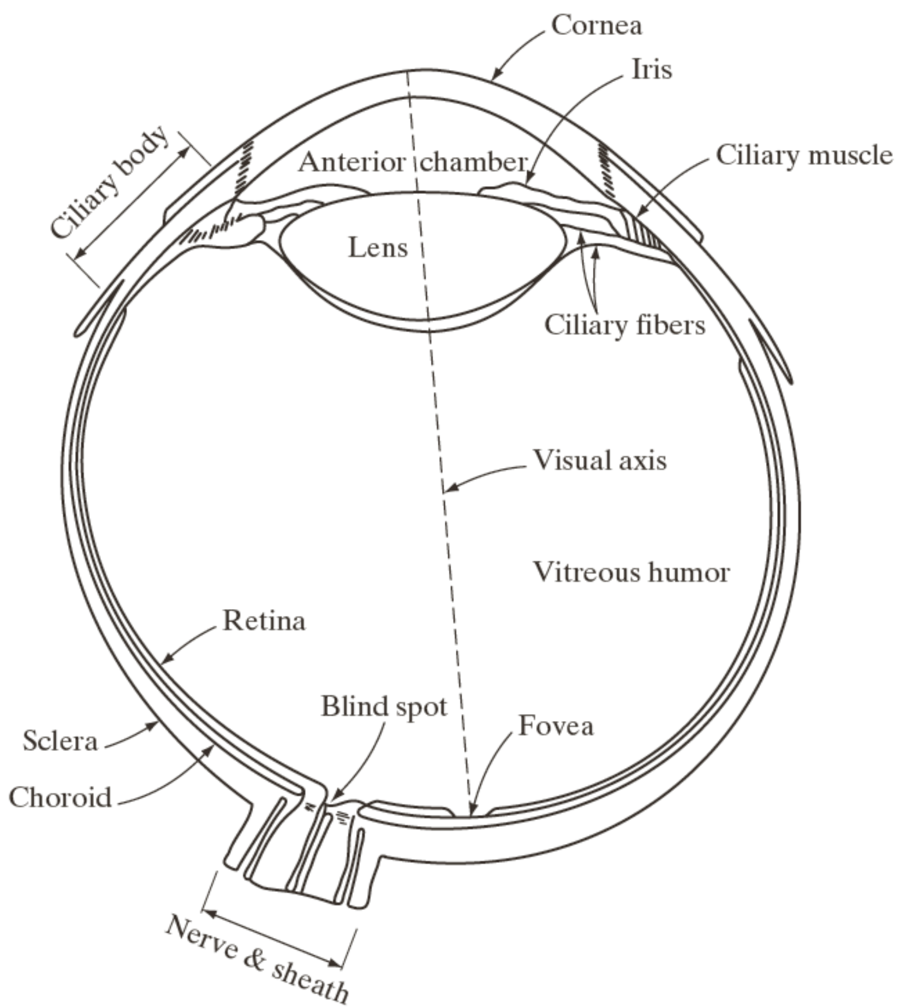
- Monochromatic light

  1. Intensity

- Chromatic light bands

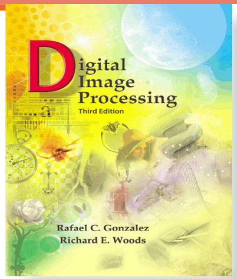
  1. Radiance (Watts-W)
  2. Luminance (Lumens-lm)
  3. Brightness

Contd…



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)



