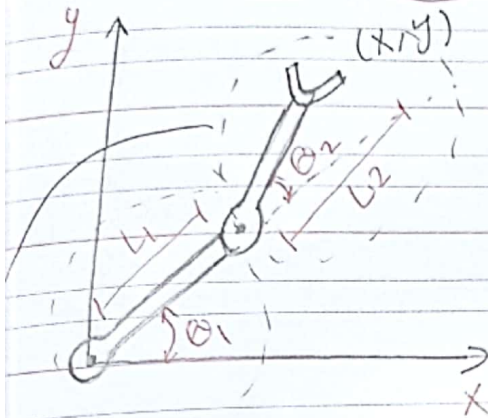


Forward Kinematics.

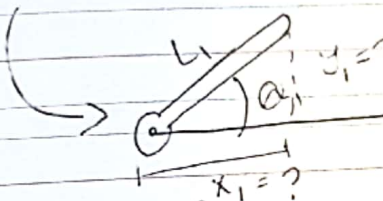


UNKNOWN

$$x = ?$$

$$y = ?$$

$$\theta = ?$$

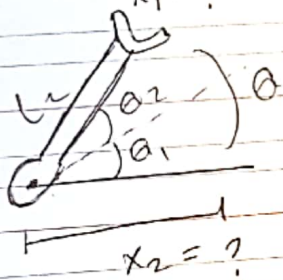


$$y_1 = ? \quad \# \cos \theta_1 = \frac{x_1}{L_1}$$

$$\Rightarrow x_1 = L_1 \cos \theta_1$$

$$\# \sin \theta_1 = \frac{y_1}{L_1}$$

$$\Rightarrow y_1 = L_1 \sin \theta_1$$



$$\# \theta = \theta_1 + \theta_2$$

$$\# \cos \theta = \frac{x_2}{L_2} \Rightarrow x_2 = L_2 \cos \theta$$

$$\Rightarrow L_2 \cos (\theta_1 + \theta_2)$$

$$\# \sin \theta = \frac{y_2}{L_2} \Rightarrow y_2 = L_2 \sin \theta$$

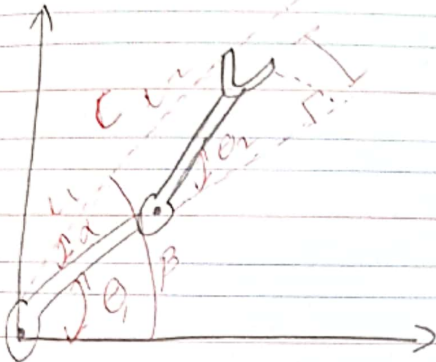
$$\Rightarrow L_2 \sin (\theta_1 + \theta_2)$$

$$\# \text{ total } x = x_1 + x_2 \Rightarrow L_1 \cos \theta_1 + L_2 \cos (\theta_1 + \theta_2)$$

$$\# \text{ total } y = y_1 + y_2 \Rightarrow L_1 \sin \theta_1 + L_2 \sin (\theta_1 + \theta_2)$$

Q1, Q2, m
x, y, q1, q2

Inverse Kinematics



##

$$x = l_1 \cos \theta_1 + l_2 \cos(\theta_1 + \theta_2)$$

$$\Rightarrow l_1 \cos \theta_1 + l_2 \cos \theta_1 \cos \theta_2 + l_2 \sin \theta_1 \sin \theta_2$$

$$y = l_1 \sin \theta_1 + l_2 \sin(\theta_1 + \theta_2)$$

$$\Rightarrow l_1 \sin \theta_1 + l_2 \sin \theta_1 \cos \theta_2 + l_2 \cos \theta_1 \sin \theta_2$$

$$C^2 = x^2 + y^2$$

$$\Rightarrow C^2 = (l_2 \sin \theta_2)^2 + (l_1 + l_2 \cos \theta_2)^2$$

Expand it

$$\Rightarrow x^2 + y^2 = l_2^2 \sin^2 \theta_2 + l_1^2 + l_2^2 \cos^2 \theta_2 + 2 l_1 l_2 \cos \theta_2$$

$\sin^2 \theta + \cos^2 \theta = 1$

$$\Rightarrow 2 l_1 l_2 \cos \theta_2 = x^2 + y^2 - l_1^2 - l_2^2$$

$$\Rightarrow \cos \theta_2 = \frac{x^2 + y^2 - l_1^2 - l_2^2}{2 l_1 l_2}$$

##

$$\theta_2 = \cos^{-1} \left(\frac{x^2 + y^2 - l_1^2 - l_2^2}{2 l_1 l_2} \right)$$

$$[\theta_1 = \theta - \theta_2]$$