INTRODUCTION TO COLOUR TELEVISION

COLOUR MIXING

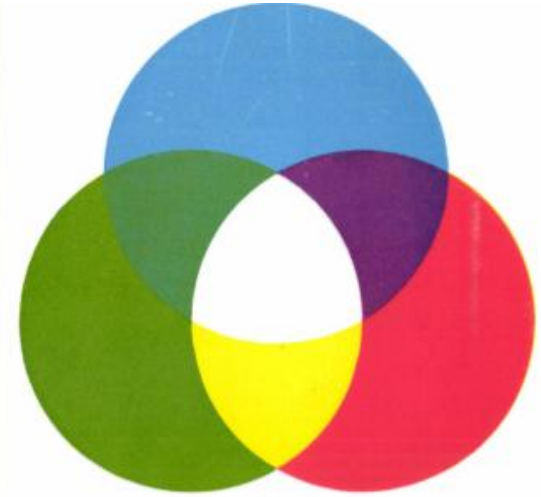
ECE 516E – ANTENNA & RADIOWAVE PROPAGATION

Tuesday, 6 October 2026

TYPES OF COLOR MIXING

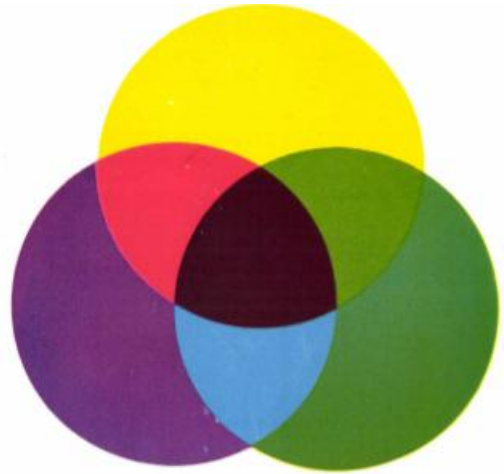
There are two types of colour mixing, i.e

1. Additive Mixing involves superimposition of light of 2 or more colours. Additive mixing occurs, for example, when two or more projectors, each with a light beam of a given colour, illuminate the apart of a projection screen. If red, green and blue are taken as the primary colours, almost all colours can be reproduced.



(a) Additive mixing

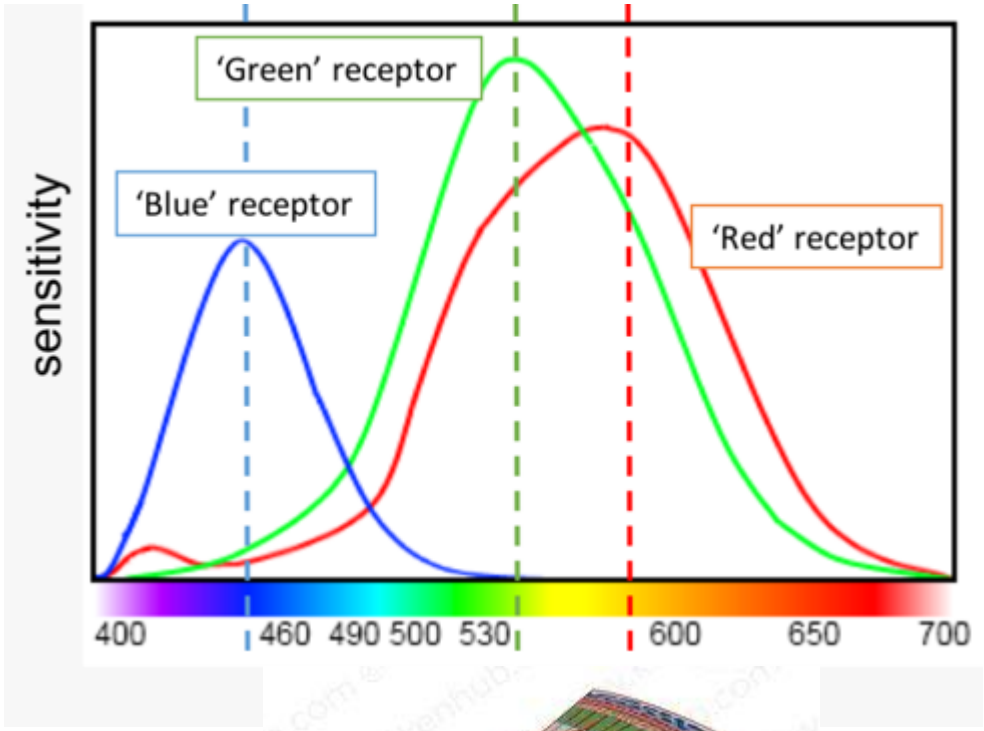
2. Subtractive Mixing arises when specific parts of the spectrum of a light source are attenuated more than others, for example by passing the light through a filter or making light reflect selectively from a surface. The latter is involved in the mixing of pigments and is, for example, the basis of modern forms of colour photography.



(a) Subtractive mixing

COLOUR VISION

1. **Colour vision** is the ability of human beings to distinguish objects based on the wavelengths (or frequencies) of the light they reflect, emit, or transmit.
2. The physiological cause of colour vision in humans is that cells in the retina are sensitive to different wavelengths of light.
3. Light rays reflect off the surface and enter your eye when you look at an object.
4. Part of your eye, called the retina, contains special cells called cones that sense the wavelengths of light.
5. There are three types of cone cells, each responding to a different range of wavelengths — short (blue), medium (green), and long (red).





