

KNOX

Color

Knox Game Design

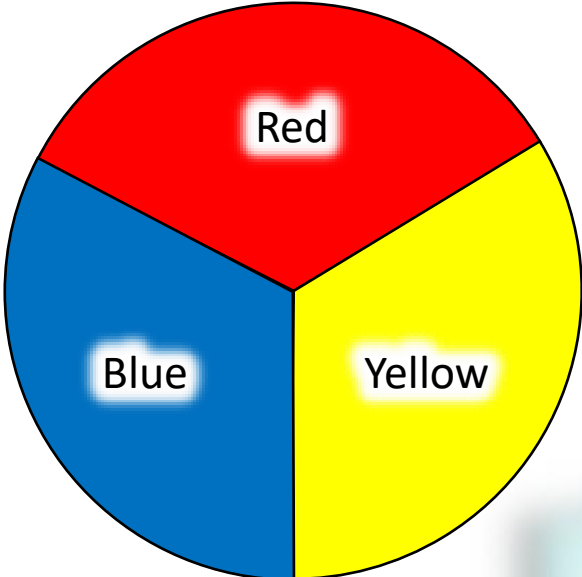
July 2020

Levi D. Smith

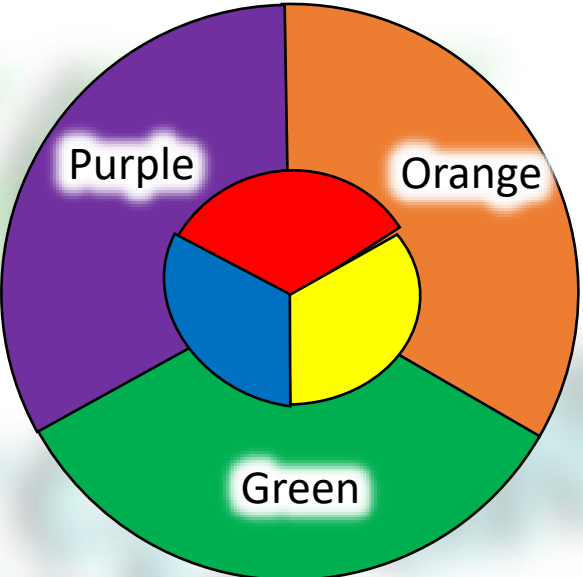
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Traditional Color Wheel

Primary Colors



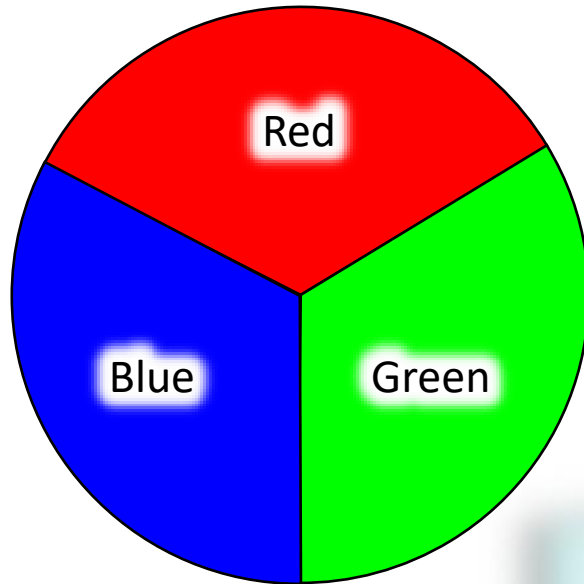
Secondary Colors



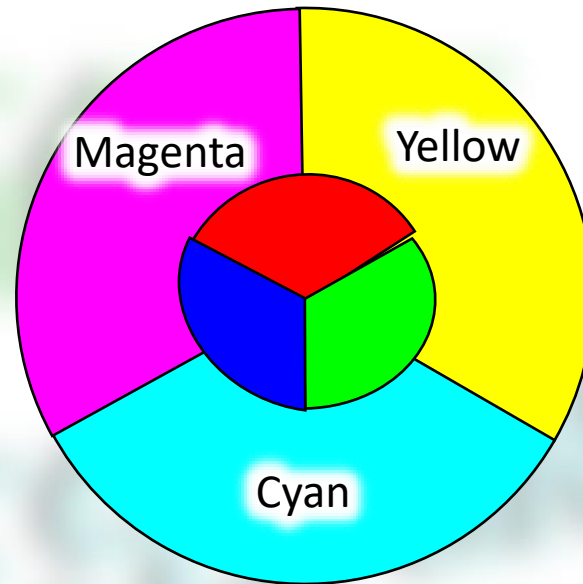
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Computer Color Wheel

