METODO DE RIGIDEZ

FLEXIBILIDAD DESPLAZAMIENTO QUE PRODUCE UNA CARGA UNITARIA.

f_{ij} — i: DESPLAZAMIENTO, j: CARGA.

- ES CONOCIDO COMO EL METODO DE LAS CARGAS.

$$\{\Delta\} = [F]\{\emptyset\}$$

EXPRESION MATEMATICA.

RIGIDEZ ES LA CARGA QUE PRODUCE UN DESPLAZAMIENTO UNITARIO.

K_{ij} — i: DIREC. CARGA, j: DESPLAZAMIENTO.

- ES CONOCIDO COMO EL METODO DE LOS DESPLAZAMIENTOS.

$$\{\emptyset\} = [K]\{\Delta\}$$

EXPRE. MATEMATICA.

DONDE: $\{\emptyset\}$ = ES UN VECTOR DE CARGAS QUE ACTUA SOBRE LOS NUDOS.

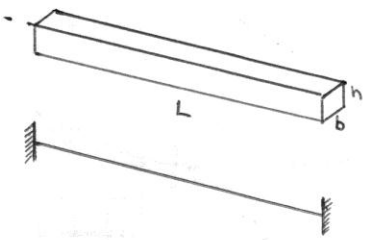
$\{\Delta\}$ = VECTOR DESPLAZAMIENTO DE NUDOS.

$[K]$ = MATRIZ DE RIGIDEZ. DE LA ESTRUCTURA. f (# DE NUDOS)

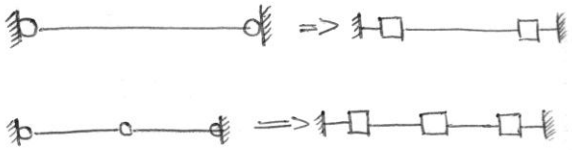
PARA "n" NUDOS.

$$\begin{Bmatrix} \emptyset_1 \\ \emptyset_2 \\ \vdots \\ \emptyset_n \end{Bmatrix} = \begin{bmatrix} K_{11} & K_{12} & \cdots & K_{1n} \\ K_{21} & K_{22} & & \\ \vdots & & \ddots & \\ K_{n1} & K & \cdots & K_{nn} \end{bmatrix} \begin{Bmatrix} \Delta_1 \\ \Delta_2 \\ \vdots \\ \Delta_n \end{Bmatrix}$$

NUDO. PARTE DIFERENCIAL DE UNA ESTRUCTURA.



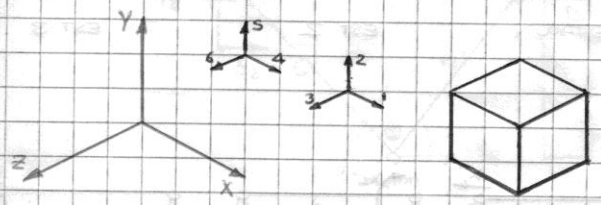
$b, h \ll L$



SE RECOMIENDA CONSIDERAR NUDOS EN:

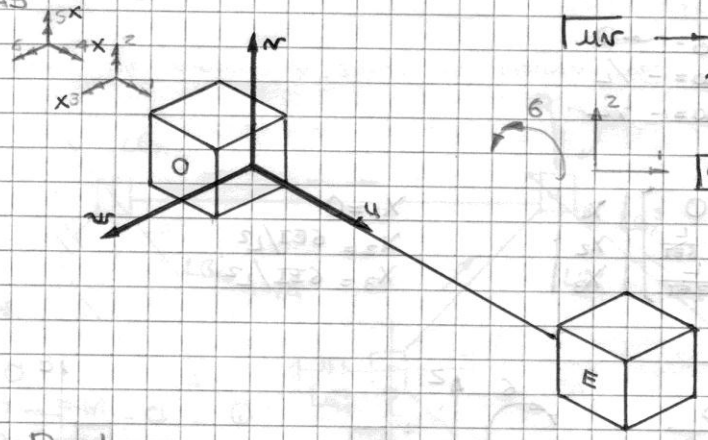
- APOYOS
- CAMBIOS DE DIRECCION
- EN EL CRUCE DE DOS O MAS ELEMENTOS.
- CAMBIO DE MATERIAL
- CAMBIO DE SECCION.
- DONDE SE QUIERE CONOCER EL DESPLAZAMIENTO.

