

IMGD 1001: Illumination

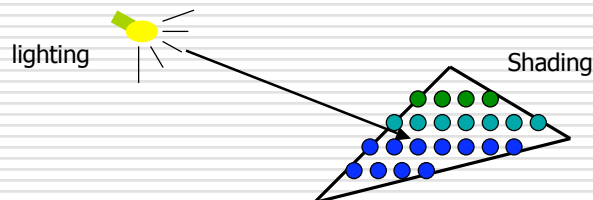
by

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3D Illumination and Shading

- Problem: Model light/surface point interactions to determine final color and brightness
- Actual light computation is too costly!
- Apply the lighting model at a set of points across the entire surface

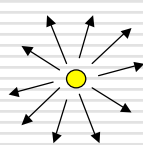


Illumination Model

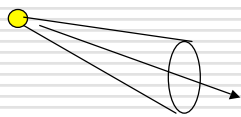
- An illumination model usually considers
 - Light attributes (intensity, color, position, direction, shape)
 - Object surface attributes (color, reflectivity, transparency, etc.)
 - Interaction among lights and objects

Basic Light Sources

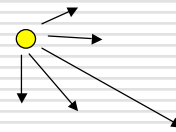
- Light intensity can be independent or dependent of the distance between object and the light source



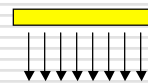
Point light



Spot light



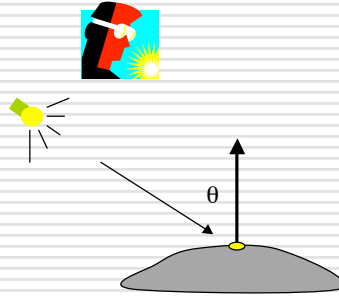
Directional light



Area light

Local Illumination

- Only consider the light, the observer position, and the object material properties

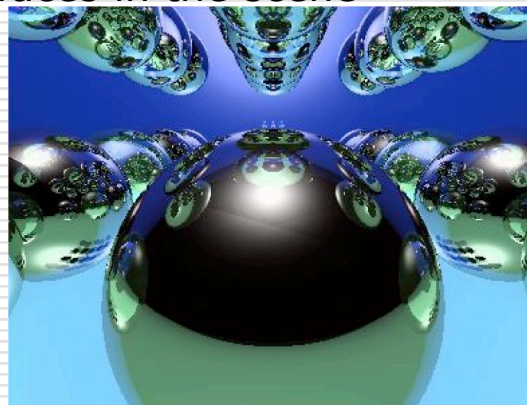
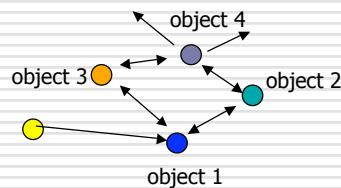


Global Illumination

- Take into account the interaction of light from all the surfaces in the scene

- Example:

- Ray Tracing
- Model light rays bouncing around

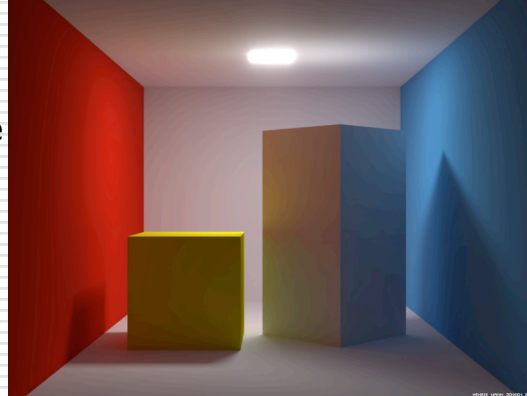


Global Illumination (cont.)

