Perception and Colour

Lecture 8

Human Vision

- Our retinas contain two primary sensors
  - rods - B&W vision
  - cones - Colour vision
- Attached to these are layers of neurons with various functions including edge detection.

Visual cues in a 2D world

- Familiarity
- Lighting (shadows and shading)
- Projections
- Depth Cue
- Hidden Line/Surface Removal

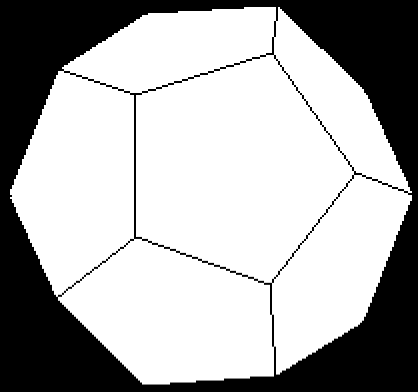
Visual Cues - Familiarity

- Placing objects next to reference object (ie familiar objects of known size).
- In large engineering projects a reference human is sometimes drawn on blueprints.
- Eye/Camera position also plays a part. A low camera height will make objects appear higher as we expect camera position to match our eyes (around 1.5m above the ground).

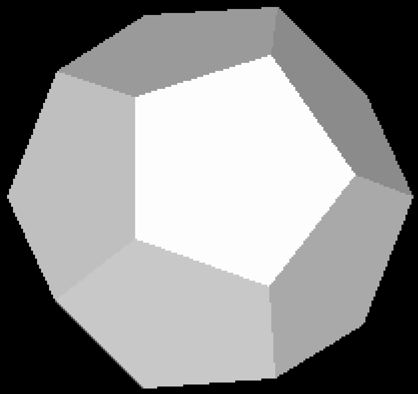
Visual Cues - Lighting / Shadows

- Facet lighting gives significant visual cues.
- Compare the cases below.
- Shading calculated based on angle between light and surface normal.

No lighting



Lighting

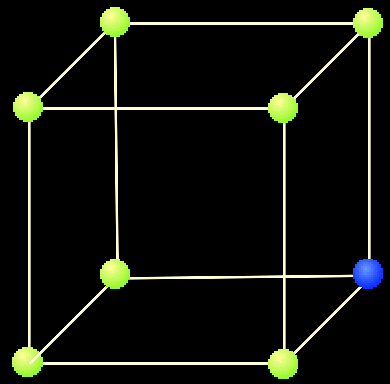


Visual Cues - Projections

- There are *many* drawing projections in use, each of which preserves some specific aspect of the 3D object (eg length, parallel lines, angles).
- Note these are general 3D to 2D projections, not cartographic projections.
- Two common projections found in computer graphics are the
  - Orthogonal projection
  - Perspective projection.

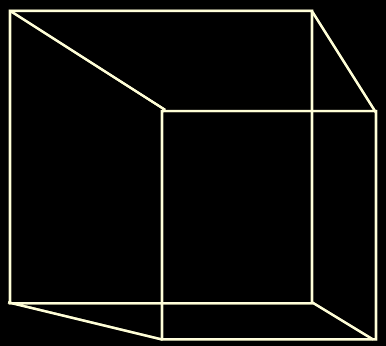
Orthogonal Projection

- This preserves lengths and is thus good for engineering drawings
- It fails to provide sufficient visual cues for problem free visual interpretations
- The Necker cube illusion demonstrates the problem
- Is the blue dot on the front edge or the back edge