TRICHROMATIC THEORY /01

1. **Trichromatric Theory** was first proposed by Thomas Young in 1802,
2. **Trichromatic theory** states that three different types of cones in the eye (red, green, and blue) are responsible for converting light into electrical signals.
3. These three types of cones each respond to different wavelengths of light, which can be combined to create all the colours we see in the visual spectrum.

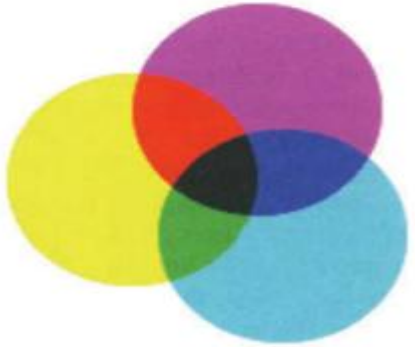
TRICHROMATIC THEORY /02

1. **Additive Colour Mixture** (Red, Green, Blue): Colour is created by mixing the visible light emitted from differently coloured light sources.



(a) Additive color mixture

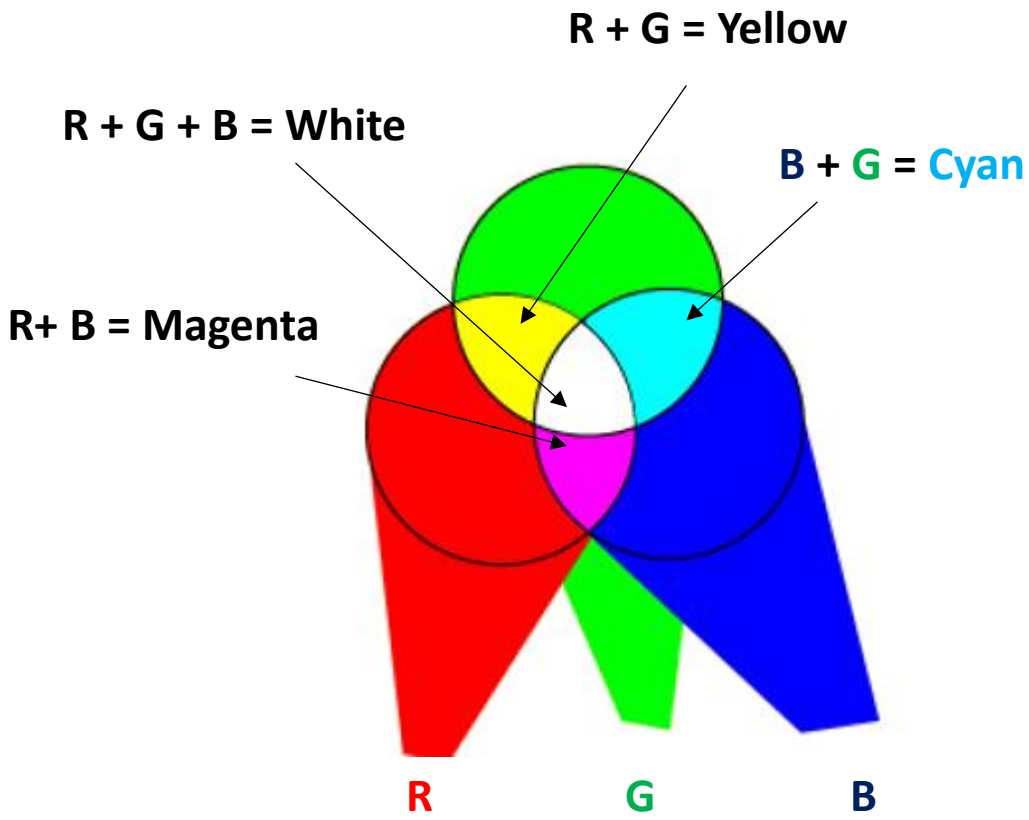
2. **Subtractive Colour Mixture** (Cyan, Magenta, Yellow): Light is removed from various parts of the visible spectrum to create colours.



