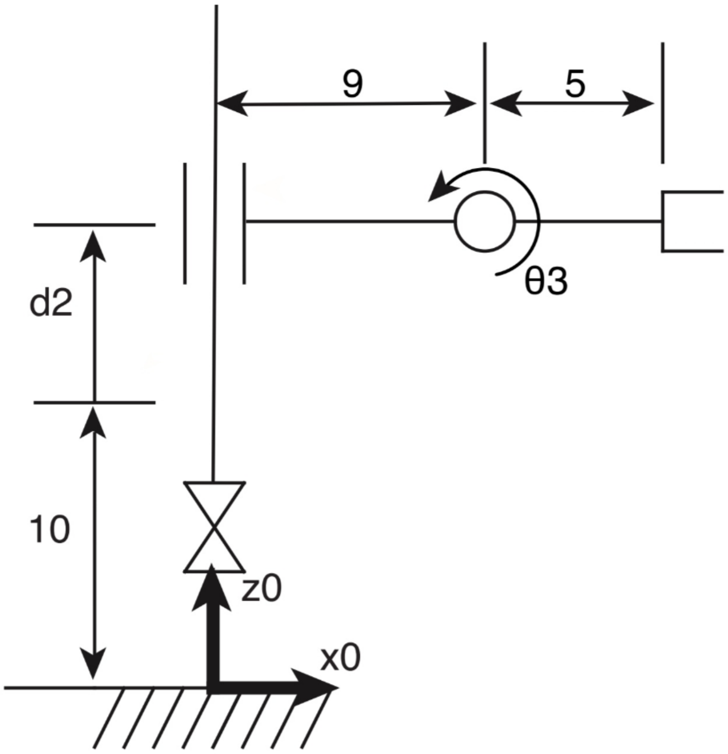
6.) Singular Configurations



The singular configuration can be determined by finding the joint angles where the rank of the jacobian decreases.

i.e solving for det(Jacobian) = 0

from above Matlab script the jacobian determinant was found to be:

$$\det(\text{jacobian}) = -\left(45\cos\theta_1^2\sin\theta_3\right) - \left(45\sin\theta_1^2\sin\theta_3\right) - \left(25\cos\theta_1^2\cos\theta_3\sin\theta_3\right) - \left(25\cos\theta_3\sin\theta_1^2\sin\theta_3\right)$$

$\therefore$ setting det(jacobian) equal to zero

$$-(45\cos\theta_1^2\sin\theta_3) - (45\sin\theta_1^2\sin\theta_3) - (25\cos\theta_1^2\cos\theta_3\sin\theta_3) = 0$$
$$-(25\cos\theta_3\sin\theta_1^2\sin\theta_3)$$

$$-45\sin\theta_3\left(\cancel{\sin^2\theta_1 + \cos^2\theta_1}\right)^{1} - 25\sin\theta_3\cos\theta_3\left(\cancel{\cos^2\theta_1 + \sin^2\theta}\right)^{1} = 0$$

$$-45\sin\theta_3 - 25\cos\theta_3\sin\theta_3 = 0$$

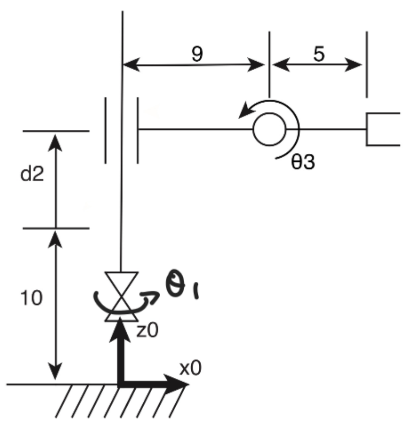
$$\sin\theta_3\left(-45 - 25\cos\theta_3\right) = 0$$

$$\therefore \sin\theta_3 = 0 \quad \text{or} \quad -45 = 25\cos\theta_3$$

$$\theta_3 = \cos^{-1}\left(-\frac{45}{25}\right)$$

N.A

$$\therefore \boxed{\theta_3 = 0, n\pi} \text{ defines the singularity}$$



From the diagram it can be seen that when $\theta_3 = 0$, neither θ_1 or d_2 can produce motion in the x-axis. & is therefore a singularity