Illumination model

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Lighting

- Light travels from the **light source**, is reflected from the **surfaces**, and absorbed in the **eye**.
- Color of the surface depends on the **reflectance**, **absorption**, and **emission** parameters of the surface.
- Reflectance, absorption and emission change with a change in **wavelength**.

Pictures courtasy of MIT, Lecture Notes 6.837

Illumination model

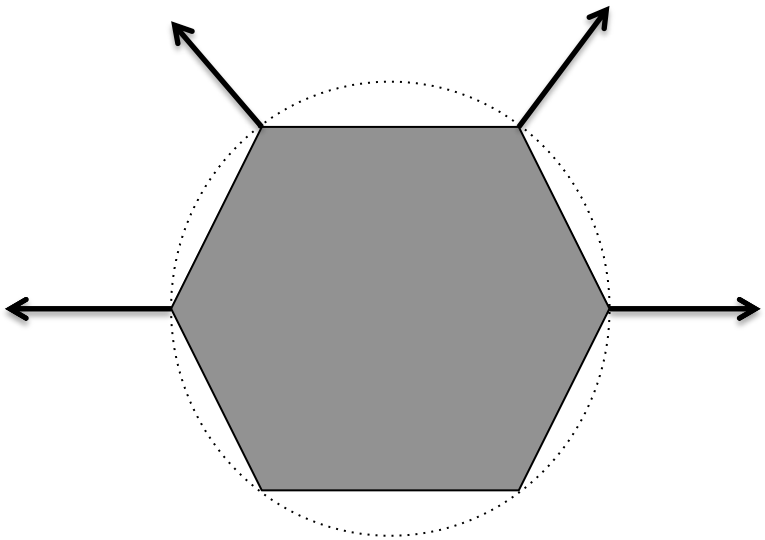
illumination model – a model describing how light travels in the environment

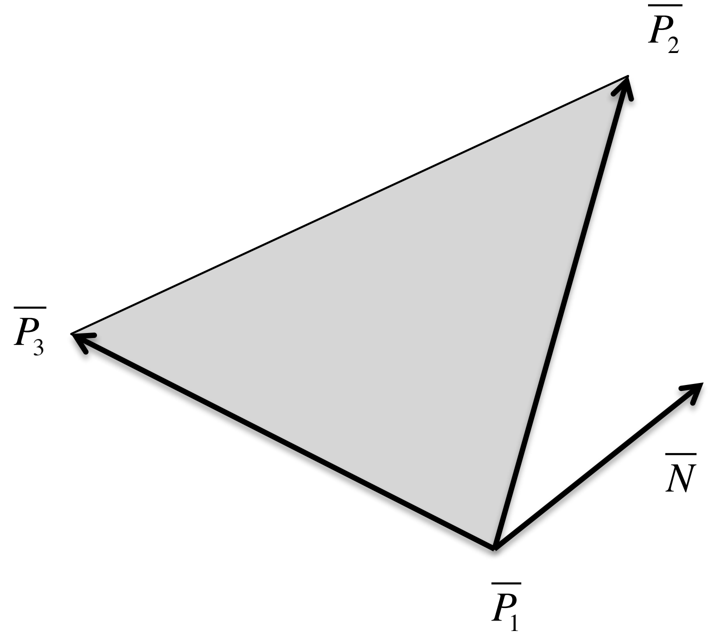
Shading – computation of the surface colors

Shading parameters:

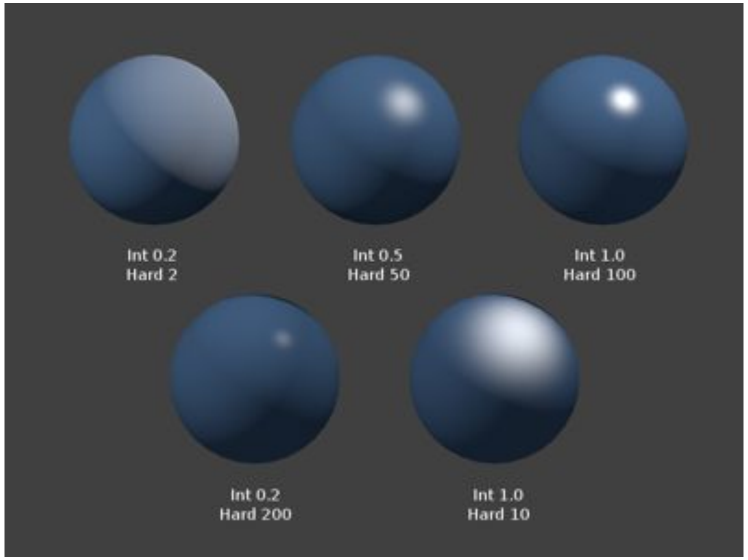
- material parameters,
- light sources,
- normal vectors
- textures,
- camera parameters.