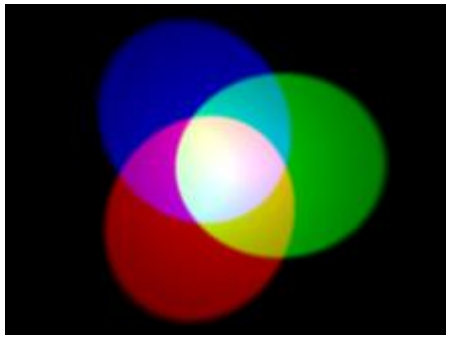
(b) Substractive color mixture

ADDITIVE COLOUR MIXING

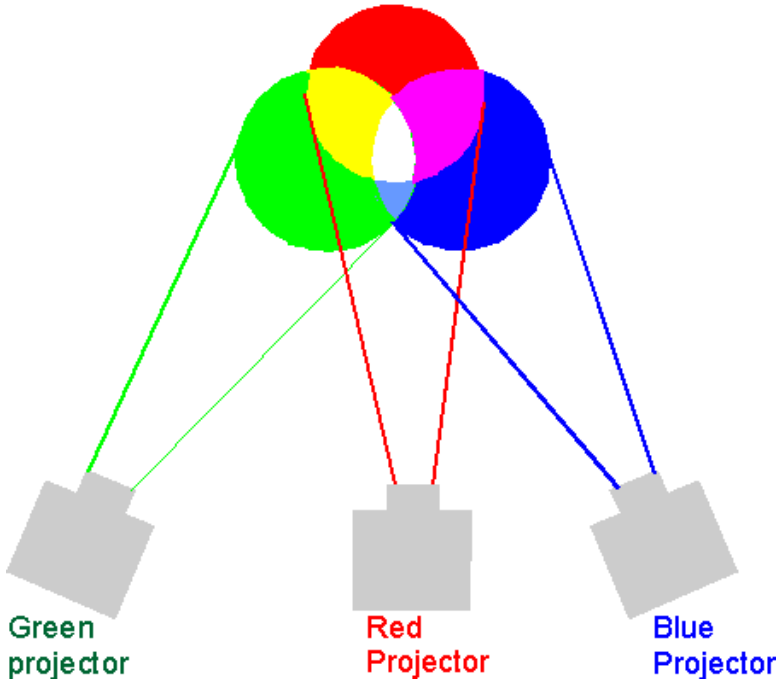
The commonly used additive primary are red, green and blue, and if you overlap all three in effectively equal mixture, you get white light as shown at the centre.



1. In the absence of colour, when no colours are showing, the result is **black**.
2. If all three primary colours are showing, the result is **white**.
3. When red and green combine, the result is **yellow**.
4. When red and blue combine, the result is **magenta**.
5. When blue and green combine, the result is **cyan**.



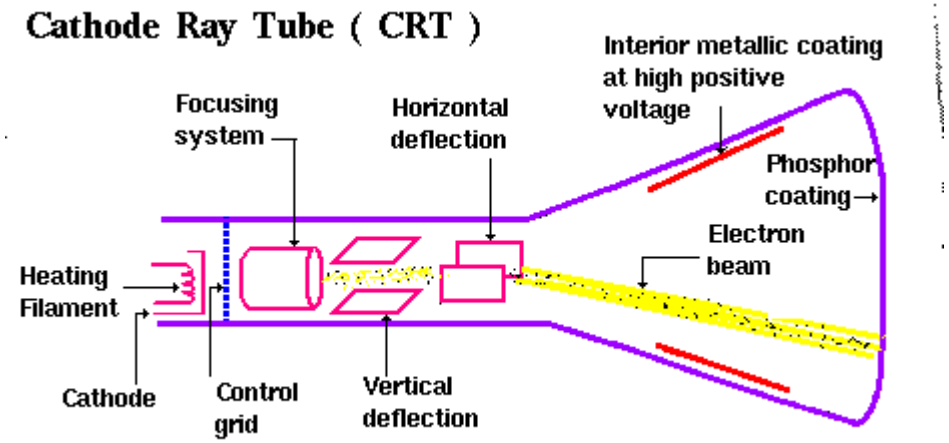
APPLICATION OF ADDITIVE MIXERS

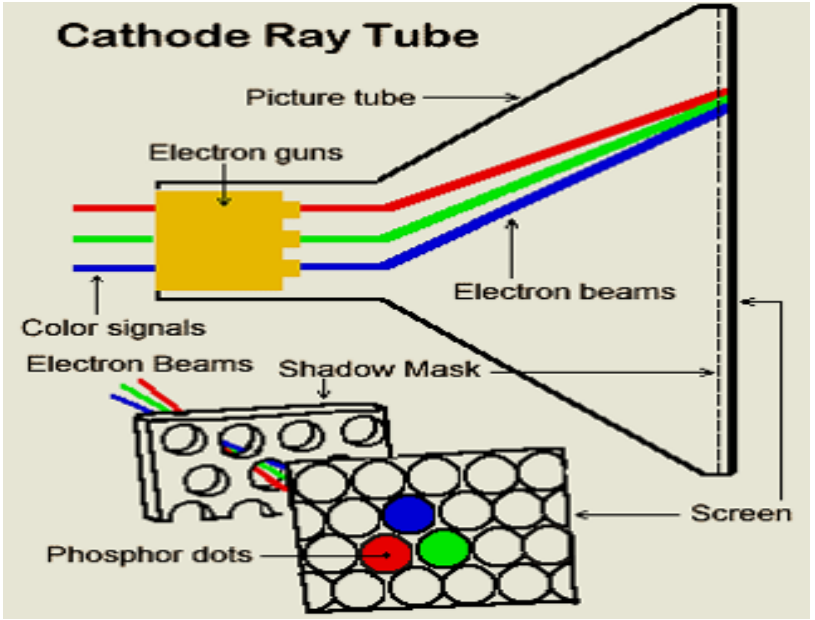


1. **Additive mixing** is used in television, overhead projectors and computer monitors, mobile phones to produce a wide range of colours using only three primary colours.
2. **A pixel in computer screens and LCD projectors** is a juxtaposition of three primary colours.
3. **Colour projectors** typically have three light beams, one for each primary colour.

CRT TV DISPLAY

1. **Cathode-Ray tube (CRT)** is a vacuum tube that contains one or more electron guns and a phosphorescent screen, and is used to display images.
2. It modulates, accelerates, and deflects electron beam(s) onto the screen to create the images.
3. The images may represent electrical waveforms (oscilloscope), pictures (television, computer monitor), radar targets, or other phenomena.