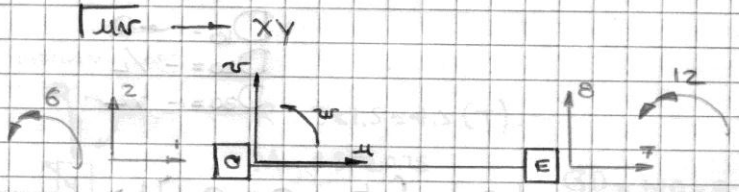
GRADO DE LIVERTAD SON LOS DESPLAZAMIENTOS QUE PUEDE TENER UN NUDO.

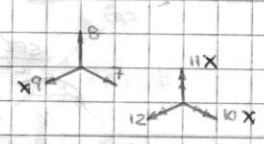


EN EL ESPACIO UN NUDO TIENE 6 GL

BARRAS

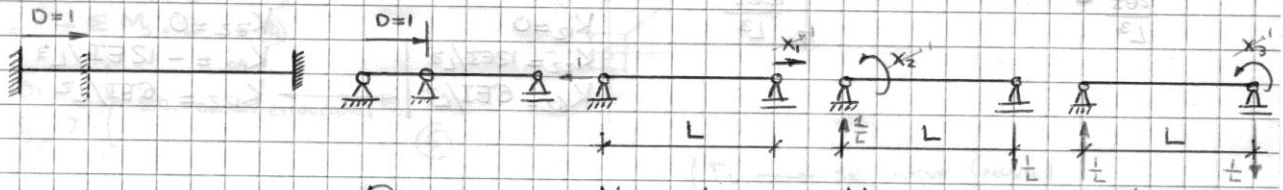






PARA $D_1 = 1$

EST 0 EST 1 EST 2 EST 3



$D_{10} = 1$	$N_2 = 1$	$N_2 = 0$	$N_2 = 0$
$D_{20} = 0$	$Q_2 = 0$	$Q_2 = \frac{1}{L}$	$Q_2 = \frac{1}{L}$
$D_{30} = 0$	$M_2 = 0$	$M_2 = \frac{X}{L} - 1$	$M_2 = \frac{X}{L}$

$$-\begin{Bmatrix} D_{10} \\ D_{20} \\ D_{30} \end{Bmatrix} = \begin{bmatrix} f_{11} & f_{12} & f_{13} \\ f_{21} & f_{22} & f_{23} \\ f_{31} & f_{32} & f_{33} \end{bmatrix} \begin{Bmatrix} X_1 \\ X_2 \\ X_3 \end{Bmatrix}$$

$$\begin{Bmatrix} 1 \\ 0 \\ 0 \end{Bmatrix} = \begin{vmatrix} \frac{L}{EA} & 0 & 0 \\ 0 & \frac{L}{3EI} & -\frac{L}{6EI} \\ 0 & -\frac{L}{6EI} & \frac{L}{3EI} \end{vmatrix} \begin{Bmatrix} X_1 \\ X_2 \\ X_3 \end{Bmatrix}$$

$$X_1 = -\frac{EA}{L}$$

$$X_2 = 0$$

$$X_3 = 0$$

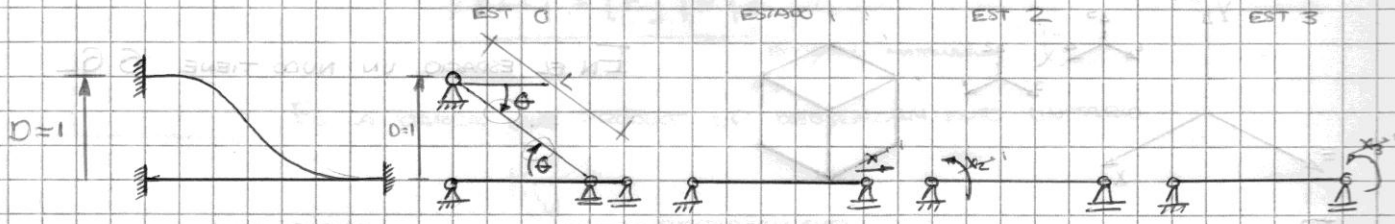
$$K = \begin{bmatrix} K_{11} & K_{12} & \cdots & K_{112} \\ K_{21} & & & \\ K_{31} & & & \\ \vdots & & & \vdots \\ K_{121} & \cdots & \cdots & K_{1212} \end{bmatrix}$$

