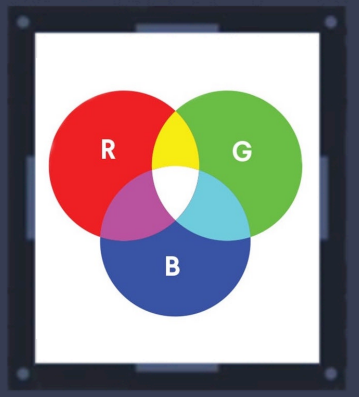
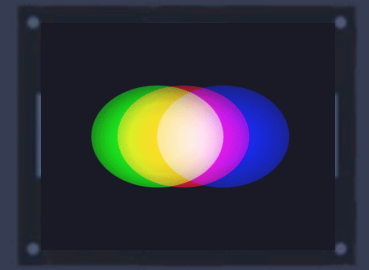
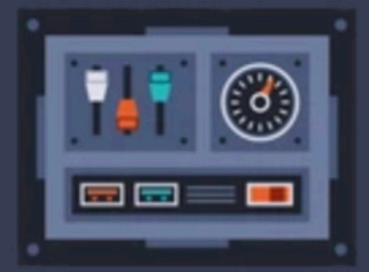
Sistema de Cores

Computação Gráfica

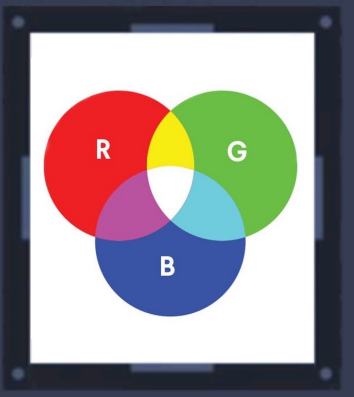


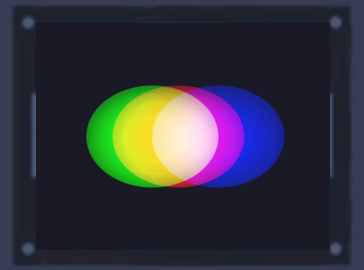




Cores

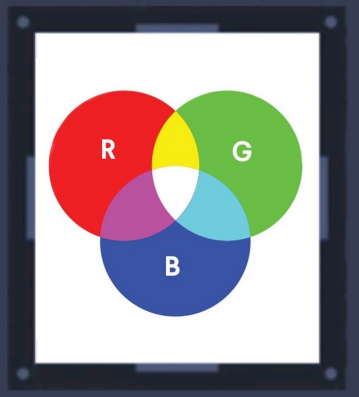
- Possuem significado próprio
- Expressam emoções
- Computação Gráfica
  - Legibilidade da informação, imagens realistas, atraem o observador, etc.
- Colorimetria
  - Técnicas para definir e comparar cores
  - Estuda e quantifica como percebemos as cores

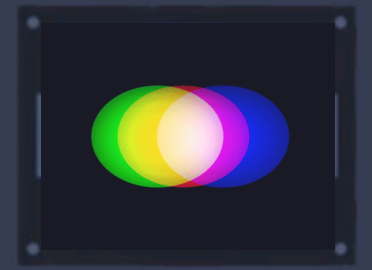


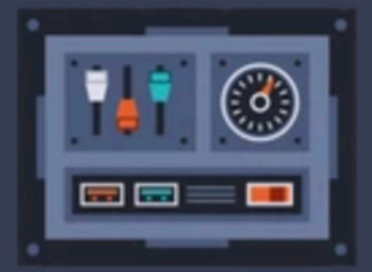


Colorimetria

- Observador padrão (determinado em experimentos)
- Cores são definidas por três parâmetros
  - Intensidade (luminância, intensidade ou brilho)
  - Tonalidade cromática (comprimento de onda)
  - Saturação (pureza da cor, a mistura de tons, etc.)
- Colorímetros
  - Aparelhos que determinam as componentes ou coordenadas tricromáticas de um estímulo de cor

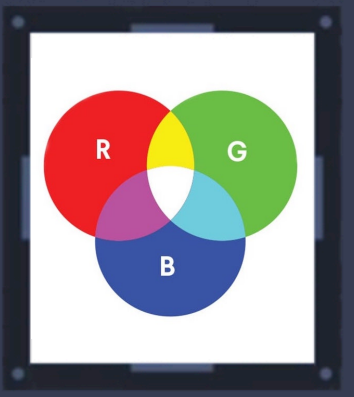






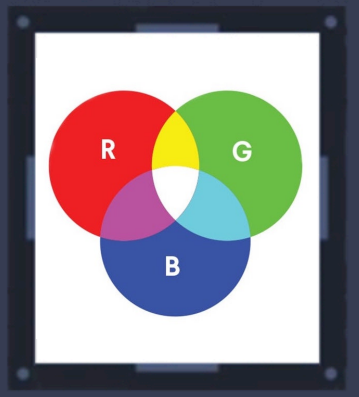
Histórico

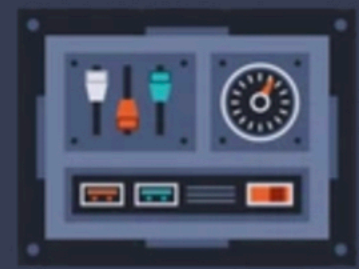
- Escola de Platão criou a Óptica Geométrica
- René Descartes e Isaac Newton (século XVIII)
  - Óptica Física ou Ondulatória
  - Modelos clássicos usados para descrever os fenômenos luminosos (corpuscular e ondulatório)
- Young (século XIX)
  - Todas as cores do espectro visível podem ser representadas por três cores primárias
  - Decorrência do sistema visual humano



Histórico

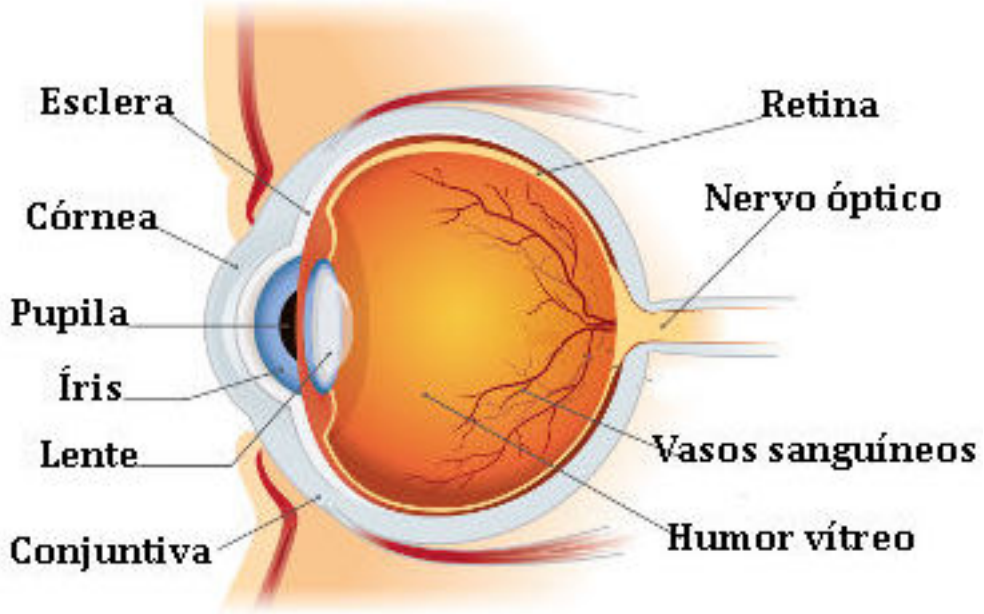
- Hermann von Helmholtz
  - Olho possui três tipos de receptores de cor (RGB)
  - Cada receptor com diferente sensibilidade
  - A cor é dada pela média de incidência luminosa
- Max Planck, Maxwell e Hertz (Dualidade)
  - Fóton (porções de energia)
  - Quantum (partículas que apresentam energia)

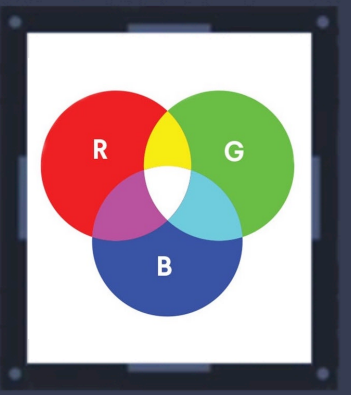


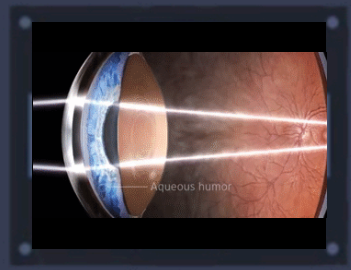


Sistema Visual Humano

- Retina do olho humano
  - Cones (Percepção de cores, região central)
  - Bastonetes (Distinguem os tons de cinza, periferia)

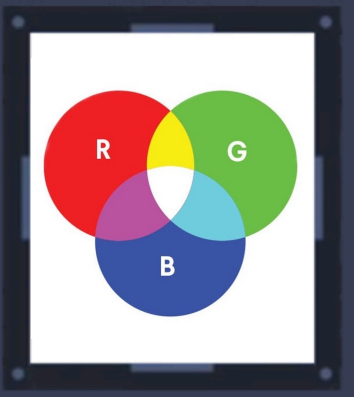


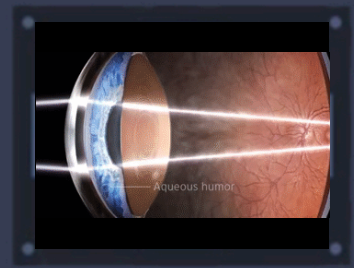


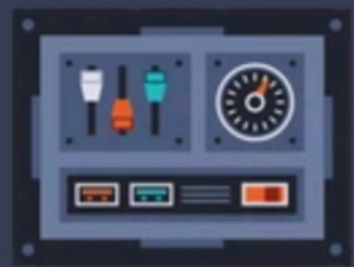


Retina

- Transforma a luz em sinais nervosos que são transmitidos para o cérebro através dos nervos óticos
- Possui um tempo de saturação
  - Visão depende do tempo de exposição
- Cegueira às cores
  - Não funcionamento ou falta de um tipo de cone
  - Daltonismo (mais comum)
    - Tricomatas
    - Dicromatas
    - Monocromatas

