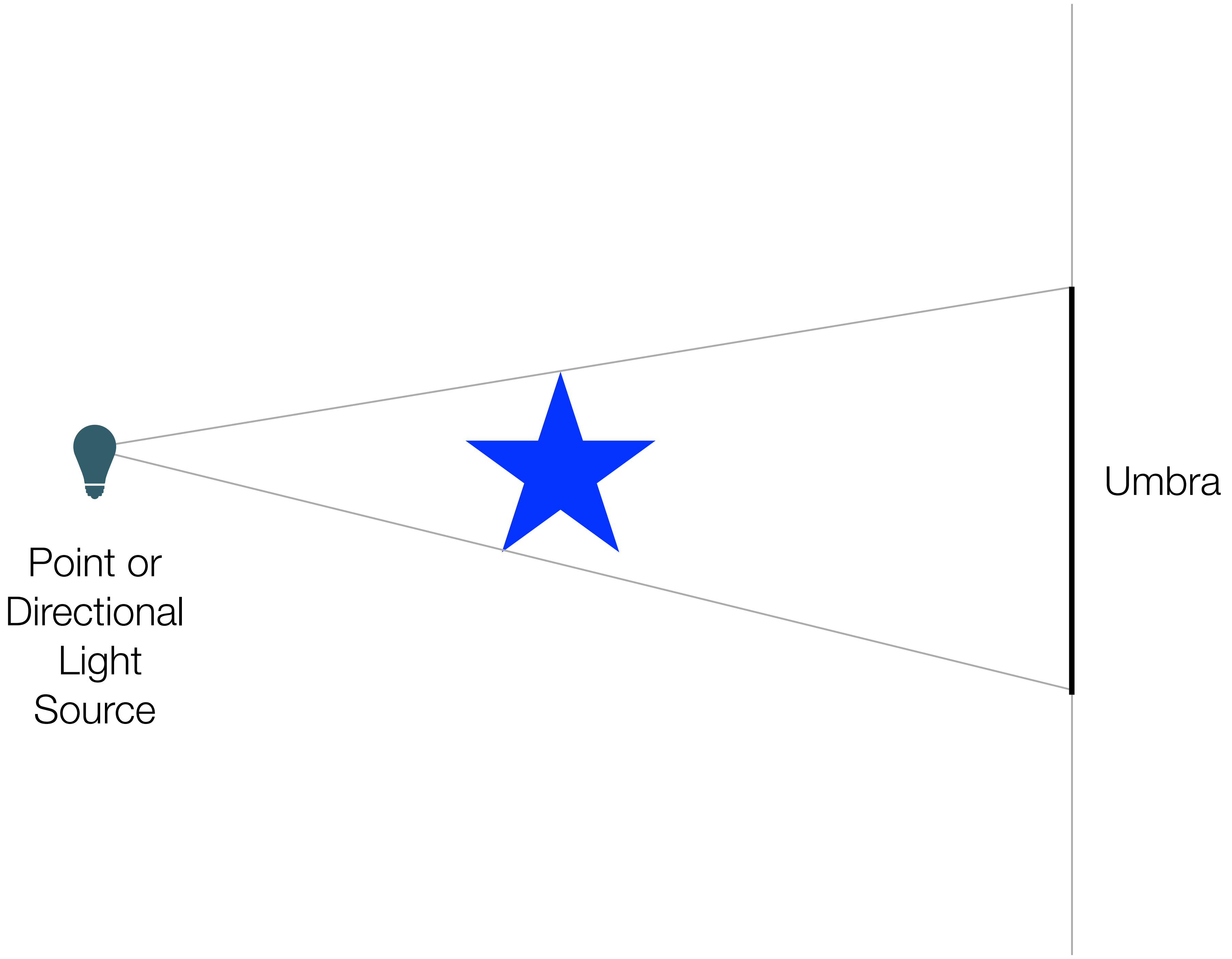
Shadows

CS 385 - Class 26
28 April 2022

Anatomy of a Shadow

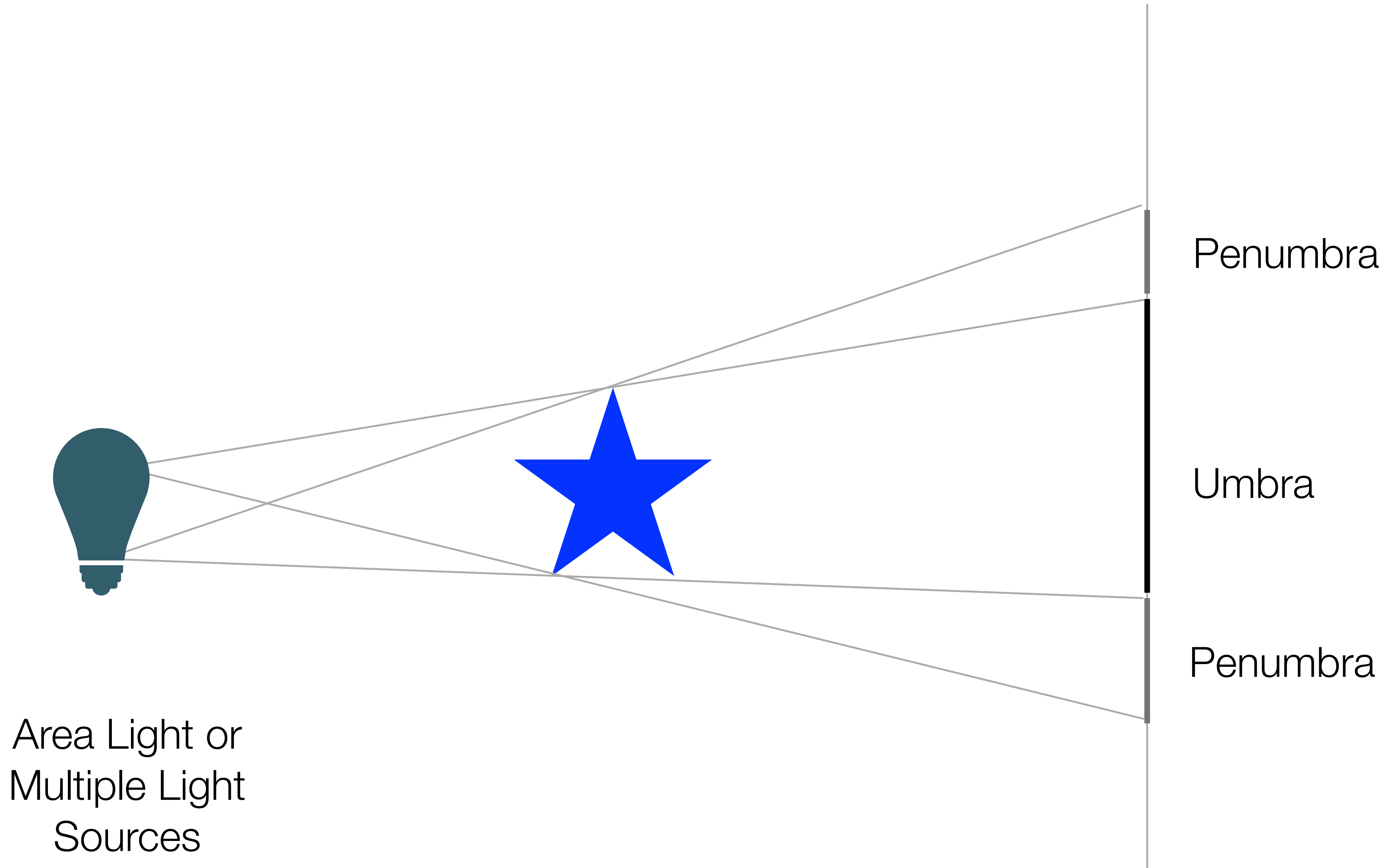
Shadow Parts

- The dark part of a shadow is called the *umbra*



