Light can be absorbed, reflected, transmitted on a material.

Total number of photons = $\sum$ ref, abs, trans

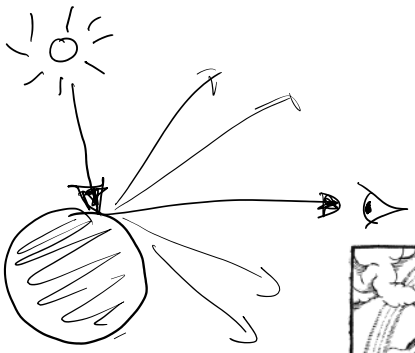
Conductors and dielectric

reflect "shiny"

glass, plastic, wood, water

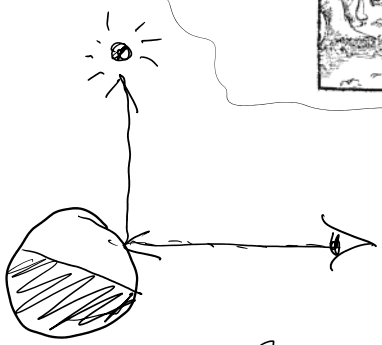
multilayered materials

eg. wood ball with a varnish coating



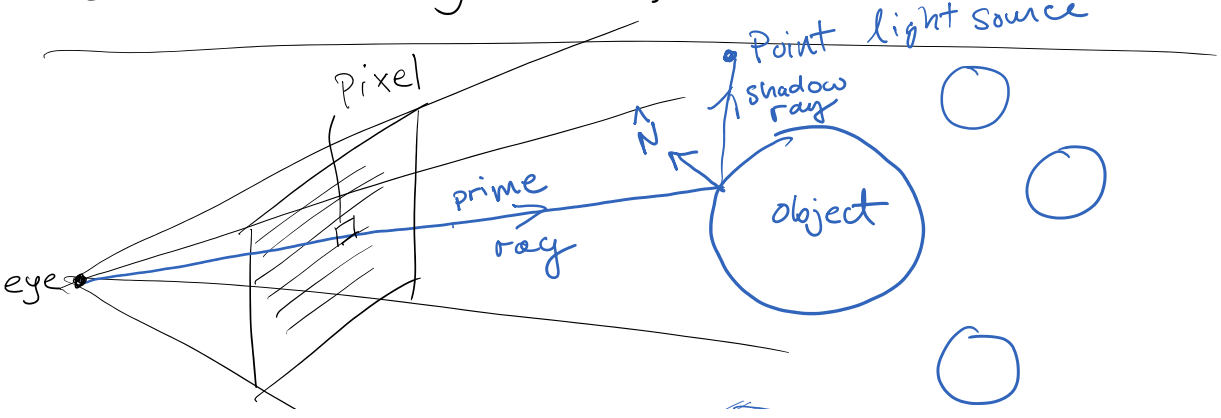
Forward Ray tracing

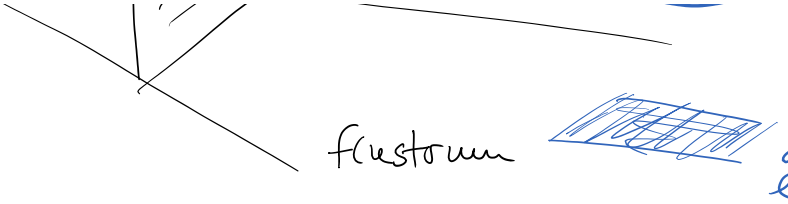
Ibn al-Haytham (Alhazen) ca. 1000



Greek idea of how light works.

Backward Ray tracing





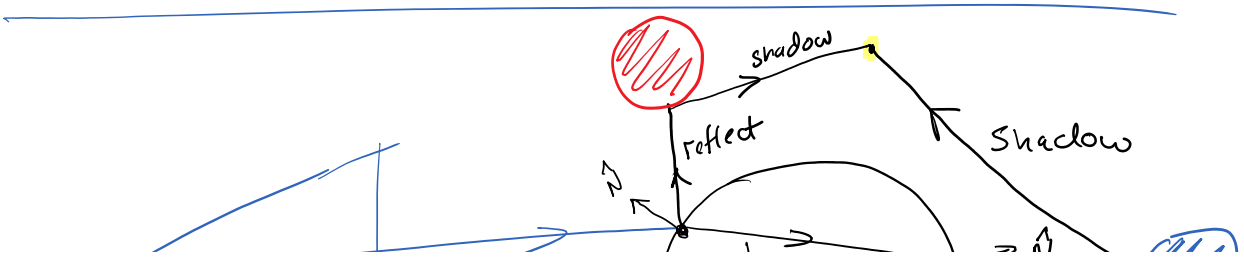
PSEUDO CODE:

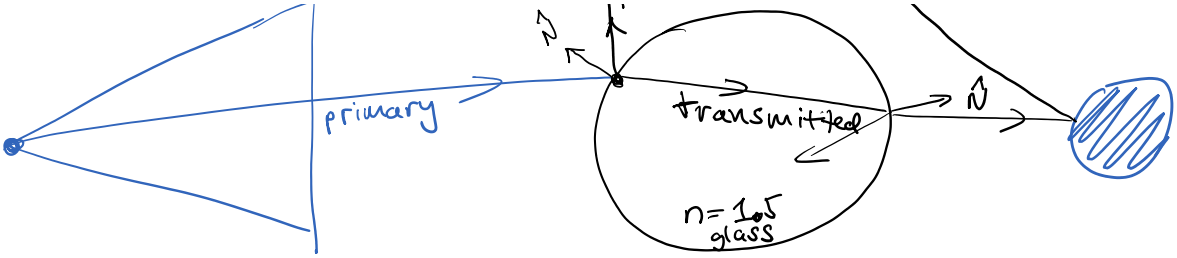
Ray { position x,y,z (origin)
Direction : unit vector

```
for (pixel) {
    primeray = ComputePrime(pixel)
    min = ∞
    for (object) {
        if (Intersect(object, primeray, pHit, NHit)){
            dist = DIST(eye, pHit)
            if (dist < min) {
                min = dist
                iObj = object
            }   iHit = pHit
        }
    }
    if (iObj) {
        Ray shadow
        shadow.direction = light pos - iHit
        isShadow = false
        for (object) {
            if (Intersect(object, shadow,
                          pHit, NHit)){
                isShadow = true
                break
            }
        }
    }
    if (!isShadow) {
        pixel = iObj -> color * light.
                                brightness.
    }
    else
        pixel = black (0,0,0)
} // loop over pixels
```

Visibility determination

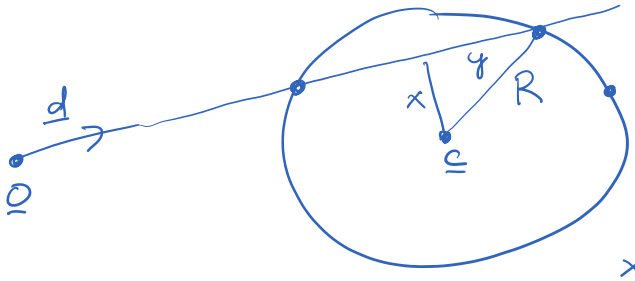
//Shading determination // Illumination





Dealing with the sphere:

Ray $\underline{r} = \underline{d}t + \underline{o}$ $\qquad \underline{r} = (\underline{p} - \underline{o})t + \underline{o}$



$f(p(t)) = 0$

$x^2 + y^2 = R^2$

$f(\underline{p}(t)) = 0 \Rightarrow (\underline{d}t + \underline{o} - \underline{c})^2 - R^2 = 0$

$\underline{d}\cdot\underline{d}\,t^2 + 2(\underline{o}-\underline{c})\cdot\underline{d}\,t + (\underline{o}-\underline{c})^2 - R^2 = 0$

$$\boxed{at^2 + bt + c = 0}$$

$a = \underline{d}\cdot\underline{d}$, $b = 2(\underline{o}-\underline{c})\cdot\underline{d}$, $c = (\underline{o}-\underline{c})^2 - R^2$

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$t = \frac{2c}{-b \pm \sqrt{b^2 - 4ac}}$$

General method:

$$q = -\frac{1}{2}\left[b + \mathrm{sgn}(b)\sqrt{b^2 - 4ac}\right]$$

$$t_1 = \frac{q}{a} \qquad t_2 = \frac{c}{q}$$