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Title: Modelo matemático completo para Robots Seriales

Author: Carla CAMPOS CALDERA

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Mail: *ccampos@itparral.edu.mx*
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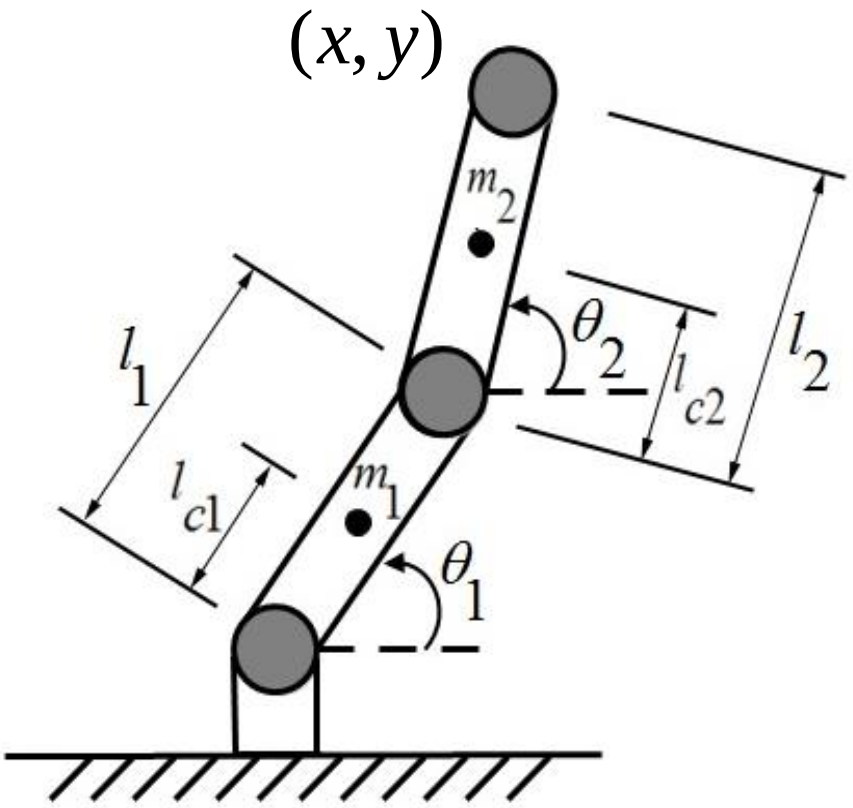
Índice.

