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Computer Graphics

Color

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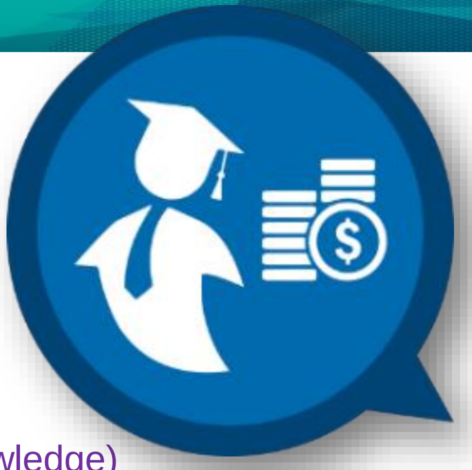
Chapter Description



- Aims
  - Basic of Computer Graphics.

- Expected Outcomes
  - Understand the basic concept of computer graphics. (CO1: Knowledge)
  - Ability to use the computer graphics technology. (CO1: Knowledge)

- References

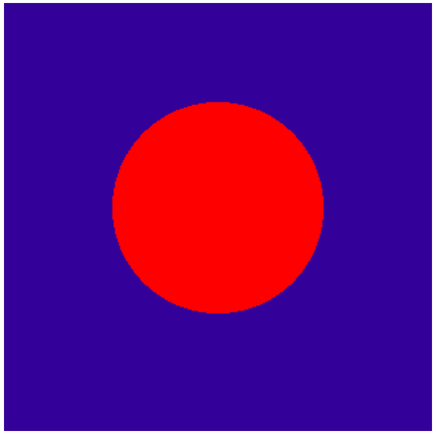
  - Computer Graphics by Zhigang Xiang, Schaum's Outlines.
  - Donald Hearn & M. Pauline Baker, Computer Graphics with OpenGL, 4th Edition, Boston : Addison Wesley, 2011.

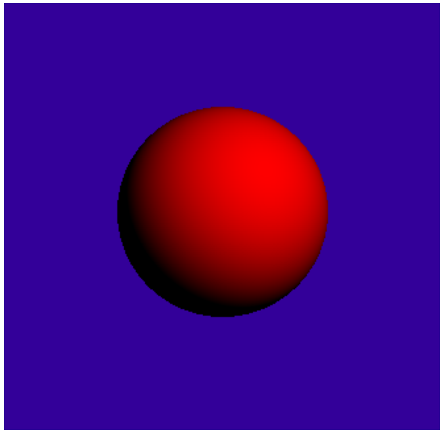
Why Lighting?

- Neurological and Psychological responses: Color is a fundamental attribute of human visual system.
- The perception of color comes from light energy.
- Visible light: Electromagnetic energy, range 400 to700 nm wavelength

Why Lighting?

- **Relevant to computer graphics**: A realistic image seems fuzzy from the light energy coming from a real scene.
- **If no lighting effects:** Then nothing looks three dimensional!





Why Lighting?

- **Why discuss color?**
  - Example: brightness, tint, luminance, shade, hue, color, chromaticity, …
  - To know how the eye recognizes color.
  - To know how the interaction between light (color) and objects for rendering (3D to viewing 2D) them accurately or realisticly.

Chromatic Light & Achromatic Light

- Chromatic light: Having color components with intensity called

- Achromatic Light: No color components, only having intensity called achromatic light

Properties of Chromatic light

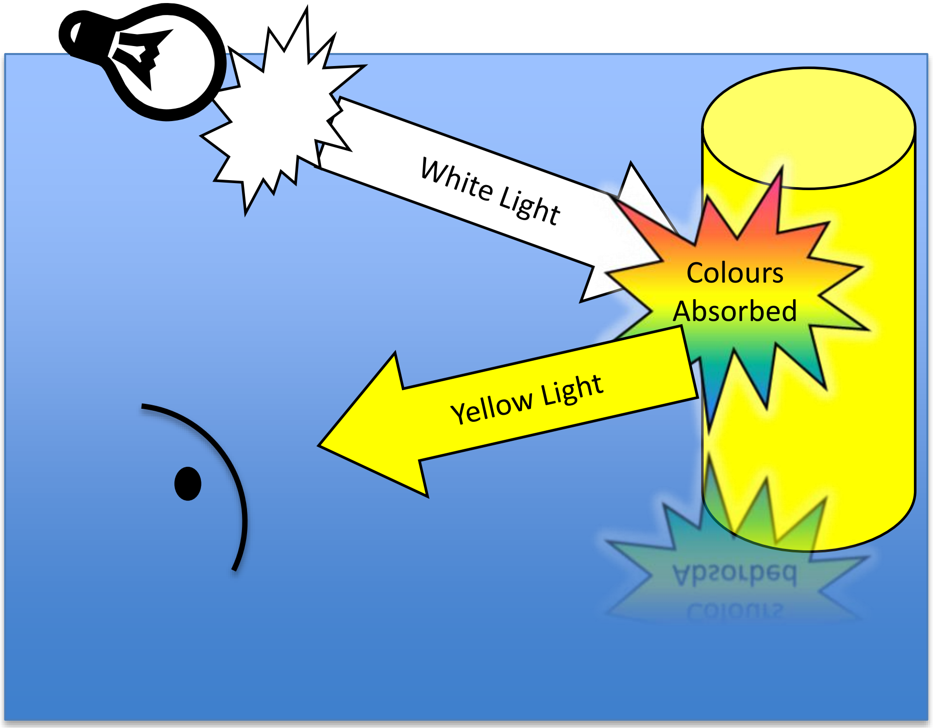
- **Brightness** ---- total amount of energy from a light source, corresponds to its physical property called luminance.
  - Higher the luminance, brighter the light to the observer.
- **Hue** --- distinguishes the white light to others
- **Saturation** ---- excitation purity, which is defined to be the percentage of luminance

