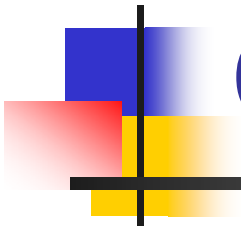
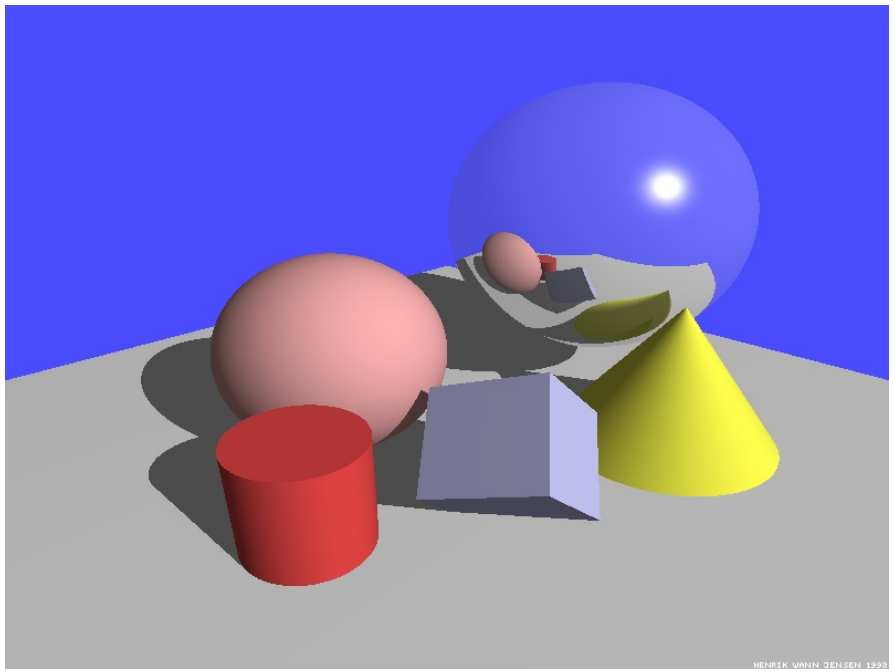
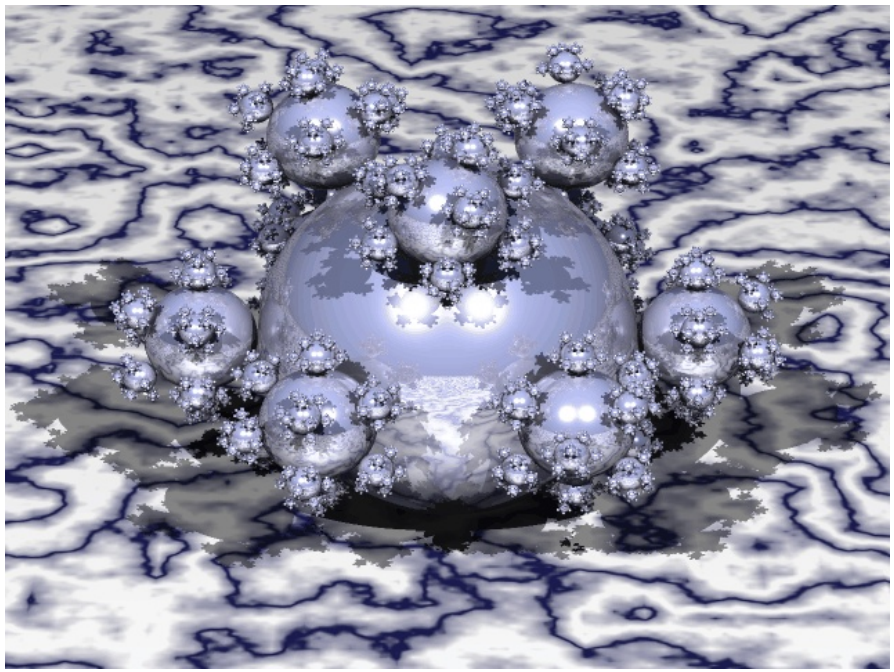