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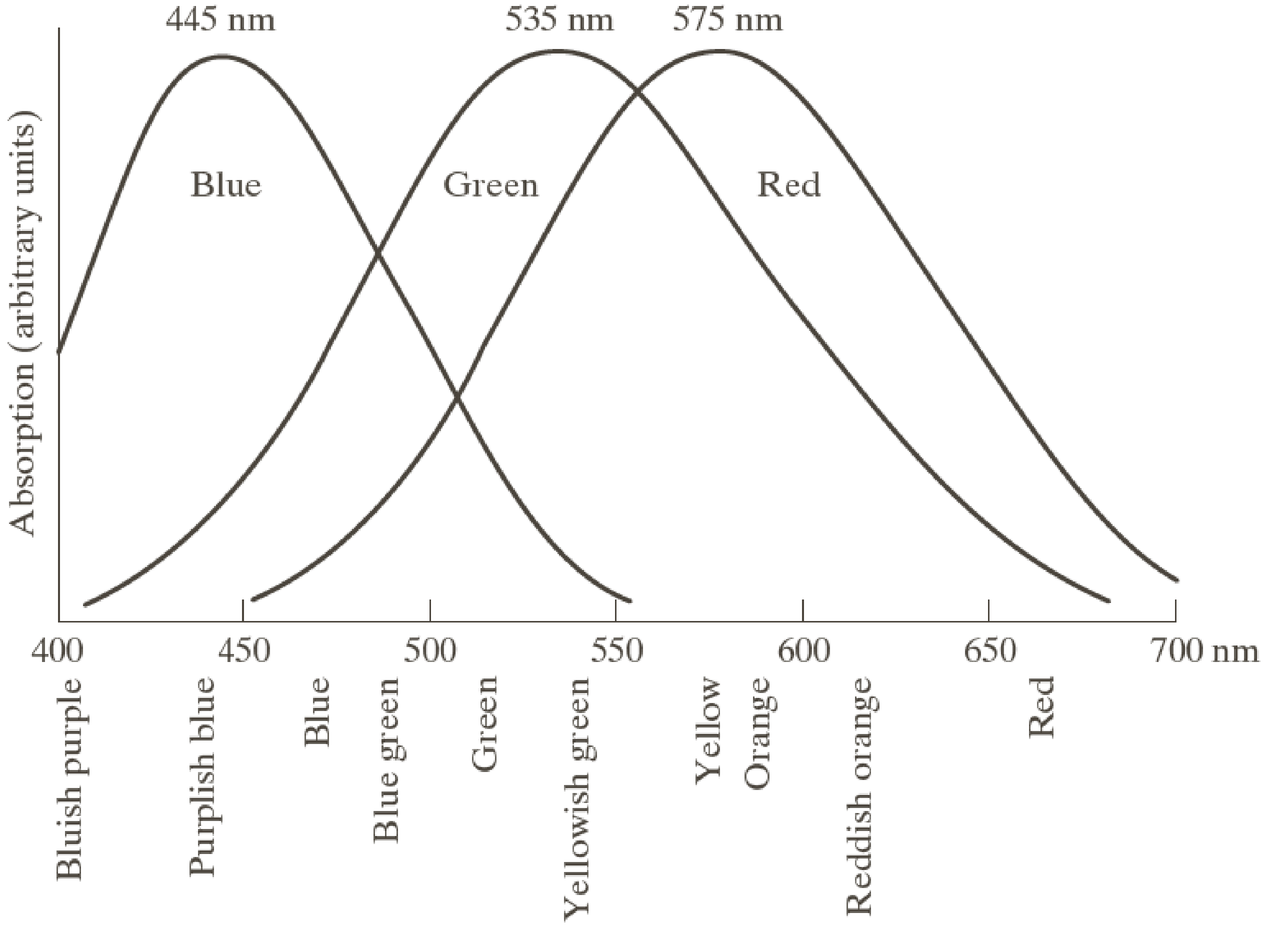
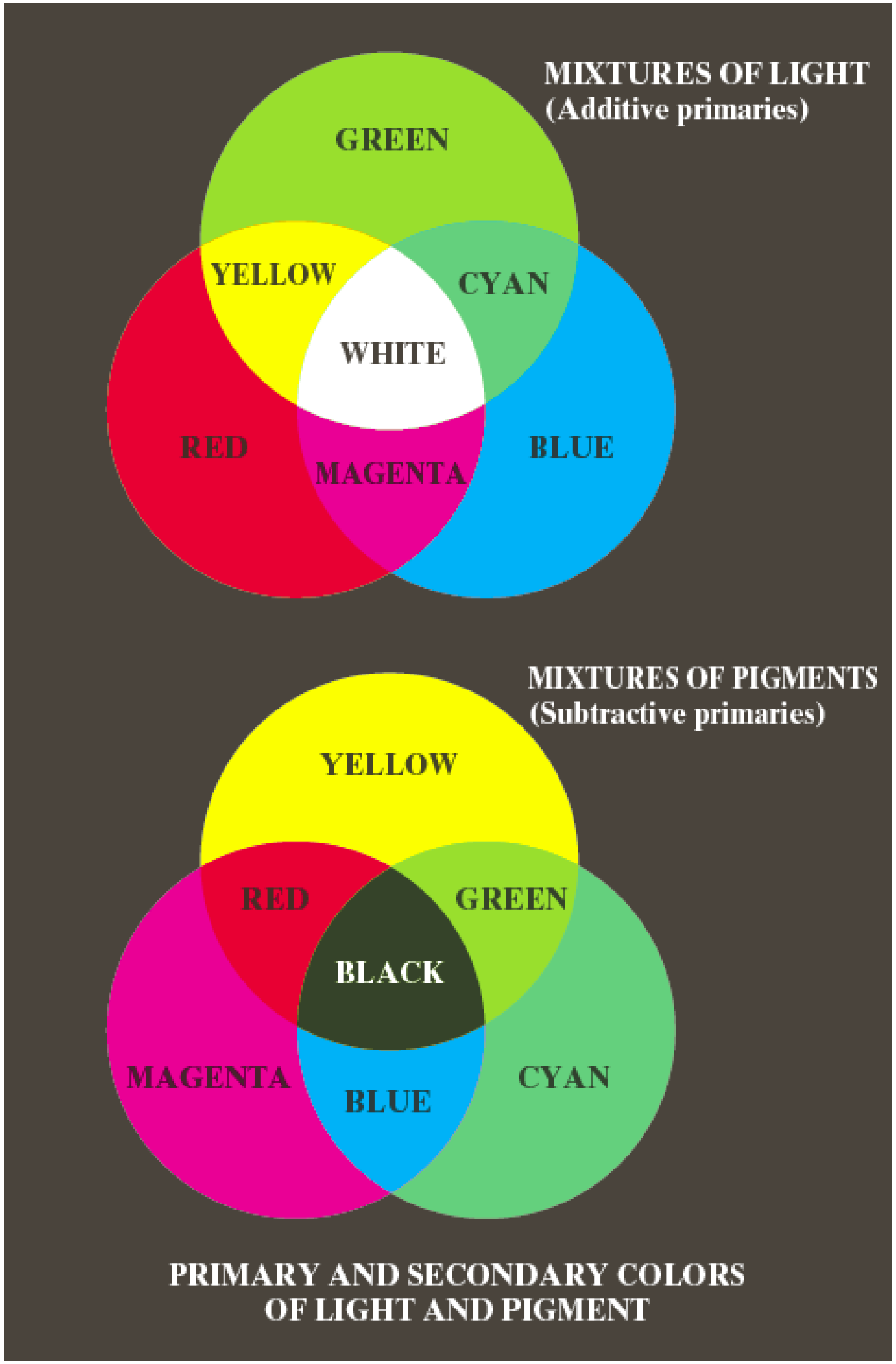
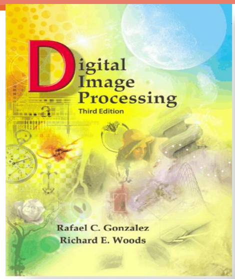


FIGURE 3 Absorption of light by the red, green, and blue cones in the human eye as a function of wavelength.



a
b

FIGURE 4 Primary and secondary colors of light and pigments.



Contd…

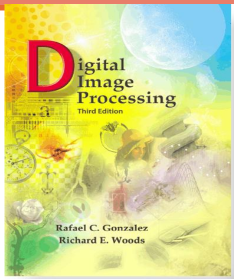
- The characteristics generally used to distinguish one color from another are brightness, hue, and saturation

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, with the degree of saturation being inversely proportional to the amount of white light added.

Ex: Pink (red and white),
Lavender (violet and white)