saturation = pure color/(pure color + white color)

Basics of Reflected Light

- Human perception for colors:
  - Determined by the nature of the light which is reflected from an object.

➢ Example: If white light is fall onto a yellow object then color with high wavelengths are absorbed, but yellow light is reflected from the object as in Figure.



Basics of Reflected Light

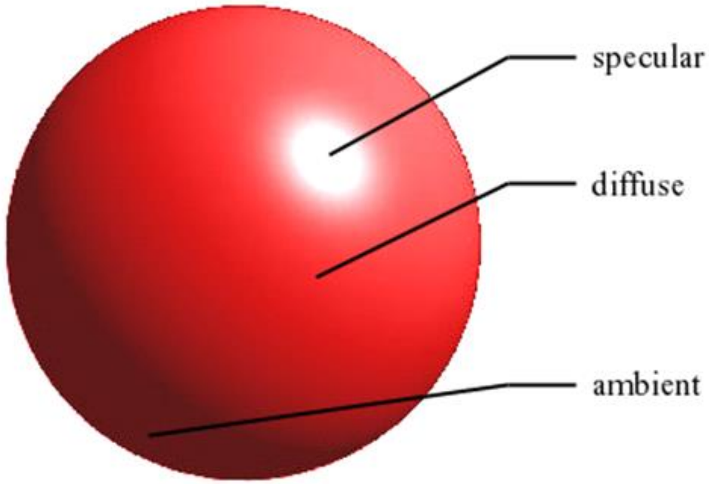
- Depends on the type of material
- Dull surfaces absorb more
- Shiny materials reflect more
- For transparent surfaces, light also transmitted through the material

Components of Reflections

Specular – near **total** of the incident light around reflection angle.

Diffuse – reflection from **incident** light with equal intensity in all directions. This depend on surface properties.

Ambient – surface visible to **incidental light** which is reflected from adjacent objects.



Real Lights and Reflection

- Real lights
  - Sun light, fluorescent or iridescent bulbs etc.
  - There exists different spectra in different directions

- Moreover
  - Light also can come from a source, or light that bouncing off another object, or after multiple bounces of light
    - Extension of sources
    - Multiple interactions between light and surface

RGB Space

- Three primary light or color that can be identified by human visual system (i.e. cone)
  - Red (R), Green (G), and Blue (B)

- Additive nature in order to produce other colors

- Practically, hardware uses three color phosphors. Therefore, Perfect for graphical imaging

CIE XYZ Color Model

- CIE --- Commission Internationale de l'Eclairage (English: International Commission on Illumination)
- standard for sharing color information
  - ✓ Two chromaticity (similar to hue or color) values: axis X and Z
  - ✓ One luminance (similar to intensity) value: axis Y