K_{ij} — i: CARGA, j: DESPLAZAMIENTO

$K_{11} = \frac{EA}{L}$ $\quad K_{41} = 0$ $\quad K_{71} = -\frac{EA}{L}$

$K_{21} = 0$ $\quad K_{51} = 0$

$K_{31} = 0$ $\quad K_{61} = 0$



$D_{10} = \sim\sim 0$

$D_{20} = -1/L$

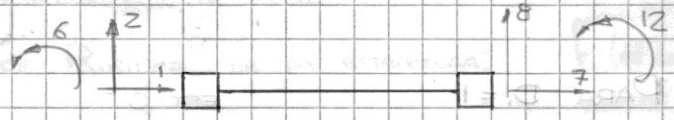
$D_{30} = -1/L$

$$\begin{Bmatrix} 0 \\ -1/L \\ -1/L \end{Bmatrix} = \begin{bmatrix} \frac{L}{EA} & 0 & 0 \\ 0 & \frac{L}{3EI} & -\frac{L}{6EI} \\ 0 & -\frac{L}{6EI} & \frac{L}{3EI} \end{bmatrix} \begin{Bmatrix} X_1 \\ X_2 \\ X_3 \end{Bmatrix}$$

$X_1 = 0$

$X_2 = 6EI/L^2$

$X_3 = 6EI/L^2$



$K_{12} = 0$

$K_{22} = 12EI/L^3$

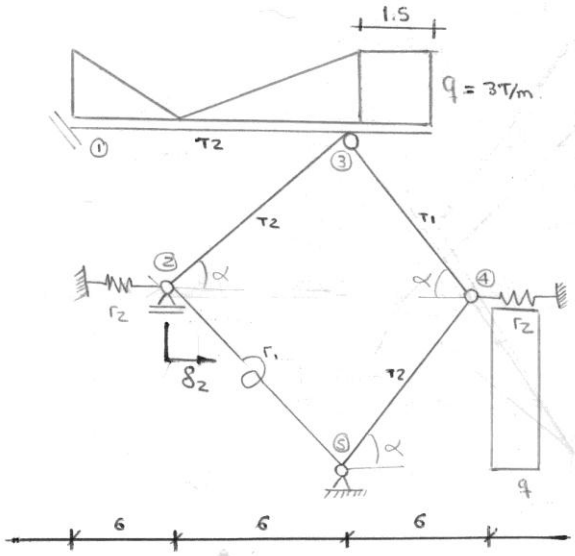
$K_{62} = 6EI/L^2$

$K_{72} = 0$

$K_{82} = -12EI/L^3$

$K_{122} = 6EI/L^2$

ORURO 6 MAYO 2010.



$T1 \rightarrow 20*45$

$T2 \rightarrow 20*40$

$r_1 = 5E3\ T-m/rad$

$r_2 = 4E3\ T.m$

$E = 2.1E5\ kg/cm^2$

Sol

① CARACTERISTICAS GEOMETRICAS.

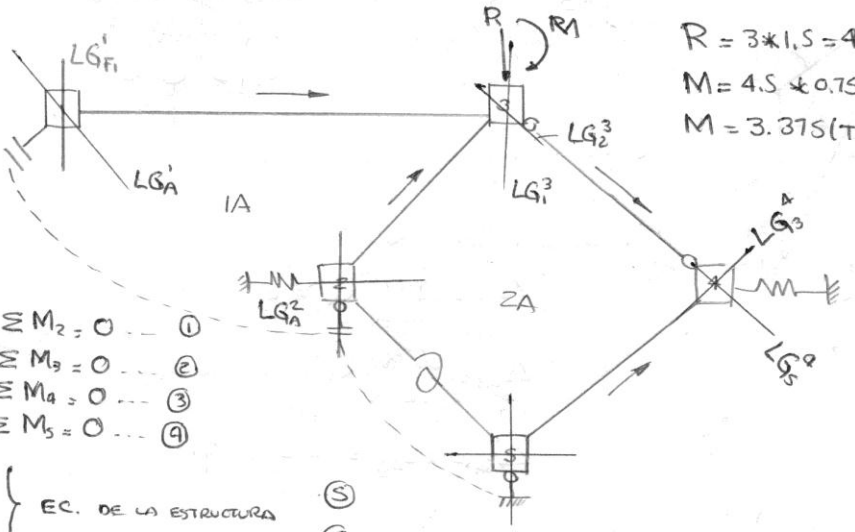
$L_{23} = L_{54} = \sqrt{3^2+6^2} = 6.708\,(m)$