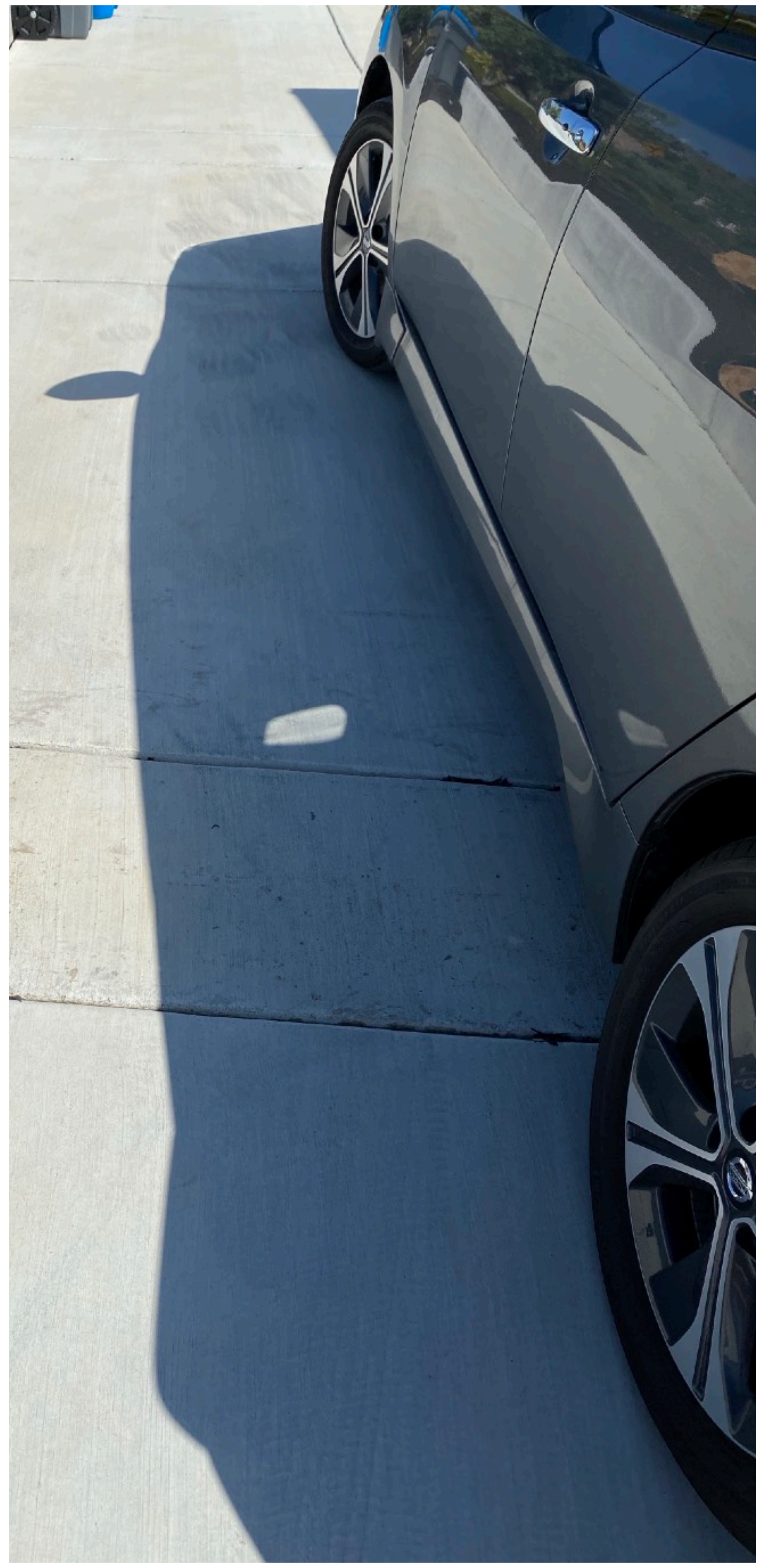
Shadow Parts

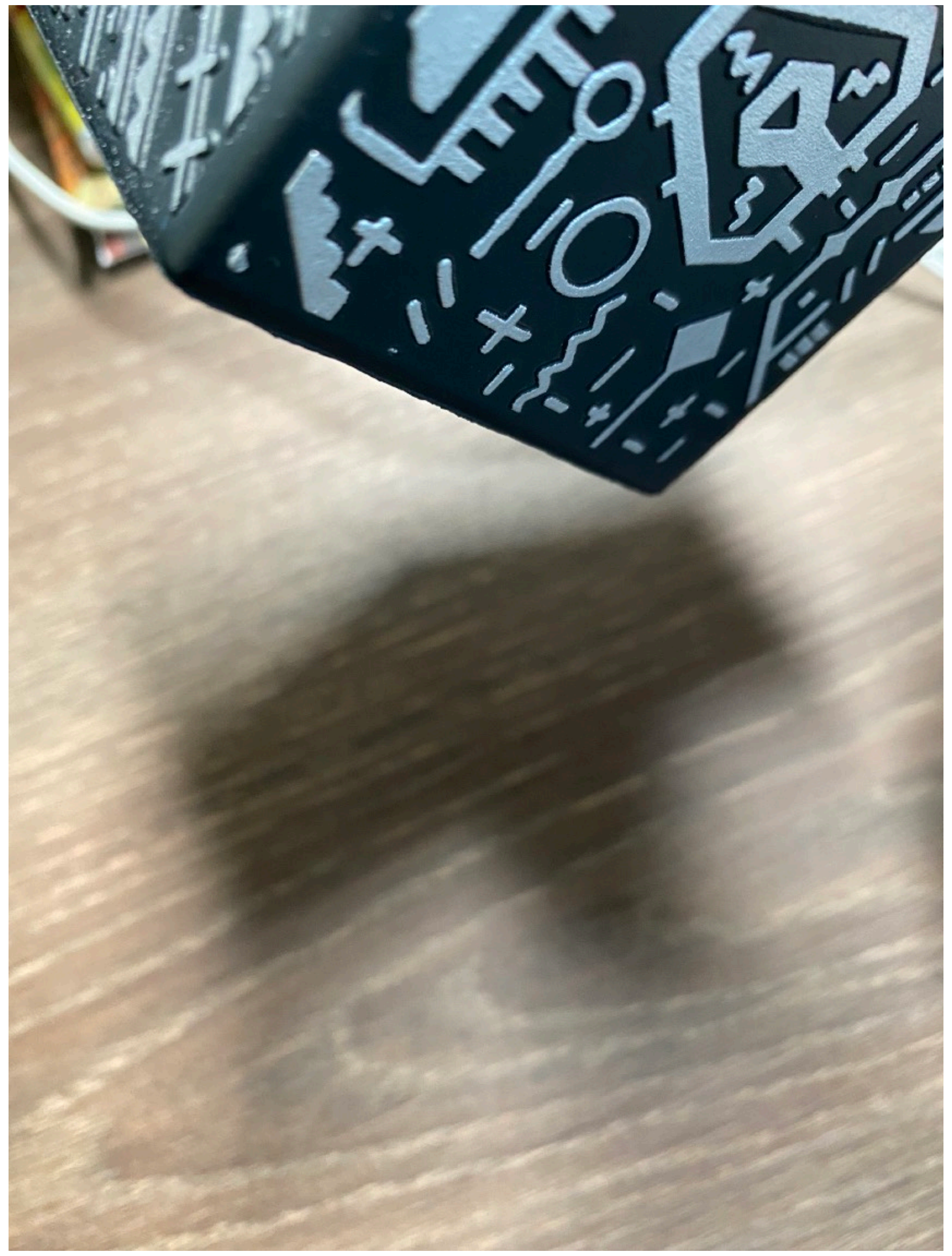
- The dark part of a shadow is called the *umbra*
- The less dark part is called the *penumbra*



What Nature Thinks ...

- The dark part of a shadow is called the *umbra*
- The less dark part is called the *penumbra*
- Point lights and directional lights will only generate an umbra
- Area lights, or multiple point lights will also generate a penumbra