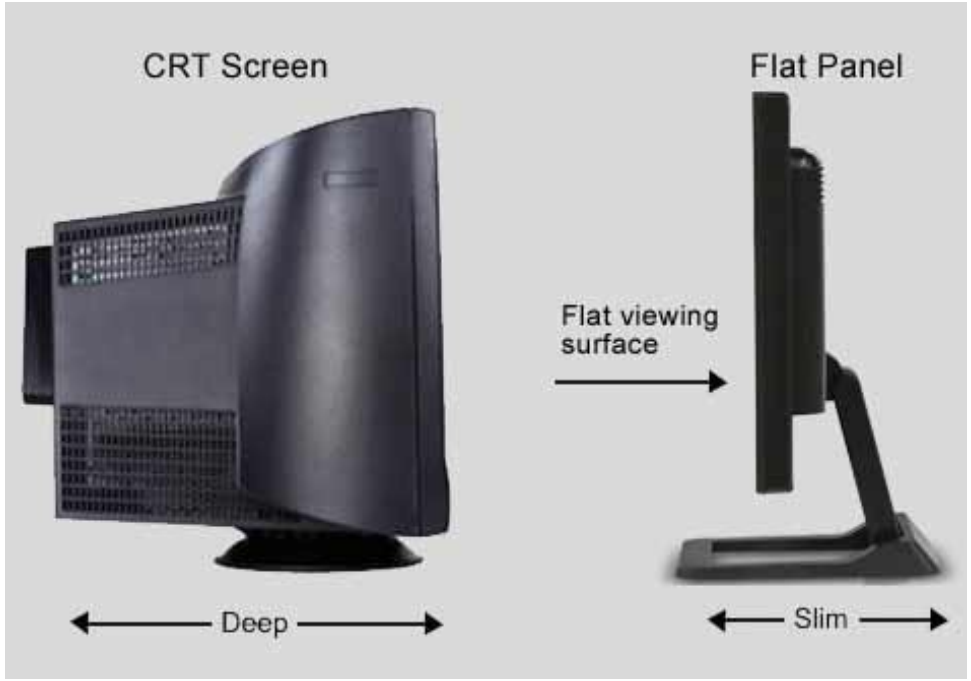




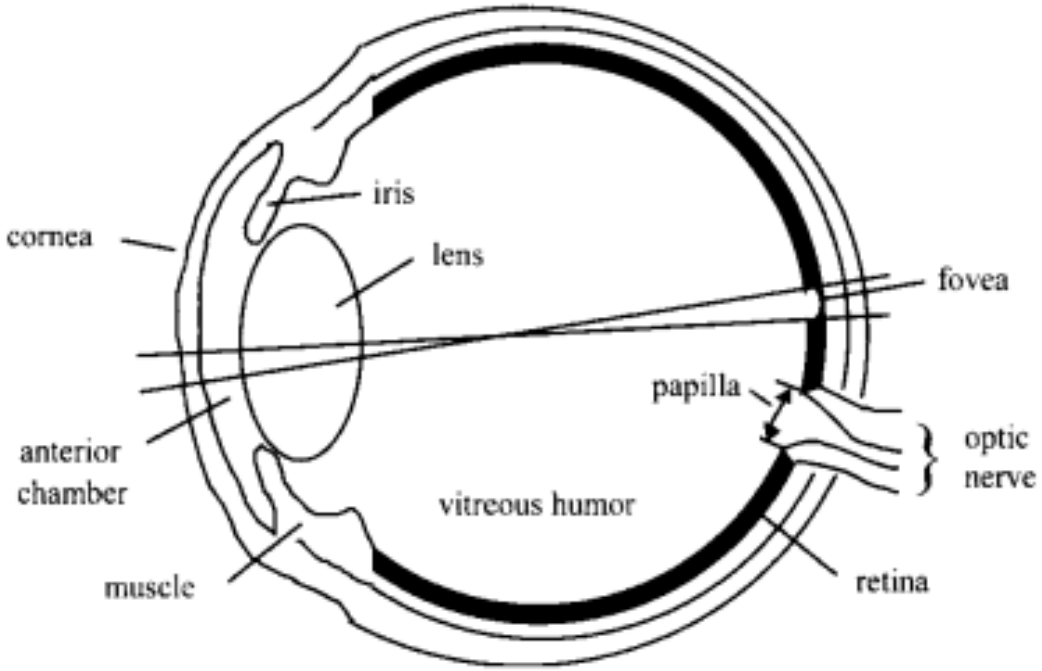
DISADVANTAGES OF CRT TV DISPLAYS

The disadvantages of a CRT TV display are:

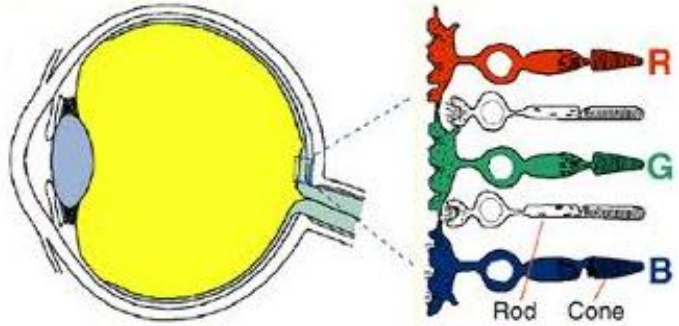
1. The display lacks in clarity.
2. The size of the screen is huge.
3. They become bulkier in size. If you increase in screen size, the length of the tube has to be increased accordingly. This, in turn increases the weight.