Perspective Projection

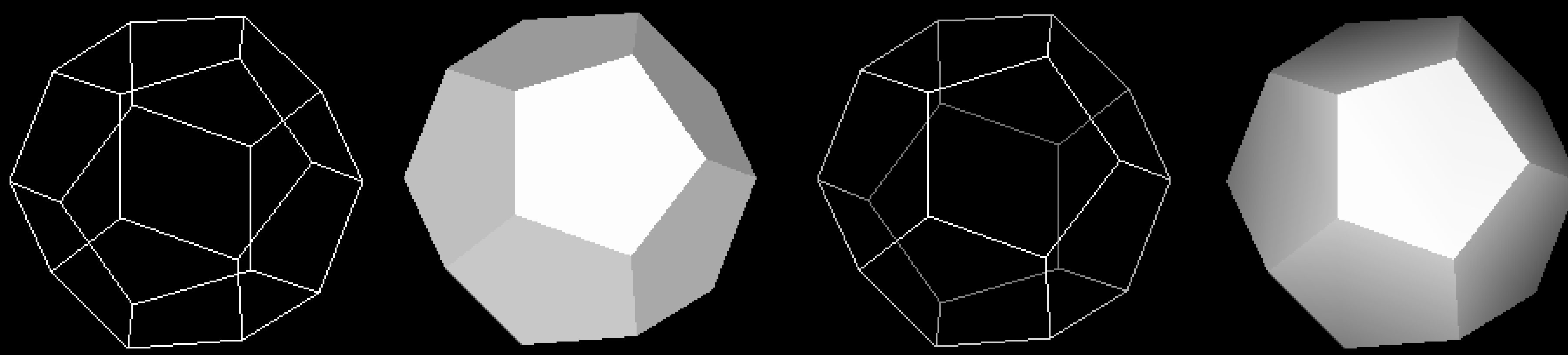
- Whilst lengths may not be preserved, there is no confusion about which face is closest to the viewer
- Inversion is still possible but the problem is reduced



Visual Cues - Depth Cue

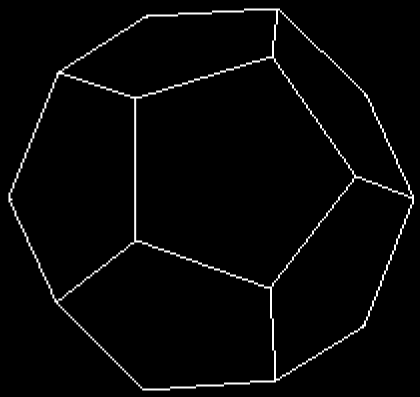
- Intensity of lines is proportional to depth
- Deeper lines (further away from viewer) are darker
- When combined with perspective, inversion problems are minimal

Normal (lit) Depth Cued



Hidden Surface Removal

- Lines and surfaces hidden by those in front are not drawn.
- Calculated using angle between surface normals and viewing direction. Any surface at an angle $> 90^{o}$ is hidden



Surface Colouring and Shading

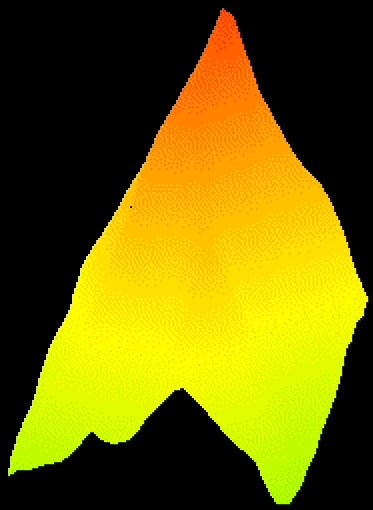
- Colouring/Shading
  - No Lighting
  - Flat
  - Gouraud
- Lighting equations
  - Simples equations are based on the dot product

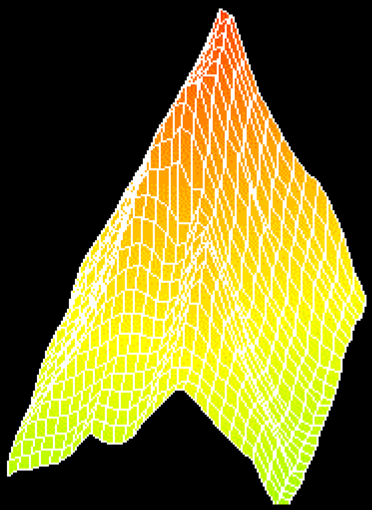
$$\text{Intensity} = \mathbf{N} \cdot \mathbf{L}$$