Cinemática directa fase simple

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

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



Cinemática Inversa fase simple

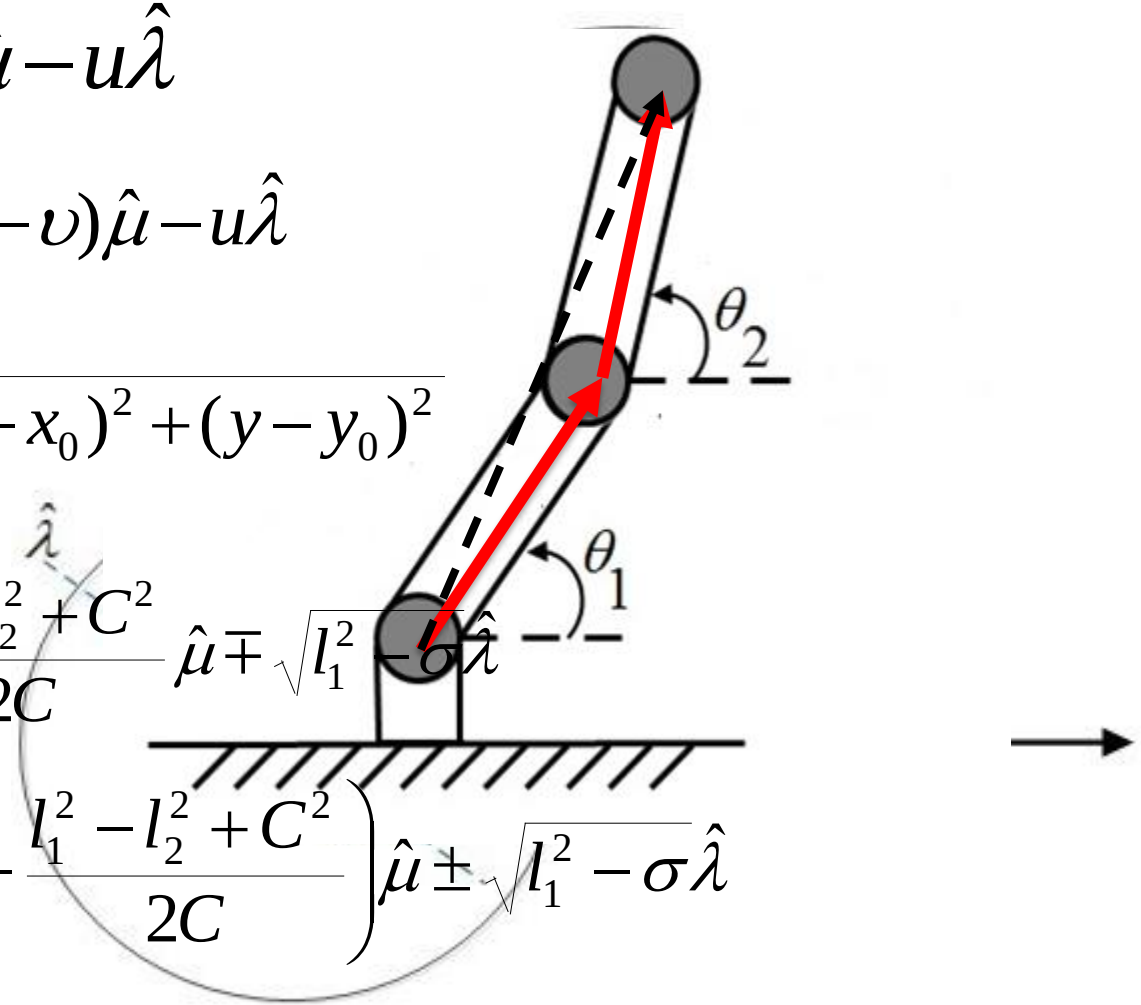
$$\hat{l}_1 = \upsilon\hat{\mu} - u\hat{\lambda}$$

$$\hat{l}_2 = (C - \upsilon)\hat{\mu} - u\hat{\lambda}$$

$$C = \sqrt{(x - x_0)^2 + (y - y_0)^2}$$

$$\hat{l}_1 = \frac{l_1^2 - l_2^2 + C^2}{2C}\hat{\mu} \mp \sqrt{l_1^2 - \sigma}\hat{\lambda}$$

$$\hat{l}_2 = \left(C - \frac{l_1^2 - l_2^2 + C^2}{2C}\right)\hat{\mu} \pm \sqrt{l_1^2 - \sigma}\hat{\lambda}$$



Cinemática inversa fase simple

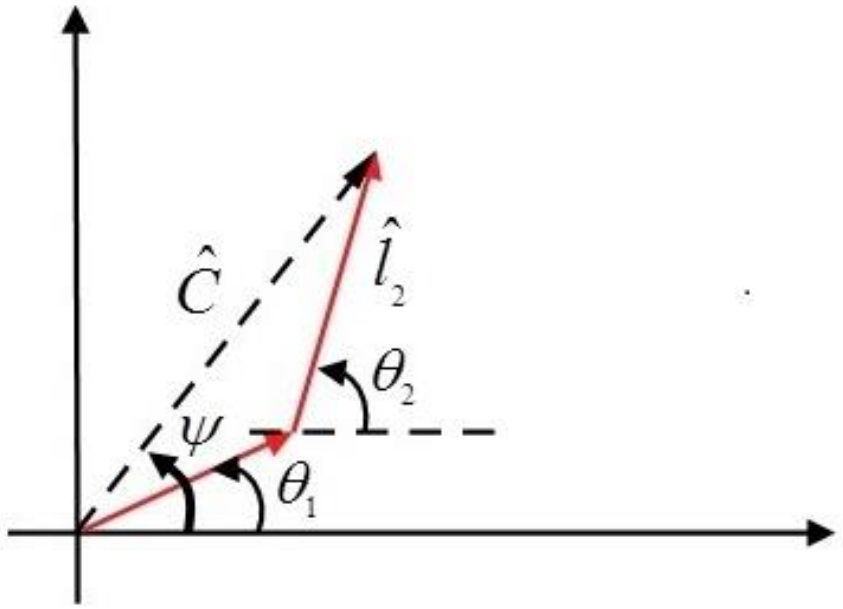
$$\hat{\mu} = [\|\hat{\mu}\|\cos\psi \quad \|\hat{\mu}\|\sin\psi \quad 0]^T = [\cos\psi \quad \sin\psi \quad 0]^T$$