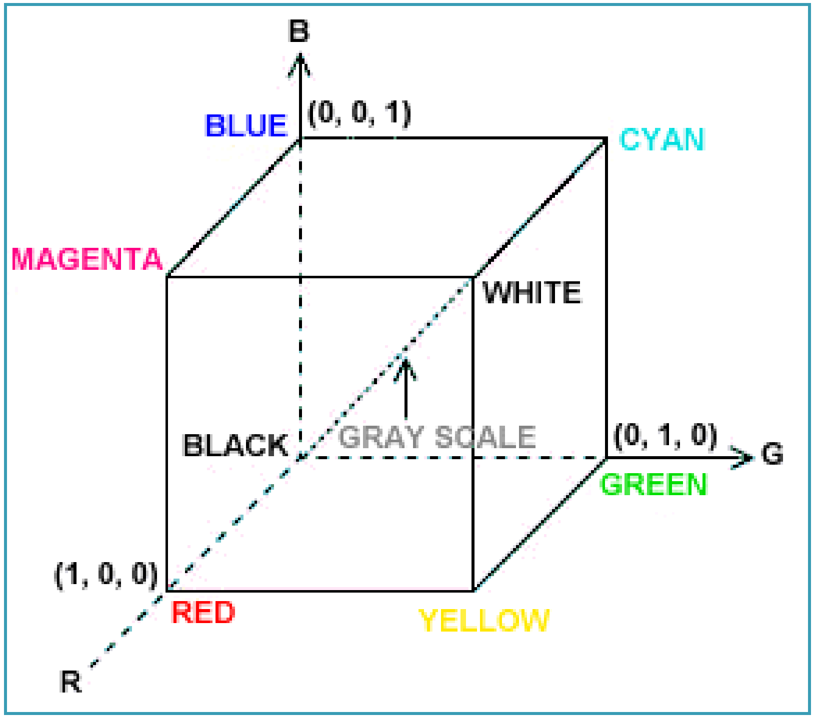
Color Model

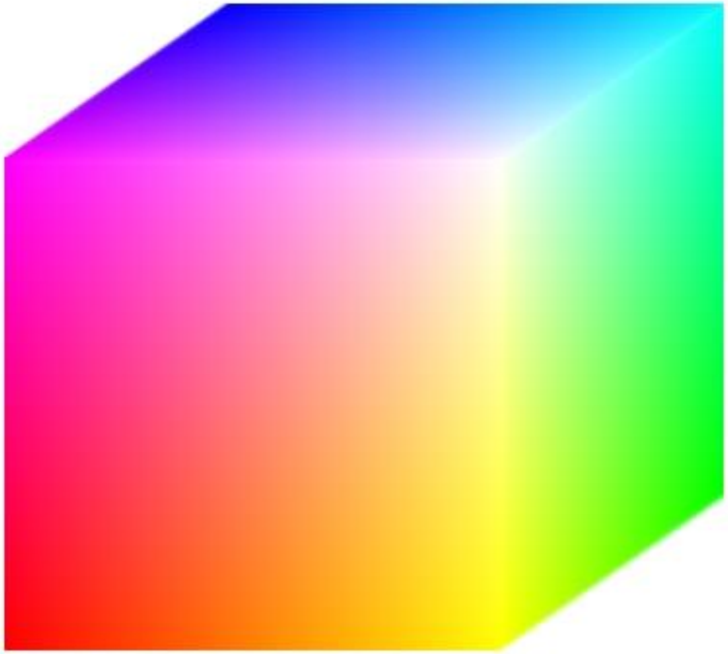
- Description of a co-ordinate system
- Each color represented by a single point.
- Two model:
  - **Hardware** oriented and
  - **Application** oriented.

Hardware Oriented Color Model

- ✓ **RGB** (Red, Green, Blue) model for color monitor
- ✓ **CMY** (Cyan, Magenta, Yellow) for video cameras
- ✓ **CMYK** (Cyan, Magenta, Yellow and Black) for color printer

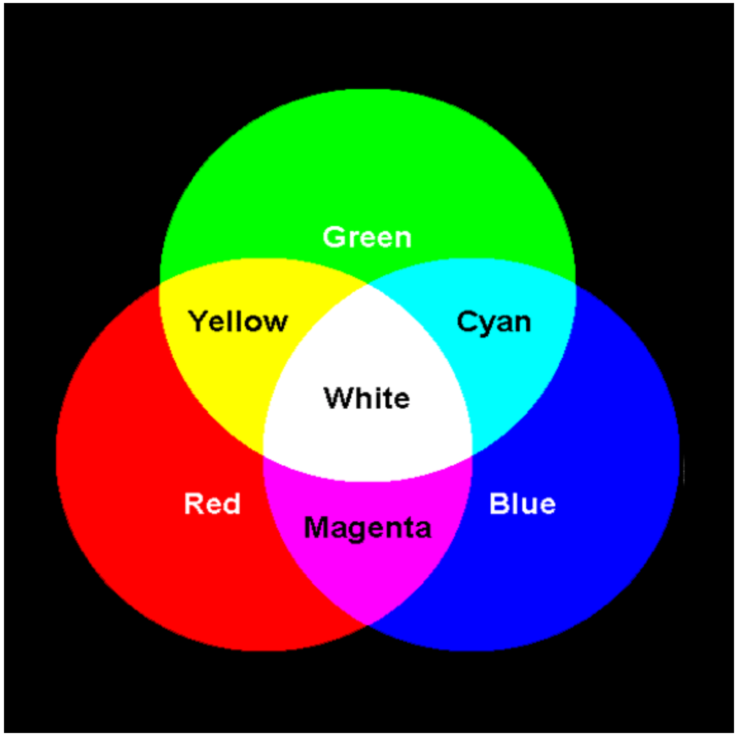
RGB Color Model





References: http://archives.sensorsmag.com/articles/0498/sum0498/
And http://www.cs.ru.nl/~ths/rt2/col/h2/2fundENG.html

Additive RGB Colors



CMY, Subtractive RGB Colors

- Secondary colors, three color: Cyan, Magenta, Yellow

- Consider the method of subtractive color

- Similar to RGB but
  - ✓ white is at the origin
  - ✓ but black is at the extent of the diagonal

CMY Color Model

- Used in color printers.

$$\begin{bmatrix} C \\ M \\ Y \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} - \begin{bmatrix} R \\ G \\ B \end{bmatrix}$$

CMYK Color Model

- Equal amount of colors primaries (i.e. cyan, magenta and yellow) will produce black.
- But for printing, combination of these colors produces a muddy-looking black.
- Therefore, forth color, black is added.