RGB



CMY



CMYK (K = black) frequently used for printing

Color Spectrum

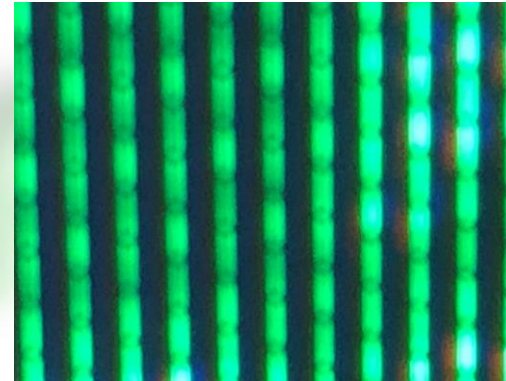
- Color is observed from electromagnetic waves
- Types of waves
 - Sound waves - requires matter to transmit (such as air)
 - Electromagnetic waves - transmits without matter
 - Gamma, X, UV, Visible, IR, Micro, Radio (FM/AM)
 - Light can act as both wave and particle (photon)
- Visible - ROY G BIV
 - Red, Orange, Yellow, Green, Blue, Indigo, Violet
 - Longest to shortest wavelength
 - Lowest to highest frequency (frequency = speed of light / wavelength)
 - Speed of light is a constant ($3.0 * 10^8$ m / s)

| Color | Wavelength (nanometers) |
|--------------|-------------------------|
| Infra Red | 740+ |
| Red | 625-740 |
| Orange | 590-625 |
| Yellow | 565-590 |
| Green | 500-565 |
| Cyan | 485-500 |
| Blue | 450-485 |
| Violet | 380-450 |
| Ultra Violet | 380- |

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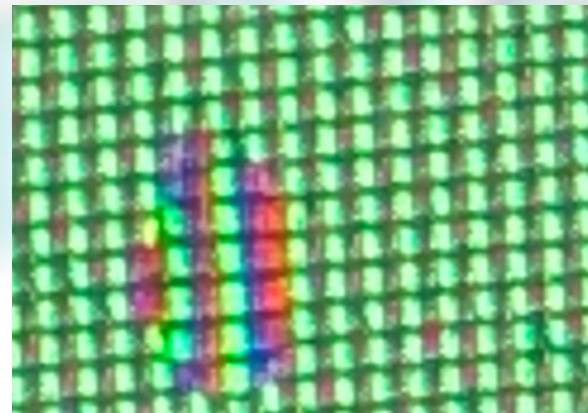
Displaying Color on the screen

- CRT - Cathode Ray Tube
 - Electron gun shoots electrons at a screen composed of RGB pixels

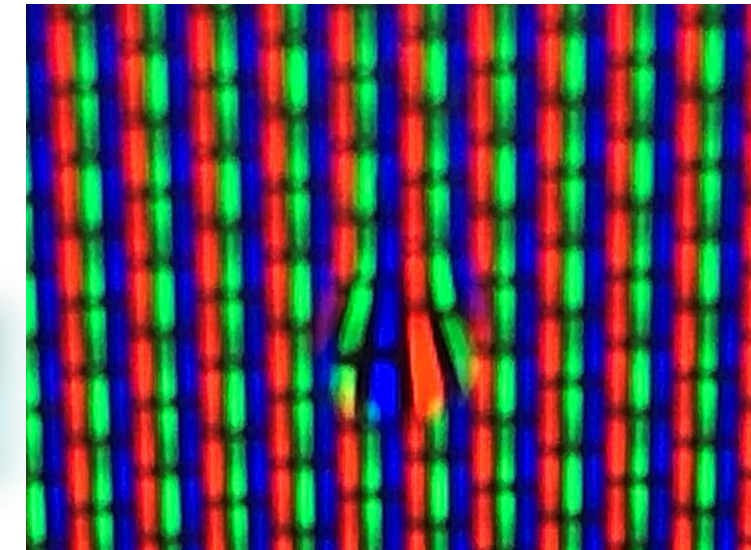


green pixels on CRT

- LED - Light Emitting Diode
 - Pixels on screen are individually illuminated



green pixels on LED



white pixels on CRT - taken with phone camera 10x magnification

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Representing Colors on the Computer