$$\hat{\lambda} = \hat{\mu} \times \hat{k} \qquad \hat{k} = [0 \quad 0 \quad 1]^T$$

$$\hat{\lambda} = [\sin\psi \quad -\cos\psi \quad 0]^T$$

$$\begin{bmatrix} l_{1x} \\ l_{1y} \end{bmatrix} = \frac{l_1^2 - l_2^2 + C^2}{2C} \begin{bmatrix} \cos\psi \\ \sin\psi \end{bmatrix} \mp \sqrt{l_1^2 - \sigma} \begin{bmatrix} \sin\psi \\ -\cos\psi \end{bmatrix}$$

$$\begin{bmatrix} l_{2x} \\ l_{2y} \end{bmatrix} = \left(C - \frac{l_1^2 - l_2^2 + C^2}{2C} \right) \begin{bmatrix} \cos\psi \\ \sin\psi \end{bmatrix} \mp \sqrt{l_1^2 - \sigma} \begin{bmatrix} \sin\psi \\ -\cos\psi \end{bmatrix}$$

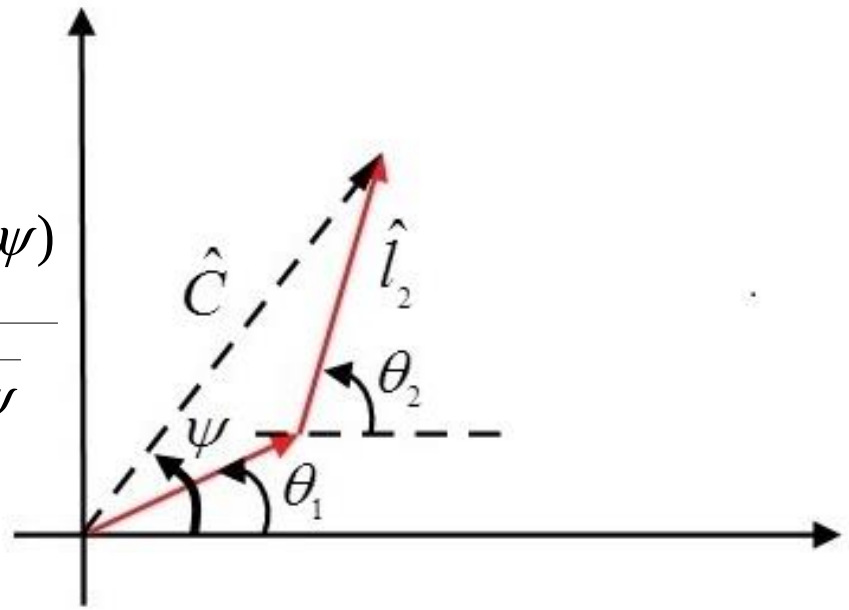


Cinemática inversa fase simple.

$$\begin{bmatrix} l_{1x} \\ l_{1y} \end{bmatrix} = \left(\frac{l_1^2 - l_2^2 + C^2}{2C} \right) \begin{bmatrix} \cos\psi \\ \sin\psi \end{bmatrix} \mp \sqrt{l_1^2 - \sigma^2} \begin{bmatrix} \sin\psi \\ -\cos\psi \end{bmatrix}$$