where **N** is facet normal, **L** is light direction

Surfaces, No Lighting

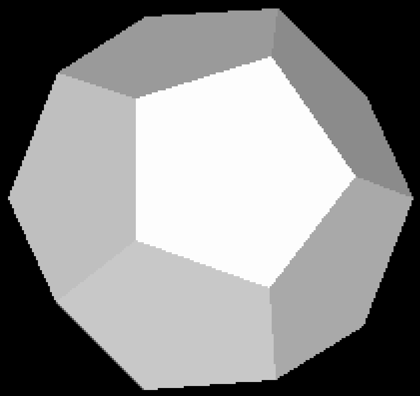
- With no direction dependent surface lighting 3D object shape cannot be determined without extra visual cues.





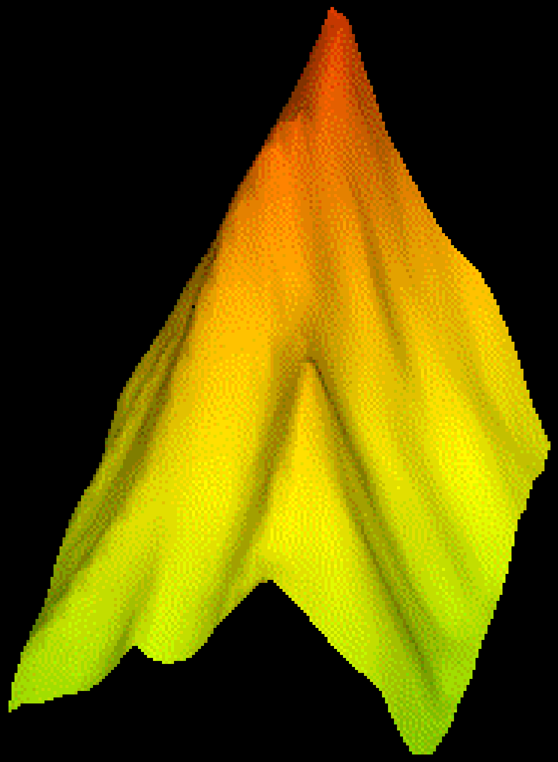
Flat Shading

- 1 vertex per facet (polygon) ->
- 1 colour per facet
- Facets are visible



Gouraud Shading

- 1 colour per vertex ->
- interpolated shading over surface
- To hide edges, vertices may be averaged
- Facets are no longer visible. Surface appears smooth

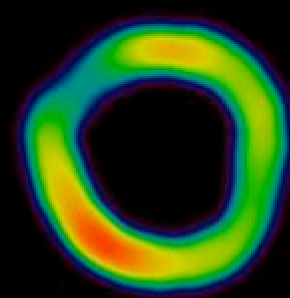


Pseudo Colour

- A greyscale image may be coloured using an arbitrary colour table (*colourmap*).
- Each (greyscale) pixel value get mapped to an RGB colour.

