Ray Tracing reflective objects

1 Reflection Geometry

When a ray from the eye hits a reflective surface, such as a mirror, a secondary reflection ray is generated to determine the color contributed by other objects in the scene.

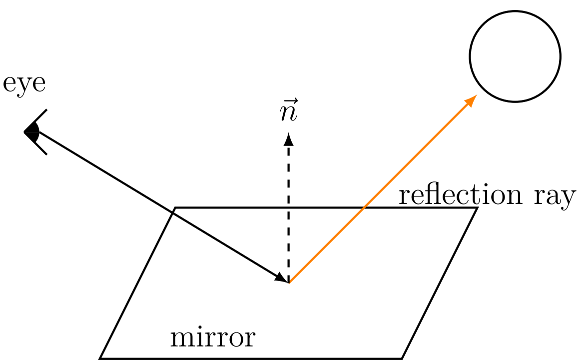


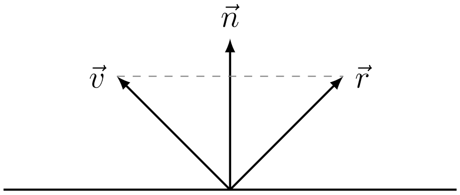
Figure 1: Conceptual diagram of a reflection ray bouncing off a mirror toward a scene object.

The final color of a reflective surface is a blend between the surface's intrinsic shaded color and the color returned by the reflection ray. The final color is calculated using the following linear interpolation:

$$C = C_o + \beta(C_r - C_o) \tag{1}$$

- **Shade surface color** (C_o): The base color of the object.
- **Shade reflection ray** (C_r): The color detected by the reflection ray.
- **Reflectance** (β): A value in the range $[0, 1]$ determining how reflective the surface is.
- If $\beta = 0$, the color is entirely the base color (C_o), representing a non-reflective surface.
- If $\beta = 1$, the color is entirely the reflected color (C_r), representing a perfect mirror.

2 Reflected direction



The reflection vector $\vec{r}$ can be derived using the incident vector $\vec{v}$ and the surface normal $\vec{n}$. We have $\|\vec{n}\| = \|\vec{v}\|$ and must ensure $\|\vec{r}\| = 1$. Note that the midpoint is on the normal vector.

$$\frac{\vec{v} + \vec{r}}{2} = a\vec{n} \tag{2}$$

Solve by taking the dot product with $\vec{n}$ and noting that $\vec{v} \cdot \vec{n} = \vec{r} \cdot \vec{n}$.

$$\vec{v} \cdot \vec{n} = a \tag{3}$$

The reflection vector $\vec{r}$ is calculated as:

$$\vec{r} = 2(\vec{v} \cdot \vec{n})\vec{n} - \vec{v} \tag{4}$$

This ensures that the angle of incidence equals the angle of reflection, where $\vec{e} \cdot \vec{n} = \vec{r} \cdot \vec{n}$.