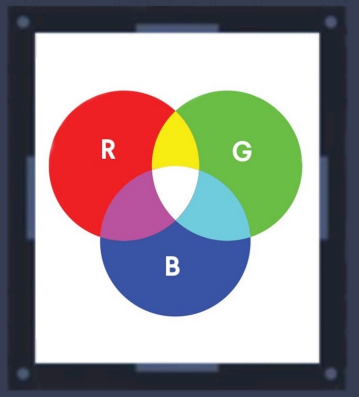


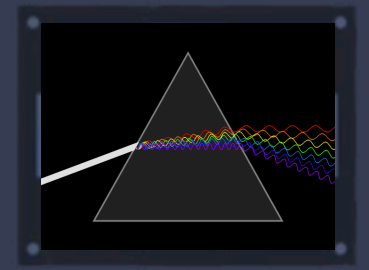




Descrição de Cor da Luz

- Cores são diferenças de comprimento de onda
  - Algumas cores são produzidas por vários comprimentos de onda
- Comprimentos de onda contidos numa cor podem ser descritos por sua curva espectral
  - Luz pura (único comprimento de onda)
  - Outras luzes (mistura de comprimentos de onda)

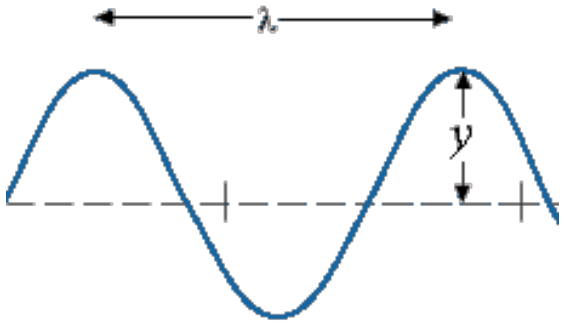


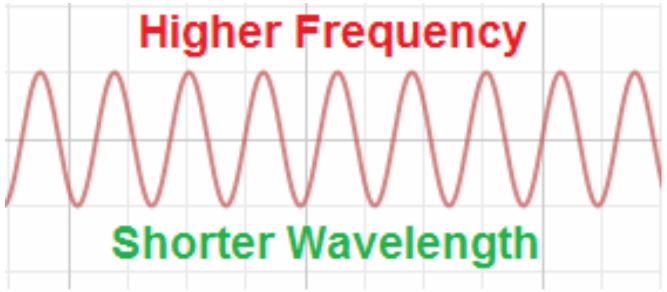


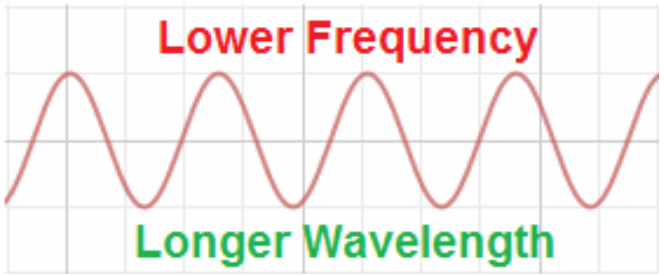
Ondas Eletromagnéticas

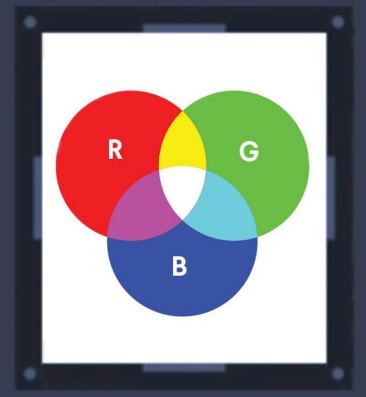
- Estudadas desde a antiguidade
- A luz é uma onda eletromagnética
- Cobrem um amplo intervalo de frequência

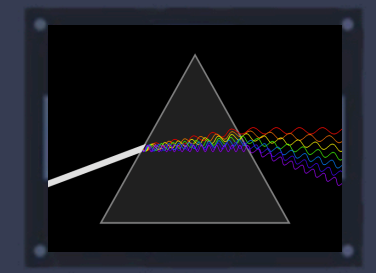
$$\lambda = \frac{v}{f}$$

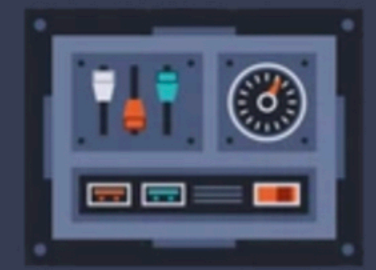




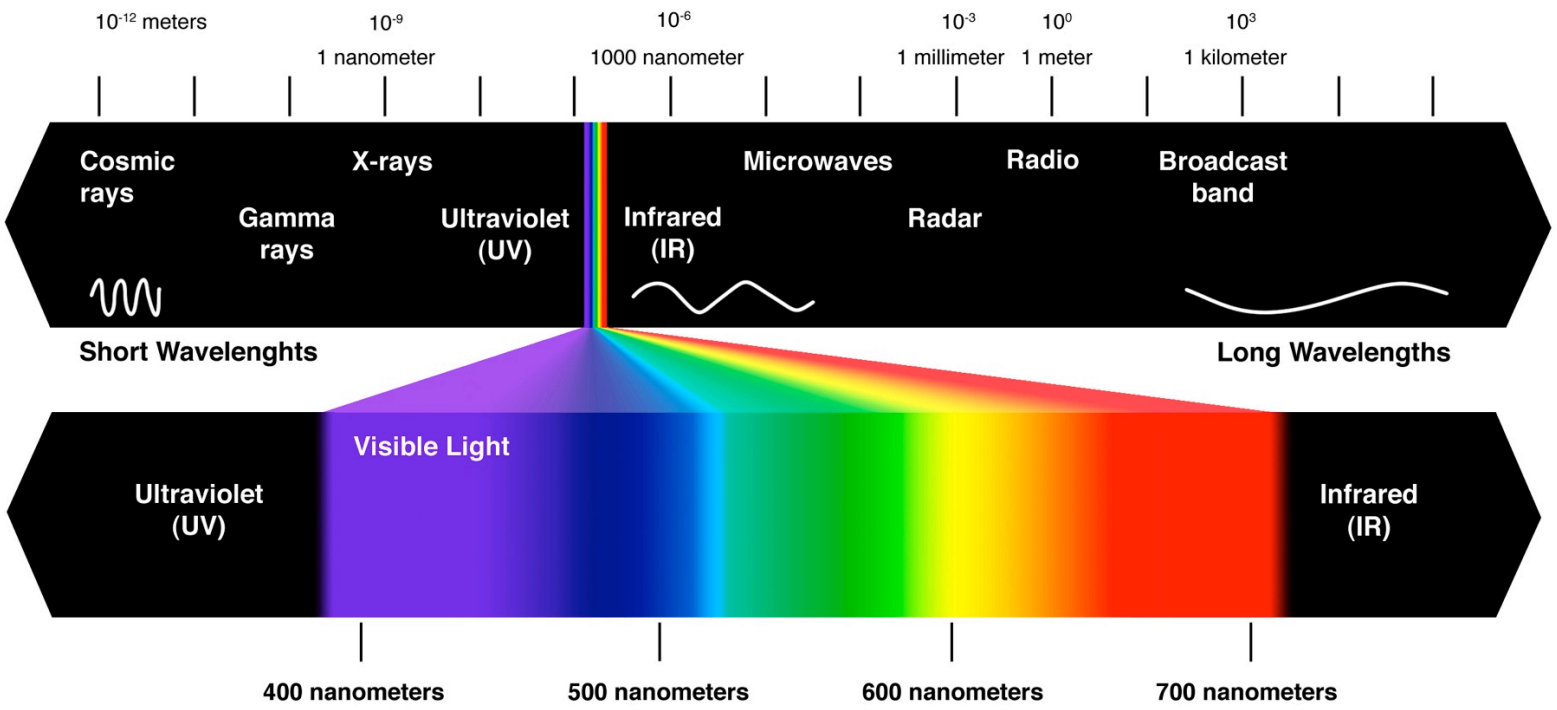


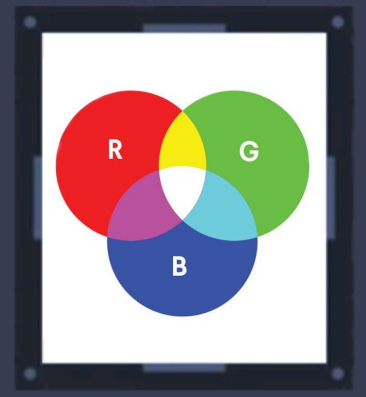


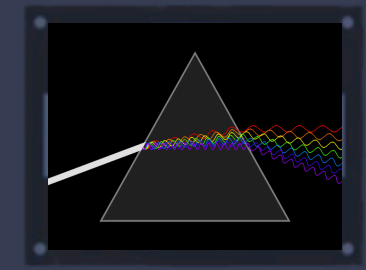


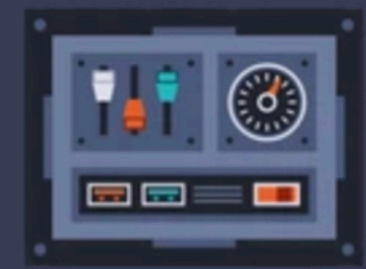


Espectro Visível



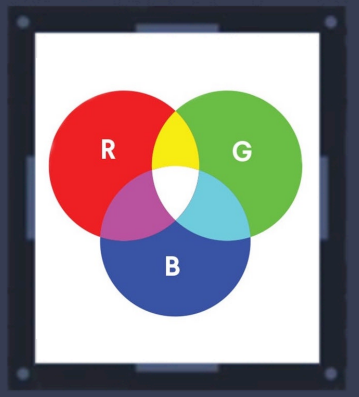


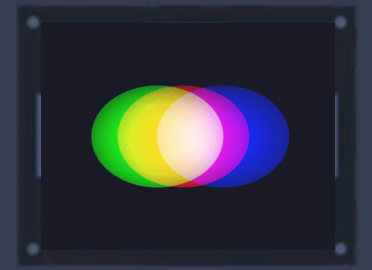


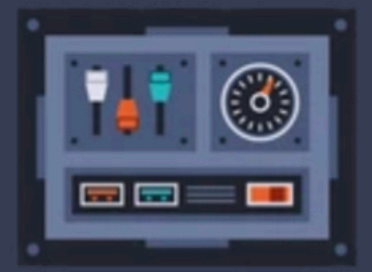


Cores Primárias

- Podem ser usadas para produzir outras cores
- Humanos têm três tipos de sensores de cor
  - Fotopigmentos azul, vermelho e verde
- Não existe um conjunto finito de cores primárias que produza todas as cores
  - Grande parte pode ser produzida a partir de cores escolhidas das extremidades e centro do espectro