CS 112 - Ray Tracing

Illumination is not accurate

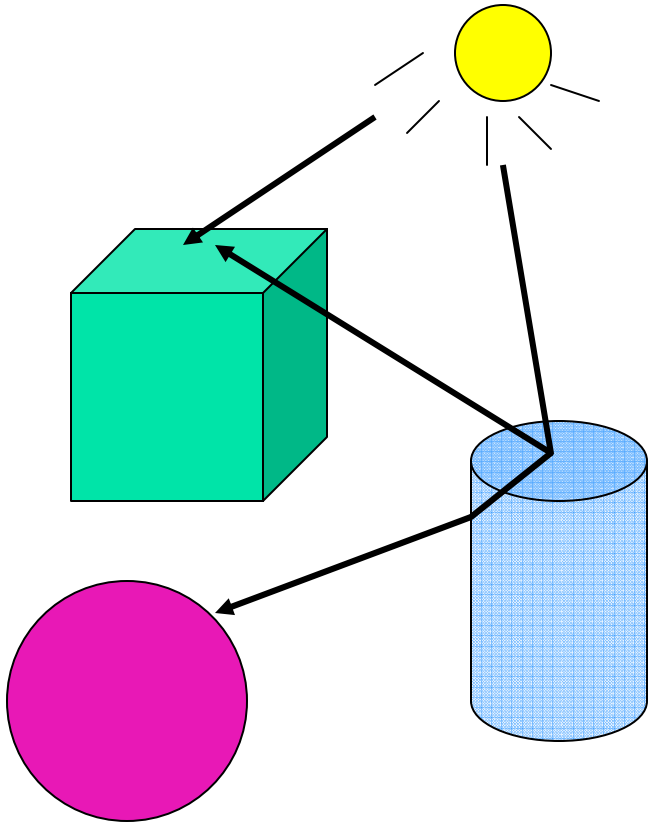




Cannot capture the effects of refraction, transparency and translucency accurately.

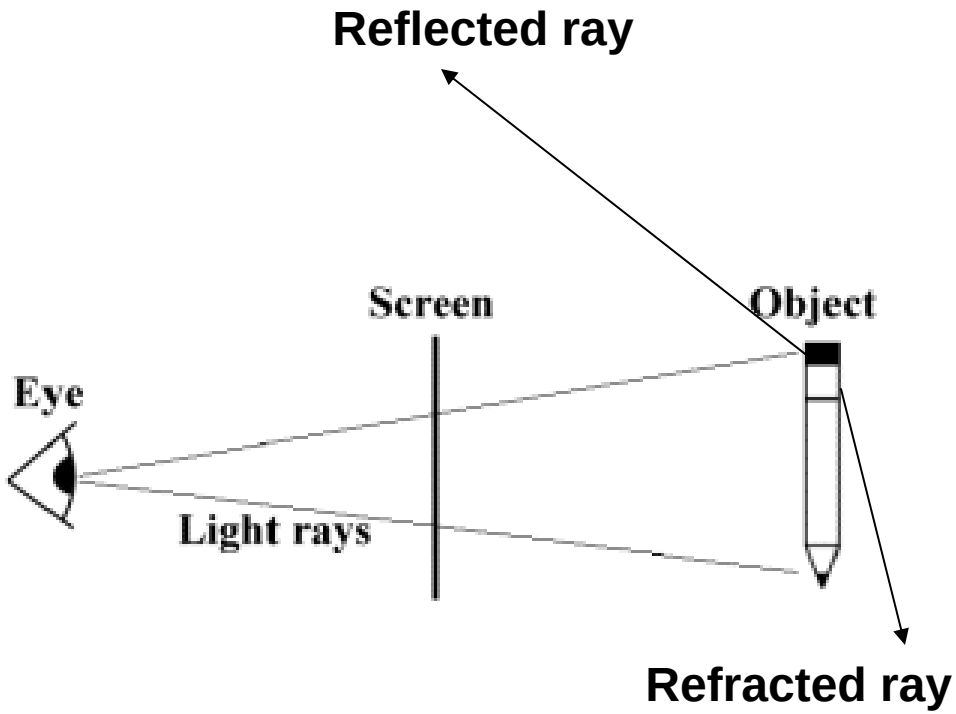
Direct and Indirect Illumination

- Capture only direct illumination
  - Light coming directly from light
- Light bounces from other objects in the scene



