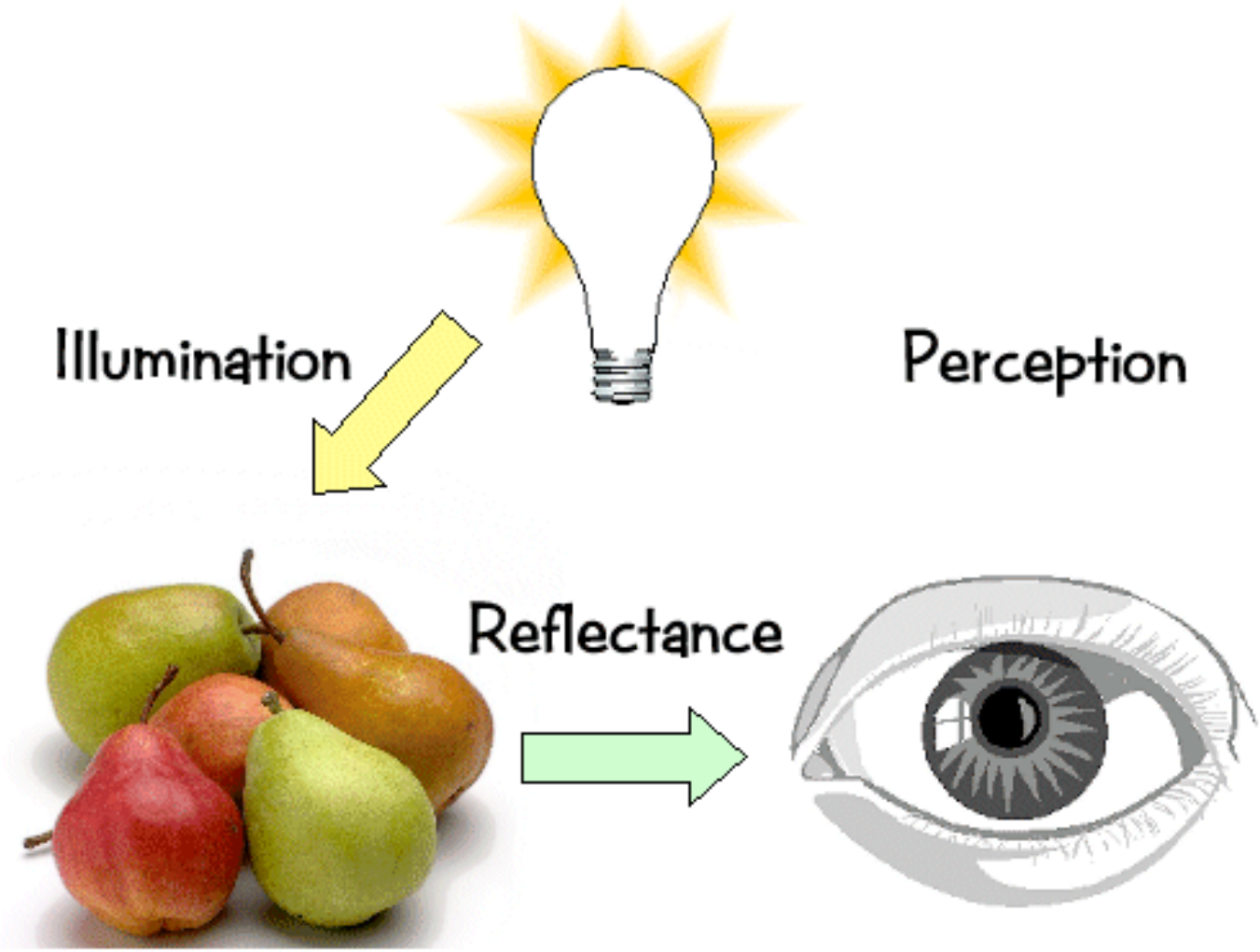
Interacció i Disseny d'Interfícies

Colour

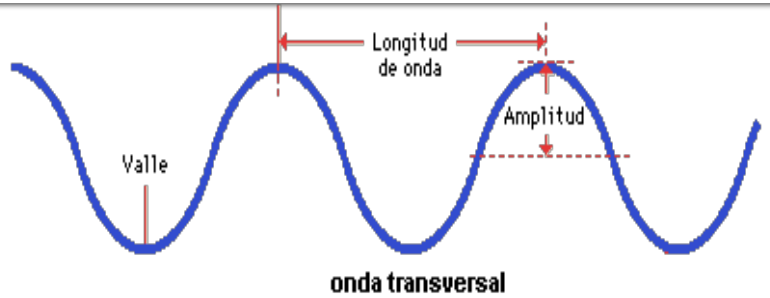
- Contents
  - Light and Colour
  - Colour perception
  - Colour Models
    - RGB
    - CMY/CMYK
    - HSV (HSB)
    - CIE
  - Color conversion

