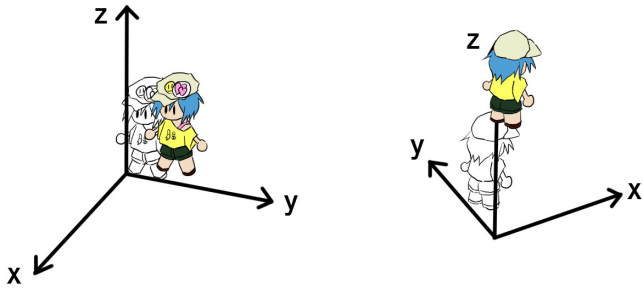


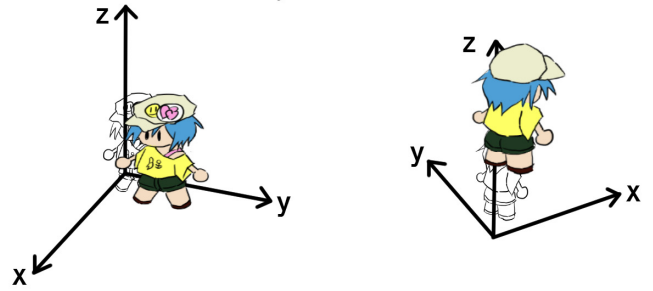
### 平行移動

$$\begin{pmatrix} x' \\ y' \\ z' \\ 1 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 \\ 2 \\ 3 \\ 1 \end{pmatrix} = \begin{pmatrix} 4 \\ 4 \\ 4 \\ 1 \end{pmatrix}$$



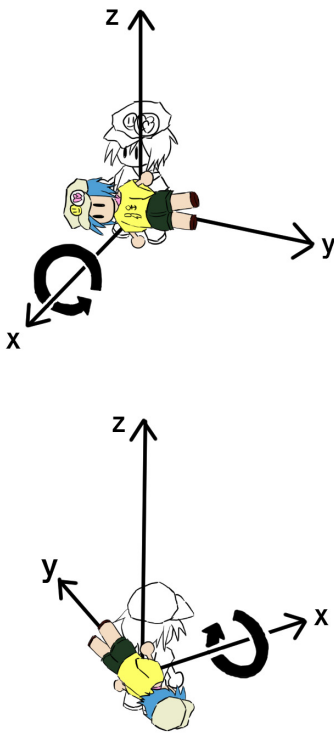
### 拡大・縮小

$$\begin{pmatrix} x' \\ y' \\ z' \\ 1 \end{pmatrix} = \begin{pmatrix} 3 & 0 & 0 & 0 \\ 0 & 3 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 \\ 1 \\ 1 \\ 1 \end{pmatrix} = \begin{pmatrix} 3 \\ 3 \\ 2 \\ 1 \end{pmatrix}$$



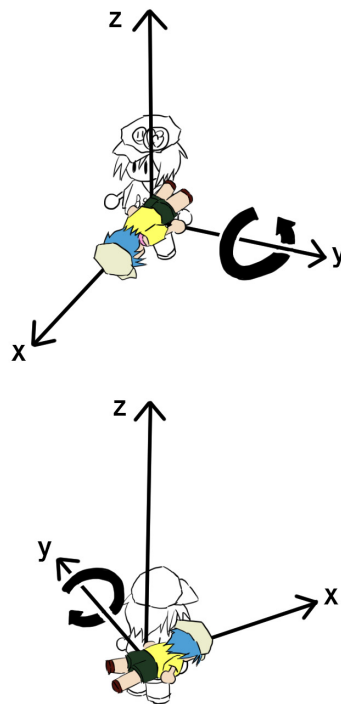
### x軸周りの回転

$$\begin{pmatrix} x' \\ y' \\ z' \\ 1 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos 90^\circ & -\sin 90^\circ & 0 \\ 0 & \sin 90^\circ & \cos 90^\circ & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}$$