| Color | RGB Float (0.0 to 1.0) | RGB Decimal (0 to 255) | RGB Hex (00 to FF) |
|---------|---------------------------|---------------------------|-----------------------|
| Red | (1.0, 0.0, 0.0) | (255, 0, 0) | #FF0000 |
| Orange | (1.0, 0.5, 0.0) | (255, 128, 255) | #FF80FF |
| Yellow | (1.0, 1.0, 0.0) | (255, 255, 0) | #FFFF00 |
| Green | (0.0, 1.0, 0.0) | (0, 255, 0) | #00FF00 |
| Cyan | (0.0, 1.0, 1.0) | (0, 255, 255) | #00FFFF |
| Blue | (0.0, 0.0, 1.0) | (0, 0, 255) | #0000FF |
| Magenta | (1.0, 0.0, 1.0) | (255, 0, 255) | #FF00FF |
| Purple | (0.5, 0.0, 0.5) | (128, 0, 128) | #800080 |
| Black | (0.0, 0.0, 0.0) | (0, 0, 0) | #000000 |
| White | (1.0, 1.0, 1.0) | (255, 255, 255) | #FFFFFF |

Hex / binary / decimal

0xF = 1111 = 15

0x8 = 1000 = 8

0x0 = 0000 = 0

0xFF = 1111 1111

= $2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^1 + 2^0$

= 128 + 64 + 32 + 16 + 8 + 4 + 2 + 1

= 255

0x80 = 1000 0000

= $2^7 + 0 + 0 + 0 + 0 + 0 + 0 + 0$

= 128 + 0 + 0 + 0 + 0 + 0 + 0 + 0

= 128

X
E
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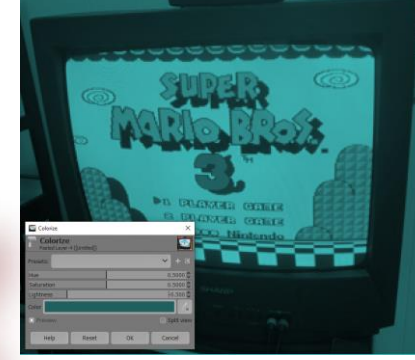
Hue, Saturation, Value (HSV)

- Hue - Position on the visible spectrum
 - Usually represented in degrees, 0 to 360
- Saturation - "fadedness" or tints
- Value - "darkness"

- HSV gives greater control in game programming to modify an image's color
 - Fading, Hue rotation, etc
 - Most vibrant colors = full saturation and value
- Can mathematically convert from RGB to HSV

