CPSC 453 – Computer Graphics
Colour

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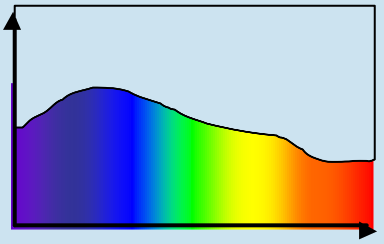
Colour

- colour is a complex subject
- understanding of it is incomplete and comes from many different subject areas
  - psychophysics, physiology, psychology, art and design
- the colour of an object depends on
  - the object itself, the light source, the surrounding colour, and the way it is perceived
- it is heavily used, part of all cultures and as such has many different pre-assigned meanings
- Why use colour?
  - to make the display more attractive
  - to emphasize and draw attention
  - to increase readability
  - to encode meaning

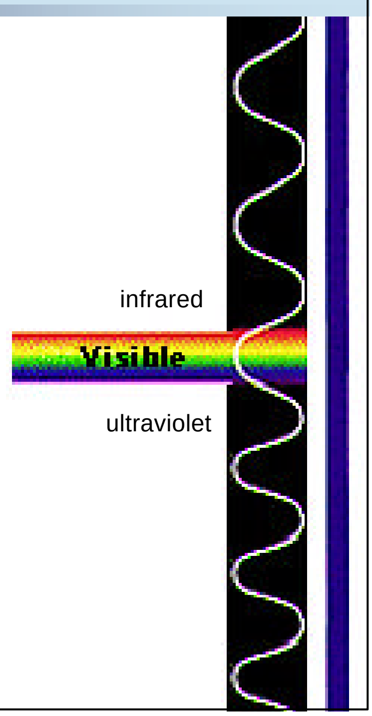
- http://msdn.microsoft.com/workshop/design/color/hess08142000.asp
- http://library.thinkquest.org/50065/art/effects.html
- http://www.colormatters.com/colortheory.html

Colour

- Light occupies wavelengths from ~350 to 780 nm
- Can be characterized by a function

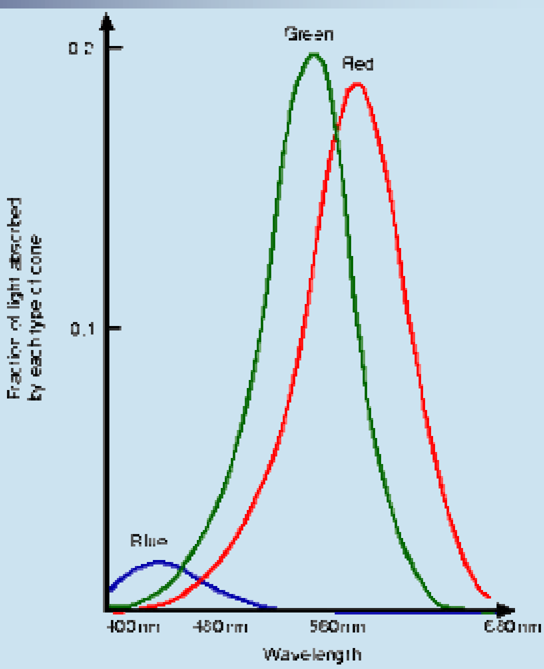


- displays do not do this
- Still if we see a colour in the real world we would like to match it on the display



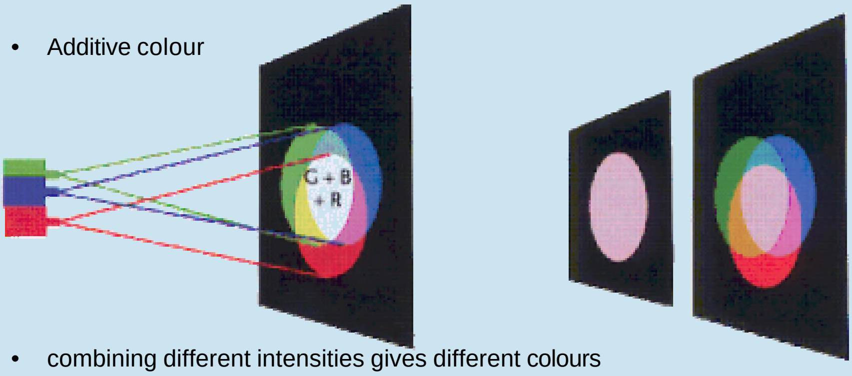
Colour

- the human retina has 3 kinds of cones.
- each type of cone responds as a function of the wavelength of the incident light
- peaks for each curve are:
  - Blue: 440nm,
  - Green 545nm
  - Red 580nm (red). Note
- (last two actually peak in the yellow part of the spectrum).
- perception of colour is an entirely arbitrary creation of our nervous system, and is not contained in the wavelengths