Normal vectors

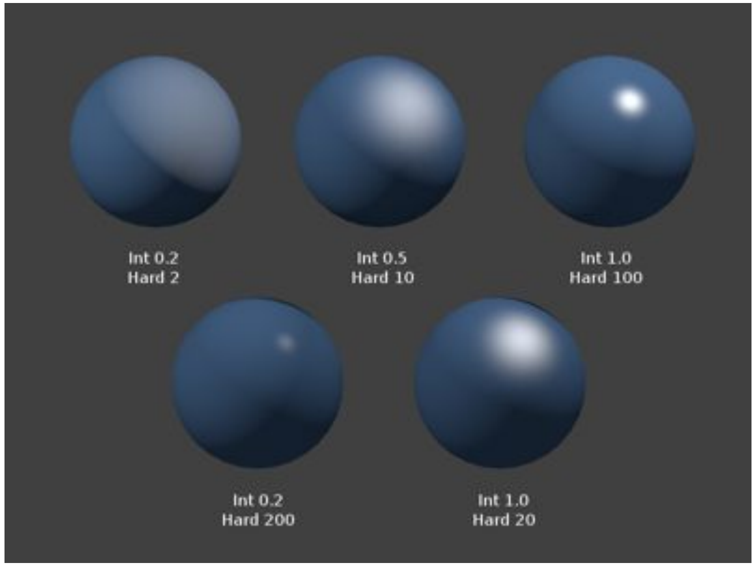




$$\overline{N} = (\overline{P}_2 - \overline{P}_1) \times (\overline{P}_3 - \overline{P}_1)$$



Cook-Torrence



Phong

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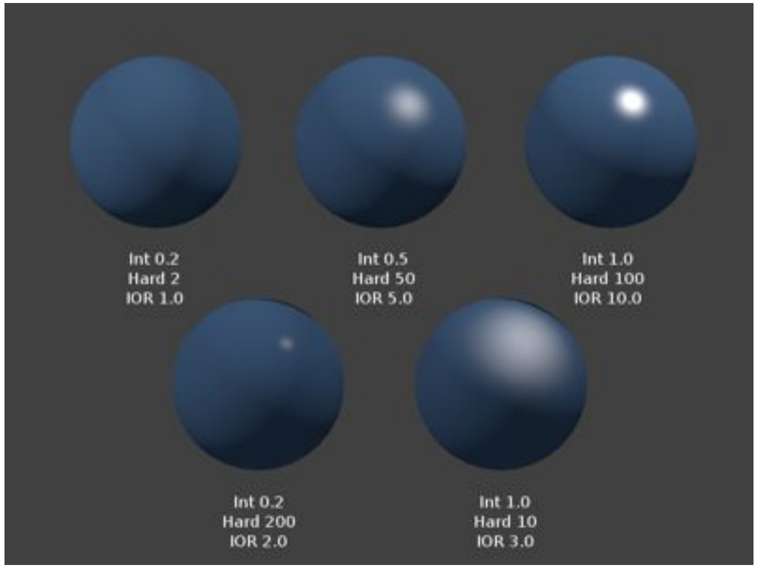
- Robert L. Cook, Kenneth E. Torrance, A reflectance model for computer graphics, 1982.
- Christophe Schlick, A Customizable Reflectance Model for Everyday Rendering, Fourth Eurographics Workshop on Rendering, 1993.



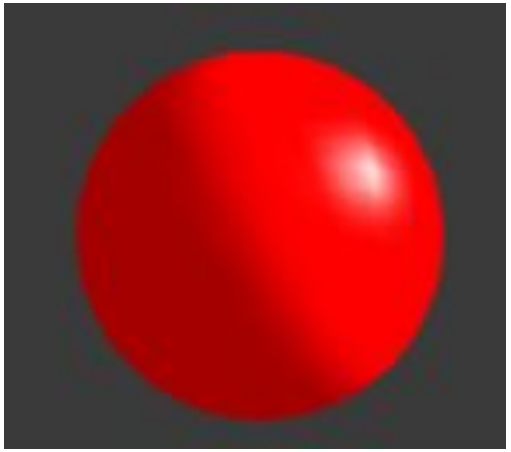
Blinn

Phong model: material parameters

ambient

ambient + specular

ambient + diffuse



ambient + diffuse + specular

Illumination equation (Phong model)