Gimp - Colorize

- change hue, saturation, and lightness values
- consistent color tone



-0.5 lightness



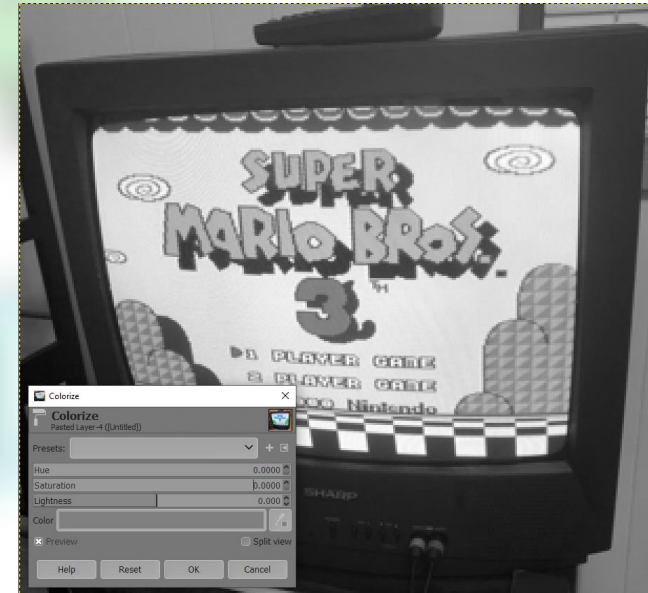
0.5 lightness



Hue change only



Full saturation

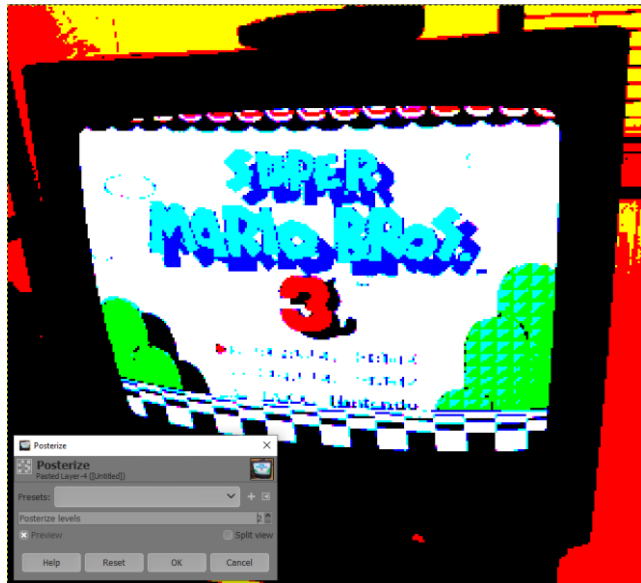


Zero saturation

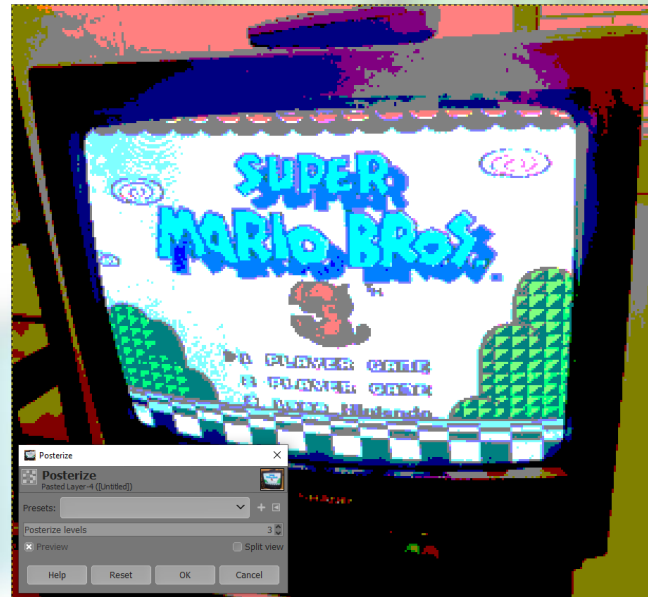
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Gimp - Posterize

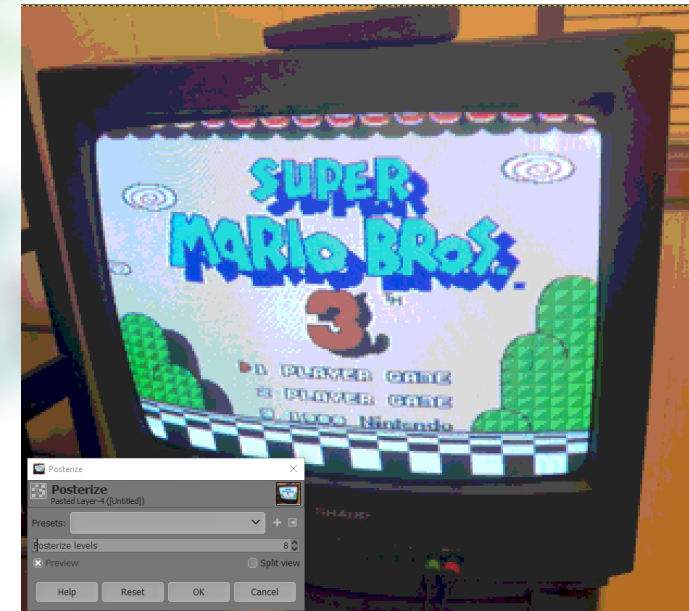
- Reduce number of colors
- Old resolution look / old CD ROM video



