Reflection Models

Last lecture

- **Phong model**
- **Microfacet models**
- **Gaussian height field on surface**
- **Self-shadowing**

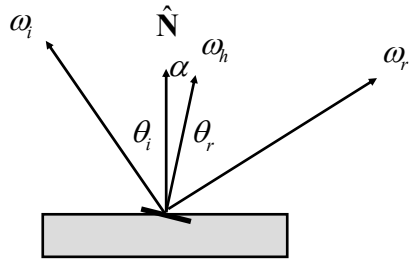
Today

- **Torrance-Sparrow model**
- **Anisotropic reflection models**
- **Multiple importance sampling**

Microfacet Model

Torrance-Sparrow Model

$$f_r(\omega_i \rightarrow \omega_r) = \frac{D(\omega_h)}{4\cos\theta_i \cos\theta_r}$$



$$D(\omega_h) = D(\alpha) = \cos^s \alpha = \left(\hat{\mathbf{N}} \bullet \omega_h\right)^s$$

Torrance-Sparrow Theory

$$f_r(\omega_i \rightarrow \omega_r) = \frac{F(\theta_i')S(\theta_i)S(\theta_r)D(\alpha)}{4\cos\theta_i \cos\theta_r}$$

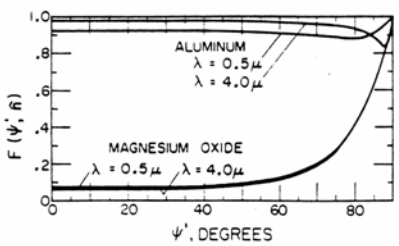


FIG. 6. Fresnel reflectance.

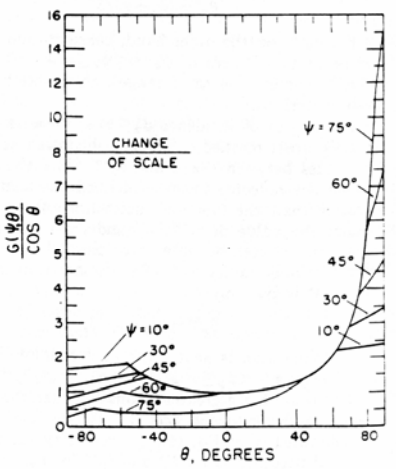
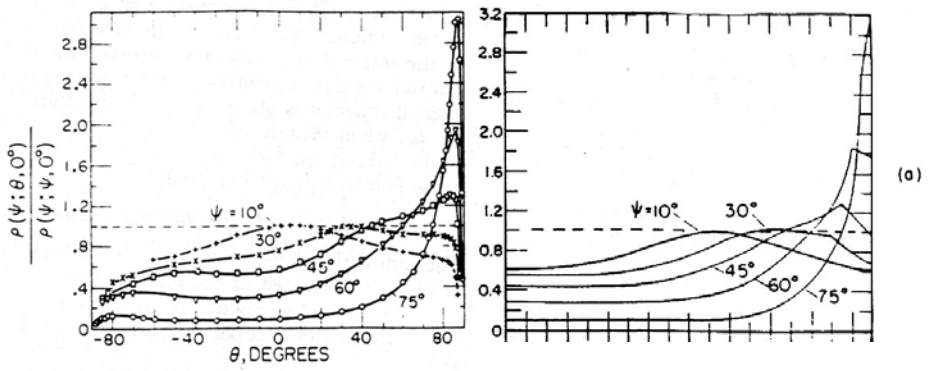


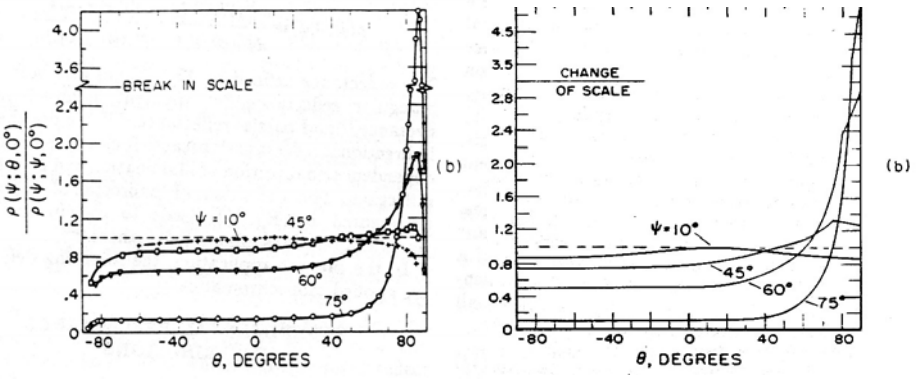
FIG. 7. The factor $G(\psi,\theta)/\cos\theta$ in the plane of incidence for various incidence angles ψ.