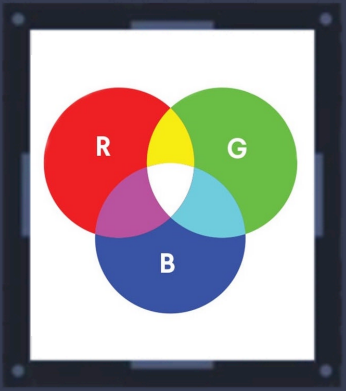


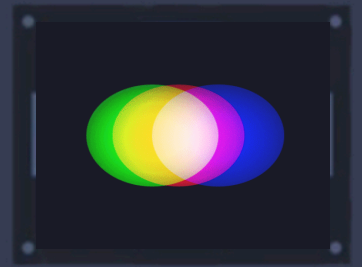




Sistema de Cores

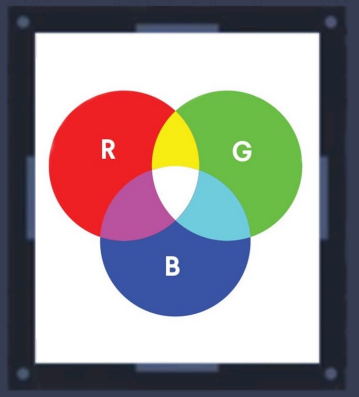
- Modelo de propriedades ou comportamento das cores
- São utilizados sistemas diferentes para ajudar a descrever diferentes características das cores
- Principais sistemas de cores
  - RGB (red, green e blue)
  - XYZ (derivado do RGB)
  - HSV (hue, saturation e value)
  - HLS (hue, lightness e saturation)

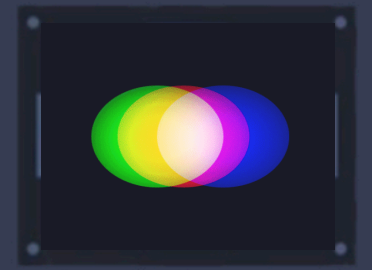


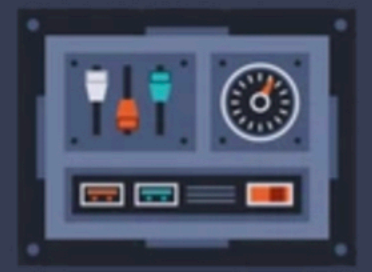


Espaço de Cores

- Universo de cores que podem ser reproduzidas por um sistema de cores (color gamut)
- Quantificar as sensações visuais das cores
- Cores mapeadas em sistemas de coordenadas
- Definir as cores visíveis através de primárias
  - Commission Internationale de l'Éclairage-CIE definiu três primárias supersaturadas
  - Usadas para produzir um gráfico das cores







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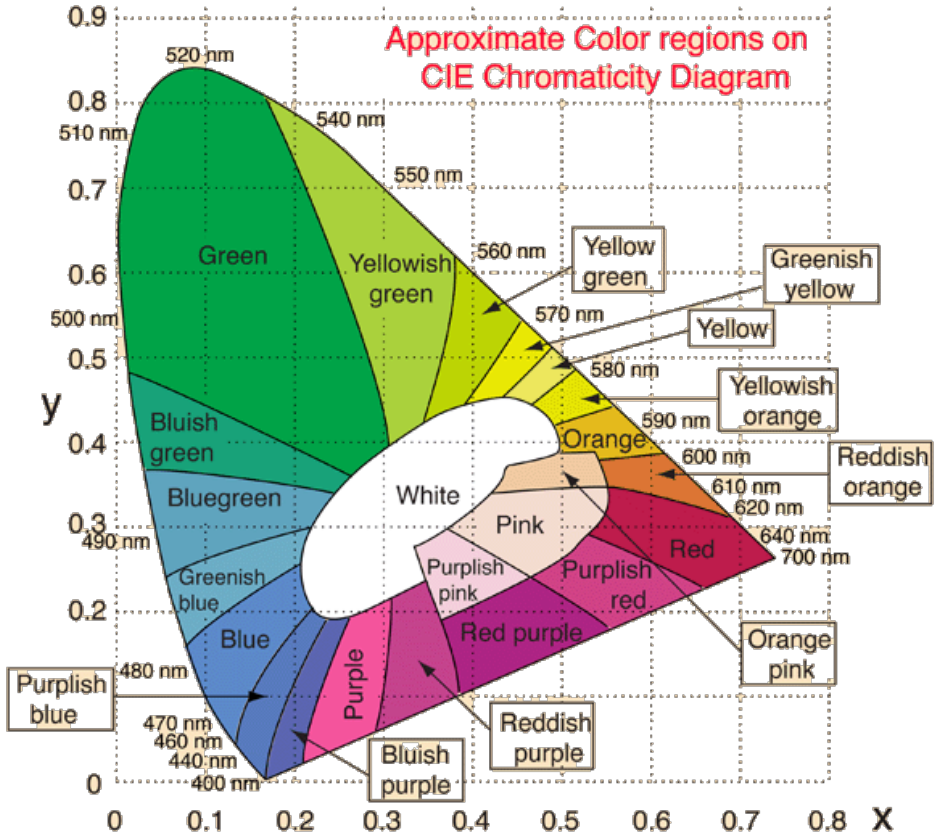
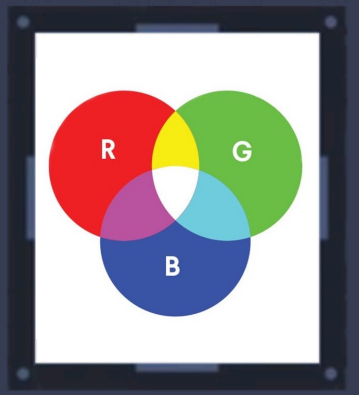
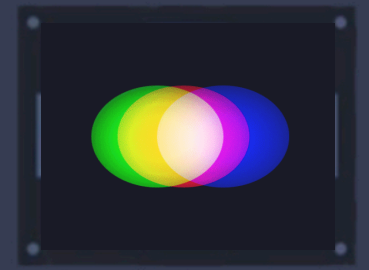
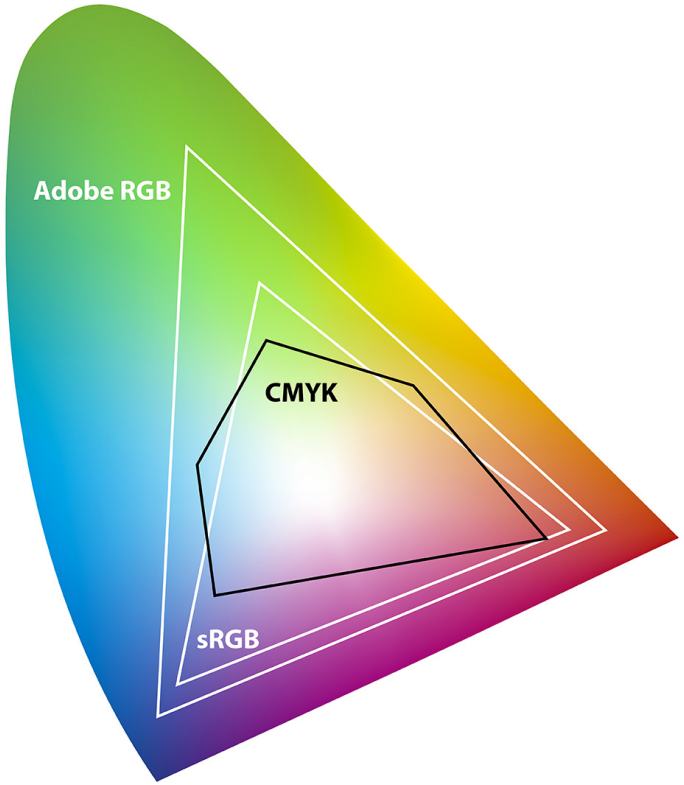
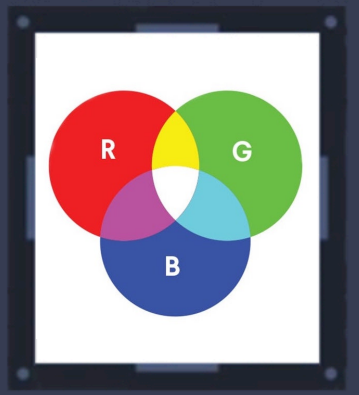