Example colourmap

Min  Max

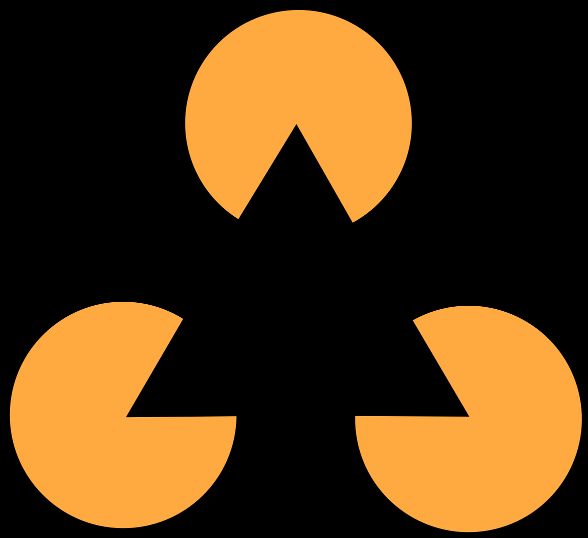


RGB vs Colour Index Mode

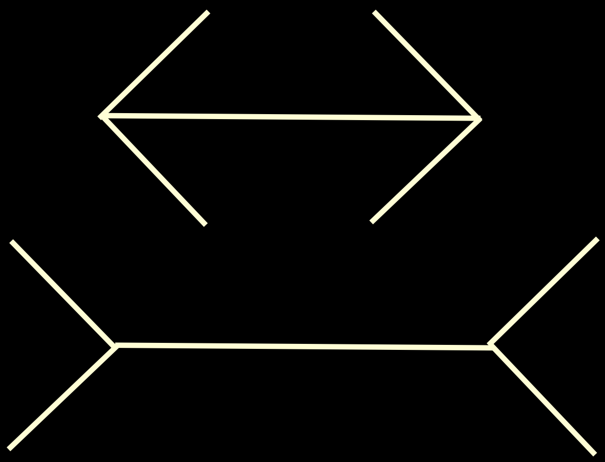
- A surface may be coloured in two ways
  - by using a colourmap to convert data values into a colour. Termed *colour index mode*
  - by assigning an RGB colour to each data value. Termed *RGB mode*.
- Colourmaps are more flexible as the colouring information resides in a small table and can be quickly changed by computer.
- In RGB mode entire surface colour has to be recalculated.

Visual Tricks

What shapes are visible ?

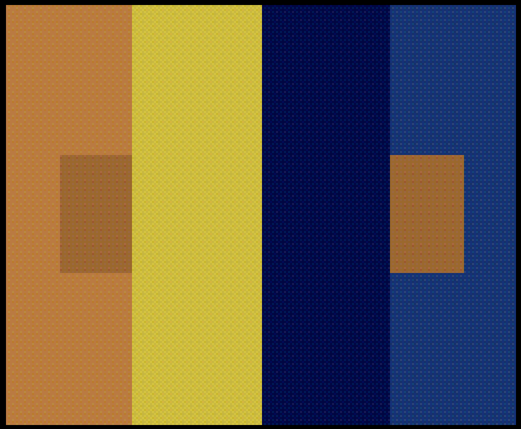


Which is longer ?



Visual Tricks…

- Which of the two smaller squares is the darkest ?



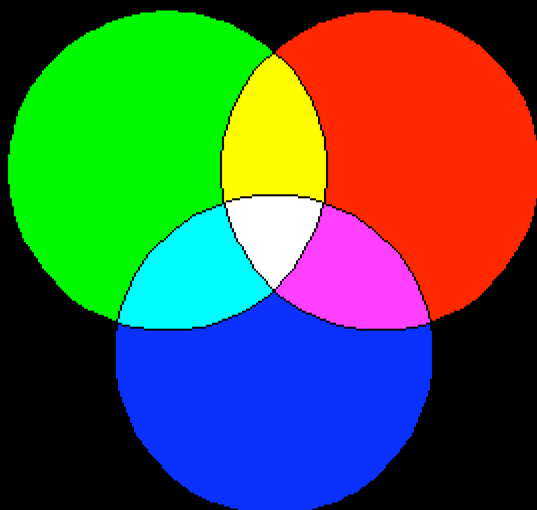
Colouring

- HSV (HSI, HLS) - human vision
- RGB - hardware
- CMY(K) - mostly printing
- CIE - standard (but convenient for neither!!)
- Luminance-chrominance - video
- and more...