EYE AND COLOR



(a) Simplified drawing of the human eye

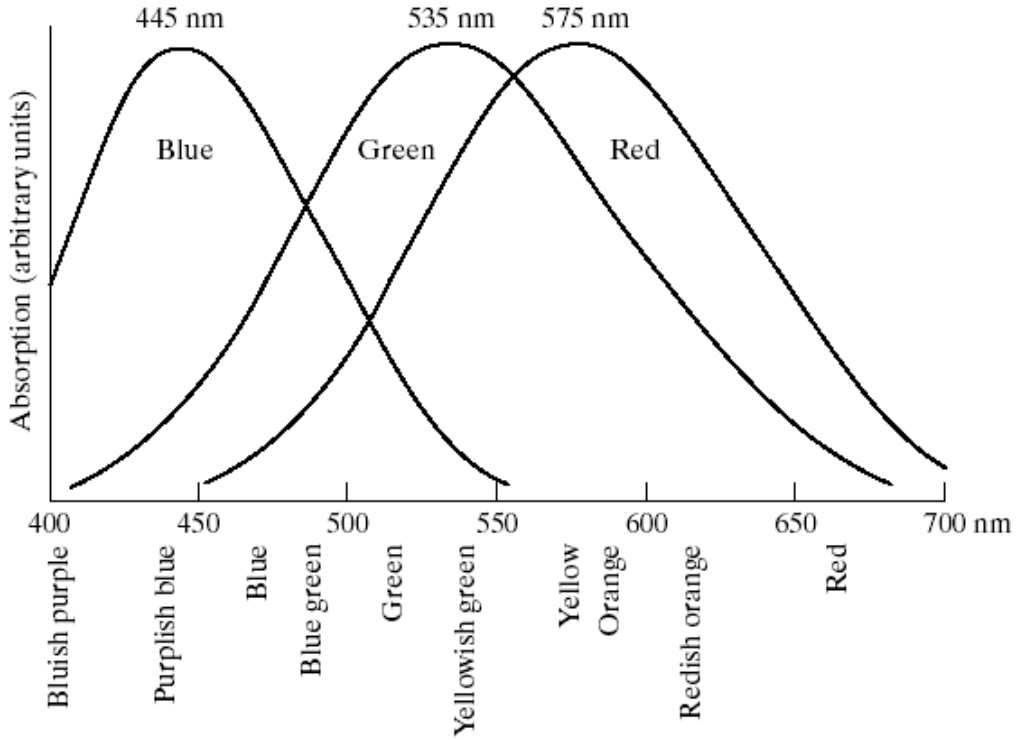


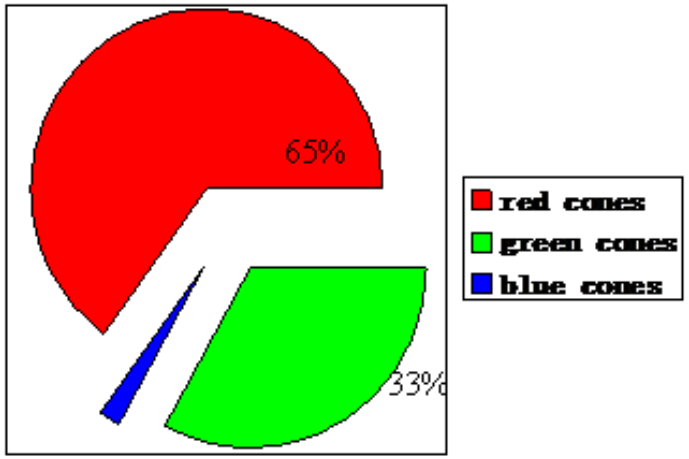
(b) Cones & Rods

- **Cones** are concentrated around the fovea and are very sensitive to color and have high spatial resolution
- **Rods** are more spread out and are sensitive to low levels of illumination with low spatial resolution.

