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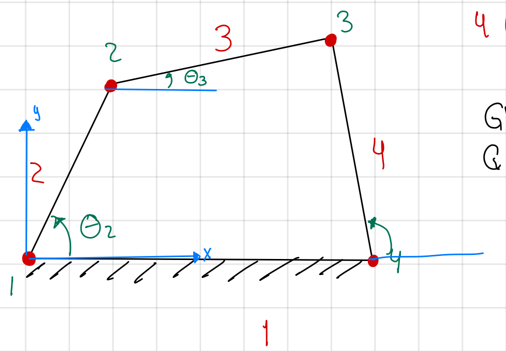


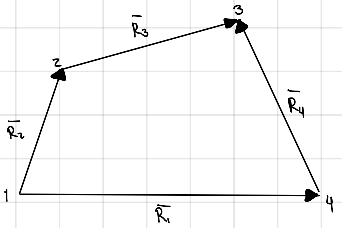
4 JUNTAS COMPLETAS
4 ESLABONES

$GDL = 3(4-1) - 2(4) - 1(\emptyset)$
$GDL = \underline{\underline{1}}$

VARIABLES: θ_3, θ_4
CONSTANTES: l_2, l_3, l_4

θ_2: Es mi variable de control (Yo la defino)

Definiendo lazos vectoriales



Ecuación de lazo

$$\bar{R}_2 + \bar{R}_3 - \bar{R}_4 - \bar{R}_1 = \bar{0}$$

Expresando vectores:

$\bar{R}_1 = l_1 \hat{i}$
$\bar{R}_2 = l_2 \hat{u}_2 = l_2(\cos\theta_2 \hat{i} + \operatorname{sen}\theta_2 \hat{j})$
$\bar{R}_3 = l_3 \hat{u}_3 = l_3(\cos\theta_3 \hat{i} + \operatorname{Sen}\theta_3 \hat{j})$
$\bar{R}_4 = l_4 \hat{u}_4 = l_4(\operatorname{Cos}\theta_4 \hat{i} + \operatorname{Sen}\theta_4 \hat{j})$

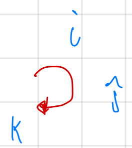
Sustituyendo en ec. de lazo

$$l_2(\operatorname{Cos}\theta_2 \hat{i} + \operatorname{Sen}\theta_2 \hat{j}) + l_3(\operatorname{Cos}\theta_3 \hat{i} + \operatorname{Sen}\theta_3 \hat{j}) - l_4(\operatorname{Cos}\theta_4 \hat{i} + \operatorname{Sen}\theta_4 \hat{j}) - l_1 \hat{i} = \bar{0}$$

Separando por componentes:

$\hat{i}: l_2 \operatorname{Cos}\theta_2 + l_3 \operatorname{Cos}\theta_3 - l_4 \operatorname{Cos}\theta_4 - l_1 = 0$ ... ①
$\hat{j}: l_2 \operatorname{Sen}\theta_2 + l_3 \operatorname{Sen}\theta_3 - l_4 \operatorname{Sen}\theta_4 = 0$ ... ②

Derivando la ecuación de lazo con respecto al tiempo obtenemos:



$$\bar{V}_2 + \bar{V}_3 - \bar{V}_4 - \bar{V}_1 = \bar{0}$$

Caso $\emptyset$ $\quad \bar{V}_1 = \bar{0}$
Caso 2 $\quad \bar{V}_2 = \bar{\omega}_2 \times \bar{R}_2 = \omega_2 \hat{k} \times l_2(\operatorname{Cos}\theta_2 \hat{i} + \operatorname{Sen}\theta_2 \hat{j}) = -\omega_2 l_2 \operatorname{Sen}\theta_2 \hat{i} + \omega_2 l_2 \operatorname{Cos}\theta_2 \hat{j}$
Caso 2 $\quad \bar{V}_3 = \bar{\omega}_3 \times \bar{R}_3 = \omega_3 \hat{k} \times l_3(\operatorname{Cos}\theta_3 \hat{i} + \operatorname{Sen}\theta_3 \hat{j}) = -\omega_3 l_3 \operatorname{Sen}\theta_4 \hat{i} + \omega_3 l_3 \operatorname{Cos}\theta_3 \hat{j}$
Caso 2 $\quad \bar{V}_4 = \bar{\omega}_4 \times \bar{R}_4 = \omega_4 \hat{k} \times l_4(\operatorname{Cos}\theta_4 \hat{i} + \operatorname{Sen}\theta_4 \hat{j}) = -\omega_4 l_4 \operatorname{Sen}\theta_4 \hat{i} + \omega_4 l_4 \operatorname{Cos}\theta_4 \hat{j}$