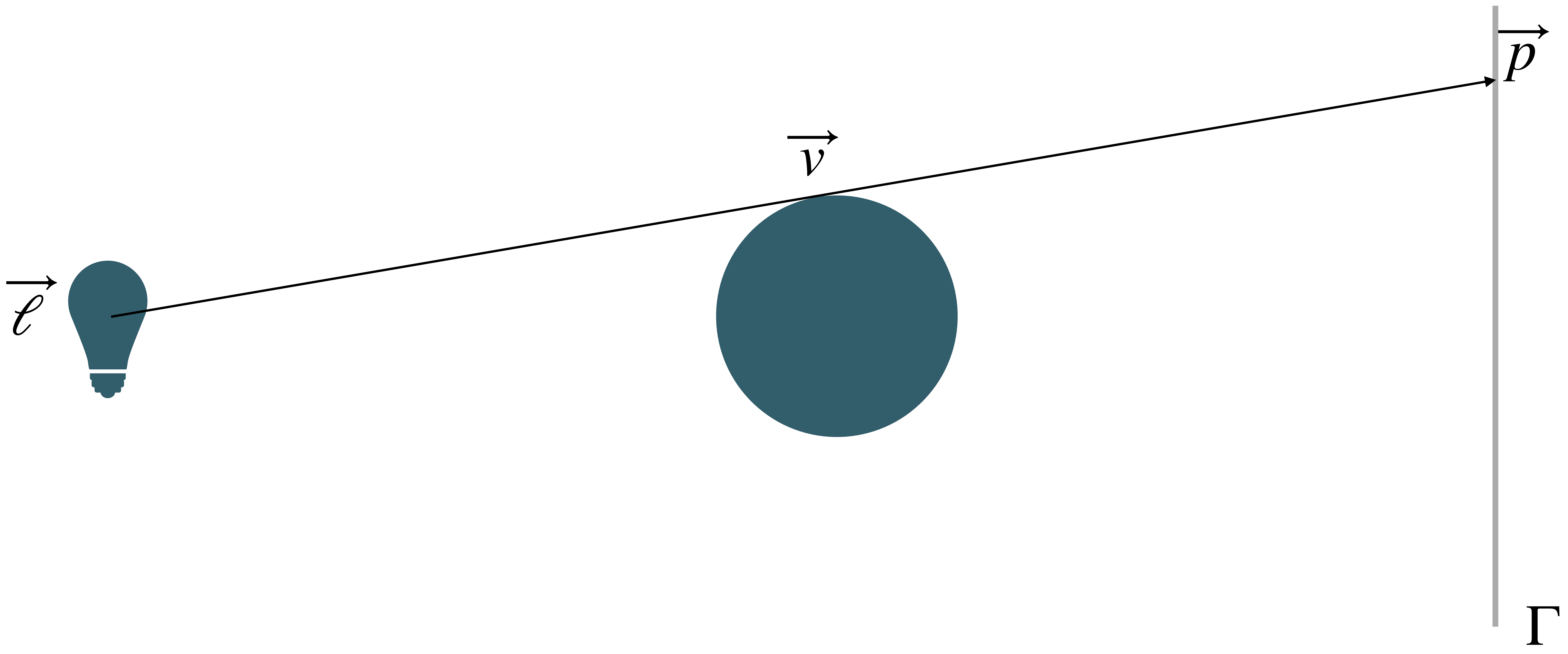




Planar Shadows

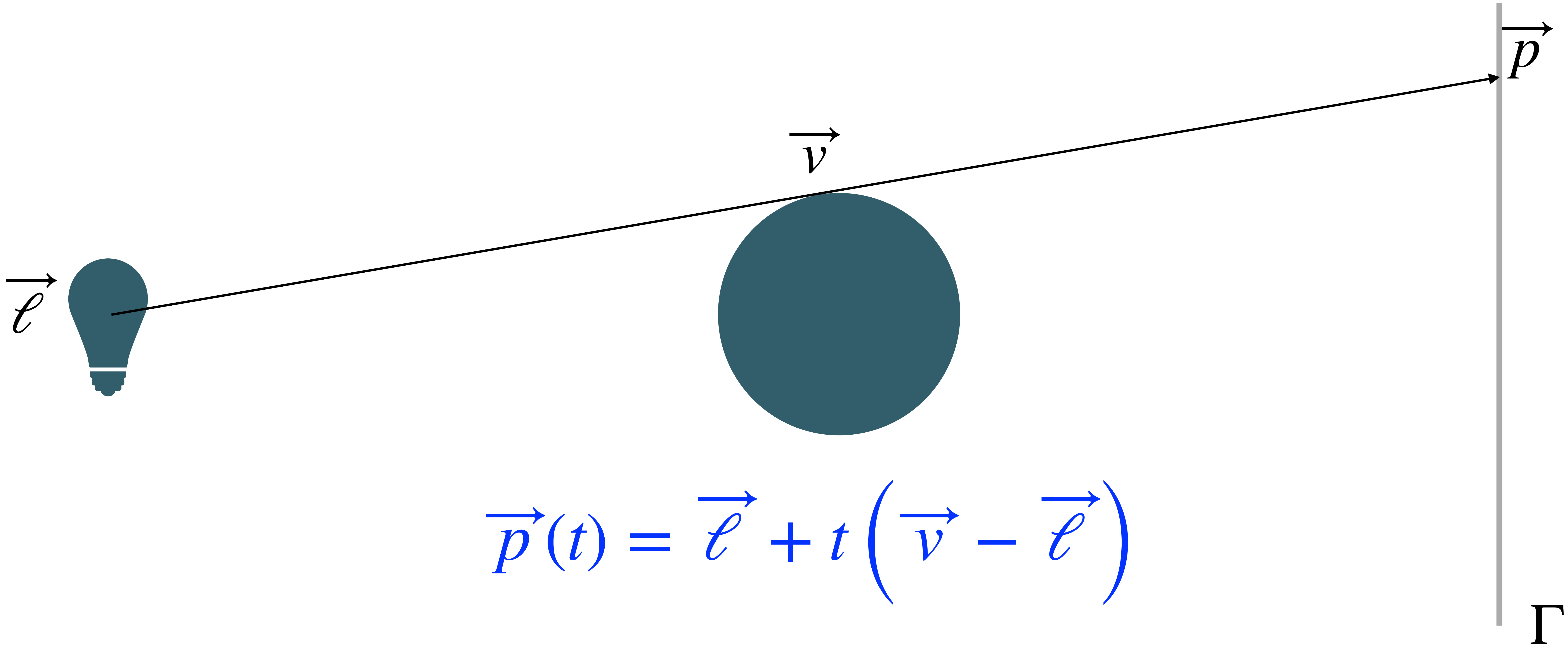
Basic Geometry of Planar Shadows

Find $\overrightarrow{p}$, given we know $\overrightarrow{\ell}$, $\overrightarrow{v}$, and the plane Γ