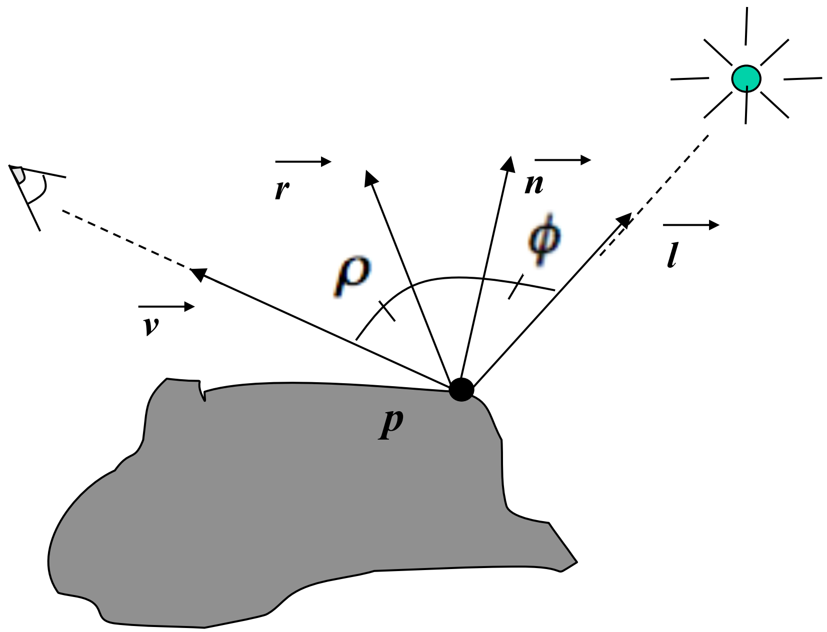
how to compute color of the point on the surface

$$i_{tot} = i_{amb} + \sum_{k=1}^{N} (i_{diff}^{k} + i_{spec}^{k})$$

$$i_{amb} = m_{amb} \cdot s_{amb}$$

$$i_{diff} = m_{diff} \cdot s_{diff} \cdot (\overline{l} \cdot \overline{n})$$

$$i_{spec} = m_{spec} \cdot s_{spec} \cdot (\overline{v} \cdot \overline{r})^{m_{shi}}$$



$$\vec{r} = 2(\vec{n} \cdot \vec{l})\vec{n} - 1$$

Ambient

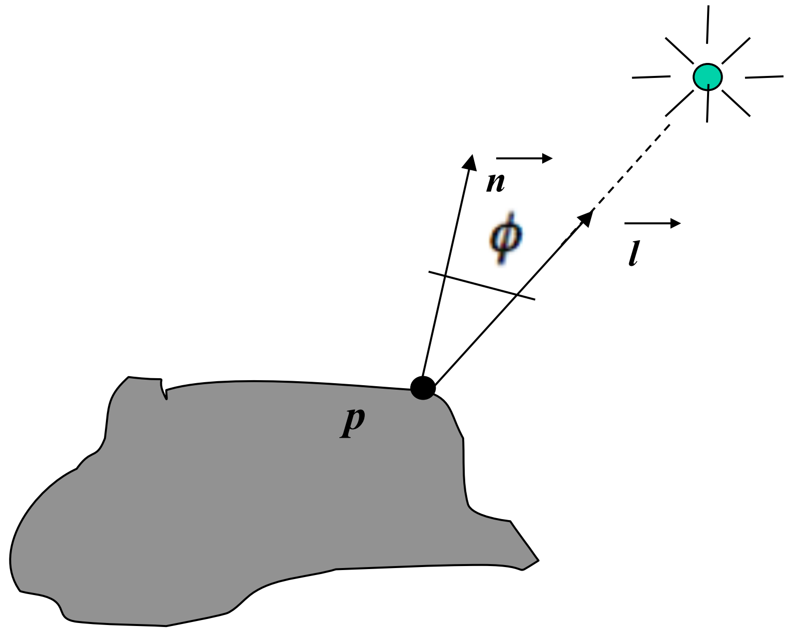
Rough approximation of the light traveling between surfaces.
Can be used to make the shadows not black.

$$i_{amb} = m_{amb} \cdot s_{amb}$$

Diffuse

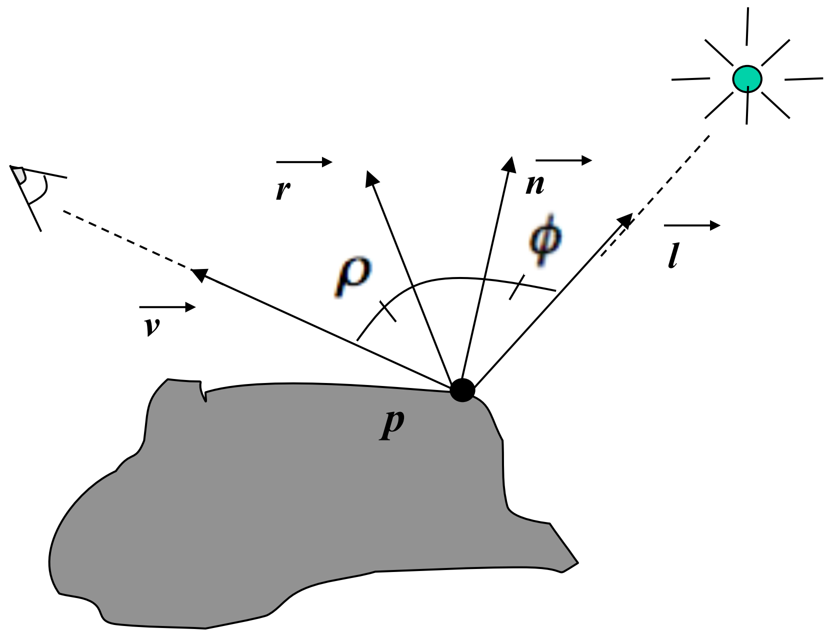
Lambert law – the amount of light reaching the surface is proportional to cosine of the angle between direction to the light and the normal vector of the surface

