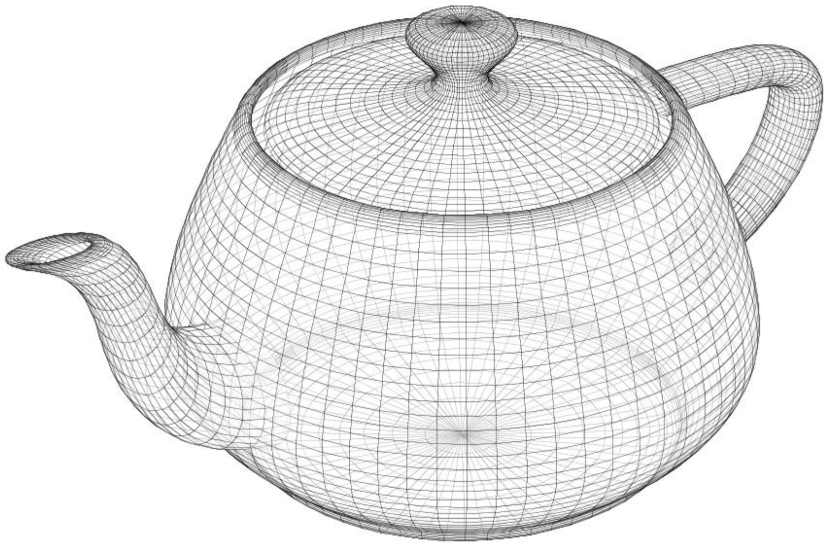


Glossy Reflection

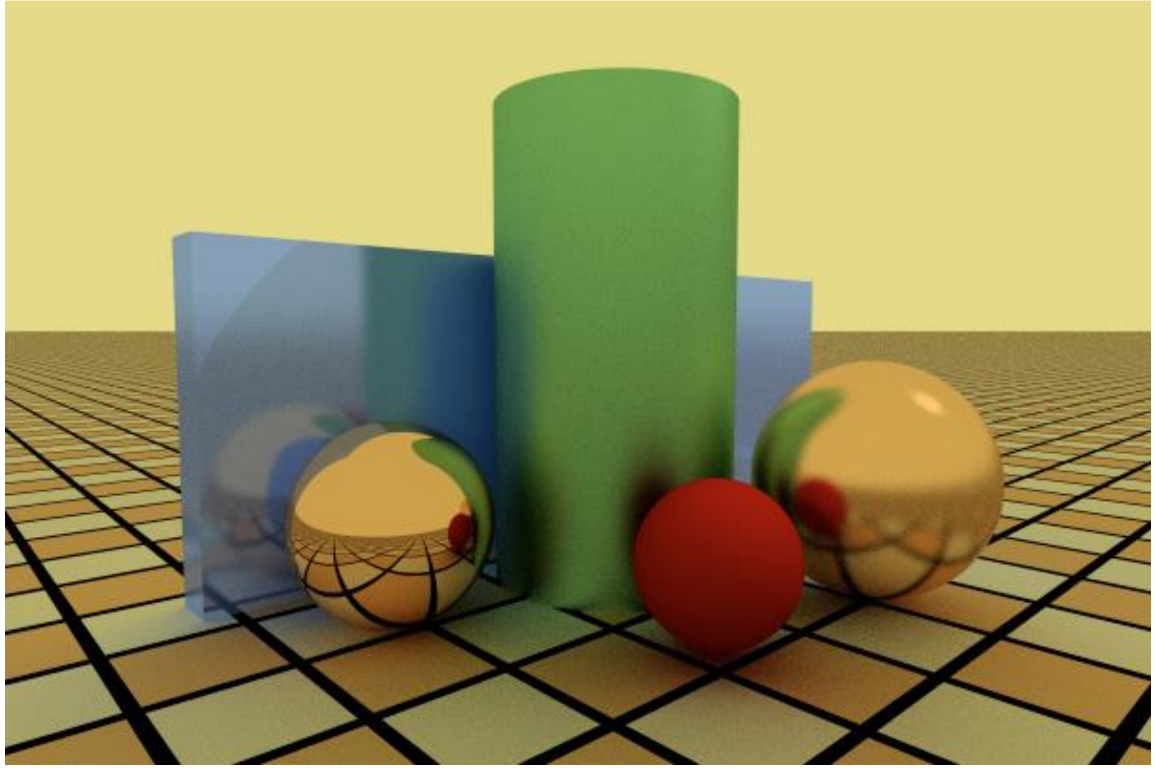
Production Computer Graphics

Eric Shaffer

ILLINOIS

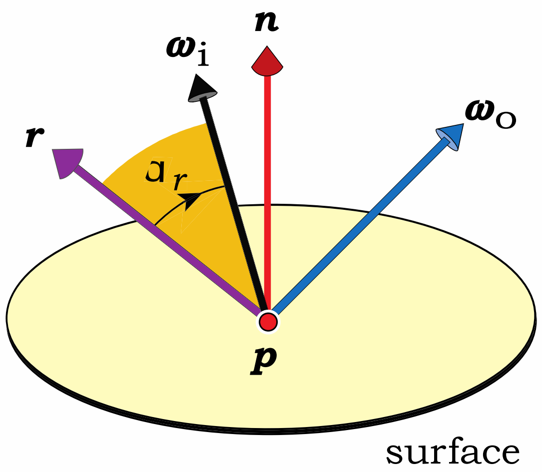
Objectives

- Remove inconsistent specular reflection effects
- Learn how to model imperfect reflectors
- Be able to implement a glossy reflection with varying roughness



Glossy Reflection

- Blurry reflection rather than perfect (mirror reflection)
- We'll shoot reflection rays in more than one direction
- Be consistent with our specular highlight model
  - Use the same cosine power formula to generate the ray directions
- Density of ray distribution is given by angle around mirror direction



$$d = (\cos q_r)^e$$

What is *e*?

Glossy BRDF Model

- Our BRDF could be

$$f_{r,s}(p,\omega_i,\omega_o) = c k_r \mathbf{c}_r \cos(\theta_r)^e = c k_r \mathbf{c}_r (r \cdot \omega_i)^e$$

- r is the mirror reflection direction
- c is a normalization constant proprtional to e+1
