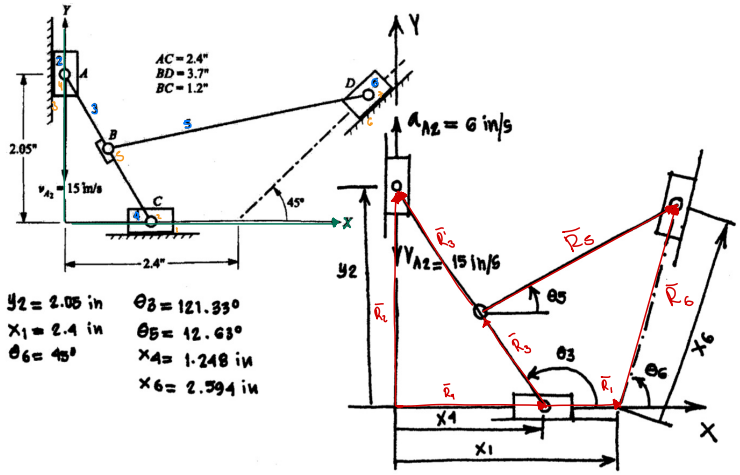
Celaya González David Alejandro

Tarea: 4



PROBLEMA 2.26

$$GDL = 3(6-1) - 2(7) - 1(0)$$
$$= 3(5) - 2(7)$$
$$= 15 - 14$$
$$= 1$$

ECUACIÓN LAZO POSICIÓN:

$$\bar{R}_1 + \bar{R}_6 - \bar{R}_5 + \bar{R}_3' - \bar{R}_2 = \bar{0}$$
$$\bar{R}_4 + \bar{R}_3 + \bar{R}_3' - \bar{R}_2 = \bar{0}$$

Posición

Definiendo vectores

$$\bar{R}_1 = l_1\hat{i} = 2.4\,\hat{i}$$
$$\bar{R}_2 = y_2\hat{j} =$$
$$\bar{R}_3 = r_3\hat{u}_3 = 1.2(\cos\theta_3\hat{i} + \operatorname{Sen}\theta_3\hat{j}) = 1.2\cos\theta_3\,\hat{i} + 1.2\operatorname{Sen}\theta_3\,\hat{j}$$
$$\bar{R}_3' = r_3\hat{u}_3 = 1.2(\cos\theta_3\hat{i} + \operatorname{Sen}\theta_3\hat{j}) = 1.2\cos\theta_3\,\hat{i} + 1.2\operatorname{Sen}\theta_3\,\hat{j}$$
$$\bar{R}_4 = x_4\,\hat{i}$$
$$\bar{R}_5 = r_5\hat{u}_5 = 3.7(\cos\theta_5\hat{i} + \operatorname{Sen}\theta_5\hat{j}) = 3.7\cos\theta_5\,\hat{i} + 3.7\operatorname{Sen}\theta_5\,\hat{j}$$
$$\bar{R}_6 = r_6\hat{u}_6 = r_6(\cos\theta_6\hat{i} + \operatorname{Sen}\theta_6\hat{j}) = \frac{\sqrt{2}}{2}x_6\,\hat{i} + \frac{\sqrt{2}}{2}x_6\,\hat{j}$$

ECUACIÓN ESCALAR ①

$$\hat{i}: 2.4 + \frac{\sqrt{2}}{2}x_6 - 3.7\cos\theta_5 + 1.2\cos\theta_3 = 0$$
$$\hat{j}: \frac{\sqrt{2}}{2}x_6 - 3.7\operatorname{Sen}\theta_5 + 1.2\operatorname{Sen}\theta_3 - y_2 = 0$$

ECUACIÓN ESCALAR ②

$$\hat{i}: x_4 + 2.4\cos\theta_3 = 0$$
$$\hat{j}: 2.4\operatorname{Sen}\theta_3 - y_2 = 0$$

Velocidad:

LCV 1: $\bar{V}_1 + \bar{V}_6 - \bar{V}_5 + \bar{V}_3' - \bar{V}_2 = \bar{0}$
LCV 2: $\bar{V}_4 + \bar{V}_3 + \bar{V}_3' - \bar{V}_2 = \bar{0}$

Definiendo vectores velocidad:

$$\bar{V}_1: 0\,\hat{i}$$
$$\bar{V}_2: V_{y_2}\hat{j} = -15\,\hat{j}$$
$$\bar{V}_3: \omega_3\hat{k} \times 1.2\cos\theta_3\hat{i} + 1.2\operatorname{Sen}\theta_3\hat{j} = -1.0250\omega_3\,\hat{i} - 0.6240\omega_3\,\hat{j}$$
$$\bar{V}_3': \omega_3\hat{k} \times 1.2\cos\theta_3\hat{i} + 1.2\operatorname{Sen}\theta_3\hat{j} = -1.0250\omega_3\,\hat{i} - 0.6240\omega_3\,\hat{j}$$
$$\bar{V}_4: V_{x_4}\,\hat{i}$$
$$\bar{V}_5: \omega_5\hat{k} \times (3.7\cos\theta_5\hat{i} + 3.7\operatorname{Sen}\theta_5\hat{j}) = -0.8090\omega_5\hat{i} - 3.6105\omega_5\hat{j}$$
$$\bar{V}_6: \frac{\sqrt{2}}{2}V_{x_6}\hat{i} + \frac{\sqrt{2}}{2}V_{x_6}\hat{j}$$

ECUACIONES

$$-1.0250\omega_3 + 0.8090\omega_5 + 0V_{x_4} + \frac{\sqrt{2}}{2}V_{x_6} = 0$$
$$-0.6240\omega_3 - 3.6105\omega_5 + 0V_{x_4} + \frac{\sqrt{2}}{2}V_{x_6} = -15$$
$$-2.05\omega_3 + 0\omega_5 + 1V_{x_4} + 0V_{x_6} = 0$$
$$-1.248\omega_3 + 0\omega_5 + 0V_{x_4} + 0V_{x_6} = -15$$

