Faculty of German Engineering and Industrial Management Education - FDIBA

Introduction to Computer Graphics

Illumination

Assoc. Prof. Stoyan Maleshkov

Technical University of Sofia

Illumination

- Light rays coming from the rest of the scene strike that surface element, and head out in different directions
- We want to calculate the color of the light that goes in the direction of the viewer from that surface element (if the viewer moves, that color will change)
- This is defined as the “illumination” of that surface element

Global Illumination

- Simulating what happens when other objects effect the light reaching a surface element is “global illumination”
- Expensive to Compute
  - there are many other objects in the scene that might affect the light reaching our surface element

Non-Global Illumination

- Concentrate on light from light sources
  - ignore the effects of all other objects in the scene when considering a particular surface element
  - Pro: scene can be rendered much faster
  - Con: pay a price in lost realism; lose interesting effects of light transport

Non-Global Illumination

- We lose effects of global illumination
  - shadows
  - inter-object reflection
  - refraction, i.e. the bending of light at translucent surfaces
  - – volumetric effects of participating media such as air, water, and fog

Simple Illumination Model

- Reflection characteristics of surfaces:
  - Ambient Reflection
  - Diffuse Reflection
  - Specular Reflection

Simple Illumination Model

- This model is **NOT** physically-based, and does **NOT** attempt to accurately calculate global illumination
  - it does attempt to simulate some of the most important observable effects of common light interactions
  - it can be computed quickly and efficiently, so it is still in use today in graphics software and especially in hardware renderers

Ambient reflection

- Independent of object position and viewer position
- Constant
- Exists in most environments
- Some light hits surface from all directions -> an approximation of indirect lighting/global illumination
- A total hack, but images without some form of ambient lighting look stark, they have too much contrast