Separando por componentes

$\hat{i}: -\omega_2 l_2 \operatorname{Sen}\theta_2 - \omega_3 l_3 \operatorname{Sen}\theta_3 + \omega_4 l_4 \operatorname{Sen}\theta_4 = 0$
$\hat{j}: \omega_2 l_2 \operatorname{Cos}\theta_2 + \omega_3 l_3 \operatorname{Cos}\theta_3 - \omega_4 l_4 \operatorname{Cos}\theta_4 = 0$

Segunda derivada a ecuación de lazo con respecto al tiempo:

$$\bar{A}_2 + \bar{A}_3 - \bar{A}_4 - \bar{A}_1 = \bar{0}$$

Caso 0 $\quad \bar{A}_1 = \bar{0}$

Caso 2 $\quad \bar{A}_2 = \bar{\alpha}_2 \times \bar{R}_2 - W_2^2 \bar{R}_2 = \alpha_2 \hat{k} \times l_2(\cos\theta_2 \hat{i} + \operatorname{Sen}\theta_2 \hat{j}) - W_2^2 l_2(\cos\theta_2 \hat{i} + \operatorname{Sen}\theta_2 \hat{j})$

$\bar{A}_2 = (-\alpha_2 l_2 \operatorname{Sen}\theta_2 - W_2^2 l_2 \cos\theta_2)\hat{i} + (\alpha_2 l_2 \cos\theta_2 - W_2^2 l_2 \operatorname{Sen}\theta_2)\hat{j}$

Caso 2 $\quad \bar{A}_3 = \bar{\alpha}_3 \times \bar{R}_3 - W_3^2 \bar{R}_3 = \alpha_3 \hat{k} \times l_3(\cos\theta_3 \hat{i} + \operatorname{Sen}\theta_3 \hat{j}) - W_3^2 l_3(\cos\theta_3 \hat{i} + \operatorname{Sen}\theta_3 \hat{j})$

$\bar{A}_3 = (-\alpha_3 l_3 \operatorname{Sen}\theta_3 - W_3^2 l_3 \cos\theta_3)\hat{i} + (\alpha_3 l_3 \cos\theta_3 - W_3^2 l_3 \operatorname{Sen}\theta_3)\hat{j}$

Caso 2 $\quad \bar{A}_4 = \bar{\alpha}_4 \times \bar{R}_4 - W_4^2 \bar{R}_4 = \alpha_4 \hat{k} \times l_4(\cos\theta_4 \hat{i} + \operatorname{Sen}\theta_4 \hat{j}) - W_4^2 l_4(\cos\theta_4 \hat{i} + \operatorname{Sen}\theta_4 \hat{j})$

$\bar{A}_4 = (-\alpha_4 l_4 \operatorname{Sen}\theta_4 - W_4^2 l_4 \cos\theta_4)\hat{i} + (\alpha_4 l_4 \cos\theta_4 - W_4^2 l_4 \operatorname{Sen}\theta_4)\hat{j}$

Separando por componentes:

$\hat{i}: -\alpha_2 l_2 \operatorname{Sen}\theta_2 - W_2^2 l_2 \cos\theta_2 - \alpha_3 l_3 \operatorname{Sen}\theta_3 - W_3^2 l_3 \cos\theta_3 + \alpha_4 l_4 \operatorname{Sen}\theta_4 + W_4^2 l_4 \cos\theta_4 = 0$

$\hat{j}: \alpha_2 l_2 \cos\theta_2 - W_2^2 l_2 \operatorname{Sen}\theta_2 + \alpha_3 l_3 \cos\theta_3 - W_3^2 l_3 \operatorname{Sen}\theta_3 - \alpha_4 l_4 \cos\theta_4 + W_4^2 l_4 \operatorname{Sen}\theta_4 = 0$