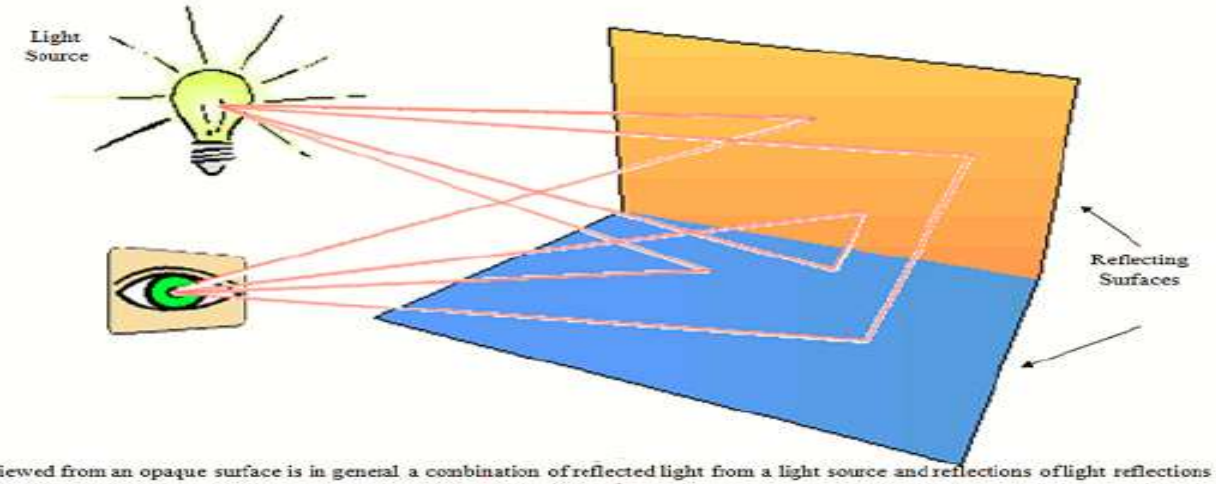
Computer Graphics
&
Multimedia Techniques

Unit-5

Illumination and Colour Models

Different light sources used in 3D modelling:

- When we view an opaque no luminous object, we see reflected light from the surfaces of the object.
- The total reflected light is the sum of the contributions from *light sources* and other reflecting surfaces in the scene.



Light viewed from an opaque surface is in general a combination of reflected light from a light source and reflections of light reflections from other surfaces.

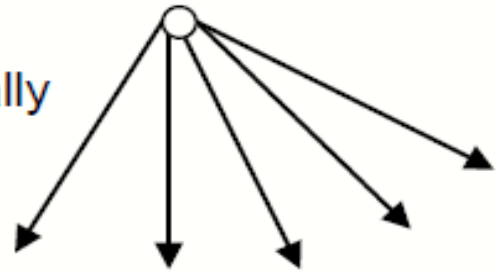
- Light sources = *light-emitting sources.*
- Reflecting surfaces = *light-reflecting sources.*
- Light source: object that radiates energy.

Sun, lamp, globe, sky…

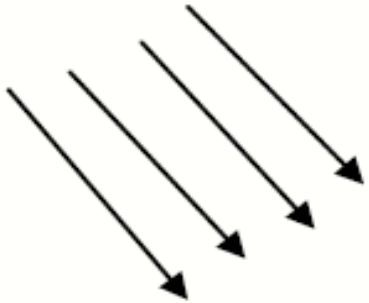
Intensity $I = (I_{red}, I_{green}, I_{blue})$,If $I_{red} = I_{green} = I_{blue}$: white light

Light Sources:

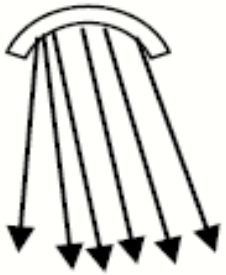
- Point Source: All light rays originate at a point and radially diverging. A reasonable approximation for sources whose dimensions are small compared to the object size.



- Parallel source: Light rays are all parallel. May be modelled as a point source at infinity (the sun).



- Distributed source : All light rays originate at a finite area in space.
  – A nearby sources such as fluorescent light.

