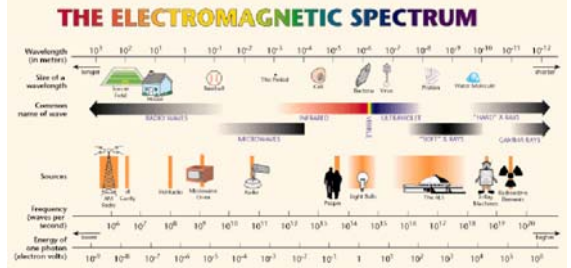


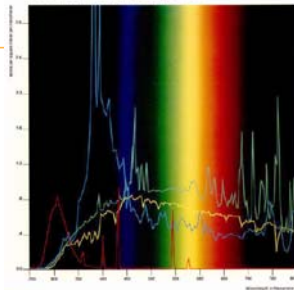
Colour Representation

What is Light?

- electromagnetic radiation, 400-700nm



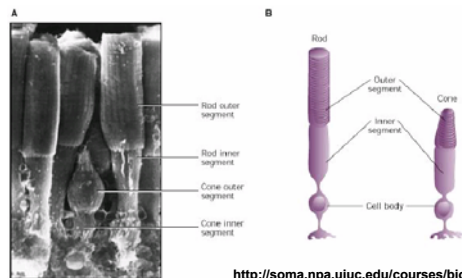
Sunlight vs Artificial Light Sources



Spectra

The Retina

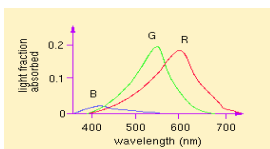
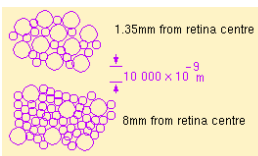
- rods and cones



<http://soma.npa.uiuc.edu/courses/bio303/Ch11.html>

Cones

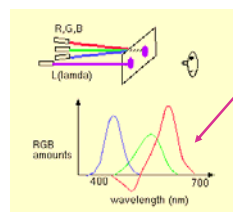
- cones
- concentrated in fovea
- three types of cones in human eye



Tristimulus Colour Theory

- match any given wavelength with a mix of some specific wavelengths:

$$R=700\text{nm}, G=546\text{nm}, B=436\text{nm}$$



RGB colour matching curves

$$R = \int P(\lambda) \bar{r}_\lambda d\lambda$$

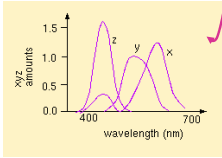
$$G = \int P(\lambda) \bar{g}_\lambda d\lambda$$

$$B = \int P(\lambda) \bar{b}_\lambda d\lambda$$

XYZ Colour Matching



- CIE: Commission Internationale d'Eclairage
- goal is to develop a colour standard that uses only positive mixing coefficients



XYZ colour matching curves

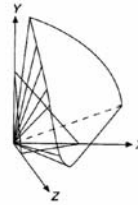
$$\begin{aligned}
 X &= k \int P(\lambda) \bar{x}_\lambda d\lambda \\
 Y &= k \int P(\lambda) \bar{y}_\lambda d\lambda \\
 Z &= k \int P(\lambda) \bar{z}_\lambda d\lambda
 \end{aligned}$$

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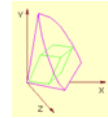
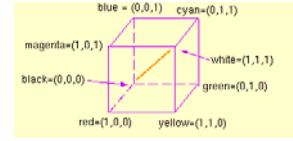
XYZ and RGB Colour Spaces



XYZ colour space



RGB colour space



RGB cube in the XYZ colour space

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XYZ and RGB colour spaces



- colour transformation matrix:
(for monochromatic R=700nm, G=546nm, B=436nm)

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 2.36460 & -0.51515 & 0.00520 \\ -0.89653 & 1.42640 & -0.01441 \\ -0.46807 & 0.08875 & 1.00921 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

- each monitor has its own RGB-to-XYZ transformation matrix
 - suppose we have a colour $R_A G_A B_A$ on monitor A and wish to view the same colour on monitor B:

$$\textcircled{2} \begin{bmatrix} R_B \\ G_B \\ B_B \end{bmatrix} = \begin{bmatrix} M_B^{-1} \\ \\ \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \quad \textcircled{1} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} M_A \\ \\ \end{bmatrix} \begin{bmatrix} R_A \\ G_A \\ B_A \end{bmatrix}$$

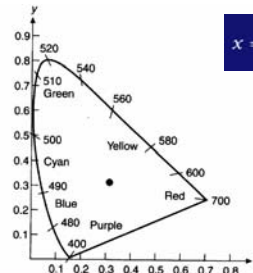
$$C_B = M_B^{-1} M_A C_A$$

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CIE Chromaticity Diagram



- produce a 2D colour space by projecting onto the plane given by $X+Y+Z = 1$



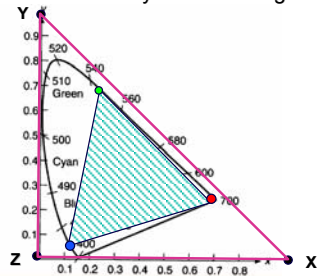
$$x = \frac{X}{X+Y+Z}, \quad y = \frac{Y}{X+Y+Z}$$

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RGB vs XYZ revisited



- another view of why the R curve goes negative

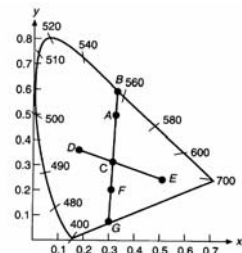


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CIE Chromaticity Diagram



- C: white point
- complementary colours
- dominant wavelength
- non-spectral colors



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