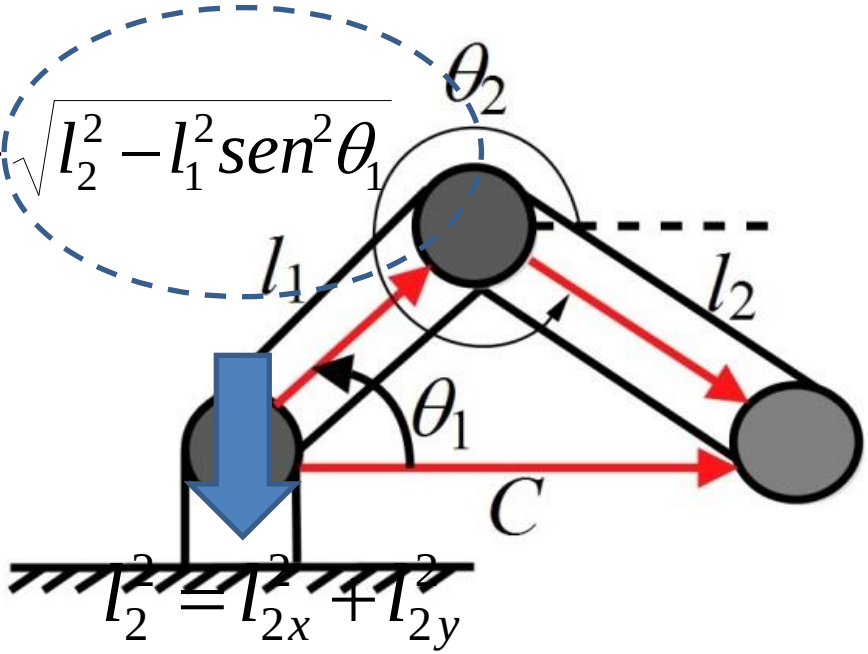
$$\theta_1 = \frac{\left(\frac{l_1^2 - l_2^2 + C^2}{2C} \right) \sin\psi \mp \sqrt{l_1^2 - \sigma^2}(-\cos\psi)}{\left(\frac{l_1^2 - l_2^2 + C^2}{2C} \right) \cos\psi \mp \sqrt{l_1^2 - \sigma^2} \sin\psi}$$

$$\theta_2 = \frac{\left(\frac{l_1^2 - l_2^2 + C^2}{2C} \right) \sin\psi \mp \sqrt{l_1^2 - \sigma^2}(-\cos\psi)}{\left(\frac{l_1^2 - l_2^2 + C^2}{2C} \right) \cos\psi \mp \sqrt{l_1^2 - \sigma^2} \sin\psi}$$



Cinemática directa cadena cerrada

$$C = l_1 \cos\theta_1 + \sqrt{l_2^2 - l_1^2 sen^2\theta_1}$$



$$l_2^2 = l_{2x}^2 + l_{2y}^2$$

$$l_{2x}^2 = l_2^2 - l_{2y}^2$$

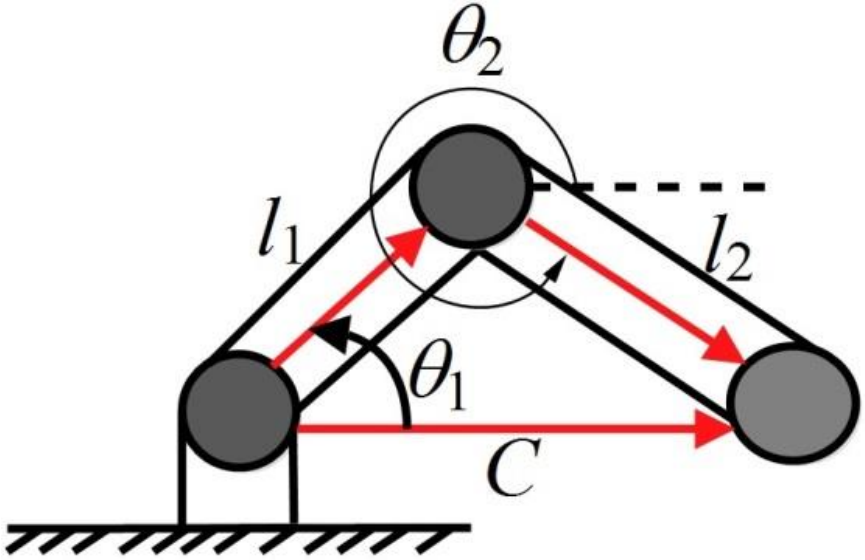
$$l_{2x} = \sqrt{l_2^2 - l_1^2 sen^2\theta_1}$$

Cinemática inversa cadena cerrada

- Cinemática inversa cadena cerrada.