Levels = 2



Levels = 3

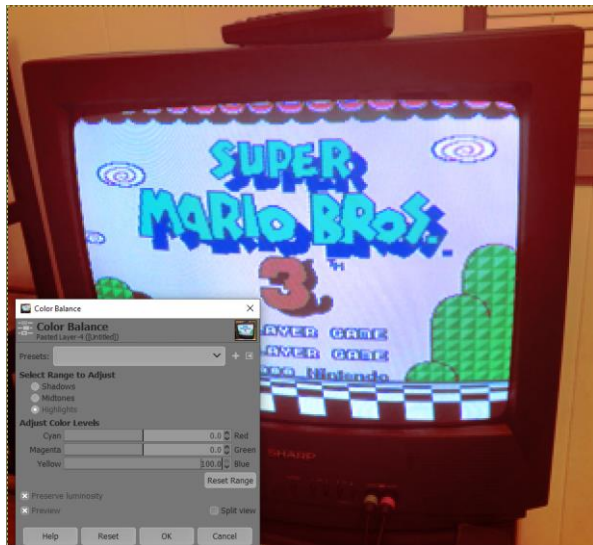


Levels = 8

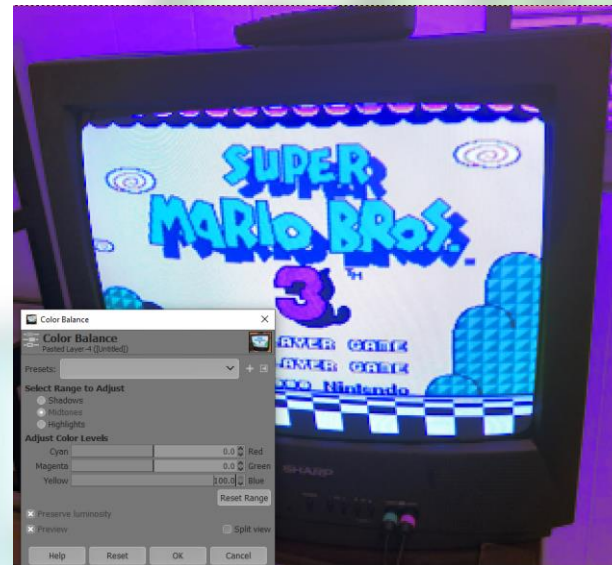
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Color Balance

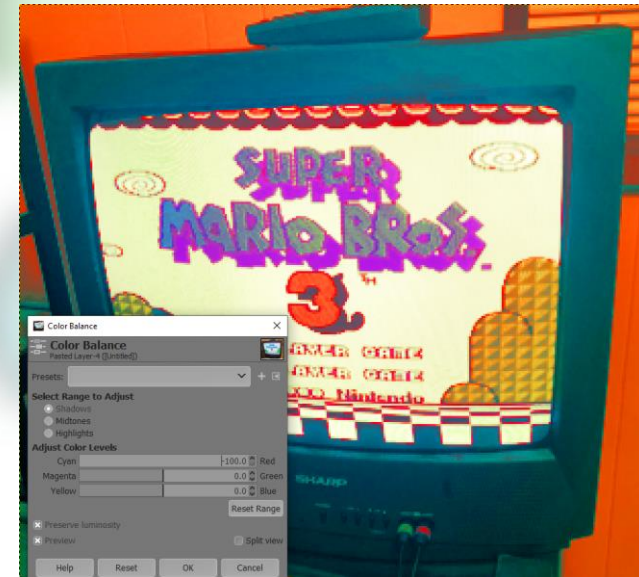
- Change Shadows, Midtones, and Highlights