Colour



Naturalesa de la llum

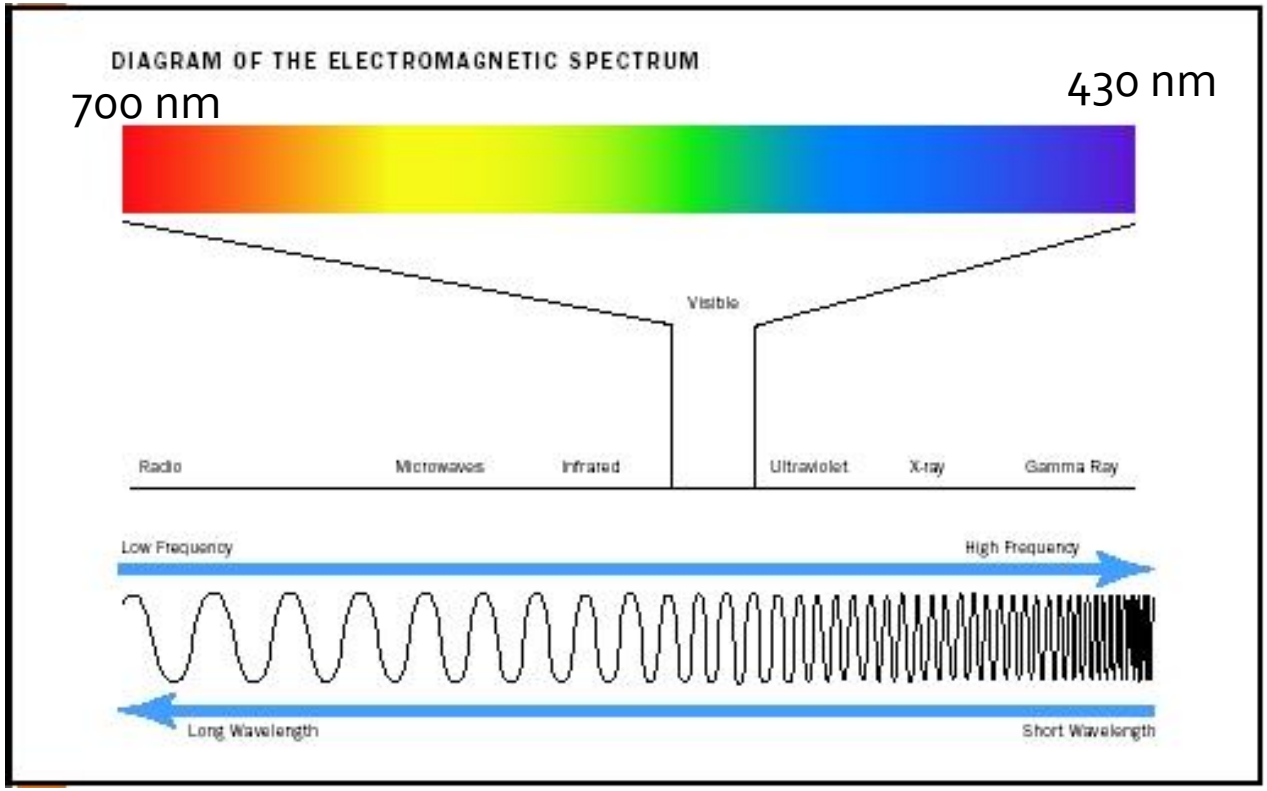
Llum: propagació d'energia electromagnètica en forma d'ones



Ona — freqüència f
— longitud d'ona λ
— amplitud A

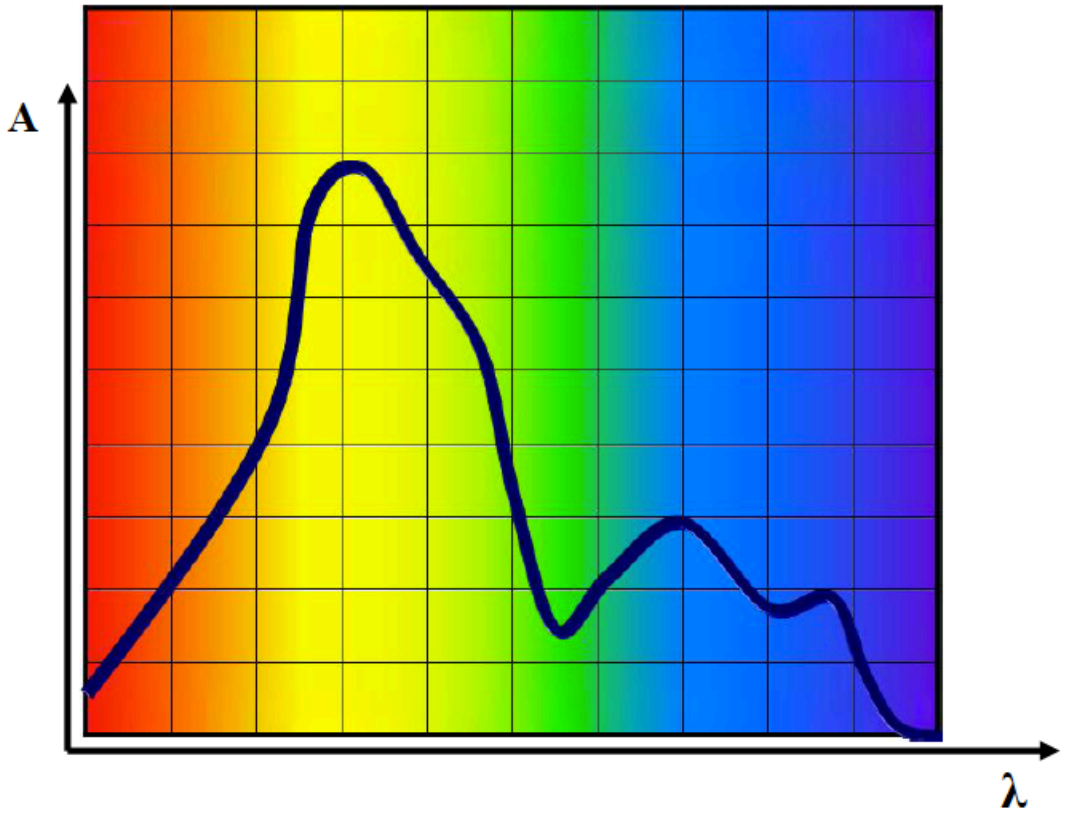
$\lambda = c / f$

(c: velocitat llum)



