$$A = T_\theta T_d T_\alpha T_a$$

$$A1 = T_\theta T_d T_\alpha = \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 & 0 & 0 \\ \sin\theta_1 & \cos\theta_1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \cos\theta_1 & 0 & \sin\theta_1 & 0 \\ \sin\theta_1 & 0 & -\cos\theta_1 & 0 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A2 = T_\alpha = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta_2 & -\sin\theta_2 & 0 \\ 0 & \sin\theta_2 & \cos\theta_2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A3 = T_\theta T_a = \begin{bmatrix} \cos(\theta_3 + \frac{\pi}{2}) & -sin(\theta_3 + \frac{\pi}{2}) & 0 & 0 \\ \sin(\theta_3 + \frac{\pi}{2}) & \cos(\theta_3 + \frac{\pi}{2}) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 3 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} -\sin\theta_3 & -\cos\theta_3 & 0 & -3\sin\theta_3 \\ \cos\theta_3 & -\sin\theta_3 & 0 & 3\cos\theta_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A4 = T_\theta T_a = \begin{bmatrix} \cos\theta_4 & -\sin\theta_4 & 0 & 0 \\ \sin\theta_4 & \cos\theta_4 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \cos\theta_4 & -\sin\theta_4 & 0 & 2\cos\theta_4 \\ \sin\theta_4 & \cos\theta_4 & 0 & 2\sin\theta_4 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A1A2A3 = \begin{bmatrix} \cos\theta_1 & 0 & \sin\theta_1 & 0 \\ \sin\theta_1 & 0 & -\cos\theta_1 & 0 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta_2 & -\sin\theta_2 & 0 \\ 0 & \sin\theta_2 & \cos\theta_2 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} -\sin\theta_3 & -\cos\theta_3 & 0 & -3\sin\theta_3 \\ \cos\theta_3 & -\sin\theta_3 & 0 & 3\cos\theta_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} \cos\theta_1 & \sin\theta_1\sin\theta_2 & \sin\theta_1\cos\theta_2 & 0 \\ \sin\theta_1 & -\cos\theta_1\sin\theta_2 & -\cos\theta_1\cos\theta_2 & 0 \\ 0 & \cos\theta_2 & -\sin\theta_2 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} -\sin\theta_3 & -\cos\theta_3 & 0 & -3\sin\theta_3 \\ \cos\theta_3 & -\sin\theta_3 & 0 & 3\cos\theta_3 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} -\cos\theta_1\sin\theta_3 + \sin\theta_1\sin\theta_2\cos\theta_3 & -\cos\theta_1\cos\theta_3 - \sin\theta_1\sin\theta_2\sin\theta_3 & \sin\theta_1\cos\theta_2 & -3\cos\theta_1\sin\theta_3 + 3\sin\theta_1\sin\theta_2\cos\theta_3 \\ -\sin\theta_1\sin\theta_3 - \cos\theta_1\sin\theta_2\cos\theta_3 & -\sin\theta_1\cos\theta_3 + \cos\theta_1\sin\theta_2\sin\theta_3 & -\cos\theta_1\cos\theta_2 & -3\sin\theta_1\sin\theta_3 - \cos\theta_1\sin\theta_2\cos\theta_3 \\ \cos\theta_2\cos\theta_3 & -\cos\theta_2\sin\theta_3 & -\sin\theta_2 & 3\cos\theta_2\cos\theta_3 + 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} x_e \\ y_e \\ z_e \end{bmatrix} = \begin{bmatrix} (-\cos\theta_1\sin\theta_3 + \sin\theta_1\sin\theta_2\cos\theta_3)(2\cos\theta_4 + 3) + 2\sin\theta_4(-\sin\theta_1\sin\theta_2\sin\theta_3 - \cos\theta_1\cos\theta_3) \\ (-\sin\theta_1\sin\theta_3 - \cos\theta_1\sin\theta_2\cos\theta_3)(2\cos\theta_4 + 3) + 2\sin\theta_4(-\cos\theta_1\sin\theta_2\sin\theta_3 + \sin\theta_1\cos\theta_3) \\ \cos\theta_2\cos\theta_3(2\cos\theta_4 + 3) + 2(-\sin\theta_4\cos\theta_2\sin\theta_3 + 1)) \end{bmatrix}$$