

CS348B: Image Synthesis

Goal: How to generate realistic images?

Applications

- **Movies**
- **Interactive entertainment**
- **Industrial design**
- **Architecture**
- **Showcase products**
- **Cultural heritage**
- **Holy Grail: Virtual reality**



Final Fantasy

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Modeling & Simulating Appearance

Models

- **Light and color**
- **Light sources**
- **Shapes**
- **Materials**
 - **Interfaces: Reflection and texture models**
 - **Medium: Atmospheric scattering models**
- **Cameras**
 - **Lens and film**

Simulation

- **Illumination**

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History: Geometric Aspects First

Transformation/clipping and the graphics pipeline

- **Evans and Sutherland**

Hidden line and surface algorithms

- **Sutherland, Sproull, Shumacker**

History: Simple Shading

Simple shading and texturing

- **Gouraud** \Rightarrow interpolating colors
- **Phong** \Rightarrow interpolating normals
- **Blinn, Catmull, Williams** \Rightarrow texturing

History: Optical Aspects Second

Reflection and texture models

- Cook and Torrance \Rightarrow BRDF
- Perlin \Rightarrow Procedural textures
- Cook, Perlin \Rightarrow Shading languages

Illumination algorithms

- Whitted \Rightarrow Ray tracing
- Cohen, Goral, Wallace, Greenberg, Torrance
Nishita, Nakamae \Rightarrow Radiosity
- Kajiya \Rightarrow Rendering equation

Lighting

Lighting Simulation

The Rendering Equation

Given a scene consisting of geometric primitives with material properties and a set of light sources, compute the illumination at each point on each surface

Challenges

- Primitives complex: lights, materials, shapes
- Infinite number of light paths

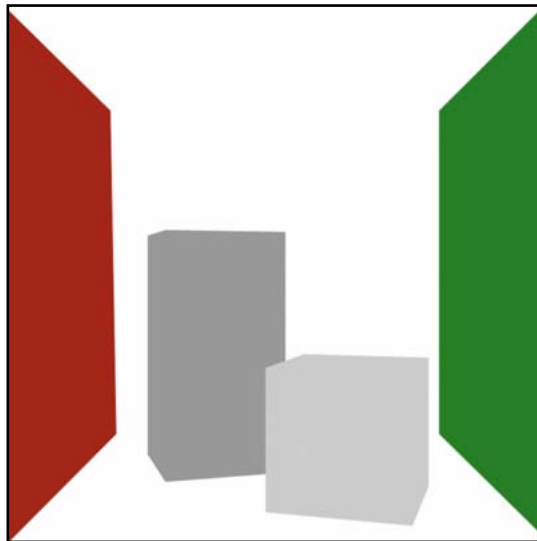
How to solve it?

- Radiosity \Rightarrow Finite element
- Ray tracing \Rightarrow Monte Carlo

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Lighting Example: Cornell Box

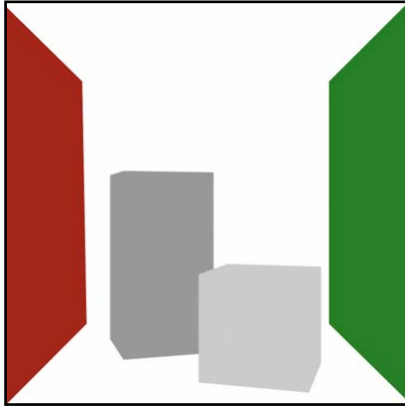


Surface Color

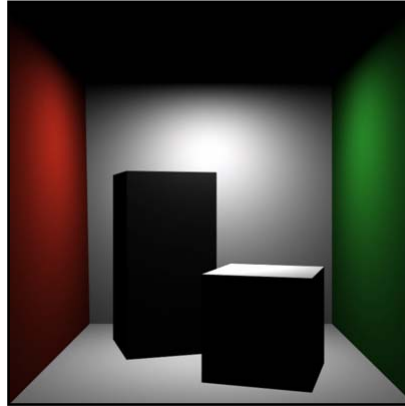
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Lighting Example: Diffuse Reflection



Surface Color

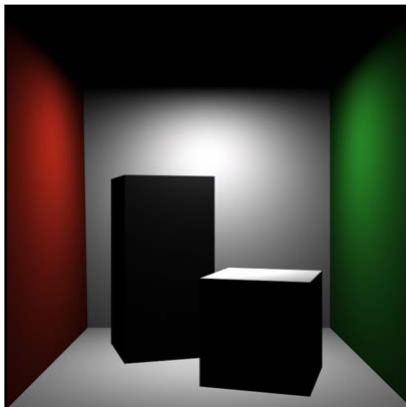


Diffuse Shading

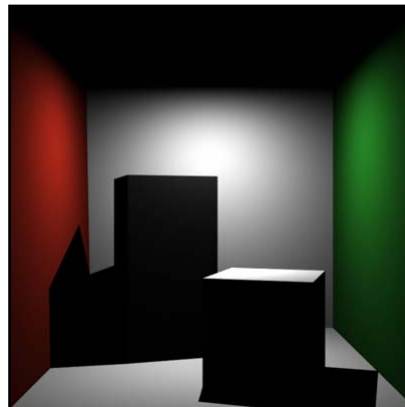
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Lighting Example: Shadows