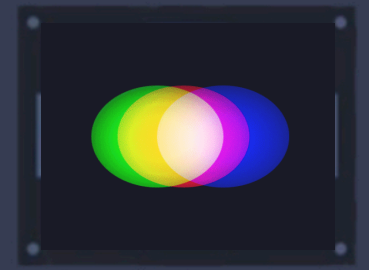


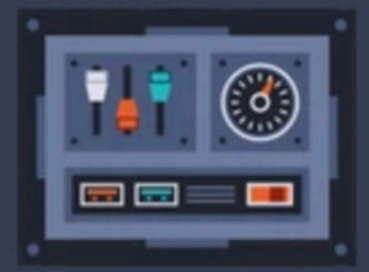


Espaço de Cores



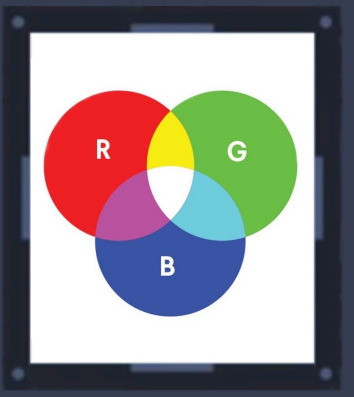


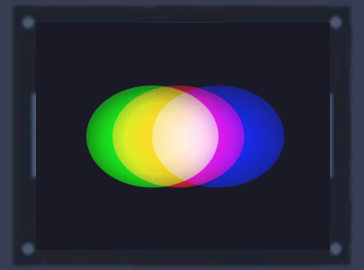




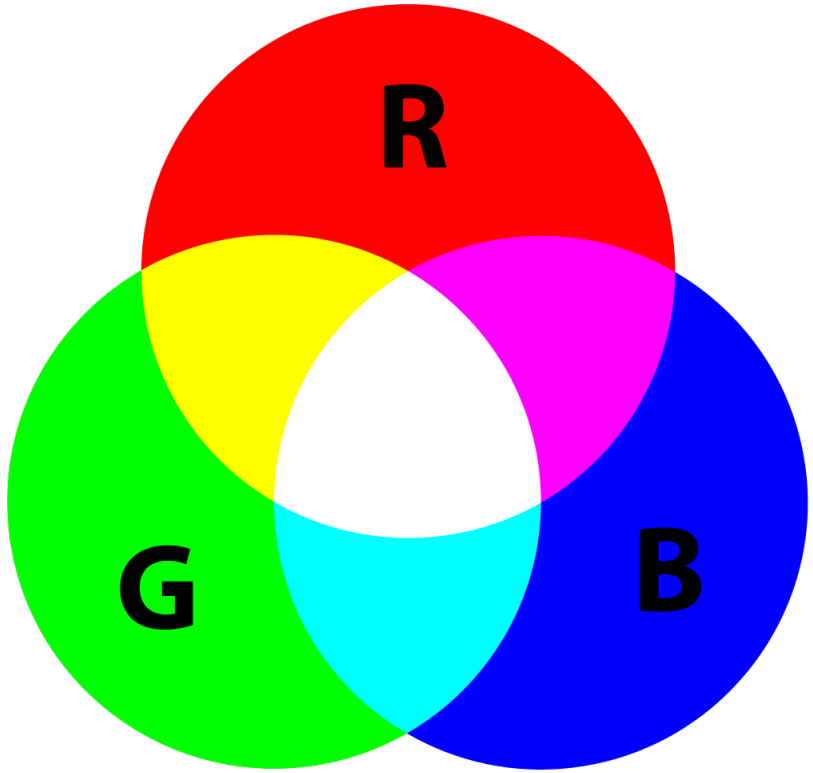
Sistemas de Cores Aditivas

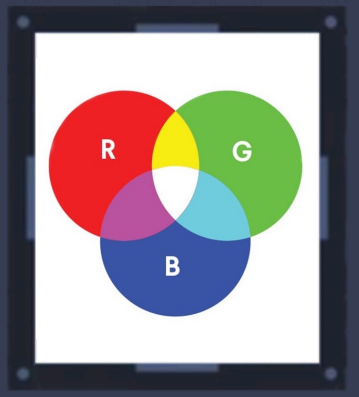
- Usado nos monitores de vídeo e televisões
- Cores geradas pela mistura de vários comprimentos de onda luminosa
- Cores primárias aditivas
  - Vermelho, verde e azul
- O preto é obtido pela ausência de cor (luz)
- O branco é a mistura de todas as cores
- Uma cor é obtida matematicamente por
  - C = r.R + g.G + b.B (onde r, g e b são coeficientes)