Colour Theory

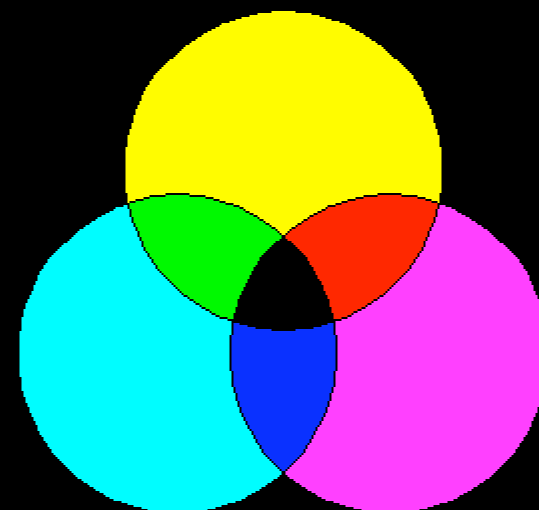
- Additive and Subtractive

Additive Primaries



RGB

Subtractive Primaries

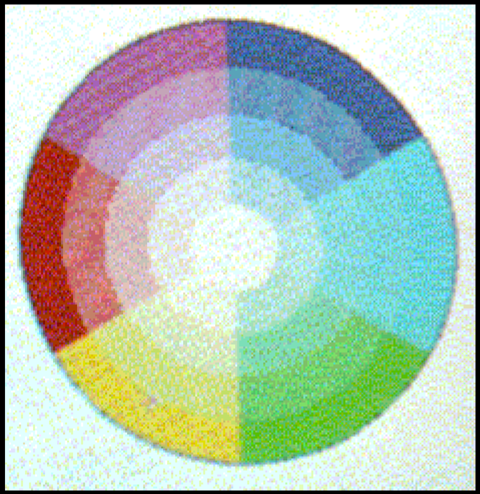


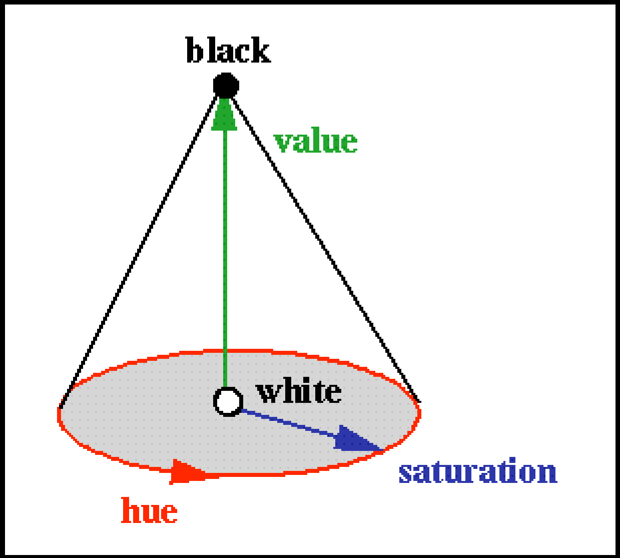
CMY

HSV

- Hue (colour)
