Understanding Color

- In electronic systems, color specified using the RGB color model
  - **R**ed, **G**reen, **B**lue

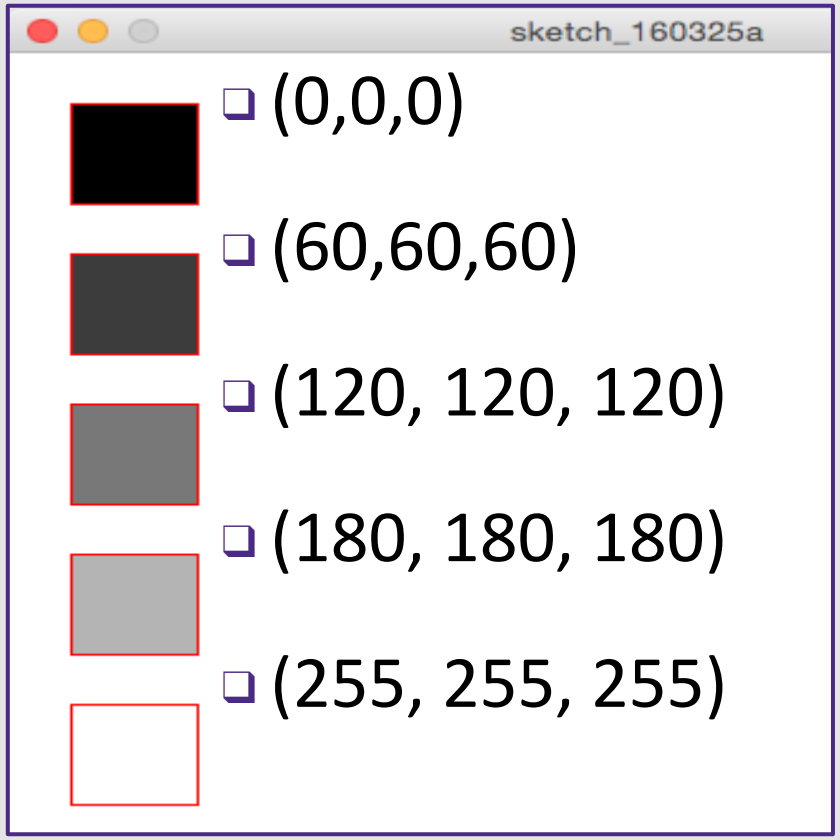
- Each pixel on your screen is made up of 3 tiny lights, one red, one green, one blue
  - Specify the intensity of each light using an integer between 0 and 255
    - 0 is completely off
    - 255 is highest intensity

Guess the Color

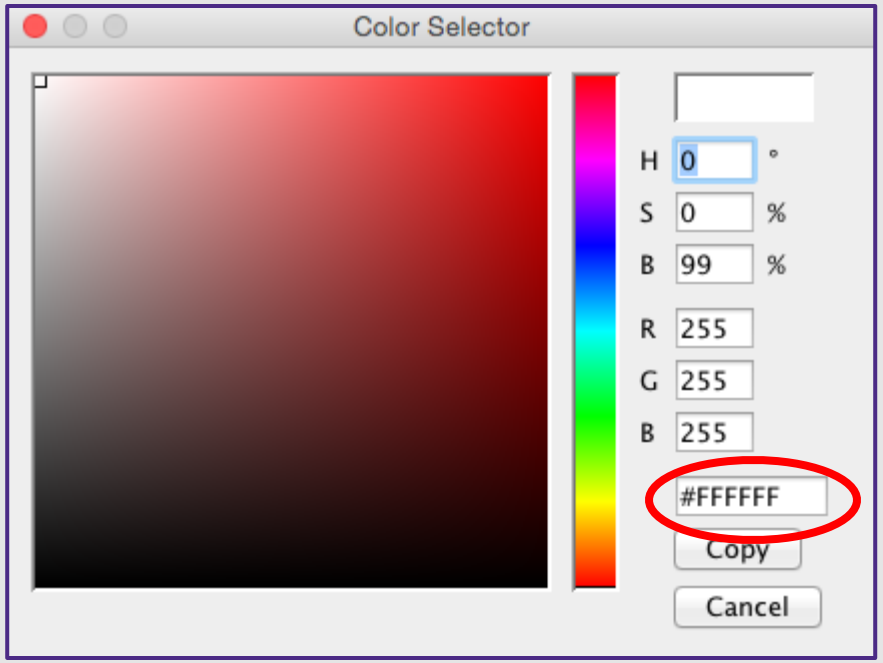
```
• Color(  R,   G,   B);
• Color(255,   0,   0); // red
• Color(  0, 255,   0); // green
• Color(  0,   0, 255); // blue
• Color(  0,   0,   0); // black
• Color(255, 255, 255); // white
• Color(255, 255,   0); // yellow
• Color(255,   0, 255); // magenta
• Color(  0, 255, 255); // cyan
```