$$\theta_1 = \cos^{-1}\left(\frac{C^2 + l_1^2 - l_2^2}{2Cl_1}\right)$$

$$\theta_2 = \cos^{-1}\left(\frac{C^2 + l_2^2 - l_1^2}{2Cl_2}\right)$$



Dinámica fase simple

$$\boldsymbol{L(q,\dot{q})} = K(\boldsymbol{q},\dot{\boldsymbol{q}}) - U(\boldsymbol{q})$$

$$K_{\boldsymbol{i}}(\boldsymbol{q},\dot{\boldsymbol{q}}) = \sum_{i=1}^{n} \frac{1}{2} m_i v_i^T v_i + \frac{1}{2} \omega_i^T I_i \omega_i$$

$$U_i(\boldsymbol{q}) = \sum_{i}^{n} m_i g h_i$$

$$\frac{d}{dt}\left[\frac{\partial \boldsymbol{L(q,\dot{q})}}{\partial \dot{\boldsymbol{q}}_i}\right] - \frac{\partial \boldsymbol{L(q,\dot{q})}}{\partial \boldsymbol{q}} = \boldsymbol{\tau}$$

Dinámica fase simple

$$\tau_1 = \ddot{\theta}_1(m_1 l_{c1}^2 + m_2 l_1^2 + I_{1zz}) + 2 l_1 l c_2 \cos(\theta_1 - \theta_2)\ddot{\theta}_2$$
$$+ 2 l_1 l c_2 sen(\theta_1 - \theta_2)\dot{\theta}_2^2 + (m_1 l c_1 + m_2 l_1) g \cos\theta_1$$

$$\tau_2 = \ddot{\theta}_2(m_2 l_{c2}^2 + I_{2zz}) + 2 l_1 l c_2 \cos(\theta_1 - \theta_2)\ddot{\theta}_1$$
$$- 2 l_1 l c_2 sen(\theta_1 - \theta_2)\dot{\theta}_1^2 + m_2 l c_2 g \cos\theta_2$$

Dinámica fase simple

$$M(\boldsymbol{q})\ddot{\boldsymbol{q}} + C(\boldsymbol{q},\dot{\boldsymbol{q}})\dot{\boldsymbol{q}} + \boldsymbol{g}(\boldsymbol{q}) = \boldsymbol{\tau}$$

$$M(\boldsymbol{q}) = \begin{bmatrix} m_1 l_{c1}^2 + m_2 l_1^2 + I_{1zz} & 2 l_1 l c_2 \cos(\theta_1 - \theta_2) \\ 2 l_1 l c_2 \cos(\theta_1 - \theta_2) & m_2 l_{c2}^2 + I_{2zz} \end{bmatrix}$$

$$C(\boldsymbol{q},\dot{\boldsymbol{q}}) = \begin{bmatrix} 0 & 2 l_1 l c_2 sen(\theta_1 - \theta_2)\dot{\theta}_2 \\ -2 l_1 l c_2 sen(\theta_1 - \theta_2)\dot{\theta}_1 & 0 \end{bmatrix}$$

$$\boldsymbol{g}(\boldsymbol{q}) = \begin{bmatrix} (m_1 l c_1 + m_2 l_1) g \cos\theta_1 & m_2 l c_2 g \cos\theta_2 \end{bmatrix}^T$$

Dinámica fase cerrada

$$\boldsymbol{q}' = [\theta_1 \quad \theta_2 \quad \theta_3]^T$$

$$\alpha(\boldsymbol{q}') = \theta_1$$

$$\Theta = [1 \quad 0 \quad 0]^T$$

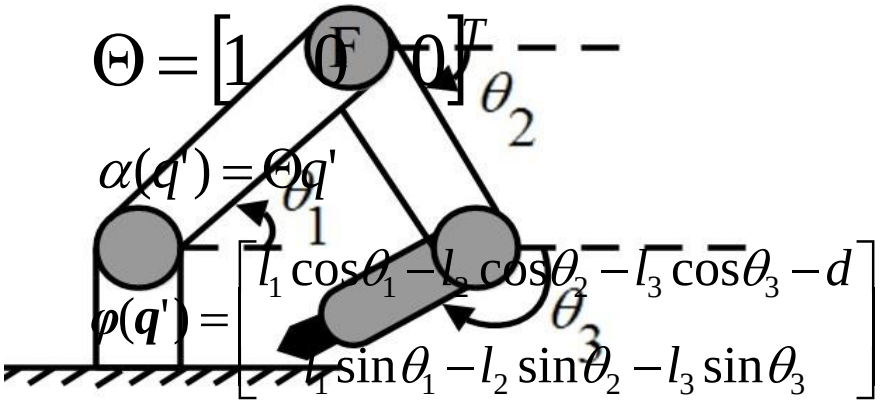
$$\alpha(\boldsymbol{q}') = \Theta \boldsymbol{q}'$$