- Saturation
- Value

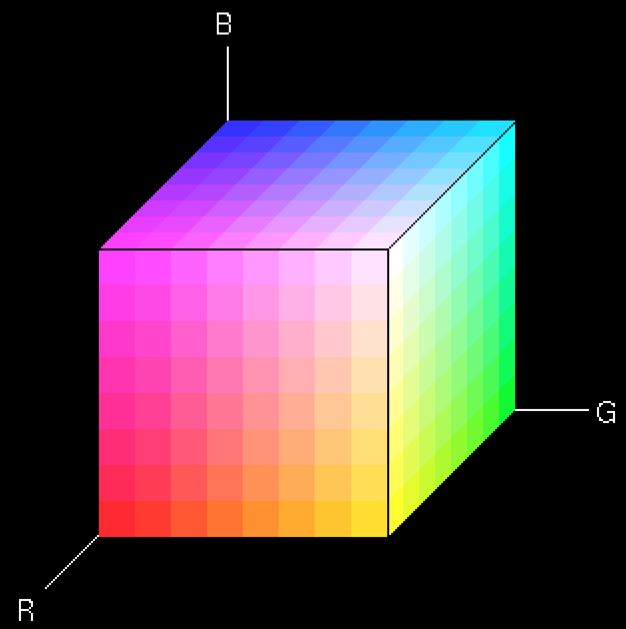
Suited to human interpretation

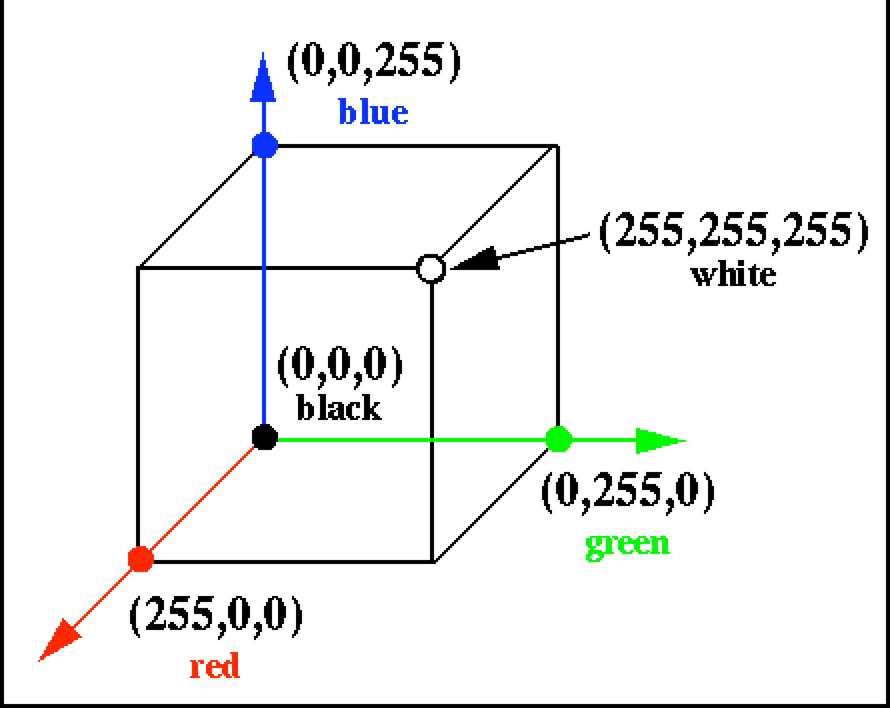




RGB

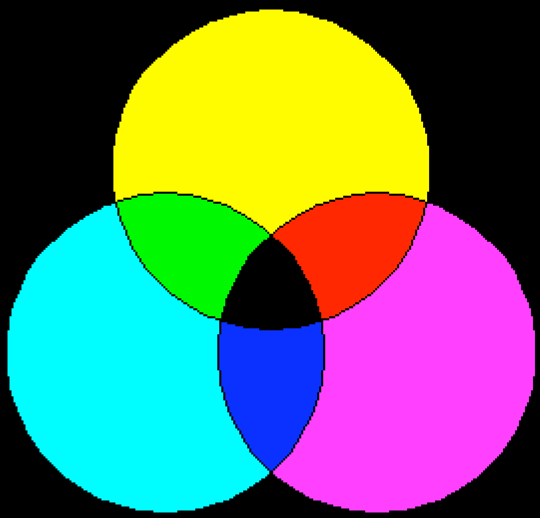
- Red, Green, Blue
- Best for computer hardware but not humans





