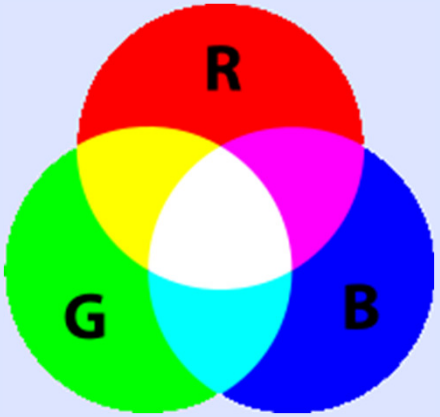
Colour

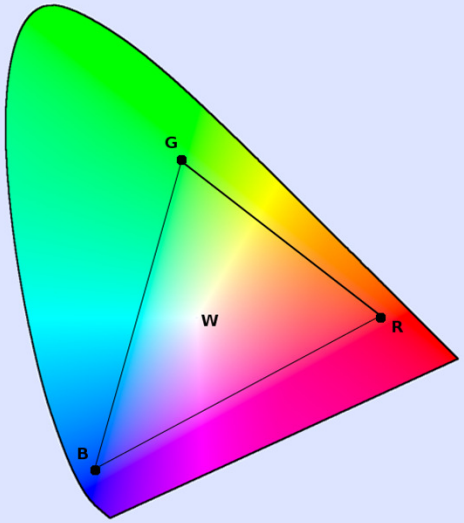
Digital Multimedia, 3rd edition

Chapter 5

RGB color

- Use standard red, green and blue as additive primary colors
  - Basis of color reproduction in TVs, computer screens, each pixel's stored value in bitmapped images, etc.
- Represents any color with three numbers (r,g,b)
  - Different color spaces exist defining the range of colors, e.g. sRGB
- Cannot created all visible colors
  - Restricted to the color space's RGB gamut





RGB example

Red channel

Green channel

Blue channel

Color depth

- Choose number of bits for each of the r, g, and b components
  - More bits per component means more colors can be distinguished, but image files will be larger
  - 8 bits (1 byte) per component is mostly used
    - 24-bit color - 16.7 million different colors
- If r = g = b, the color is a shade of grey, so greyscale can be represented by a single value
  - 8 bits allows for 256 different greys

Color depth

24 bit
16.7 million colors

8 bit
256 colors

4 bit
16 colors

1 bit
2 colors

Indexed color

- 8-bit color only permits 256 colors
- Instead of storing (r, g, b) for each pixel, store an index into a palette / color lookup table (CLUT)
  - Palette stores up to 256 24-bit values
- To determine color of a pixel, look at the stored index, and use it to look up full 24-bit (r, g, b) value in palette
- Used in GIF images

Indexed color

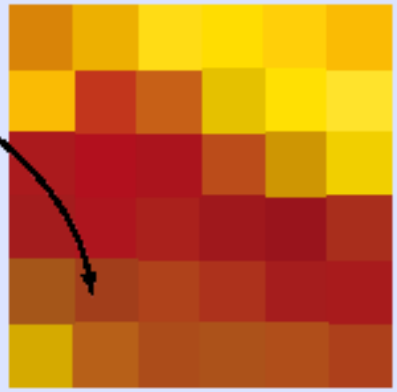
1A	1C	20	21	1F	1E
0D	16	17	1B	22	23
0A	13	09	15	18	1D
03	10	08	01	00	07
05	02	11	0E	04	06
10	14	0B	0C	12	09

stored values

00	99141B
01	A0191C
02	A23E1A
03	A51B1C
04	A51D1C
05	A65619
06	A9191C
07	A92E1C
08	AB201C
09	AC111C
0A	AC191D
0B	AC4C1A
0C	AC5219
0D	AD111D
0E	AD331C
0F	AD401B