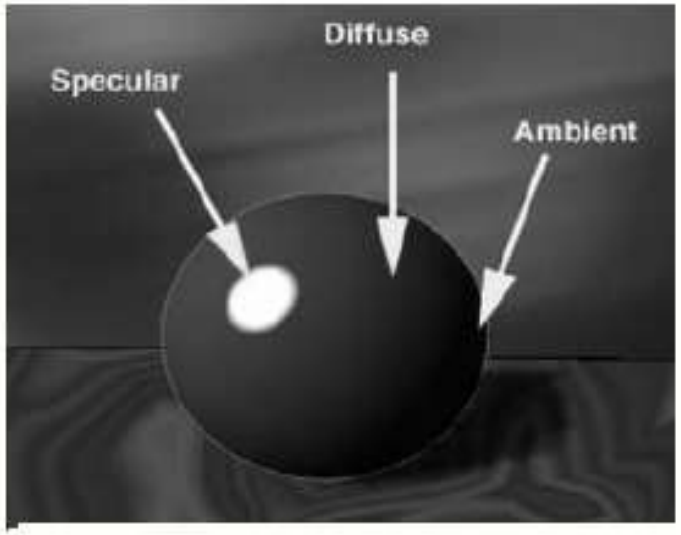


Basic Illumination Model:

- Simplified and fast methods for calculating surfaces intensities.
- Calculations are based on optical properties of surfaces and the lighting conditions (no reflected sources nor shadows).
- Light sources are considered to be point sources.
- A reasonably good approximation for most scenes.

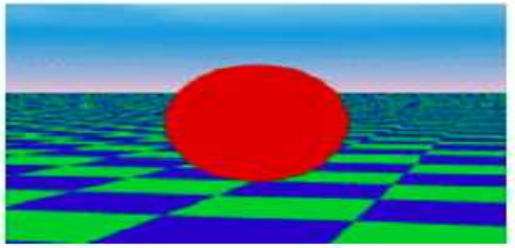
Phong Shading Model

1. ambient
2. diffuse
3. specular



Illumination Model: Ambient Light

- Even though an object in a scene is not directly lit it will still be visible. This is because light is reflected from nearby objects.
- Ambient light has no spatial or directional characteristics.
- The amount of ambient light incident on each object is a constant for all surfaces and over all directions.
- The amount of ambient light that is reflected by an object is independent of the objects position or orientation and depends only on the optical properties of the surface.
- The level of ambient light in a scene is a parameter I_a , and each surface illuminated with this constant value.



Ambient light shading.

- Illumination equation for ambient light is

$$I = k_a I_a$$

where

I is the resulting intensity

I_a is the incident ambient light intensity

k_a is the object's basic intensity, *ambient-reflection coefficient*.

Illumination Model: Diffuse Reflection

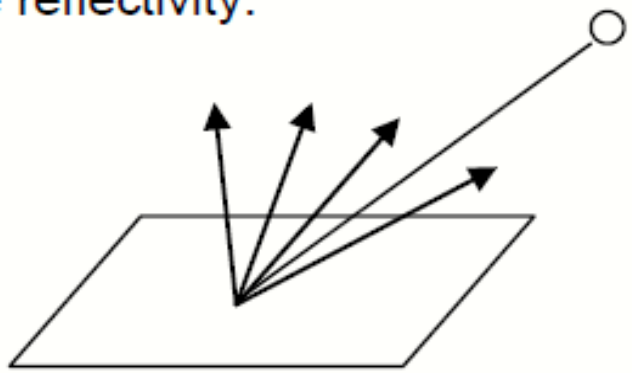
- Diffuse reflections are constant over each surface in a scene, independent of the viewing direction.
- The amount of the incident light that is diffusely reflected can be set for each surface with parameter k_d, the diffuse-reflection coefficient, or diffuse reflectivity.

