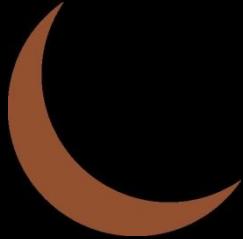


Illumination Model

**Dr. Sk. Mohammad Masudul Ahsan
&
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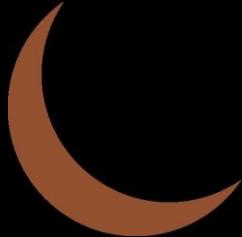




What You'll See Today

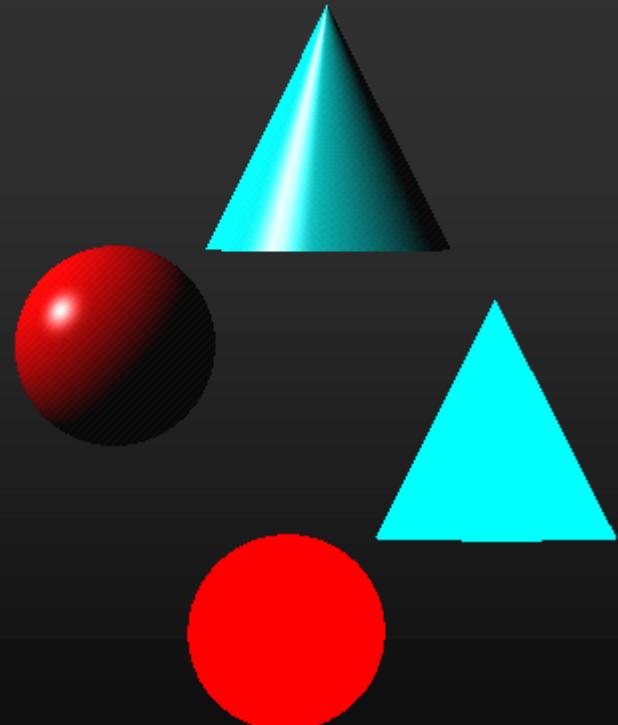
- Lighting Principles
- Illumination Model
- Ambient
- Diffuse
- Specular
- Shading

Lighting Principles

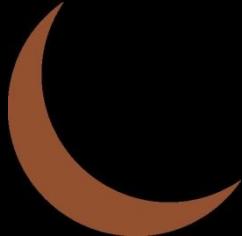


Lighting simulates how objects reflect light

- material composition of object
- light's color and position
- global lighting parameters
 - ambient light
 - two sided lighting
- available in both color index and RGBA mode

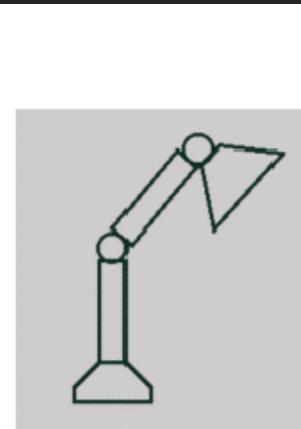
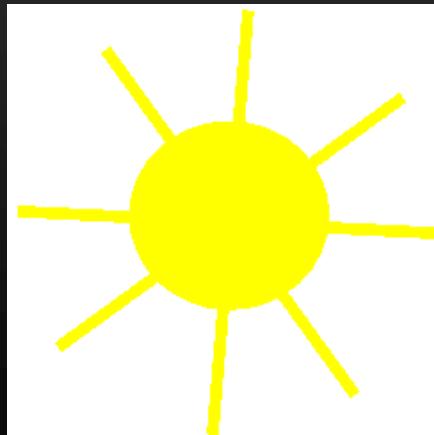


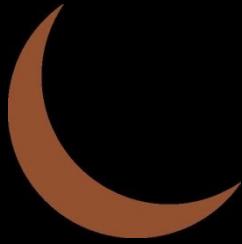
Light Source Model



Simple Mathematical Models:

- Point light
- Directional light
- Spot light

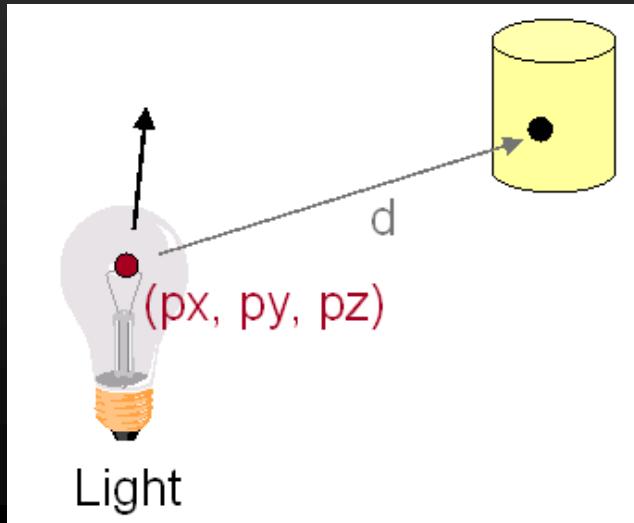




Point Light Source

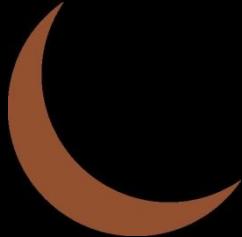
Models Omni-Directional Point Source (E.g., Bulb)

