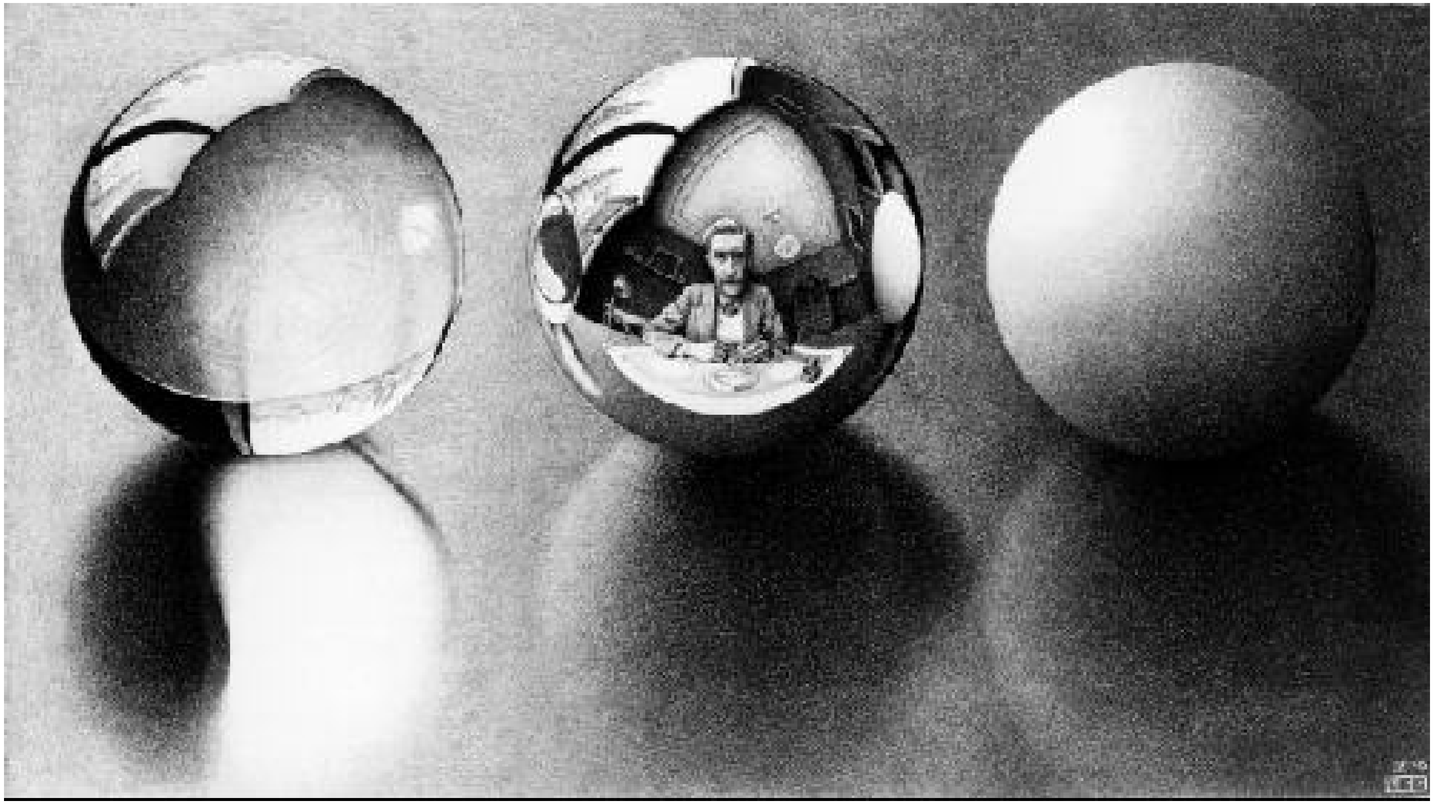
Shadows and Transparency

Foley & Van Dam, Chapter 16

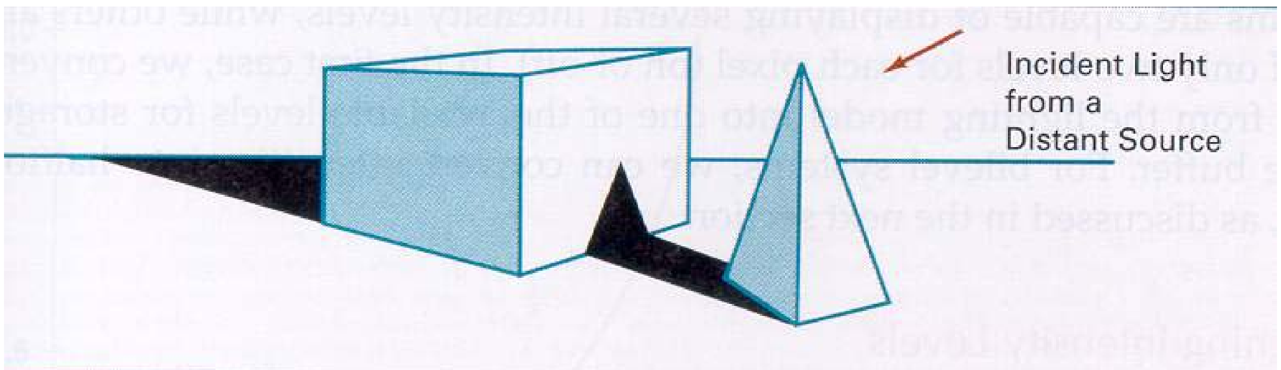


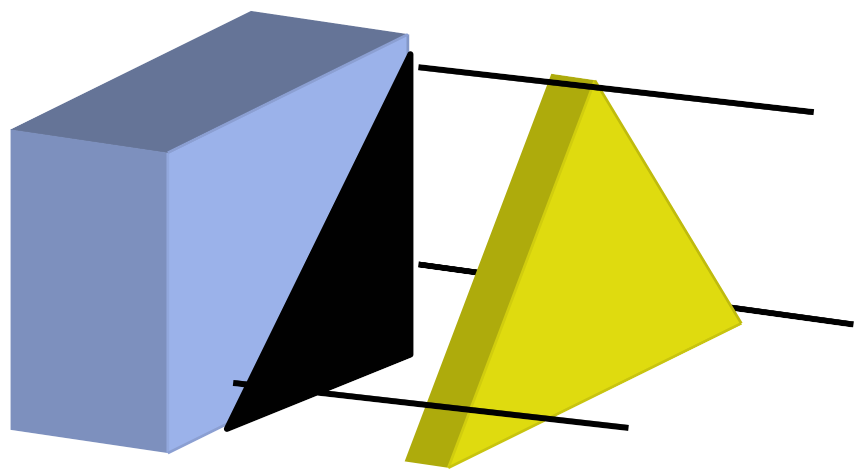
Shadows and Transparency

- Shadows
  - Object and Image Precision Algorithms
  - Two-Pass z-Buffer Shadow Algorithm
- Transparency
  - Nonrefractive Transparency
  - Refractive Transparency

Shadows

- A shadow covers surfaces that are not “visible” by the light source while being visible by the viewer





Shadows