  $0 \leq k_d \leq 1$;

  k_d near 1 – highly reflective surface;

  k_d near 0 – surface that absorbs most of the incident light;

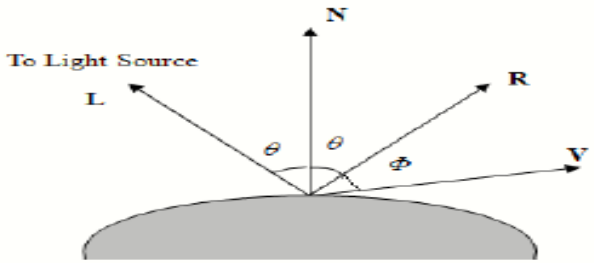
  k_d is a function of surface color;



- Diffuse (Lambertian) surfaces are rough or grainy (like clay, soil,fabric).
- The surface appears equally bright from all viewing directions.

Illumination Model: Specular Reflection

- *Specular reflection* is the result of total, or near total, reflection of the incident light in a concentrated region around the *specular-reflection angle.*
- Shiny surfaces have a narrow specular-reflection range.
  Dull surfaces have a wider reflection range.



Modeling specular reflection.

The above Figure shows the specular reflection direction at a point on the illuminated surface. In this figure,

- R represents the unit vector in the direction of specular reflection;
- L – unit vector directed toward the point light source;
- V – unit vector pointing to the viewer from the surface position;
- Angle Φ is the viewing angle relative to the specular-reflection direction R.

Half toning Technique:

1.Newspaper, photographs simulate a grey-scale image that can printed using only black ink.
2.A newspaper picture is, in fact, made up of a pattern of tiny black dots of varying size.
3.The human visual system has a tendency to average brightness over small areas, so the black dots and their white background merge and are perceived as an intermediate shade of grey.
4.The process of generating a binary pattern of black and white dots from an image is termed half toning.
5.In traditional newspaper and magazine production, this process is carried out photographically by projection of a transparency through a 'halftone screen' onto film.
6.The screen is a glass plate with a grid etched into it.
7.Different screens can be used to control the size and shape of the dots in the half toned image.
8.In computer graphics, half toning reproductions are approximated using rectangular pixel region say 2 x 2 pixels or 3 x 3 pixels.
9.These regions are called as “Halftone Patters” or “Pixel Patterns”.

Half toning Technique:

2 x 2 pixel patterns for creating five intensity levels are shown in figure 43.

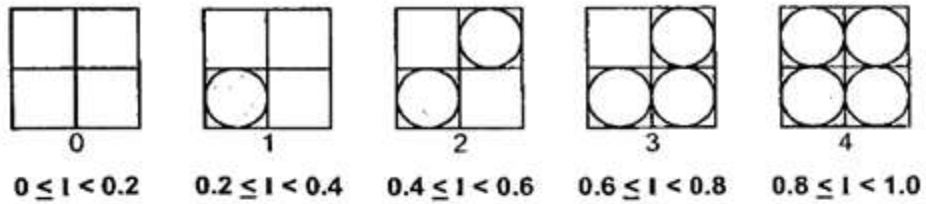


Figure 43

3 x 3 pixel patterns for creating ten intensity levels are shown in figure 44.