- Intensity (I_0)
- Position (px, py, pz)
- Factors (k_c, k_l, k_q) for attenuation with distance (d)



$$I_L = \frac{I_0}{k_c + k_l d + k_q d^2}$$

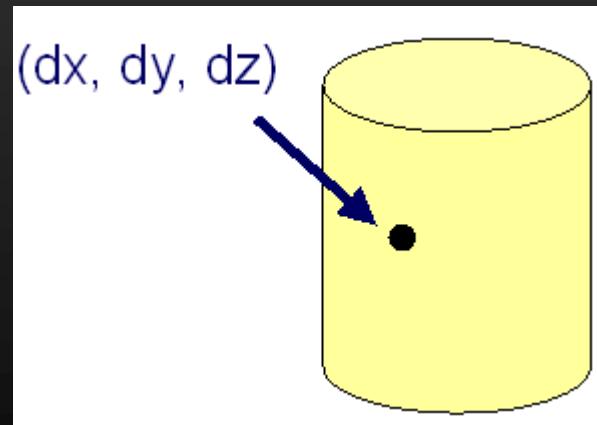
Directional Light Source



Models Point Light Source at Infinity (E.g., Sun)

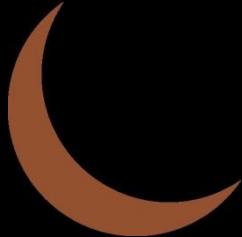
- Intensity (I_0)
- Direction (dx, dy, dz)

No attenuation
with distance



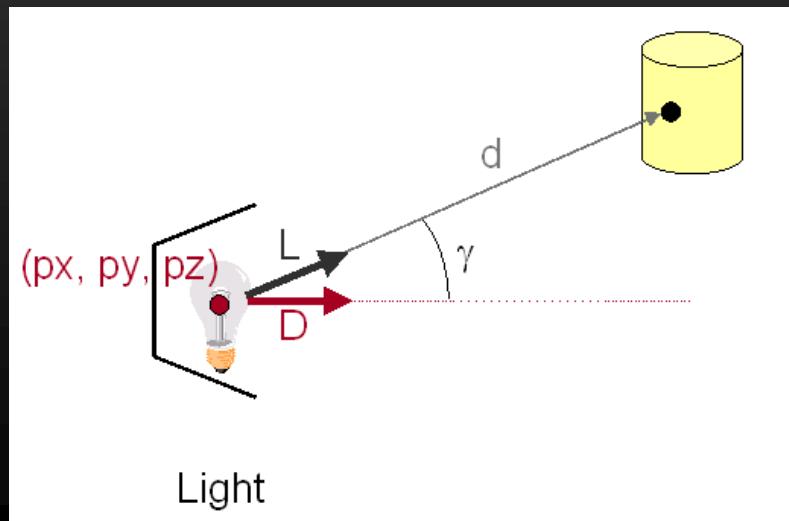
$$I_L = I_0$$

Spot Light Source



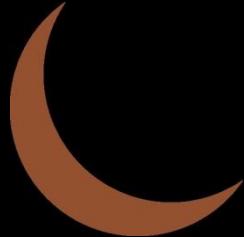
Models Point Light Source with Direction (E.g., Luxo)

- Intensity (I_0)
- Position (p_x, p_y, p_z)
- Direction (d_x, d_y, d_z)
- Attenuation