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- **Tristimulus**

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

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

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

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

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

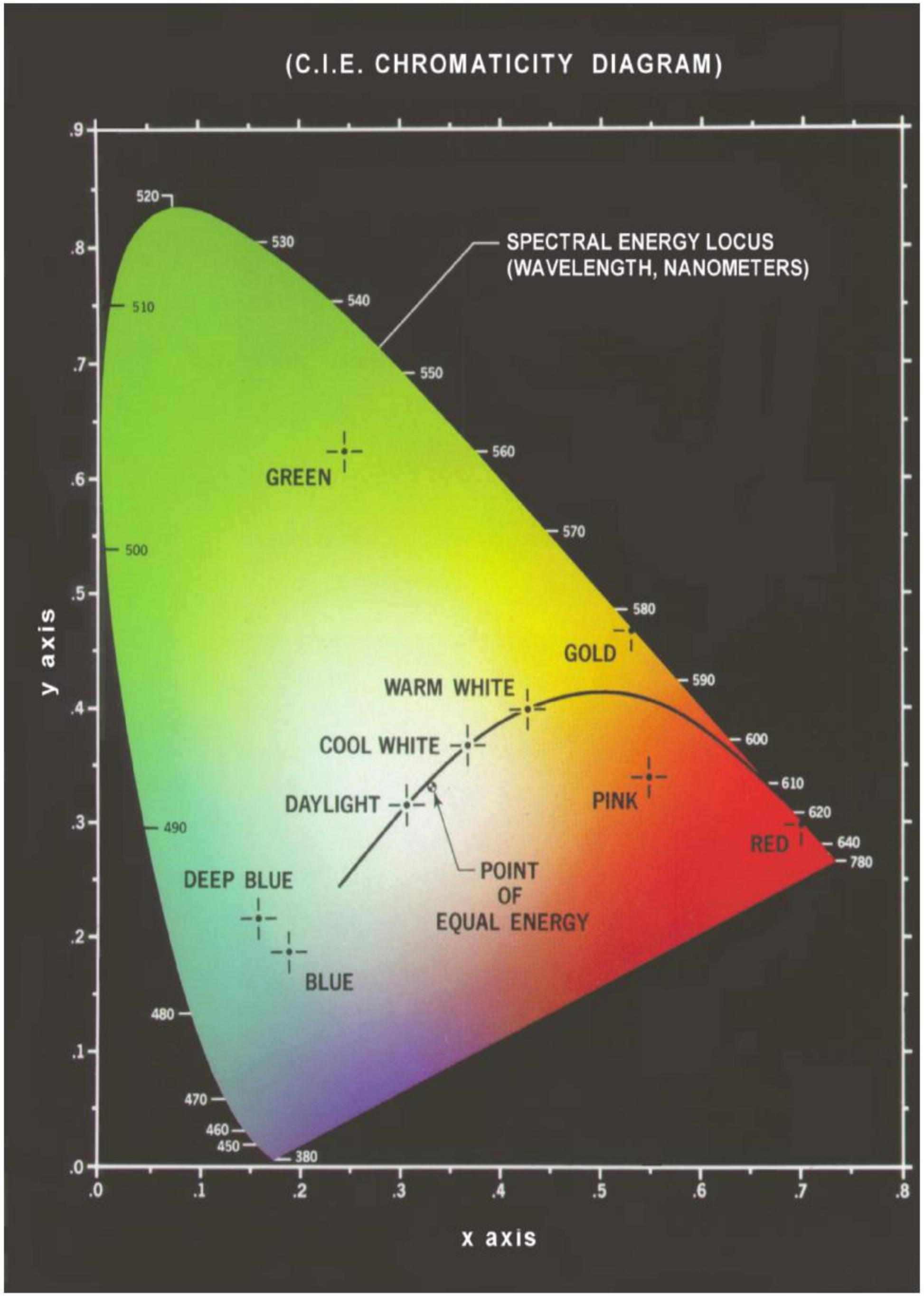
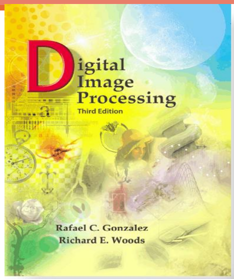
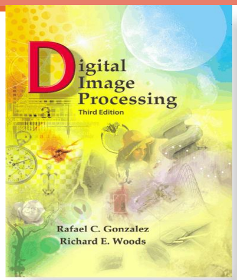


FIGURE 5 Chromaticity diagram.



Color Models & Conversion

- RGB Color Model
- CMY & CMYK Color Model
- HSI Color Model
- Converting RGB to HSI Color Model
- Converting HSI to RGB Color Model



RGB Color Model

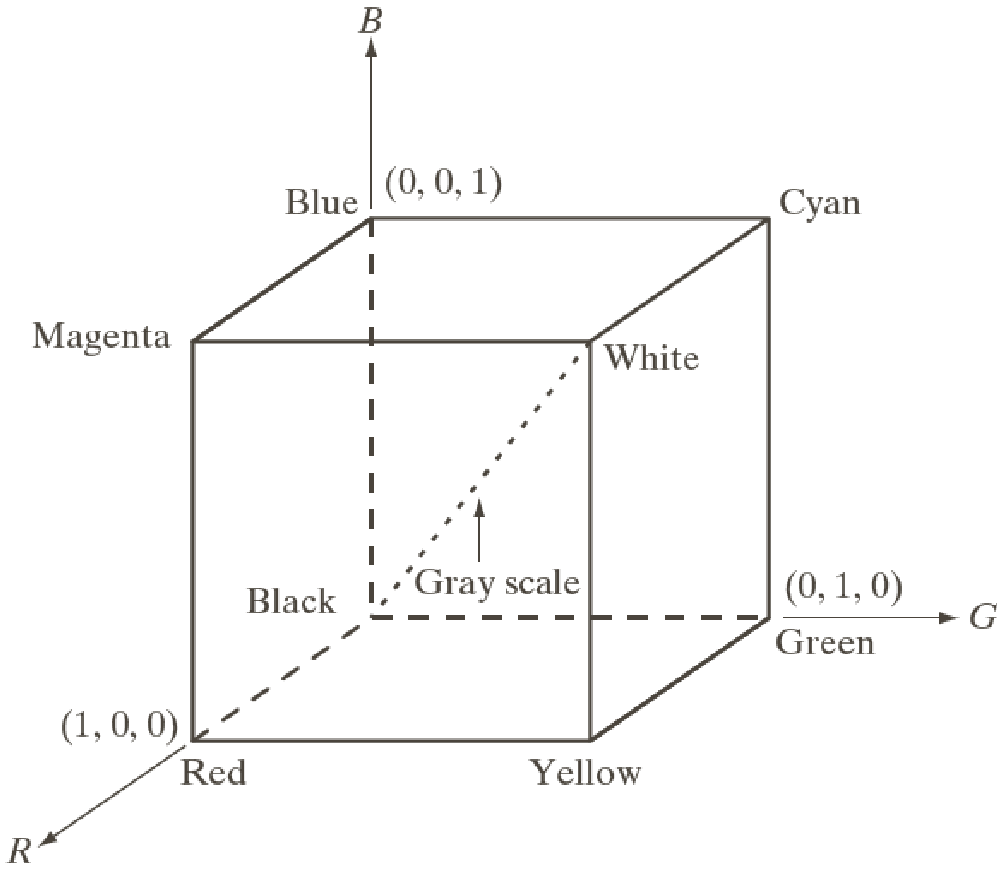


FIGURE 7
Schematic of the RGB color cube. Points along the main diagonal have gray values, from black at the origin to white at point (1, 1, 1).

