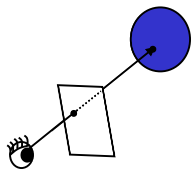
ray casting



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

luminance

the luminance of a point on a surface depends on
- lights in scene
- material properties of surface
- geometry of scene

luminance

for each channel we'll **approximate** the luminance at the intersection point as the sum of five terms
- emission
- ambient
- diffuse reflection
- specular reflection
- transmission

We'll describe the terms for the red channel.

luminance

for each channel we'll approximate the luminance at the intersection point as the sum of five terms
- **emission**
- ambient
- diffuse reflection
- specular reflection
- transmission

red emission term

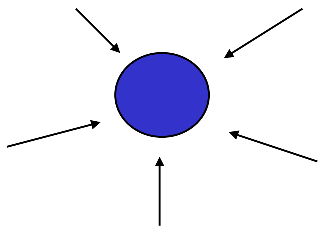
mer the material red emission

NOTE: terms shown in red are input parameters

luminance

for each channel we'll approximate the luminance at the intersection point as the sum of five terms
- emission
- **ambient**
- diffuse reflection
- specular reflection
- transmission

ambient light



uniform from every direction in scene

10/5/2003

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

10/5/2003

luminance

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

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

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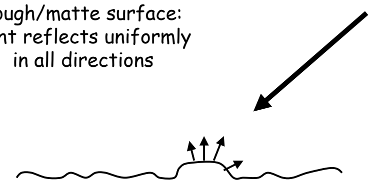
diffuse reflections

rough/matte surface: light reflects uniformly in all directions



diffuse reflections provide the surface "color"

10/5/2003

red diffuse term

the red diffuse reflection term is $(1-k_{trans}) \Sigma R_{L,D}$ 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
- k_{trans} is the transmission coefficient

Note: terms in green are explained in subsequent slides

10/5/2003

$R_{L,D}$

depends on

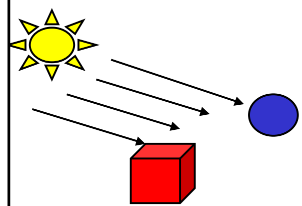
- type of light
- geometry of scene
- material properties of surface

10/5/2003

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

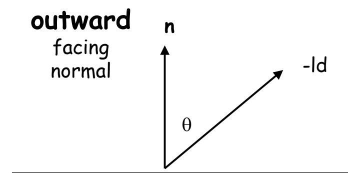
$R_{L,D}$ = 0 if L is occluded

$R_{L,D}$ = *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

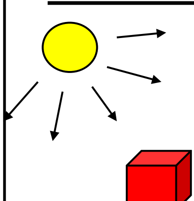
Note: you need to compute terms in blue

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

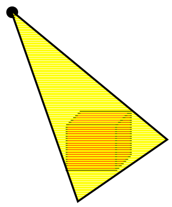
$R_{L,D}$ for point light L

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

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

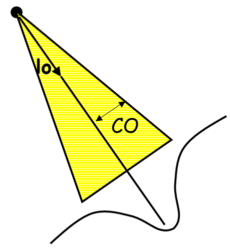
- *mdr* , *lr* , and **n** are as previously defined
- **ld** is the unit vector **from** the light position P_L to the intersection point
- $A = 1/(ca + la * d + qa * d^2)$ is the attenuation term, d is the distance between the light and the surface point

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 • SP • *mdr* • *lr* • max(0,(**n** • **-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 • lo)^{128*DO} otherwise

Diffuse reflection term for each light L

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

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

spot light effect

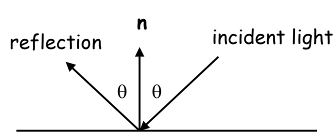
positional/spot light attenuation

luminance

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

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

specular reflections



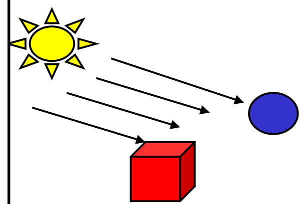
specular reflections provide highlights

red specular

the red specular reflection term is
$\Sigma R_{L,S}$ where

- the summation is taken over all lights L
- $R_{L,S}$ is 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

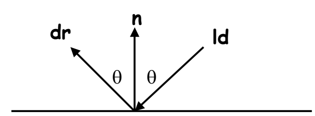
$R_{L,S}$ for directional light L

$R_{L,S}$ = 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**

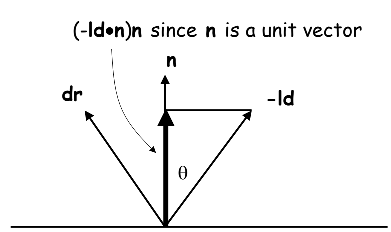
(all unit vectors)