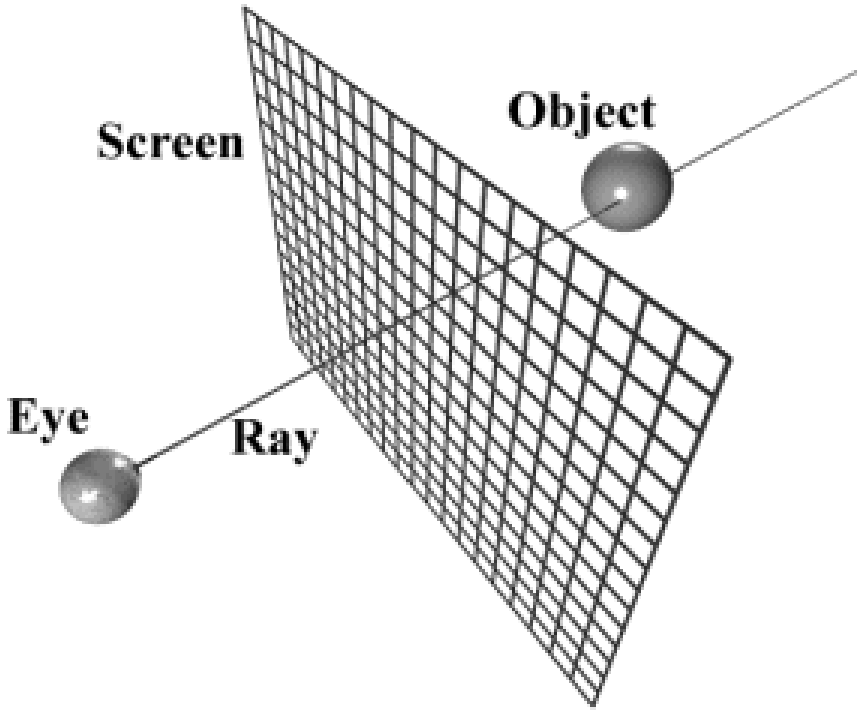
Ray Tracing

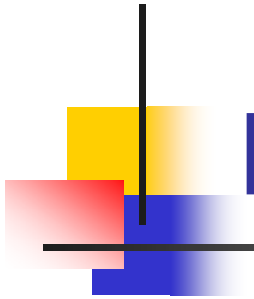
- Start from the light and find how each ray is getting reflected to from different objects to reach the viewer
  - Exponentially complex problem
- Reverse operation
  - Start from the viewer and see how a particular ray has traveled



Ray Tracing

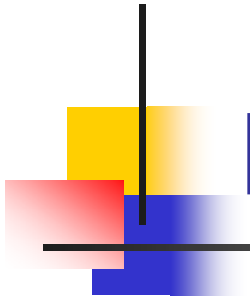
- Casts one ray per pixel
- Casts a bunch of ray in the scene
- Find out how the ray traverses





Recursive Ray Tracing

- Ray hits an object at P
  - Cast a shadow ray S from P to each light
  - If shadow ray does not intersect any other object, calculate direct illumination from light I_L
  - Cast a reflected ray R from P and find its contribution, I_R
  - Cast a refracted ray T from P and find its contribution, I_T
  - $C = w_L I_L + w_R I_R + w_T I_T$

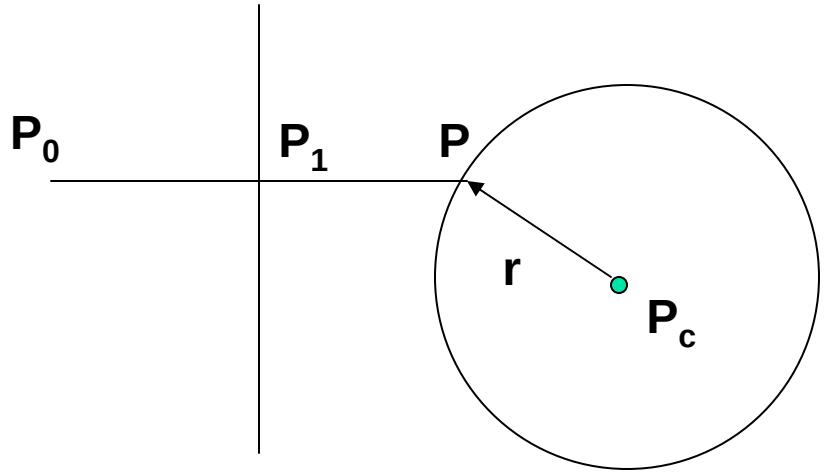


How to stop the recursion?

- If a ray has travelled beyond
  - A threshold distance
  - A threshold number of hops
  - Energy is the ray has fallen beyond a certain threshold

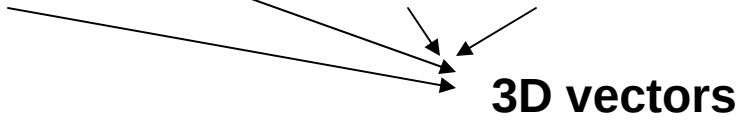
Intersections (Ray-Sphere)

- $|P-P_c|^2 - r^2 = 0$
- $P = P_0 + t(P_1-P_0)$
- $|P_0-P_c + t(P_1-P_0)|^2 - r^2 = 0$
- Will give you a quadratic equation to solve for t



Ray-Triangle Intersection

- V_0, V_1, V_2 – Triangle
  - $V_0 + u(V_1-V_0) + v(V_2-V_0)$
- P_0, P_1 - Ray
  - $P_0 + t(P_1-P_0)$
- Intersection point I, such that
  - $V_0 + u(V_1-V_0) + v(V_2-V_0) = P_0 + t(P_1-P_0)$
  - $u(V_1-V_0) + v(V_2-V_0) + t(P_0-P_1) = P_0-V_0$
  - $uA + vB + tC = D$



Ray Triangle Intersection

$$\begin{bmatrix} A_x & B_x & C_x \\ A_y & B_y & C_y \\ A_z & B_z & C_z \end{bmatrix} \begin{bmatrix} u \\ v \\ t \end{bmatrix} = \begin{bmatrix} D_x \\ D_y \\ D_z \end{bmatrix}$$

$$\begin{bmatrix} u \\ v \\ t \end{bmatrix} = \begin{bmatrix} A_x & B_x & C_x \\ A_y & B_y & C_y \\ A_z & B_z & C_z \end{bmatrix}^{-1} \begin{bmatrix} D_x \\ D_y \\ D_z \end{bmatrix}$$

Antialiasing

- Shoot more than one ray through the pixels
  - Super-sampling
- Average their contribution
  - Filtering