Torrance-Sparrow Comparison



Aluminum

Torrance-Sparrow Comparison



Magnesium Oxide

"Diffuse" Reflection

Experimental

- **Pressed magnesium oxide powder used as an example of a diffuse reflector**
- **Reflection greater at high angles of incidence**

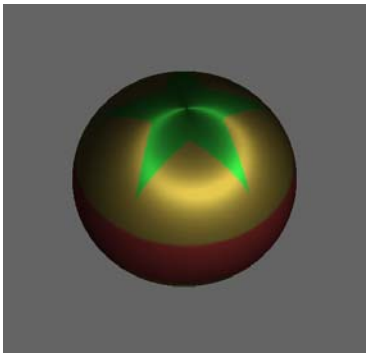
Theoretical

- **Bouguer - Microfacet distribution**
  - **No microfacet distribution can reflect rays equally in all directions**
- **Multiple surface or subsurface reflections**

Paint manufactures attempt to create ideal diffuse

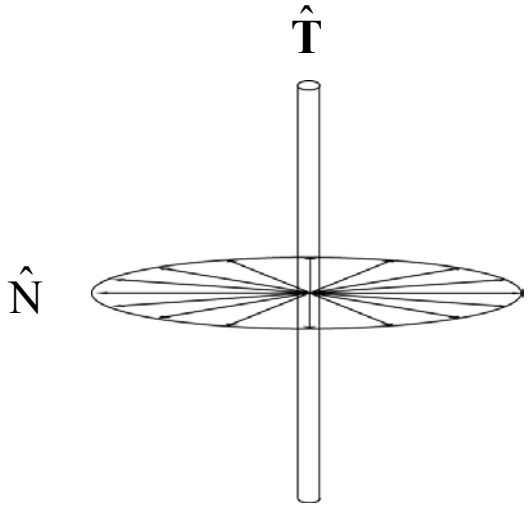