$\alpha = tg^{-1}(3/6) = 26.565^\circ$

$EI_1 = \frac{0.2*0.45^3}{12} * 2.1E6 = 3189.375\ (T-m^2)$

$EI_2 = \frac{0.2*0.4^3}{12} * 2.1E6 = 2240.000\ (T-m^2)$

② CONFIGURACION DE VINCULOS Y GRADO DE DESPLAZABILIDAD



$R = 3*1.5 = 4.5\ (T)$

$M = 4.5 * 0.75$

$M = 3.375\ (T-m)$

$GD = ND - A$

$GD = 4 - 2 = 2$

INCOGNITAS.

$\theta_1 = 0$

$\theta_2 = ? \rightarrow \sum M_2 = 0 \ldots$ ①

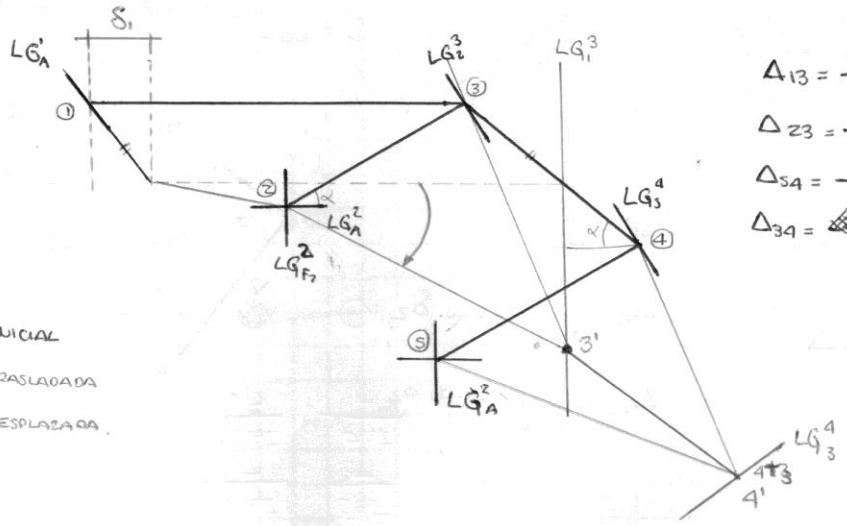
$\theta_3 = ? \rightarrow \sum M_3 = 0 \ldots$ ②

$\theta_4 = ? \rightarrow \sum M_4 = 0 \ldots$ ③

$\theta_5 = ? \rightarrow \sum M_5 = 0 \ldots$ ④

$\delta_1 = ?$, $\delta_2 = ?$ } EC. DE LA ESTRUCTURA ⑤ ⑥

③ ESTRUCTURA DESPLAZADA Y CALCULO DE DESPLAZAMIENTOS. { F_1 → SE MUEVE (MOVIL); F_2 → PERMANECE FIJO (NO SE MUEVE



$\Delta_{13} = -\overline{3T_1\,3'}$

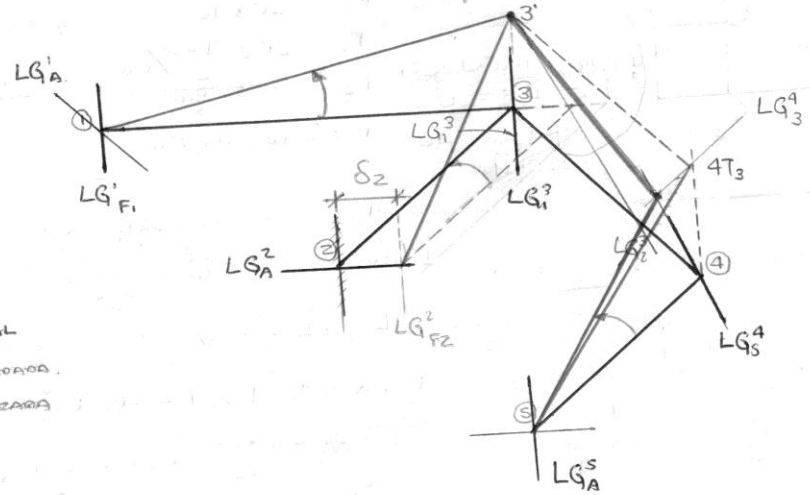
$\Delta_{23} = -\overline{33'}$

$\Delta_{54} = -\overline{44'}$

$\Delta_{34} =$ [illegible]

- ESTRUC. INICIAL
- ESTRUC TRASLADADA
- ESTRUC. DESPLAZADA.

