Ray Tracing
Geometry
Camera Setup
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\[
\tan(\theta) = \frac{\text{yres} \times \text{pixelHeight}}{N} \\
\text{pixelHeight} = \frac{\tan(\theta_y) \times N}{\text{yres}} \\
\text{pixelWidth} = \frac{\tan(\theta_x) \times N}{\text{xres}}
\]
Screen Placement

How do images differ if the resolution doesn’t change?
Pixel Calculation

\[
\tan(\theta) = \frac{\text{yres} \times \text{pixelHeight}}{N}
\]

\[
\text{pixelHeight} = \tan(\theta_y) \times \frac{N}{\text{yres}}
\]

\[
\text{pixelWidth} = \tan(\theta_x) \times \frac{N}{\text{xres}}
\]

\[
\text{AspectRatio} = \frac{\text{pixelWidth}}{\text{pixelHeight}}
\]

Coordinate (in u, v, n space) of upper left corner of screen = ?
Pixel Calculation

Coordinate (in u,v,n space) of upper left corner of screen = ?

Assume virtual screen is one unit away (N=1) in -n direction

Eye + (-n) - (xres/2)*PixelWidth*u + (yres/2)*PixelHeight *v
Pixel Calculation

Coordinate (in u,v,n space) of upper left pixel center = ?

Eye + (-n) - (xres/2)*PixelWidth*u + (yres/2)*PixelHeight *v

+ (pixelWidth/2)*u + (pixelHeight/2)*v
Interate through pixel Centers

\[
\text{pixelCenter} = \\
\text{scanlineStart} = \text{Eye} + \\
(-n) - \\
(xres/2)*\text{PixelWidth}*u + \\
(yres/2)*\text{PixelHeight}*v + \\
(pixelWidth/2)*u + \\
(pixelHeight/2)*v
\]

\[
\text{pixelCenter} += \text{pixelWidth} \\
\text{scanlineStart} += \text{pixelHeight}
\]
Organization of Ray Tracer

For each pixel {
    Form ray from eye through pixel
dmin = infinity
For each object {
    If (d=intersect(ray,object)) {
        If (d<dmin) {
            closestObject = object
dmin = d
        }
    }
}
Organization of Ray Tracer

If ($d_{\text{min}} == \infty$) {
    \text{pixelColor} = \text{background color}
} else

\text{pixelColor} = \text{color of object at \(d\) along ray}
Ray-Sphere Intersection - geometric

\[ r^2 = k^2 + s^2 \]
\[ t^2 = (k+d)^2 + s^2 \]
\[ d+k = (C\text{-}eye) \cdot \text{Ray} \]
Ray-Sphere Intersection - algebraic

\[ x^2 + y^2 + z^2 = r^2 \]

\[ p = \text{eye} + d*\text{Ray} \]

Substitute definition of \( p \) into first equation:

\[ (\text{eye}.x + d*\text{ray}.x)^2 + (\text{eye}.x + d*\text{ray}.x)^2 + (\text{eye}.x + d*\text{ray}.x)^2 = r^2 \]

Exand squared terms and collect terms based on powers of \( d \):

\[ A*d^2 + B*d + C = 0 \]
Determine Color

FOR LAB #1

Use z-component of normal vector

objectColor*kd*N_z

What the normal at a point on the sphere?