$$I_L = \frac{I_0(D \cdot L)}{k_c + k_l d + k_q d^2}$$

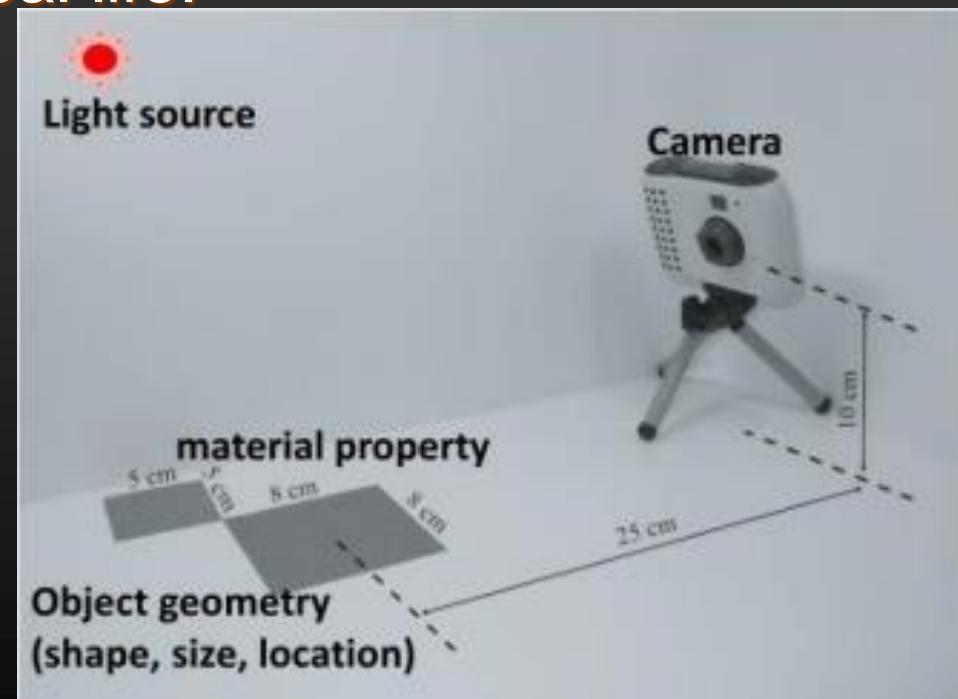
Illumination Model



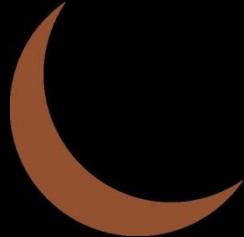
- How to compute color to represent a scene
- As in taking a photo in real life:

- Camera
- Lighting
- Object
 - Geometry
 - Material

- Illumination model:
 - Combine all to produce a color Light source



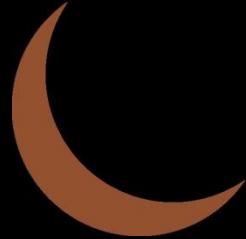
Illumination Model



- An object is illuminated from ambient light and from interrelated light source.
- The important components are:
 - Ambient Light
 - Diffuse Refection
 - Specular Reflection

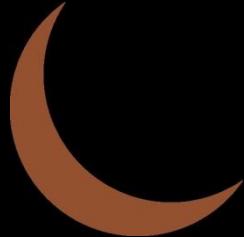
Global Illumination = Ambient Light + Diffuse Light + Specular Light + Emissive Light

Ambient Light



- Also called background light
- General level of illumination that does not come directly from a light source
- Consists of light that has been reflected and re-reflected so many times
- When ambient light strikes a surface, it's scattered equally in all directions.
- Its direction is impossible to determine

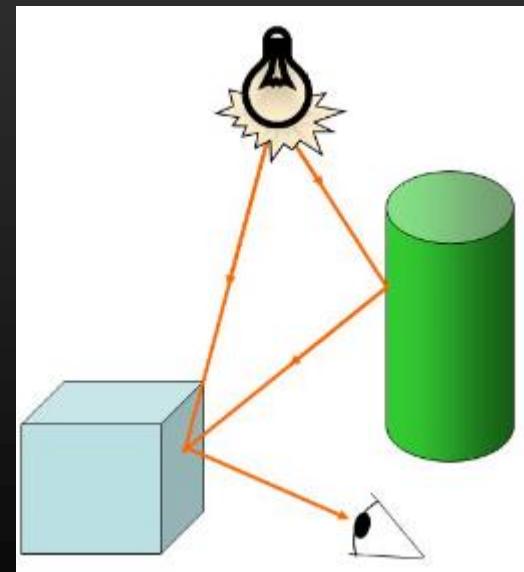
Ambient Light

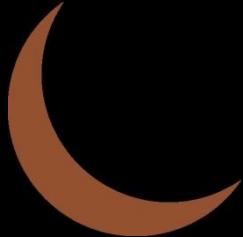


Light from environment

- Light reflected or scattered from other objects
- Coming uniformly from all directions and then reflected equally to all directions.

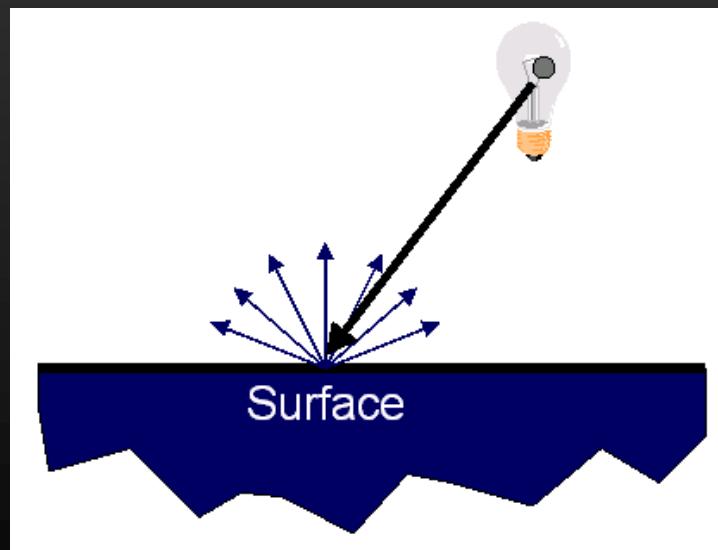
$$I_A = K_A I_{AL}$$



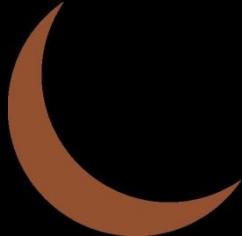


Diffuse Reflection

- Light that comes from one direction
- Light scattered with equal intensity in all directions (ideal diffuse reflection)