LCV 1:

$$\hat{i}: \frac{\sqrt{2}}{2}V_{x_6} + 0.8090\omega_5 - 1.0250\omega_3 = 0$$
$$\hat{j}: \frac{\sqrt{2}}{2}V_{x_6} - 3.6105\omega_5 - 0.6240\omega_3 + 15 = 0$$

LCV 2:

$$V_{x_4} - 2.05\omega_3 = 0$$
$$-1.248\omega_3 + 15 = 0$$

$\therefore \omega_3 = 12.0192$ [rad/s]
$\omega_5 = 4.4846$ [rad/s]
$V_{x4} = 24.6394$ [in/s]
$V_{x6} = 12.2920$ [in/s]

ACELERACION

$$\bar{A}_1 + \bar{A}_6 - \bar{A}_5 + \bar{A}_3 - \bar{A}_2 = \bar{0}$$

$$\bar{A}_4 + \bar{A}_3 + \bar{A}_{3'} - \bar{A}_2 = \bar{0}$$

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

$\bar{A}_2 = a_{A2}\hat{j} = 6$ [in/s^2] $\hat{j}$

$\bar{A}_3 = \bar{\alpha}_3 \times \bar{R}_3 - \omega_3^2 \bar{R}_3 = \alpha_3 \hat{k} \times (1.2\cos\theta_3 \hat{i} + 1.2\operatorname{sen}\theta_3 \hat{j}) - \omega_3^2 (1.2\cos\theta_3 \hat{i} + 1.2\operatorname{sen}\theta_3 \hat{j})$

$= -1.0250\alpha_3 \hat{i} - 0.6240\alpha_3 \hat{j} + 90.1437\ \hat{i} - 148.0726\ \hat{j}$

$\bar{A}_3 = \bar{\alpha}_3 \times \bar{R}_3 - \omega_3^2 \bar{R}_3 = \alpha_3 \hat{k} \times (1.2\cos\theta_3 \hat{i} + 1.2\operatorname{sen}\theta_3 \hat{j}) - \omega_3^2 (1.2\cos\theta_3 \hat{i} + 1.2\operatorname{sen}\theta_3 \hat{j})$

$= -1.0250\alpha_3 \hat{i} - 0.6240\alpha_3 \hat{j} + 90.1437\ \hat{i} - 148.0726\ \hat{j}$

$\bar{A}_4 = x_4 \hat{i}$

$\bar{A}_5 = \bar{\alpha}_5 \times \bar{R}_5 - \omega_5^2 \bar{R}_5 = \alpha_5 \hat{k} \times (-3.7\cos\theta_5 \hat{i} + 3.7\operatorname{sen}\theta_5 \hat{j}) - \omega_5^2 (0.8090 i + 3.6105 \hat{j})$

$-0.8090\alpha_5 \hat{i} + 3.6105\alpha_5 \hat{j} - 72.6030 i - 16.2703 \hat{j}$

$\bar{A}_6 = \sqrt{2}/2\, x_6 \hat{i} + \sqrt{2}/2\, x_6 \hat{j}$

$i: \sqrt{2}/2\, x_6 + 0.8090\alpha_5 + 72.6030 - 1.0250\alpha_3 + 90.1437 = 0$

$j: \sqrt{2}/2\, x_6 - 3.6105\alpha_5 + 16.2703 - 0.6240\alpha_3 - 148.0726 - 6 = 0$

$i: x_4 - 2.05\alpha_3 + 180.2874 = 0$

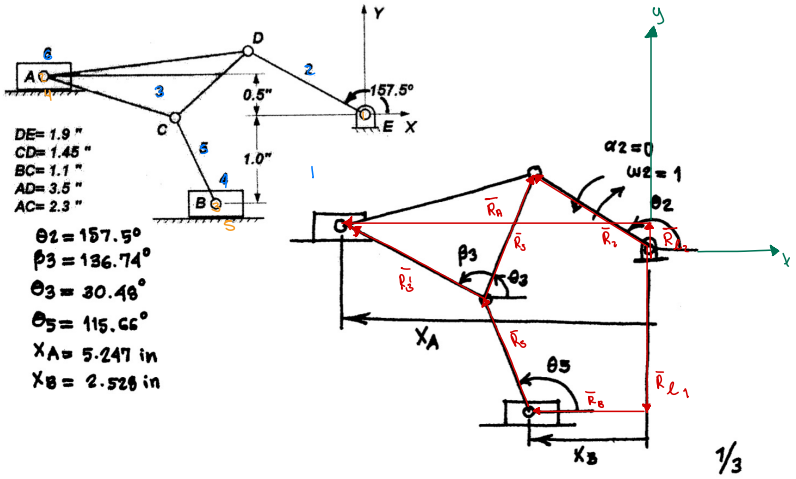
$j: -1.248\alpha_3 - 296.1452 - 6 = 0$

ECUACIONES

$$\begin{aligned}
-1.0250\alpha_3 + 0\, x_4 + 0.8090\alpha_5 + \sqrt{2}/2\, x_6 &= -162.7467 \\
-0.6240\alpha_3 + 0\, x_4 - 3.6105\alpha_5 + \sqrt{2}/2\, x_6 &= 137.8023 \\
-2.05\alpha_3 + 1\, x_4 + 0\, \alpha_5 + 0\, x_6 &= -180.2874 \\
-1.248\alpha_3 + 0\, x_4 + 0\, \alpha_5 + 0\, x_6 &= 302.1452
\end{aligned}$$

$\alpha_3 = -242.1035$ [rad/s^2]
$x_4 = -676.5996$ [in/s^2]
$\alpha_5 = -89.9723$ [rad/s^2]
$x_6 = -478.1717$ [in/s^2]

PROBLEMA 2.26



1/3

$GDL = 3(6-1) - 2(7)$
$= 15 - 14$
$= 1$

$Var\{\theta_2, \theta_3, X_A, \theta_5, X_B\}$

$Inc\{\theta_3, X_A, \theta_5, X_B\}$

EC. LAZO

$\bar{R}_{\ell_1} + \bar{R}_B + \bar{R}_5 + \bar{R}_3' - \bar{R}_A - \bar{R}_{\ell_2} = \bar{0} \quad \ldots (1)$
$\bar{R}_{\ell_1} + \bar{R}_B + \bar{R}_5 + \bar{R}_3 - \bar{R}_2 = \bar{0} \quad \ldots (2)$

Definiendo vectores.