Ambient reflection

$$I = I_a k_a$$

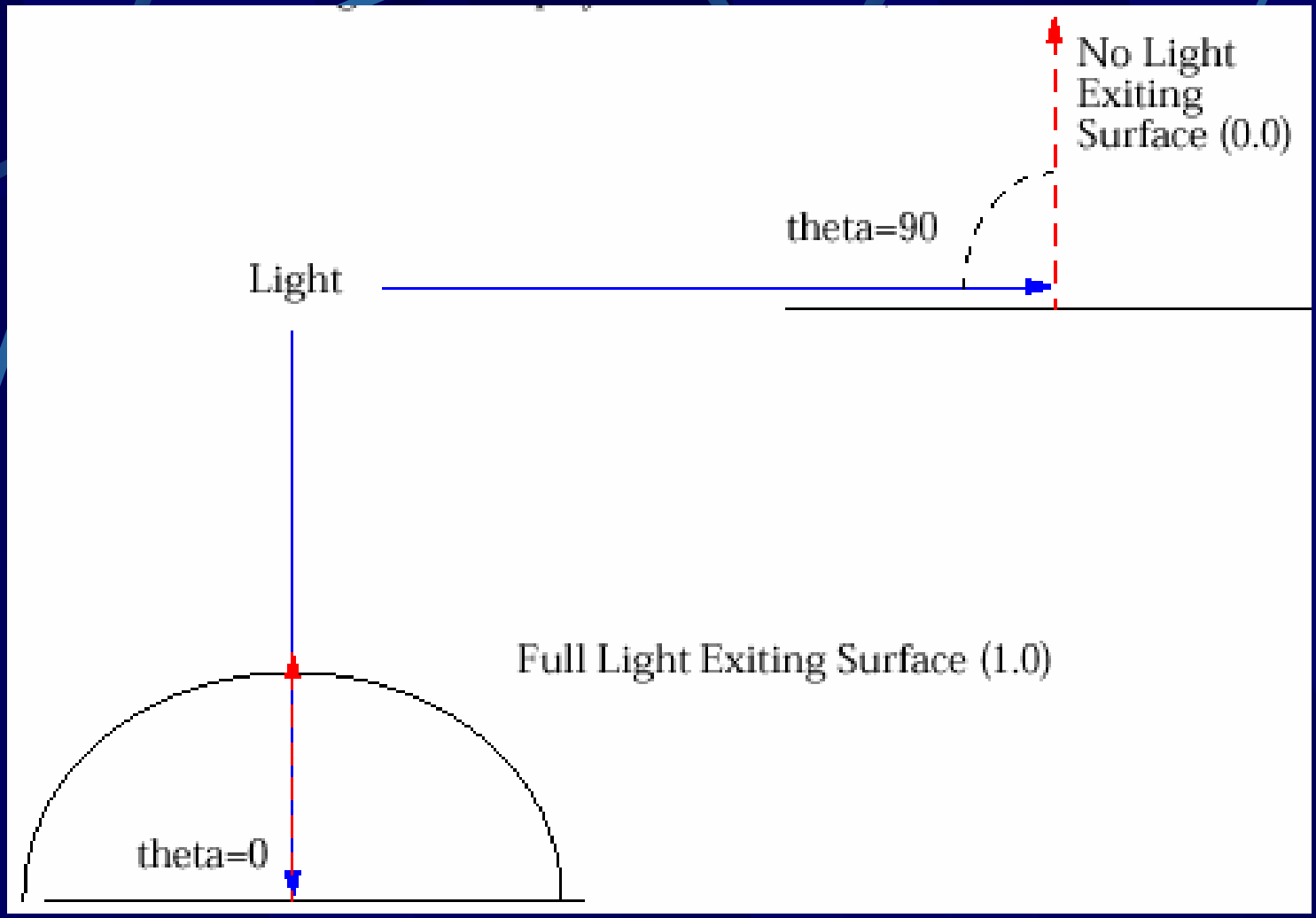
I_a — intensity of ambient light

k_a — fraction reflected, $0 \le k_a \le 1$

Diffuse (Lambertian) reflection

- typical of dull, matte surfaces (e.g. carpet)
- independent of viewer position
- dependent on light source position (in this case a point source, again a non-physical abstraction)

Diffuse (Lambertian) reflection

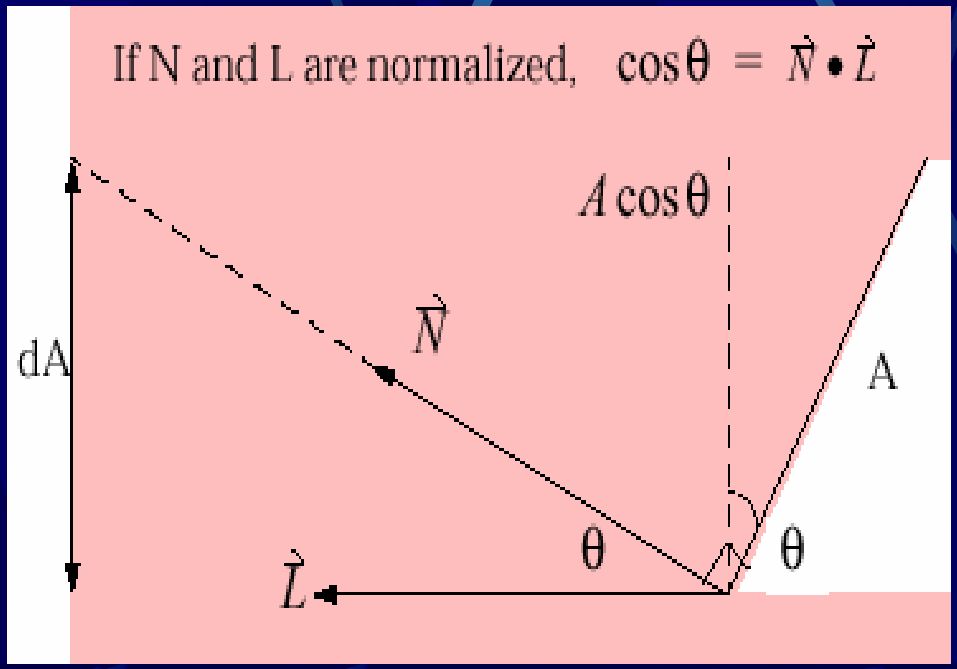


Lambert's cosine law:

$$I = I_p k_d \cos\theta$$

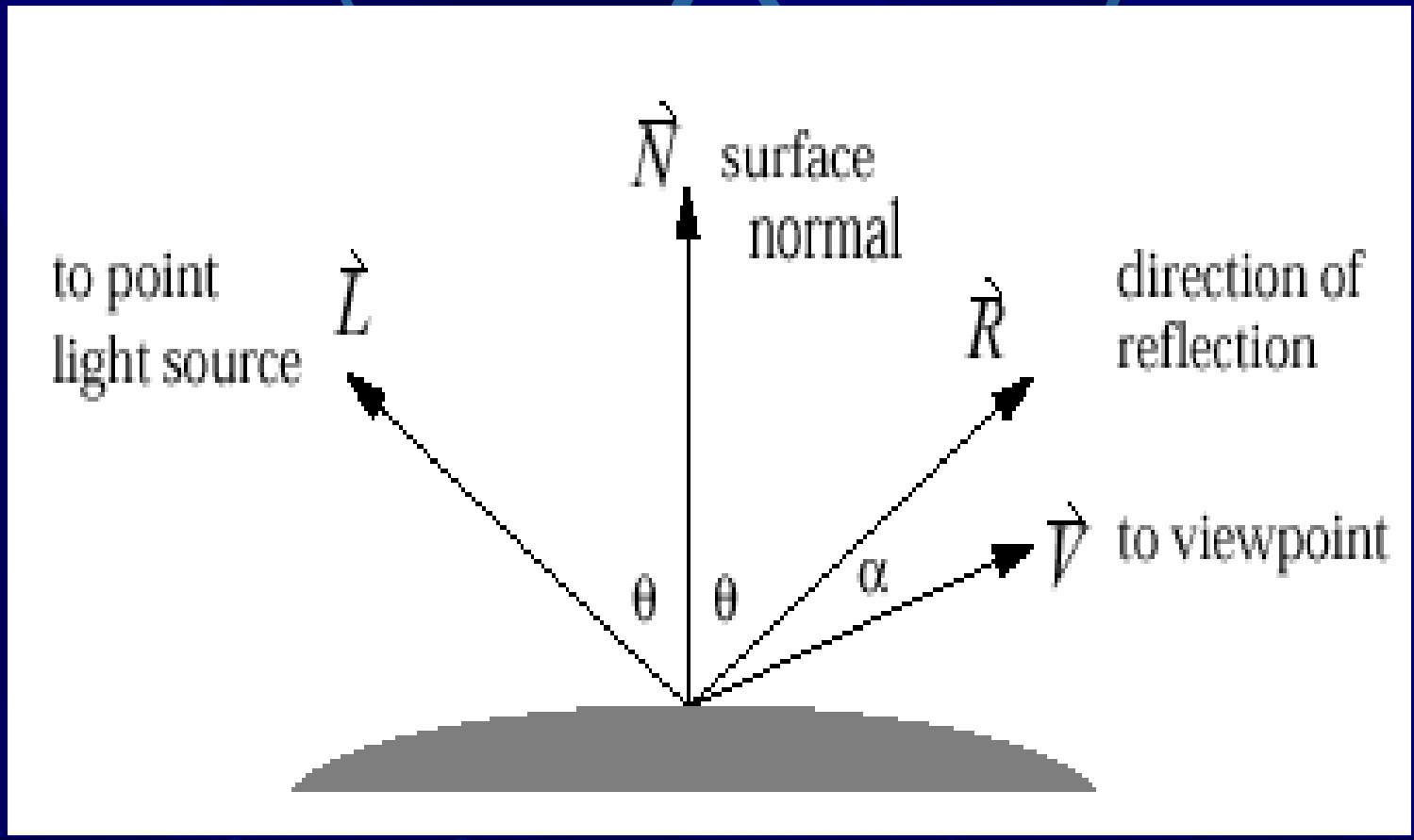
$$I = I_p k_d (\vec{N} \bullet \vec{L})$$

I_p — intensity of point light source
k_d —diffuse reflection coefficient;
specifies fraction of I_p reflected



Specular Reflection

- Directed reflection from shiny surfaces
  – typical of bright, shiny surfaces, e.g. mirrors



Specular Reflection

Dependent on light source position and viewer position

– Early model by Phong neglected effect of material color on specular highlight -> made all surfaces look plastic

– for perfect reflector we see reflected light if angle alpha=0

– for real reflector, reflected light falls off as angle alpha increases. Relationship:

alpha =0 -> reflected value =1?

alpha =90 -> reflected value =0?

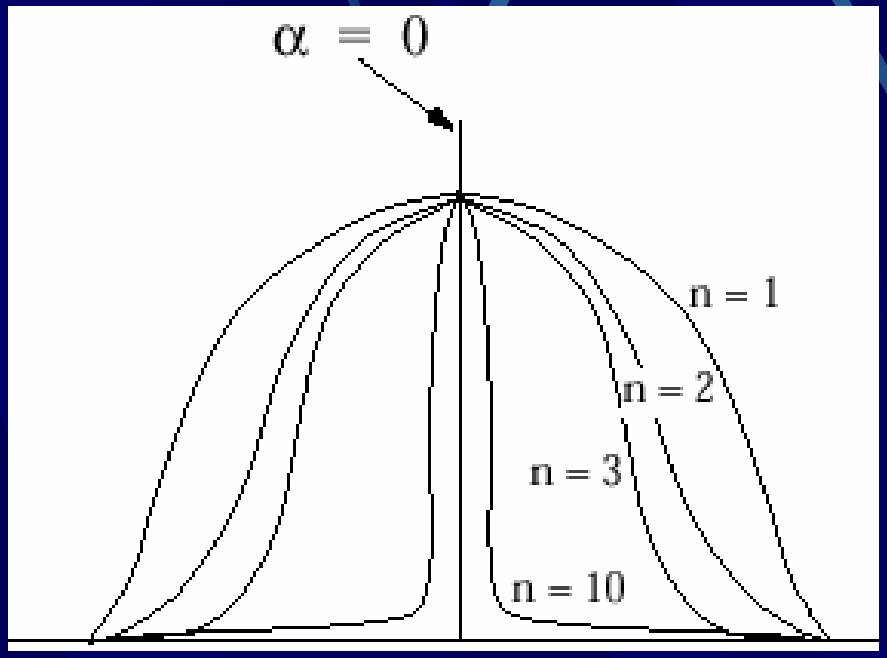
cosine again? … Not exactly

Specular Reflection

Phong Approximation

$$\cos^n \alpha$$

as ***n*** increases, highlight is more concentrated, surface appears glossier



A Simple Illumination Model

- **Non-Physical Lighting Equation**
- Energy from a single light reflected by a single surface element
- For multiple point lights, simply sum contributions

Practical approaches to illumination

- Flat shading
- Gouraud shading
- Phong shading
- Ray tracing
- Radiosity
- Ray tracing + radiosity