Anisotropic Reflection Model

Anisotropic Reflection

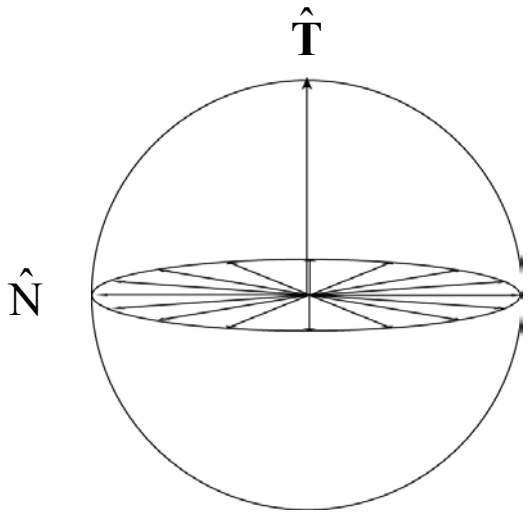


Quarterhorse

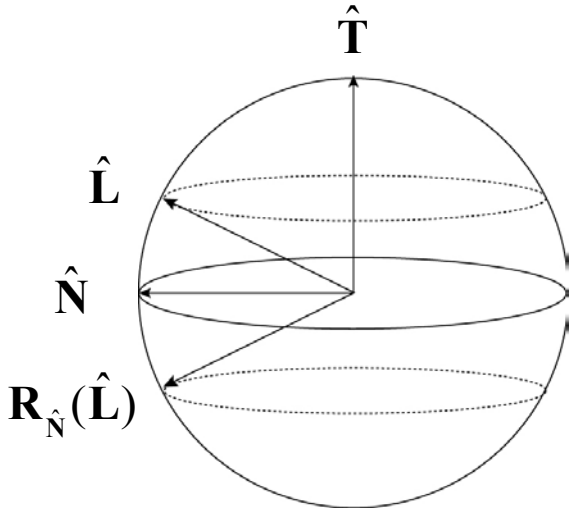
Reflection from a Cylinder



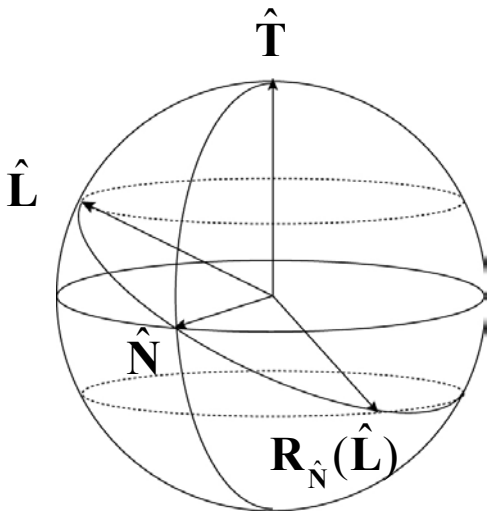
Reflection from a Cylinder



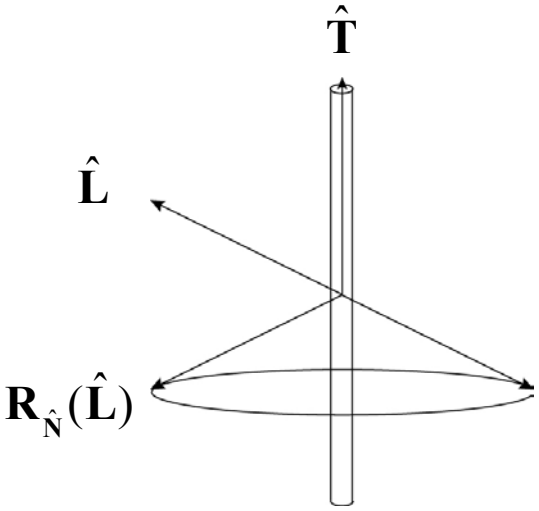
Reflection from a Cylinder



Reflection from a Cylinder

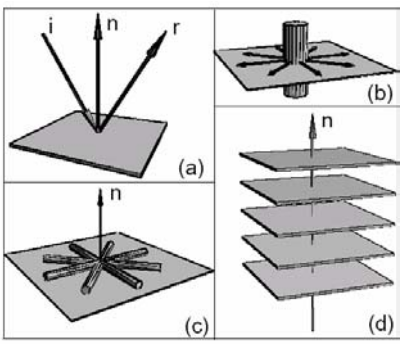


Reflection from a Cylinder



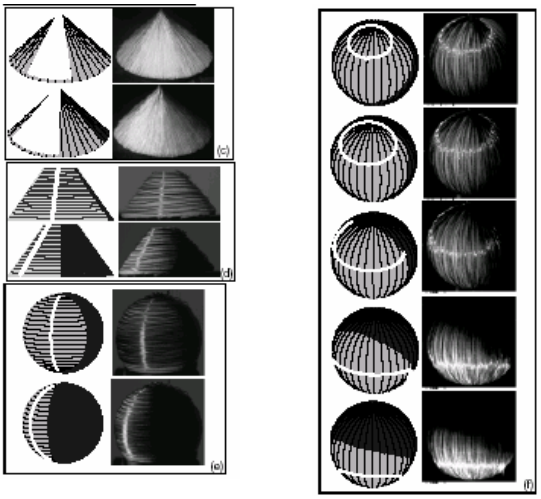
Shape of Anisotropic Highlights

Fibers tangent to the plane defined by the halfway vector reflect light