etc

Colour Lookup Table



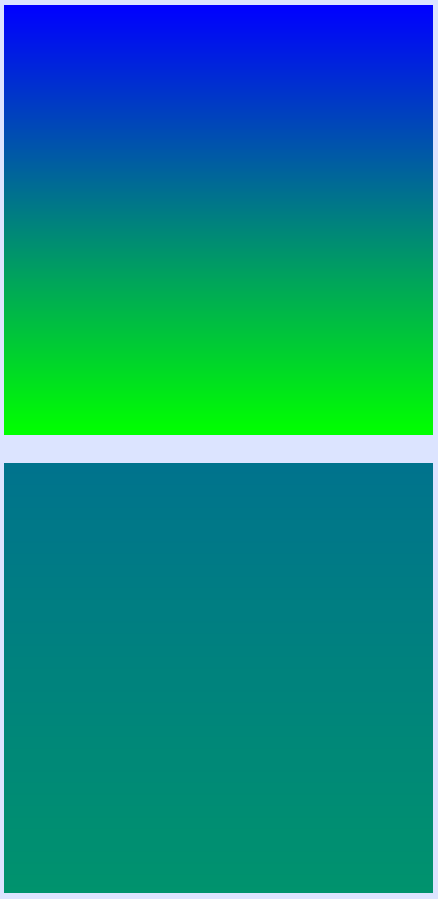
displayed pixels

Indexed color palettes

- Ideally choose 256 most important colors in an image to store in its palette
- When 24-bit image is reduced to indexed color, some colors may be missing from the palette
  - Nearest color - replace missing colors by the closest ones in the palette
    - Could lead to banding, posterization, etc.
  - Dither - use pattern of dots to create an “illusion” of more colors than actually exist
    - Loss of detail, very visible distortions when zoomed