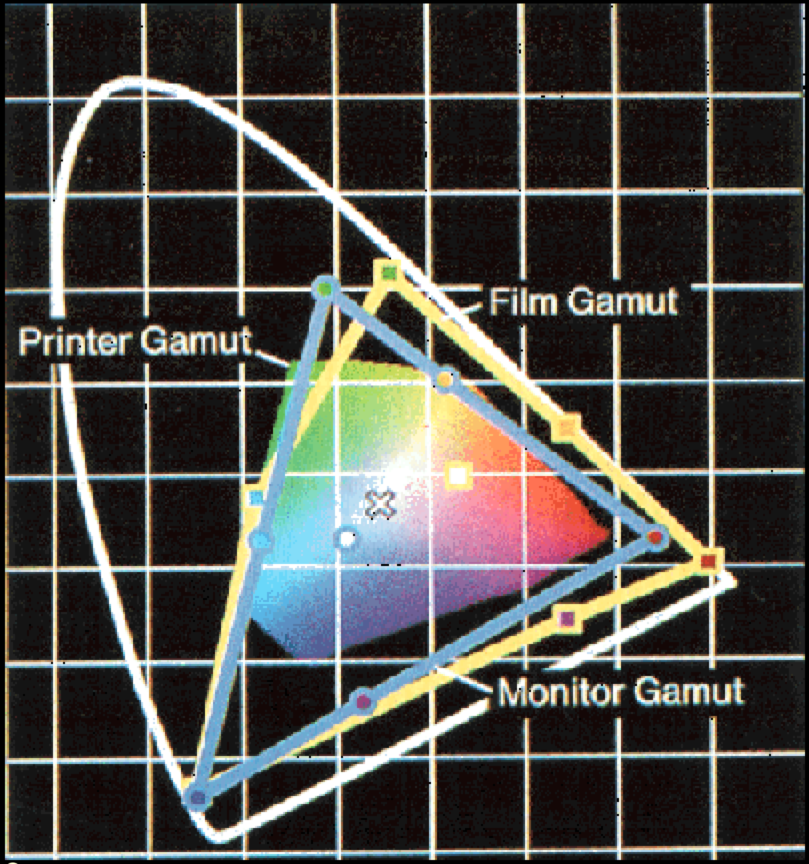
CMY(K)

- Cyan, Magenta, Yellow, (Black)
- CMY(K) used in printing (subtractive primaries)
- C+M+Y => Black
- Black is very common, making it from 3 colours wastes ink and may not produce good results.
- Hence black is usually supplied separately as a fourth ink.



CIE

- Industry Standard
- Complex!



CIE Chromaticity Diagram

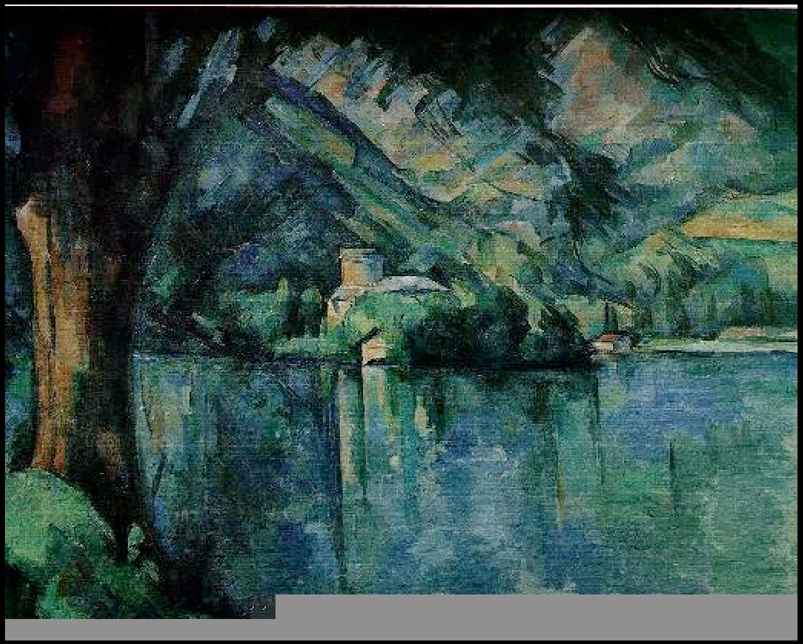
Human perception of colour

- Setting Mood
- Cultural Programming
- Cultural Differences

Mood Setting

- Colour choice sets mood

Bords d'une rivière - *Cézanne (1904)*



Le lac d'Annecy - *Cézanne (1896)*

Cultural Programming

- Some colours have implied interpretation
- Going against this causes problems.
- Example
  - Temperature: Blue implies cold, Red implies hot.
  - Danger: Green implies safe, Red implies danger.

Cultural Differences

- Do the blue and red rectangles have any meaning to you ?