$\bar{R}_{\ell_1} = l_1 \hat{i} = -1\hat{j}$
$\bar{R}_{\ell_2} = l_2 \hat{j} = 0.5\hat{j}$
$\bar{R}_2 = r_2 \hat{u}_2 = 1.9\cos\theta_2 \hat{i} + 1.9\operatorname{Sen}\theta_2 \hat{j}$
$\bar{R}_3 = r_3 \hat{u}_3 = 1.45\cos\theta_3 \hat{i} + 1.45\operatorname{Sen}\theta_3 \hat{j}$
$\bar{R}_3' = r_3' \hat{u}_3' = 2.3\cos(\beta_3)\hat{i} + 2.3\operatorname{Sen}(\beta_3)\hat{j}$
$\bar{R}_5 = r_5 \hat{u}_5 = 1.1\cos\theta_5 \hat{i} + 1.1\operatorname{Sen}\theta_5 \hat{j}$
$\bar{R}_A = -X_A \hat{i}$
$\bar{R}_B = -X_B \hat{i}$

POSICIÓN

$\hat{i}: -X_B + 1.1\cos\theta_5 + 2.3\cos(\beta_3) + X_A = 0$
$\hat{j}: -1 + 1.1\operatorname{Sen}\theta_5 + 2.3\operatorname{sen}(\beta_3) - 0.5 = 0$

$\hat{i}: -X_B + 1.1\cos\theta_5 + 1.45\cos\theta_3 - 1.9\cos\theta_2 = 0$
$\hat{j}: -1 + 1.1\operatorname{Sen}\theta_5 + 1.45\operatorname{Sen}\theta_3 - 1.9\operatorname{Sen}\theta_2 = 0$

Velocidad

$\bar{V}_{\ell_1} + \bar{V}_B + \bar{V}_5 + \bar{V}_3' - \bar{V}_A - \bar{V}_{\ell_2} = \bar{0} \quad \ldots (1)$
$\bar{V}_{\ell_1} + \bar{V}_B + \bar{V}_5 + \bar{V}_3 - \bar{V}_2 = \bar{0} \quad \ldots (2)$

$\bar{V}_{\ell_1} = 0\hat{j}$
$\bar{V}_{\ell_2} = 0\hat{j}$
$\bar{V}_2 = \omega_2 \hat{k} \times \bar{R}_2 = -0.7271\omega_2 \hat{i} - 1.7554\omega_2 \hat{j}$
$\bar{V}_3 = \omega_3 \hat{k} \times \bar{R}_3 = -0.7355\omega_3 \hat{i} + 1.2496\omega_3 \hat{j}$
$\bar{V}_3' = \omega_3 \hat{k} \times \bar{R}_3' = -1.5762\omega_3 \hat{i} - 1.6750\omega_3 \hat{j}$
$\bar{V}_5 = \omega_5 \hat{k} \times \bar{R}_5 = -0.9915\omega_5 \hat{i} - 0.4763\omega_5 \hat{j}$
$\bar{V}_A = -V_{X_A} \hat{i}$
$\bar{V}_B = -V_{X_B} \hat{i}$

$\hat{i}: -V_{X_B} - 0.9915\omega_5 - 1.5762\omega_3 + V_{X_A} = 0$
$\hat{j}: -0.4763\omega_5 - 1.6750\omega_3 = 0$

$\hat{i}: -V_{X_B} - 0.9915\omega_5 - 0.7355\omega_3 + 0.7271\omega_2 = 0$
$\hat{j}: -0.4763\omega_5 + 1.2496\omega_3 + 1.7554\omega_2 = 0$

$$
\begin{aligned}
1\,V_{xA} - 1\,V_{xB} - 1.5762\,W_3 - 0.9915\,W_5 &= 0\\
0\,V_{xA} + 0\,V_{xB} - 1.6750\,W_3 - 0.4763\,W_5 &= 0\\
0\,V_{xA} - 1\,V_{xB} - 0.7355\,W_3 - 0.9915\,W_5 &= 0.7271\\
0\,V_{xA} - 0\,V_{xB} + 1.2496\,W_3 - 0.4763\,W_5 &= 1.7554
\end{aligned}
$$

$$
\begin{aligned}
0\,V_{xA} - 1\,V_{xB} - 0.7355\,W_3 - 0.9915\,W_5 &= 0.7271\\
0\,V_{xA} - 0\,V_{xB} + 1.2496\,W_3 - 0.4763\,W_5 &= 1.7554\\
1\,V_{xA} - 1\,V_{xB} - 1.5762\,W_3 - 0.9915\,W_5 &= 0\\
0\,V_{xA} - 0\,V_{xB} - 1.6750\,W_3 - 0.4763\,W_5 &= 0
\end{aligned}
$$

$V_{xA} = -0.2225\ [in/s]$
$V_{xB} = 0.9243\ [in/s]$
$W_3 = 0.6007\ [rad/s]$
$W_5 = -2.1107\ [rad/s]$

ACELERACION.