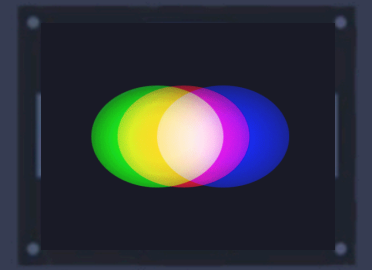


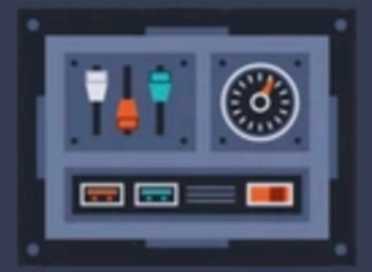


Sistemas de Cores Aditivas

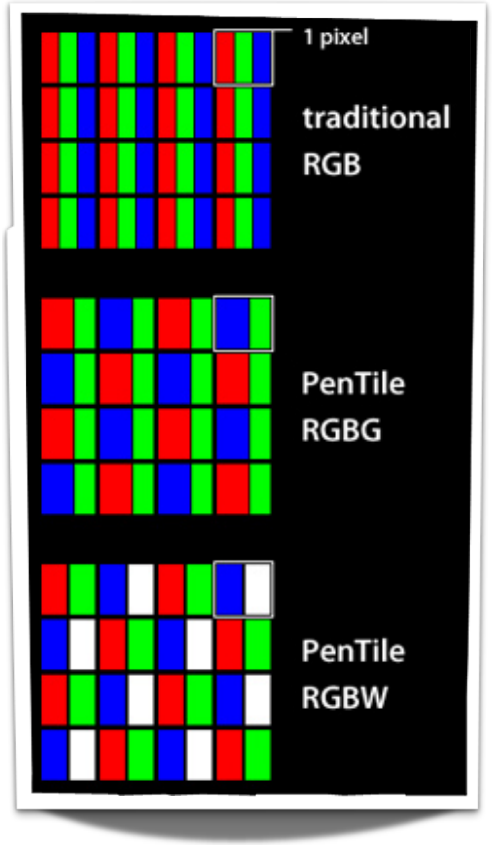


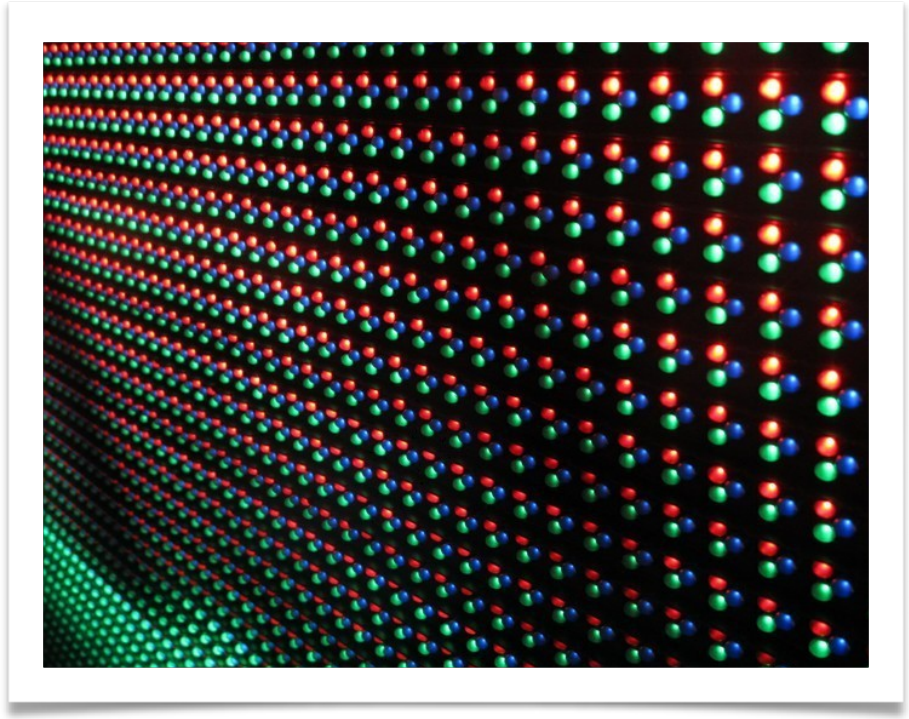


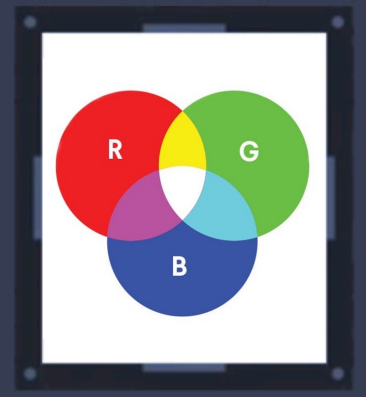


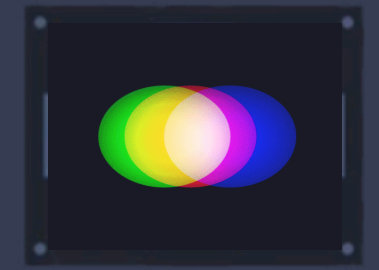


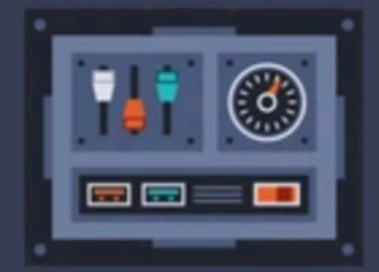
Sistemas de Cores Aditivas



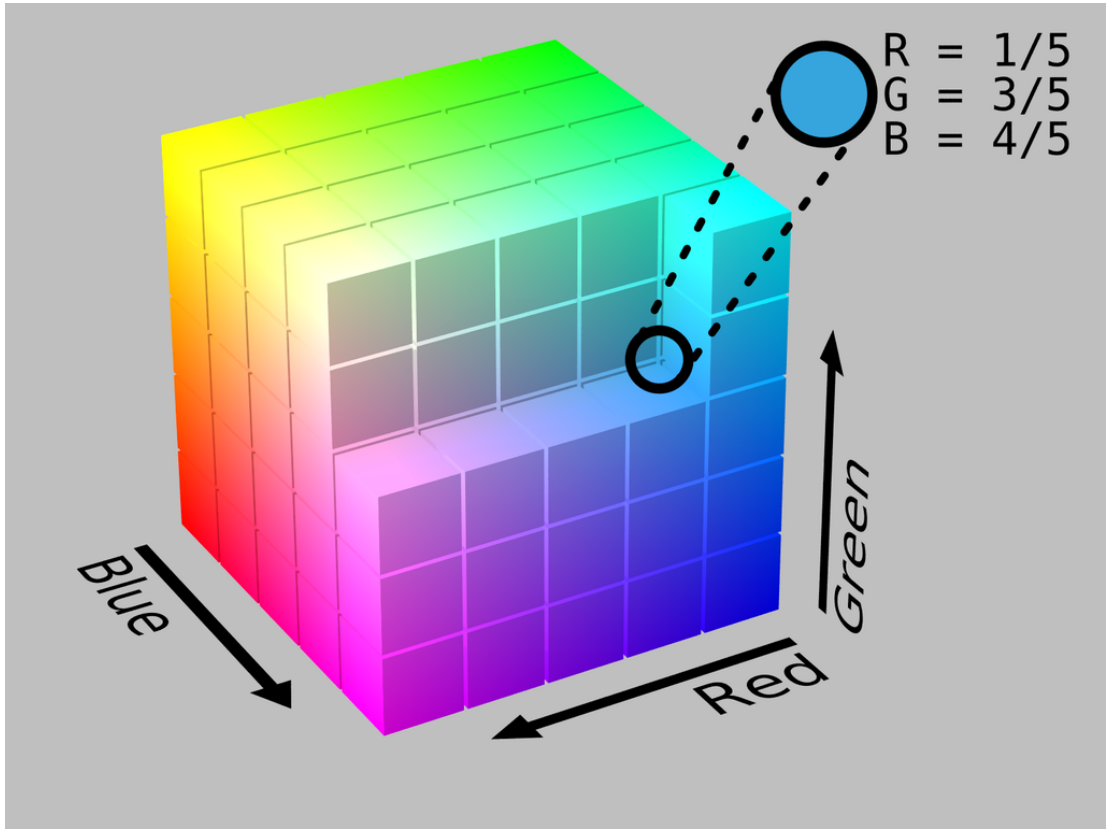


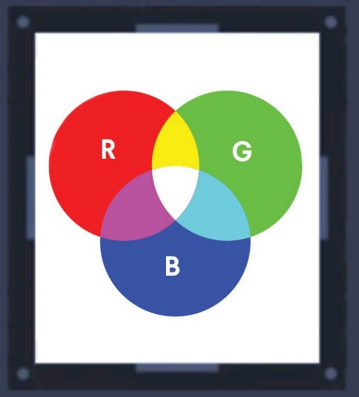


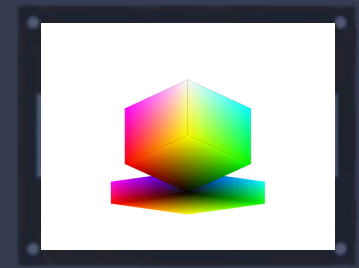


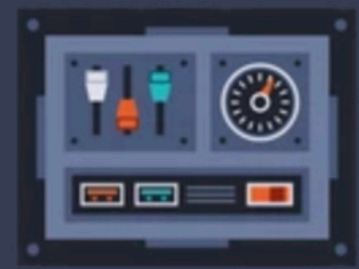


Modelo RGB

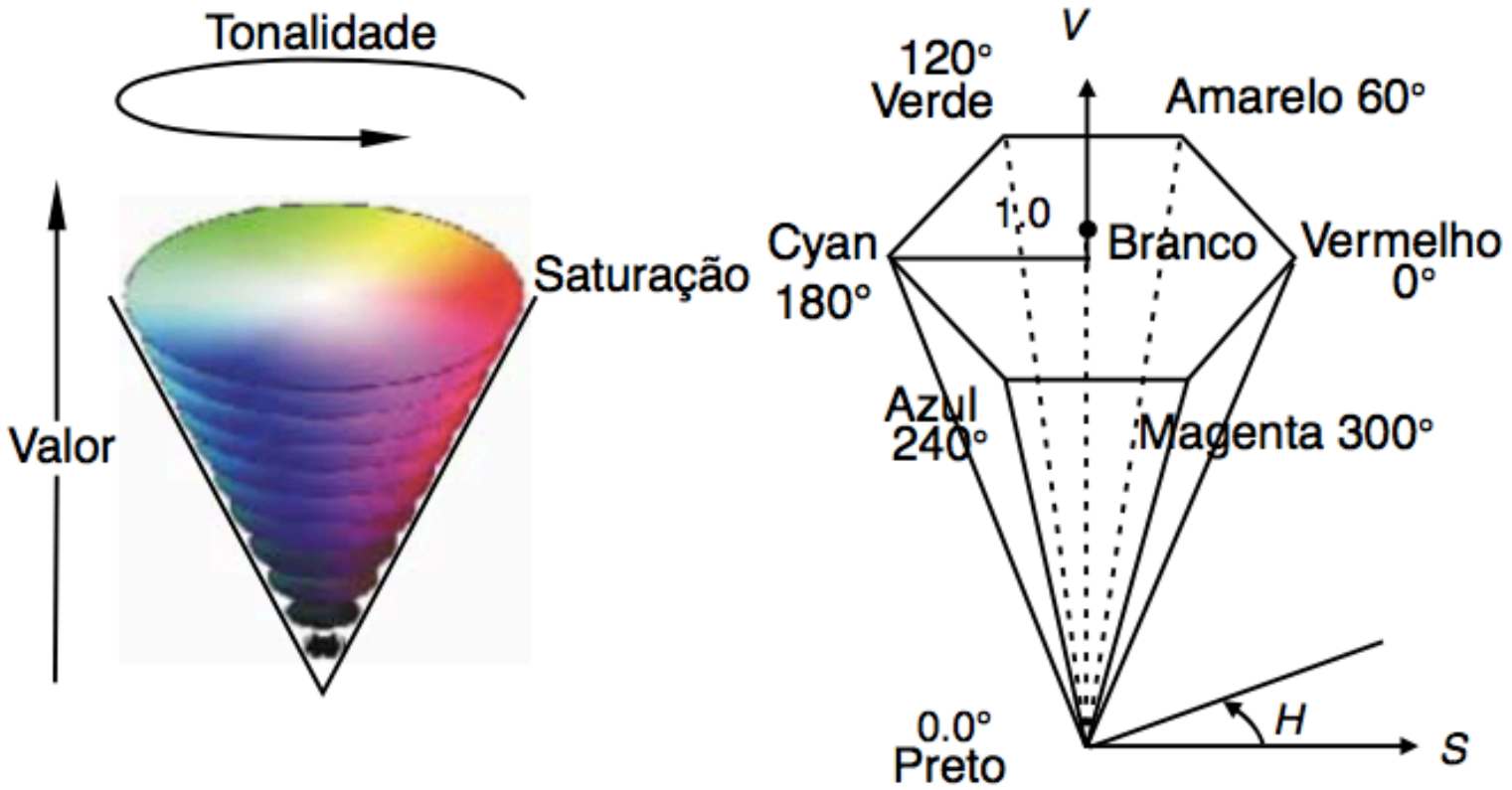


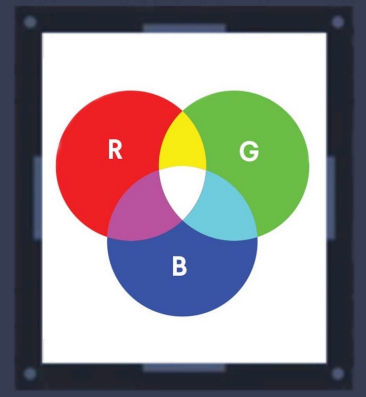


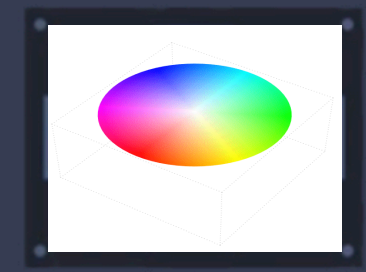


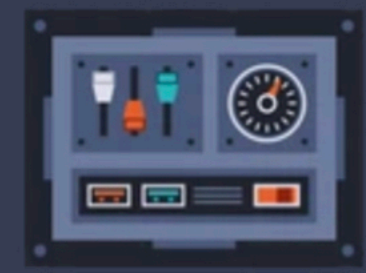


Modelo HSV

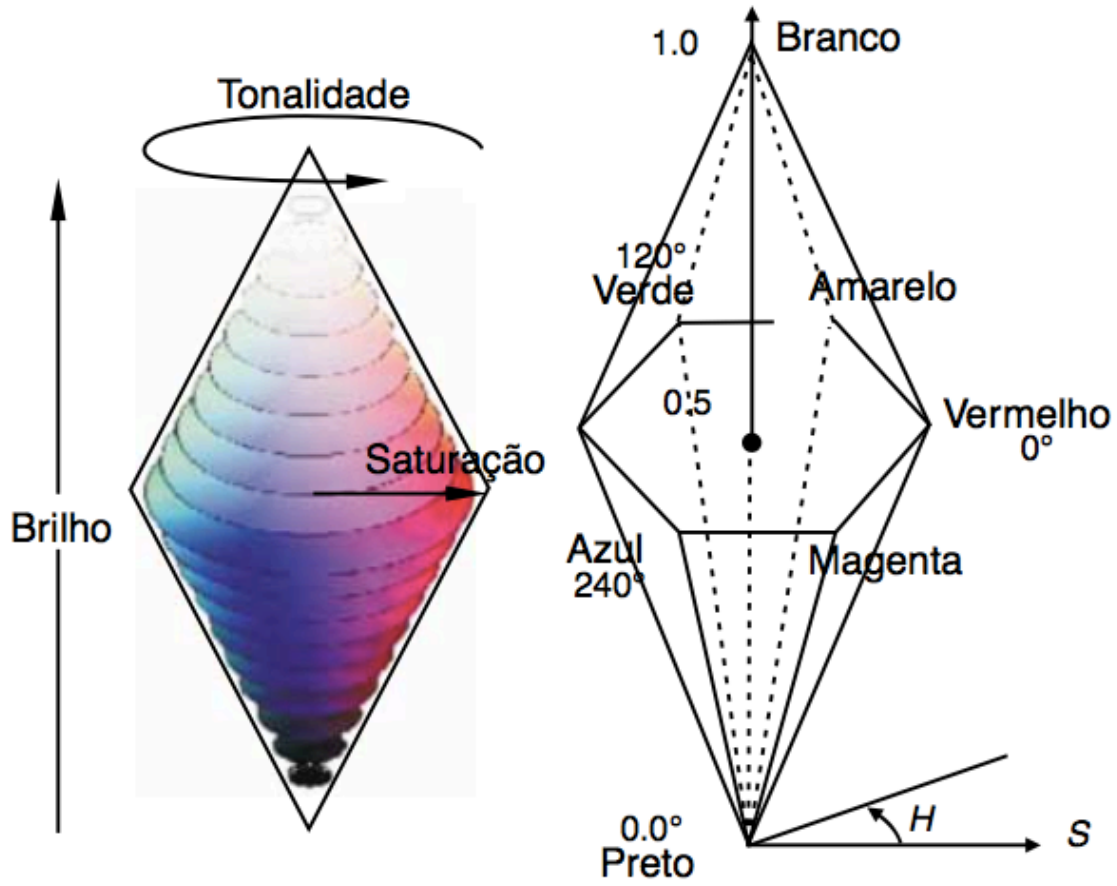

Tonalidade
Saturação
Valor
V
120°
Verde
Amarelo 60°
1.0
Cyan
180°
Branco
Vermelho
0°
Azul
240°
Magenta 300°
0.0°
Preto
H
S