ESTRUCTURA DESPLAZADA PARA δ_2 } $F_2 \rightarrow$ MOVIL
$F_1 \rightarrow$ FIJO



- EST. INICIAL
- EST. TRASLADADA.
- EST. DESPLAZADA

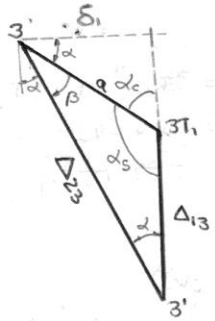
$\Delta_{13} = \overline{33'}$

$\Delta_{23} = \overline{3T_2\,3'}$

$\Delta_{54} = \overline{44'}$

$\Delta_{34} = -\overline{4^T_3\,4'}$

CALCULO DE DESNIVELES PARA δ_1



$\alpha = 26.565°$

$\alpha_c = 90 - \alpha = 63.435°$

$\alpha_s = 180 - \alpha_c = 116.565°$

$\beta = 90 - 2\alpha = 36.870°$

$\cos\alpha = \frac{\delta_1}{a} \rightarrow a = 1.118\,\delta_1$

$\Delta_{13} = -3^T_1\,3'$

$\Delta_{23} = -\overline{33'}$

$\Delta_{54} = -\overline{44'}$

$\Delta_{34} = 0$

POR LA LEY DE SENOS.

$\Delta_{13} = \frac{\sin\beta}{\sin\alpha}\,a = 1.500\,\delta_1$

$\Delta_{23} = \frac{\sin\alpha_s}{\sin\alpha}\,a = 2.236\,\delta_1$

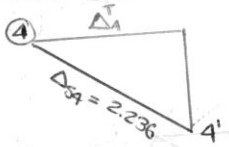
$\Delta_{54} = \Delta_{23} = 2.236\,\delta_1$

DESPLAZAMIENTO EN LOS RESORTES.

NUDO ② FIJO

$\Delta^T_2 = 0$

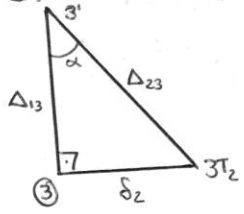
NUDO ④



~~$\Delta_{54} = \Delta_{23} = 2.236\,\delta_1$~~

$\Delta^T_4 = 2.236\,\delta_1 \operatorname{sen}\alpha = 1.000\,\delta_1$

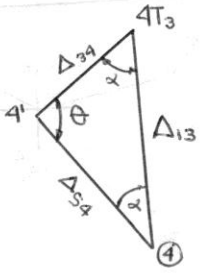
CALCULO DESNIVELES PARA δ_2



$tg\alpha = \frac{\delta_2}{\Delta_{13}}$

$\Delta_{13} = \frac{\delta_2}{tg\alpha} = 2.000\,\delta_2$

$\Delta_{23} = \frac{\delta_2}{\operatorname{sen}\alpha} = 2.236\,\delta_2$



$\theta = 180 - 2\alpha = 126.87°$

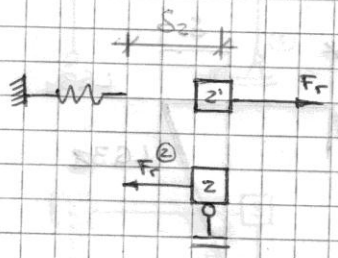
$\Delta_{34} = \frac{\operatorname{sen}\alpha}{\operatorname{sen}\theta}\,\Delta_{13} = 1.$

$\Delta_{54} = \frac{\operatorname{sen}\alpha}{\operatorname{sen}\theta}\,\Delta_{13} = 1.$

DESPLAZAMIENTO EN LOS RESORTES

NUDO (2)