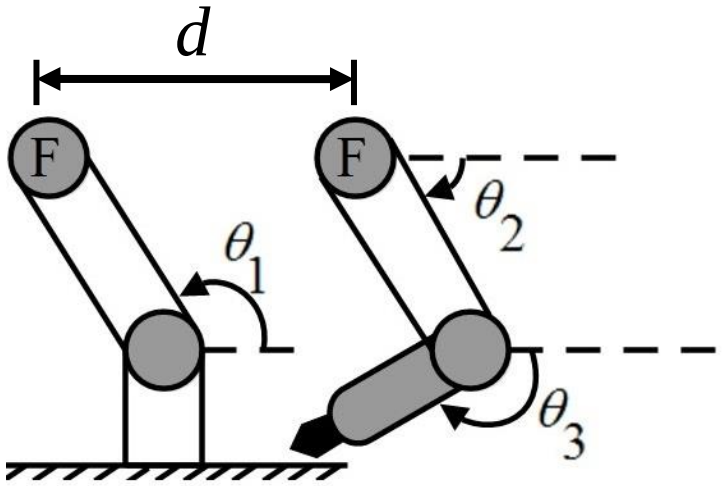
$$\varphi(\boldsymbol{q}') = \begin{bmatrix} l_1\cos\theta_1 - l_2\cos\theta_2 - l_3\cos\theta_3 - d \\ l_1\sin\theta_1 - l_2\sin\theta_2 - l_3\sin\theta_3 \end{bmatrix}$$

$$\boldsymbol{R} = [\varphi(\boldsymbol{q}') \quad \alpha(\boldsymbol{q}')]^T$$

$$\gamma(\boldsymbol{q}') = \partial \boldsymbol{R} / \partial \boldsymbol{q}'$$

$$\boldsymbol{R}(\boldsymbol{q}') = \gamma_{q'}^{-1}(\boldsymbol{q}') \begin{bmatrix} 0_{(n'-n)xn} \\ \boldsymbol{I}_{n\times n} \end{bmatrix}$$





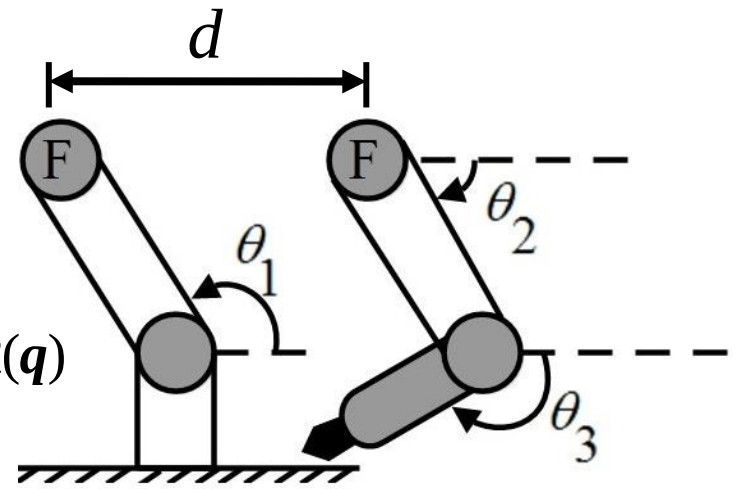
Dinámica fase cerrada

$$M^*(\boldsymbol{q}') = \boldsymbol{R}(\boldsymbol{q}')^T M(\boldsymbol{q}') R(\boldsymbol{q}')$$