Contd…

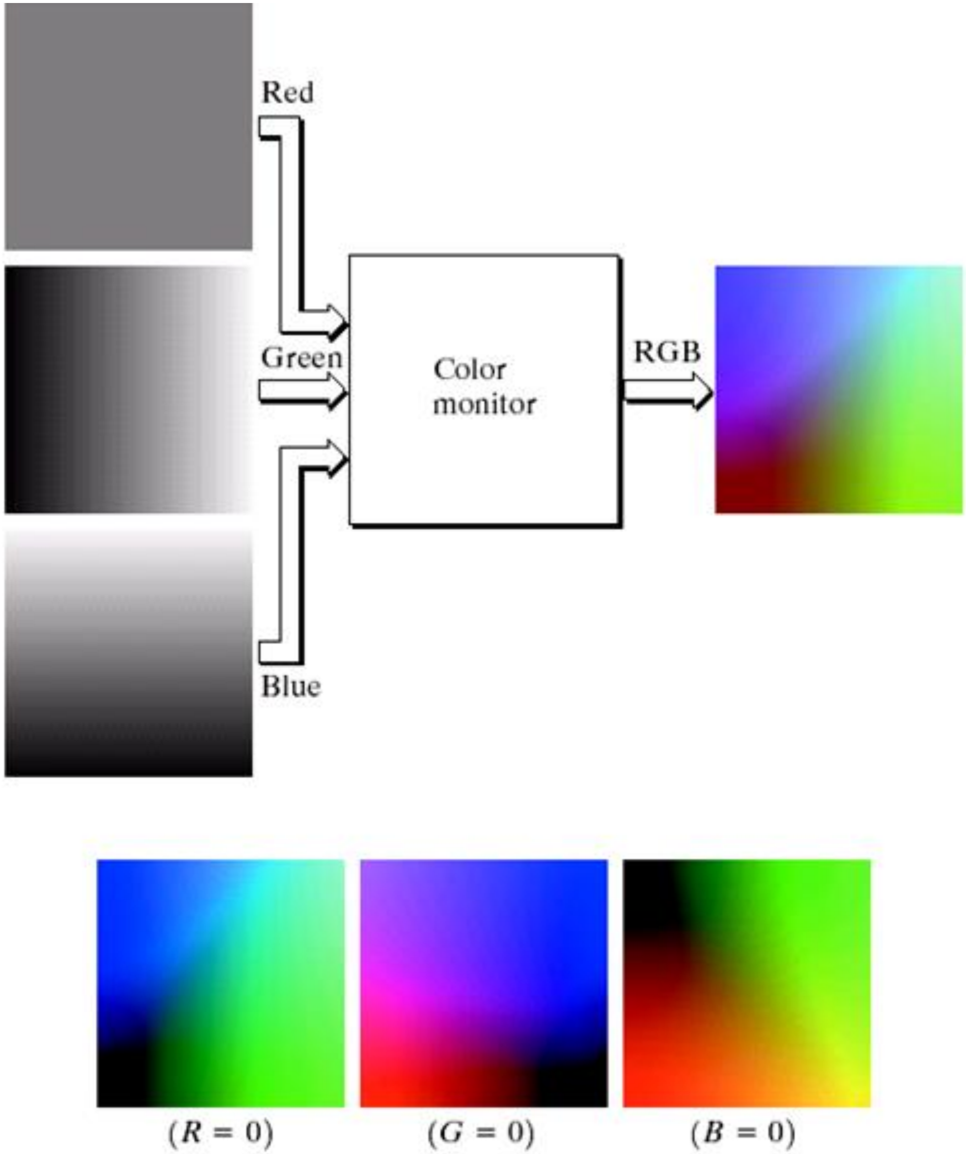
FIGURE 8 RGB 24-bit color cube.