EYE AND COLOUR PERCEPTION

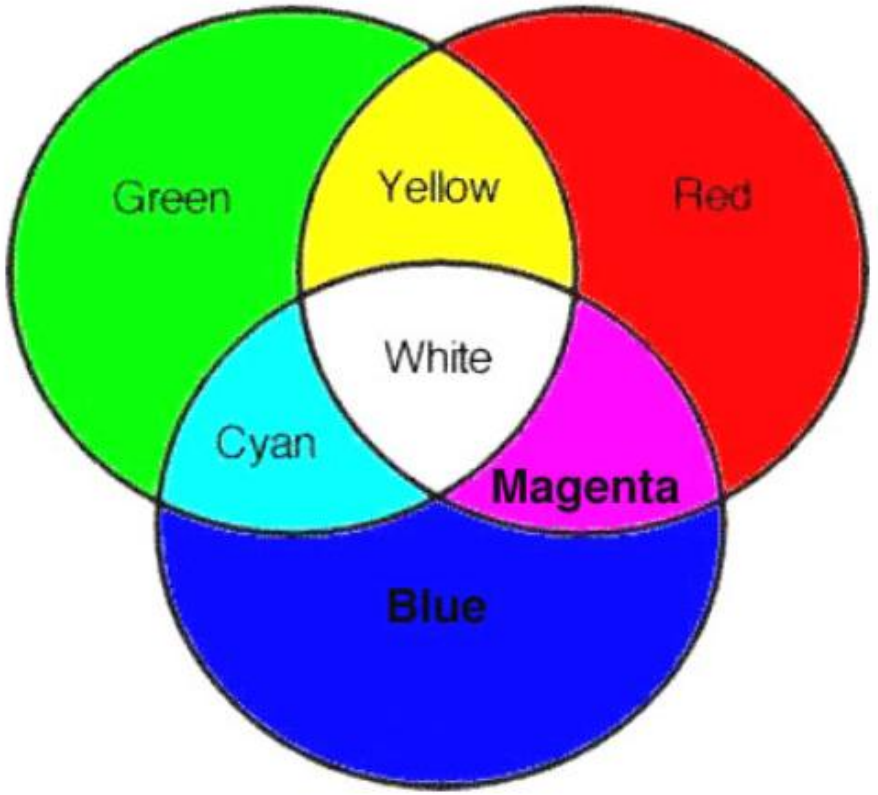
- Approximately 65% of these cones are sensitive to red light, 33% to green light and 2% to blue light
- Absorption curves for the different cones have been determined experimentally





GRASSMAN'S LAWS

1. **Grassmann's law** refers to the property of the eye response which depends on the algebraic sum of RGB. According to the law, the eye is not able to distinguish each of the colours that form a new colour but is able to perceive the resultant colour.
2. The law can be generally stated as follows**: For a given colour with a spectral power distribution I(λ) the RGB coordinates are given by:**
   - $\boldsymbol{R = \int_0^\infty I(\lambda) r(\lambda) d\lambda}$
   - $\boldsymbol{G = \int_0^\infty I(\lambda) g(\lambda) d\lambda}$
   - $\boldsymbol{B = \int_0^\infty I(\lambda) b(\lambda) d\lambda}$

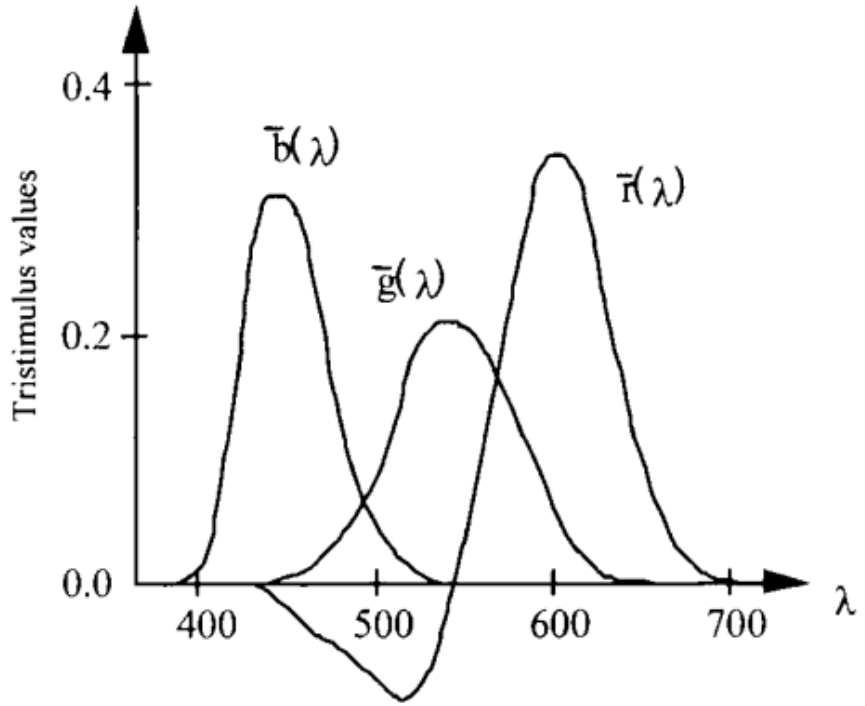


- The laws were published in 1853 by Hermann Grassmann – a German Physicist.

STANDARD COLOUR SYSTEM

- The colour stimulus standardized with **S(λ)** produce the spectral tristimulus values

$$\overline{m}(\lambda) = \overline{r}(\lambda)\cdot\mathbf{R} + \overline{g}(\lambda)\cdot\mathbf{G} + \overline{b}(\lambda)\cdot\mathbf{B}$$



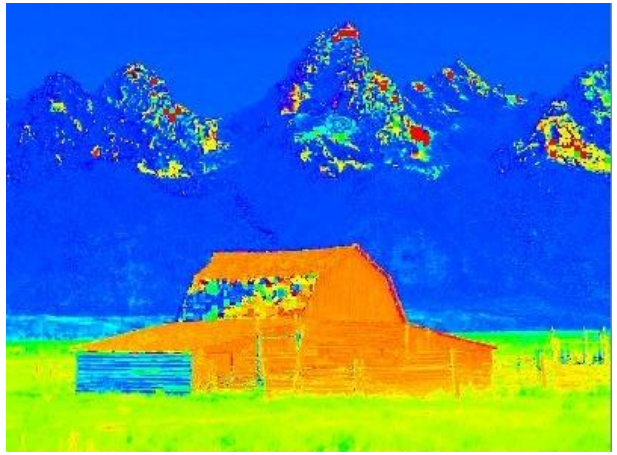
RECEPTORAL COLOR INFORMATION

- The colours that we perceive in our environment are divided into two classes:
    1. **Chromatic:** pure colour that contains no hints of white, black, or gray. Examples red, orange, blue, green.
    2. **Achromatic:** neutral colours are used in decorating including black, white, and gray.