- As e → ∞ the BRDF becomes a delta function
  - Only reflects in the mirror direction

Monte Carlo Estimator

Our approximation of reflected indirect light is now an integral

- Because we're using more than one direction

$$L_{indirect}(p,\omega_o) = c k_r \mathbf{c}_{\mathbf{r}} \int_{2\pi+} (\omega_{i,j} \cdot r)^e L_o(r_c(p,\omega_i), -\omega_i) \cos\theta_i \, d\omega_i$$

$$\left\langle L_r(p,\omega_o) \right\rangle = \frac{c k_r \mathbf{c}_{\mathbf{r}}}{n} \sum_{j=1}^{n} \frac{(\omega_{i,j} \cdot r)^e L_o(r_c(p,\omega_{i,j}), -\omega_{i,j}) \cos\theta_{i,j}}{p(\omega_{i,j})}$$

The pdf

The pdf should be proportional to the BRDF

$$p(\omega_{i,j}) \propto (r \cdot \omega_i)^e$$

But we need the cos to go away

- So it matches perfect mirror reflection when e → ∞

$$p(\omega_{i,j}) \propto (r \cdot \omega_i)^e (n \cdot \omega_i)$$

- So then the estimator simplifies to

$$\langle L_r(p,\omega_o) \rangle = \frac{k_r \mathbf{c}_{\mathbf{r}}}{n} \sum_{j=1}^{n} L_o(r_c(p,\omega_{i,j}), -\omega_{i,j})$$