- **Intuition:** hidden surface detection and shadow generation are in practice the same problem
- Illumination equation for *m* sources, and including attenuation and shadows:

$$I = I_a K_a + \sum_{1 \le i \le m} S_i f_{att_i} I_p \left(K_d \left(\bar{N} \cdot \bar{L} \right) + K_s \left(\bar{R} \cdot \bar{V} \right)^n \right)$$

where

$$S_i = \begin{cases} 0, & \text{if light } i \text{ is blocked at this point;} \\ 1, & \text{otherwise} \end{cases}$$

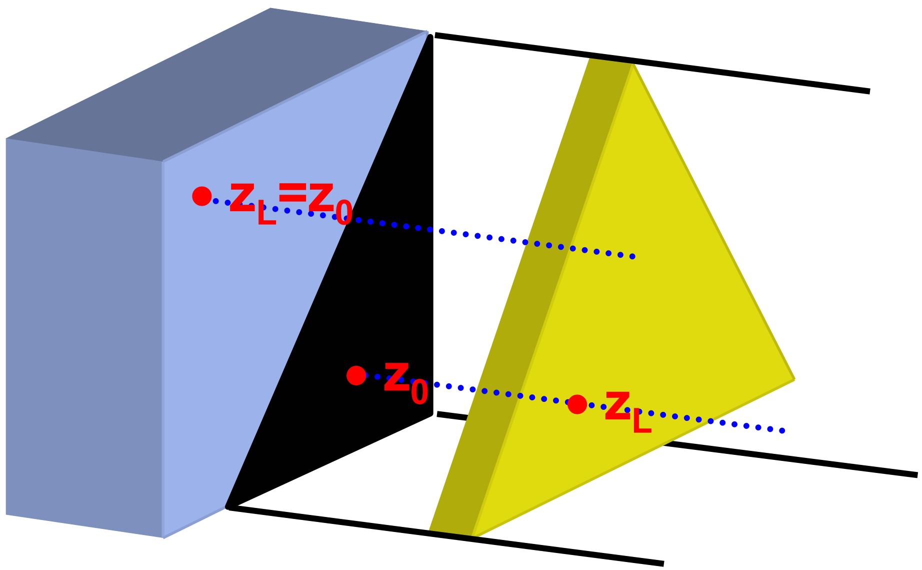
- **Observation:** ambient light is not affected by shadows and attenuation