□ Example:

■ Radiosity

- Model *energy* moving from emitters (e.g., lights) into the scene
- View independent



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7

Simple Local Illumination

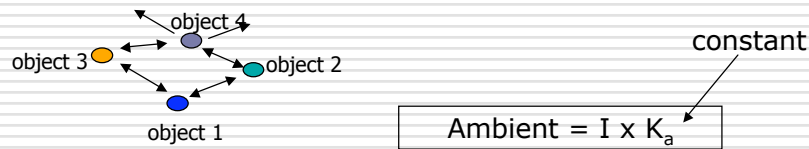
- Reduce the complex workings of light to three components
 - Ambient
 - Diffuse
 - Specular
- Final illumination at a point (vertex) = ambient + diffuse + specular
- Materials reflect each component differently
 - Use different material reflection coefficients
 - K_a , K_d , K_s

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8

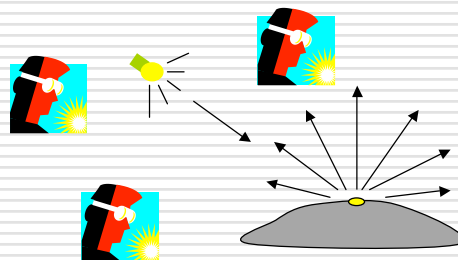
Ambient Light Contribution

- Ambient light = background light
- Light that is scattered by the environment
 - It's just there
- **Frequently assumed to be constant**
- Very simple approximation of global illumination
- No direction: independent of light position, object orientation, observer's position/orientation



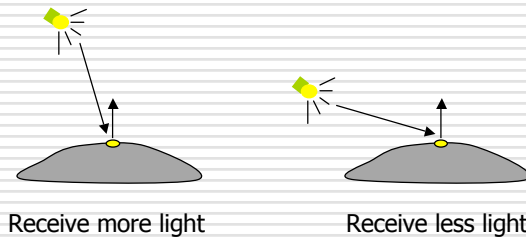
Diffuse Light Contribution

- Diffuse light: The illumination that a surface receives from a light source that reflects equally in all direction
 - Eye point does not matter



Diffuse Light Calculation

- Need to decide how much light the object point receives from the light source
 - Based on **Lambert's Law**



Diffuse Light Calculation (cont.)

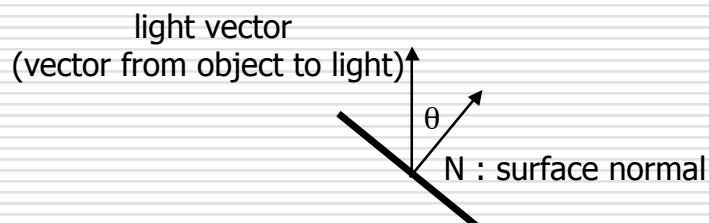
- Lambert's law: the radiant energy D that a small surface patch receives from a light source is:

$$\text{Diffuse} = K_d \times I \times \cos(\theta)$$

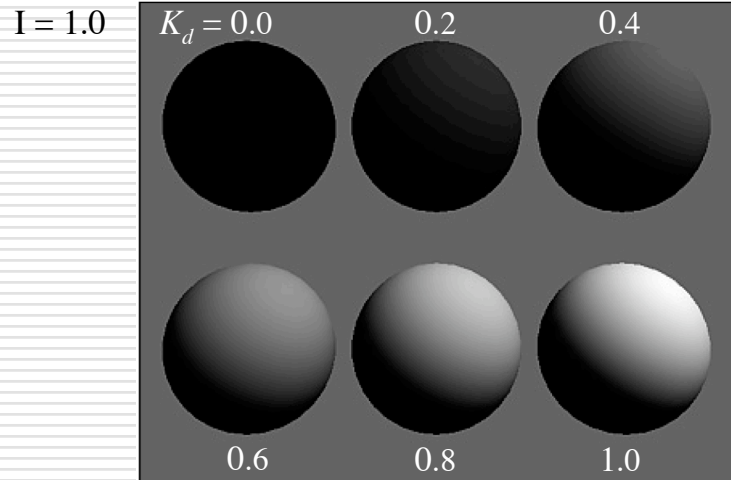
K_d : diffuse reflection coefficient

I : light intensity

θ : angle between the light vector and the surface normal

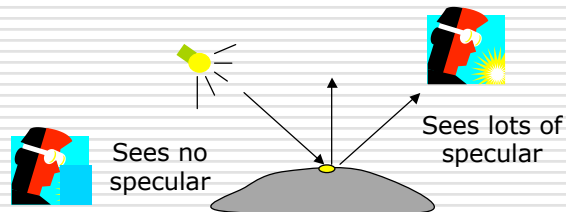


Diffuse Light Examples



Specular Light Contribution

- The bright spot on the object
- The result of total reflection of the incident light in a concentrate region

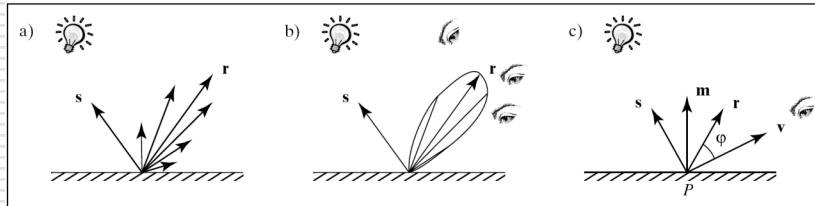


Specular Light Calculation

- How much reflection you can see depends on where you are
 - But for non-perfect surface you will still see specular highlight when you move a little bit away from the ideal reflection direction

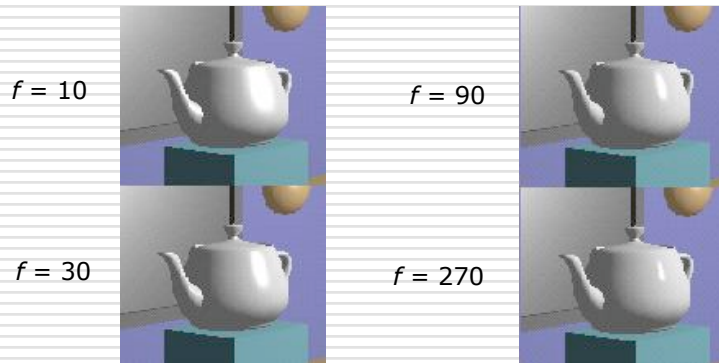
ϕ is deviation of view angle from mirror direction

- When ϕ is small, you see more specular highlight

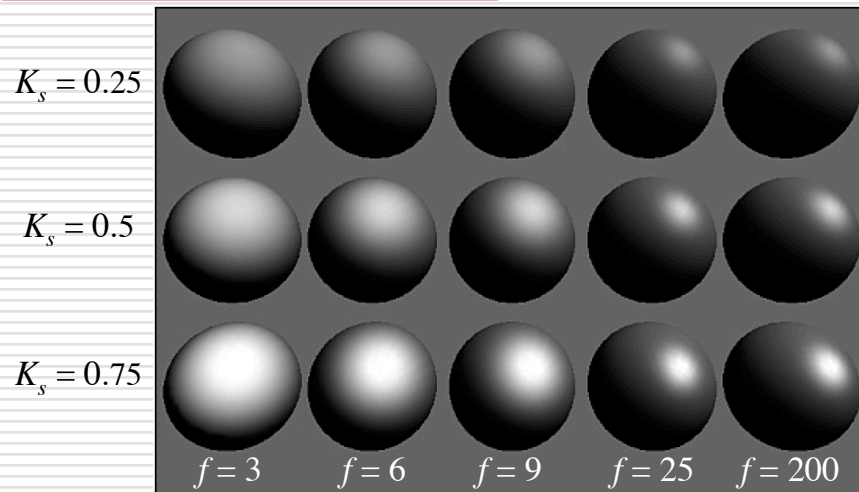


Specular Light Calculation (cont.)

