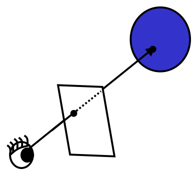
ray casting



- cast ray through pixel into scene
- find intersection point (if any) that is closest to eye
- **compute color at intersection**

color

the color of a point on a surface depends on

- lights in scene
- material properties of surface
- geometry of scene

color

for each channel we'll **approximate** the color at the intersection point as the sum of five terms

- emission
- ambient reflection
- diffuse reflection
- specular reflection
- specular transmission

We'll describe the terms for the red channel.

color

for each channel we'll approximate the color at the intersection point as the sum of five terms

- **emission**
- ambient reflection
- diffuse reflection
- specular reflection
- specular transmission

red emission term

mer the material red emission

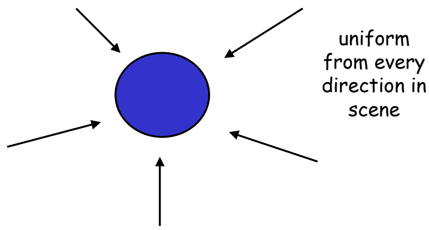
NOTE: terms shown in red are input parameters

color

for each channel we'll approximate the color at the intersection point as the sum of five terms

- emission
- **ambient reflection**
- diffuse reflection
- specular reflection
- specular transmission

ambient light



red ambient term

the red ambient term is $ar * mar$ where

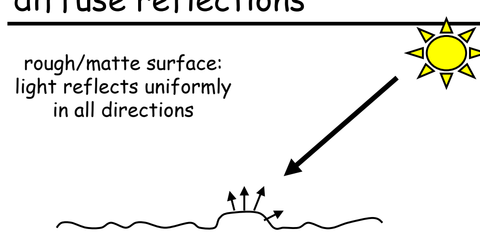
- ar is the red intensity of the ambient light
- mar is the response of the surface to red ambient light

color

for each channel we'll approximate the color e at the intersection point as the sum of five terms

- emission
- ambient reflection
- **diffuse reflection**
- specular reflection
- specular transmission

diffuse reflections



diffuse reflections provide the surface "color"

red diffuse term

the red diffuse reflection term is $\Sigma R_{L,D}$ where

- the summation is taken over all lights L
- $R_{L,D}$ is the intensity of the red, diffuse reflection of light L at the intersection point

Note: terms in green are explained in subsequent slides

$R_{L,D}$

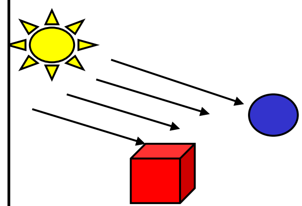
depends on

- type of light
- geometry of scene
- material properties of surface

types of lights

- directional light
- point light
- spot light

directional light



- light positioned at "infinity"; intensity and incident angle are constant for all points in scene
- specification
  - direction
  - red, green, and blue intensity

$R_{L,D}$ for directional light L

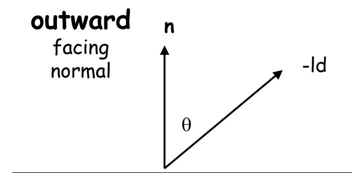
$R_{L,D}$ = 0 if L is occluded

$R_{L,D}$ = *mdr* • *lr* • max(0,(**n** ● -**ld**))
otherwise

- *mdr* is the diffuse response of the surface material to red light
- *lr* is the red intensity of light L
- **n** is the unit normal of the surface at the point of intersection
- **ld** is a unit vector in direction the light falls

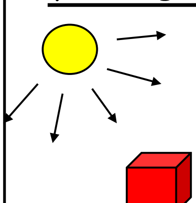
Note: you need to compute terms in blue

normal



reflection decreases as θ increases. if |θ| > 90° the light falls on the back of the surface and is not reflected

point light



- light emanates uniformly in all directions
- specification
  - location in world coordinates
  - red, green, and blue intensity
  - how the light drops off with distance

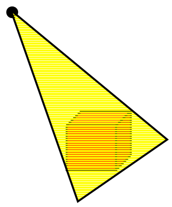
$R_{L,D}$ for point light L

$R_{L,D}$ = 0 if L is occluded

$R_{L,D}$ = *A* • *mdr* • *lr* • max(0, **n** ● -**ld**))
otherwise

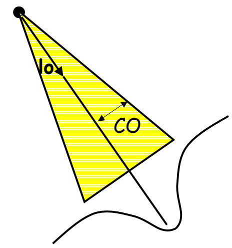
- *mdr* , *lr* , and **n** are as previously defined
- **ld** is the unit vector **from** the light position P_L to the intersection point
- $A = 1/(ca + la * d + qa * d^2)$ is the attenuation term, d is the distance between the light and the surface point

spot light



- light emanates in a cone
- specifications
  - location in world coordinates
  - red, green, and blue intensity
  - how the light drops off with distance
  - **how light drops with angle from center**

spot light



- light emanates in a cone
- specifications
  - location in world coordinates
  - red, green, and blue intensity
  - how the light drops off with distance
  - **how light drops with angle from center**
    - light orientation vector **lo**
    - cutoff angle *CO*
    - drop off exponent DO

