Art & Science of Shadows
Cast Shadows

Size and sharpness of a cast shadow depends on:
• Size of the light source
• Distance from light to object
• Distance from light to wall
Cast Shadow for Directional Light

A directional light has parallel light rays so the cast shadow is simple to trace on the wall. Dark shadow called the **umbra**.

Shadow is sharp (not fuzzy).
Light rays spread out from a point light source, such as a bright light bulb or a candle.

Size of shadow depends on:
* Distance from the light to object
* Distance from object to wall

Shadow is sharp (not fuzzy).
Cast Shadow for Area Lights

Rays from a large light source to wall to map out location of deep shadow (umbra) and fuzzy shadow (penumbra).

The larger the light source, the smaller the umbra.
Solar Shadows

The width of the penumbra for a shadow cast by the Sun equals about 1% of the distance from the object to its shadow.

Example: If an object is 9 feet (108 inches) from the ground, the penumbra is a little more than 1 inch wide.
Umbra and Penumbra

An ant on the ground standing in the penumbra could see part of the sun.

Standing in the umbra part of the shadow, the ant wouldn’t see the sun at all.
Penumbra Size

Notice how the size of the shadows’ penumbra increases as the shadow gets farther from the base of the tree.

Very far from the base the penumbras on each side meet and there’s no more umbra.
Penumbra and Distance

Notice how the cast shadow of Ellie’s arm is sharp while the shadows of the leaves of the tree on their faces are fuzzy.

The farther the object is from the light, the wider the penumbra.
Spot Light in Maya

Cone, cube, sphere on a table lit with single spot light.

Penumbra = -10°

Penumbra = +10°

Light cone is 60°
No shadows mentalray render
Spot Light in Maya

Cone, cube, sphere on a table lit with single spot light.

Light cone is 60° -10° penumbra
Raytrace shadows mentalray render
Reflections and Shadows on Water

Reflections and shadows on water depend on the surface’s smoothness, on the water’s clarity and on the light.
Reflections and Shadows on Water

Strong reflection and no shadow on calm, clear water

Weak reflection and shadow on rippled or muddy water

No tree shadow

Tree shadow
Clean Water versus Muddy Water

- Weak reflection on calm, flat water
- Cast shadow on bottom

- Strong reflection and highlight
- Cast shadow on surface
Shadows in Water

For the clear water the shadows are cast on the bottom of the pool.

In muddy water the shadows are cast on the surface.
Refraction of Shadow

Shadow bends due to refraction of light rays crossing the surface of the water.
Milky Water versus Muddy Water

- **No visible reflection**
- **Strong reflection**

- **Diffuse cast shadow with blue edge on surface**
- **Sharp cast shadow with sharp edge**
Reflections & Shadows in Water

Both the reflections and the shadows tell us a great deal about the water in the scene.
Fog Shadows

Shadow seen due to scattering by fog of the non-shadowed light rays.
Sun Rays

See rays because part of the light is blocked by clouds.
Sun rays are “inverse” fog shadows created by the openings in clouds.

Sun Rays in Paintings

Braddon Varde

Aidan Sugano
Sun Rays & Perspective

Light from the sun is nearly parallel so we see spreading ray pattern due to perspective.
Sun Rays & Perspective

This is what you think you see
Sun Rays & Perspective

This is what the sun’s rays are actually doing
Sun Rays & Perspective

Compare reality with perception
Sun rays appear in front of these mountains, given the position of the clouds.
Colored Shadows

An outdoor shadow may look blue due to the ambient light of the blue sky.
Demo: Colored Shadows

Separate shadows for the green and magenta light sources

Magenta = Red + Blue so
White = Green + Magenta
Simultaneous Contrast

An outdoor shadow may also look blue due to simultaneous contrast.

Direct sunlight
Simultaneous Contrast

The green circles are identical in hue, saturation, and value. That is, they’re exactly the same color.

The bright yellow background makes the green circle look slightly darker and bluer.

The dark cyan background makes the green circle look slightly lighter and yellower.
Simultaneous Contrast

The green circles are identical in hue, saturation, and value. That is, they’re exactly the same color.

The bright yellow background makes the green circle look slightly darker and bluer.

The dark cyan background makes the green circle look slightly lighter and yellower.
Demo: 3D Shadows

Can create stereoscopic shadows by the anaglypht method

Green/Magenta
3D glasses

Anaglyph image of my office mess
Demo: Colored Shadows

Shadow looks stereoscopic and appears to move out of the sheet as the object is moved.
See you at the next workshop on April 15th