Light path from light source to camera

$$normalize(v) := \frac{v}{\|v\|}$$

$n1 := 1.1111 \quad n2 := 1.0$

$n := normalize\left(\begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}\right)$ surface normal the source

$l := normalize\left(\begin{bmatrix} 1 \\ 1 \\ 0 \end{bmatrix}\right) = \begin{bmatrix} 0.707 \\ 0.707 \\ 0 \end{bmatrix}$ ray from source toward the surface

$cos\_\theta1 := n \cdot l = 0.707$ must be positive

$rr := l - (2 \cdot (n \cdot l)) \cdot n = \begin{bmatrix} 0.707 \\ -0.707 \\ 0 \end{bmatrix}$ reflected ray

$cos\_\theta2 := \sqrt{1 - \left(\frac{n2}{n1}\right)^2 \cdot \left(1 - (cos\_\theta1)^2\right)} = 0.771$

$rf := \frac{n2}{n1} \cdot l - \left(\frac{n2}{n1} \cdot cos\_\theta1 - cos\_\theta2\right) \cdot n = \begin{bmatrix} 0.636 \\ 0.771 \\ 0 \end{bmatrix}$ refracted ray

Reverse light path from camera to light source

$rd := -rf = \begin{bmatrix} -0.636 \\ -0.771 \\ 0 \end{bmatrix}$ primary ray i.e. -refracted ray

secondary ray B (i.e. reflected ray from source)
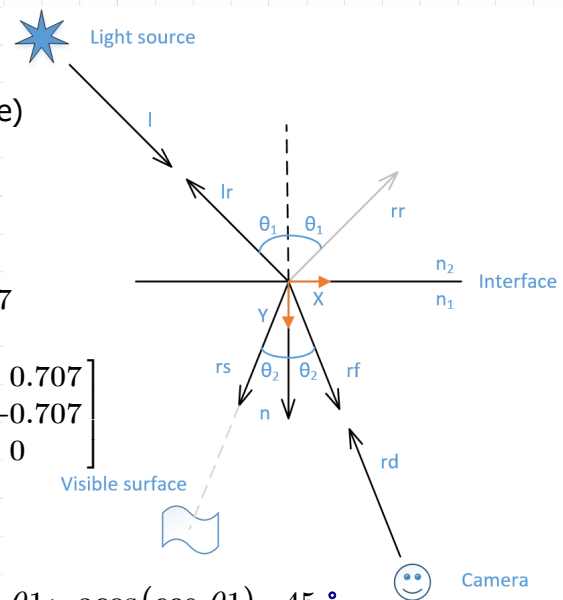
$cos\_\theta2 := -n \cdot rd = 0.771$

$cos\_\theta1 := \sqrt{1 - \left(\frac{n1}{n2}\right)^2 \cdot \left(1 - (cos\_\theta2)^2\right)} = 0.707$

$rr := -\frac{n1}{n2} \cdot rd - \left(\frac{n1}{n2} \cdot cos\_\theta2 + cos\_\theta1\right) \cdot n = \begin{bmatrix} 0.707 \\ -0.707 \\ 0 \end{bmatrix}$

secondary ray A (i.e. -ray from source)

$l := rr - (2 \cdot (n \cdot rr)) \cdot n = \begin{bmatrix} 0.707 \\ 0.707 \\ 0 \end{bmatrix}$

$lr := -l = \begin{bmatrix} -0.707 \\ -0.707 \\ 0 \end{bmatrix}$

$rs := rd - 2 (n \cdot rd) n = \begin{bmatrix} -0.636 \\ 0.771 \\ 0 \end{bmatrix}$

$\theta1 := acos(cos\_\theta1) = 45°$

$\theta2 := acos(cos\_\theta2) = 39.524°$

PG1, rev. 04