~~Ray~~ tracing

LECTURE 9

- Can build many nice effects on top of it.
  - much more difficult in rasterization framework.
  - e.g., shadows, refections.

→ look over their ray-tracing assignment.

Recall Blinn-Phong ~~Sh.~~ Reflectance Model

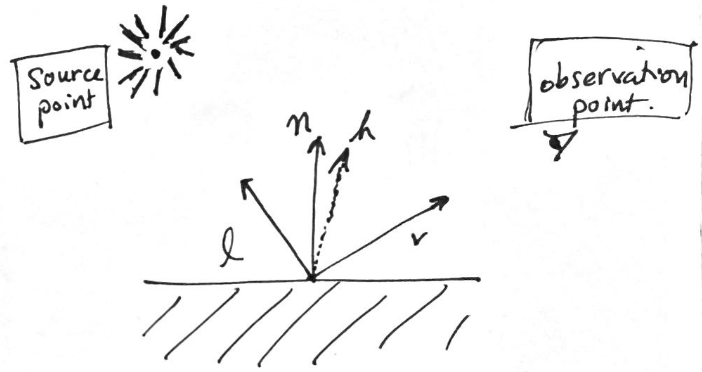
~~$$L = k_a I_a + k_d I_d \max(0, n \cdot l) + k_s I_s \max(0, n \cdot h)^p$$~~

$$I^i = L^i_a R_a + L^i_d R_d \max(0, n \cdot l) + L^i_s R_s \max(0, n \cdot h)^e$$

Multiple light sources

~~$$L = k_a I_a + \sum_{i=1}^{N} \left(k_d (I_d)_i \max(0, n \cdot l_i) + k_s (I_s)_i \max(0, n \cdot h_i)^e \right)$$~~

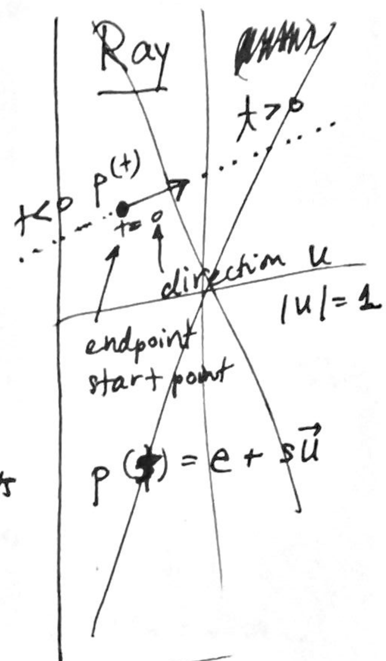
$$I = \sum_i I^i$$



$$h = \frac{v + l}{|v + l|}$$

Types of Rays

1. Eye/ pixel rays
2. Illumination / shadow rays.
3. Reflection rays – specular highlight
   – reflect other objects
4. Transmission / transparency rays.



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1 Eye rays

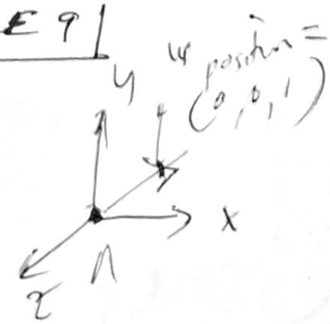
* automatically get a perspective view when trace from eye.

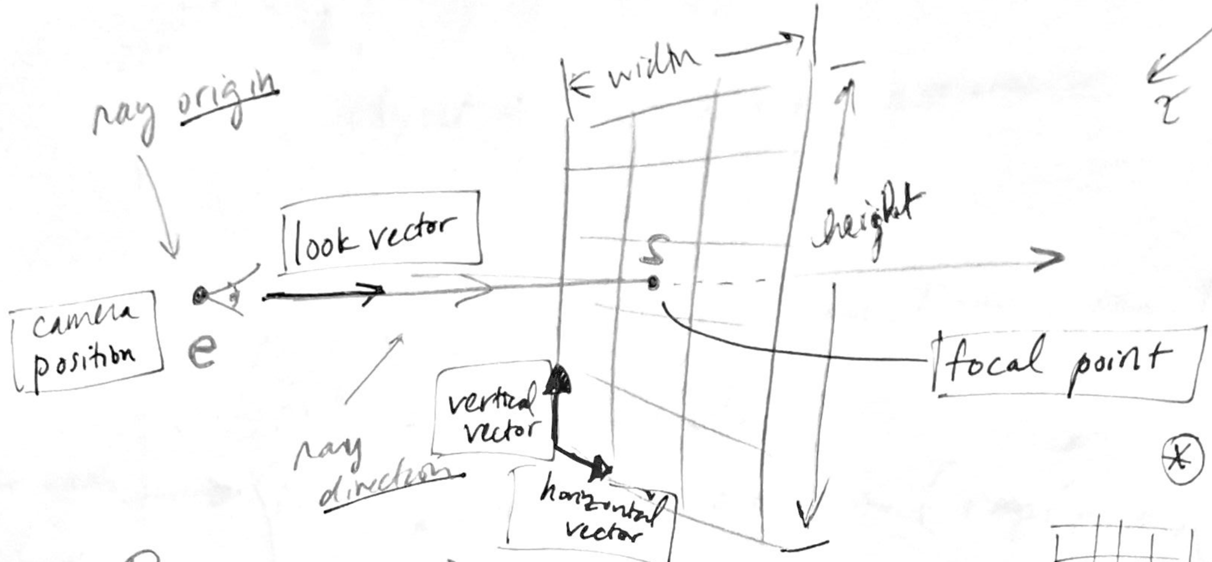
Q. How would you get an ~~orthogonal~~ orthographic view?

Illumination / Shadow Rays.

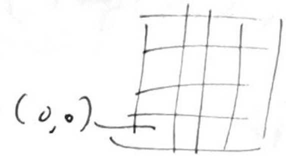
LECTURE 9

Computing View Rays.





⊛ Camera members



Ray equation:

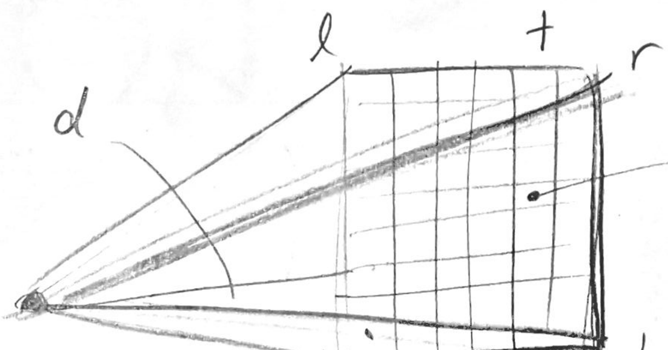
$$p(t) = \underset{\sim}{e} + t(\underset{\sim}{s} - \underset{\sim}{e})$$

$v = s - e$

Notes: $p(0) = \underset{\sim}{e}$

$p(1) = \underset{\sim}{s}$

$p(\alpha)$, $\alpha < 0$ behind the eye.



(i,j)

(position $[0, n_x] \times [0, n_y]$ $\longrightarrow$ $[l, r] \times [b, t]$

$u = l + \frac{\frac{1}{2} + i}{n_x}(r - l)$, $v = b + \frac{(j + \frac{1}{2})}{n_y}(t - b)$

...dows [Shirley, 4.7]

$\overset{u}{\underset{e}{\cdot\!\!\longrightarrow}}$ ....

ray = ray(e, u, 0, ∞)

Cast-Ray (ray , parent-ray)

if (object = closest-intersection (ray))

then

$p = (e + ray.t\_max\ u) = ray.Point(ray.t\_max)$

color = $L_a R_a$

for each light source. → if (! closest_intersection (ray(p, l, (ε), (∞))) then ← Shadow ray.

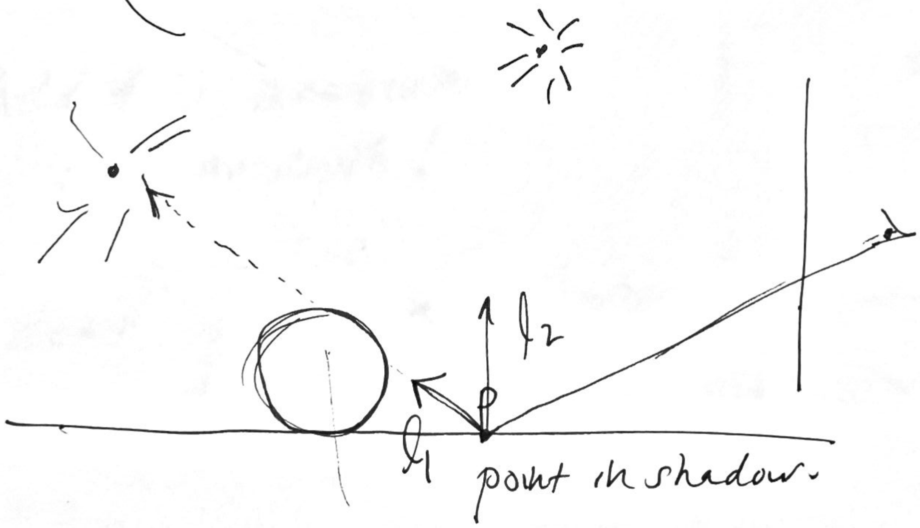
(ε: avoid speckles; ∞: semi-inf = true)

$h = \ldots \frac{l + v}{\|l + v\|}$

$c \mathrel{+}= L_d R_d \cdot \max(0, n \cdot l) + L_s R_s (n \cdot h)^e$

else

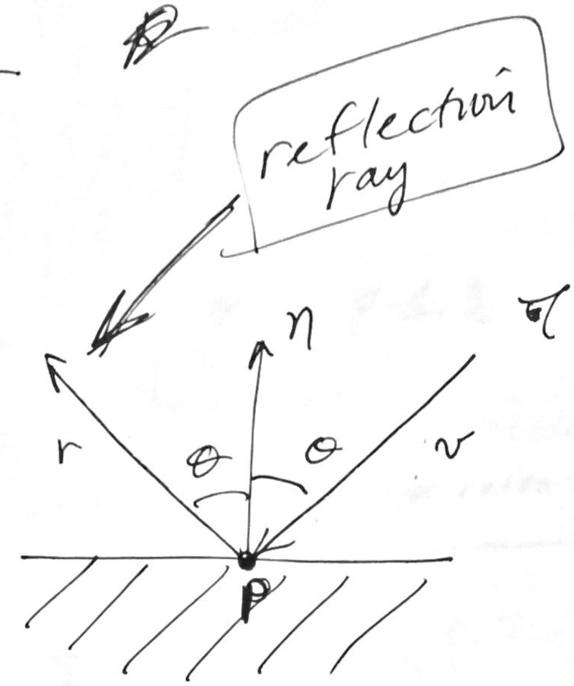
return background color.



Ideal Specular Reflection

[Shirley 4.8]

mirror reflection

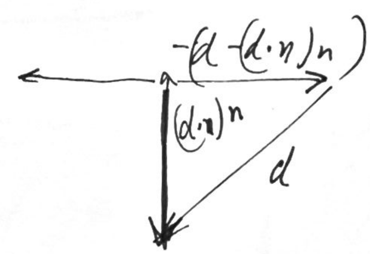


$$r = v - 2(v \cdot n)n$$

$$\text{Color } c = (1-k_m)c + k_m \text{ Ray\_Color}(\text{ray}(p, r, \varepsilon, \infty))$$

$(1-k_m)$ — in my solution

important to avoid intersecting w/ self (the ε)



$$r = -d + 2(d - (d \cdot n)n)$$
$$= +d - 2(d \cdot n)n$$

- Add a maximum recursion depth!
- don't generate a reflection if $k_m == 0$ (no reflection).

Ray-Object intersection

Find the first intersection with any object where $t > 0$.

$f(p) = 0$ Implicit function describing surface

Solve $\boxed{f(\underbrace{e + td}_{*}) = 0}$ for t.

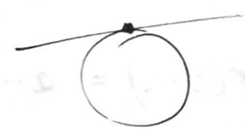
E.g., sphere

$$f(p) = (p-c)\cdot(p-c) - r^2 = 0.$$

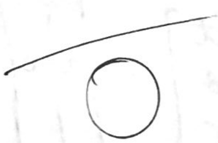
plugging (*) into $f(\cdot)$ gives a quadratic equation in t.

discriminant

0 1 solution



< 0 no real solution



> 0 2 solutions

Check t values.

valid intersection if $t > 0$.

E.g., ray-plane

$$f(p) = (p-q)\cdot n = 0$$

$$f(p(t)) = (e + td - q)\cdot n = 0$$

$$t(d\cdot n) = (q-e)\cdot n \Rightarrow \boxed{t = \frac{(q-e)\cdot n}{(d\cdot n)}}$$

$$\left(t = \frac{(q-e)\cdot n}{(s-e)\cdot n} \text{ for } d = s-e\right)$$