Colour

- match any colour with a mixture of 3 lights (primaries) – reasonable approach but have reduced a continuous function to 3 numbers
- Additive colour

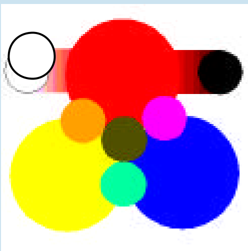


- combining different intensities gives different colours
- $\mathbf{C} = T_1\mathbf{R} + T_2\mathbf{G} + T_3\mathbf{B}$
- $T_1 = T_2 = T_3 = 1.0$ gives white, $T_1 = T_2 = T_3 = 0.0$ gives black,
- Shades of grey $T_1 = T_2 = T_3$

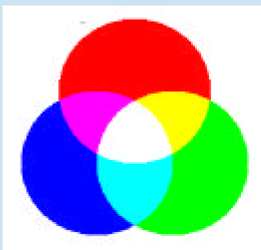
Colour

- CRT, printer, film, paint, human eye – all operate differently in regards to primaries

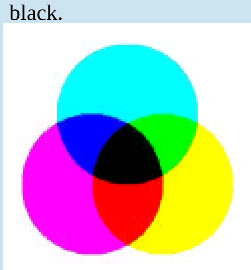
Paint Colours
- tints and shades
- red, yellow, blue
- all three primaries give brown



RGB Colour
- additive colours
- computer monitors
- red, green, and blue
- absence all three colours gives black, all three gives white.

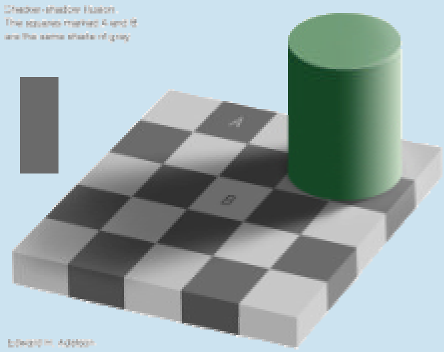


CMYK Colour
- Colour Subtraction
- printing
- cyan, magenta, yellow
- absence all three colours gives white, all three gives black.

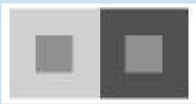


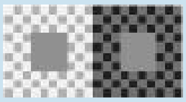
- Translations between maybe mathematically accurate without being visually accurate

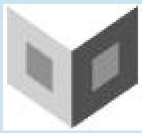
Perceiving Colour

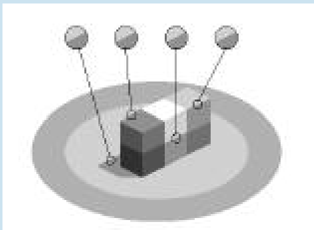


- An active organizing process
- Many illusions – experiments from psychology (if interested *Information Visualization: Perception for Design.* Colin Ware)
- Colour, as we perceive, it is not just a matter of measuring wavelength
- We perceive difference – not absolutes
- The eye is not a photometer

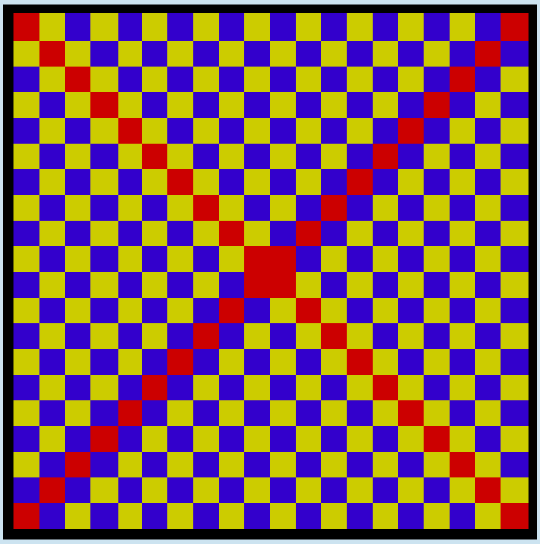








Colour and context

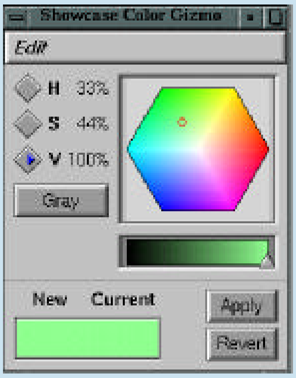


Chromatic colour

- Munsell system – set of standard (from human observers) samples in a 3D space of