$R_{L,D}$ for spot light L

$R_{L,D}$ = 0 if L is occluded

$R_{L,D} = A \cdot SP \cdot mdr \cdot lr \cdot \max(0,(\mathbf{n} \bullet -\mathbf{ld}))$

where

- *A*, *mdr*, *lr*, and **ld** are as previously defined
- SP is the "spot light effect"
  - SP=0 if angle between lo and ld is greater than *CO*
  - SP = $\max(0, ld \bullet lo)^{128*DO}$ otherwise

Diffuse reflection term for each light L

$R_{L,D}$ = 0 if L is occluded

$R_{L,D} = A \cdot SP \cdot mdr \cdot lr \cdot \max(0,(\mathbf{n} \bullet -\mathbf{ld}))$

spot light effect

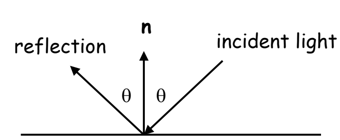
positional/spot light attenuation

color

for each channel we'll approximate the color at the intersection point as the sum of five terms

- emission
- ambient reflection
- diffuse reflection
- **specular reflection**
- specular transmission

specular reflections

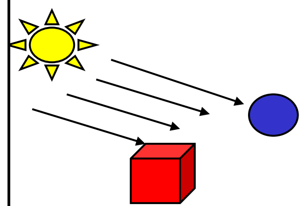


specular reflections provide highlights

red specular

the red specular reflection term is $(1-k_{trans})\ \Sigma\ R_{L,S}$ where
- the summation is taken over all lights L
- $R_{L,S}$ is the intensity of the red, specular reflection of light L at the intersection point (details to follow shortly)

directional light



light positioned at infinity; intensity and incident angle are constant for all surface points in scene

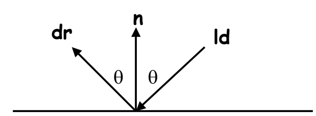
$R_{L,S}$ for directional light L

$R_{L,S}$ = 0 if light is occluded

$R_{L,S} = msr \cdot lr \cdot \max(0,(-v \bullet dr))^{128} * k_{spec}$ otherwise

- *msr* is the specular response of the surface material to red light
- *lr* *is* as previously defined
- v is the direction of the incoming ray
- **dr** is a unit vector in the direction of reflection
- k_{spec} is the shininess constant

vector of reflection



compute **dr** given **n** and **ld**

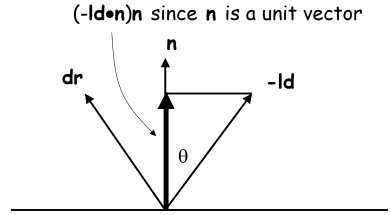
(all unit vectors)

$R_{L,S}$

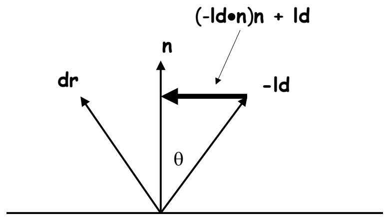
depends on
- type of light
- geometry of scene
- material properties of surface

vector of reflection

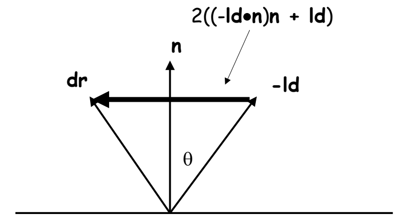
(-**ld**•**n**)**n** since **n** is a unit vector



vector of reflection

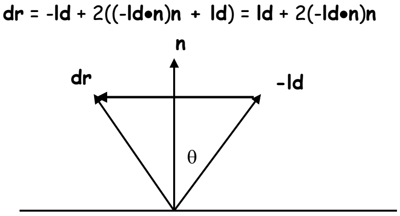


vector of reflection

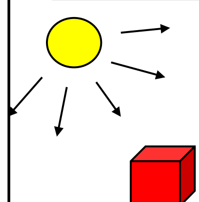


vector of reflection

dr = -**Id** + 2((-**Id**•**n**)**n** + **Id**) = **Id** + 2(-**Id**•**n**)**n**



point light



- light emanates uniformly in all directions
- specification
  - location in world coordinates
  - red, green, and blue intensity
  - how the light drops off with distance

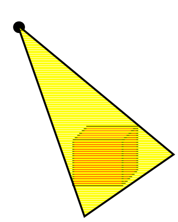
$R_{L,S}$ for point light L

$R_{L,S}$ = 0 if light is occluded

$R_{L,S} = A \cdot msr \cdot lr \cdot \max(0,(-\mathbf{v} \bullet \mathbf{dr}))^{128*k_{spec}}$
otherwise

all terms are as previously defined

spot light



- light emanates in a cone
- specification
  - location in world coordinates
  - red, green, and blue intensity
  - how the light drops off with distance
  - how light drops with angle from center

Specular reflection term for each light L

$R_{L,S}$ = 0 if L is occluded

$R_{L,S} = A \cdot SP \cdot msr \cdot lr \cdot \max(0,(-\mathbf{v} \bullet \mathbf{dr}))^{128 * k_{spec}}$

spot light effect

positional/spot light attenuation

$R_{L,S}$ for spot light L

$R_{L,S}$ = 0 if L is occluded

$R_{L,S} = A \cdot SP \cdot msr \cdot lr \max(0,(-\mathbf{v} \bullet \mathbf{dr}))^{128 * k_{spec}}$ otherwise

all terms are as previously described

color

for each channel we'll approximate the color at the intersection point as the sum of five terms

- emission
- ambient reflection
- diffuse reflection
- specular reflection
- **specular transmission**

THIN SURFACE for now