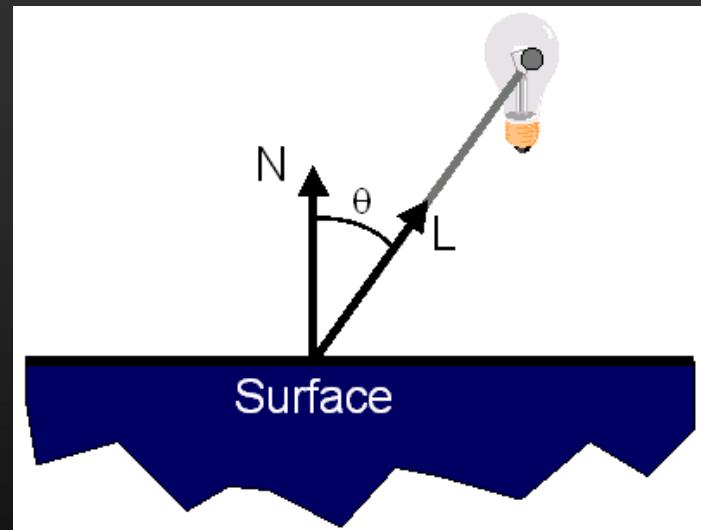


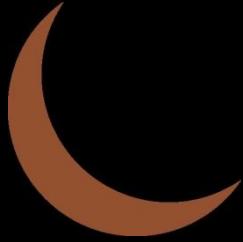
Diffuse Reflection



- How Much Light is Reflected?
 - Depends on angle of incident light

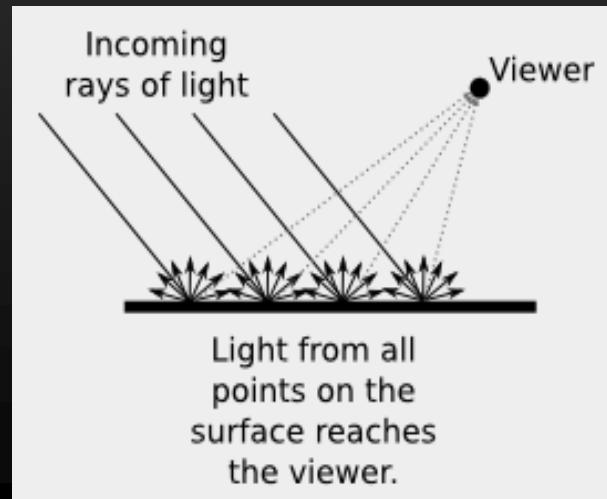
$$I_D = K_D (\mathbf{N} \cdot \mathbf{L}) I_L$$

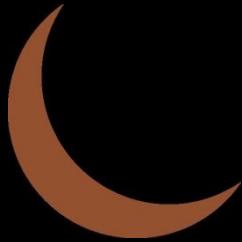




Diffuse Reflection

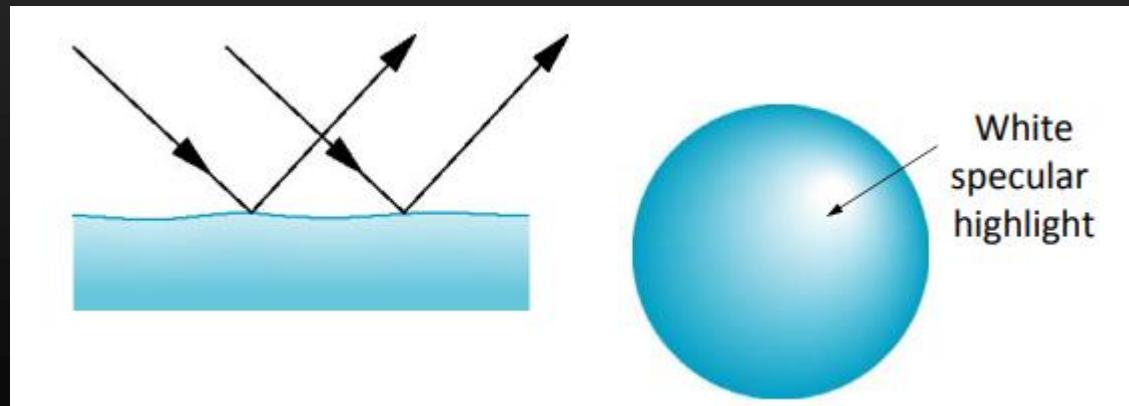
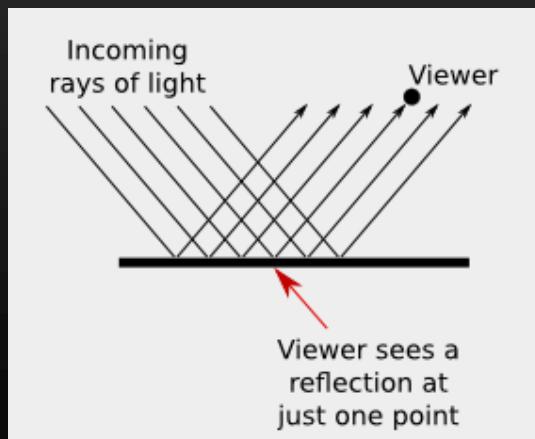
- Light from a point is independent on viewing direction (equally bright in all directions)
- Once it hits a surface, however, it's scattered equally in all directions, so it appears equally bright, no matter where the eye is located.