- Phong lighting model
 - Not Phong shading model $\text{Specular} = K_s \times I \times \cos^f(\phi)$
- The effect of 'f' in the Phong model



Specular Light Examples



Putting It All Together

- Illumination from a light

Illum = ambient + diffuse + specular

$$= K_a \times I + K_d \times I \times \cos(\theta) + K_s \times I \times \cos^f(\phi)$$

- If there are N lights

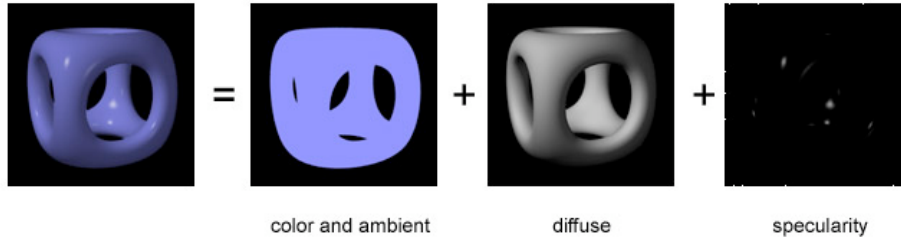
Total illumination for a point P = Σ (Illum)

- Some more terms to be added

- Self emission
- Global ambient
- Light distance attenuation and spot light effect

Putting It All Together (cont.)

□ **Illum = ambient + diffuse + specular**



Ambient Lighting Example



Diffuse Lighting Example



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21

Specular Lighting Example



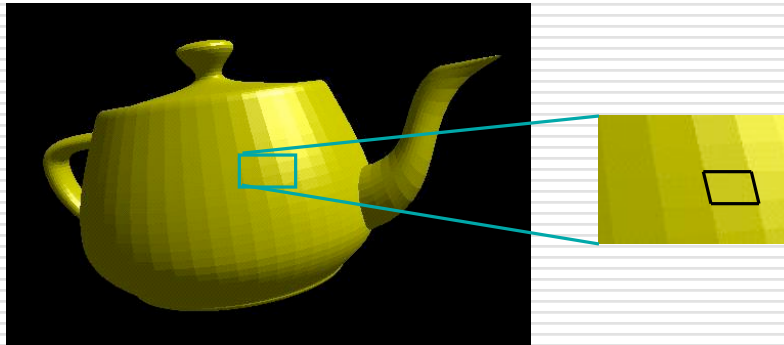
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Polygon Shading Models

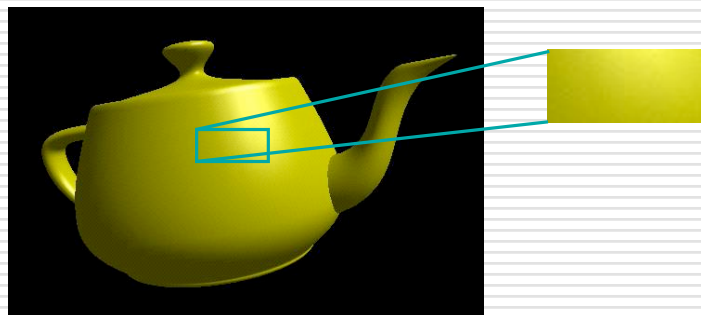
□ Flat shading

- Compute lighting once and assign the color to the whole polygon (or mesh)

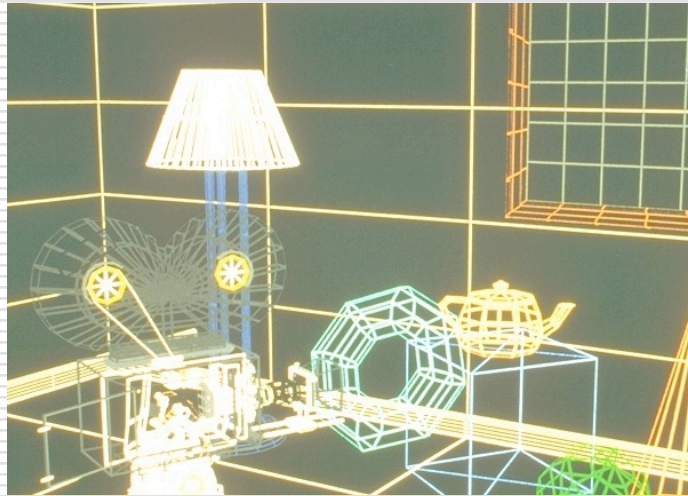


Gouraud Shading

- Lighting is calculated for each of the polygon vertices
- Colors are interpolated for interior pixels



