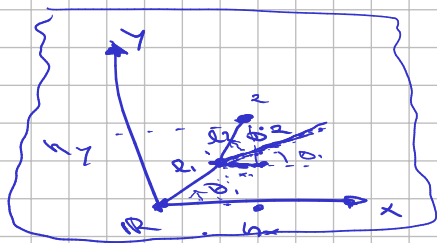


Cinematica Manipulador



$$x_1 = l_1 \cos(\theta_1)$$

$$y_1 = l_1 \sin(\theta_1)$$

$$x_2 = l_2 \cos(\theta_1 + \theta_2)$$

$$y_2 = l_2 \sin(\theta_1 + \theta_2)$$

$$x = x_1 + x_2 \quad x = l_1 \cos(\theta_1) + l_2 \cos(\theta_1 + \theta_2)$$

$$y = y_1 + y_2 \quad y = l_1 \sin(\theta_1) + l_2 \sin(\theta_1 + \theta_2)$$

$$\dot{x} = -l_1 \sin(\theta_1) \dot{\theta}_1 - l_2 \sin(\theta_1 + \theta_2) (\dot{\theta}_1 + \dot{\theta}_2)$$

$$\dot{y} = l_1 \cos(\theta_1) \dot{\theta}_1 + l_2 \cos(\theta_1 + \theta_2) (\dot{\theta}_1 + \dot{\theta}_2)$$

$$\begin{bmatrix} \dot{x} \\ \dot{y} \end{bmatrix} = \begin{bmatrix} -l_1 \sin(\theta_1) - l_2 \sin(\theta_1 + \theta_2) & -l_2 \sin(\theta_1 + \theta_2) \\ l_1 \cos(\theta_1) + l_2 \cos(\theta_1 + \theta_2) & + l_2 \cos(\theta_1 + \theta_2) \end{bmatrix} \begin{bmatrix} \dot{\theta}_1 \\ \dot{\theta}_2 \end{bmatrix}$$

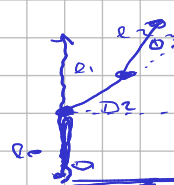
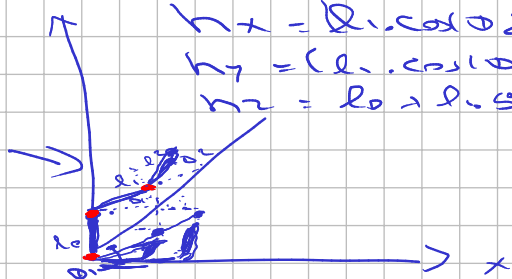
$$x_1 = l_1 \cos(\theta_2) \cdot \cos(\theta_1) \quad x_2 = l_2 \cos(\theta_2 + \theta_3) \cdot \cos(\theta_1)$$

$$y_1 = l_1 \cos(\theta_2) \cdot \sin(\theta_1) \quad y_2 = l_2 \cos(\theta_2 + \theta_3) \cdot \sin(\theta_1)$$