$\Delta'_2 = \delta_2$

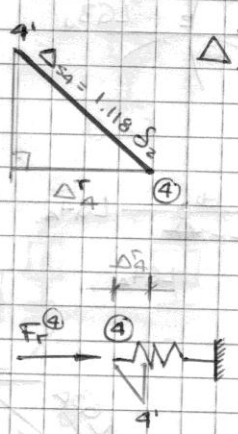


$F_1^2 = r_2 \delta_2$

NUDO (4)

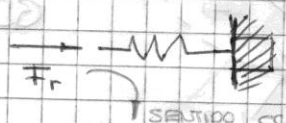
$\Delta_4^r = 1.118 \delta_2 \operatorname{sen}\alpha$

$\Delta_4^r = 0.5 \delta_2$



(*) ACORTAMIENTO DEL RESORTE

$\Delta_4^r = \delta_1 - 0.5 \delta_2$



$[4] \xleftarrow{F_2} = r_2(\delta_1 - 0.5\delta_2)$

- RESUMEN DE DESNIVELES TOTALES.

$\Delta_{13} = -1.5\delta_1 + 2\delta_2$

$\Delta_{23} = -2.236\delta_1 + 2.236\delta_2$

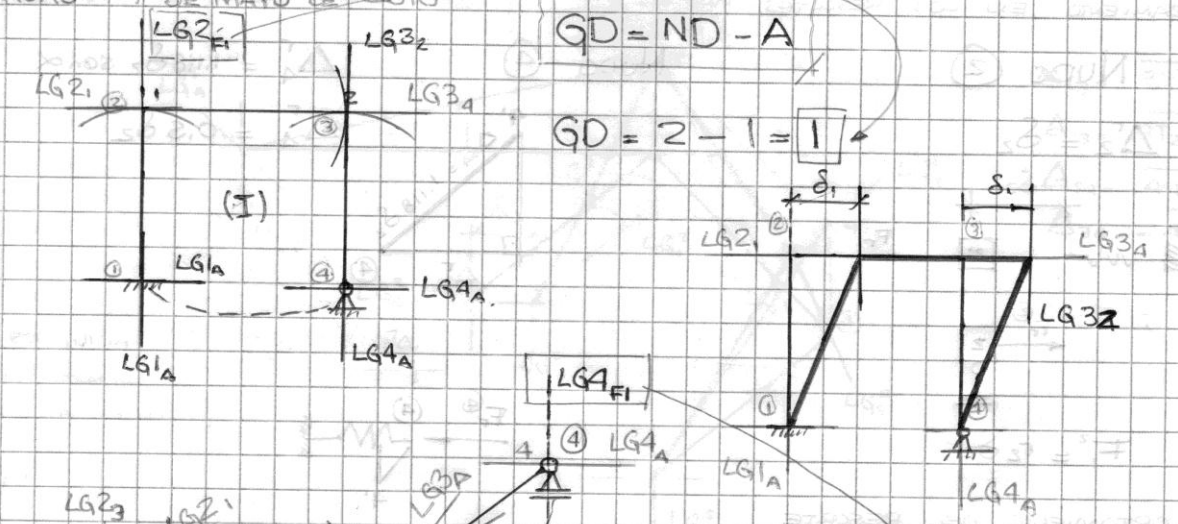
$\Delta_{54} = -2.236\delta_1 + 1.118\delta_2$