$$i_{diff} = m_{diff} \cdot s_{diff} \cdot (\bar{l} \cdot \bar{n})$$



Specular

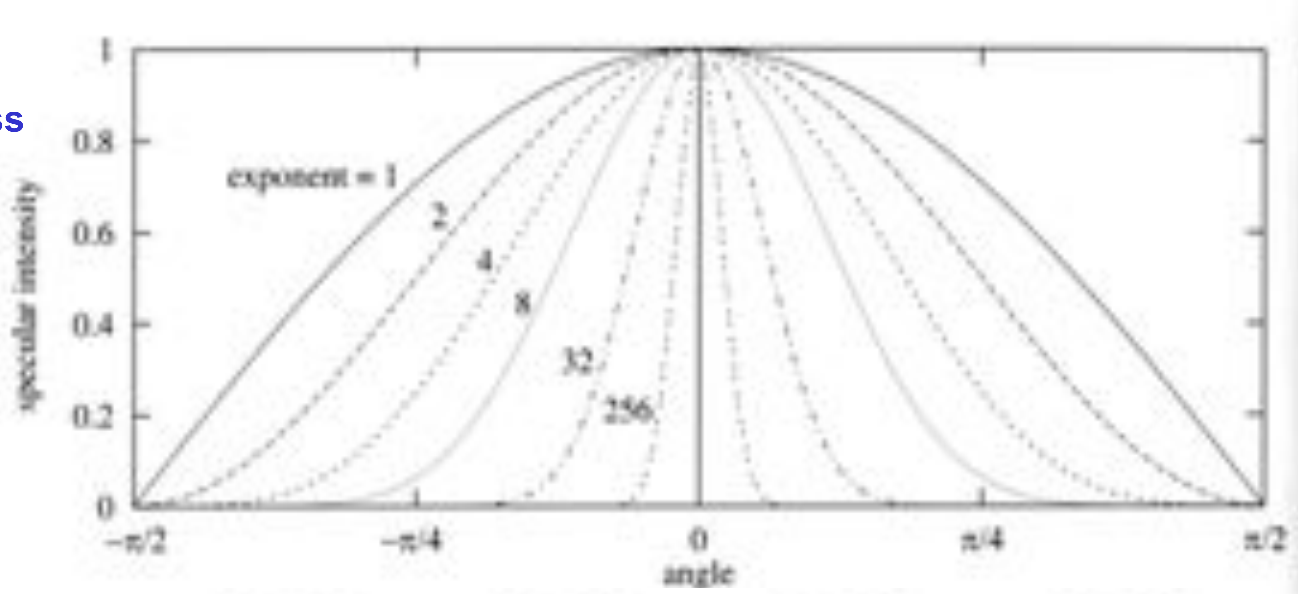
$$i_{spec} = m_{spec} \cdot s_{spec} \cdot (\overline{v} \cdot \overline{r})^{m_{shi}}$$

