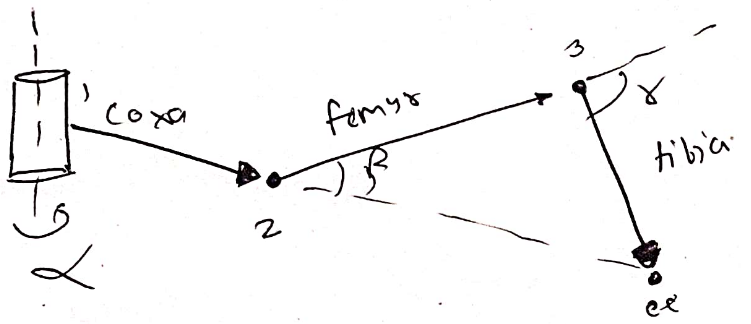

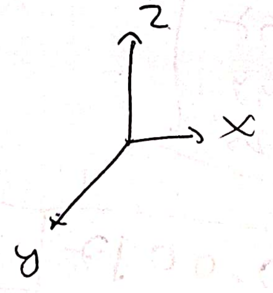

$$T_{01} = \begin{bmatrix} c_1 & -s_1 & 0 & 0 \\ s_1 & c_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad T_{12} = \begin{bmatrix} c_2 & 0 & -s_2 & L_1 \\ 0 & 1 & 0 & 0 \\ s_2 & 0 & c_2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_{23} = \begin{bmatrix} c_3 & 0 & -s_3 & L_2 \\ 0 & 1 & 0 & 0 \\ s_3 & 0 & c_3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \qquad T_{3ee} = \begin{bmatrix} 1 & 0 & 0 & L_3 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Now, $T_{0ee} = T_{01} T_{12} T_{23} T_{3ee}$

$$T_{0ee} = \begin{bmatrix} c_1 & -s_1 & 0 & 0 \\ s_1 & c_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} c_2 & 0 & -s_2 & L_1 \\ 0 & 1 & 0 & 0 \\ s_2 & 0 & c_2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} c_3 & 0 & -s_3 & L_2 \\ 0 & 1 & 0 & 0 \\ s_3 & 0 & c_3 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & L_3 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

The last column gives us

x, y, z

$$x = L_3 c_1 c_2 c_3 - L_3 c_1 s_2 s_3 + L_2 c_1 c_2 + L_1 c_1$$

$$y = L_3 s_1 s_2 c_3 - L_3 s_1 s_2 s_3 + L_2 s_1 c_2 + L_1 s_1$$

$$z = L_3 s_2 c_3 + L_2 c_2 s_3 + L_2 s_2$$

$$x = L_3 c_1 [c_2 c_3 - s_2 s_3] + c_1 [L_2 c_2 + L_1]$$

$$x = c_1 [L_3 \cos(\beta + \gamma) + L_2 c_2 + L_1]$$

Similarly $y = s_1 [L_3 \cos(\beta + \gamma) + L_2 c_2 + L_1]$

$$z = L_3 s_2 s_3 + L_3 c_2 s_3 + L_2 s_2$$

So, $x = \cos\alpha [15 \cos(\beta + \gamma) + 10 \cos\beta + 5]$

$$y = \sin\alpha [15 \cos(\beta + \gamma) + 10 \cos\beta + 5]$$

$$z = 15 \sin(\beta + \gamma) + 10 \sin\beta$$

$$\frac{x}{y} = \frac{1}{\tan\alpha}$$

$$\alpha = \tan^{-1}\left(\frac{y}{x}\right)$$

We use Jacobin to calc. β, γ