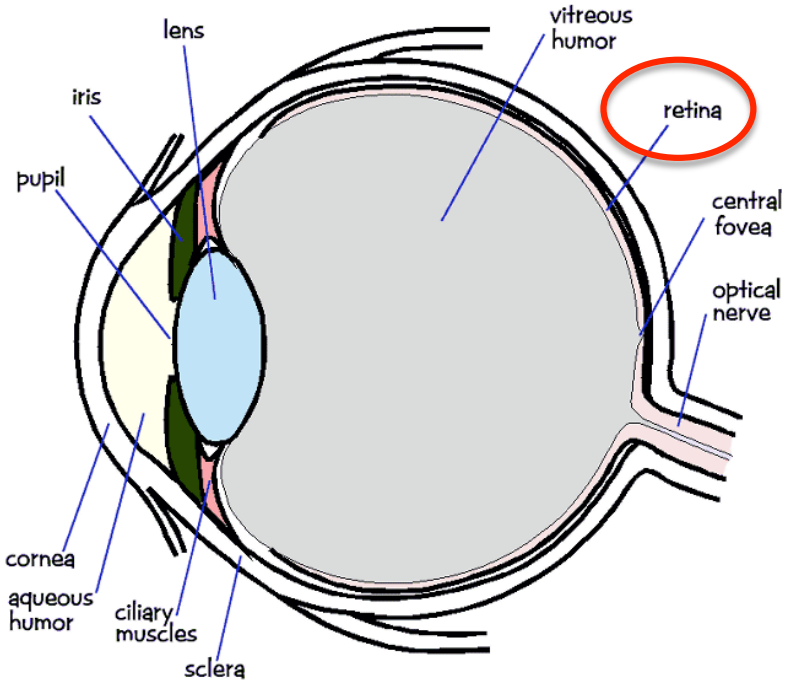
Colour

- A certain colour will be represented by a certain signal



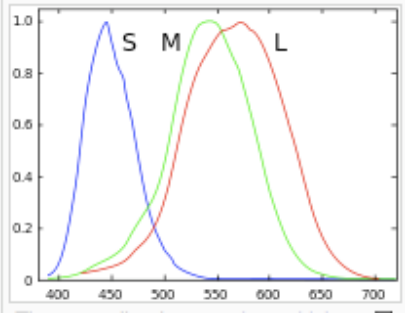
Colour

- The photosensitive part of the eye is called the retina.
- Two types of cells:
  - Rods and cones
  - Cones are responsible for colour perception.

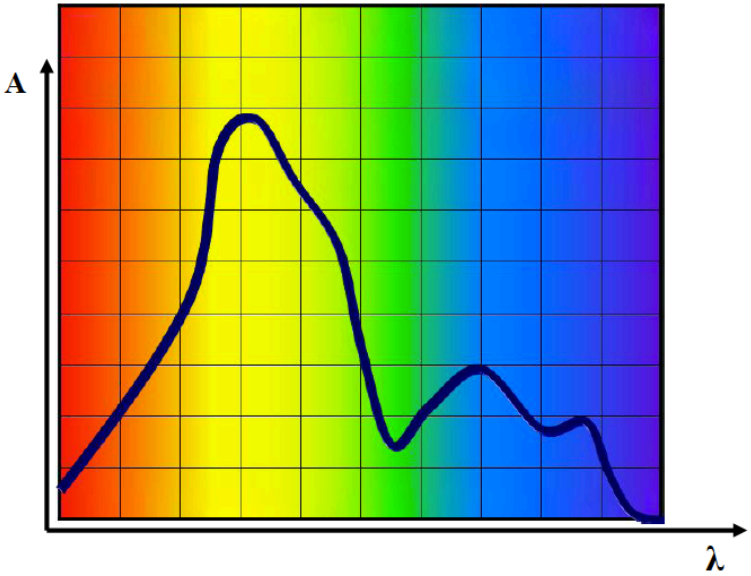


Colour

- Cones are most densely packed within a region of the eye called the fovea.
- There are three types of cones: S, M, and L.
  - Roughly equivalent to blue, green, and red sensors, respectively.
  - Their peak sensitivities are located at approximately 430nm, 560nm, and 610nm for the "average" observer.



Colour



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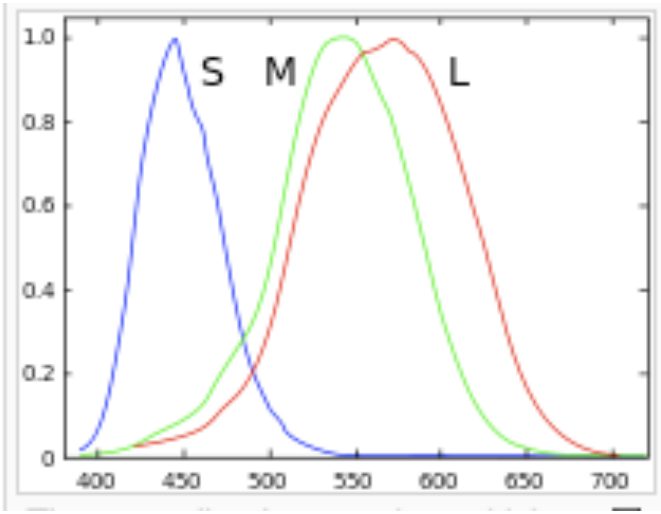


