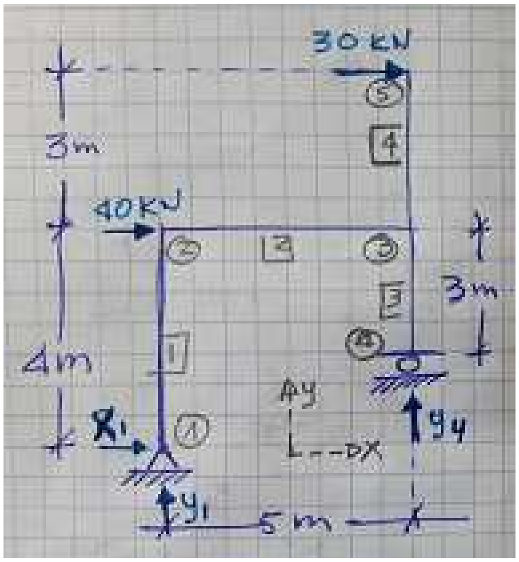


[CaseMode := Sensitive, InputMode := Word]

$$\left[E := 2.1\cdot 10^{7},\ Icol := \frac{0.4^{4}}{12},\ Ivig := \frac{0.3^{4}}{12}\right]$$

Determinar los desplazamientos hacia la derecha de los nudos 3, 4 y 5, utilizando el método de la **Carga Unitaria Ficticia**:

Equilibrio estático:

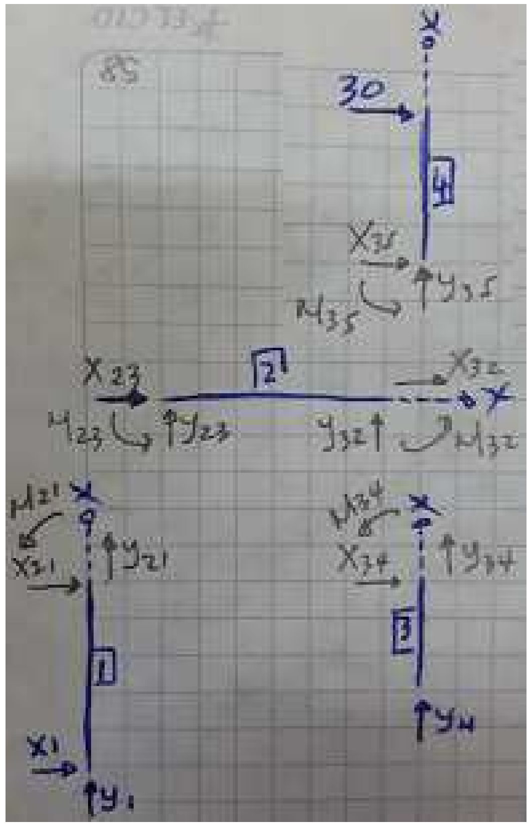
[X1 :=, Y1 :=, Y4 :=]

$$\begin{bmatrix} X1 + 40 + 30 = 0 \\ Y1 + Y4 = 0 \\ Y4\cdot 5 - 40\cdot 4 - 30\cdot 7 = 0 \end{bmatrix}$$

[X1 := −70, Y1 := −74, Y4 := 74]

Diagramas de cuerpo libre (DCL):

$$\begin{bmatrix} X21 := & Y21 := & M21 := \\ X23 := & Y23 := & M23 := \\ X32 := & Y32 := & M32 := \\ X34 := & Y34 := & M34 := \\ X35 := & Y35 := & M35 := \end{bmatrix}$$



Secuencia: elemento e1, nudo n2, e3, e4, n3:

$$\begin{bmatrix} X21 + X1 = 0 & Y21 + Y1 = 0 & M21 + X1 \cdot 4 = 0 \\ X21 + X23 = 40 & Y21 + Y23 = 0 & M21 + M23 = 0 \\ X34 = 0 & Y4 + Y34 = 0 & M34 = 0 \\ X35 + 30 = 0 & Y35 = 0 & M35 - 30 \cdot 3 = 0 \\ X32 + X34 + X35 = 0 & Y32 + Y34 + Y35 = 0 & M32 + M34 + M35 = 0 \end{bmatrix}$$

$$\begin{bmatrix} M21 := 280 & M23 := -280 & M32 := -90 & M34 := 0 & M35 := 90 \\ X21 := 70 & X23 := -30 & X32 := 30 & X34 := 0 & X35 := -30 \\ Y21 := 74 & Y23 := -74 & Y32 := 74 & Y34 := -74 & Y35 := 0 \end{bmatrix}$$