Basic Geometry of Planar Shadows

$\overrightarrow{p}$ lies on the line between $\overrightarrow{\ell}$ and $\overrightarrow{v}$

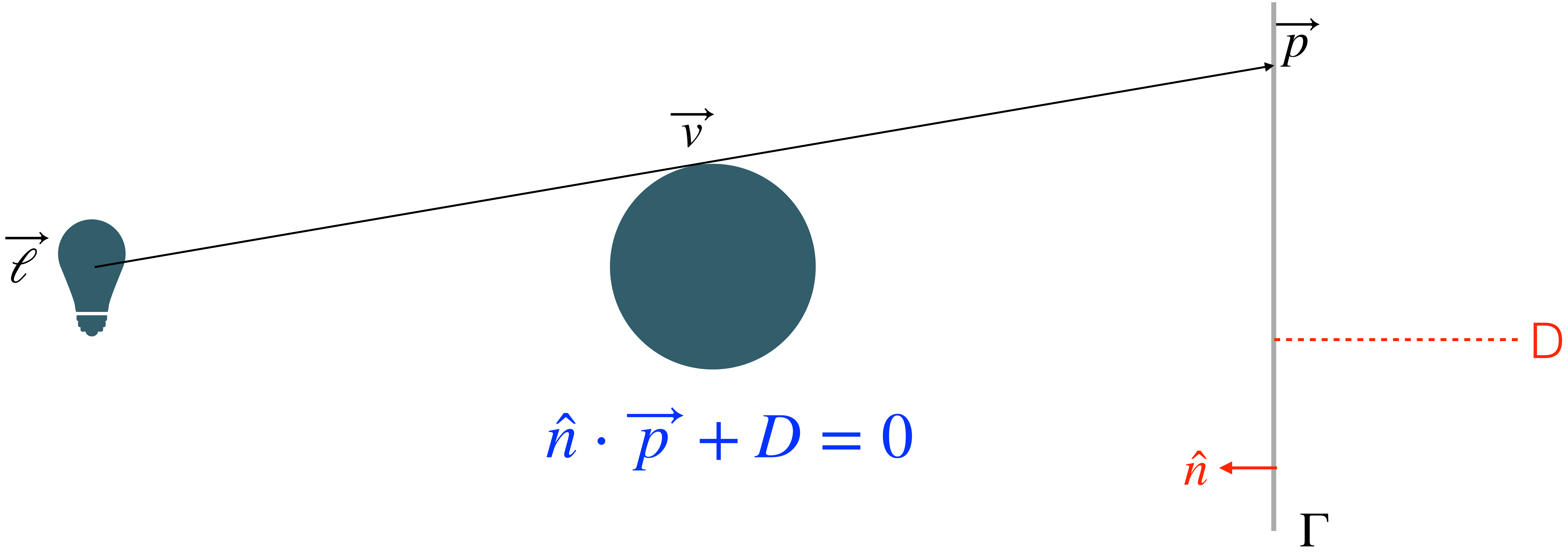


$$\overrightarrow{p}(t) = \overrightarrow{\ell} + t\left(\overrightarrow{v} - \overrightarrow{\ell}\right)$$

often, we'll normalize $\overrightarrow{v} - \overrightarrow{\ell}$ and call it $\hat{d}$