Pixel depth

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

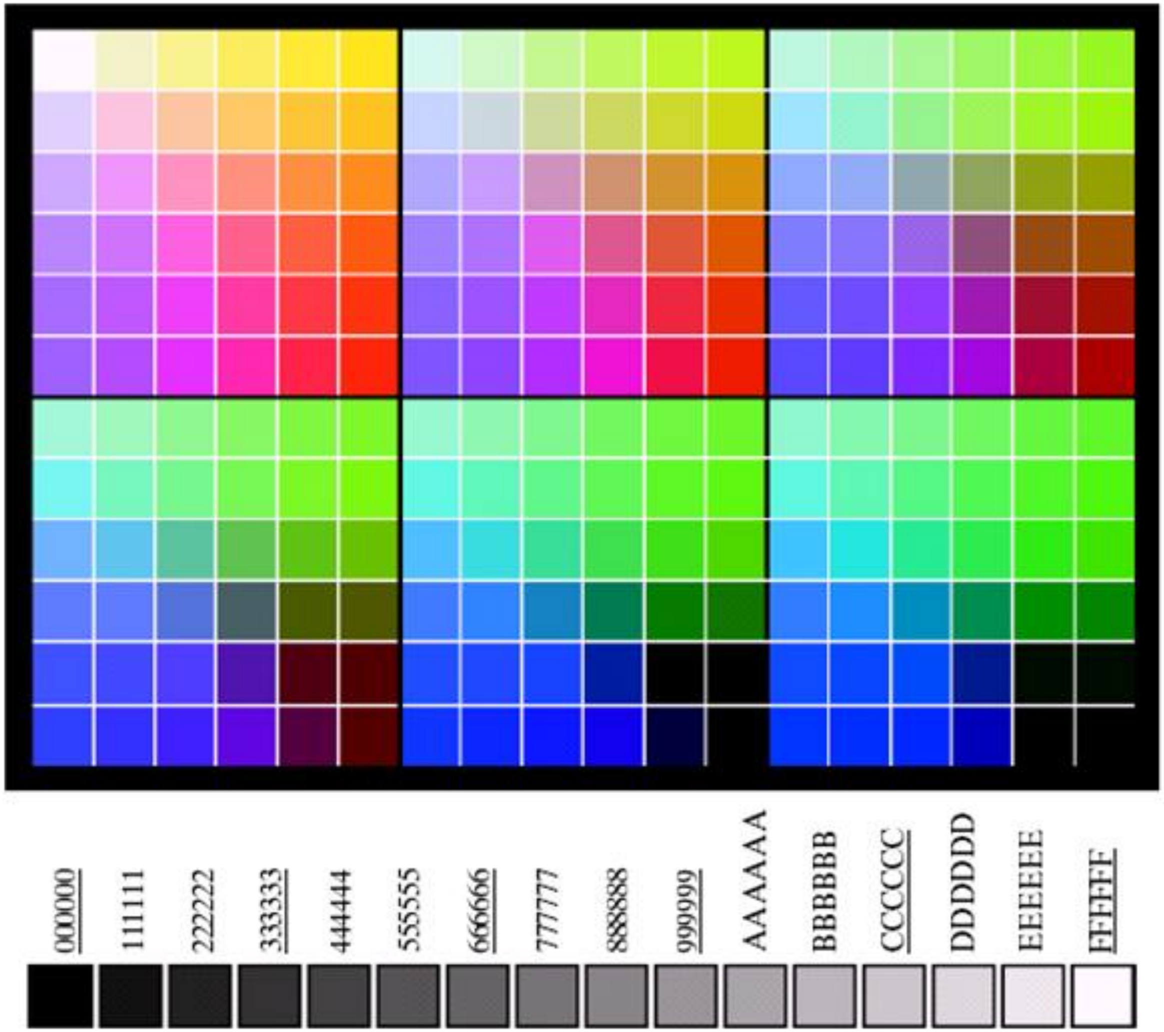
a
b

FIGURE 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. 8.



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

TABLE 1 Valid values of each RGB component in a safe color.



a
b

FIGURE 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).

Contd….

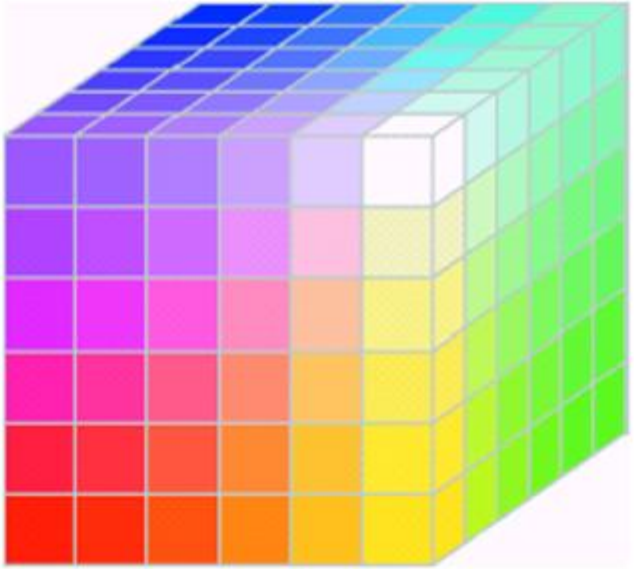


FIGURE 11 The RGB safe-color cube.

Safe RGB colors (or **safe Web colors**) are reproduced faithfully, reasonably independently of viewer hardware capabilities

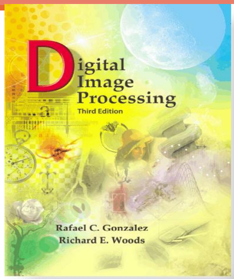
The CMY and CMYK Color Models

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

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



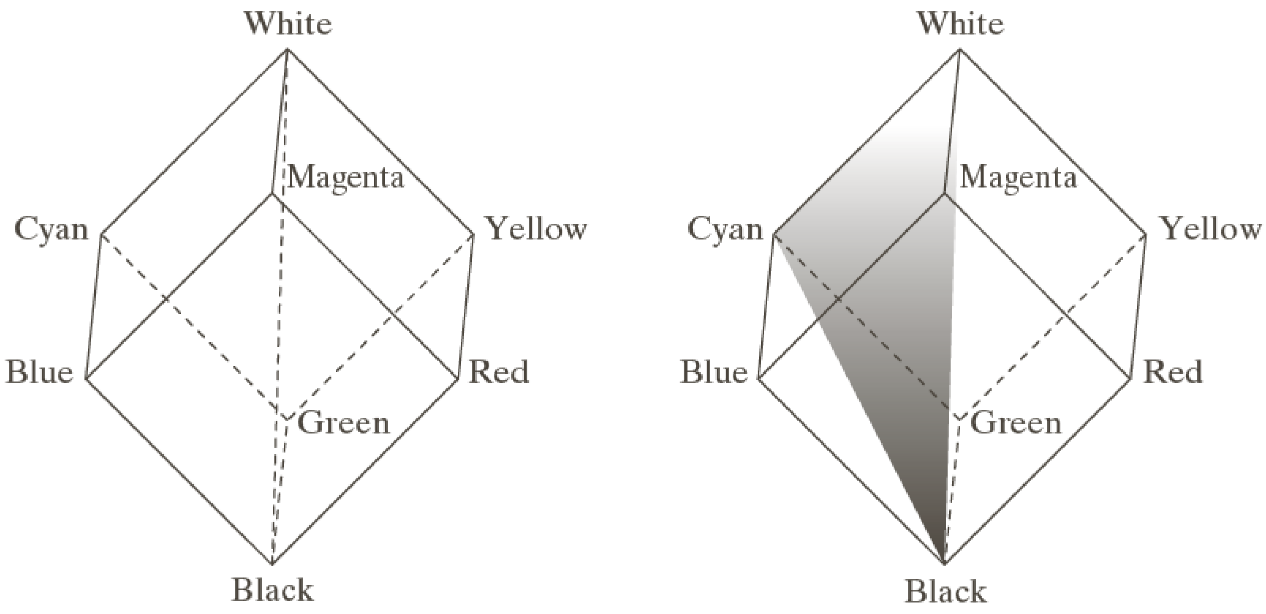
HSI Color Model

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.

brightness: the achromatic notion of **Intensity**.

Contd…



a b

FIGURE 12 Conceptual relationships between the RGB and HSI color models.