Generating Reflection Rays

The parameter e controls the blur

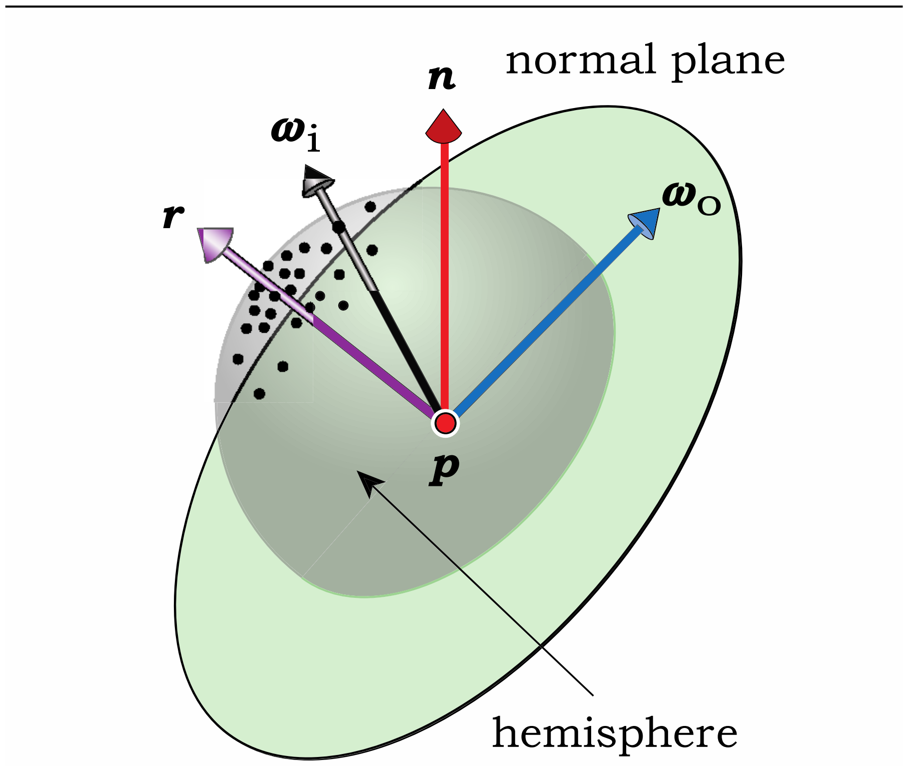
- Higher e makes the material shinier
- What kind reflection happens at e=1 ?

To construct the ray we

- need to generate samples on a hemisphere
  - (s_x , s_y , s_z)
- map those samples to the hemisphere around r

Construct an orthonormal basis (u,v,w)