Three stimulus (tristimulus) values

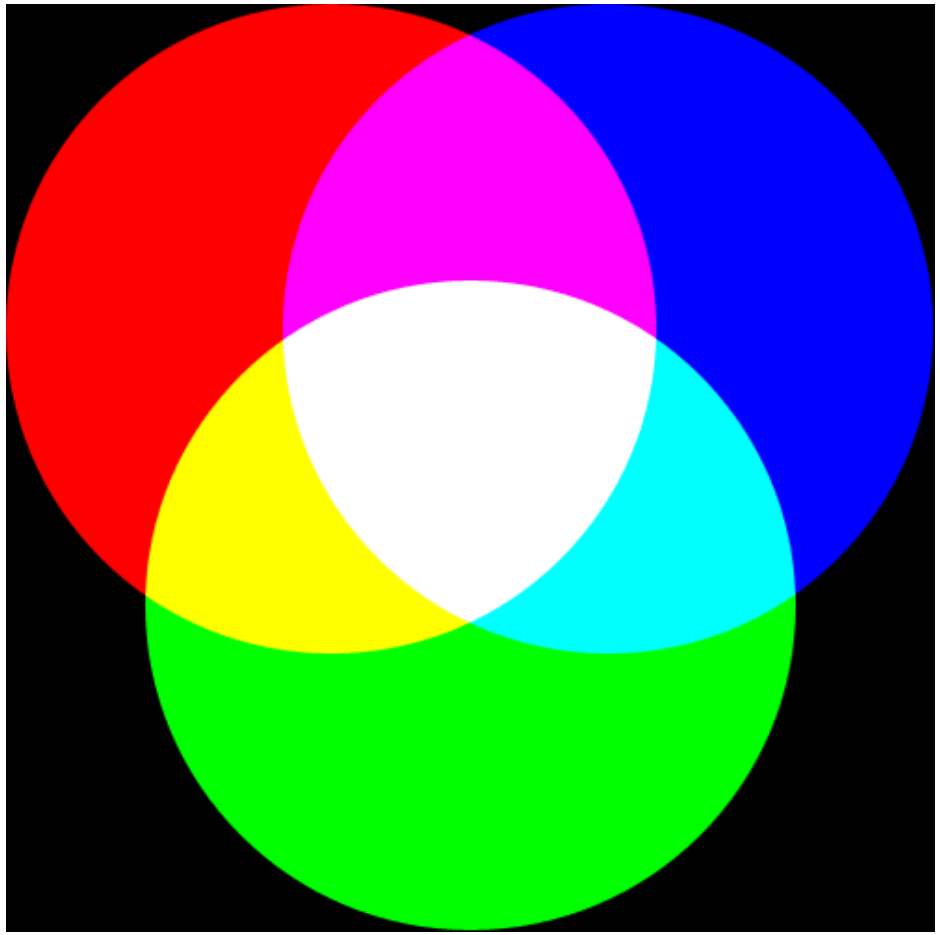
Colour

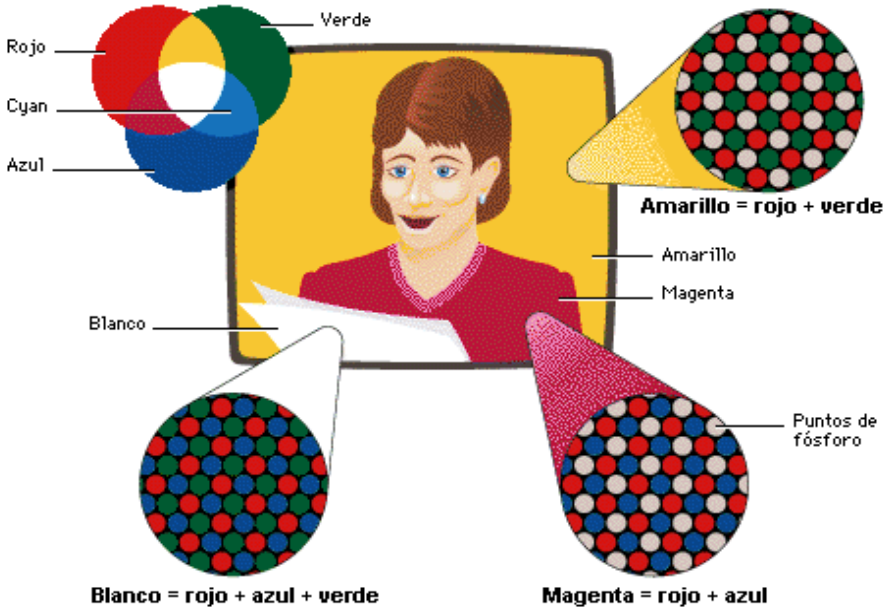
- Colour representations
  - **Additive colour:**

    Reproduce the red, green and blue parts of the image by adding together red, green and blue lights, starting with darkness.
  - **Subtractive colour**

