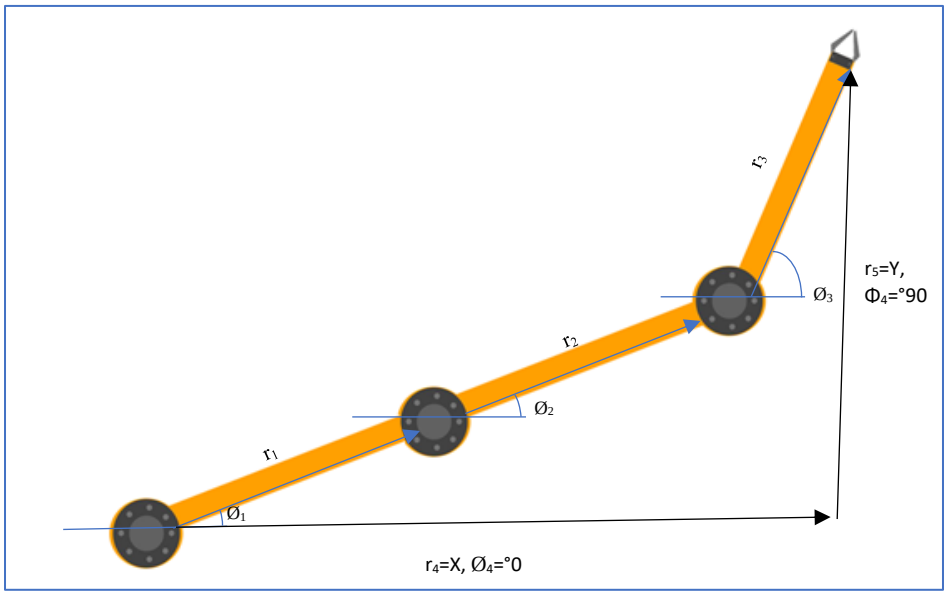
Forward Kinematics:



$$r_1 + r_2 + r_3 = r_4 + r_5$$

sin cos sin cos sin cos sin cos sin cos

Cos:

$$\overset{X}{\cancel{r_4}} = r_1 \cos\theta_1 + r_2 \cos\theta_2 + r_3 \cos\theta_3$$

Sin:

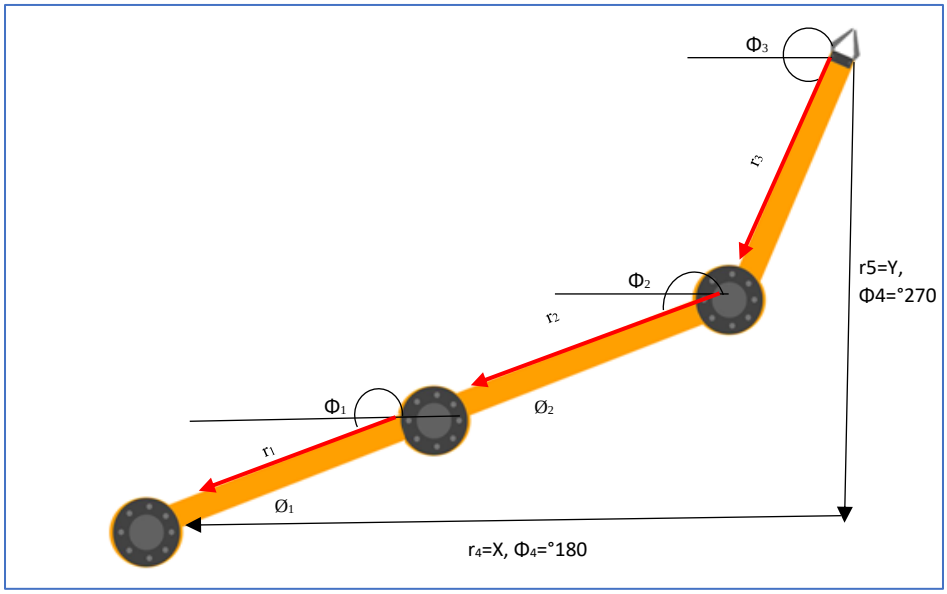
$$\overset{Y}{\cancel{r_5}} = r_1 \sin\theta_1 + r_2 \sin\theta_2 + r_3 \sin\theta_3$$

Forward Kinematic eq.:

$$X = r_1 \cos\theta_1 + r_2 \cos\theta_2 + r_3 \cos\theta_3$$

$$Y = r_1 \sin\theta_1 + r_2 \sin\theta_2 + r_3 \sin\theta_3$$

Inverse Kinematics:



Inverse:

$r_5 + r_4 = r_3 + r_2 + r_1$

$\cos\Phi$

$-X = r_3\cos\Phi_3 + r_2\cos\Phi_2 + r_1\cos\Phi_1$

$\Phi_4 = 180°$

$\Phi_5 = 270°$

$\sin\Phi$

$-Y = r_3\sin\Phi_3 + r_2\sin\Phi_2 + r_1\sin\Phi_1$

2 eqs, 2 unknown

? $\Phi_1 = \theta_1 + 180°$

? $\Phi_2 = \theta_2 + 180°$

$\Phi_3 = \theta_3 + 180°$

X ✓

Y ✓

$$\Phi_2 = \cos^{-1}\left[\frac{X - r_3\cos\Phi_3 - r_1\cos\Phi_1}{r_2}\right]$$

Substitutes in $\sin\Phi$ eq.