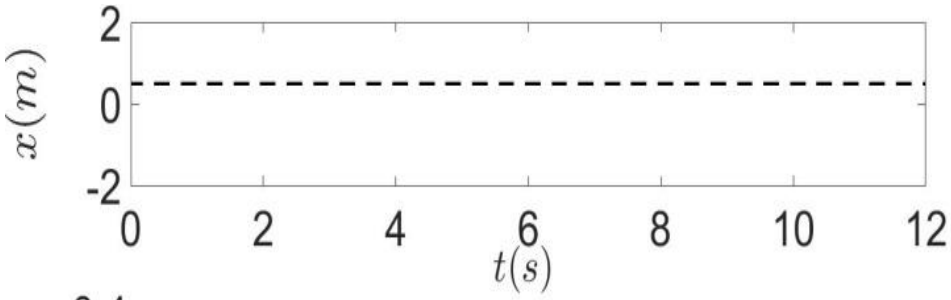
$$C^*(\boldsymbol{q}') = \boldsymbol{R}(\boldsymbol{q}')^T C(\boldsymbol{q}', \dot{\boldsymbol{q}}') \boldsymbol{R}(\boldsymbol{q}') + \boldsymbol{R}(\boldsymbol{q}')^T M(\boldsymbol{q}') \dot{\boldsymbol{R}}(\boldsymbol{q})$$

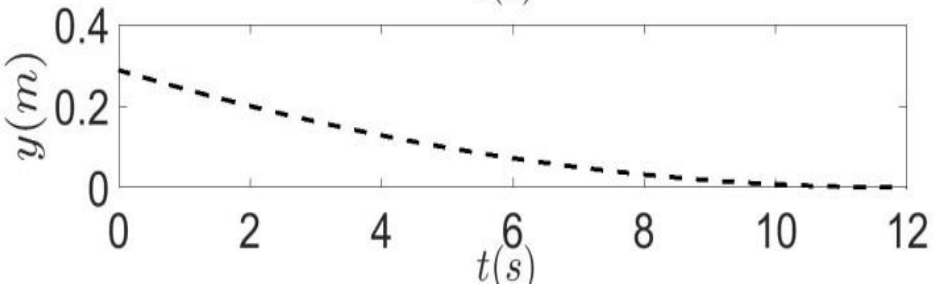
$$\boldsymbol{g}^* = \boldsymbol{R}(\boldsymbol{q})^T \boldsymbol{g}(\boldsymbol{q}') \boldsymbol{R}(\boldsymbol{q})$$

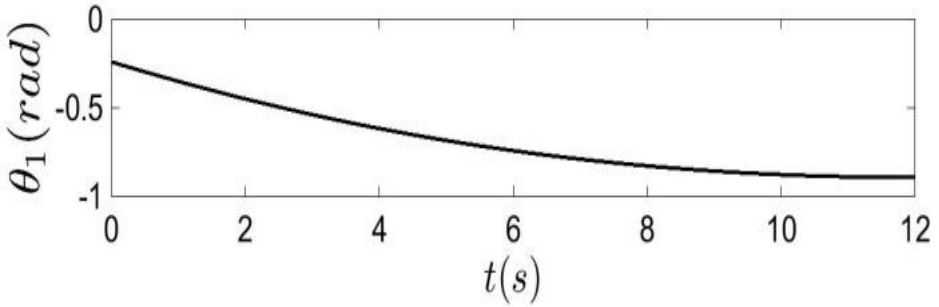
$$M^*(\boldsymbol{q}')\ddot{\boldsymbol{q}} + C(\boldsymbol{q}', \dot{\boldsymbol{q}}')\dot{\boldsymbol{q}}' + \boldsymbol{g}(\boldsymbol{q}') = \boldsymbol{\tau}$$

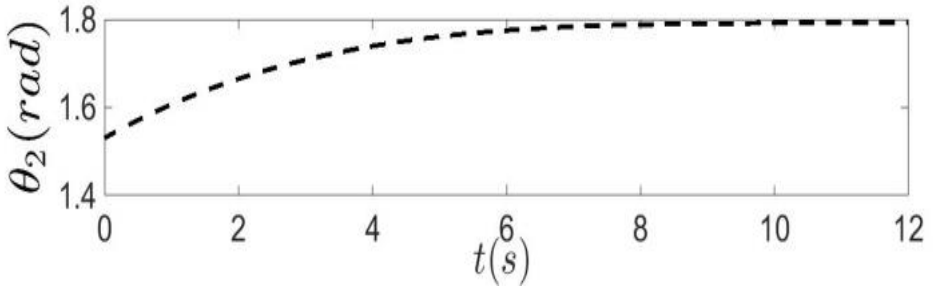


Simulación y animación.