Basic Geometry of Planar Shadows

But we also know the equation of the plane Γ, that $\overrightarrow{p}$ lives on



$$\hat{n} \cdot \overrightarrow{p} + D = 0$$

Basic Geometry of Planar Shadows

Substitute, and

solve for t

$$\hat{n} \cdot \overrightarrow{p}(t) + D = 0$$

$$\hat{n} \cdot \left[\overrightarrow{\ell} + t\hat{d}\right] + D = 0$$

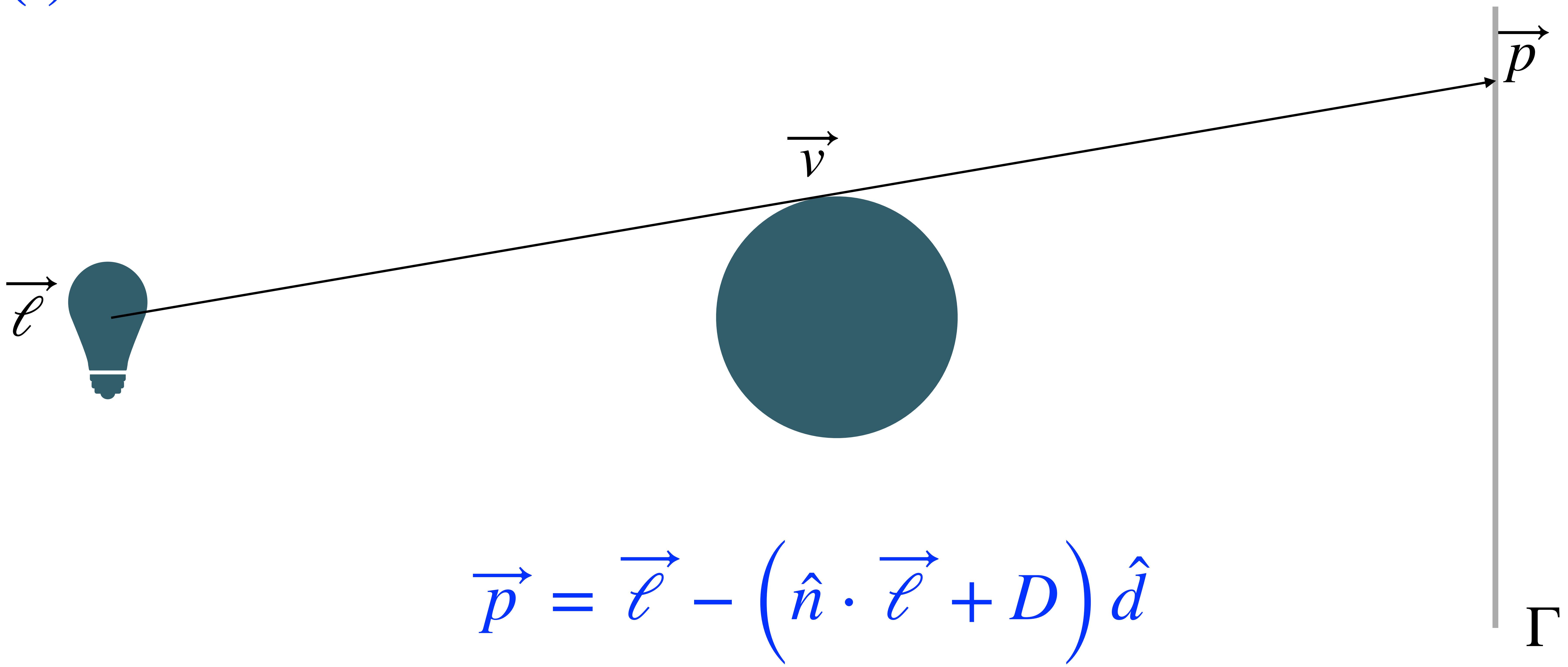
$$\hat{n} \cdot \overrightarrow{\ell} + \hat{n} \cdot t\hat{d} + D = 0$$

$$t = \frac{-\left(\hat{n} \cdot \overrightarrow{\ell} + D\right)}{(\hat{n} \cdot \hat{d})}$$

$$\boxed{t = -\left(\hat{n} \cdot \overrightarrow{\ell} + D\right)}$$

Basic Geometry of Planar Shadows

$$\overrightarrow{p}(t) = \overrightarrow{\ell} + t\hat{d}$$



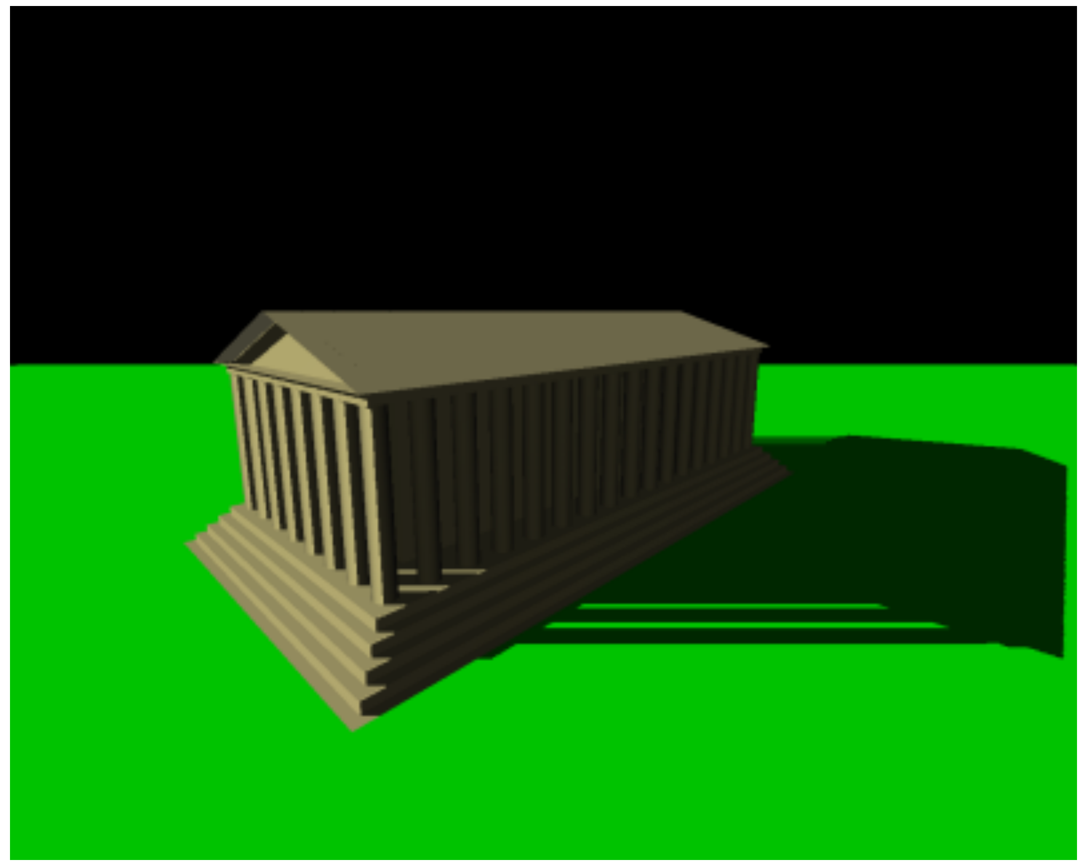
$$\overrightarrow{p} = \overrightarrow{\ell} - \left(\hat{n} \cdot \overrightarrow{\ell} + D\right)\hat{d}$$