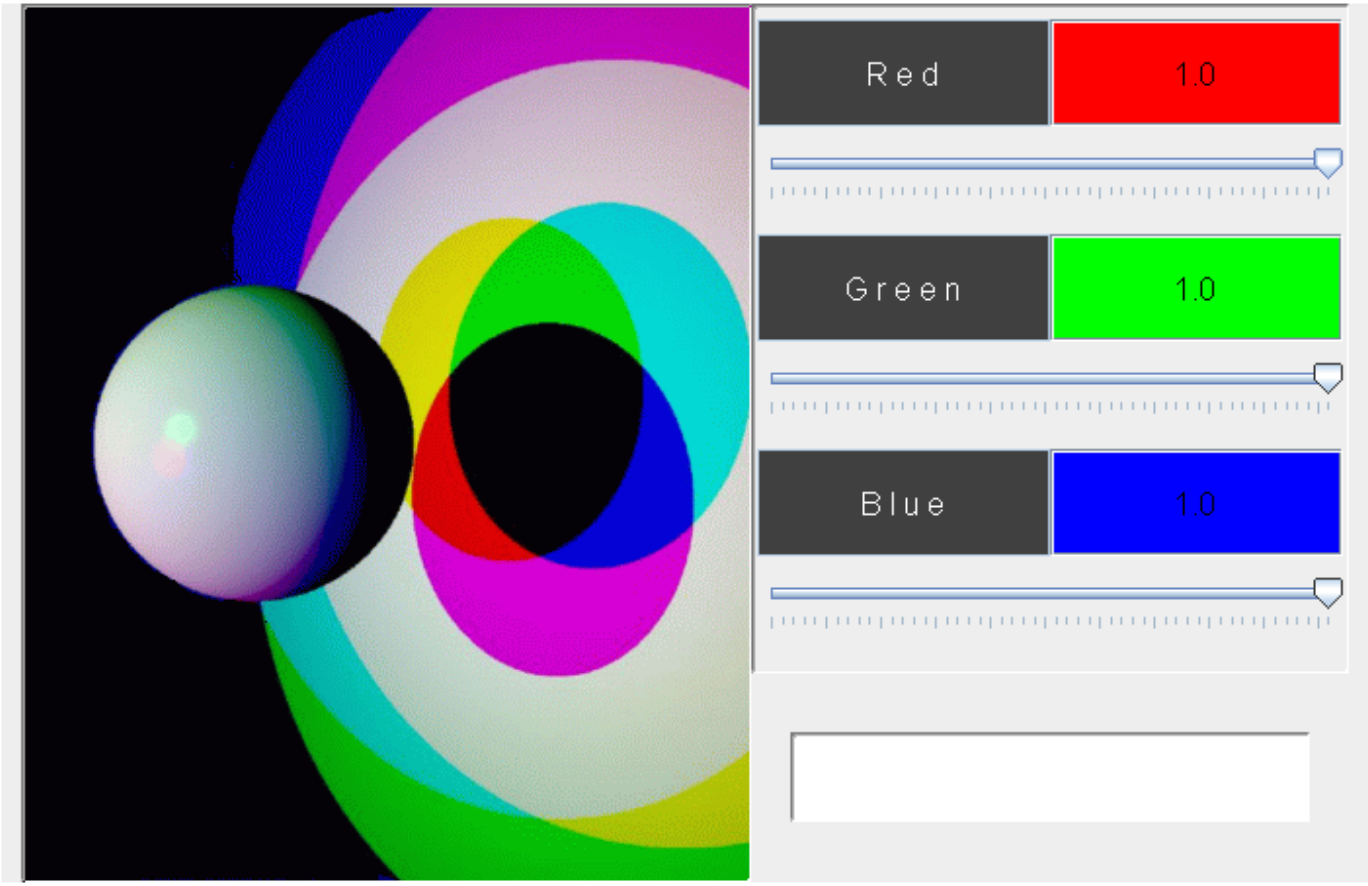
    Filter the red, green and blue components of the image from white light.
    - Use coloured filters that in theory modulate only the red, green and blue components of the spectrum

Colour: RBG model



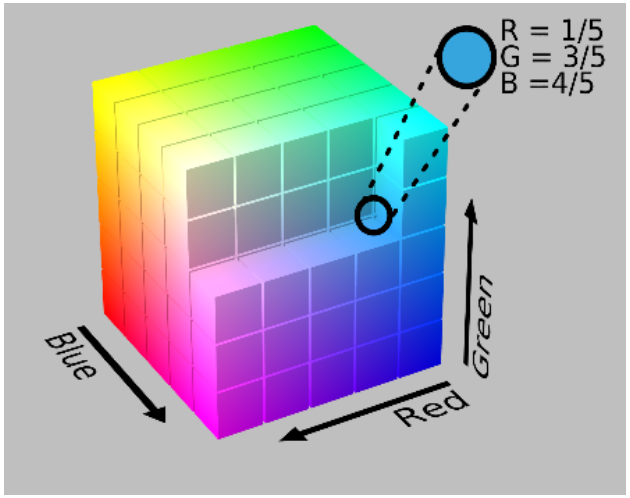


Applet CD



Colour

- RGB: Colours are represented by varying intensities of red, green, and blue light.
  - Intensity of the components on a scale [0..255]
    - 0 no light emitted
    - 255 maximum intensity



Colour

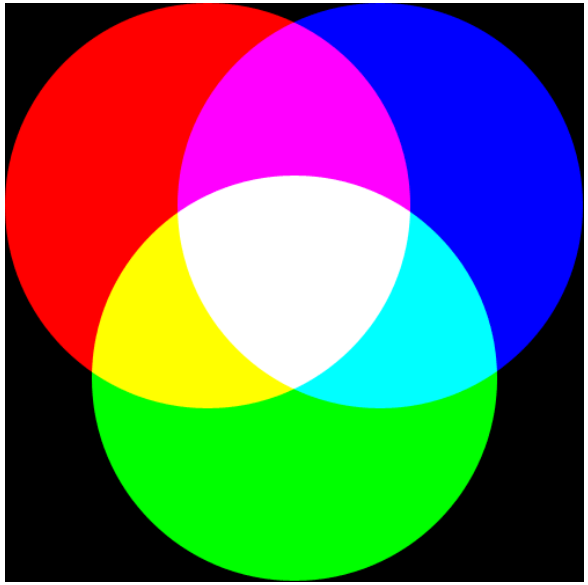
- Colour representations
  - **Additive colour:**