- **Chromatic colours** can be characterized by three components: hue, saturation, and luminance
    1. **Hue describes the type of chromaticity a colour** has and is indicated generally with words such as red, yellow, and blue.
    2. **Saturation describes the purity of a colour,** or the measure of the degree to which a pure color is diluted by white light. As saturation decreases, colors appear more faded.
    3. **Luminance indicates the strength of light sensitivity** as it is connected to each colour sensitivity. The greater the strength of the lighting, the lighter the colour appears.

RECEPTORAL COLOUR –HUE SATURATION





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COLOUR SPACE /01

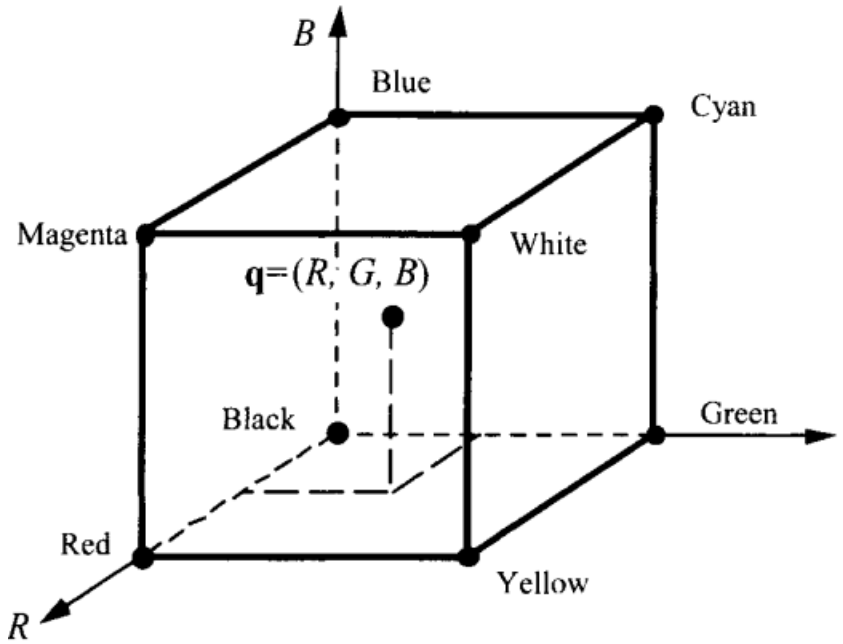
- Colour spaces indicate colour coordinate systems in which the image values of a color image are represented.
- The difference between two image values in a colour space is called colour distance.

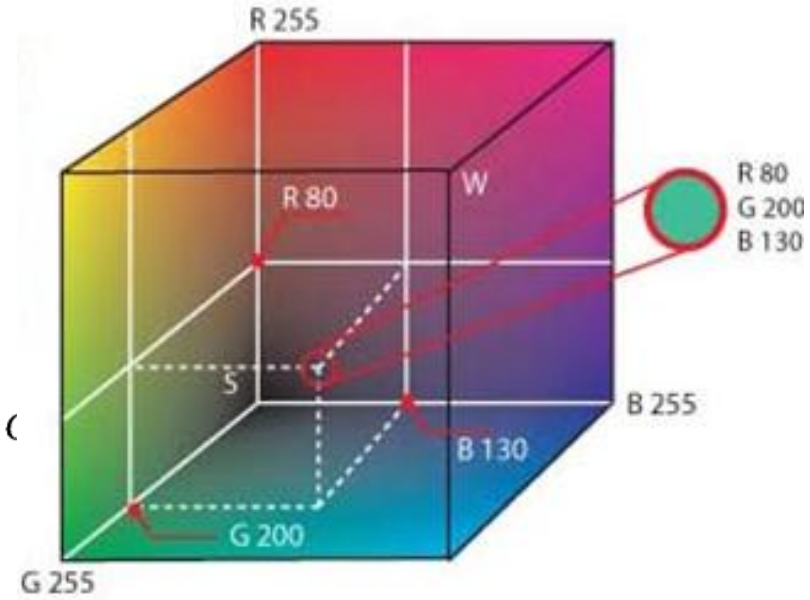
There are three categories of colour spaces, i.e

1. **Physics and Technics-based** Colour Spaces
   - **RGB (Red, Green and Blue), CMY (Cyan, Magenta and Yellow)**
   - **YUV** (one luminance component (Y) meaning physical linear-space brightness, and two chrominance components, called U (blue projection) and V (red projection))
2. **Perception-based** Color Spaces :
   - HSI/HSV/HSL/HSB (**H**ue **S**aturation **I**ntensity/ **H**ue **S**aturation **L**uminance/ **H**ue **S**aturation **B**rightness)
3. **Uniform Color Spaces :** XYZ

RGB COLOUR SPACE /01

- The most commonly employed colour space in computer technology, especially in colour displays.
- It is based on the additive mixture of three primary colors Red, Green, and Blue.