No Shadows

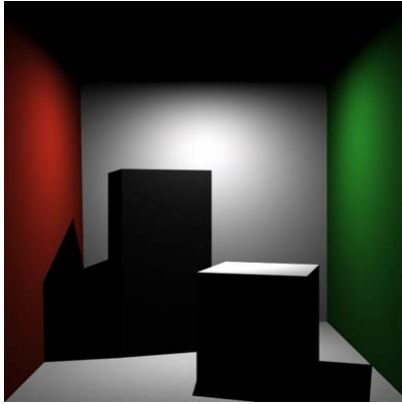


Shadows

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Lighting Example: Soft Shadows



Hard Shadows
Point Light Source

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Soft Shadows
Area Light Source

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Radiosity: Indirect Illumination



Program of Computer Graphics
Cornell University

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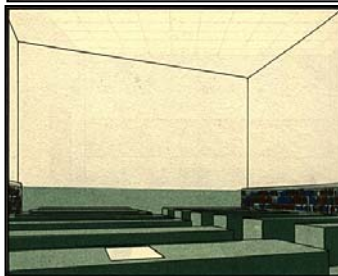
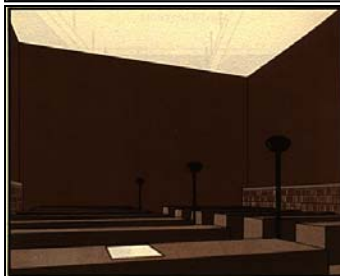
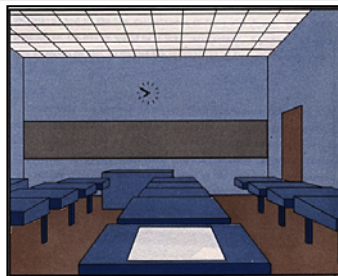
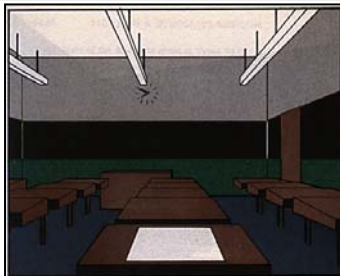
Early Radiosity



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Early, Early Radiosity



Parry Moon and Domina Spencer (MIT), *Lighting Design*, 1948

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Early Diffuse+Glossy

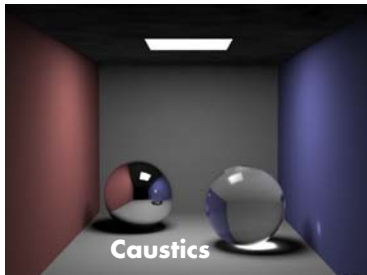
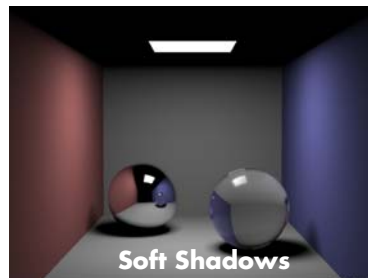


Tribute to Vermeer
Program of Computer Graphics, Cornell

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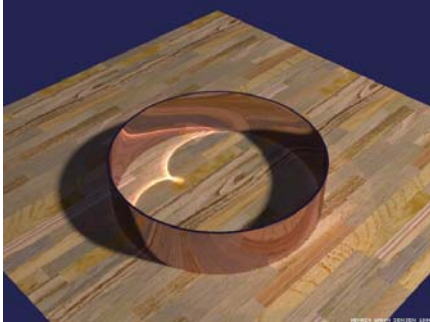
Lighting Effects: Glossy Materials



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Caustics



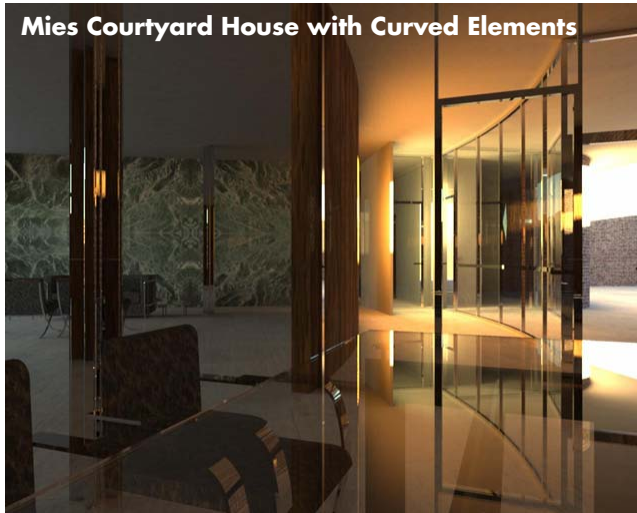
Jensen 1995

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Complex Indirect Illumination

Mies Courtyard House with Curved Elements



Modeling: Stephen Duck; Rendering: Henrik Wann Jensen

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Radiosity: "Turing Test"