(do this in the vertex shader)

Shadow Maps

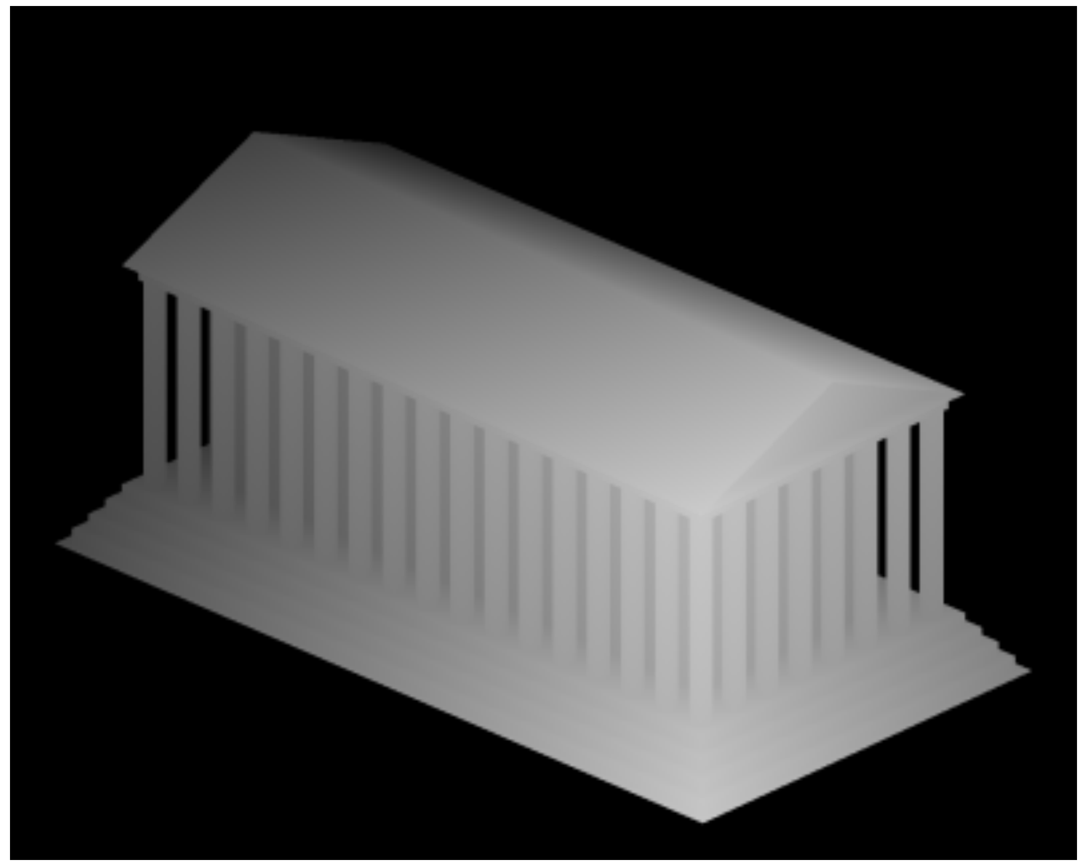
Shadow Rendering

- Multi-pass algorithm
  - one pass to generate the shadow map (depth texture)
  - one pass to shade the scene