50 Shades of Gray….

- When the values for RGB are all the same, then the color will be white, black, or some shade of gray



Typical Color Selector



What's #FFFFFF?

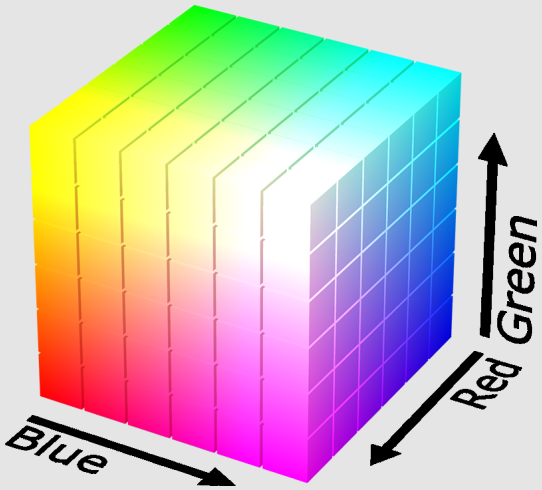
- To save space we store colors using 1 memory space instead of 3.
- That is every color is really just a 32 bit integer.
- #FFFFFF

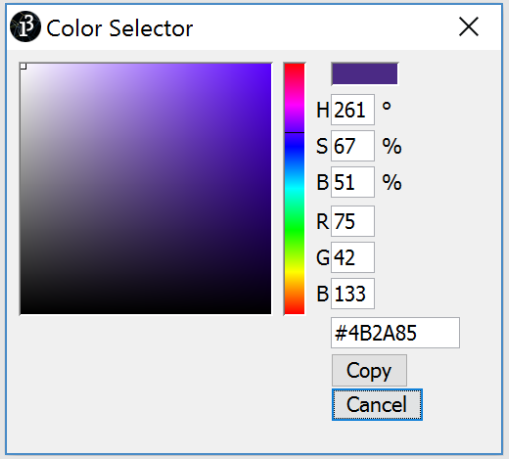
Binary and Hexadecimal

- Binary is base 2
  - Symbols: 0, 1
- Example: What is 0b110 in base 10?
  - $0b110 = 110_2 = (1 \times 2^2) + (1 \times 2^1) + (0 \times 2^0) = 6_{10}$
- Hexadecimal (hex, for short) is base 16
  - Symbols? 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, …? 9, A, B, C, D, E, F
- Example: What is 0xA5 in base 10?
  - $0xA5 = A5_{16} = (10 \times 16^1) + (5 \times 16^0) = 165_{10}$
- Example: What is 132 in base 15?
  - 132 / 16 = 8; 132 % 16 = 4. So, 0x84