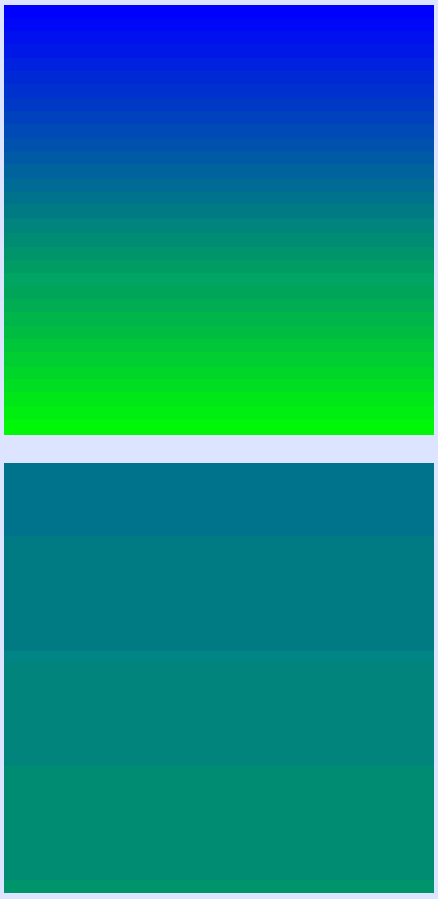
Nearest color vs. dithering

Original, 24-bit



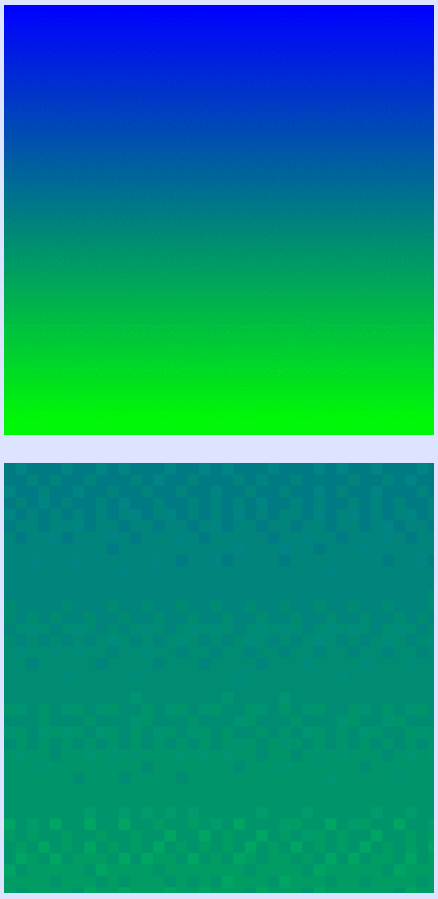
8 x zoom

Nearest color, 8-bit



8 x zoom

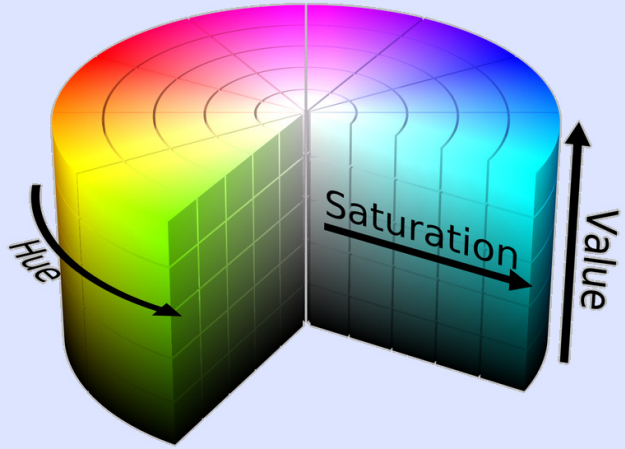
Dithering, 8-bit



8 x zoom

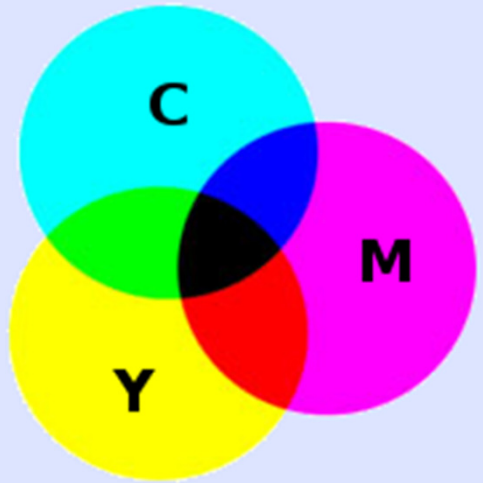
HSV (HSB)

- Alternative way of specifying RGB color
- Basis of many popular styles of color pickers
- Hue (color)
- Saturation (purity, intensity)
- Value (brightness)



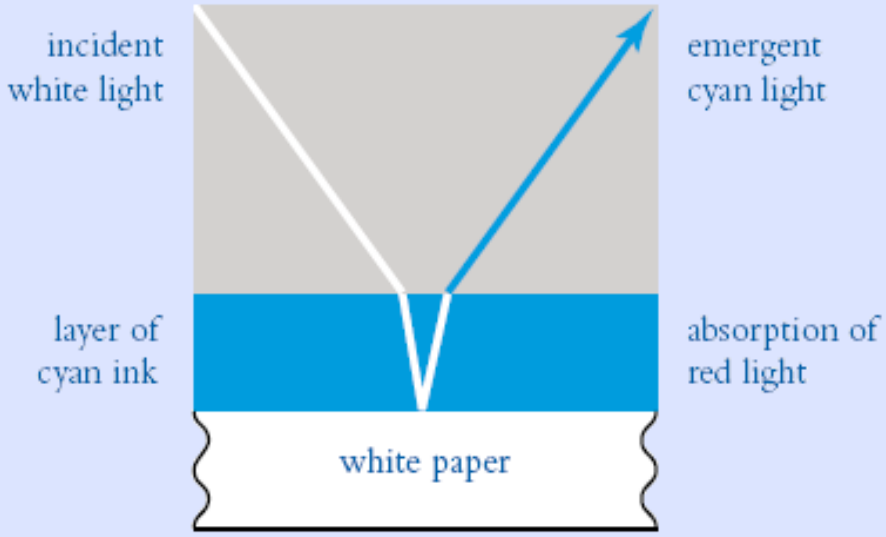
Complementary colors

- Subtracting an additive primary color from white gives its complementary color
  - Or add the other two additive primaries
    - W-R = G+B = **C**
    - W-G = R+B = **M**
    - W-B = R+G = **Y**
- Cyan, magenta and yellow are subtractive primary colors (ink/paint) - used when printing