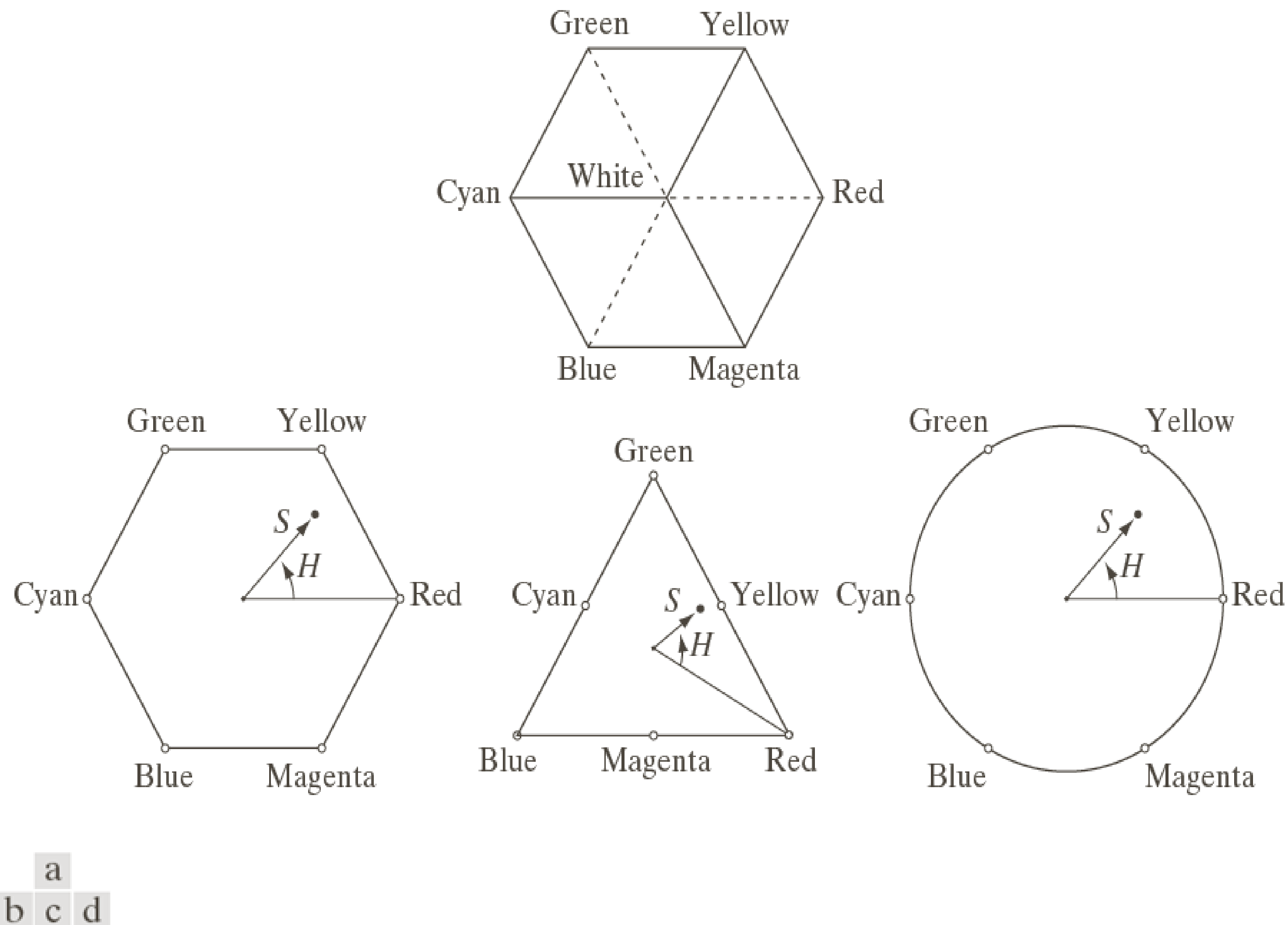
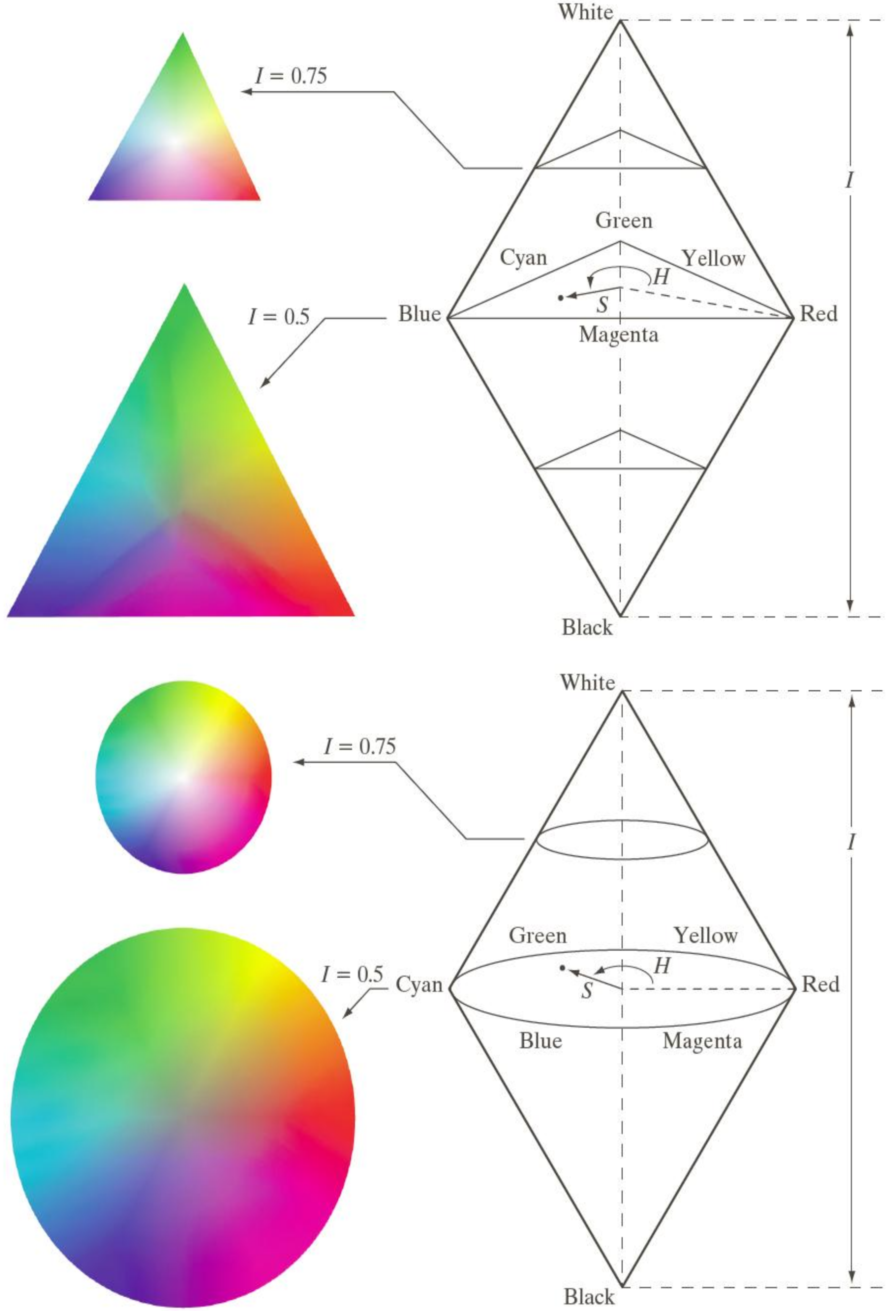
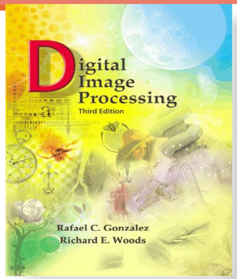


FIGURE 13 Hue and saturation in the HSI color model. The dot is an arbitrary color point. The angle from the red axis gives the hue, and the length of the vector is the saturation. The intensity of all colors in any of these planes is given by the position of the plane on the vertical intensity axis.



a
b

FIGURE 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.