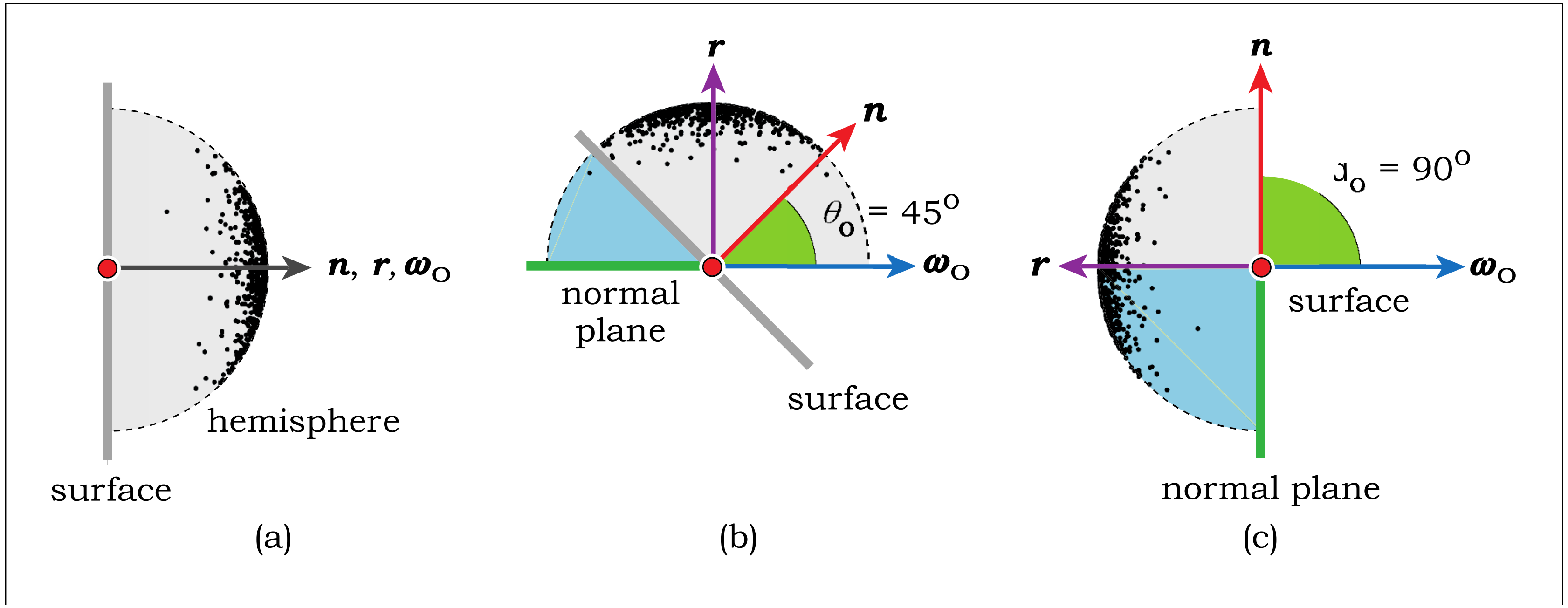
- w is parallel to r and v,w are in plane normal to r
- map origin to p
- ray direction is $s_x u + s_y v + s_z w$



Sampling Issues

Rays can be generated that are below the object surface

- Why?

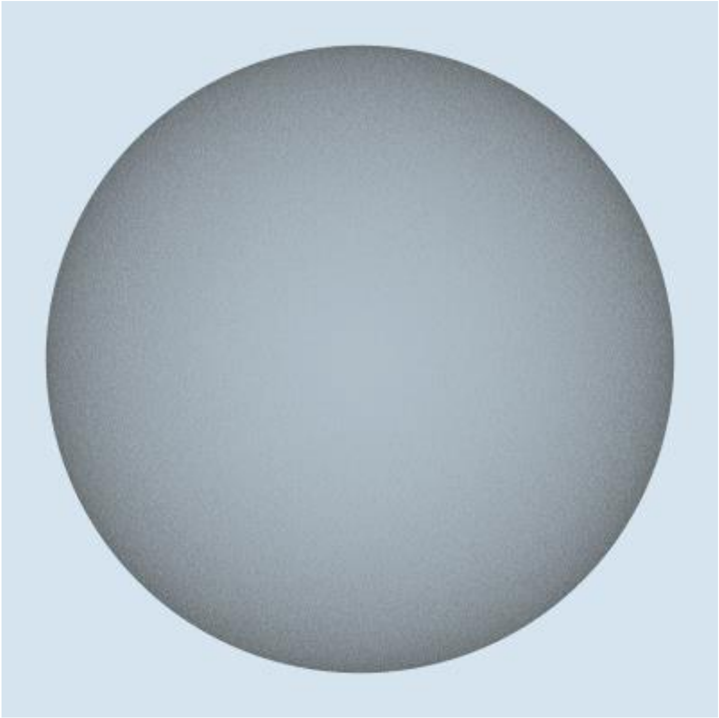


Sampling Issues

Test image e=1, k_r=0.8, c_r=white, 100 rays per pixel

Color of sphere should be constant

- Why?