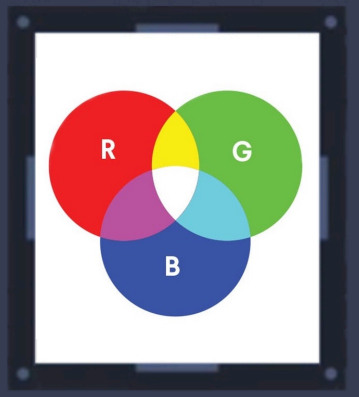

R
G
B

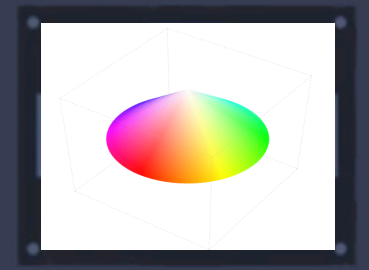


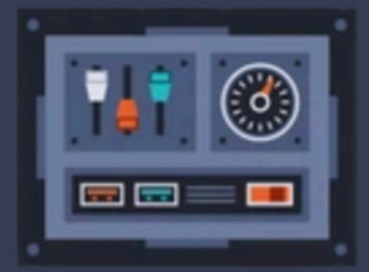


Modelo HSL


Tonalidade
Brilho
Saturação
1.0
Branco
120°
Verde
Amarelo
0.5
Vermelho
0°
Azul
240°
Magenta
0.0°
Preto
H
S

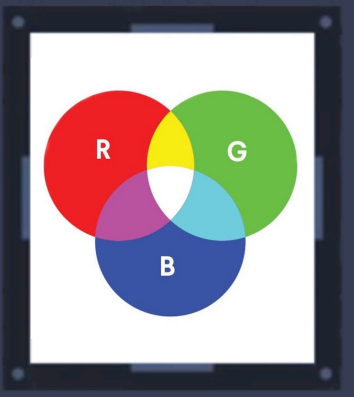

R
G
B

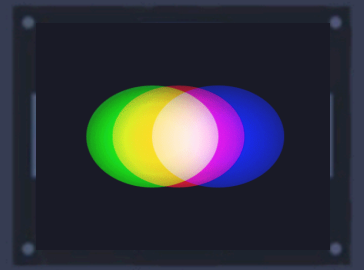




Sistemas de Cores Subtrativas

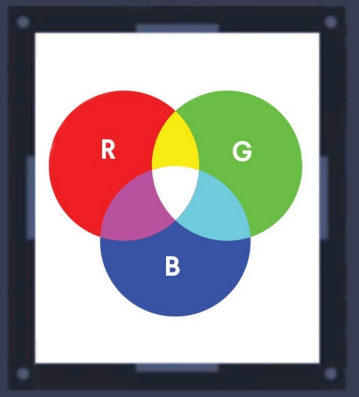
- Usado nas impressoras e pinturas
- Luz branca atinge um objeto
  - Absorção parcial da luz
  - A luz refletida determina a cor do objeto
- Cores primárias subtrativas
  - Magenta, amarelo e ciano
  - Absorvem alguma cor da luz branca
- O branco corresponde a ausência de cor
- O preto é a presença de todas as cores

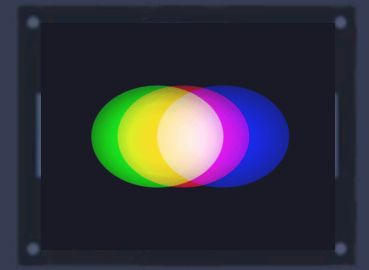


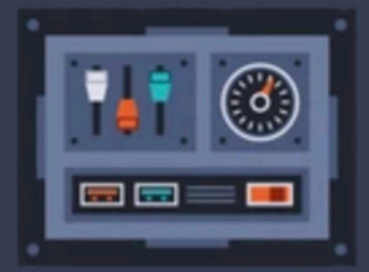


Sistemas de Cores Subtrativas

- Ciano
  - Absorve a componente vermelha da luz branca
  - É a soma de verde e azul
- Magenta
  - Retira a componente verde da luz branca
  - É a soma de vermelho e azul
- Amarelo
  - Subtrai a componente azul da luz branca
  - É a soma de verde e vermelho