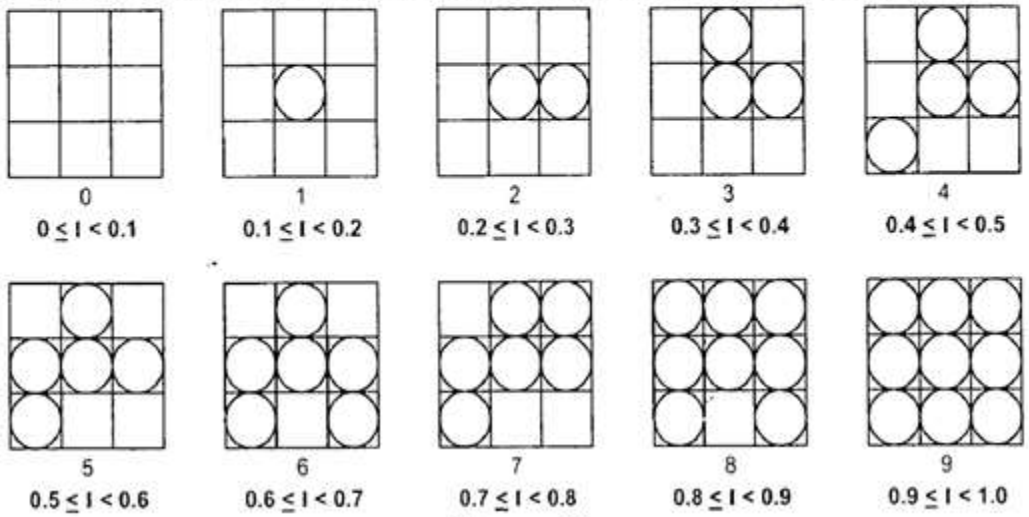
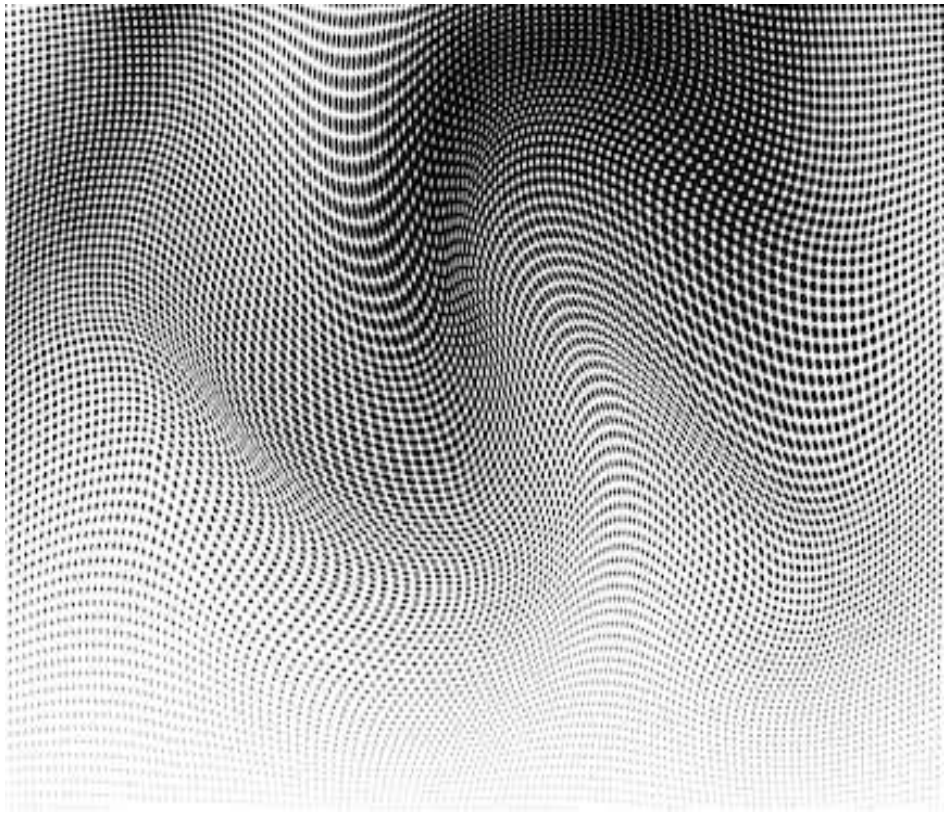


Figure 44



Dithering technique:

1. Another technique for digital half toning is dithering.
2. It is the technique for approximating halftones without reducing resolution, as pixel grid patterns do.
3. Dithering can be accomplished by Thresholding the image against a dither matrix.
4. To obtain n2 intensity levels, it is necessary to setup an n x n dither matrix Dn whose elements are distinct positive integers in the range of 0 to n2 – 1.
5. Matrix for 4 intensity level and 9 intensity level is shown below.

$$D2 = \begin{bmatrix} 3 & 1 \\ 0 & 2 \end{bmatrix} \qquad D3 = \begin{bmatrix} 7 & 2 & 6 \\ 4 & 0 & 1 \\ 3 & 8 & 5 \end{bmatrix}$$

Dithering technique:

1. The elements of a dither matrix are thresholds.
2. The matrix is laid like a tile over the entire image and each pixel value is compared with the corresponding threshold from the matrix.
3. The pixel becomes white if its value exceeds the threshold or black otherwise.
4. This approach produces an output image with the same dimensions as the input image, but with less detail visible.
5. High order dither matrices can be obtained from lower order matrices with the recurrence relation.