Shadows and Transparency

- **Problem:** to compute for each point and for each light source, the function S_i in illumination equation
- As in the case of hidden surface detection, shadow algorithms can be object or image precision
- A hidden surface detection algorithm can be easily adapted to shadows calculation

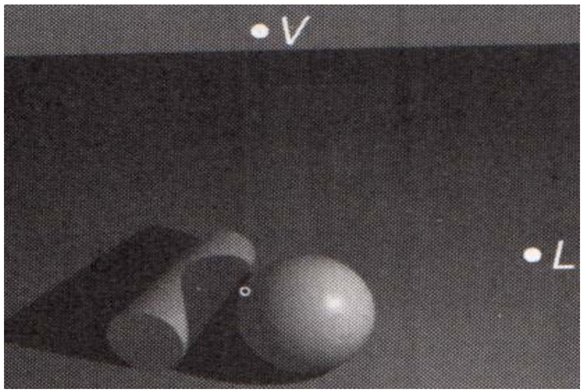
Z-Buffer Shadow Generation

- **Algorithm:**
  - Render the scene from the light source “view point” and save the *Z* depth z_L
  - Render the scene again from the observer view point and save the *Z* depth z_0
  - Transform each pixel into light source coordinates and compare the *Z* values z_L and z_0
  - If z_L is closer to the light than z_0, than there is something blocking the light and the pixel is shaded (S_i=0). Otherwise the pixel is illuminated (S_i=1)