$\Delta_{34} = 0\delta_1 - 1.118\delta_2$

$\Delta'_2 = 0\delta_1 + \delta_2$

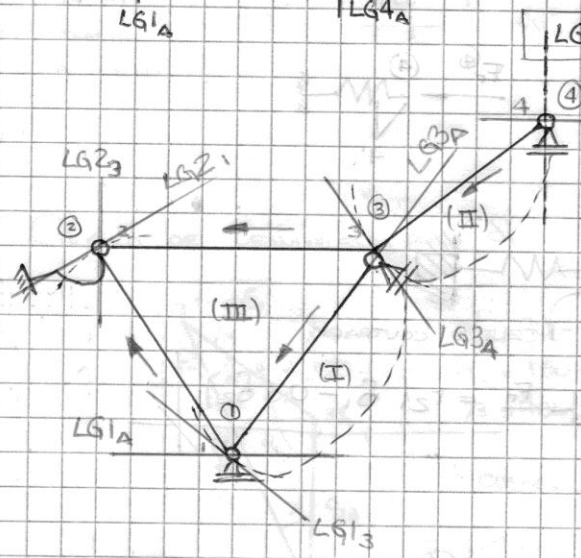
$\Delta'_4 = \delta_1 - 0.5\delta_2$

ORURO 7 DE MAYO DE 2010



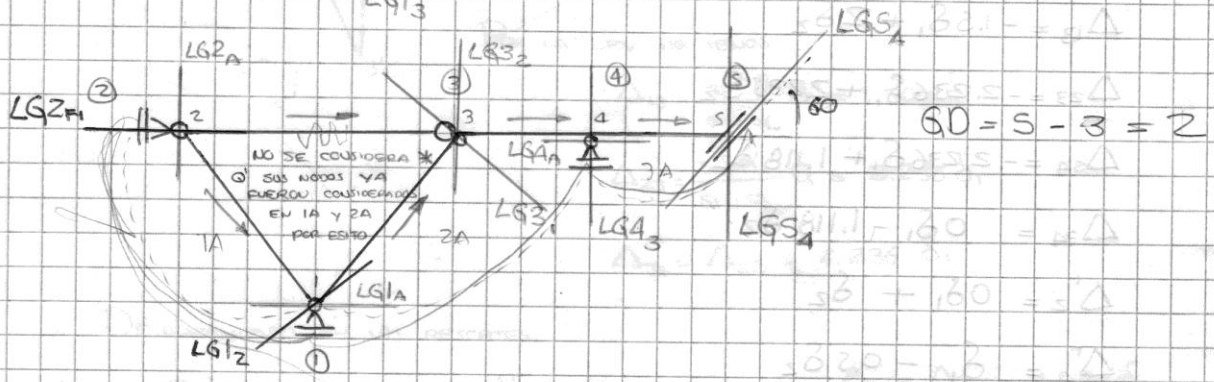
$$GD = ND - A$$

$$GD = 2 - 1 = \boxed{1}$$



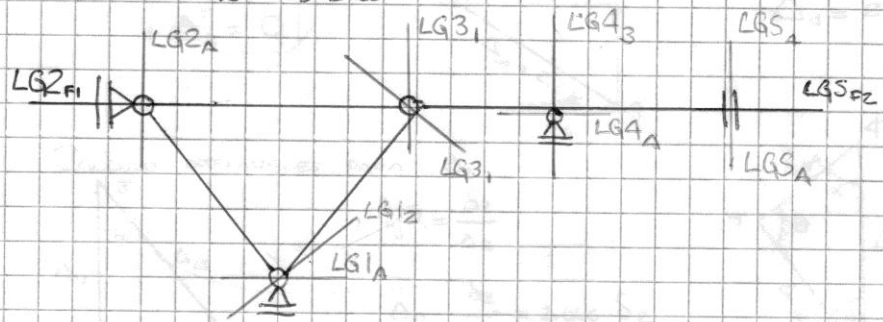
$$GD = ND - A$$

$$= 4 - 3 = \boxed{1}$$



$$GD = S - 3 = 2$$

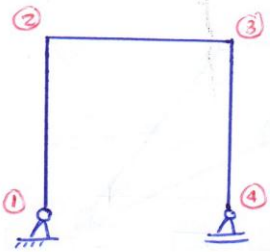
CAMBIANDO UN APOYO TENEMOS



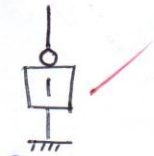
$$GD = ND - A$$

$$GD = S - 3 = 2$$

CONFIGURACIÓN DE NUDOS