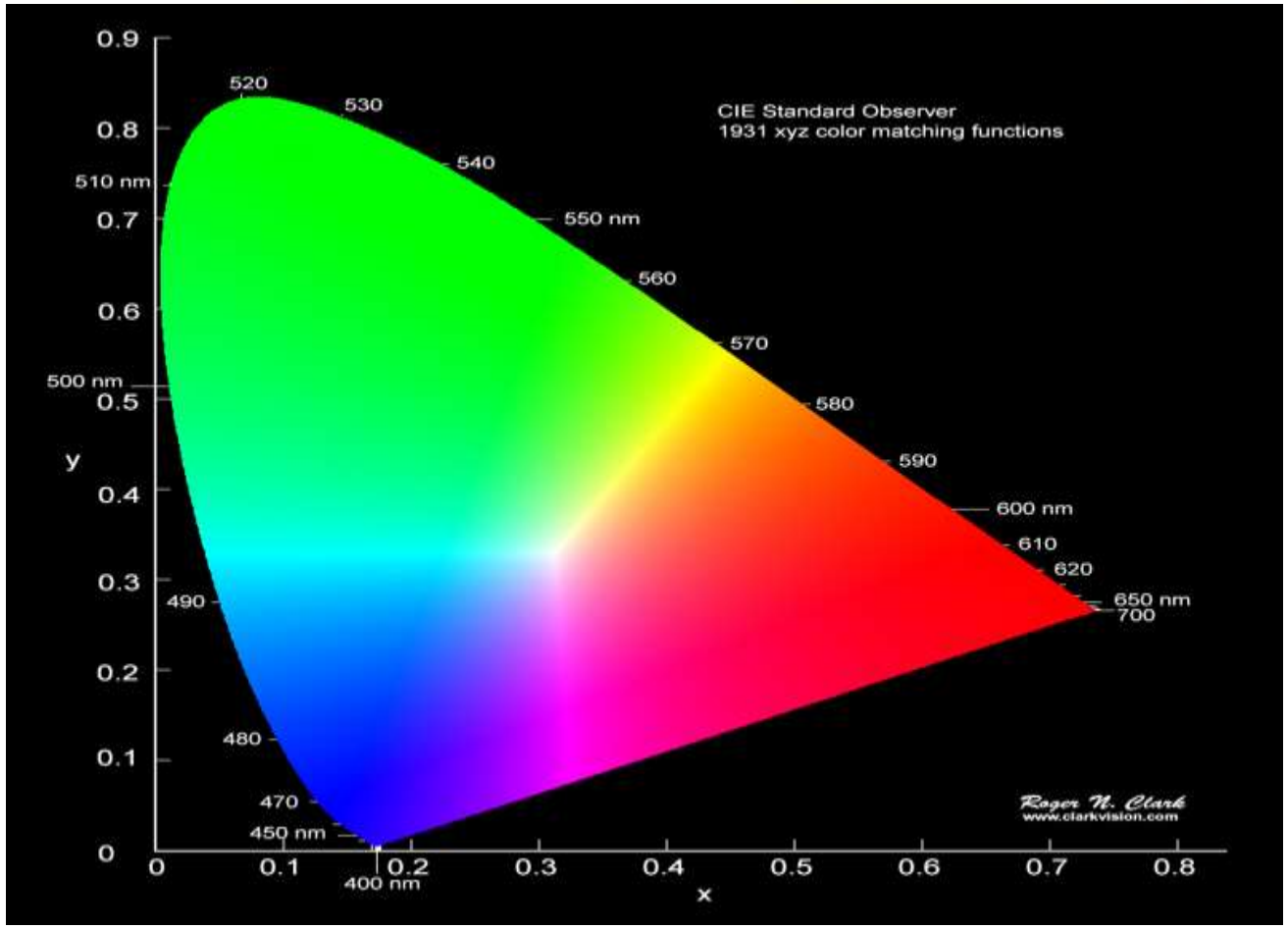
$$D_n = \begin{bmatrix} 4D_{n/2} + D_2(1,1)u_{n/2} & 4D_{n/2} + D_2(1,2)u_{n/2} \\ 4D_{n/2} + D_2(2,1)u_{n/2} & 4D_{n/2} + D_2(2,2)u_{n/2} \end{bmatrix}$$