Binary Encoding – Colors

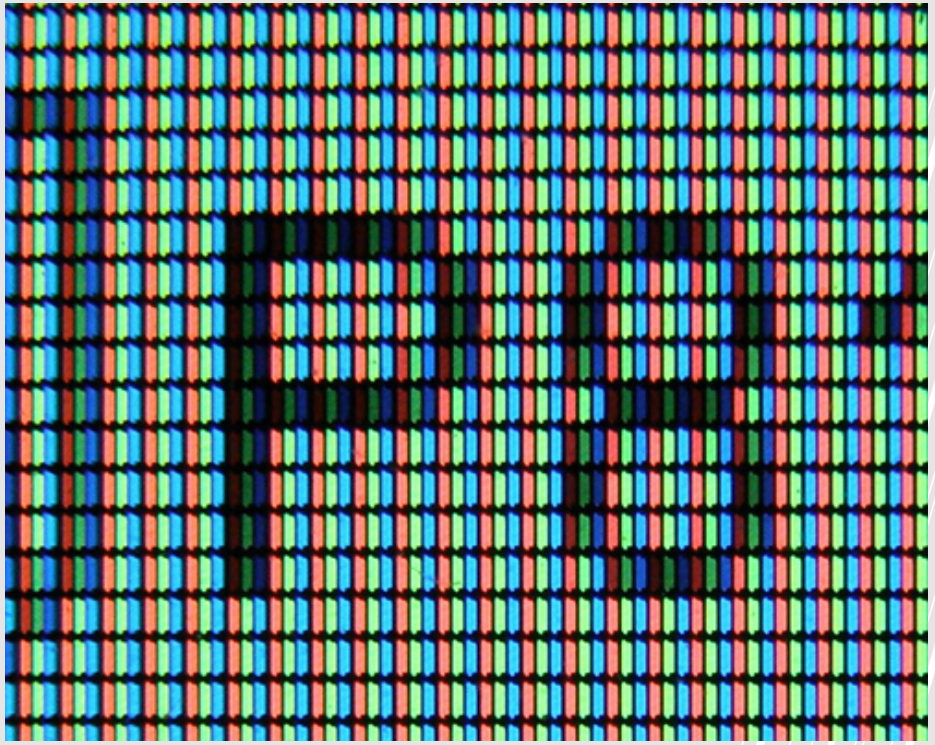
- RGB – Red, Green, Blue
  - Additive color model (light): byte (8 bits) for each color
  - Commonly seen in hex (in HTML, photo editing, etc.)
  - Examples: Purple→0x4B2A85, Gold→0xBAA47B, Orange→ 0xE2661A, Turqoise→0x33997E





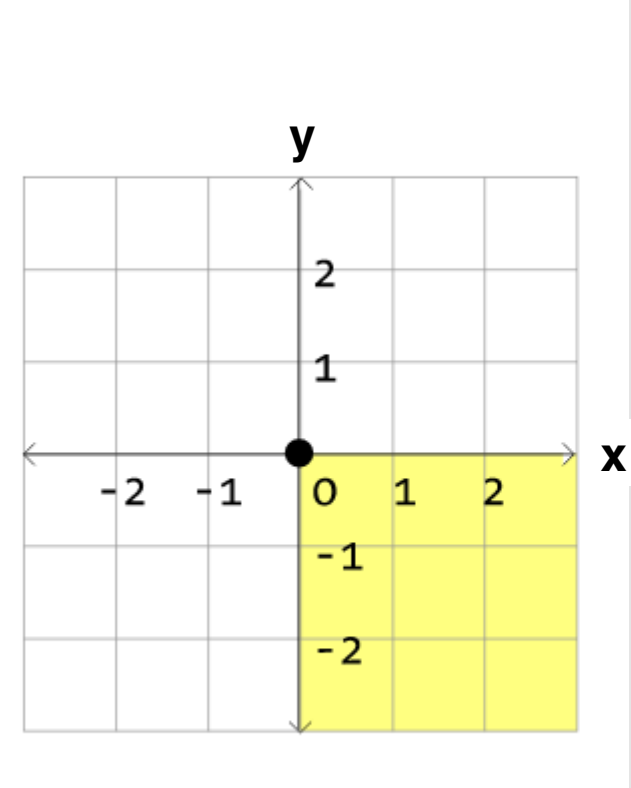
Images

- An image is just a 2-dimensional set of pixels
  - The image has a *width* and a *height*
  - Each pixel has an associated (RGB) *color*
- In Java, one way to represent an image is as a double array of int data
  - BufferedImage Class