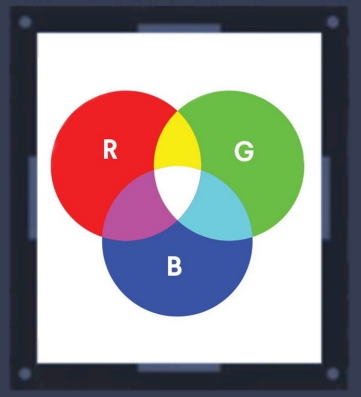


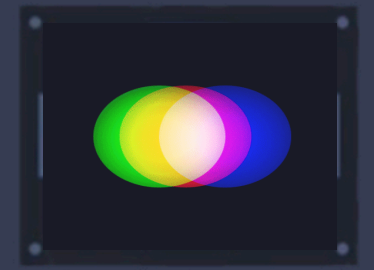
Sistemas de Cores Subtrativas

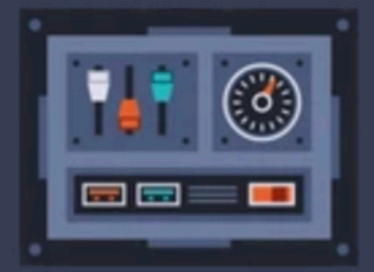
Amarelo + Ciano = Verde

Magenta + Amarelo = Vermelho

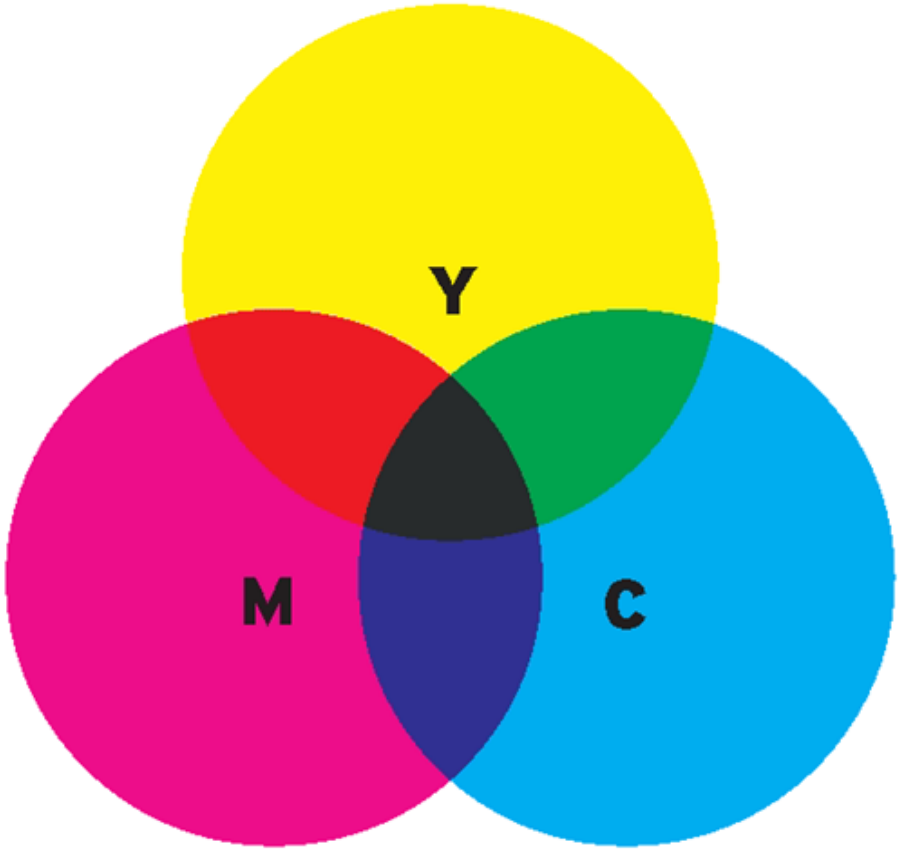
Ciano + Magenta = Azul

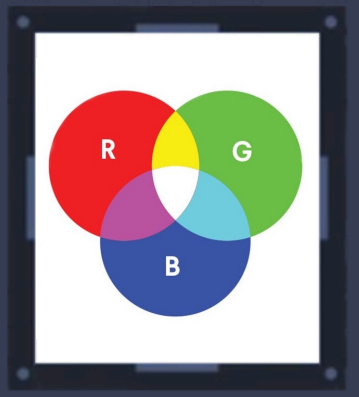


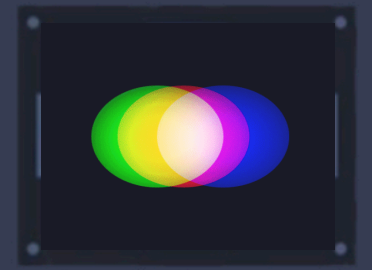


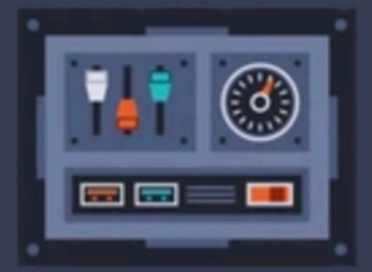


Sistemas de Cores Subtrativas

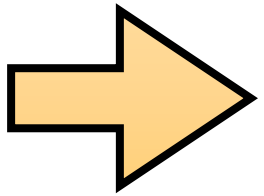


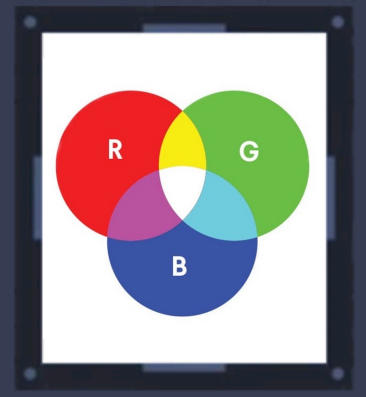


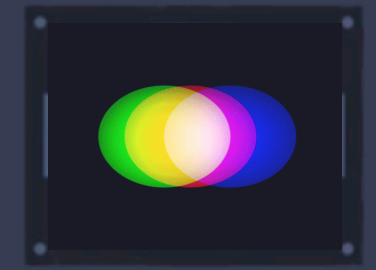


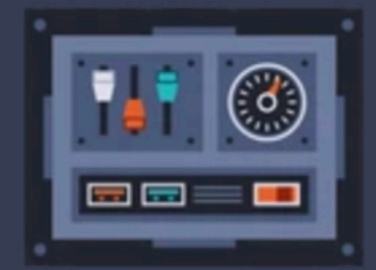


Sistemas de Cores Subtrativas

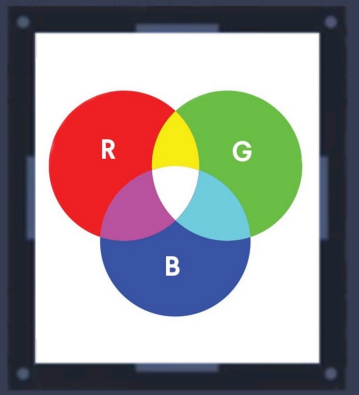


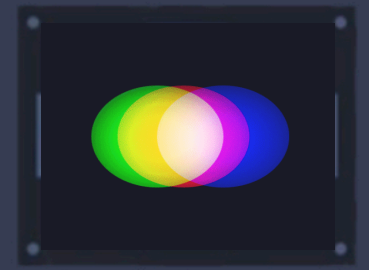






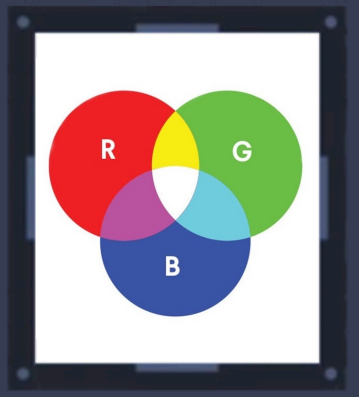
Modelo CYMK

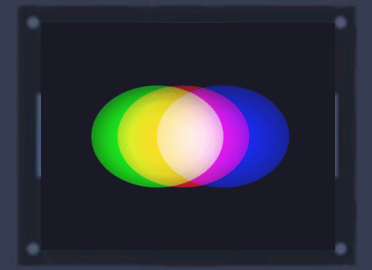


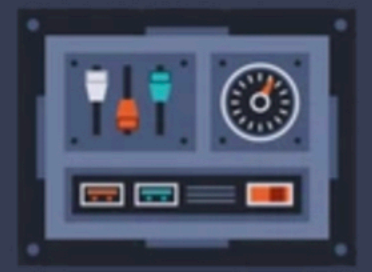


Histograma de Cores

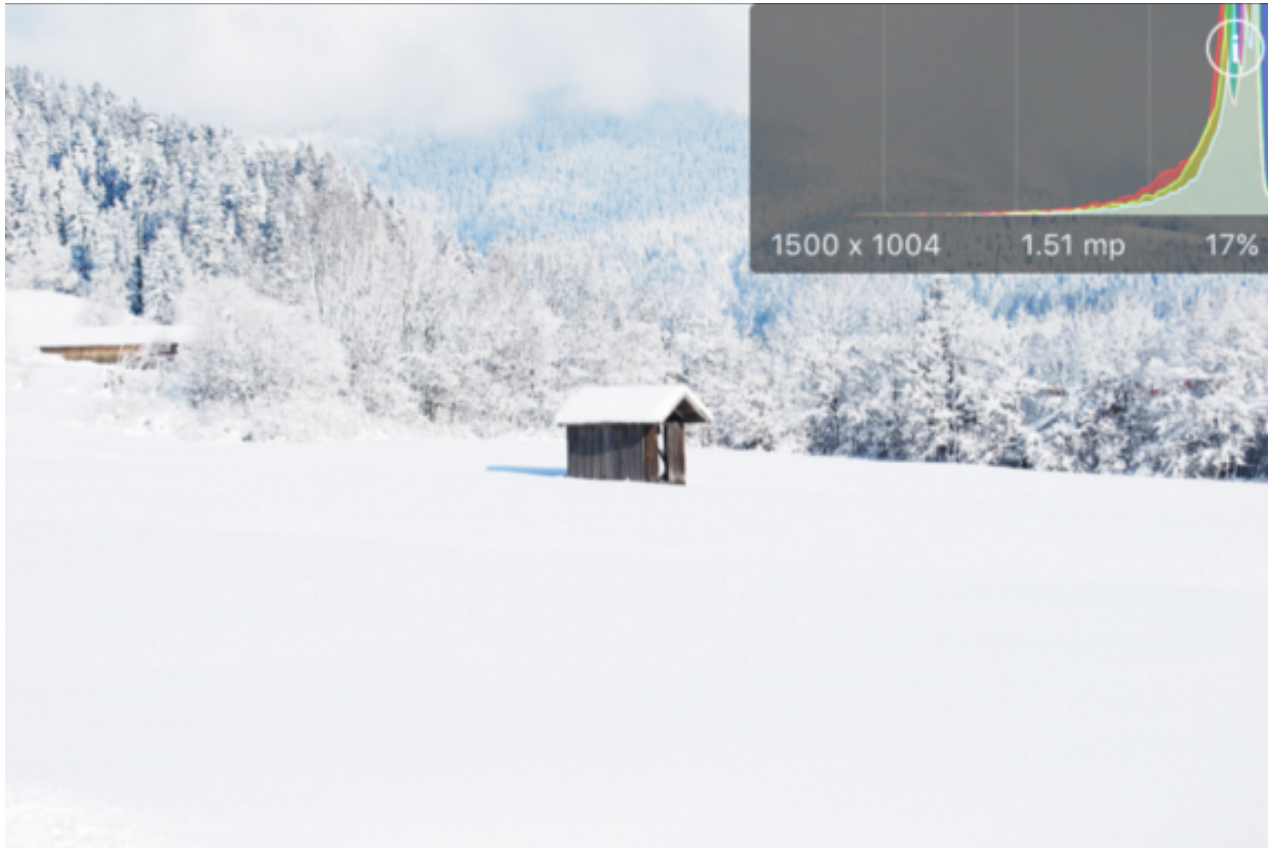
- Caracteriza a distribuição de cores em uma imagem
- Cada ponto da imagem (pixel) pode ser representado como um vetor 3D no espaço (r, g, b)
- Imagens terão um histograma para cada canal de cor
- O valor de cada pixel I[x,y] da imagem I é:
  - $V_c = (I_r[x, y],\ I_g[x, y],\ I_b[x, y])$
- Depois, conta-se o número de ocorrências de cada intensidade para cada canal e plota-se o gráfico