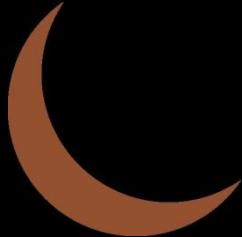


Specular Reflection

- Light comes from a particular direction, and it tends to bounce off the surface in a preferred direction.
- Depends on angle of incident light and angle to viewer
- Intensity depends on where the viewer is!

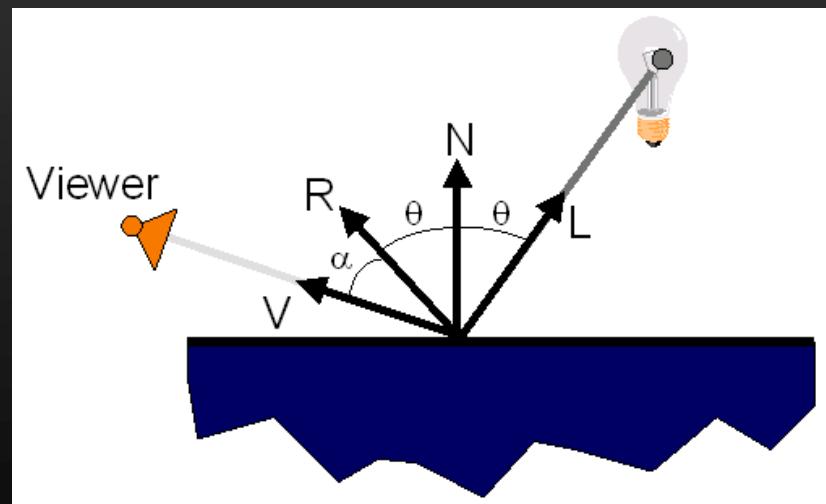


Specular Reflection

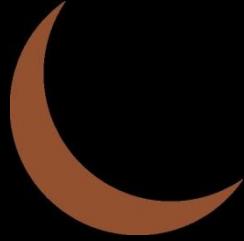


- How Much Light is Reflected?
 - Depends on angle of incident light and angle to viewer

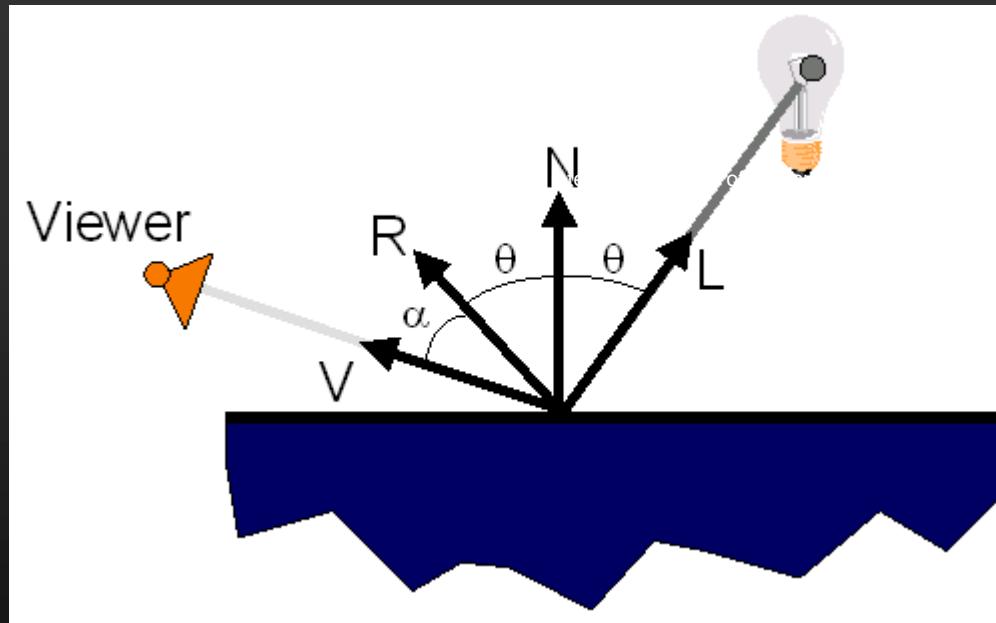
$$I_S = K_S (\mathbf{V} \cdot \mathbf{R})^n I_L$$