$\bar{A}_{L_1} + \bar{A}_B + \bar{A}_5 + \bar{A}_3' - \bar{A}_A - \bar{A}_{L_2} = \bar{0}$ ... ①

$\bar{A}_{L_1} + \bar{A}_B + \bar{A}_5 + \bar{A}_3 - \bar{A}_2 = \bar{0}$ ... ②

DESCRIBIENDO ACELERACIONES

$\bar{A}_{L_1} = \bar{0}$

$\bar{A}_{L_2} = \bar{0}$

$\bar{A}_2 = \alpha_2 \hat{k} \times \bar{R}_2 - W_2^2 \bar{R}_2 = \alpha_2 \hat{k} \times (-1.7554\,i + 0.7270\,j) - W_2^2 (-1.7554\,i + 0.7270\,j)$

$= (-0.7270\alpha_2 + 1.7554)\,i + (-1.7554\alpha_2 - 0.727)\,j$

$\bar{A}_3 = \alpha_3 \hat{k} \times \bar{R}_3 - W_3^2 \bar{R}_3 = \alpha_3 \hat{k} \times (1.45\cos\theta_3\,i + 1.45\,\mathrm{Sen}\,\theta_3\,j) - W_3^2 (1.45\cos\theta_3\,i + 1.45\,\mathrm{Sen}\,\theta_3\,j)$

$= (-0.7355\alpha_3 - 0.4502)\,i + (1.2496\alpha_3 - 0.2650)\,j$

$\bar{A}_3' = \alpha_3 \hat{k} \times \bar{R}_3' - W_3^2 \bar{R}_3' = \alpha_3 \hat{k} \times (2.3\cos(\beta_3)\,i + 2.3\,\mathrm{Sen}(\beta_3)\,j) - W_3^2 (2.3\cos(\beta_3)\,i + 2.3\,\mathrm{Sen}(\beta_3)\,j)$

$= (-1.5762\alpha_3 + 0.6034)\,i + (-1.6750\alpha_3 - 0.5678)\,j$

$\bar{A}_5 = \alpha_5 \hat{k} \times \bar{R}_5 - W_5^2 \bar{R}_5 = \alpha_5 \hat{k} \times (1.1\cos\theta_5\,i + 1.1\,\mathrm{Sen}\,\theta_5\,j) - W_5^2 (1.1\cos\theta_5\,i + 1.1\,\mathrm{Sen}\,\theta_5\,j)$

$= (-0.9915\alpha_5 + 2.1221)\,i + (-0.4763\alpha_5 - 4.4173)\,j$

$\bar{A}_A = -a_{xA}\,\hat{i}$

$\bar{A}_B = -a_{xB}\,\hat{i}$

ECUACIONES DE LAZO EN COMPONENTES

$i: \; -a_{xB} - 0.9915\alpha_5 + 2.1221 - 1.5762\alpha_3 + 0.634 + a_{xA} = 0$

$j: \; -0.4763\alpha_5 - 4.4173 - 1.6750\alpha_3 - 0.5678 = 0$

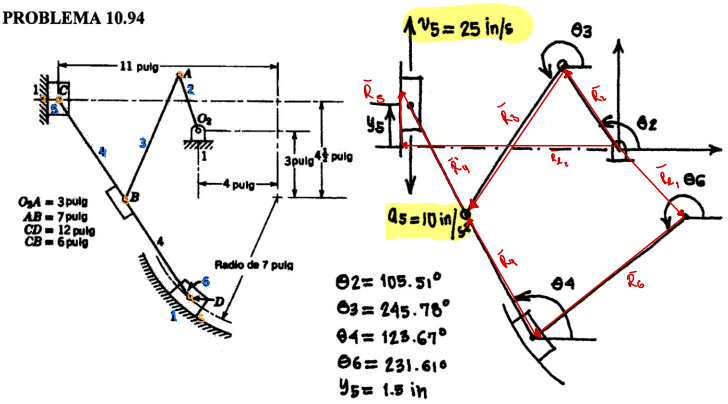
$i: \; -a_{xB} - 0.9915\alpha_5 + 2.1221 - 0.7355\alpha_3 - 0.4502 - 1.7554 = 0$

$j: \; -0.4763\alpha_5 - 4.4173 + 1.2496\alpha_3 - 0.2650 + 0.7271 = 0$

$$
\begin{aligned}
a_{xA} - a_{xB} - 1.5762\alpha_3 - 0.9915\alpha_5 &= -2.7561\\
0\,a_{xA} + 0\,a_{xB} - 1.6750\alpha_3 - 0.4763\alpha_5 &= 4.9851\\
0\,a_{xA} - a_{xB} - 0.7355\alpha_3 - 0.9915\alpha_5 &= 0.0835\\
0\,a_{xA} - 0\,a_{xB} + 1.2496\alpha_3 - 0.4763\alpha_5 &= 3.9553
\end{aligned}
$$

$a_{xA} = -3.1356\ [in/s^2]$
$a_{xB} = 9.3251\ [in/s^2]$
$\alpha_3 = -0.3521\ [rad/s^2]$
$\alpha_5 = -9.2280\ [rad/s^2]$

PROBLEMA 10.94



$GDL = 3(6-1) - 2(7) - 1(0)$

$GDL = 15 - 14$

$GDL = 1$

$Var = \{\theta_2, \theta_3, \theta_4, \theta_6, Y_5\}$

$Inc = \{\theta_2, \theta_3, \theta_4, \theta_6\}$

ECUACIONES DE LAZO

$$\bar{R}_2 + \bar{R}_3 + \bar{R}_4 - \bar{R}_5 - \bar{R}_{L2} = \bar{0}$$

$$R_{L1} + \bar{R}_6 + \bar{R}_4 - \bar{R}_3 - \bar{R}_2 = \bar{0}$$

$\bar{R}_{L1} = 4\hat{i} - 3\hat{j}$

$\bar{R}_{L2} = -7\hat{i}$

$\bar{R}_2 = 3\cos\theta_2\hat{i} + 3\operatorname{Sen}\theta_2\hat{j}$

$\bar{R}_3 = 7\cos\theta_3\hat{i} + 7\operatorname{Sen}\theta_3\hat{j}$

$\bar{R}_4 = 6\cos\theta_4\hat{i} + 6\operatorname{Sen}\theta_4\hat{j}$

$\bar{R}_4 = 6\cos\theta_4\hat{i} + 6\operatorname{Sen}\theta_4\hat{j}$

$\bar{R}_5 = Y_5\hat{j}$

$R_6 = 7\cos\theta_6\hat{i} + 7\operatorname{Sen}\theta_6\hat{j}$

ECUACIONES DE LAZO EN COMPONENTES

LV 1:

$\hat{i}$: $3\cos\theta_2 + 7\cos\theta_3 + 6\cos\theta_4 - 0 + 7 = 0$

$\hat{j}$: $3\operatorname{Sen}\theta_2 + 7\operatorname{Sen}\theta_3 + 6\operatorname{Sen}\theta_4 - Y_5 - 0 = 0$

$\hat{i}$: $4 + 7\cos\theta_6 + 6\cos\theta_4 - 7\cos\theta_3 - 3\cos\theta_2 = 0$

$\hat{j}$: $-3 + 6\operatorname{Sen}\theta_6 + 6\operatorname{Sen}\theta_4 - 7\operatorname{Sen}\theta_3 - 3\operatorname{Sen}\theta_2 = 0$

DERIVANDO LAS EC. DE LAZO RESPECTO AL TIEMPO

$$\bar{V}_2 + \bar{V}_3 + \bar{V}_4 - \bar{V}_5 - \bar{V}_{L2} = \bar{0} \qquad \bar{V}_{L1} + \bar{V}_6 + \bar{V}_4 - \bar{V}_3 - \bar{V}_2 = \bar{0}$$

$\bar{V}_{L1} = \bar{0}$

$\bar{V}_{L2} = \bar{0}$

$\bar{V}_2 = W_2\hat{k} \times \bar{R}_2 = W_2\hat{k} \times (3\cos\theta_2\hat{i} + 3\operatorname{Sen}\theta_2\hat{j}) = -2.8907W_2\hat{i} - 0.8022W_2\hat{j}$

$\bar{V}_3 = W_3\hat{k} \times \bar{R}_3 = W_3\hat{k} \times (7\cos\theta_3\hat{i} + 7\operatorname{Sen}\theta_3\hat{j}) = 6.3838W_3\hat{i} - 2.8717W_3\hat{j}$

$\bar{V}_4 = W_4\hat{k} \times \bar{R}_4 = W_4\hat{k} \times (6\cos\theta_4\hat{i} + 6\operatorname{Sen}\theta_4\hat{j}) = -4.9935W_4\hat{i} - 3.3265W_4\hat{j}$

$\bar{V}_4 = W_4\hat{k} \times \bar{R}_4 = W_4\hat{k} \times (6\cos\theta_4\hat{i} + 6\operatorname{Sen}\theta_4\hat{j}) = -4.9935W_4\hat{i} - 3.3265W_4\hat{j}$

$\bar{V}_5 = V_{Y5}\hat{j} = 25\hat{j}$

$\bar{V}_6 = W_6\hat{k} \times \bar{R}_6 = W_4\hat{k} \times (7\cos\theta_6\hat{i} + 7\operatorname{Sen}\theta_6\hat{j}) = 5.4866W_6\hat{i} - 4.3471W_6\hat{j}$

ECUACIONES DE LAZO EN COMPONENTES

LV 1:

$\hat{i}$: $-2.8907W_2 + 6.3838W_3 - 4.9935W_4 - 0 - 0 = 0$

$\hat{j}$: $-0.8022W_2 - 2.8717W_3 - 3.3265W_4 - 25 - 0 = 0$

LV 2:

$\hat{i}$: $0 + 5.4866W_6 - 4.9935W_4 - 6.3838W_3 + 2.8907W_2 = 0$

$\hat{j}$: $0 - 4.3471W_6 - 3.3265W_4 + 2.8717W_3 + 0.8022W_2 = 0$

$$-2.8907\,W_2 + 6.3838\,W_3 - 4.9935\,W_4 - 0\,W_6 = 0$$
$$-0.8022\,W_2 - 2.8717\,W_3 - 3.3265\,W_4 - 0\,W_6 = 25$$
$$2.8907\,W_2 - 6.3838\,W_3 - 4.9935\,W_4 + 5.4866\,W_6 = 0$$
$$0.8022\,W_2 + 2.8717\,W_3 - 3.3265\,W_4 - 4.3471\,W_6 = 0$$

$W_2 = -7.3411\ [rad/s]$
$W_3 = -4.6667\ [rad/s]$
$W_4 = -1.7164\ [rad/s]$
$W_6 = -3.1242\ [rad/s]$

DERIVANDO EC. DE LAZO CON RESPECTO AL TIEMPO

$$\bar{A}_2 + \bar{A}_3 + \bar{A}_4 - \bar{A}_5 - \bar{A}_{e_2} = \bar{0} \qquad \bar{A}_{e_1} + \bar{A}_6 + \bar{A}_4 - \bar{A}_3 - \bar{A}_2 = 0$$

$\bar{A}_{e_1} = \bar{0}$
$\bar{A}_{e_2} = \bar{0}$

$$\bar{A}_2 = \alpha_2 \hat{k} \times \bar{R}_2 - W_2^2 \bar{R}_2 = \alpha_2 \hat{k} \times (3\cos\theta_2 \hat{i} + 3\sin\theta_2 \hat{j}) - W_2^2 (3\cos\theta_2 \hat{i} + 3\sin\theta_2 \hat{j})$$
$$= (-2.8907\alpha_2 + 43.2330)\hat{i} + (-0.8022\alpha_2 - 155.7876)\hat{j}$$

$$\bar{A}_3 = \alpha_3 \hat{k} \times \bar{R}_3 - W_3^2 \bar{R}_3 = \alpha_3 \hat{k} \times (7\cos\theta_3 \hat{i} + 7\sin\theta_3 \hat{j}) - W_3^2 (7\cos\theta_3 \hat{i} + 7\sin\theta_3 \hat{j})$$
$$= (6.3838\alpha_3 + 62.5399)\hat{i} + (-2.8717\alpha_3 + 139.0278)\hat{j}$$