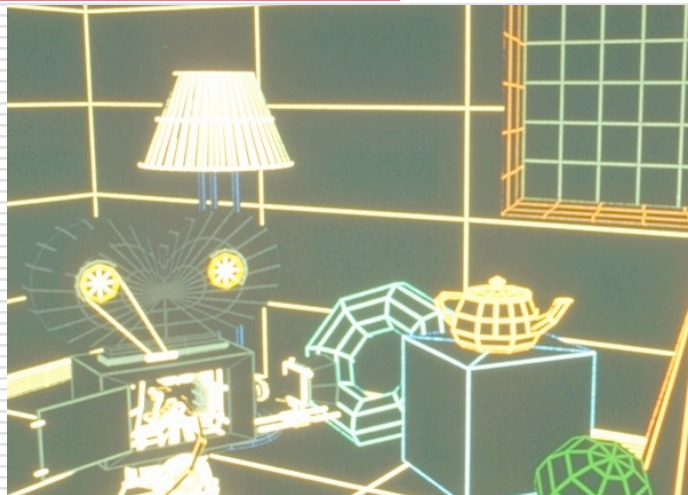
Colored Wireframe



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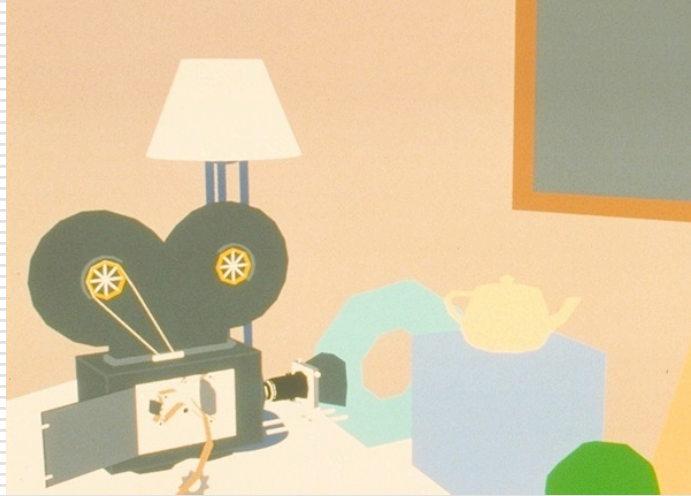
Colored Hidden-Line Removal



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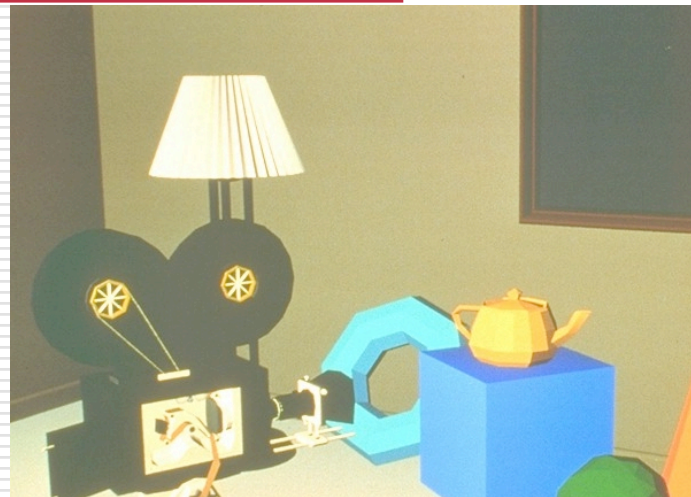
Ambient Term Only



