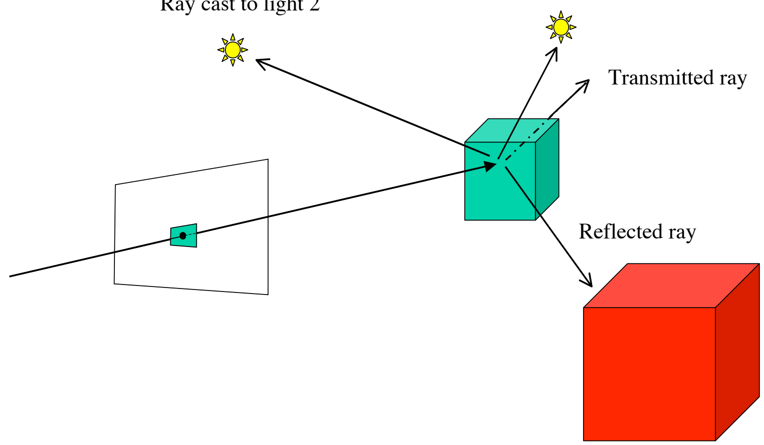
Recursive ray tracing

H&B, page 597



Recursive ray tracing rendering algorithm

- Cast ray from pinhole (projection center) through pixel, determine nearest intersection
- Compute components by casting rays
  - to sources = shadow ray (diffuse and for specular lobe)
  - along reflected direction = reflected ray
  - along transmitted dir = refracted ray
- Determine each component and add them up with contribution from ambient illumination.
- To determine some of the components, the ray tracer must be called **recursively**.

Recursive ray tracing rendering (cont)

- Recursion needs to stop at some point!
- Contributions die down after multiple bounces---there is no such thing as a perfect reflector---so we either set mirror reflections to be less than 100% (even if the user asks for 100%), or simply include an attenuation factor for each new ray.
- Can also model absorbtion due to light traveling in medium
  - Usually ignored in air, but depends on the application
  - Translucent absorption is exponential in depth

$$I = I_0 e^{-\alpha d}$$

- Recursion is stopped when contributions are too small
  - need to track the cumulative effect
  - common to also limit the depth explicitly

Mechanics

- Primary issue is intersection computations.
  - E.g. sphere, triangle.
- Polygon (should feel familiar!)
- Find point on plane of polygon and then determine if it is inside
  - One way is to make an argument with angles
  - Another way---thinking of the polygon as a surface of a polyhedra---is to check if the point is on the inside side of each of the other planes of the polyhedra.
- Sphere, relatively simple algebra (see book page 602)

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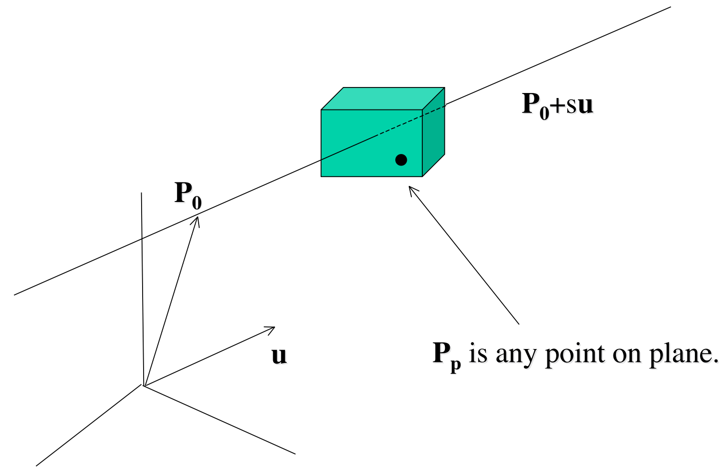
Poly details

May be helpful for A6.



Poly details

May be helpful for A6.

To find the intersection of the ray and the plane, solve:

$$\left(\mathbf{P}_0 + s\mathbf{u} - \mathbf{P}_\mathrm{p}\right) \bullet \mathbf{n} = 0$$

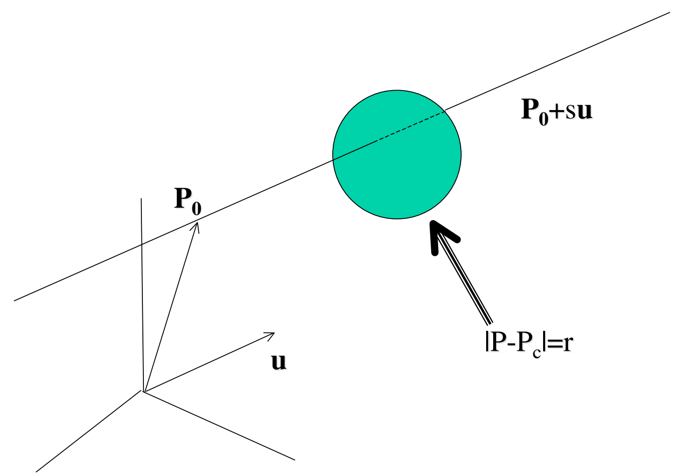
Once you have the point of intersection, $\mathbf{P}_\mathrm{i}$, test that it is inside by testing against all other faces.

$$\left(\mathbf{P}_\mathrm{i} - \mathbf{P}_\mathrm{p}\right) \bullet \mathbf{n} < 0$$

Note that **n** and $\mathbf{P_p}$ are now from those other faces.

Sphere details (H&B, 602)

May be helpful for grad version of A6.



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$$|\mathbf{P}_0 + s\mathbf{u} - \mathbf{P}_c| = r$$

$$|\Delta\mathbf{P} + s\mathbf{u}| = r$$

$$(\Delta\mathbf{P} + s\mathbf{u}) \bullet (\Delta\mathbf{P} + s\mathbf{u}) = r^2$$

$$\Delta\mathbf{P} \bullet \Delta\mathbf{P} - r^2 + 2s\Delta\mathbf{P} \bullet \mathbf{u} + s^2\mathbf{u} \bullet \mathbf{u} = 0$$

The last expression is easily solved using the quadratic equation. If the discriminant is negative (complex solutions), then the ray does not intersect the sphere.

Sphere details (H&B, 602)

May be helpful for grad version of A6.

Recall that if: $as^2 + bs + c = 0$

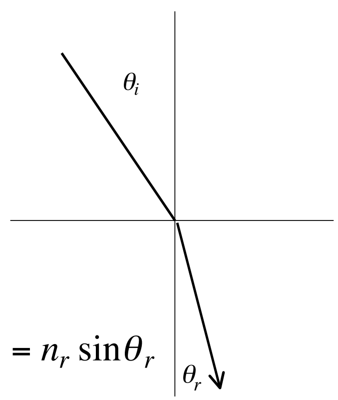
The “descriminant” is: $b^2 - 4ac$

The solution is: $s = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Note that in the book, **u** is a unit vector, so **u•u**=1, thus a=1, and b has a factor of 2 that is removed by dividing by 2a=2, to get equation 10-71.

Refraction Details

Index of refraction, n, is the ratio of speed of light in a vacuum, to speed of light in medium.



Typical values:

air:	1.00 (nearly)
water:	1.33
glass:	1.45-1.6
diamond:	2.2

$$n_i \sin\theta_i = n_r \sin\theta_r$$

The indicies of refraction for the two media, and the incident angle, θ_i, yield the refracted angle θ_r.