$$x = l_1 \cos(\theta_2) + l_2 \cos(\theta_2 + \theta_3) \cos(\theta_1)$$

$$y = (l_1 \cos(\theta_2) + l_2 \cos(\theta_2 + \theta_3)) \sin(\theta_1)$$

$$z = l_0 + l_1 \sin(\theta_2) + l_2 \sin(\theta_2 + \theta_3)$$



$$x_1 = l_1 \cos(\theta_2)$$

$$y_1 = l_1 + l_1 \sin(\theta_2)$$

$$x_2 = l_2 \cos(\theta_2 + \theta_3)$$

$$y_2 = l_2 \sin(\theta_2 + \theta_3)$$

$$x_1 = 0$$

$$y_1 = l_0$$

$$x_2 = l_1 \sin(\theta_2)$$

$$y_2 = l_1 \cos(\theta_2)$$

$$x_3 = l_2 \sin(\theta_2 + \theta_3)$$

$$y_3 = l_2 \cos(\theta_2 + \theta_3)$$

$$x_4 = l_3 \sin(\theta_2 + \theta_3 + \theta_4)$$

$$y_4 = l_3 \cos(\theta_2 + \theta_3 + \theta_4)$$

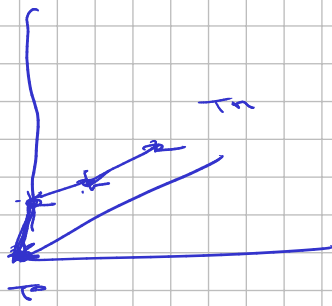
$$x = 0 - l_1 \sin(\theta_2) - l_2 \sin(\theta_2 + \theta_3) - l_3 \sin(\theta_2 + \theta_3 + \theta_4) \cos(\theta_1)$$

$$y = l_0 + l_1 \cos(\theta_2) + l_2 \cos(\theta_2 + \theta_3) + l_3 \cos(\theta_2 + \theta_3 + \theta_4) \sin(\theta_1)$$

$$\dot{x} = (l_1 \sin(\theta_2) + l_2 \sin(\theta_2 + \theta_3) + l_3 \sin(\theta_2 + \theta_3 + \theta_4)) \cos(\theta_1) \dot{\theta}_1$$

$$\dot{y} = (l_1 \cos(\theta_2) + l_2 \cos(\theta_2 + \theta_3) + l_3 \cos(\theta_2 + \theta_3 + \theta_4)) \sin(\theta_1) \dot{\theta}_1$$

$$z = (l_0 + l_1 \cos(\theta_2) + l_2 \cos(\theta_2 + \theta_3) + l_3 \cos(\theta_2 + \theta_3 + \theta_4))$$



$$\vec{r} = \vec{r}^T \vec{r}$$

$$T_0 =$$

$$\vec{r} = \vec{S} \cdot \vec{V}$$

$$R^3$$

$$R^{3 \times 5}$$

$$R^5$$

$$3 \times 1 = 3 \times 5 \quad 5 \times 1$$

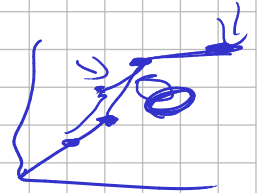
$$\vec{r} = \vec{S} \cdot \vec{V}$$

$$V = \vec{r}^T Q \vec{r}$$

$$R^3$$

$$\vec{r} = \vec{r}_0 - \vec{r}$$

$$\vec{r} = \begin{bmatrix} x_0 - x \\ y_0 - y \\ z_0 - z \end{bmatrix}$$



$$V = \vec{S}^T (\vec{r}_0 + k_2 \cdot \ln k_1 (\vec{r}_0 - \vec{r}_1))$$

$$\begin{bmatrix} 2x + 3y + 4z \\ 3x + 2y + 5z \\ 2x + 0y + 1z \end{bmatrix} = \begin{bmatrix} 2 \\ 3 \\ 1 \end{bmatrix}$$

$$3 \times 5$$

$$5 \times 3$$

$$3 \times 6$$

$$[A] [x] = b$$

$$[A]$$

$$[x]$$

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} 2 \\ 3 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} 2 \\ 3 \\ 1 \end{bmatrix}$$

$$3 \times 1$$

$$R^6$$

$$A^T A$$

$$\begin{bmatrix} 0 & 0 & 0 \end{bmatrix}$$

3x5

$$\vec{v} = \vec{S}^{-1} \left(h_0 + k_1 \tan(k_2^{-1} k_1 x) \right) + (I - \vec{S}^T \vec{S}) \cdot \vec{v}_0$$

$$\vec{v}_0 = \vec{q}_0 - \vec{q}$$

$$\vec{q}_0 =$$

$$\begin{bmatrix} q_{01} \\ q_{02} \\ q_{03} \\ q_{04} \\ q_{05} \end{bmatrix}$$

