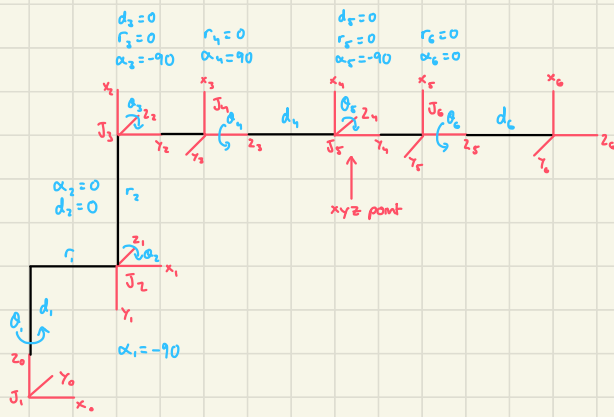
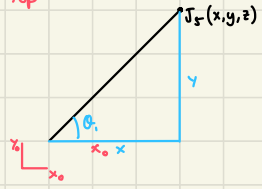


Kin Model



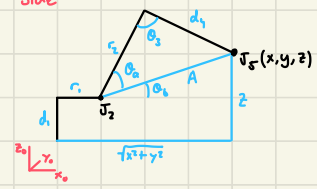
θ_1, θ_2 & θ_3

Top



$$\theta_1 = \tan^{-1}(y/x)$$

Side



triangle $r_2 d_4 A$ ($A = \text{distance between } J_2 \text{ and } P$)

$$\theta_2 = \cos^{-1}\left(\frac{A^2 + r_2^2 - d_4^2}{2A r_2}\right)$$

$$\theta_3 = \tan^{-1}\left(\frac{z - d_1}{\sqrt{x^2 + y^2} - r_1}\right)$$

$$\theta_4 = \theta_2 + \theta_3$$

$$\theta_5 = \cos^{-1}\left(\frac{d_1^2 + r_1^2 - A^2}{2d_1 r_1}\right)$$

$$J_2 = (r_1 \cos \theta_1, r_1 \sin \theta_1, d_1)$$

θ_4, θ_5 & θ_6

$$R_{3,6} = \begin{bmatrix} c(\theta_4)c(\theta_5)c(\theta_6) - s(\theta_4)s(\theta_6) & -s(\theta_4)c(\theta_6) - c(\theta_4)c(\theta_5)s(\theta_6) & -c(\theta_4)s(\theta_5) \\ s(\theta_4)c(\theta_5)c(\theta_6) + s(\theta_4)c(\theta_6) & c(\theta_4)c(\theta_6) - s(\theta_4)c(\theta_5)s(\theta_6) & -s(\theta_4)s(\theta_5) \\ s(\theta_5)c(\theta_6) & -s(\theta_5)s(\theta_6) & c(\theta_5) \end{bmatrix}$$

$$t_4: \frac{R_{2,3}}{R_{4,3}} = \frac{-s(\theta_4)s(\theta_5)}{-c(\theta_4)s(\theta_5)} = \tan(\theta_4) \Rightarrow \theta_4 = \tan^{-1}\left(\frac{R_{2,3}}{R_{4,3}}\right)$$

$$t_6: \frac{R_{3,2}}{R_{3,1}} = \frac{-s(\theta_5)s(\theta_6)}{s(\theta_5)c(\theta_6)} = -\tan(\theta_6) \Rightarrow \theta_6 = \tan^{-1}\left(\frac{-R_{3,2}}{R_{3,1}}\right)$$

$$t_5: \frac{(R_{1,3}^2 + R_{2,3}^2)^{1/2}}{R_{3,3}} = \frac{(c^2(\theta_4)s^2(\theta_5) + s^2(\theta_4)s^2(\theta_5))^{1/2}}{c(\theta_5)} = \frac{s(\theta_5)}{c(\theta_5)} = \tan(\theta_5) \Rightarrow \theta_5 = \tan^{-1}\left(\frac{(R_{1,3}^2 + R_{2,3}^2)^{1/2}}{R_{3,3}}\right)$$