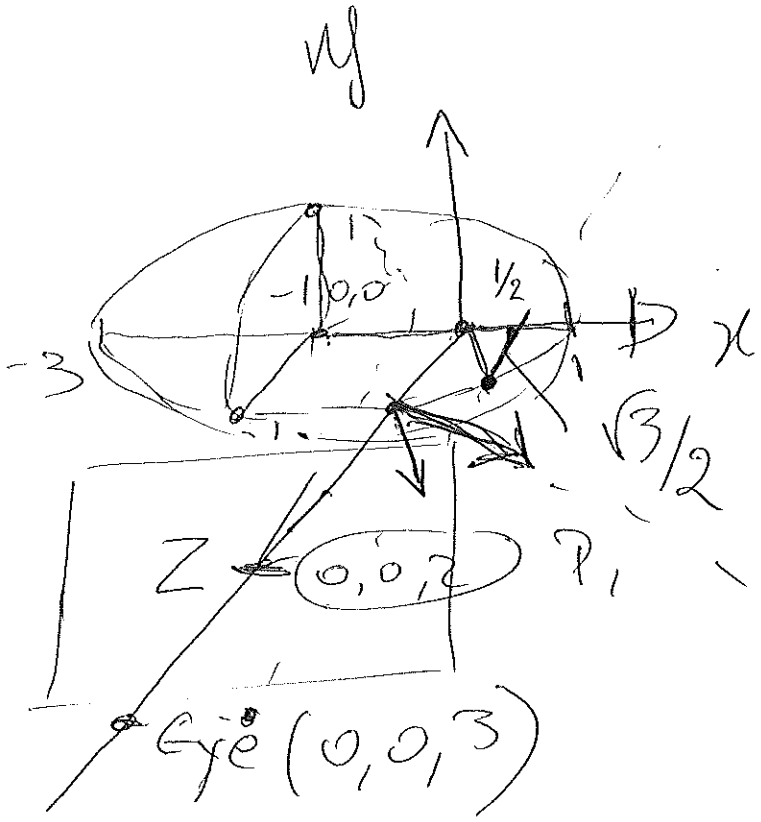
Part III
11.



$$d = \text{Pixel Position} - \text{Eye} = \begin{pmatrix} 0 \\ 0 \\ -1 \end{pmatrix}$$

$$r = \begin{pmatrix} 0 \\ 0 \\ 3 \end{pmatrix} + t \begin{pmatrix} 0 \\ 0 \\ -1 \end{pmatrix}$$

$$\left(\begin{array}{c|c} I & t \\ \hline 0 & 1 \end{array}\right)$$

$$M = T(-1,0,0)\,S(2,1,1)$$

$$= TS$$

$$M^{-1} = (TS)^{-1} = S^{-1}T^{-1} =$$

$$= S(1/2,1,1)\,T(1,0,0)$$

$$M^{-1} = \begin{pmatrix} 1/2 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$= \begin{pmatrix} 1/2 & 0 & 0 & 1/2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$r = \begin{pmatrix} 0 \\ 0 \\ 3 \\ 1 \end{pmatrix} + t \begin{pmatrix} 0 \\ 0 \\ -1 \\ 0 \end{pmatrix}$$

$$\tilde{r} = M^{-1} eye + t M^{-1} d$$

$$= M^{-1} \begin{pmatrix} 0 \\ 0 \\ 3 \\ 1 \end{pmatrix} + t M^{-1} \begin{pmatrix} 0 \\ 0 \\ -1 \\ 0 \end{pmatrix}$$

$$= \begin{pmatrix} 1/2 \\ 0 \\ 3 \\ 1 \end{pmatrix} + t \begin{pmatrix} 0 \\ 0 \\ -1 \\ 0 \end{pmatrix}$$

Sphere: $p \cdot p - 1 = 0$

$$t_{\pm} = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

$d \begin{pmatrix} 0 \\ 0 \\ -1 \end{pmatrix}$

$eye \begin{pmatrix} 1/2 \\ 0 \\ 3 \end{pmatrix}$

$A = 1$

$B = -6$

$C = 9.25 - 1 = 8 + 1/4 = \frac{33}{4}$

$$t_{\pm} = \frac{6 \pm \sqrt{36 - 33}}{2}$$

$$= 3 \pm \sqrt{3}/2$$