$$\bar{A}_4 = \alpha_4 \hat{k} \times \bar{R}_4 - W_4^2 \bar{R}_4 = \alpha_4 \hat{k} \times (6\cos\theta_4 \hat{i} + 6\sin\theta_4 \hat{j}) - W_4^2 (6\cos\theta_4 \hat{i} + 6\sin\theta_4 \hat{j})$$
$$= (-4.9935\alpha_4 + 9.7998)\hat{i} + (-3.3265\alpha_4 - 14.7109)\hat{j}$$

$$\bar{A}_4 = \alpha_4 \hat{k} \times \bar{R}_4 - W_4^2 \bar{R}_4 = (-4.9935\alpha_4 + 9.7998)\hat{i} + (-3.3265\alpha_4 - 14.7109)\hat{j}$$

$$\bar{A}_5 = a_{y_5}\hat{j} = -10\hat{j}$$

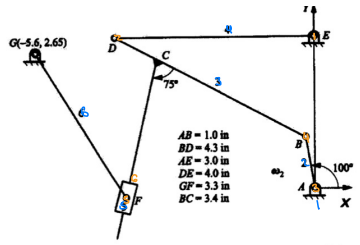
$$\bar{A}_6 = \alpha_6 \hat{k} \times \bar{R}_6 - W_6^2 \bar{R}_6 = \alpha_6 \hat{k} \times (7\cos\theta_6 \hat{i} + 7\sin\theta_6 \hat{j}) - W_6^2 (7\cos\theta_6 \hat{i} + 7\sin\theta_6 \hat{j})$$
$$= (5.4866\alpha_6 + 42.4302)\hat{i} + (-4.3471\alpha_6 + 53.5528)\hat{j}$$

$\hat{i}$: $-2.8907\alpha_2 + 43.2330 + 6.3838\alpha_3 + 62.5399 - 4.9935\alpha_4 + 9.7998 - 0 - 0 = 0$
$\hat{j}$: $-0.8022\alpha_2 - 155.7876 - 2.8717\alpha_3 + 139.0278 - 3.3265\alpha_4 - 14.7109 + 10 - 0 = 0$

$\hat{i}$: $0 + 5.4866\alpha_6 + 42.4302 - 4.9935\alpha_4 + 9.7998 - 6.3838\alpha_3 - 62.5399 + 2.8907\alpha_2 - 43.2330 = 0$
$\hat{j}$: $0 - 4.3471\alpha_6 + 53.5528 - 3.3265\alpha_4 - 14.7109 + 2.8717\alpha_3 - 139.0278 + 0.8022\alpha_2 + 155.7876 = 0$

$$-2.8907\alpha_2 + 6.3838\alpha_3 - 4.9935\alpha_4 + 0\,\alpha_6 = -115.5727$$
$$-0.8022\alpha_2 - 2.8717\alpha_3 - 3.3265\alpha_4 + 0\,\alpha_6 = 21.4707$$
$$2.8907\alpha_2 - 6.3838\alpha_3 - 4.9935\alpha_4 + 5.4866\alpha_6 = 53.5429$$
$$0.8022\alpha_2 + 2.8717\alpha_3 - 3.3265\alpha_4 - 4.3471\alpha_6 = -55.6017$$

$\alpha_2 = -0.6387\ [rad/s^2]$
$\alpha_3 = -13.9211\ [rad/s^2]$
$\alpha_4 = 5.7174\ [rad/s^2]$
$\alpha_6 = -0.8987\ [rad/s^2]$



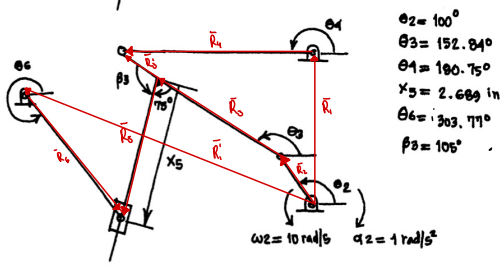
$GDL = 3(6-1) - 2(7) - 1(0)$

$GDL = 15 - 14$

$GDL = 1$

Var: $\{\theta_2, \theta_3, \theta_4, x_5, \theta_6\}$

Inc: $\{\theta_3, \theta_4, x_5, \theta_6\}$



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EC. LAZO

LV1: $\bar{R}_2 + \bar{R}_3' - \bar{R}_4 - \bar{R}_1 = \bar{0}$

LV2: $\bar{R}_2 + \bar{R}_3 + \bar{R}_5 - \bar{R}_6 - \bar{R}_1' = \bar{0}$

$\bar{R}_1 = 3\hat{j}$

$\bar{R}_1' = -5.6\hat{i} + 2.65\hat{j}$

$\bar{R}_2 = \cos\theta_2\hat{i} + \operatorname{Sen}\theta_2\hat{j}$

$\bar{R}_3 = 3.4\cos\theta_3\hat{i} + 3.4\operatorname{Sen}\theta_3\hat{j}$

$\bar{R}_3' = 4.3\cos\theta_3\hat{i} + 4.3\operatorname{Sen}\theta_3\hat{j}$

$\bar{R}_4 = 4\cos\theta_4\hat{i} + 4\operatorname{Sen}\theta_4\hat{j}$

$\bar{R}_5 = x_5\cos(\theta_3 + \beta_3)\hat{i} + x_5\operatorname{Sen}(\theta_3 + \beta_3)\hat{j}$

$\bar{R}_6 = 3.3\cos\theta_6\hat{i} + 3.3\operatorname{Sen}\theta_6\hat{j}$

ECUACIÓN DE LAZO EN COMPONENTES:

LV1:

$\hat{i}$: $\cos\theta_2 + 4.3\cos\theta_3 - 4\cos\theta_4 = 0$

$\hat{j}$: $\operatorname{Sen}\theta_2 + 4.3\operatorname{Sen}\theta_3 - 4\operatorname{Sen}\theta_4 - 3 = 0$