Algorithm to halftone an image using a dither matrix

```
For all x & y do
    if f(x,y) > m(x,y) then
        g(x,y) = white
    else
        g(x,y) = black
    end if
End for
```

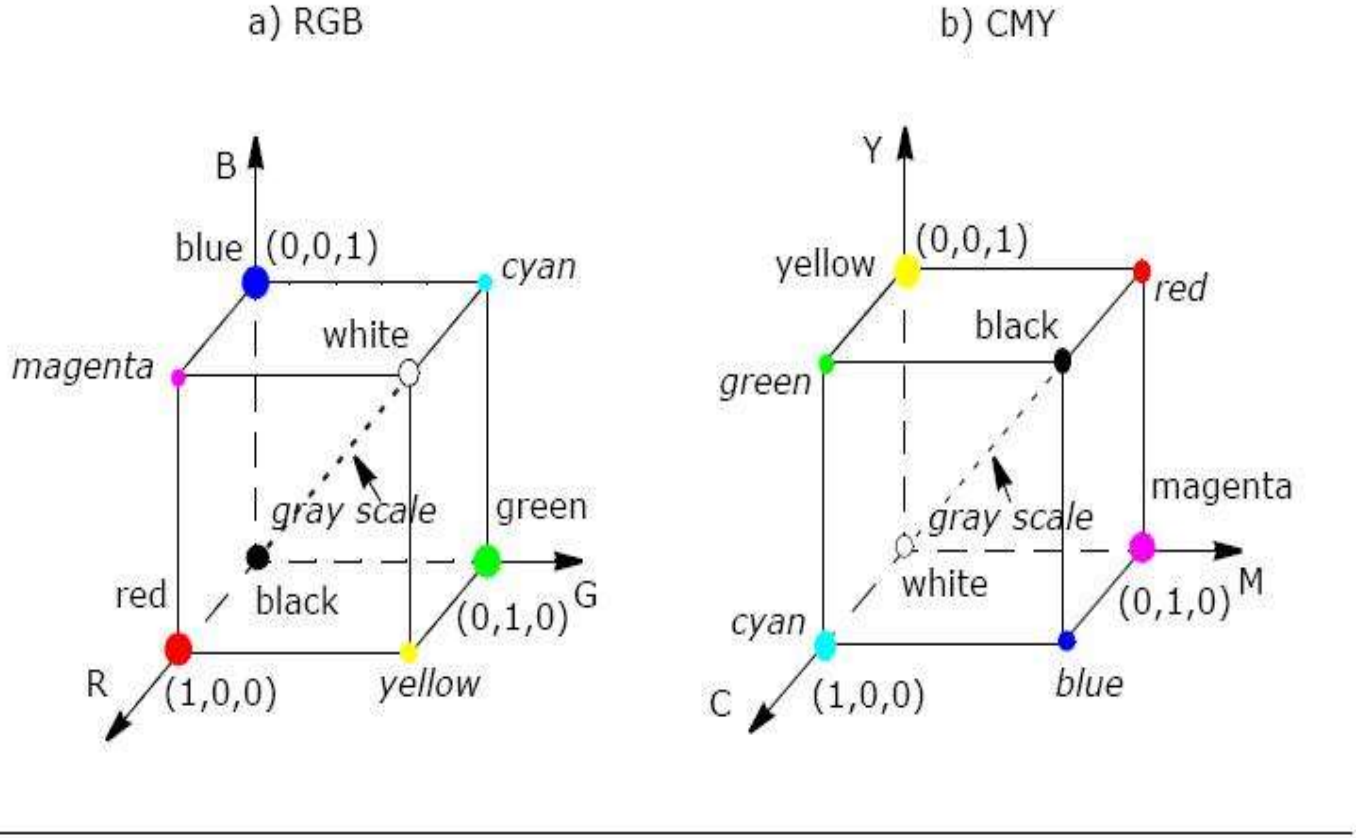
Chromaticity diagram:

Chromaticity is an objective specification of the quality of a color regardless of its luminance. Chromaticity consists of two independent parameters, often specified as hue (h) and colorfulness (s), where the latter is alternatively called saturation, chroma, intensity, or excitation purity.