Measured



Simulated

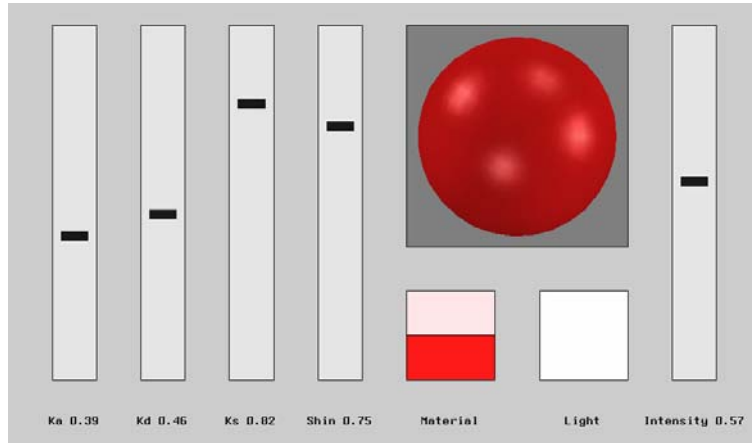
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Materials

Classic Computer Graphics Model

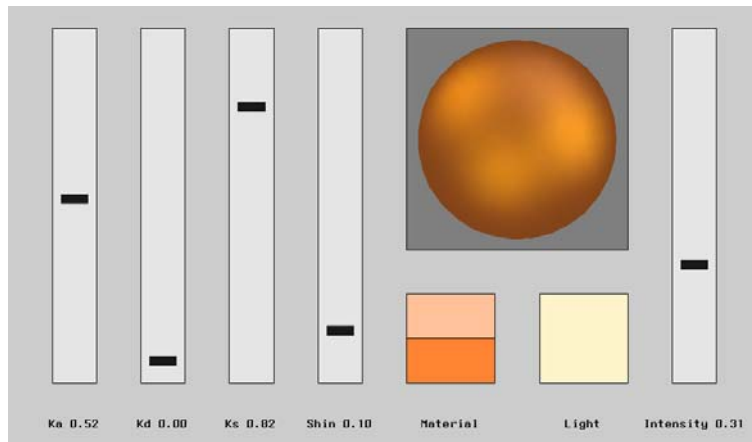


Plastic

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Classic Computer Graphics Model



Brushed Copper

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Material Taxonomy

RenderMan



Plastic
Shiny Plastic



Rough Metal
Shiny Metal



Matte

From Apodaca and Gritz, *Advanced RenderMan*

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Shadows on Rough Surfaces



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Translucency



Surface Reflection

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Subsurface Reflection

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Water Flows on the Venus



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Patinas



A Sense of Time

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Virtual Actors: Faces



Square USA
The digital heroine of the Final Fantasy film.



**Final Fantasy
SquareUSA**

**Jensen,
Marschner,
Levoy,
Hanrahan**

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Virtual Actors: Hair



Black



Brown

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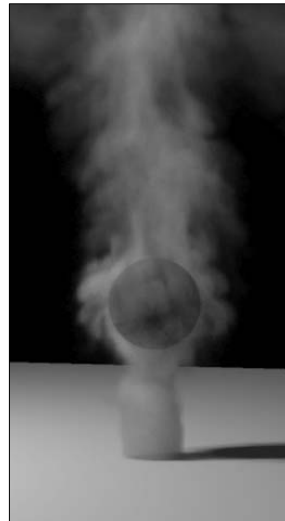
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Coupling Modeling & Rendering



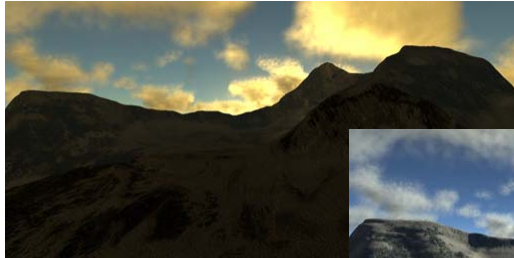
Fedkiw, Stam, Jensen 2001

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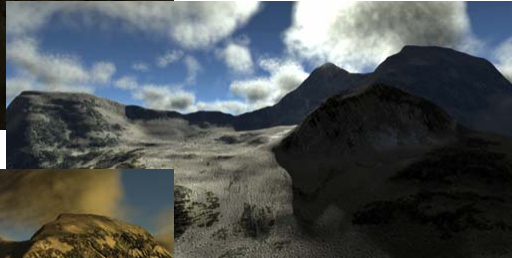
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Clouds and Atmospheric Phenomena



**Hogum Mountain
Sunrise and sunset**

7am



**Modeling: 9am
Simon Premoze
William Thompson
Rendering:
Henrik Wann Jensen**

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6:30pm

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The Everyday World ...



Troy Maxwell-Hanrahan

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Interdisciplinary

Computer science

- Computational geometry
- Software engineering

Physics

- Radiometry and light fields
- Bidirectional reflectance distribution function
- Radiative transport

Mathematics

- Integral equations
- Monte Carlo and finite element methods

Perception

Art

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