LV2:

$\hat{i}$: $\cos\theta_2 + 3.4\cos\theta_3 + x_5\cos(\theta_3 + \beta_3) - 3.3\cos\theta_6 + 5.6 = 0$

$\hat{j}$: $\operatorname{Sen}\theta_2 + 3.4\operatorname{Sen}\theta_3 + x_5\operatorname{Sen}(\theta_3 + \beta_3) - 3.3\operatorname{Sen}\theta_6 - 2.65 = 0$

Derivando ec de lazo con respecto al tiempo:

LV1: $\bar{V}_2 + \bar{V}_3' - \bar{V}_4 - \bar{V}_1 = 0$ LV2: $\bar{V}_2 + \bar{V}_3 + \bar{V}_5 - \bar{V}_6 - \bar{V}_1 = 0$

$\bar{V}_1 = \bar{0}$

$\bar{V}_1' = \bar{0}$

$\bar{V}_2 = \omega_2\hat{k} \times \bar{R}_2 = \omega_2\hat{k} \times (\cos\theta_2\hat{i} + \operatorname{Sen}\theta_2\hat{j}) = -0.9848\omega_2\hat{i} - 0.1736\omega_2\hat{j}$

$\bar{V}_3 = \omega_3\hat{k} \times \bar{R}_3 = \omega_3\hat{k} \times (3.4\cos\theta_3\hat{i} + 3.4\operatorname{Sen}\theta_3\hat{j}) = -1.5520\omega_3\hat{i} - 3.0251\omega_3\hat{j}$

$\bar{V}_3' = \omega_3\hat{k} \times \bar{R}_3' = \omega_3\hat{k} \times (4.3\cos\theta_3\hat{i} + 4.3\operatorname{Sen}\theta_3\hat{j}) = -1.9629\omega_3\hat{i} - 3.8259\omega_3\hat{j}$

$\bar{V}_4 = \omega_4\hat{k} \times \bar{R}_4 = \omega_4\hat{k} \times (4\cos\theta_4\hat{i} + 4\operatorname{Sen}\theta_4\hat{j}) = 0.0524\omega_4\hat{i} - 3.9997\omega_4\hat{j}$

$\bar{V}_5 = v\hat{u} + \omega_3\hat{k} \times \bar{R}_5 = (-0.2106 v_5 + 2.6286\omega_3)\hat{i} + (-0.9775 v_5 - 0.5685\omega_3)\hat{j}$

$\bar{V}_6 = \omega_6\hat{k} \times \bar{R}_6 = \omega_6\hat{k} \times (3.3\cos\theta_6\hat{i} + 3.3\operatorname{Sen}\theta_6\hat{j}) = 2.7432\omega_6\hat{i} + 1.8343\omega_6\hat{j}$

ECUACIONES LAZO EN COMPONENTES.

$\hat{i}$: $-0.9848\omega_2 - 1.9629\omega_3 - 0.0524\omega_4 - 0 = 0$

$\hat{j}$: $-0.1736\omega_2 - 3.8259\omega_3 + 3.9997\omega_4 - 0 = 0$

$\hat{i}$: $-0.9848\omega_2 - 1.5520\omega_3 + 2.6286\omega_3 - 0.2106 v_5 - 2.7432\omega_6 - 0 = 0$

$\hat{j}$: $-0.1736\omega_2 - 3.0251\omega_3 - 0.5685\omega_3 - 0.9775 v_5 - 1.8346\omega_6 - 0 = 0$

$$
\begin{aligned}
-1.9629\,W_3 - 0.0524\,W_4 - 0\,W_6 - 0\,V_5 &= 9.848\\
-3.8259\,W_3 + 3.9997\,W_4 - 0\,W_6 - 0\,V_5 &= 1.736\\
1.0766\,W_3 + 0\,W_4 - 2.7432\,W_6 - 0.2106\,V_5 &= 9.848\\
-3.5936\,W_3 + 0\,W_4 - 1.8346\,W_6 - 0.9725\,V_5 &= 1.736
\end{aligned}
$$

$W_3 = -4.9034$ [rad/s]
$W_4 = -4.2563$ [rad/s]
$W_6 = -7.9003$ [rad/s]
$V_5 = 31.0782$ [in/s]

Derivando ec de lazo con respecto al tiempo

LV1: $\bar{A}_2 + \bar{A}_3 - \bar{A}_4 - \bar{A}_1 = 0$ LV2: $\bar{A}_2 + \bar{A}_3 + \bar{A}_5 - \bar{A}_6 - \bar{A}_1 = 0$

$\bar{A}_1 = \bar{0}$; $\bar{A}'_1 = \bar{0}$

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

$= (-\operatorname{Sen}(100)\alpha_2 - W_2^2\cos(100))\,i + (\cos(100)\alpha_2 - W_2^2 \operatorname{Sen}(100))\,\hat{j}$

$\bar{A}_3 = \alpha_3 \hat{k} \times \bar{R}_3 - W_3^2 \bar{R}_3 = \alpha_3 \hat{k} \times (3.4\cos\theta_3 \hat{i} + 3.4\operatorname{Sen}\theta_3 \hat{j}) - W_3^2(3.4\cos\theta_3 \hat{i} + 3.4\operatorname{Sen}\theta_3 \hat{j})$

$= (-3.4\alpha_3 \operatorname{Sen}(152.84) - 3.4 W_3^2 \cos(152.84))\,i + (3.4\alpha_3 \cos(152.84) - 3.4 W_3^2 \operatorname{Sen}(152.84))\,\hat{j}$

$\bar{A}'_3 = \alpha_3 \hat{k} \times \bar{R}'_3 - W_3^2 \bar{R}'_3 = \alpha_3 \hat{k} \times (4.3\cos\theta_3 \hat{i} + 4.3\operatorname{Sen}\theta_3 \hat{j}) - W_3^2(4.3\cos\theta_3 \hat{i} + 4.3\operatorname{Sen}\theta_3 \hat{j})$