Chequeo en elemento 2:

$[X23 + X32 = 0, Y23 + Y32 = 0, M23 + M32 + Y32 \cdot 5 = 0]$

[true, true, true]

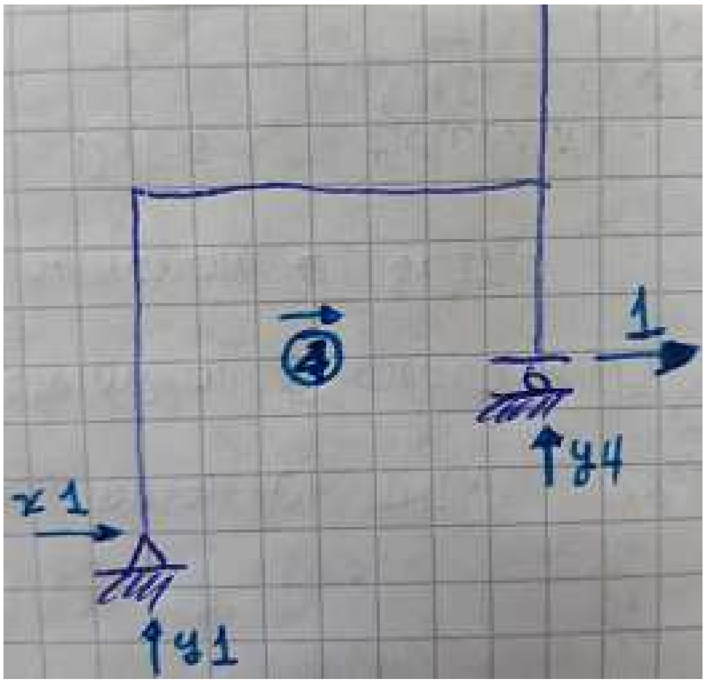
Funciones de **momento flector** en cada elemento individual:

[MF1(x) :=, MF2(x) :=, MF3(x) :=, MF4(x) :=]

$$\begin{bmatrix} MF1(x) := -X1\cdot x \\ MF2(x) := -M23 + Y23\cdot x \\ MF3(x) := 0 \\ MF4(x) := -M35 - X35\cdot x \end{bmatrix}$$

$$\begin{bmatrix} MF1(x) := 70\cdot x \\ MF2(x) := 280 - 74\cdot x \\ MF3(x) := 0 \\ MF4(x) := 30\cdot x - 90 \end{bmatrix}$$

Aplicación de una **carga unitaria ficticia en el nudo 4**:



Equilibrio estático:

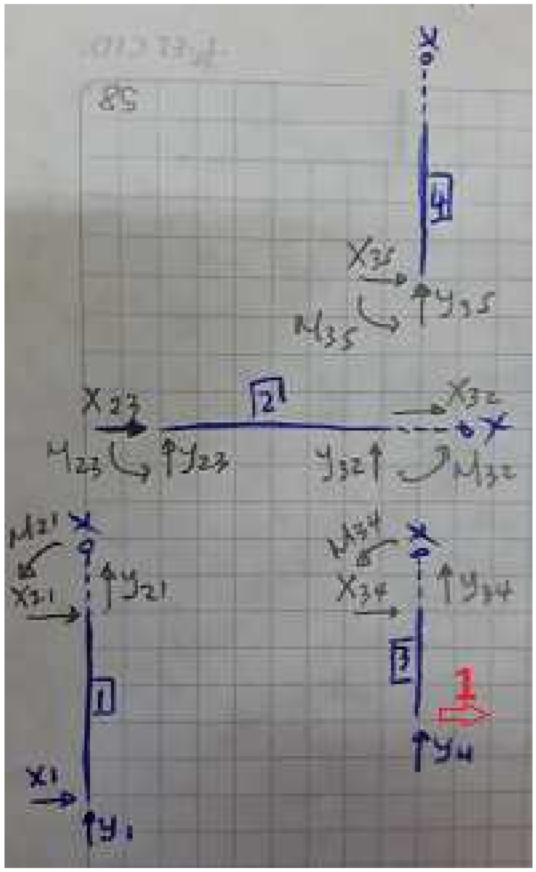
[x1n4 :=, y1n4 :=, y4n4 :=]

$$\begin{bmatrix} x1n4 + 1 = 0 \\ y1n4 + y4n4 = 0 \\ y4n4\cdot 5 - 1\cdot 1 = 0 \end{bmatrix}$$