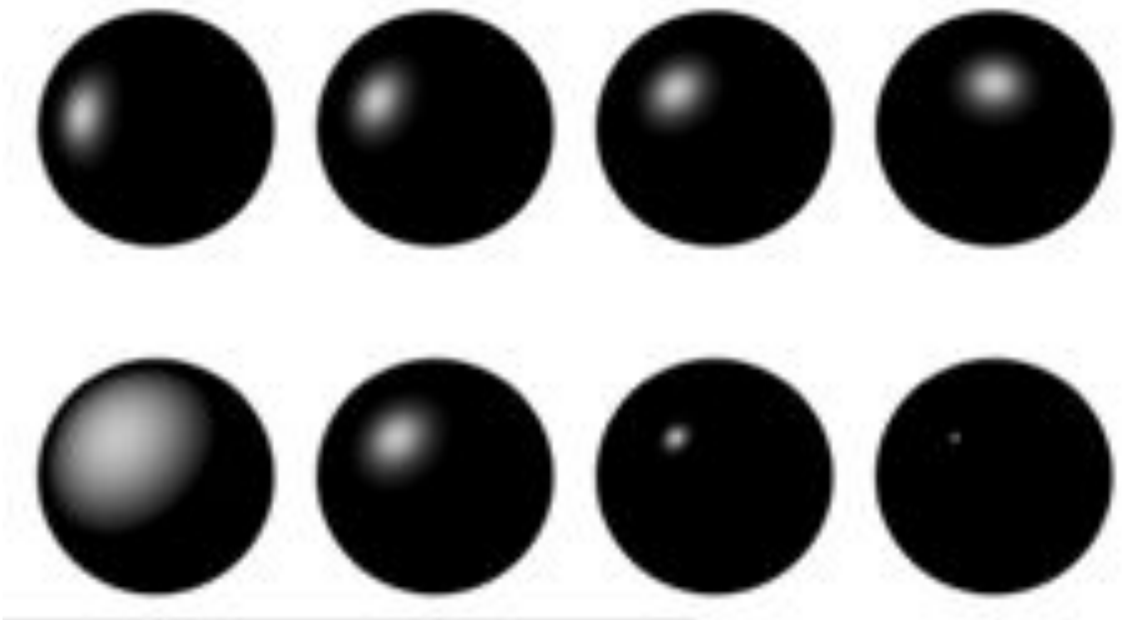


Location of observer is important

Specular highlights

shininess





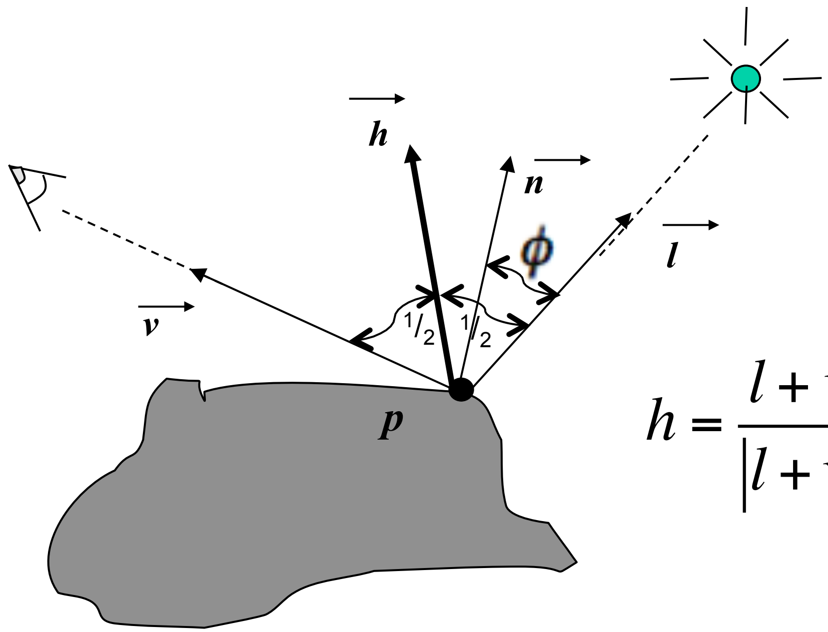
Illumination equation (Blinn model)

$$i_{tot} = i_{amb} + \sum_{k=1}^{N} (i_{diff}^{k} + i_{spec}^{k})$$

$$i_{amb} = m_{amb} \cdot s_{amb}$$

$$i_{diff} = m_{diff} \cdot s_{diff} \cdot (\bar{l} \cdot \bar{n})$$

$$i_{spec} = m_{spec} \cdot s_{spec} \cdot (\bar{n} \cdot \bar{h})^{m_{shi}}$$

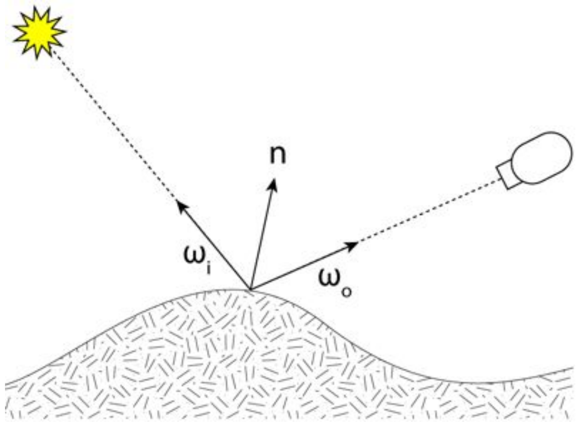


$$h = \frac{l + v}{|l + v|}$$

BRDF

Bidirectional Reflectance Distribution Function (BRDF

anizotropic surfaces



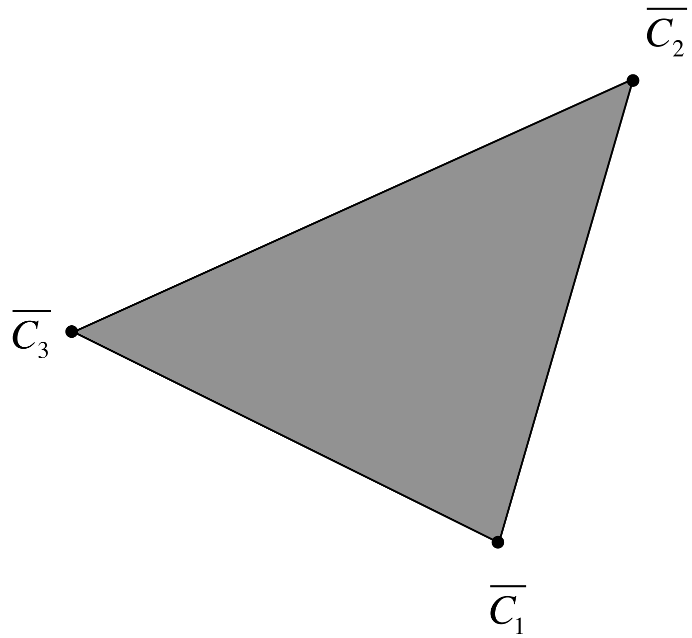
$$f_r(\omega_i,\omega_o) = \frac{dL_r(\omega_o)}{dL_i(\omega_i)\cos\theta_i d\omega_i}$$