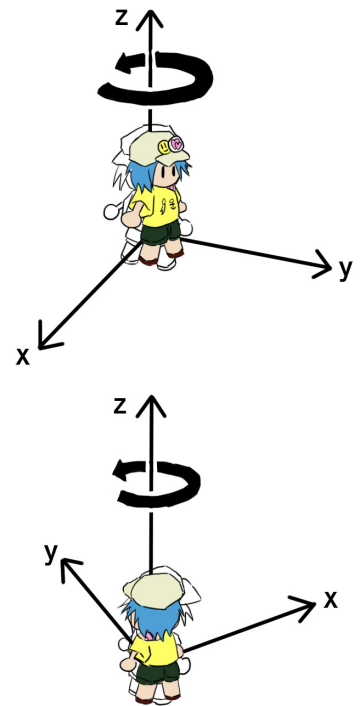
### y軸周りの回転

$$\begin{pmatrix} x' \\ y' \\ z' \\ 1 \end{pmatrix} = \begin{pmatrix} \cos 90^\circ & 0 & \sin 90^\circ & 0 \\ 0 & 1 & 0 & 0 \\ -\sin 90^\circ & 0 & \cos 90^\circ & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}$$



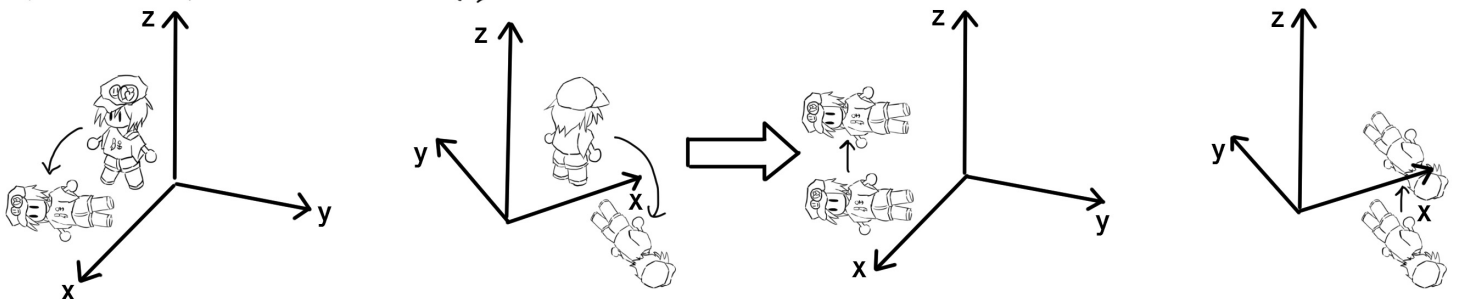
### z軸周りの回転

$$\begin{pmatrix} x' \\ y' \\ z' \\ 1 \end{pmatrix} = \begin{pmatrix} \cos 90^\circ & -\sin 90^\circ & 0 & 0 \\ \sin 90^\circ & \cos 90^\circ & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}$$