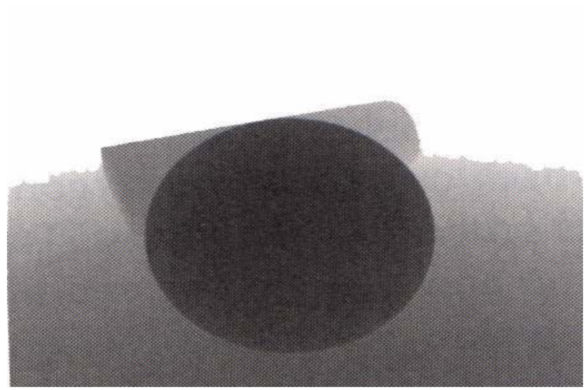


Z-Buffer Shadows Generation

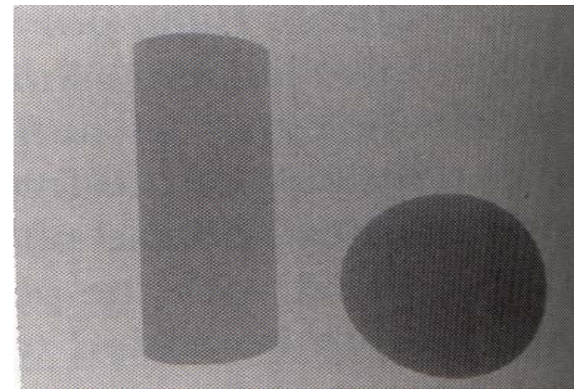
- **Example:**



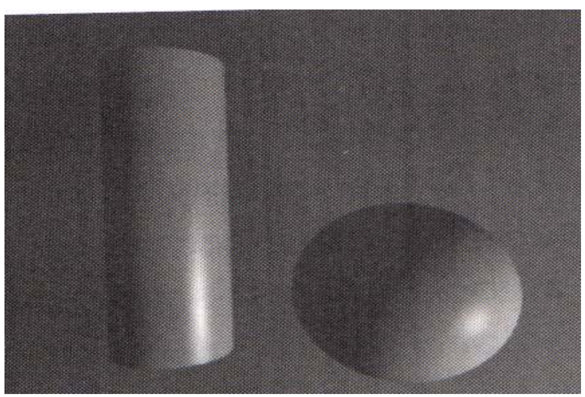
Overview



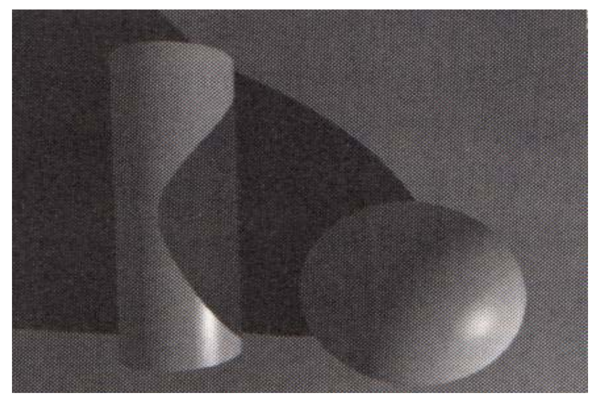
Light's Z-buffer



Observer's Z-buffer



Observer's Image



With shadows

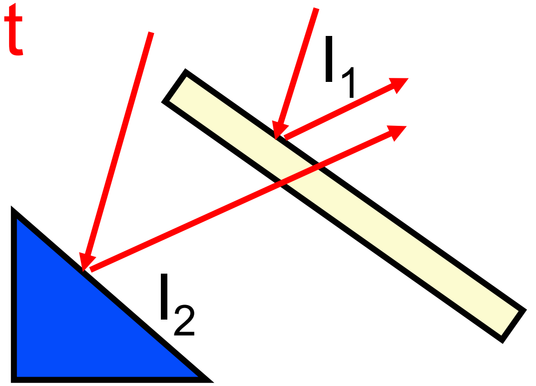
Transparency

- A transparent surface produces both, reflected and transmitted light
- The relative contribution of transmitted light depends on the degree of transparency of the surface

$$\boxed{I = (1-K_1)\, I_1 + K_1\, I_2}$$

K_1 is the transmission coefficient

- $K_1 = 0$ for an opaque surface
- $K_1 = 1$ if the surface is completely transparent



Nonrefractive Transparency

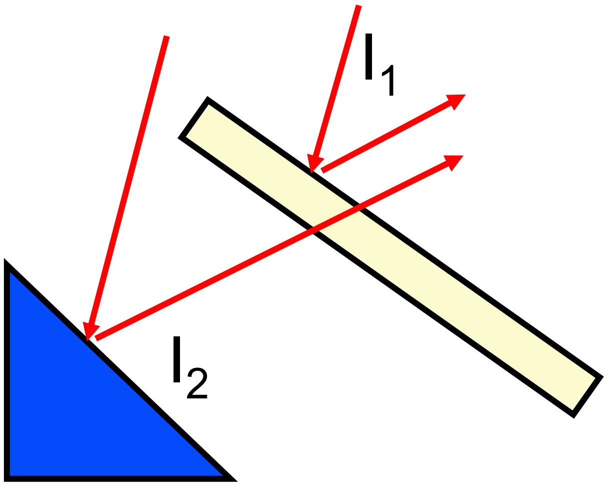
- **Interpolated transparency**

$$\boxed{I = (1-K_1)\, I_1 + K_1\, I_2}$$

K_1 is the transmission coefficient of surface 1

- **Filtered transparency**

$$\boxed{I = I_1 + K_{1\lambda}\, I_2}$$



$K_{1\lambda}$ is the transparency color of surface 1. Depends on wavelength λ

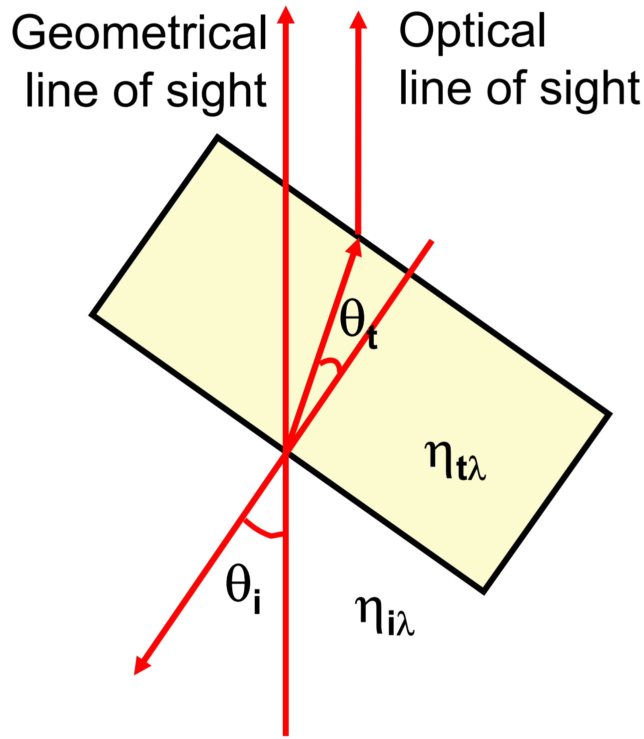
RefractiveTransparency

- Geometrical and optical lines of sight are **different**
- Harder to model than nonrefractive transparency

- Refraction angle depends on both material and wavelength

- Snell's Law: $$\frac{\sin\theta_i}{\sin\theta_t} = \frac{\eta_{t\lambda}}{\eta_{i\lambda}}$$

where $\eta_{i\lambda}$ and $\eta_{t\lambda}$ are the refraction indices of the materials for the wavelength λ



Transparency

- **Example:**