Pictures courtasy of MIT, Lecture Notes 6.837

Flat interpolation

Arithmetic average

$$\overline{C} = \frac{\overline{C_1} + \overline{C_2} + \overline{C_3}}{3}$$

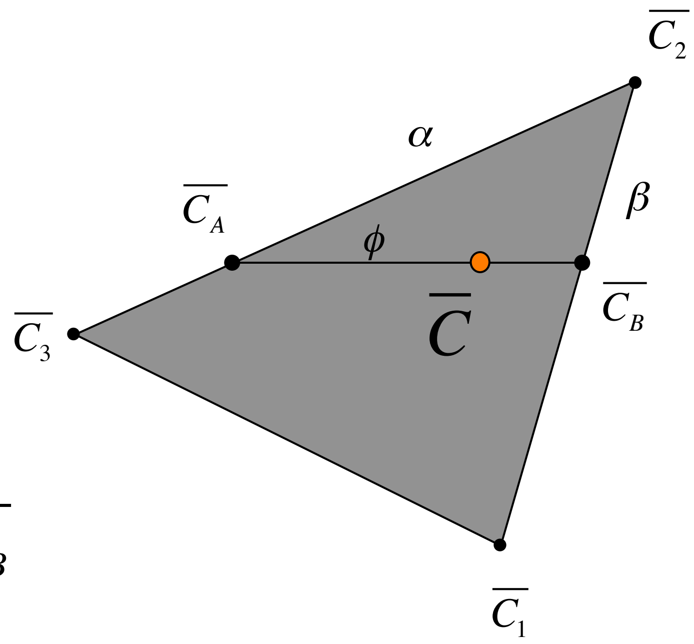


Gouraud interpolation

Linear interpolation

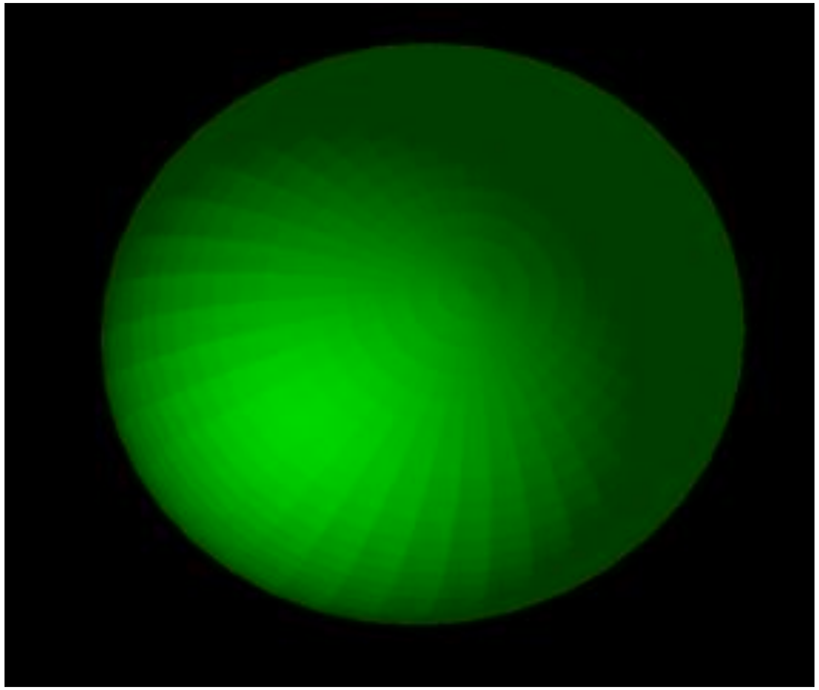
$$\overline{C_A} = \alpha \cdot \overline{C_3} + (1-\alpha) \cdot \overline{C_2}$$