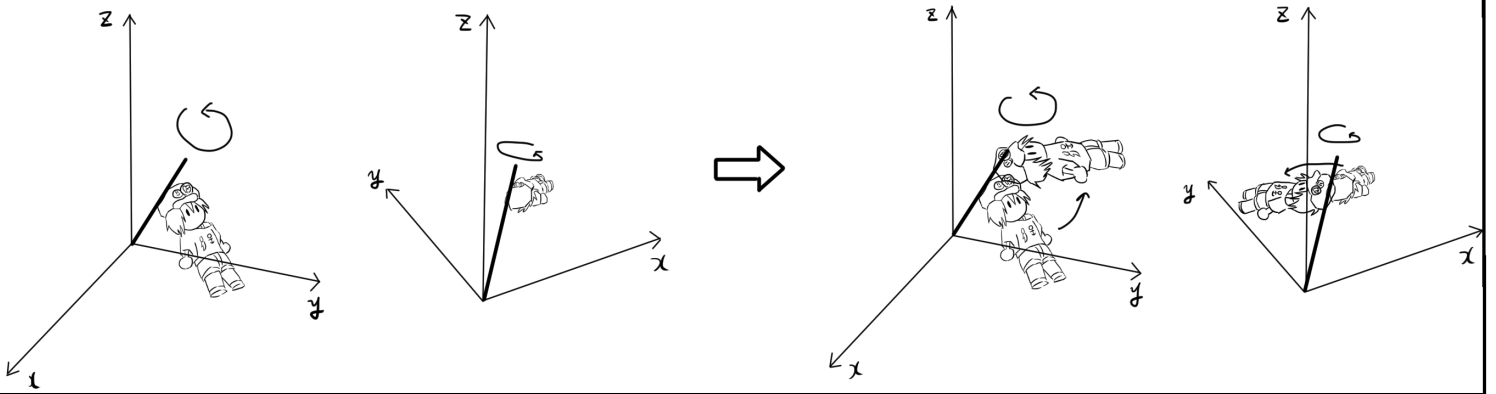


(3, 0, 3)にいるいっちゃんをx軸周りに90°回転したあとで(0, 0, 3)平行移動したとき

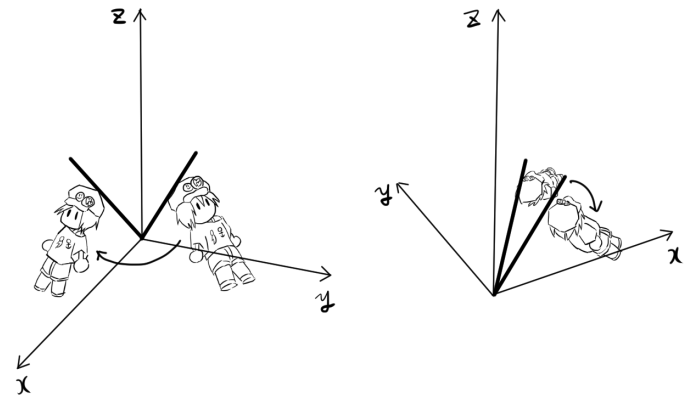
$$\begin{pmatrix} x' \\ y' \\ z' \\ 1 \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 3 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos 90^\circ & -\sin 90^\circ & 0 \\ 0 & \sin 90^\circ & \cos 90^\circ & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} 3 \\ 0 \\ 3 \\ 1 \end{pmatrix}$$



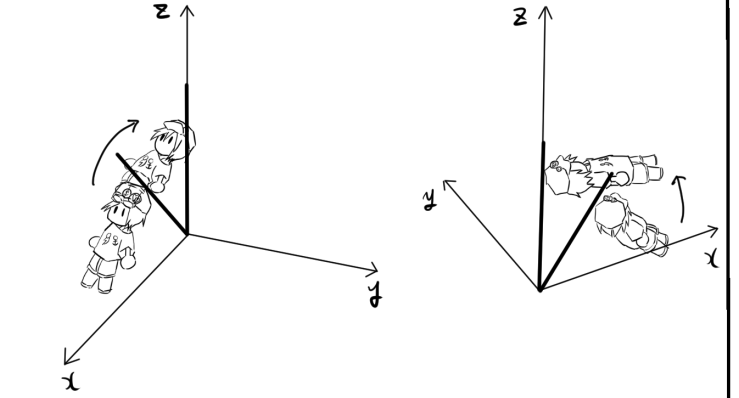
$(\frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}}, \frac{1}{\sqrt{3}})$  を中心に いっちゃんを  $90^\circ$  だけ回転したいとき