    Reproduce the red, green and blue parts of the image by adding together red, green and blue lights, starting with darkness.
  - **Subtractive colour**

    Filter the red, green and blue components of the image from white light.
    - Use coloured filters that in theory modulate only the red, green and blue components of the spectrum

Colour: CMY model

- Additive versus subtractive colour representations



Colour: CMYK model

- CMY(K): Subtractive colour model used in colour printing.
  - Known as "four-colour process" or simply "process" colour.
  - All of the colours in the printable portion of the colour spectrum can be achieved by overlapping "tints" of cyan, magenta, yellow and black inks.
  - Combining cyan, magenta and yellow should form black
    - Because of the impurities in ink it produces a muddy brown colour.
    - Black ink is added to this system to compensate for these impurities.

Converting between colour spaces

- RGB to CMY and CMYK
  - RGB to CMY

```
C = 1-R;
M = 1-G;
Y = 1-B;
```

  - RGB to CMYK with a percentage *s* of black :

```
K = min(1-R, 1-G, 1-B)*s/100;
C = 1-R-K;
M = 1-G-K;
Y = 1-B-K;
```

Converting between colour spaces

- CMY and CMYK to RGB
  - From CMY to RGB:

```
R = 1-C;
G = 1-M;
B = 1-Y;
```

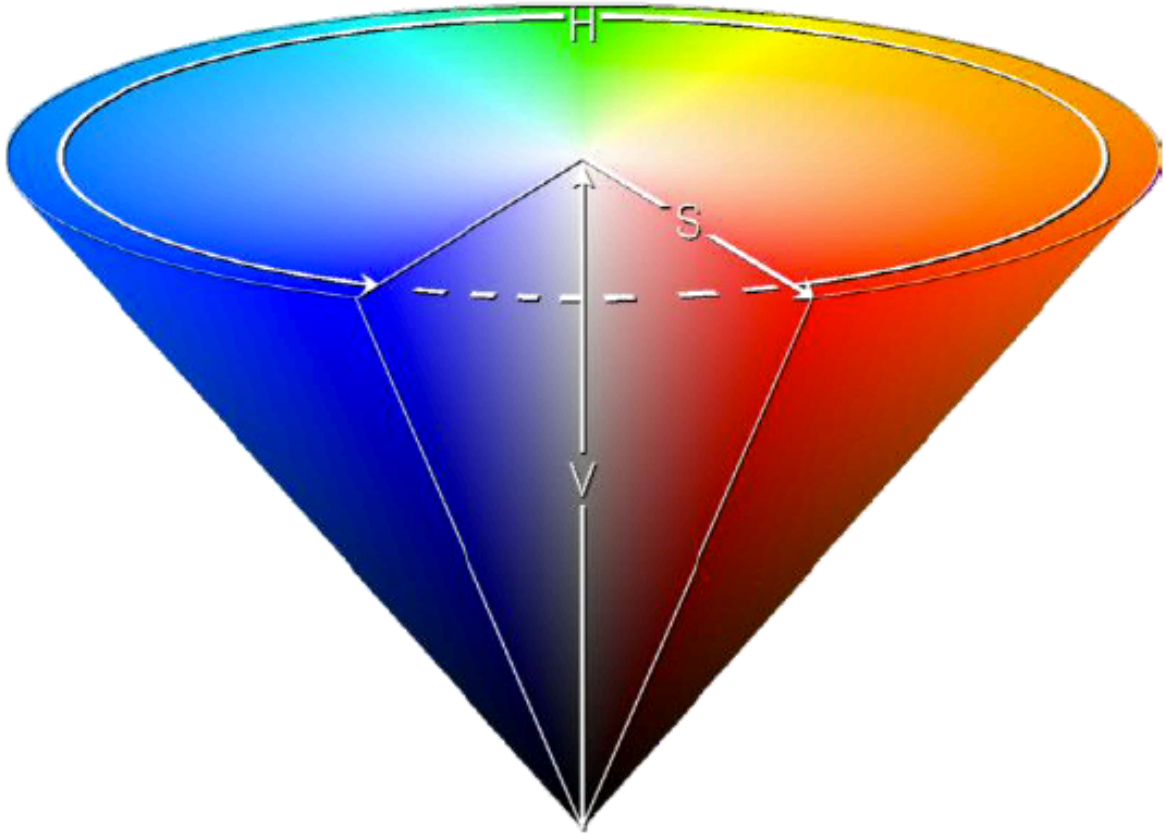
  - CMYK to RGB:

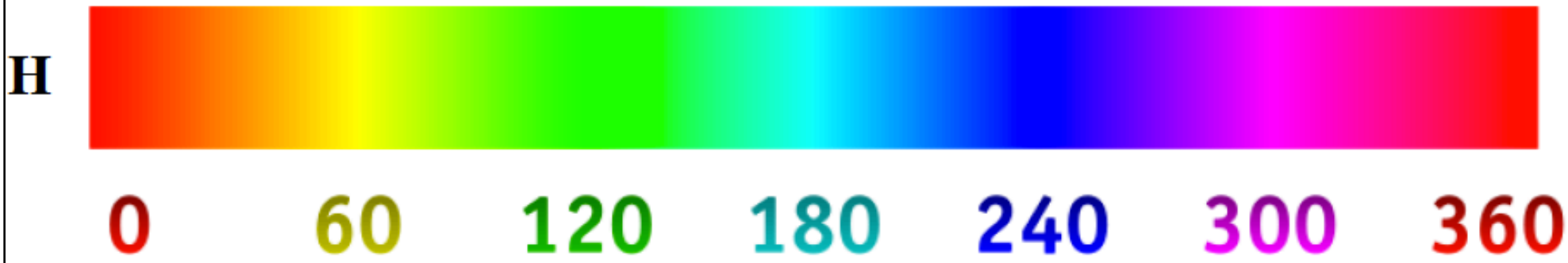
```
R := max(1-C-K,0);
G := max(1-M-K,0);
B := max(1-Y-K,0);
```

Colour: HSV model

- Encodes a colour using three components: Hue, Saturation, and Intensity (Value):
  - **Hue**: the actual colour of the object. It is an angle from 0 degrees to 360 degrees.
  - **Saturation**: measure of purity. Saturation indicates the range of grey in the colour space. It ranges from 0 (grey) to 100% (pure colour).
  - **Intensity (value)**: how light the colour is.
    - The brightness of the colour
    - Varies with colour saturation.

Colour: HSV model





Converting between colour spaces

- RGB to HSV (VIG):

```
max = maximum of RGB
min = minimum of RGB

V = max
S = (max - min) / max

if S = 0, H is undefined, else
  delta = max-min

  if R = max, H = (G-B)/delta
  if G = max, H = 2 + (B-R)/delta
  if B = max, H = 4 + (R-G)/delta

  H = H*60
  if H < 0, H = H + 360
```

Converting between colour spaces

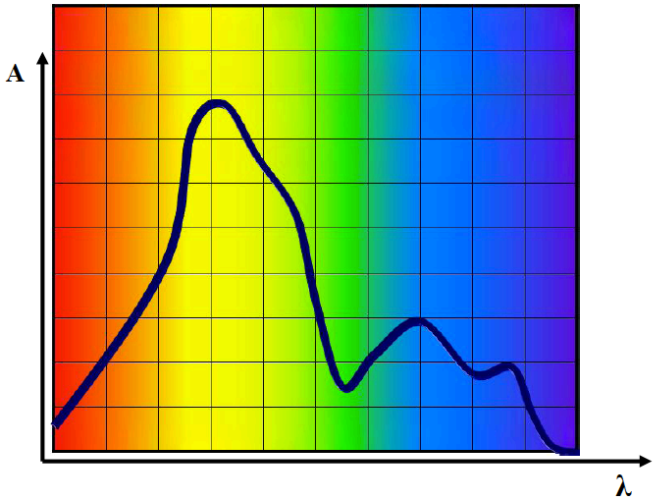
- HSV to RGB

```
if S = 0 and H = undefined, R = G = B = V

  if H = 360, H = 0
  H = H / 60
  i = floor(H)
  f = H - i
  p = V*(1-S)
  q = V*(1-(S*f))
  t = V*(1 - (S * (1-f)))

  if i = 0, R = v, G = t, B = p
  if i = 1, R = q, G = v, B = p
  if i = 2, R = p, G = v, B = t
  if i = 3, R = p, G = q, B = v
  if i = 4, R = t, G = p, B = v
  if i = 5, R = v, G = p, B = q
```

Colour: CIE

- **CIE: Standardized a set of primaries and colour matching functions**
  - Based on actual human response
  - The basis for most colour measurement instruments used today
  - Tristimulus values are notated X, Y and Z.
    - Often reduced to two dimensions by projecting them onto the X+Y+Z=1 plane