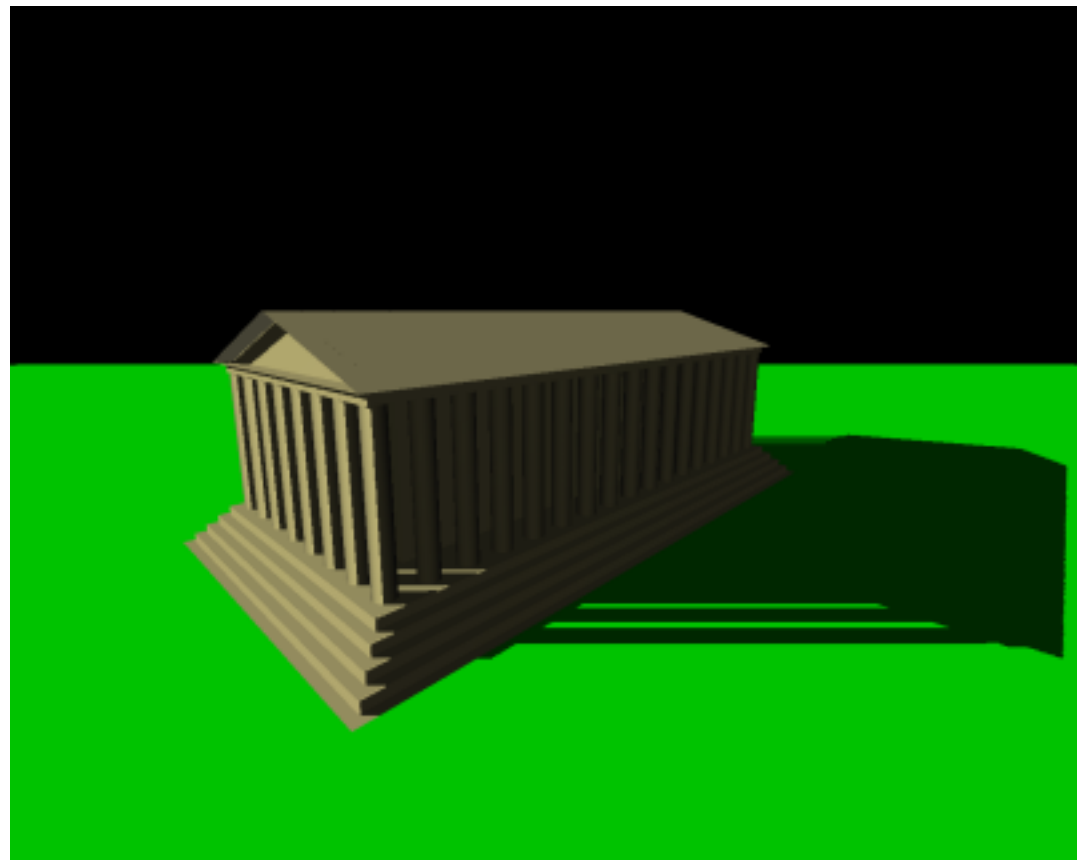
Depth Textures

- Single-channel texture map
- Distance from light to geometry at each pixel
- Just like rendering color, except:
    - use the light's position instead of the eye's position
    - record the depth, as compared to the fragment's color
        - this can be automatically done using a depth attachment to an FBO
- Often called a *shadow map*

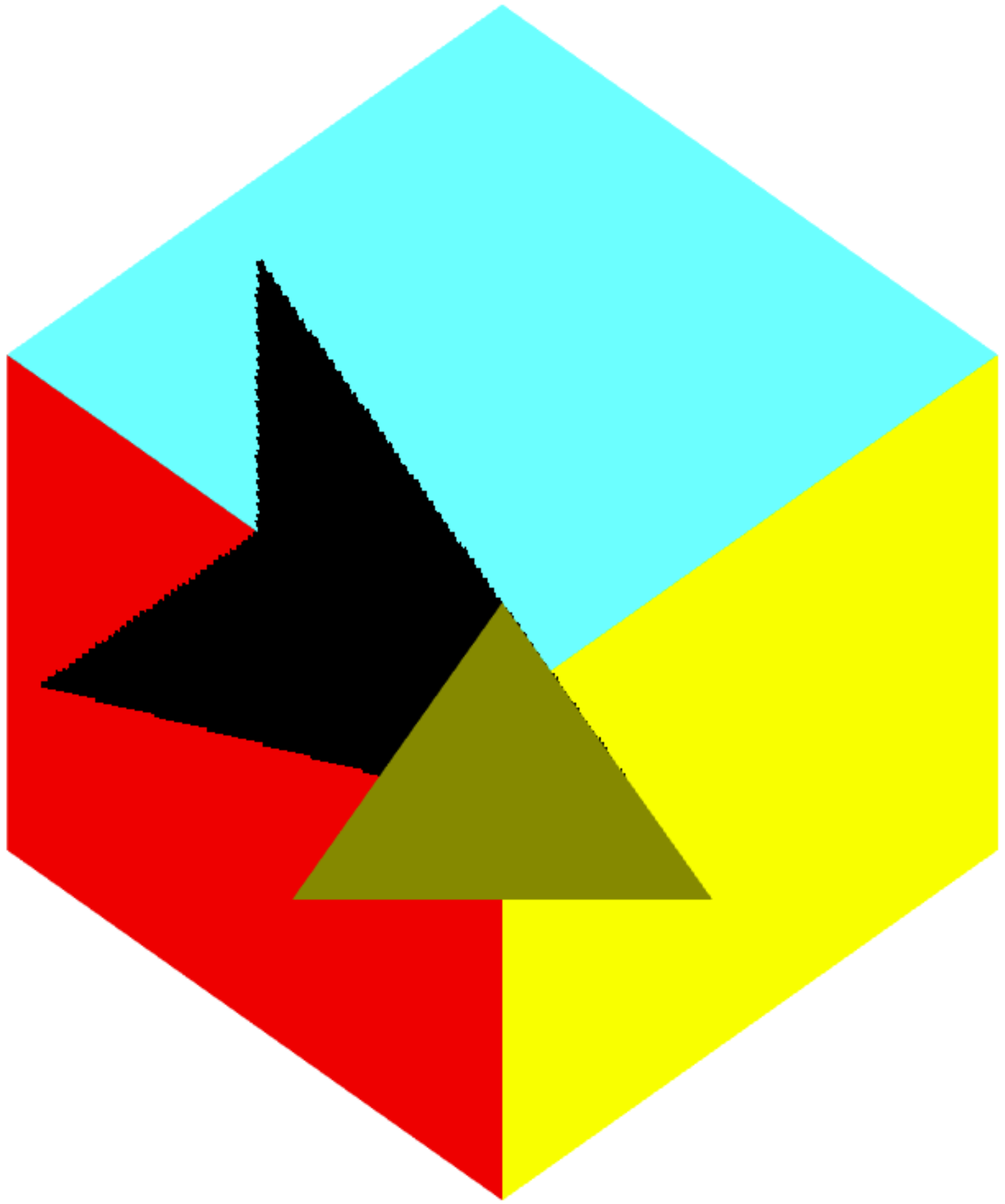


Shadow Rendering

- Render the scene as normal
- Modify the fragment shader to:
  - compute the distance to the object from the light
  - retrieve the shadow distance from the shadow map
- Compare the distances
  - if the shadow map value is less than the object distance, it's in shadow
  - otherwise, it's in the light, and illuminate accordingly



Demo!



Projected Textures

Demo!