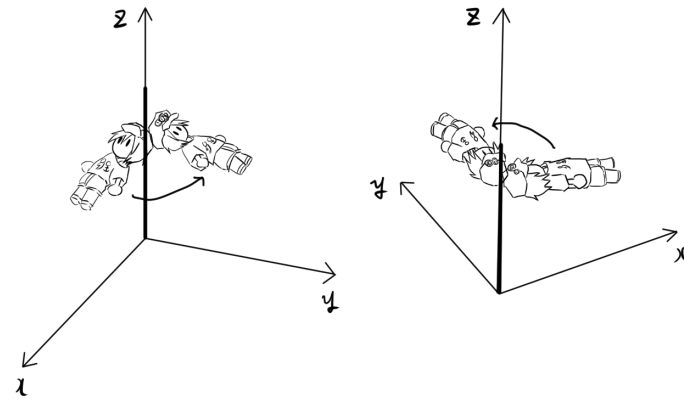
① z軸周りに  $-45^\circ$  回転



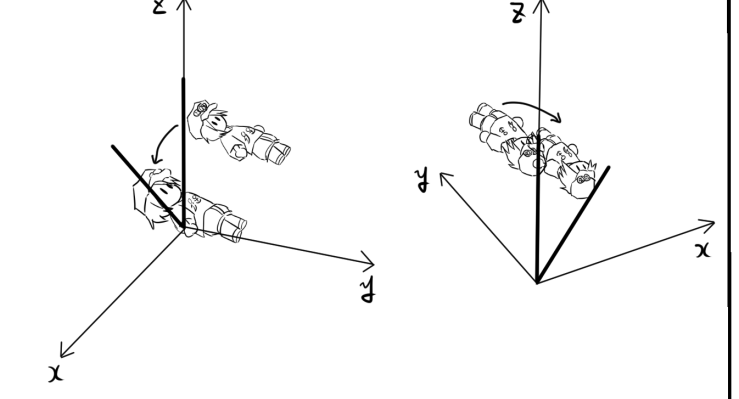
② y軸周りに  $-45^\circ$  回転



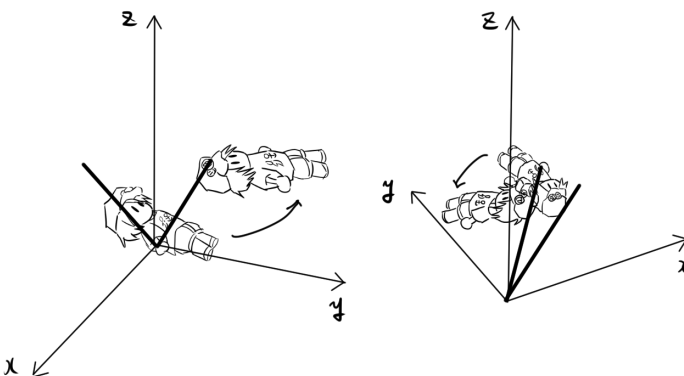
③ z軸周りに  $90^\circ$  回転



④ y軸周りに  $45^\circ$  回転



⑤ z軸周りに  $45^\circ$  回転



$$\begin{pmatrix} x' \\ y' \\ z' \\ 1 \end{pmatrix} = R_z(45^\circ) R_y(45^\circ) R_z(90^\circ) R_y(-45^\circ) R_z(-45^\circ) \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}$$

$$R_z(45^\circ) = \begin{pmatrix} \cos 45^\circ & -\sin 45^\circ & 0 & 0 \\ \sin 45^\circ & \cos 45^\circ & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad R_y(45^\circ) = \begin{pmatrix} \cos 45^\circ & 0 & \sin 45^\circ & 0 \\ 0 & 1 & 0 & 0 \\ -\sin 45^\circ & 0 & \cos 45^\circ & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad R_z(90^\circ) = \begin{pmatrix} \cos 90^\circ & -\sin 90^\circ & 0 & 0 \\ \sin 90^\circ & \cos 90^\circ & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

$$R_y(-45^\circ) = \begin{pmatrix} \cos 45^\circ & 0 & -\sin 45^\circ & 0 \\ 0 & 1 & 0 & 0 \\ \sin 45^\circ & 0 & \cos 45^\circ & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \quad R_z(-45^\circ) = \begin{pmatrix} \cos 45^\circ & \sin 45^\circ & 0 & 0 \\ -\sin 45^\circ & \cos 45^\circ & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

よって

$$\begin{pmatrix} x' \\ y' \\ z' \\ 1 \end{pmatrix} = \frac{1}{4} \begin{pmatrix} 1 & -1 & 2+\sqrt{2} & 0 \\ 1+2\sqrt{2} & -1-2\sqrt{2} & -2+\sqrt{2} & 0 \\ -2+\sqrt{2} & 2-\sqrt{2} & 2 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} x \\ y \\ z \\ 1 \end{pmatrix}$$