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27

Flat Shading

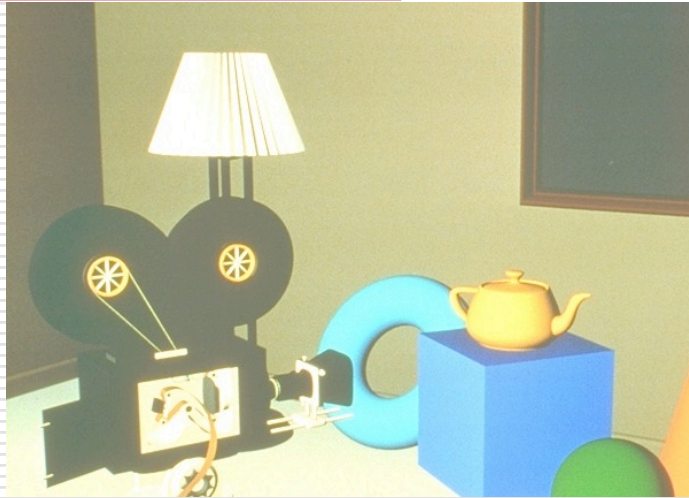


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28

Diffuse Shading + Interp. Normals

WPI

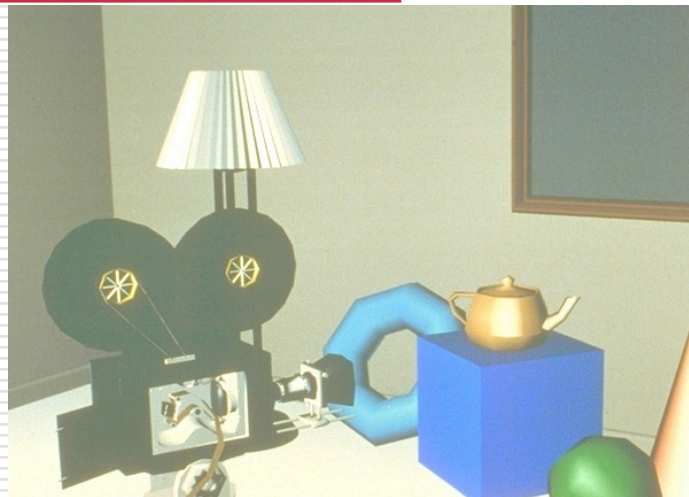


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29

Gouraud Shading

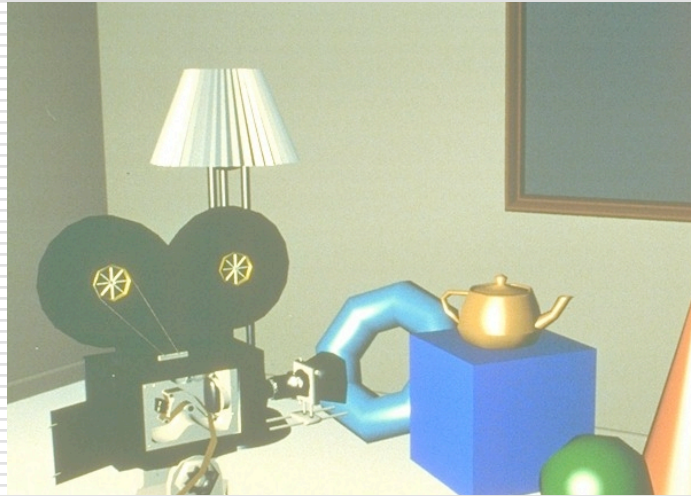
WPI



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30

Ambient + Diffuse + Specular



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Ambient + Diffuse + Specular + Interpolated Normals



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Radiosity



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Texture Mapping



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Texture Mapping + Ray Tracing



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35