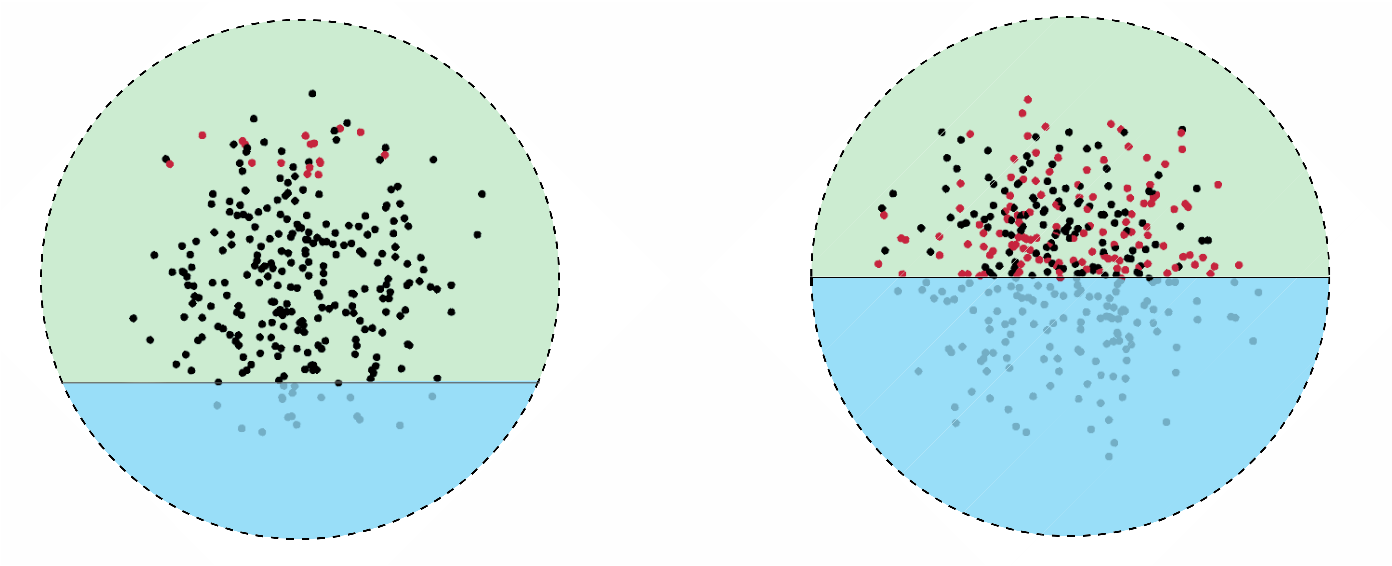


It's not

- Why?

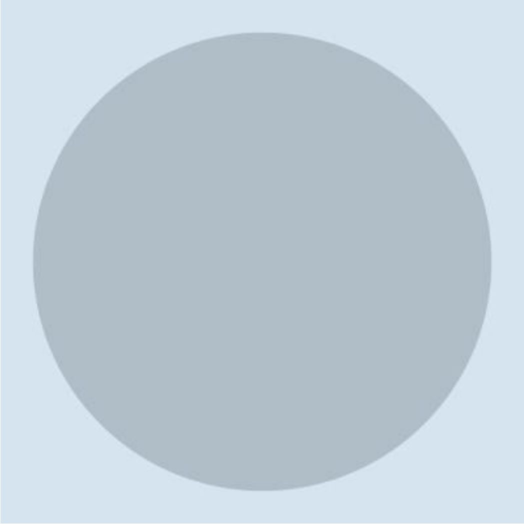
Fixing the Sampling Issues

- Reflect rays below surface through r
  - Moves them above surface
  - Biases distribution but it's still better



Fixing the Sampling Issues

- Test for ray below surface $n \times w_i < 0$
- Reflected ray $w_i = - s_x u - s_y v + s_z w$



Examples: Varying e