[x1n4 := −1, y1n4 := −0.2, y4n4 := 0.2]

Diagramas de cuerpo libre:

$$\begin{bmatrix} x21n4 := & y21n4 := & m21n4 := \\ x23n4 := & y23n4 := & m23n4 := \\ x32n4 := & y32n4 := & m32n4 := \\ x34n4 := & y34n4 := & m34n4 := \\ x35n4 := & y35n4 := & m35n4 := \end{bmatrix}$$



Secuencia: elemento e1, nudo n2, e3, e4, n3:

$$\begin{bmatrix} x21n4 + x1n4 = 0 & y21n4 + y1n4 = 0 & m21n4 + x1n4 \cdot 4 = 0 \\ x21n4 + x23n4 = 0 & y21n4 + y23n4 = 0 & m21n4 + m23n4 = 0 \\ x34n4 + 1 = 0 & y4n4 + y34n4 = 0 & m34n4 + 1 \cdot 3 = 0 \\ x35n4 = 0 & y35n4 = 0 & m35n4 = 0 \\ x32n4 + x34n4 + x35n4 = 0 & y32n4 + y34n4 + y35n4 = 0 & m32n4 + m34n4 + m35n4 = 0 \end{bmatrix}$$

$$\begin{bmatrix} m21n4 := 4 & m23n4 := -4 & m32n4 := 3 & m34n4 := -3 & m35n4 := 0 \\ x21n4 := 1 & x23n4 := -1 & x32n4 := 1 & x34n4 := -1 & x35n4 := 0 \\ y21n4 := 0.2 & y23n4 := -0.2 & y32n4 := 0.2 & y34n4 := -0.2 & y35n4 := 0 \end{bmatrix}$$

Chequeo en elemento 2:

$[x23n4 + x32n4 = 0,\ y23n4 + y32n4 = 0,\ m23n4 + m32n4 + y32n4 \cdot 5 = 0]$

$[true,\ true,\ true]$

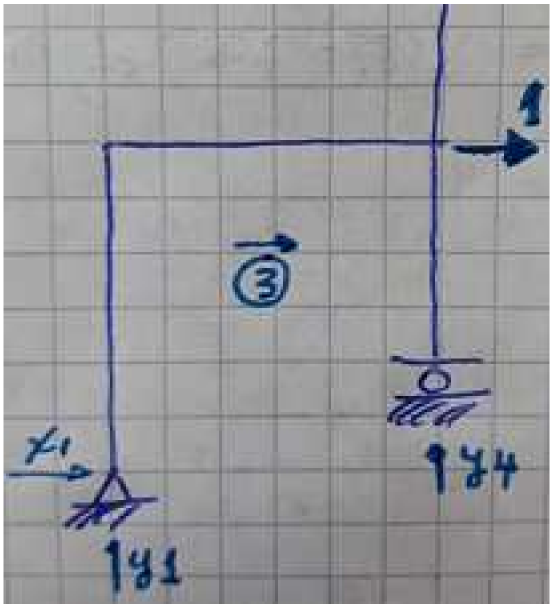
Funciones de momento flector:

$[mf1n4(x) :=,\ mf2n4(x) :=,\ mf3n4(x) :=,\ mf4n4(x) :=]$

$$\begin{bmatrix} mf1n4(x) := -\ x1n4 \cdot x \\ mf2n4(x) := -m23n4 + y23n4 \cdot x \\ mf3n4(x) := -\ 1 \cdot x \\ mf4n4(x) := -m35n4 - x35n4 \cdot x \end{bmatrix}$$

$$\begin{bmatrix} mf1n4(x) := x \\ mf2n4(x) := 4 - 0.2 \cdot x \\ mf3n4(x) := -x \\ mf4n4(x) := 0 \end{bmatrix}$$

Aplicación de una **carga unitaria ficticia en el nudo 3**:



Equilibrio estático:

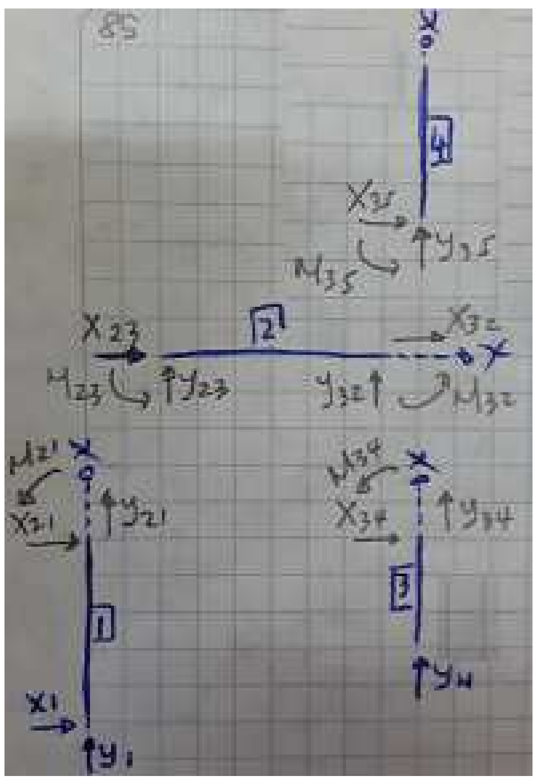
[x1n3 :=, y1n3 :=, y4n3 :=]

$$\begin{bmatrix} x1n3 + 1 = 0 \\ y1n3 + y4n3 = 0 \\ y4n3 \cdot 5 - 1 \cdot 4 = 0 \end{bmatrix}$$

$$[x1n3 := -1,\ y1n3 := -0.8,\ y4n3 := 0.8]$$

Diagramas de cuerpo libre:

$$\begin{bmatrix} x21n3 := & y21n3 := & m21n3 := \\ x23n3 := & y23n3 := & m23n3 := \\ x32n3 := & y32n3 := & m32n3 := \\ x34n3 := & y34n3 := & m34n3 := \\ x35n3 := & y35n3 := & m35n3 := \end{bmatrix}$$



Secuencia: elemento e1, nudo n2, e3, e4, n3:

$$\begin{bmatrix} x21n3 + x1n3 = 0 & y21n3 + y1n3 = 0 & m21n3 + x1n3 \cdot 4 = 0 \\ x21n3 + x23n3 = 0 & y21n3 + y23n3 = 0 & m21n3 + m23n3 = 0 \\ x34n3 = 0 & y4n3 + y34n3 = 0 & m34n3 = 0 \\ x35n3 = 0 & y35n3 = 0 & m35n3 = 0 \\ x32n3 + x34n3 + x35n3 = 1 & y32n3 + y34n3 + y35n3 = 0 & m32n3 + m34n3 + m35n3 = 0 \end{bmatrix}$$

$$\begin{bmatrix} m21n3 := 4 & m23n3 := -4 & m32n3 := 0 & m34n3 := 0 & m35n3 := 0 \\ x21n3 := 1 & x23n3 := -1 & x32n3 := 1 & x34n3 := 0 & x35n3 := 0 \\ y21n3 := 0.8 & y23n3 := -0.8 & y32n3 := 0.8 & y34n3 := -0.8 & y35n3 := 0 \end{bmatrix}$$

Chequeo en elemento 2:

$$[x23n3 + x32n3 = 0,\ y23n3 + y32n3 = 0,\ m23n3 + m32n3 + y32n3 \cdot 5 = 0]$$

$$[true,\ true,\ true]$$

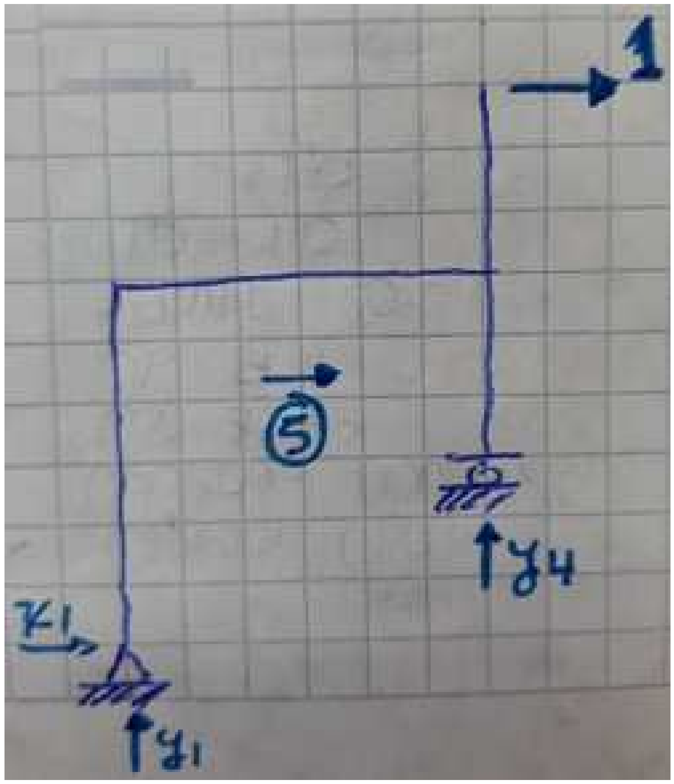
Funciones de momento flector:

$$[mf1n3(x) :=,\ mf2n3(x) :=,\ mf3n3(x) :=,\ mf4n3(x) :=]$$

$$\begin{bmatrix} mf1n3(x) := -\ x1n3 \cdot x \\ mf2n3(x) := -m23n3 + y23n3 \cdot x \\ mf3n3(x) := 0 \\ mf4n3(x) := -m35n3 - x35n3 \cdot x \end{bmatrix}$$

$$\begin{bmatrix} mf1n3(x) := x \\ mf2n3(x) := 4 - 0.8 \cdot x \\ mf3n3(x) := 0 \\ mf4n3(x) := 0 \end{bmatrix}$$

Aplicación de una **carga unitaria ficticia en el nudo 5**:



Equilibrio estático:

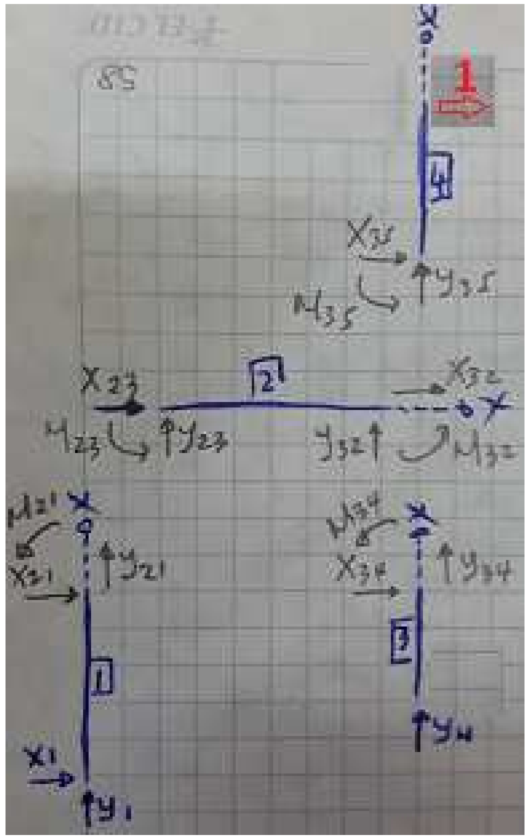
[x1n5 :=, y1n5 :=, y4n5 :=]

$$\begin{bmatrix} x1n5 + 1 = 0 \\ y1n5 + y4n5 = 0 \\ y4n5 \cdot 5 - 1 \cdot 7 = 0 \end{bmatrix}$$

[x1n5 := −1, y1n5 := −1.4, y4n5 := 1.4]

Diagramas de cuerpo libre:

$$\begin{bmatrix} x21n5 := & y21n5 := & m21n5 := \\ x23n5 := & y23n5 := & m23n5 := \\ x32n5 := & y32n5 := & m32n5 := \\ x34n5 := & y34n5 := & m34n5 := \\ x35n5 := & y35n5 := & m35n5 := \end{bmatrix}$$



Secuencia: elemento e1, nudo n2, e3, e4, n3:

$$\left[\begin{array}{ccc} x21n5 + x1n5 = 0 & y21n5 + y1n5 = 0 & m21n5 + x1n5 \cdot 4 = 0 \\ x21n5 + x23n5 = 0 & y21n5 + y23n5 = 0 & m21n5 + m23n5 = 0 \\ x34n5 = 0 & y4n5 + y34n5 = 0 & m34n5 = 0 \\ x35n5 + 1 = 0 & y35n5 = 0 & m35n5 - 1 \cdot 3 = 0 \\ x32n5 + x34n5 + x35n5 = 0 & y32n5 + y34n5 + y35n5 = 0 & m32n5 + m34n5 + m35n5 = 0 \end{array}\right]$$

$$\left[\begin{array}{ccccc} m21n5 := 4 & m23n5 := -4 & m32n5 := -3 & m34n5 := 0 & m35n5 := 3 \\ x21n5 := 1 & x23n5 := -1 & x32n5 := 1 & x34n5 := 0 & x35n5 := -1 \\ y21n5 := 1.4 & y23n5 := -1.4 & y32n5 := 1.4 & y34n5 := -1.4 & y35n5 := 0 \end{array}\right]$$