Red shadows, blue highlights



blue midtones



Red midtones, yellow highlights,
Cyan shadows

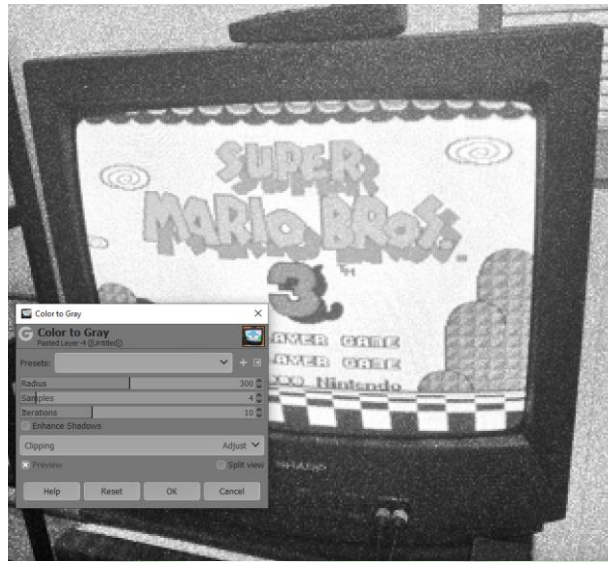
More tools



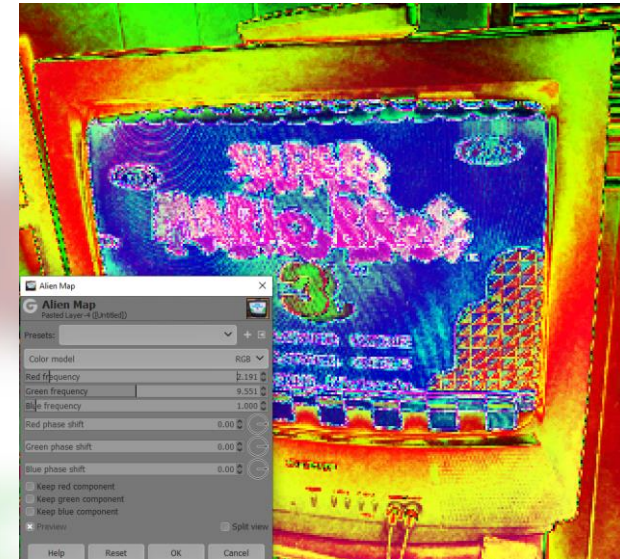
Invert (like a film negative)



Hue - Chroma



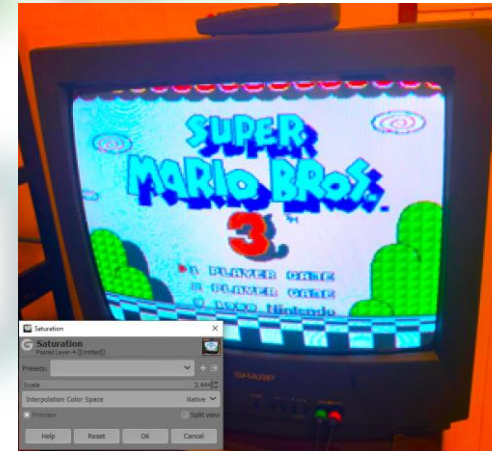
Desaturate > Color to Gray (like newspaper photo)



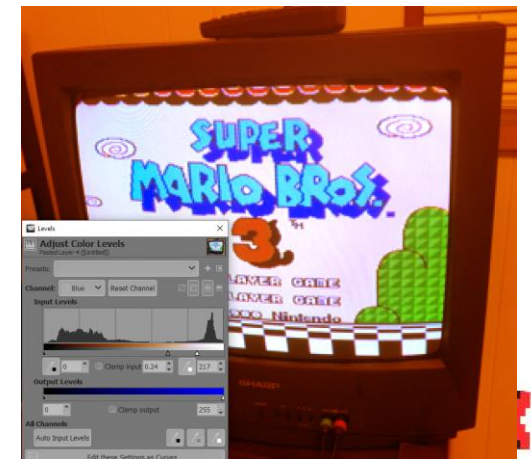
Alien Map



Brightness - Contrast (Darks darker, Lights lighter)



Saturation (more options)