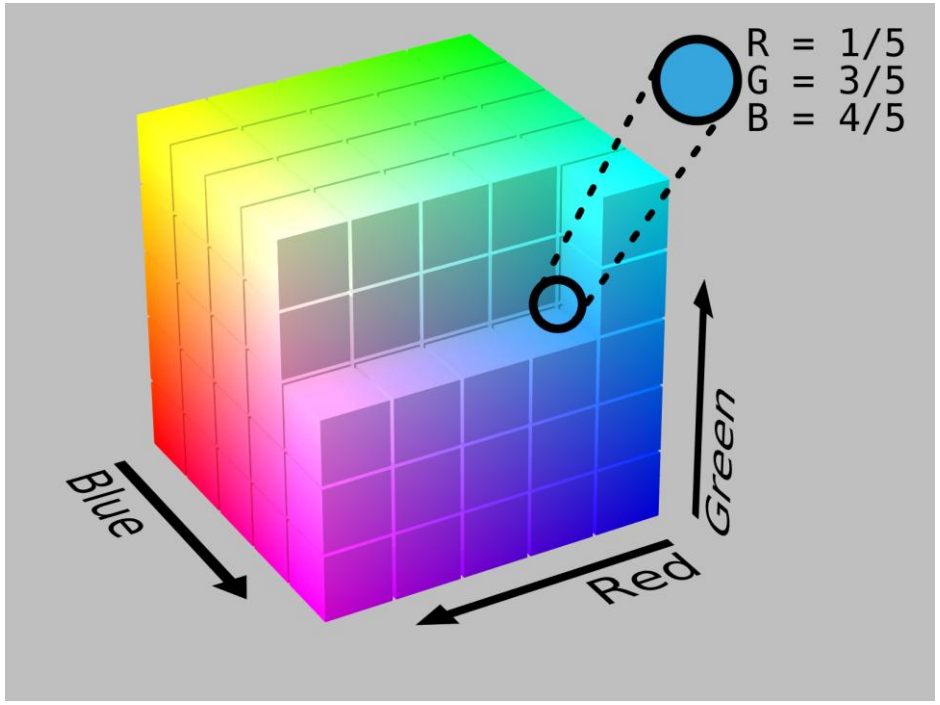


RGB COLOUR SPACE /02

1. The primary colours (RGB) form the base vectors of a **three-dimensional orthogonal (colour)-vector space**
2. The origin (zero-vector) represents black .
3. Any colour can therefore be viewed as a linear combination of the base vectors in the RGB space.

4. In RGB colour space, a colour image is mathematically treated as a vector function with three components.

$$\mathbf{C}(x,y) = \big(R(x,y), G(x,y), B(x,y)\big)^T = (R,G,B)^T$$



RGB COLOUR SPACE MATRICES

- The Transform from RBG to NTSC

$$\begin{pmatrix} R_N \\ G_N \\ B_N \end{pmatrix} = \begin{pmatrix} 0.842 & 0.156 & 0.091 \\ -0.129 & 1.320 & -0.203 \\ 0.008 & -0.069 & 0.897 \end{pmatrix} \cdot \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

RGB->NTSC

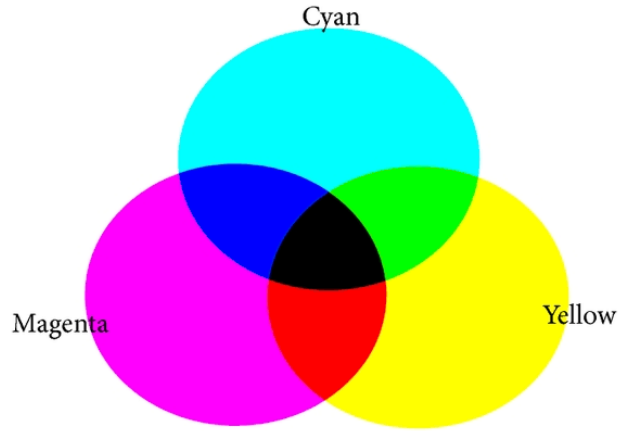
- The Transform of RBG to sRGB

$$\begin{pmatrix} R_{sRGB} \\ G_{sRGB} \\ B_{sRGB} \end{pmatrix} = \begin{pmatrix} 3.2410 & -1.5374 & -0.4986 \\ -0.9692 & 1.8760 & 0.0416 \\ 0.05556 & -0.2040 & 1.0570 \end{pmatrix} \cdot \begin{pmatrix} X \\ Y \\ Z \end{pmatrix}$$

RGB->sRGB

CMY COLOUR SPACE

1. A **subtractive colour space** consists of subtractive primary colours cyan, magenta, and yellow as well as possibly an additional black
2. It is used for colour printing process.



3. RGB colour space and the CMY color space can be transferred through the following transformations.

$$\begin{pmatrix} R \\ G \\ B \end{pmatrix} = \begin{pmatrix} G_{max} \\ G_{max} \\ G_{max} \end{pmatrix} - \begin{pmatrix} C \\ M \\ Y \end{pmatrix}$$

$$\begin{pmatrix} C \\ M \\ Y \end{pmatrix} = \begin{pmatrix} G_{max} \\ G_{max} \\ G_{max} \end{pmatrix} - \begin{pmatrix} R \\ G \\ B \end{pmatrix}$$