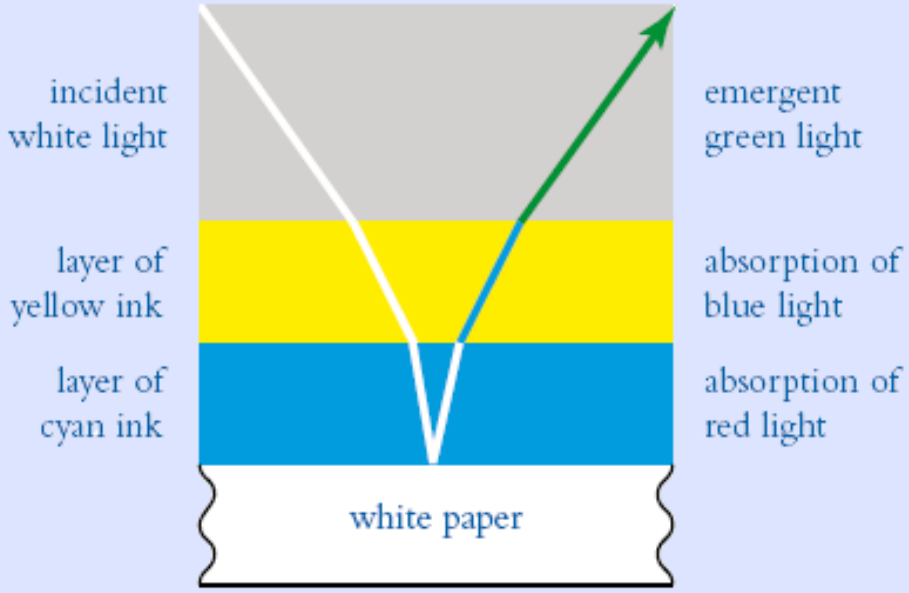


Complementary color ink/paint

Cyan ink absorbs red light:
White light => cyan light



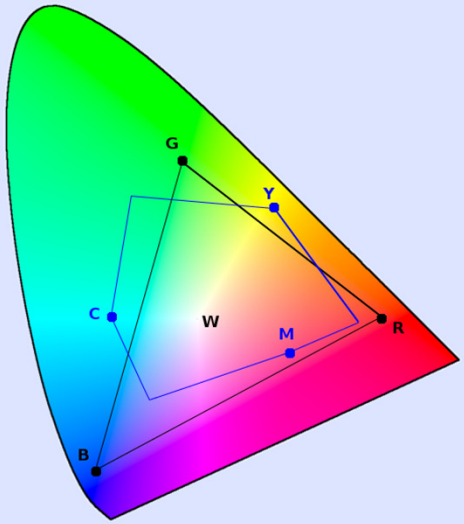
Cyan + yellow ink absorb red light +blue light:
White light => green light



So, cyan + yellow + magenta ink = no light / black? Only in theory

CMYK Color

- Real inks do not correspond to ideal subtractive primaries
- Combining three inks for black doesn't result in true black, but dark grey
  - Printers use four ink colors: cyan, magenta, yellow and black: CMYK
- CMYK gamut is not the same as for RGB
  - Potential problem when using images prepared for print (CMYK) on screens (RGB), and vice versa
  - Most graphics programs let you choose between working with RGB or CMYK colors



CMYK example

With cyan, magenta, yellow, and black ink:

Cyan channel

Magenta channel

Yellow channel

Black channel

With only cyan, magenta, and yellow ink:

Cyan channel

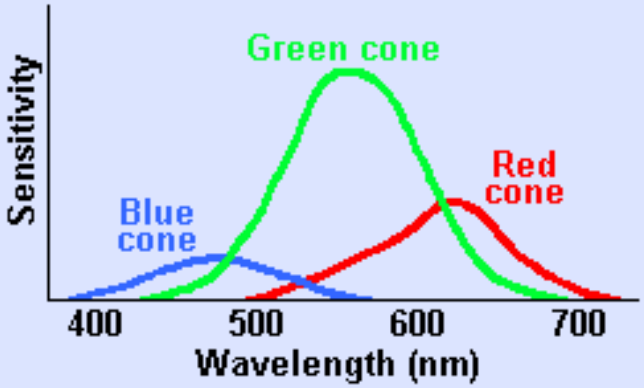
Magenta channel

Yellow channel

Much more cyan, magenta and yellow ink used, and no real black possible in printed image

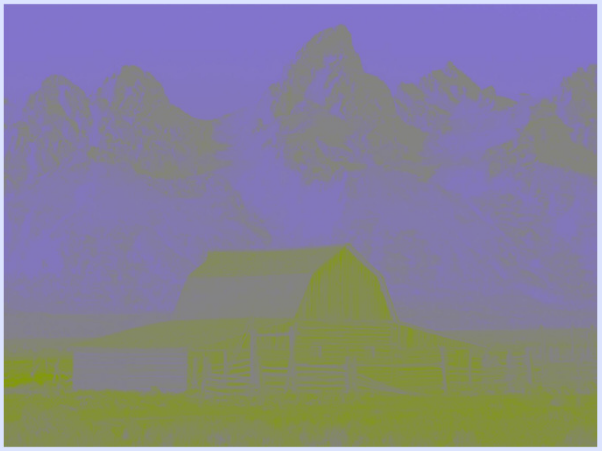
YCbCr

- Sometimes it is useful to separate brightness (luminance) and color information, especially for video
  - Luminance (Y) not simply related to R, G and B because our eyes are more sensitive to some colors:
    - Y = 0.2125R + 0.7154G + 0.0721B
  - Some standards use different values, e.g. for old standard definition TV:
    - Y = 0.299R + 0.587G + 0.114B
- Store Y plus two color values, Cb and Cr



YCbCr example

Y channel



Cb channel

Cr channel