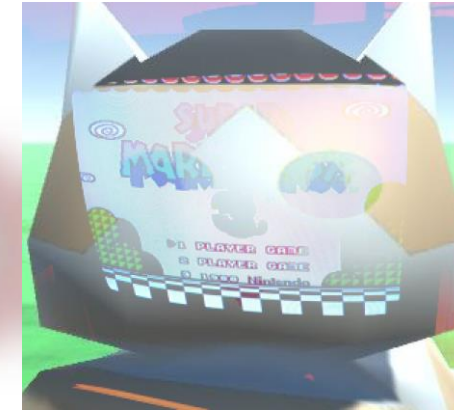


Color > Levels
Fine grain controls over color channels using histogram

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Layers

- Can apply a tint, but preserve some original color



Lighten Only



Dodge



Red layer, Mode Normal, 50%



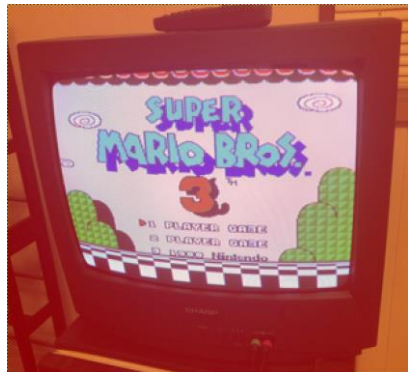
Merge 50%



Screen



Addition



Red layer, Mode Normal, 25%



Overlay



Hard light



Difference



Luminance

Other color schemes

- VT100 color codes
 - BBS / terminals
 - <http://www.termsys.demon.co.uk/vtansi.htm>
- QBasic
 - <https://www.tek-tips.com/viewthread.cfm?qid=33506>

| Red | Green | Blue | Value (binary),(decimal) | Colour |
|-----|-------|------|--------------------------|--------------|
| 0 | 0 | 0 | 000 0 | Black |
| 0 | 0 | 1 | 001 1 | Blue |
| 0 | 1 | 0 | 010 2 | Green |
| 0 | 1 | 1 | 011 3 | Cyan |
| 1 | 0 | 0 | 100 4 | Red |
| 1 | 0 | 1 | 101 5 | Magenta |
| 1 | 1 | 0 | 110 6 | Yellow/Brown |
| 1 | 1 | 1 | 111 7 | White/Grey |

```
0      Reset all attributes
1      Bright
2      Dim
4      Underscore
5      Blink
7      Reverse
8      Hidden

      Foreground Colours
30     Black
31     Red
32     Green
33     Yellow
34     Blue
35     Magenta
36     Cyan
37     White

      Background Colours
40     Black
41     Red
42     Green
43     Yellow
44     Blue
45     Magenta
46     Cyan
47     White
```

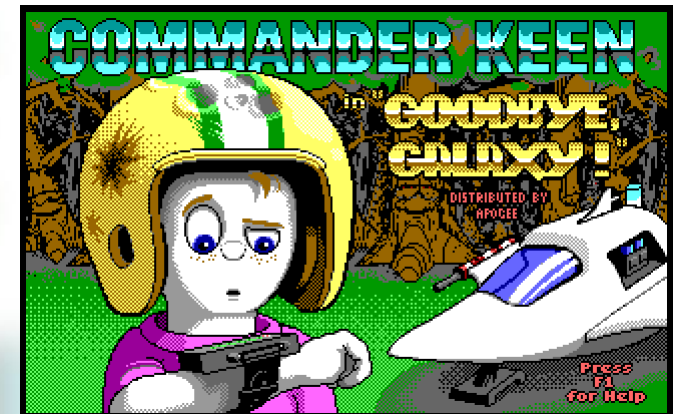
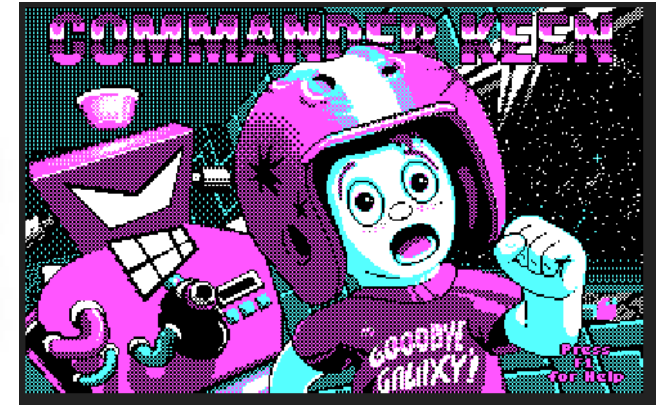
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Console Color Palettes