Chequeo en elemento 2:

$[x23n5 + x32n5 = 0,\ y23n5 + y32n5 = 0,\ m23n5 + m32n5 + y32n5 \cdot 5 = 0]$

$$[true, true, true]$$

Funciones de momento flector:

[mf1n5(x) :=, mf2n5(x) :=, mf3n5(x) :=, mf4n5(x) :=]

$$\begin{bmatrix} mf1n5(x) := -\ x1n5 \cdot x \\ mf2n5(x) := -m23n5 + y23n5 \cdot x \\ mf3n5(x) := 0 \\ mf4n5(x) := -m35n5 - x35n5 \cdot x \end{bmatrix}$$

$$\begin{bmatrix} mf1n5(x) := x \\ mf2n5(x) := 4 - 1.4 \cdot x \\ mf3n5(x) := 0 \\ mf4n5(x) := x - 3 \end{bmatrix}$$

Deformaciones laterales (sentido +X) en los nudos 3,4 y 5:

[dx3 :=, dx4 :=, dx5 :=]

$$\begin{bmatrix} dx4=\frac{1}{E}\cdot\left(\frac{1}{Icol}\cdot\left(\int_0^4 MF1(x)\cdot mf1n4(x)\ dx+\int_0^3 MF3(x)\cdot mf3n4(x)\ dx+\int_0^3 MF4(x)\cdot mf4n4(x)\ dx\right)+\frac{1}{Ivig}\cdot\int_0^5 MF2(x)\cdot mf2n4(x)\ dx\right) \\ dx3=\frac{1}{E}\cdot\left(\frac{1}{Icol}\cdot\left(\int_0^4 MF1(x)\cdot mf1n3(x)\ dx+\int_0^3 MF3(x)\cdot mf3n3(x)\ dx+\int_0^3 MF4(x)\cdot mf4n3(x)\ dx\right)+\frac{1}{Ivig}\cdot\int_0^5 MF2(x)\cdot mf2n3(x)\ dx\right) \\ dx5=\frac{1}{E}\cdot\left(\frac{1}{Icol}\cdot\left(\int_0^4 MF1(x)\cdot mf1n5(x)\ dx+\int_0^3 MF3(x)\cdot mf3n5(x)\ dx+\int_0^3 MF4(x)\cdot mf4n5(x)\ dx\right)+\frac{1}{Ivig}\cdot\int_0^5 MF2(x)\cdot mf2n5(x)\ dx\right) \end{bmatrix}$$

$$dx4=\frac{1}{E}\cdot\left(\frac{1}{Icol}\cdot\left(\int_0^4 (70\cdot x)\cdot x\ dx+\int_0^3 0\cdot(-x)\ dx+\int_0^3 (30\cdot x-90)\cdot 0\ dx\right)+\frac{1}{Ivig}\cdot\int_0^5 (280-74\cdot x)\cdot(4-0.2\cdot x)\ dx\right)$$

$$dx3=\frac{1}{E}\cdot\left(\frac{1}{Icol}\cdot\left(\int_0^4 (70\cdot x)\cdot x\ dx+\int_0^3 0\cdot 0\ dx+\int_0^3 (30\cdot x-90)\cdot 0\ dx\right)+\frac{1}{Ivig}\cdot\int_0^5 (280-74\cdot x)\cdot(4-0.8\cdot x)\ dx\right)$$

$$dx5=\frac{1}{E}\cdot\left(\frac{1}{Icol}\cdot\left(\int_0^4 (70\cdot x)\cdot x\ dx+\int_0^3 0\cdot 0\ dx+\int_0^3 (30\cdot x-90)\cdot(x-3)\ dx\right)+\frac{1}{Ivig}\cdot\int_0^5 (280-74\cdot x)\cdot(4-1.4\cdot x)\ dx\right)$$

$$\begin{bmatrix} dx4 = 0.1614932392 \\ dx3 = 0.1438565549 \\ dx5 = 0.1322466563 \end{bmatrix}$$

Abajo se muestra la deformación correspondiente al análisis bajo el método de los Elementos finitos: