we know \( \text{persp at } z = -d \)

\[
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 \\
0 & 0 & \frac{1}{-d} & 0 \\
\end{bmatrix}
\]

but plane \( B \) rear plane: \(-d = n\) so:
we want to have points on the near plane be on the near plane & points on the far plane be on the far plane

so:

\[
\begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & \frac{w+f}{w} & -f \\
0 & 0 & \frac{1}{w} & 0
\end{bmatrix}
\]

check on board

set rid of \( \frac{1}{w} \)

\[
\begin{bmatrix}
N & 0 & 0 & 0 \\
0 & N & 0 & 0 \\
0 & 0 & N + f & -f \\
0 & 0 & 1 & 0
\end{bmatrix}
= N \cdot \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
0 & 0 & \frac{w+f}{w} & -f \\
0 & 0 & \frac{1}{w} & 0
\end{bmatrix}
\]
Concurrent View Volume

3D: \[ x = \pm 1 \]
\[ y = \pm 1 \]
\[ z = \pm 1 \]

How?
1) translate to the origin
2) scale length 2 in each dim.

\[
\begin{bmatrix}
\frac{2}{X_{\text{max}} - X_{\text{min}}} & 0 & 0 & 0 \\
0 & \frac{2}{Y_{\text{max}} - Y_{\text{min}}} & 0 & 0 \\
0 & 0 & \frac{2}{Z_{\text{max}} - Z_{\text{min}}} & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
1 & 0 & 0 & -\frac{X_{\text{max}} + X_{\text{min}}}{2} \\
0 & 1 & 0 & -\frac{Y_{\text{max}} + Y_{\text{min}}}{2} \\
0 & 0 & 1 & -\frac{Z_{\text{max}} + Z_{\text{min}}}{2} \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

What is \( X_{\text{max}} \), \( X_{\text{min}} \), \( Y_{\text{max}} \), \( Y_{\text{min}} \), \( Z_{\text{max}} \), \( Z_{\text{min}} \)?

So

\[
\begin{bmatrix}
\frac{2}{r-1} & 0 & 0 & 0 \\
0 & \frac{2}{T-B} & 0 & 0 \\
0 & 0 & \frac{2}{N-F} & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
1 & 0 & 0 & -\frac{r}{r-1} \\
0 & 1 & 0 & -\frac{b+T}{2} \\
0 & 0 & 1 & -\frac{n+f}{2} \\
0 & 0 & 0 & 1
\end{bmatrix}
\]

\[
\begin{bmatrix}
\frac{2}{r-1} & 0 & 0 & 0 \\
0 & \frac{2}{T-B} & 0 & 0 \\
0 & 0 & \frac{2}{N-F} & 0 \\
0 & 0 & 0 & 0
\end{bmatrix}
\begin{bmatrix}
\frac{(2)}{r-L} \left( \frac{r}{r-L} \right) = \frac{r}{r-L} \\
\frac{(2)}{T-B} \left( \frac{b+T}{2} \right) = \frac{b+T}{B-T} \\
\frac{(2)}{N-F} \left( \frac{n+f}{2} \right) = \frac{n+f}{F-N}
\end{bmatrix}
\]
\[ M_{\text{screen}} = \begin{bmatrix}
\frac{N_x}{2} & 0 & 0 & \frac{N_x-1}{2} \\
0 & \frac{N_y}{2} & 0 & \frac{N_y-1}{2} \\
0 & 0 & 1 & 0 \\
0 & 0 & 0 & 1
\end{bmatrix} \]