$$\overline{C_B} = \beta \cdot \overline{C_1} + (1-\beta) \cdot \overline{C_2}$$

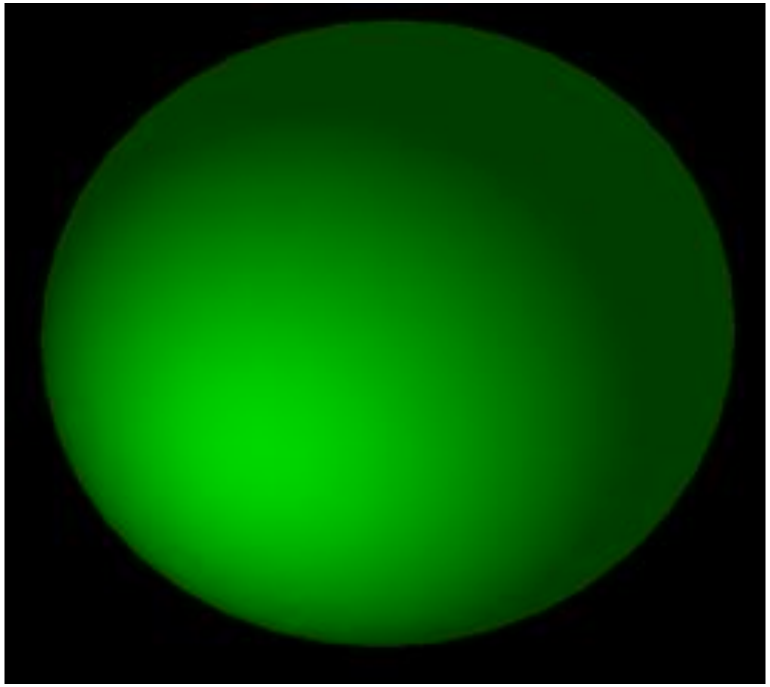


$$\overline{C} = \phi \cdot \overline{C_A} + (1-\phi) \cdot \overline{C_B}$$

Color interpolation

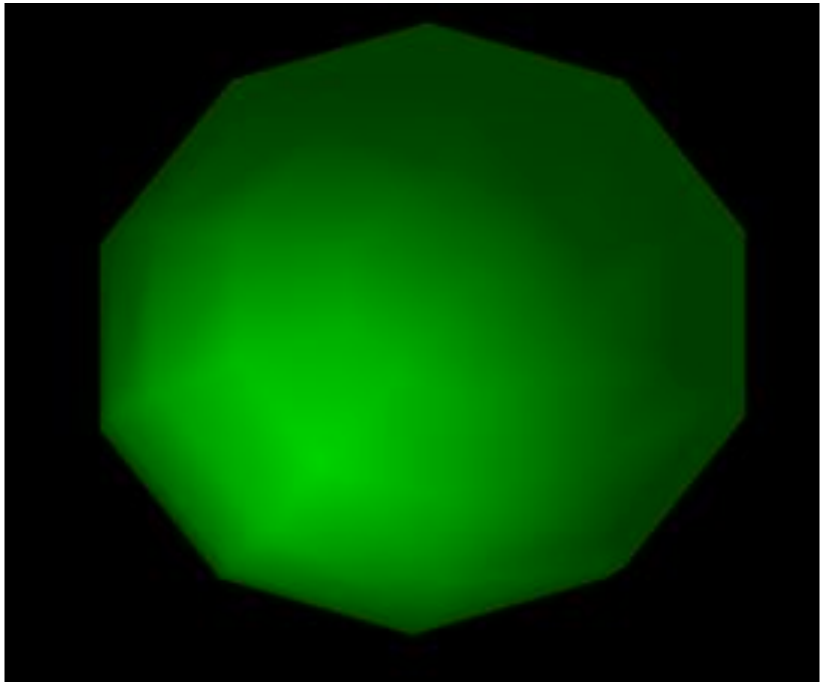


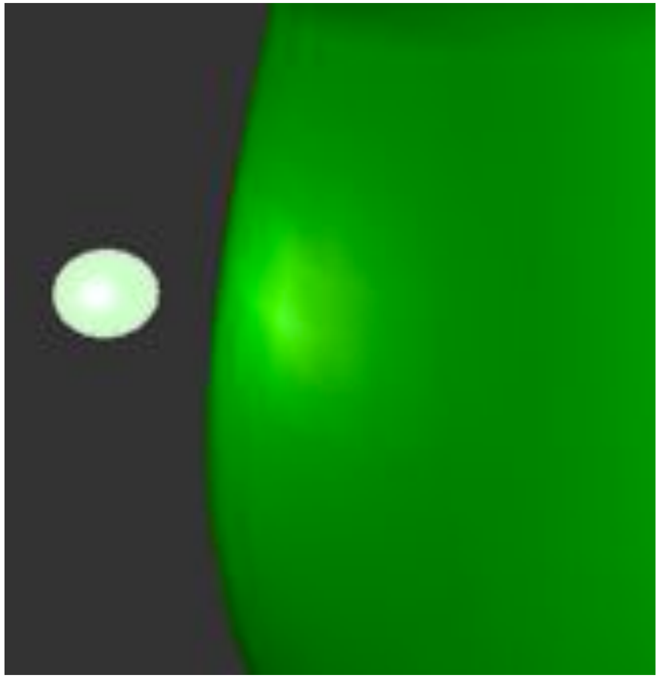
flat shading



Gouraud'a shading
(for the same number of triangles)