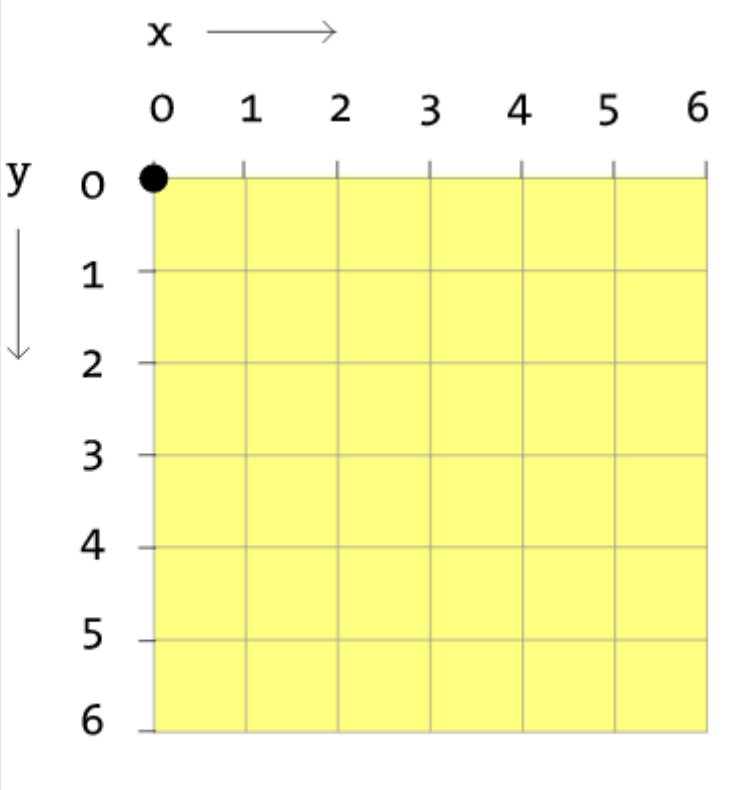


Coordinate System for Images

Math



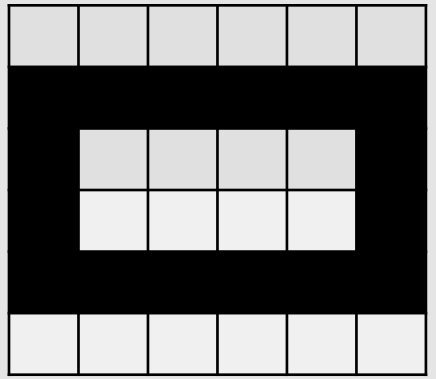
Images



Representation

- Width, Height?

- Pixels: W – white pixel, B – black pixel
  - WWWWWW
    BBBBBB
    BWWWWB
    BWWWWB
    BBBBBB
    WWWWWW
  - W = 0xFFFFFF
  - B = 0x000000



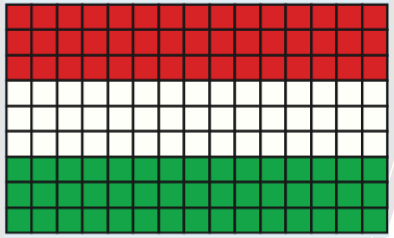
Representation

- Width, Height?

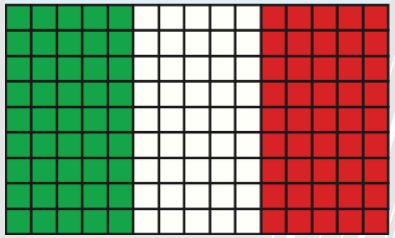
- Pixels: W – white, R – red, G – green

  - R = (205,33,42) = 0xCD212A
  - G = (0, 140, 69) = 0x008C45
  - W = (255,255,255) = 0xFFFFFF

Hungary



Italy



Color as Data in Java

- **Recall:** all data on a computer is stored using *binary encoding*
  - Including colors, though we won't cover exactly how

- Java has a Color Object

```
Color color = new Color( this.pixels[x][y]);  // takes any integer
int red = color.getRed();      // integer between 0 and 255
int blue = color.getBlue();
int green = color.getGreen();
```