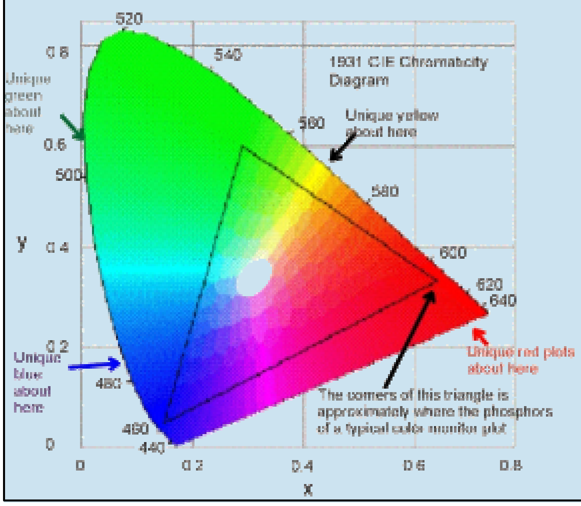
  Hue, Saturation, Value (HSV)

- Complimentary colours – add together to give white



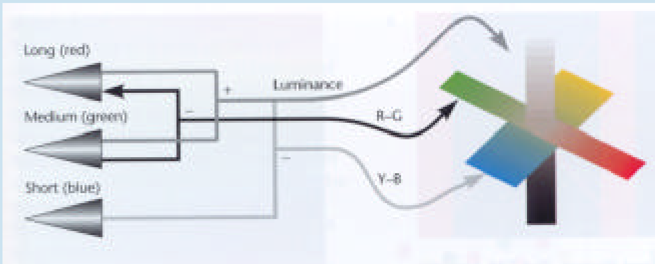
Colour

- Colour Gamut – the range of colours that can be created by mixing a given set of primary colours



Aside - Opponent Process Theory

- Late 19th C. Ewald Hering
- 6 elementary colours
- arranged perceptually as opponent pairs along 3 axes:
  - black – white
  - red – green
  - blue – yellow



- cornerstone of modern colour theory
- well established physiological basis

Colour

- In OpenGL API
- RGB model – conceptually 3 buffers – R, G, and B
- A given number of bits per buffer
- 8 per buffer or 24 in total

  gives 2^{24} colours or 16 M (where M is 1024)
- R, G and B are specified separately

  glColor3f(1.0, 0.0, 0.0);

- Actually GL uses a fourth colour specification RGBA
- Alpha → transparency

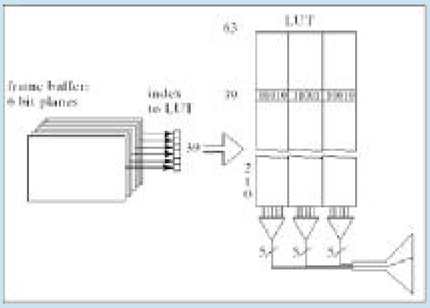
  glClearColor(1.0, 1.0, 1.0, 1.0);

Colour – indexed colour

- Is it possible to have a reasonable range of colours with a small frame buffer?

Indexed Colour

- Alternative method of associating pixel values with colour
- Colour Look Up Table (LUT)



- Example: setcolour (colour-index, red-value, blue-value, green-value);
- Palette: set of possible colours that the system is capable of displaying

Colour: number of palettes

- k: number of planes in the frame buffer (bit)
- m: width of each entry in the LUT per colour (bits)
  (2^m reds, 2^m greens, 2^m blues)
- 2^{3m} possible colours (palettes)
- 2^k colors at one time
- User constructs LUT – using m bits for each RGB
- Entries in the LUT can specified by index

- Advantages
  - Less cost of memory
  - More flexible
  - Largely used when frame buffer cannot support *full* colour

Colour References

Information Visualization, Perception for Design; Colin Ware. Morgan Kaufmann Publishers.

An Introduction to Natural Vision; S. A. J. Winder. PhD Thesis: “From Cones to Contours: A Parallel Simulation of Neural Mechanisms in the Primate Vision System”, 1995.

http://school.discovery.com/homeworkhelp/worldbook/atozpictures/lr001100.html

http://www.ccrs.nrcan.gc.ca/ccrs/eduref/sradar/chap2/c2p2_g2e.html