Interpolation



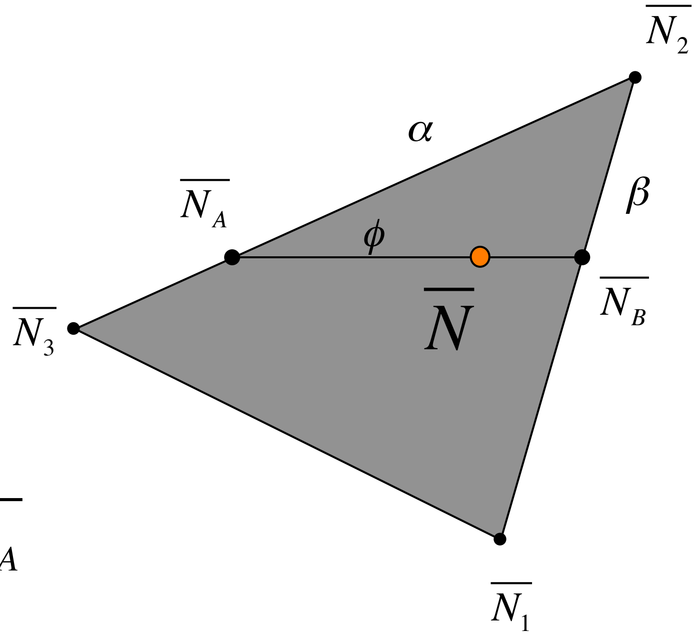


Gouraud shading - artefacts

Normal vector interpolation

$$\overline{N_A} = \alpha \cdot \overline{N_3} + (1-\alpha) \cdot \overline{N_2}$$

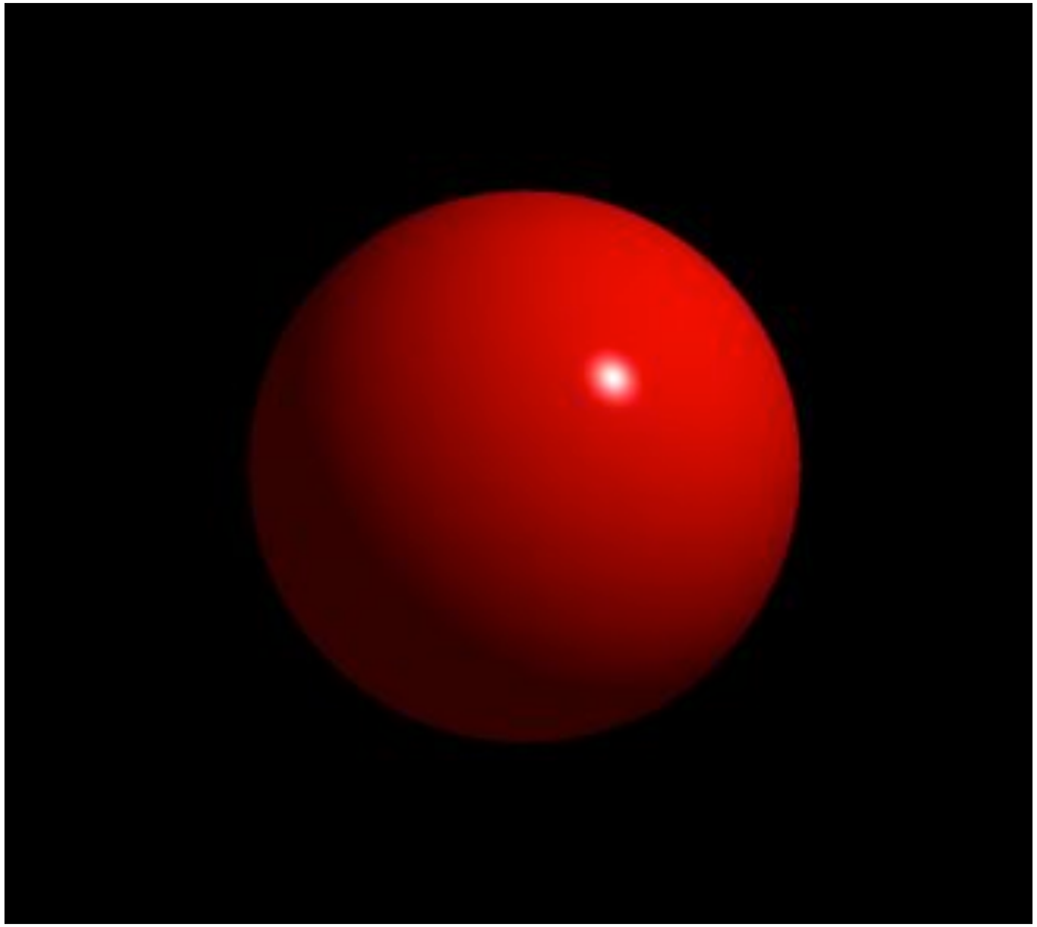
$$\overline{N_B} = \beta \cdot \overline{N_1} + (1-\beta) \cdot \overline{N_2}$$



$$\overline{N} = \phi \cdot \overline{N_B} + (1-\phi) \cdot \overline{N_A}$$

Per pixel shading

illumination equation is solved for each pixel



Literatura

1. Tomas Moller, Eric Haines, Real-Time Rendering, A K Peters, ISBN 1-56881-101-2