RGB and CMY Color Model:

The RGB color model is one of the most widely used color representation method in computer graphics. It use a color coordinate system with three primary colors. Each primary color can take an intensity value ranging from 0(lowest) to 1(highest). Mixing these three primary colors at different intensity levels produces a variety of colors. The collection of all the colors obtained by such a linear combination of red, green and blue forms the cube shaped RGB color space



HSV Color Model:

HSV is a cylindrical color model that remaps the RGB primary colors into dimensions that are easier for humans to understand. Like the Munsell Color System, these dimensions are hue, saturation, and value.

. *Hue* specifies the angle of the color on the RGB color circle. A 0° hue results in red, 120° results in green, and 240° results in blue.

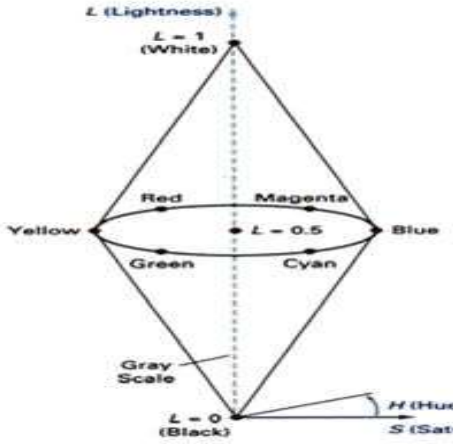
. *Saturation* controls the amount of color used. A color with 100% saturation will be the purest color possible, while 0% saturation yields grayscale.

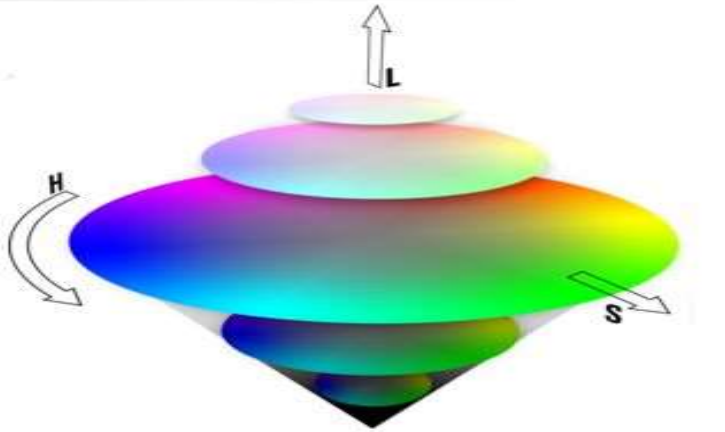
. *Value* controls the brightness of the color. A color with 0% brightness is pure black while a color with 100% brightness has no black mixed into the color. Because this dimension is often referred to as brightness, the HSV color model is sometimes called HSB, including in P5.js.

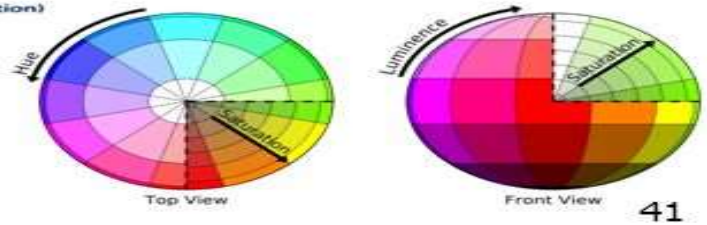
HLS Color Model:

The HLS Color Model

- HLS color model
  - Another model based on intuitive color parameter
  - Used by the Tektronix Corporation
  - The color space has the double-cone representation
    - Used hue (H), lightness (L) and saturation (S) as parameters







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Thanks!