$= (-4.3\alpha_3 \operatorname{Sen}(152.84) - 4.3 W_3^2 \cos(152.84))\,i + (4.3\alpha_3 \cos(152.84) - 4.3 W_3^2 \operatorname{Sen}(152.84))\,\hat{j}$

$\bar{A}_4 = \alpha_4 \hat{k} \times \bar{R}_4 - W_4^2 \bar{R}_4 = \alpha_4 \hat{k} \times (4\cos\theta_4 \hat{i} + 4\operatorname{Sen}\theta_4 \hat{j}) - W_4^2(4\cos\theta_4 \hat{i} + 4\operatorname{Sen}\theta_4 \hat{j})$

$= (4\alpha_4 \operatorname{Sen}(180.75) - 4 W_4^2 \cos(180.75))\,i + (4\alpha_4 \cos(180.75) - 4 W_4^2 \operatorname{Sen}(180.75))\,\hat{j}$

$\bar{A}_5 = a_5 \hat{u} + 2 W_3 \hat{k} \times (V_5 \hat{u}_5) + \alpha_3 \hat{k} \times \bar{R}_5 - W_3^2 \bar{R}_5$

$a_5 \hat{u} = a_5 \cos(257.84)\,\hat{i} + a_5 \operatorname{Sen}(257.84)\,\hat{j}$

$2 W_3 \hat{k} \times (V_5 \hat{u}_5) = 2 W_3 \times (V_5 \cos(257.84)\,i + V_5 \operatorname{Sen}(257.84)\,\hat{j})$

$= (-2 V_5 W_3 \operatorname{Sen}(257.84))\,\hat{i} + (2 V_5 W_3 \cos(257.84))\,\hat{j}$

$\alpha_3 \hat{k} \times \bar{R}_5 = \alpha_3 \hat{k} \times (X_5 \cos(\theta_3 + \beta_3)\,\hat{i} + X_5 \operatorname{Sen}(\theta_3 + \beta_3)\,\hat{j})$

$= (-\alpha_3 X_5 \operatorname{Sen}(257.84))\,\hat{i} + (\alpha_3 X_5 \cos(257.84))\,\hat{j}$

$-W_3^2 \bar{R}_5 = -W_3^2 X_5 \cos(257.84)\,\hat{i} - W_3^2 X_5 \operatorname{Sen}(257.84)\,\hat{j}$

$\bar{A}_6 = \alpha_6 \hat{k} \times \bar{R}_6 - W_6^2 \bar{R}_6 = \alpha_6 \hat{k} \times (3.3\cos\theta_6 \hat{i} + 3.3\operatorname{Sen}\theta_6 \hat{j}) - W_6^2(3.3\cos\theta_6 \hat{i} + 3.3\operatorname{Sen}\theta_6 \hat{j})$

$= (-3.3\alpha_6 \operatorname{Sen}(303.77) - 3.3 W_6^2 \cos(303.77))\,i + (3.3\alpha_6 \cos(303.77) - 3.3 W_6^2 \operatorname{Sen}(303.77))\,\hat{j}$

ECUACIONES DE LAZO EN COMPONENTES

i: $-\operatorname{Sen}(100)\alpha_2 - W_2^2\cos(100) - 4.3\alpha_3 \operatorname{Sen}(152.84) - 4.3 W_3^2 \cos(152.84) - 4\alpha_4 \operatorname{Sen}(180.75) + 4 W_4^2 \cos(180.75) = 0$

$\hat{j}$: $\cos(100)\alpha_2 - W_2^2 \operatorname{Sen}(100) + 4.3\alpha_3 \cos(152.84) - 4.3 W_3^2 \operatorname{Sen}(152.84) - 4\alpha_4 \cos(180.75) + 4 W_4^2 \operatorname{Sen}(180.75) = 0$

i: $-\operatorname{Sen}(100)\alpha_2 - W_2^2\cos(100) - 3.4\alpha_3 \operatorname{Sen}(152.84) - 3.4 W_3^2 \cos(152.84) + a_5 \cos(257.84) - 2 V_5 W_3 \operatorname{Sen}(257.84) - \alpha_3 X_5 \operatorname{Sen}(257.84) - W_3^2 X_5 \cos(257.84) + 3.3\alpha_6 \operatorname{Sen}(303.77) + 3.3 W_6^2 \cos(303.77) = 0$

$\hat{j}$: $\cos(100)\alpha_2 - W_2^2 \operatorname{Sen}(100) + 3.4\alpha_3 \cos(152.84) - 3.4 W_3^2 \operatorname{Sen}(152.84) + a_5 \operatorname{Sen}(257.84) + 2 V_5 W_3 \cos(257.84) + \alpha_3 X_5 \cos(257.84) - W_3^2 X_5 \operatorname{Sen}(257.84) - 3.3\alpha_6 \cos(303.77) + 3.3 W_6^2 \operatorname{Sen}(303.77) = 0$

$$
\begin{aligned}
-1.9628\,\alpha_3 - 0.0523\,\alpha_4 + 0\,a_5 + 0\,\alpha_6 &= -37.8779 \\
-3.8259\,\alpha_3 + 3.9996\,\alpha_4 + 0\,a_5 + 0\,\alpha_6 &= 146.4491 \\
1.0766\,\alpha_3 + 0\,\alpha_4 - 0.2106\,a_5 - 2.7432\,\alpha_6 &= 78.7480 \\
-3.5915\,\alpha_3 + 0\,\alpha_4 - 0.9776\,a_5 - 1.8343\,\alpha_6 &= 179.4385
\end{aligned}
$$

$\alpha_3 = 17.87\ [rad/s^2]$

$\alpha_4 = 57.71\ [rad/s^2]$

$a_5 = -243.61\ [m/s^2]$

$\alpha_6 = -2.9951\ [rad/s^2]$