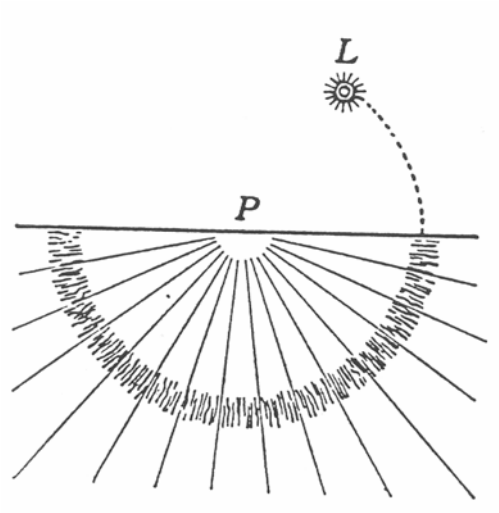
From Lu, Koenderink, Kappers

Shape of Anisotropic Highlights

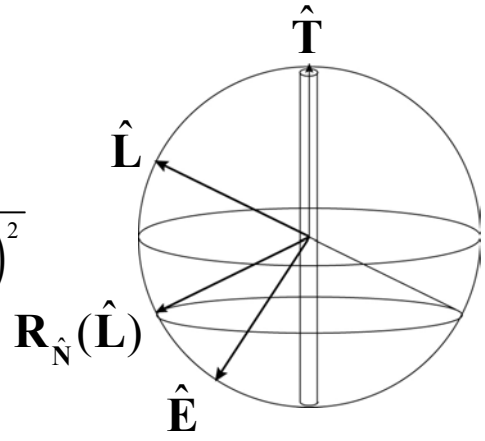


From Lu, Koenderink, Kappers

Anisotropic Reflection



Kajiya-Kay Model



Diffuse

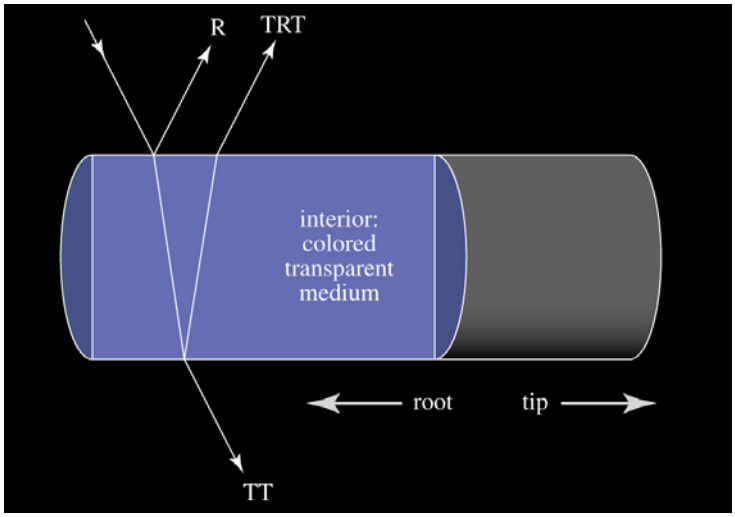
$$\sin\theta_L = \sqrt{1 - \left(\hat{\mathbf{T}} \bullet \hat{\mathbf{L}}\right)^2}$$

Specular

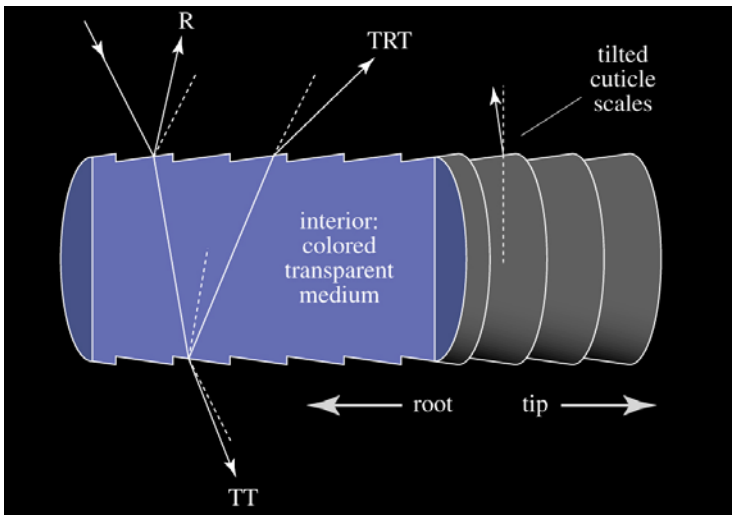
$$\cos^s\left(\theta_E - \theta_L\right) = \left(\cos\theta_E \cos\theta_L + \sin\theta_E \sin\theta_L\right)^s$$