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

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

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

Contd…

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

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

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

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

Converting Colors from HSI to RGB

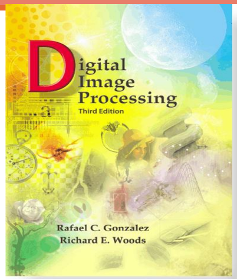
- RG sector $(0^\circ \leq H < 120^\circ)$

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

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

and

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



Contd…

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

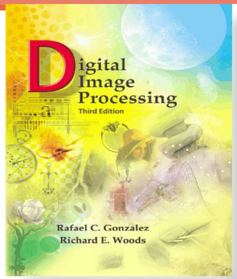
$$H = H - 120^\circ$$

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

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

and

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



Contd…

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

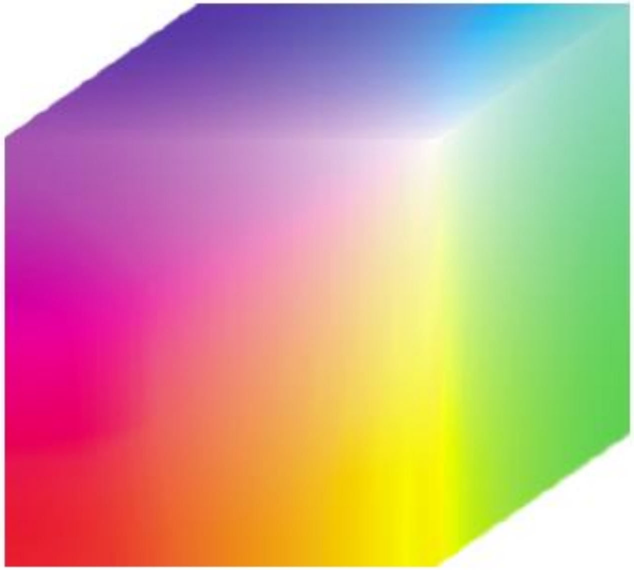
$$H = H - 240^\circ$$

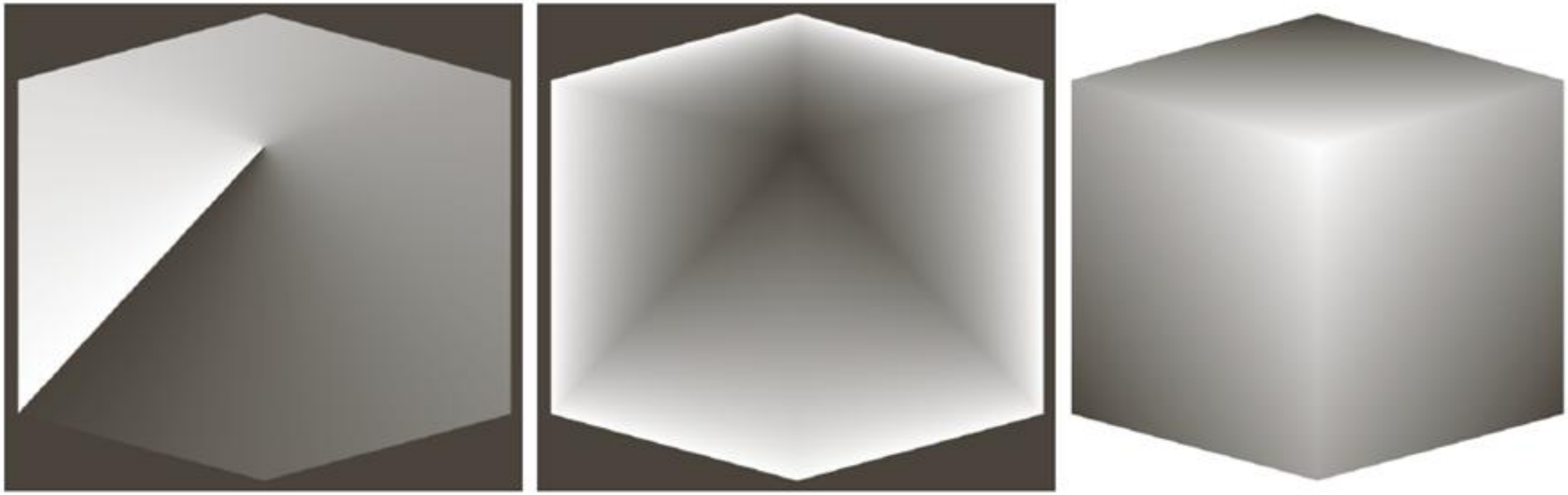
$$G = I(1 - S)$$

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

and

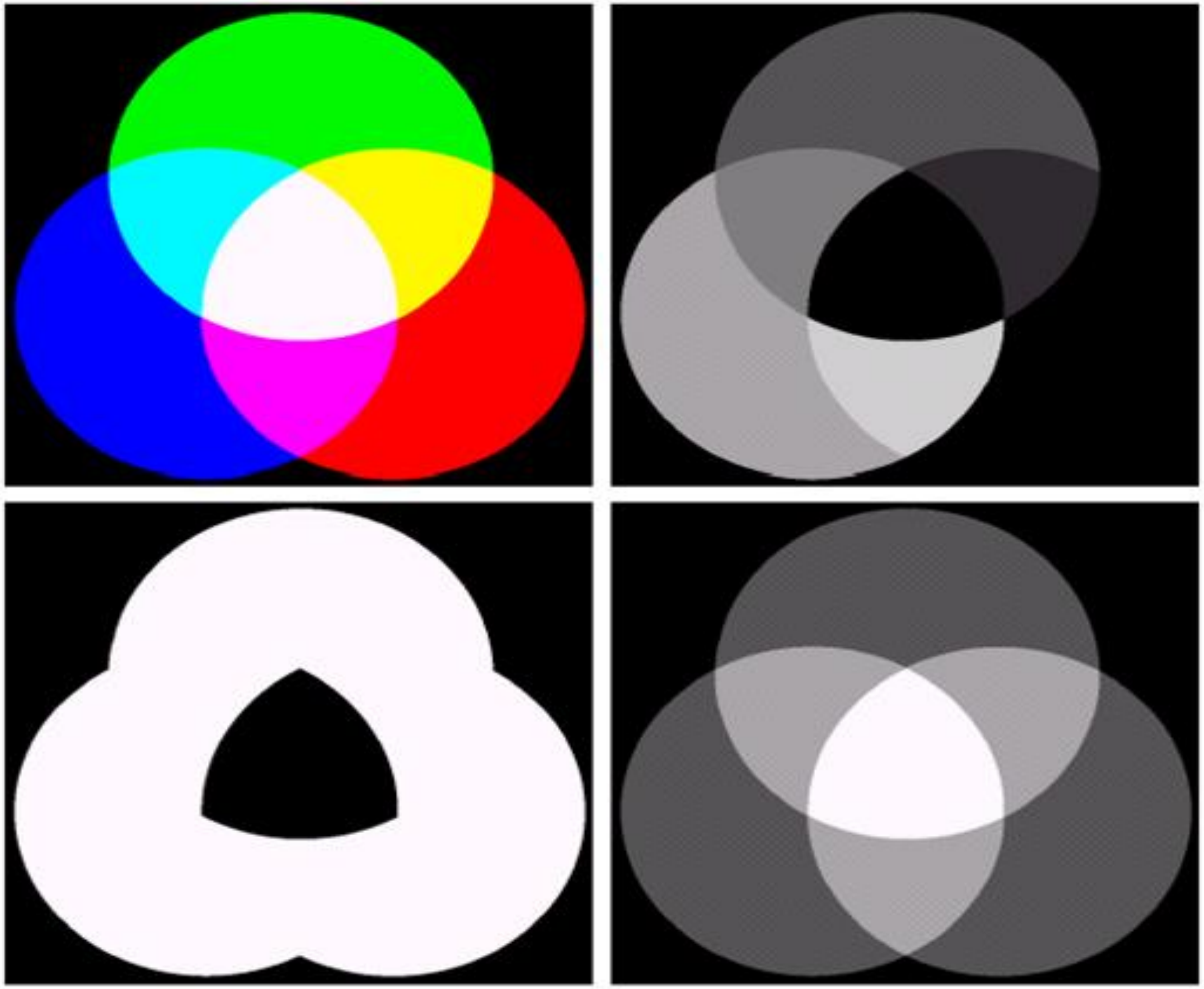
$$R = 3I - (G + B)$$





a b c

FIGURE 15 HSI components of the image in Fig. 8. (a) Hue, (b) saturation, and (c) intensity images.



a b
c d

FIGURE 16 (a) RGB image and the components of its corresponding HSI image: (b) hue, (c) saturation, and (d) intensity.

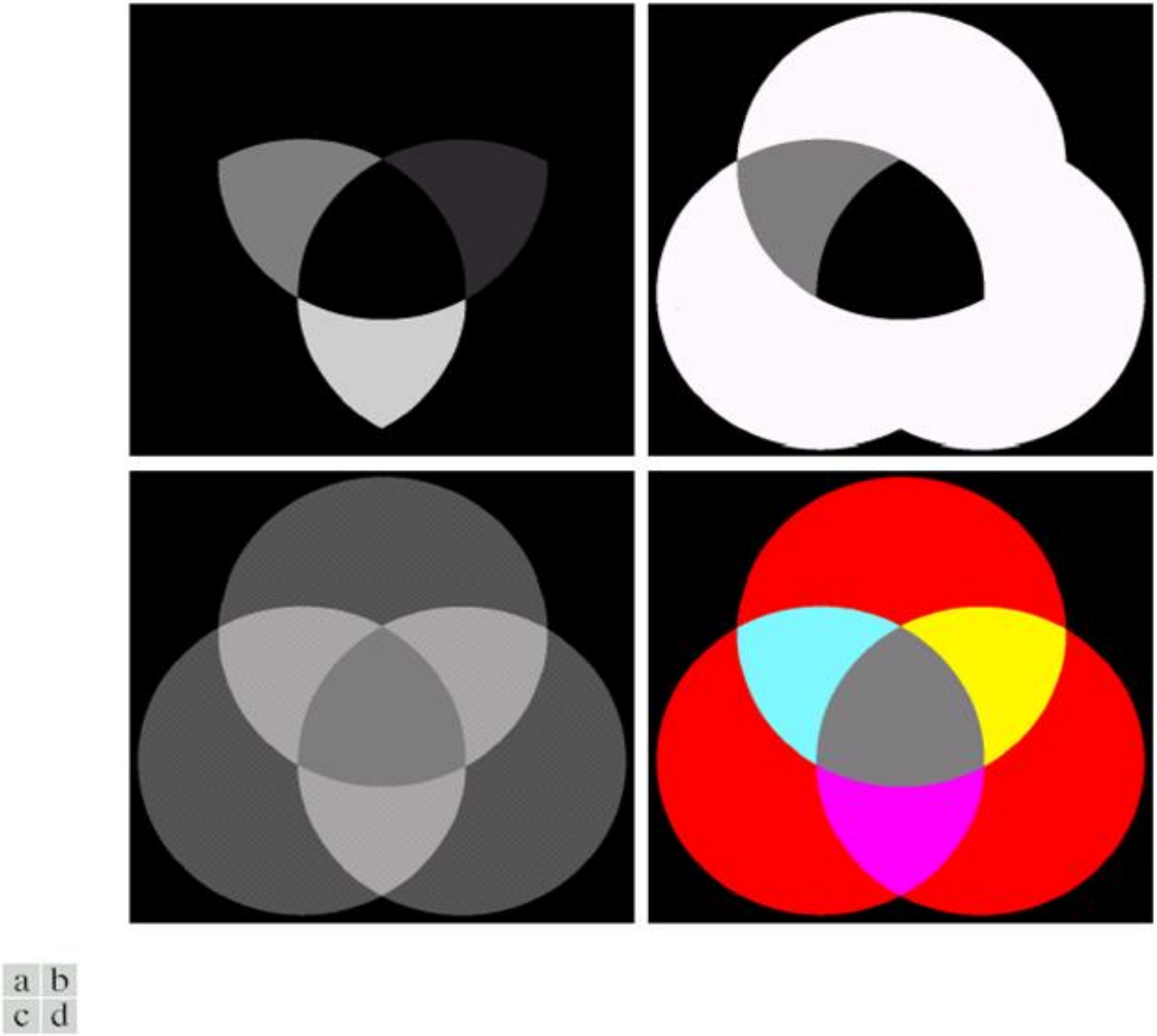


FIGURE 17 (a)–(c) Modified HSI component images. (d) Resulting RGB image.