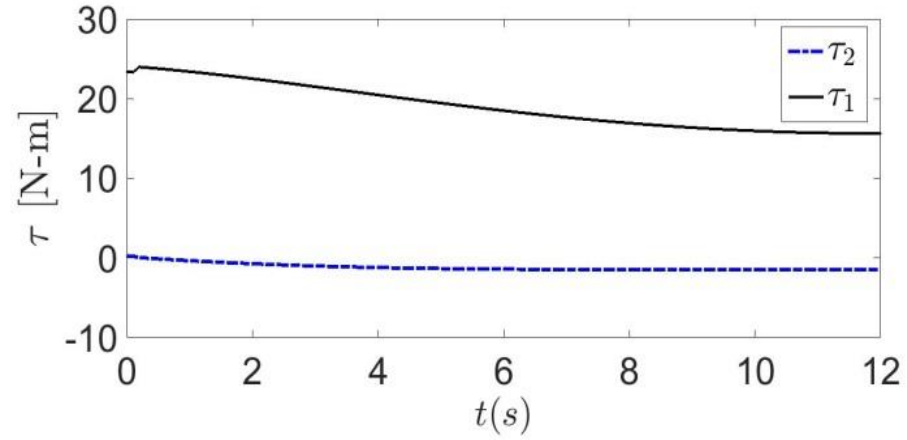


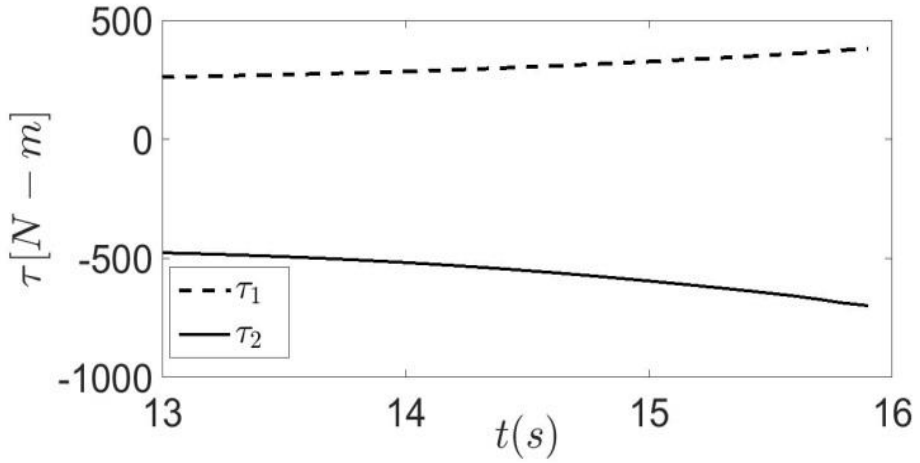




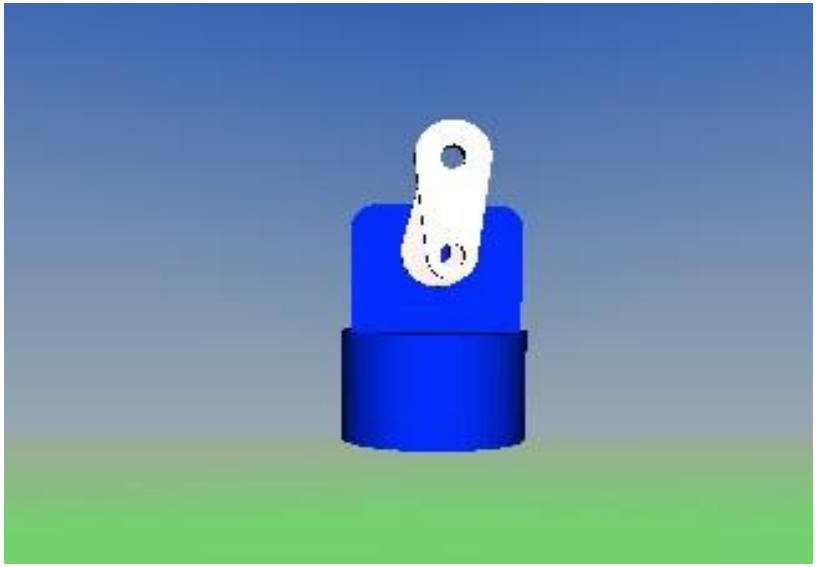


Simulación y animación.





Simulación y animación.



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