Herbert

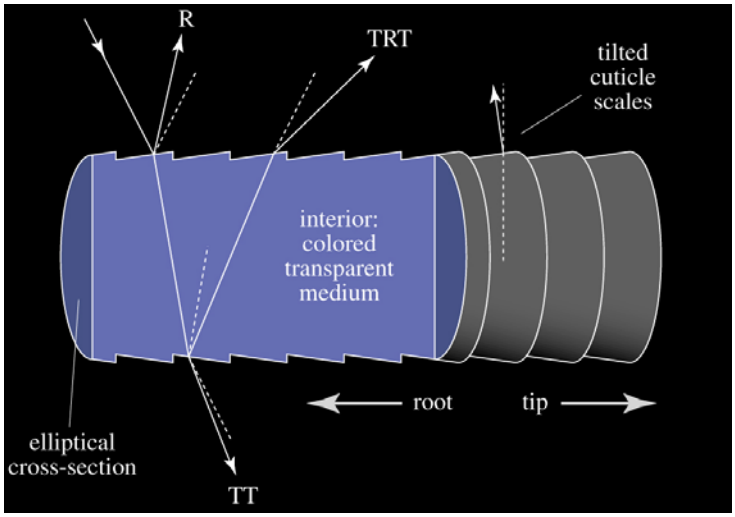
Fiber Model



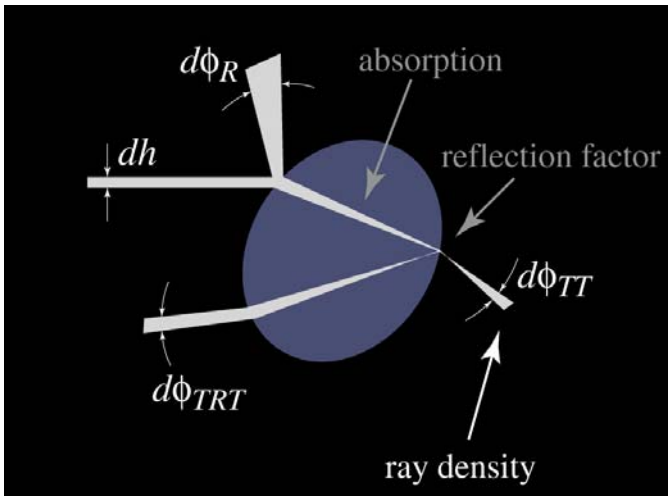
Fiber Model



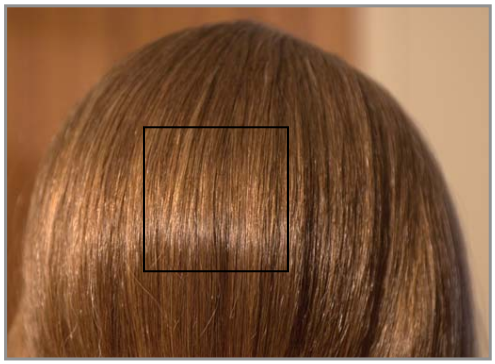
Fiber Model



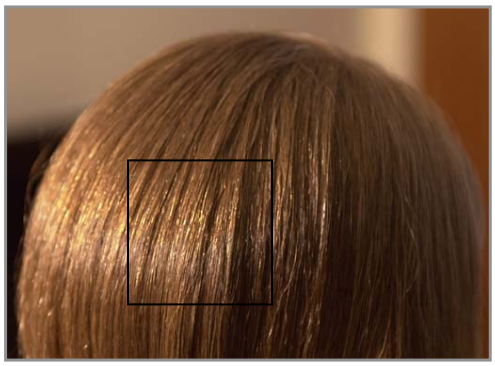
Caustics

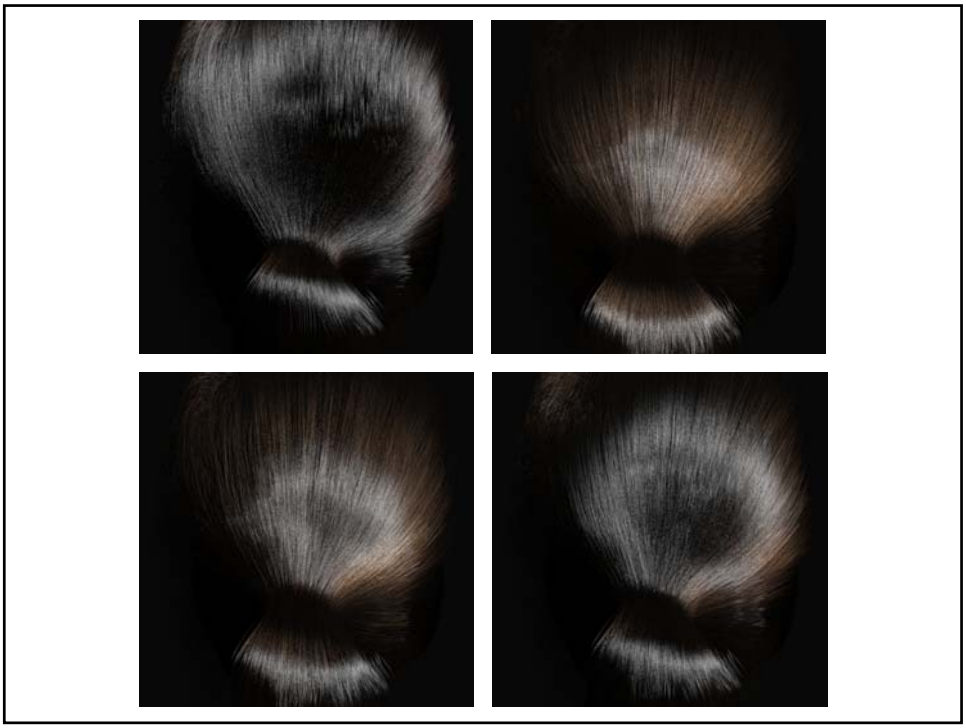


Hair Appearance



Hair Appearance

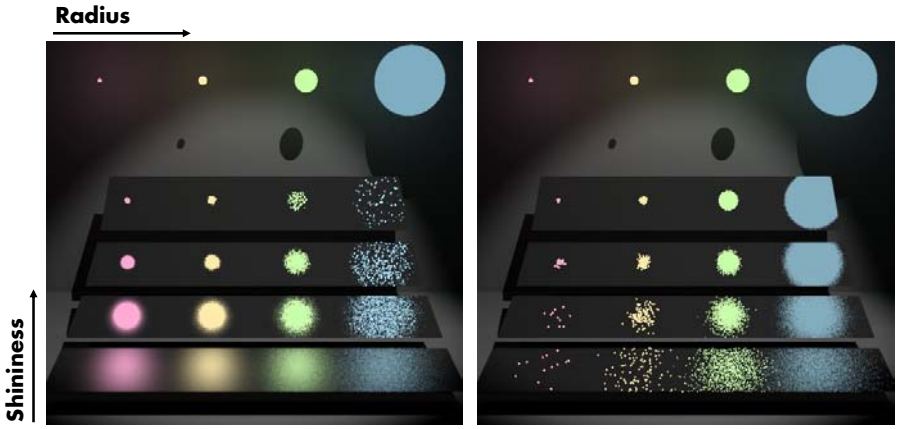




Multiple Importance Sampling

Multiple Importance Sampling

Reflection of a circular light source by a rough surface



Sampling the light source **Sampling the BRDF**

$$\int f(x)g(x)\,dx$$

Multiple Importance Sampling

Two sampling techniques

$$X_{1,i} \sim p_1(x) \qquad X_{2,i} \sim p_2(x)$$

$$Y_{1,i} = \frac{f(X_{1,i})}{p_1(X_{1,i})} \qquad Y_{2,i} = \frac{f(X_{2,i})}{p_2(X_{2,i})}$$

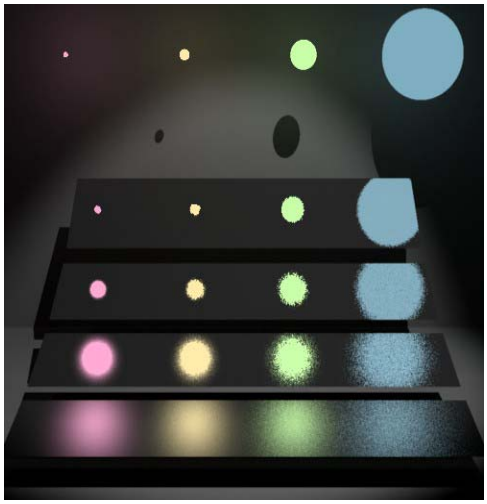
Form weighted combination of samples

$$Y_i = w_1 Y_{1,i} + w_2 Y_{2,i}$$

The balance heuristic

$$w_i(x) = \frac{p_i(x)}{p_1(x) + p_2(x)} \Rightarrow p(x) = w_1(x)p_1(x) + w_2(x)p_2(x)$$

Multiple Importance Sampling



Source: Veach and Guibas