Colour: CIE



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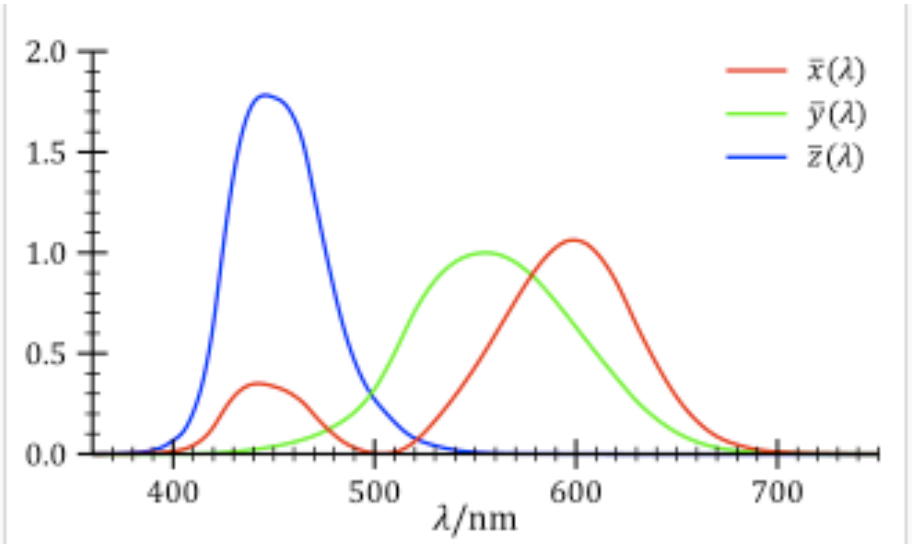
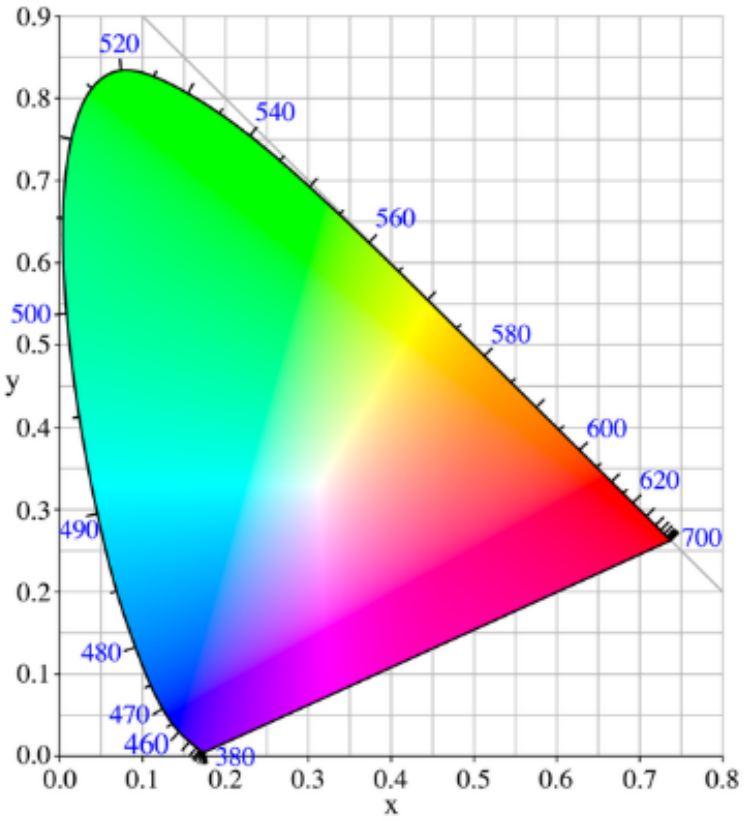


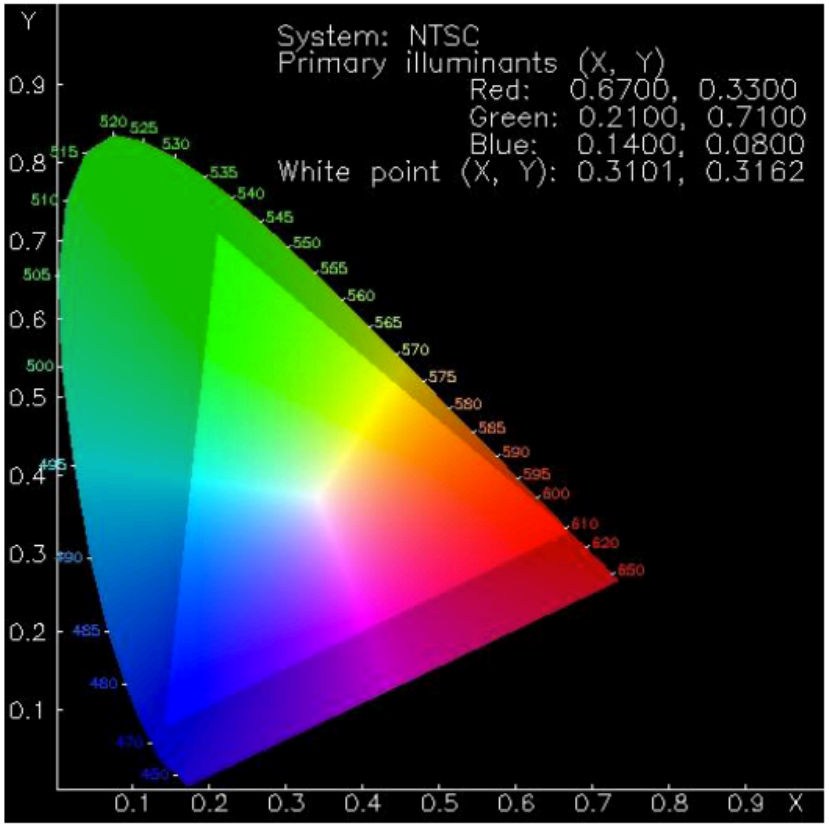
Tristimulus (X, Y, Z)

x= X/(X+Y+Z); y=Y/(X+Y+Z); z=Z/(X+Y+Z)

chromaticity coordinates *x* and *y* + Y

Colour


0.9
0.8
0.7
0.6
500
0.5
y
0.4
0.3
490
0.2
480
0.1
470
460
0.0
520
540
560
580
600
620
700
380
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
x


Y
System: NTSC
Primary illuminants (X, Y)
Red: 0.6700, 0.3300
Green: 0.2100, 0.7100
Blue: 0.1400, 0.0800
White point (X, Y): 0.3101, 0.3162
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 X

Exercises

- Un triangle de color verd s'envia a imprimir a una impressora CMY. El paper que hi ha és groc. De quin color es veurà pintat el triangle en el paper? Raona la resposta.

Exercises

- Donat el color (1.0, 0.0, 0.5) en CMY, doneu una expressió d'un color RGB de la mateixa tonalitat i saturació però menys brillant.

Exercises

- Es vol imprimir un dibuix de color RGB = (1,0.5,0.5), en un full blanc usant una impressora que utilitza tintes Cyan, Magenta i Yellow. Contesta i justifica les respostes:
- Quines tintes s'han d'usar i en quina quantitat per a obtenir aquest dibuix?
- Si la impressora s'ha quedat sense tinta magenta, i imprimeix igualment, de quin color quedarà imprès el dibuix?