Surface Illumination Calculation

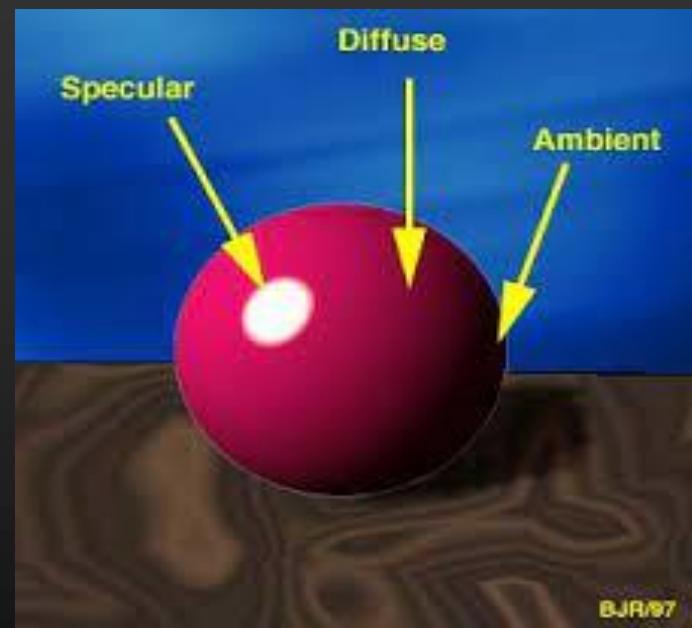
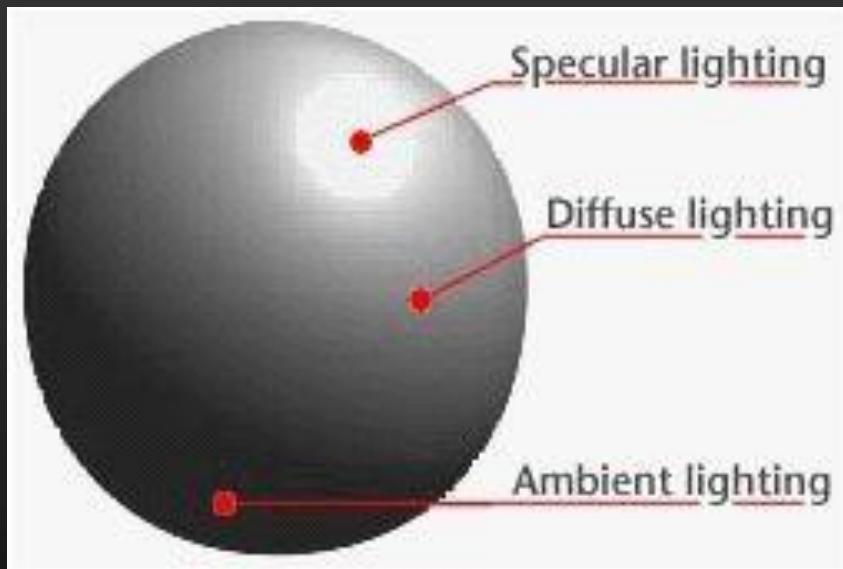
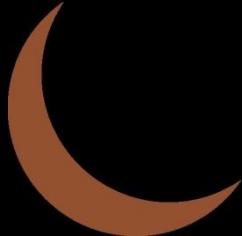


- Single Light Source:



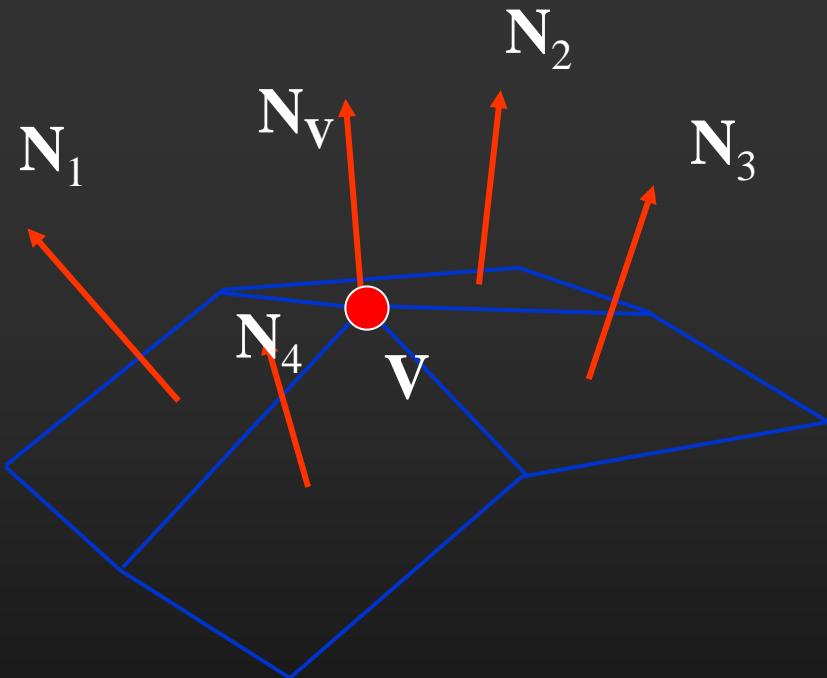
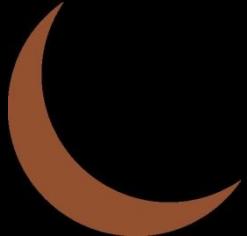
$$I = I_E + K_A I_{AL} + K_D (N \cdot L) I_L + K_S (V \cdot R)^n I_L$$

At a glance



BJR/97

Gouraud Surface Rendering (cont...)