- NES - 56 colors (2^6 , some black repeated)
 - Only a subset of colors could be displayed at once
- GameBoy - 4 colors (2^2)
- SNES - 32,768 colors (15 bit, 2^{15})
- 16 bit color = 65,536 colors
- 24 bit (True color) = 16 million+ colors

Historical Video Modes

- CGA - Color Graphics Adapter
 - Example modes: 320 x 200, 4 colors or 640 x 200, 2 colors
- EGA - Enhanced Graphics Adapter
 - Example mode: 640 x 350, 16 colors
- VGA - Video Graphics Array
 - Example mode: 640 x 480, 16 colors
- Super VGA
 - Example modes: 800 x 600 or 1024 x 768
- HD
 - 720p - 1280 x 720
 - 1080p - 1920 x 1080
- 4K
 - 3840 x 2160



<https://tcubedinteractive.wordpress.com/2016/08/20/cgaegavga/>

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Color Palettes

- <https://color.adobe.com/create/color-wheel>

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Color Pickers

HTML Color Picker

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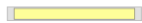
Pick a Color:



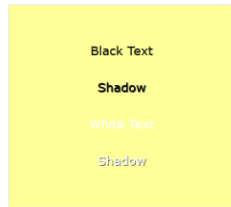
Or Enter a Color:

Color value OK

Or Use HTML5:

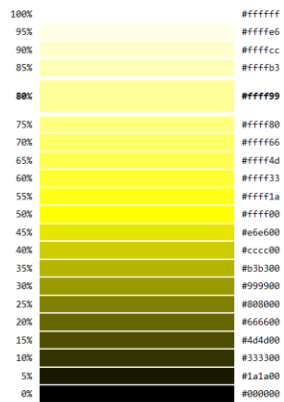


Selected Color:

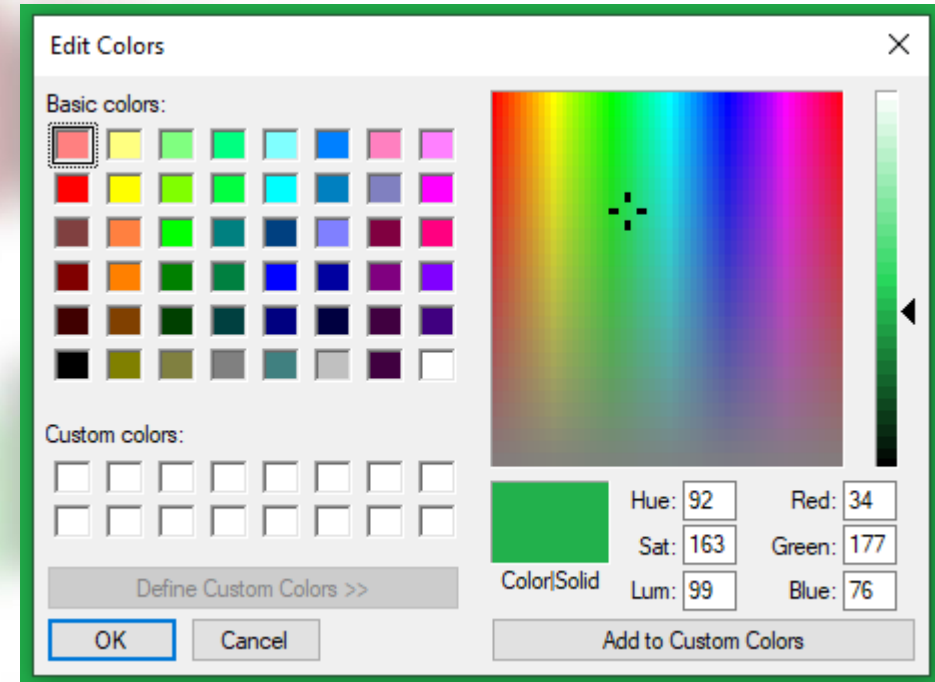


#ffff99
rgb(255, 255, 153)
hsl(60, 100%, 80%)

Lighter / Darker:



MS Paint



- https://www.w3schools.com/colors/colors_picker.asp

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