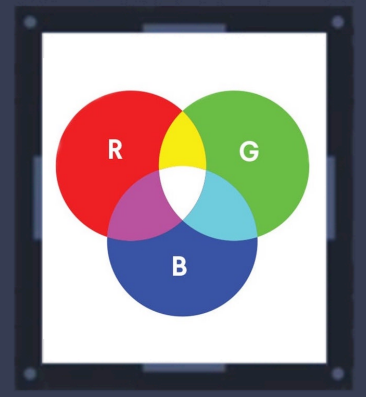


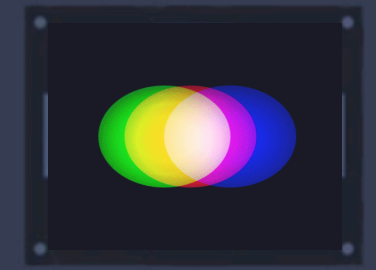


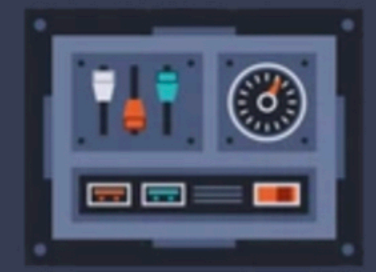


Histograma de Cores

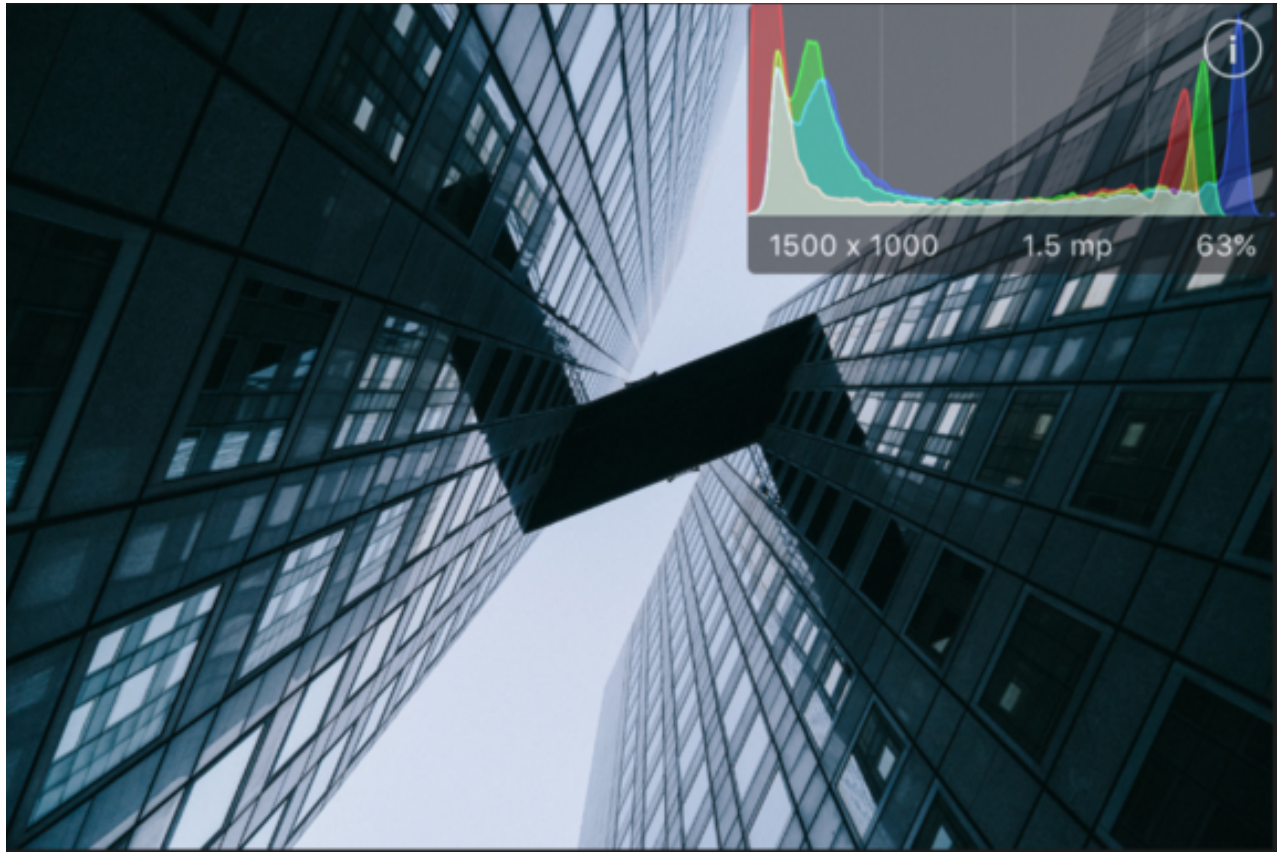


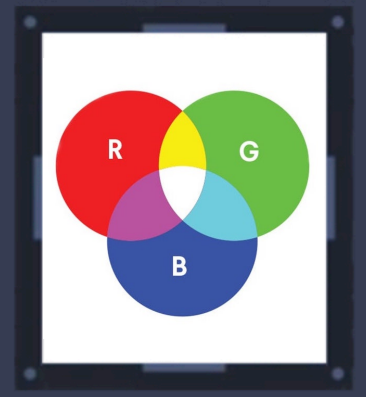


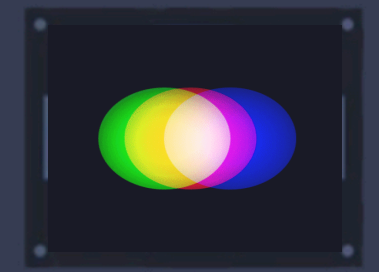


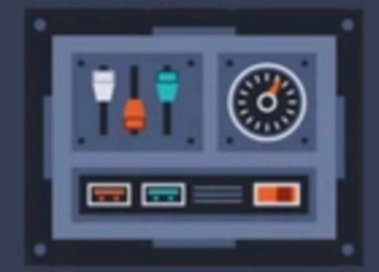


Histograma de Cores

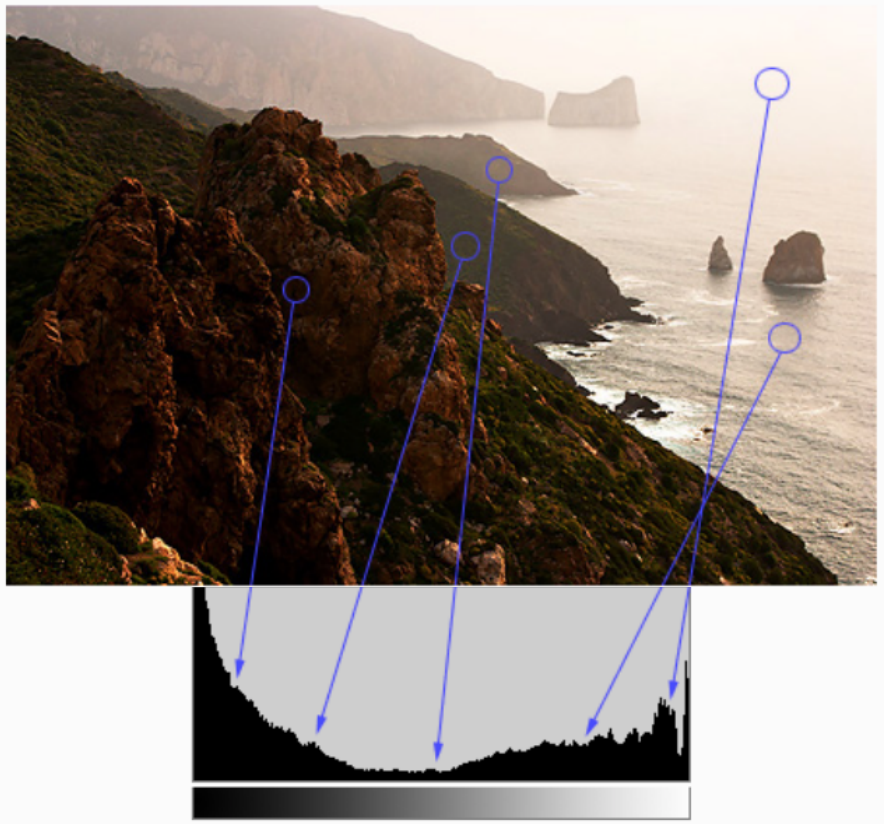


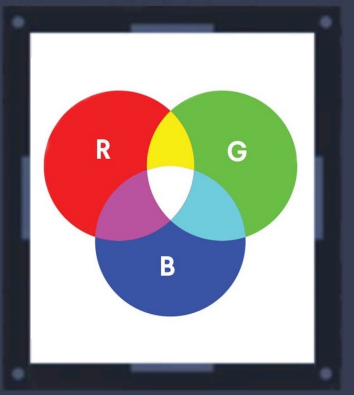


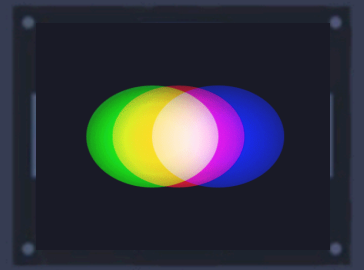


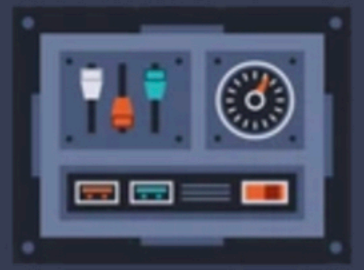


Histograma de Cores





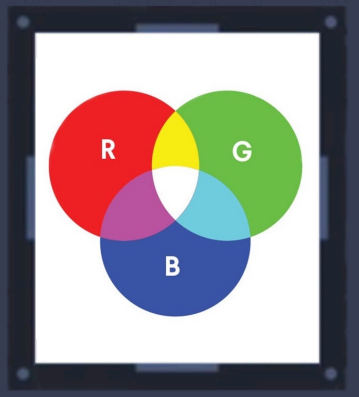


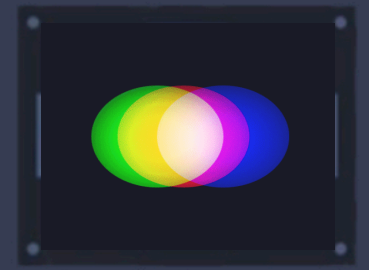


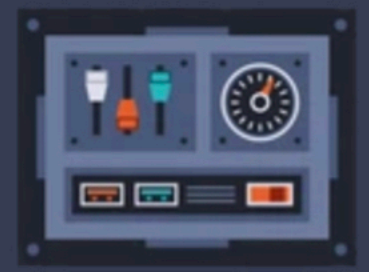
Cores em OpenGL

- glColor3f, glColor4f
- glColor3ub, glColor4ub

Vermelho	glColor3f(1.0f,0.0f,0.0f);
Verde	glColor3f(0.0f,1.0f,0.0f);
Azul	glColor3f(0.0f,0.0f,1.0f);
Branco	glColor3f(1.0f,1.0f,1.0f);
Preto	glColor3f(0.0f,0.0f,0.0f);

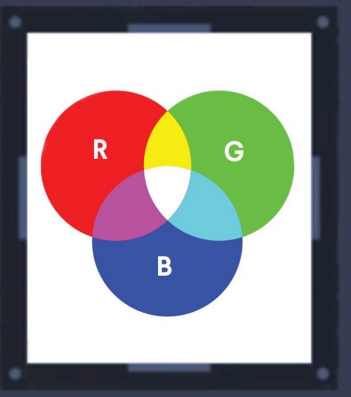


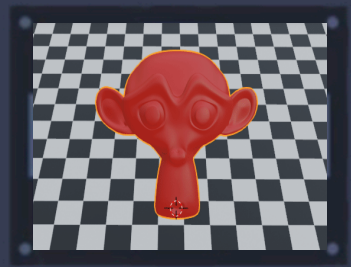




Transparência em OpenGL

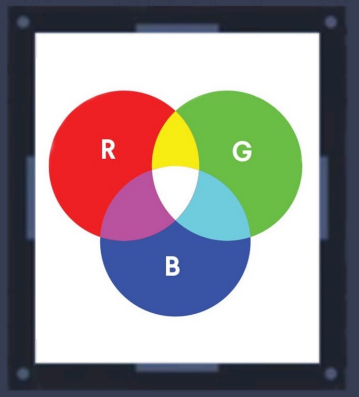
- Funções de Blend
  - Misturam as cores dos objetos
  - glEnable(GL_BLEND)
- Canal Alfa
  - Quarta componente de cor
  - Modifica a transparência de um objeto
  - glEnable(GL_ALFA_TEST)

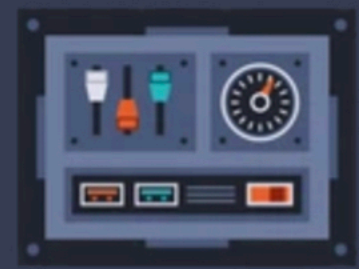




Transparência em OpenGL

- Tipo de Blend (média ponderada)
  - Ponto da tela e o ponto do objeto desenhado
  - glBlendFunc(GL_SRC_ALPHA, GL_ONE_MINUS_SRC_ALPHA)
- Ex:
  - Cor= CorObj * AlfaObj + CorTela * (1-AlfaObj);
  - GL_SRC_ALPHA: O peso da cor do objeto que está sendo desenhado é o valor de alfa
  - GL_ONE_MINUS_SRC_ALPHA: O peso da cor que já está na tela será (1 - alfa)





Exemplo