$R_{L,S}$

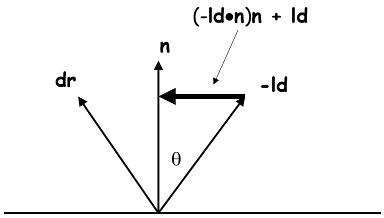
depends on

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

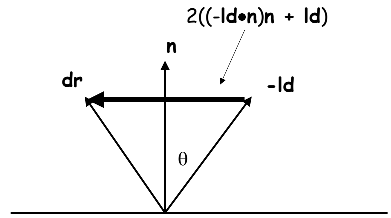
vector of reflection



vector of reflection

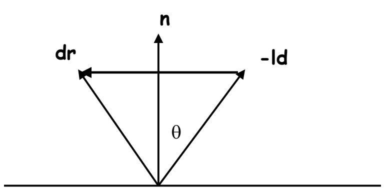


vector of reflection

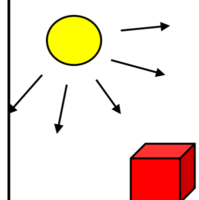


vector of reflection

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

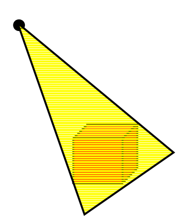
$R_{L,S}$ for point light L

$R_{L,S}$ = 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 (SP)

positional/spot light attenuation (A)

$R_{L,S}$ 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

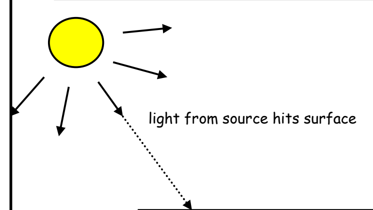
luminance

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

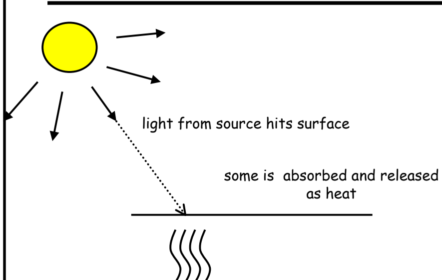
- emission
- ambient
- diffuse reflection
- specular reflection
- **transmission**

THIN SURFACE for now

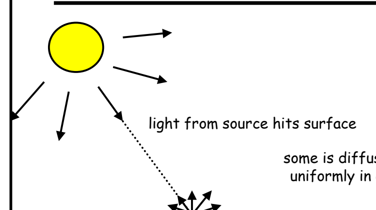
first a recap



first a recap



first a recap



Diffuse reflection

$(1-k_{trans}) \Sigma R_{L,D}$

$R_{L,D}$ = 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 (SP)

positional/spot light attenuation (A)

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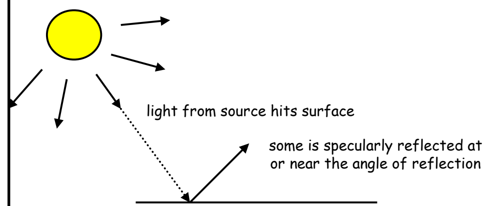
first a recap



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Specular reflection

$\Sigma R_{L,S}$

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

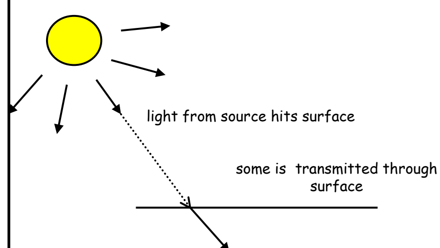
$R_{L,S} = A \cdot SP \cdot msr \cdot lr \cdot \max(0,(-\mathbf{v} \bullet \mathbf{dr}))^{128 * k_{spec}}$

spot light effect (SP)

positional/spot light attenuation (A)

10/5/2003

first a recap



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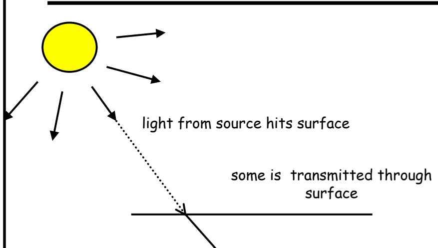
first a recap



does transmission behave like specular reflection, diffuse reflection, both, neither?

10/5/2003

red transmission term

the red transmission term is $\Sigma R_{L,T}$ where

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

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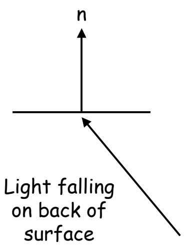
transmission



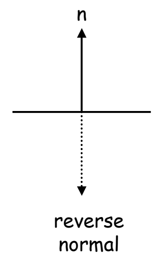
$R_{L,T} = k_{trans} R^{back}_{L,D}$

where

- $R^{back}_{L,D}$ is the luminance of diffuse reflections on the back of the surface

10/5/2003

transmission computation



- compute $R_{L,D}$ with the reverse normal.
- scale by k_{trans}

10/5/2003