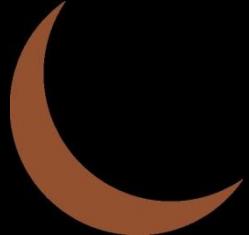
- The average unit normal vector at V is given as:

$$N_v = \frac{N_1 + N_2 + N_3 + N_4}{|N_1 + N_2 + N_3 + N_4|}$$

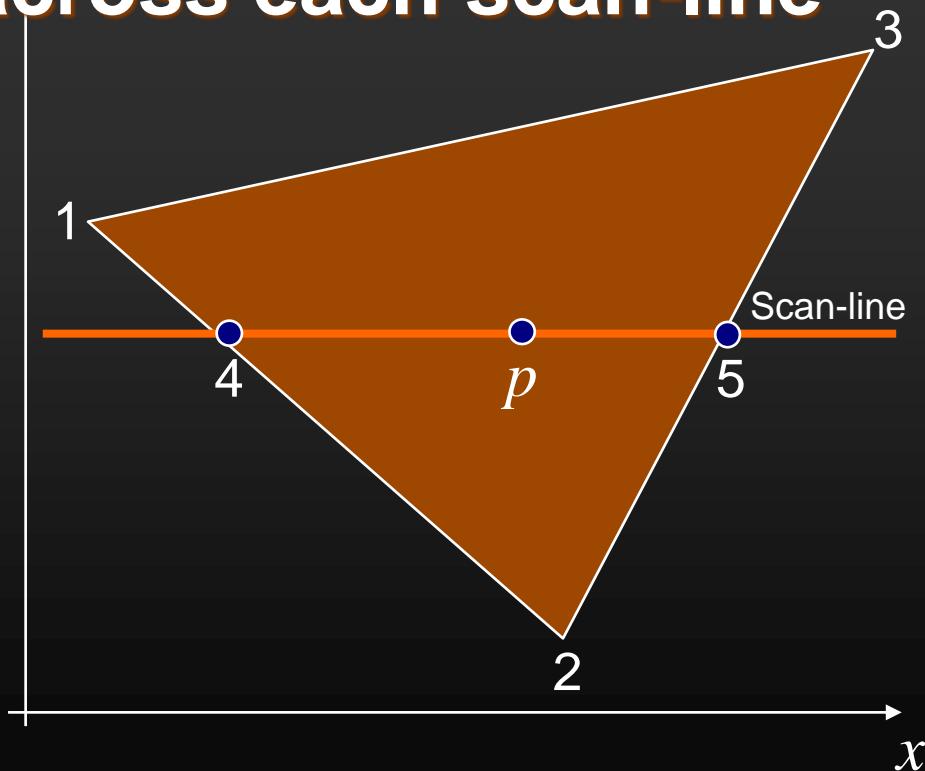
- or more generally:

$$N_v = \frac{\sum_{i=1}^n N_i}{\left| \sum_{i=1}^n N_i \right|}$$

Gouraud Surface Rendering (cont...)



- Illumination values are linearly interpolated across each scan-line

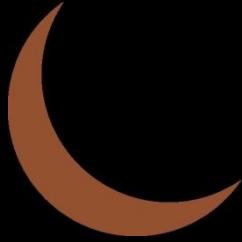


$$I_4 = \frac{y_4 - y_2}{y_1 - y_2} I_1 + \frac{y_1 - y_4}{y_1 - y_2} I_2$$

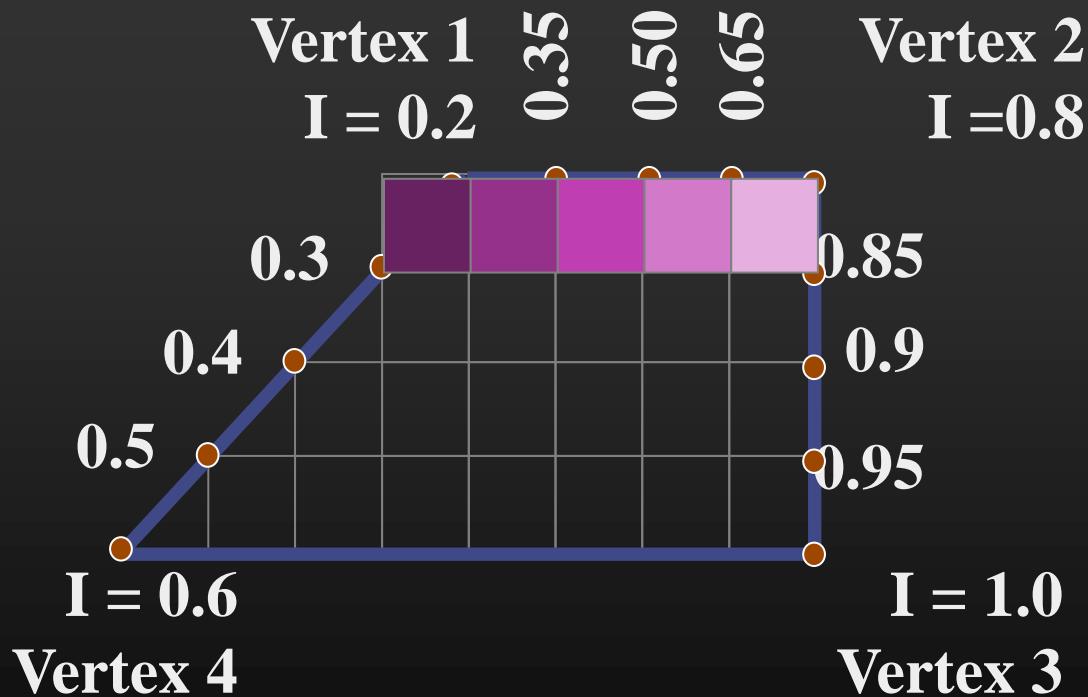
$$I_5 = \frac{y_5 - y_2}{y_3 - y_2} I_3 + \frac{y_3 - y_5}{y_3 - y_2} I_2$$

$$I_p = \frac{x_5 - x_p}{x_5 - x_4} I_4 + \frac{x_p - x_4}{x_5 - x_4} I_5$$

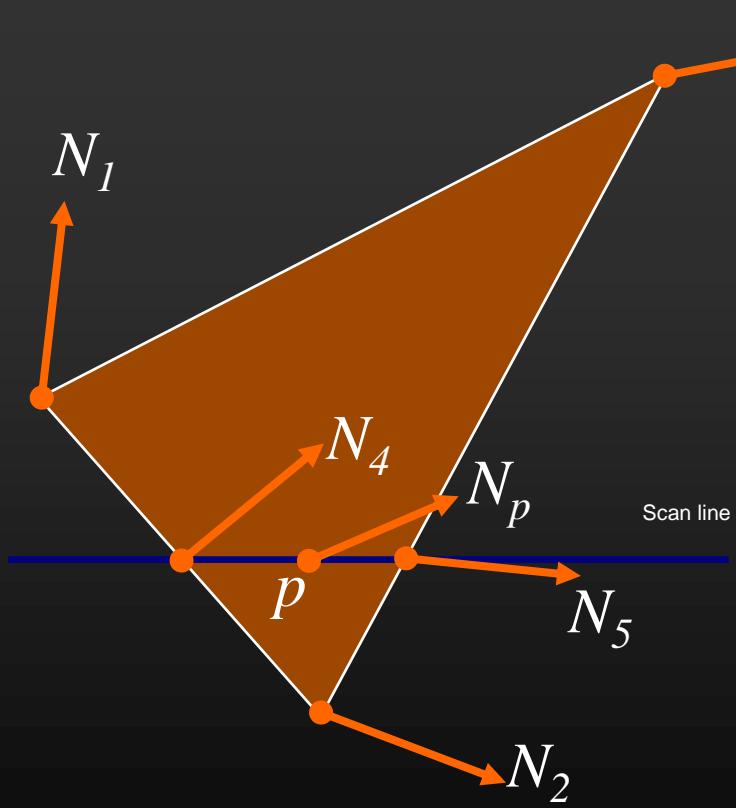
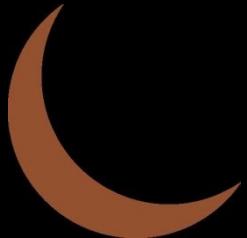
Gouraud Shading



An Example



Phong Surface Rendering (cont...)

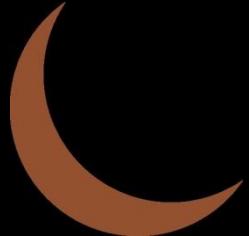


$$N_4 = \frac{y_4 - y_2}{y_1 - y_2} N_1 + \frac{y_1 - y_4}{y_1 - y_2} N_2$$

$$N_5 = \frac{y_5 - y_2}{y_3 - y_2} N_3 + \frac{y_3 - y_5}{y_3 - y_2} N_2$$

$$N_p = \frac{y_p - y_5}{y_4 - y_5} N_4 + \frac{y_4 - y_p}{y_4 - y_5} N_5$$

Gouraud Vs Phong Surface Rendering

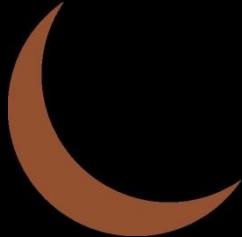


Gouraud Surface Rendering



Phong Surface Rendering

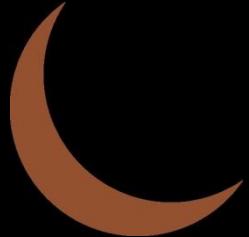
Assignment (B1)



1. Implement lighting on your previous assignment.
2. Your scene should have point light, directional light spot light and emissive light.
3. Use keys 1 to turn on and off directional light, 2 to turn on and off point light, 3 to turn on and off spot light respectively.
4. Use keys 4 to turn on and off ambient light, 5 to turn on and off diffuse light, 6 to turn on and off specular light of the light sources.



REFERENCES



- Anonymously Collected