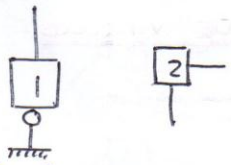


Nudo 1



$\theta_1 = 0$

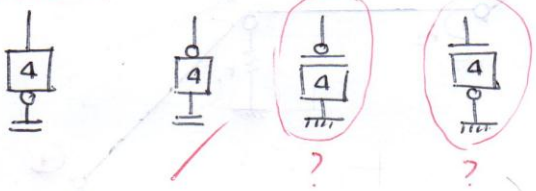
Nudo 2

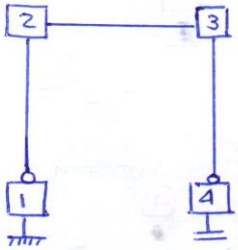


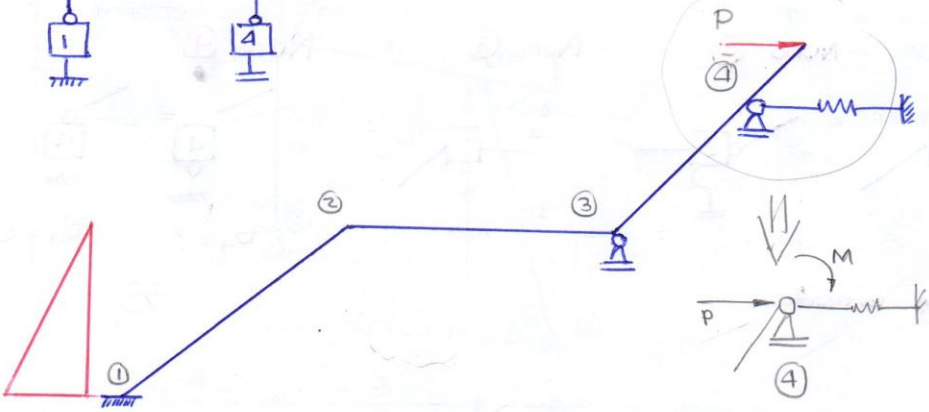
$\theta_1 = ?$

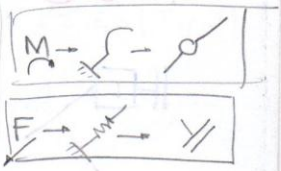
Nudo 3

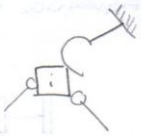
Nudo 4









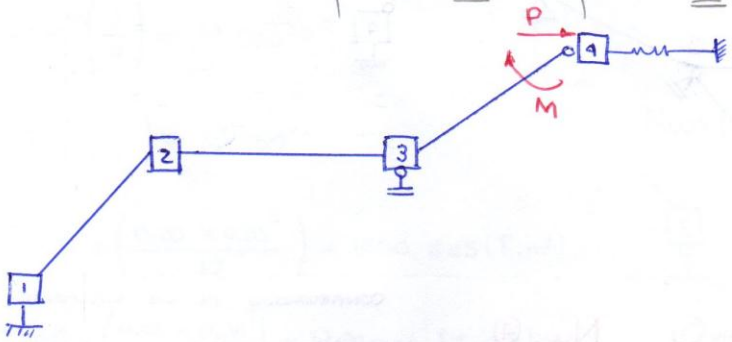


EL RESORTE NO TRABAJA

Nudo 1 | Nudo 2 | Nudo 3 | Nudo 4

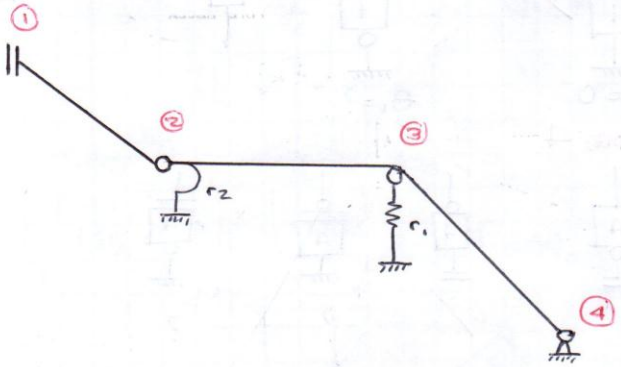
$\theta_4 = ?$

$\theta_4 = 0$

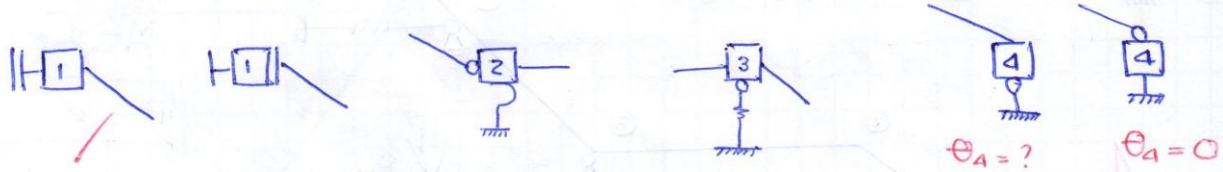


MAYO 11 DE 2010

CONFIGURACION DE VINCULOS.

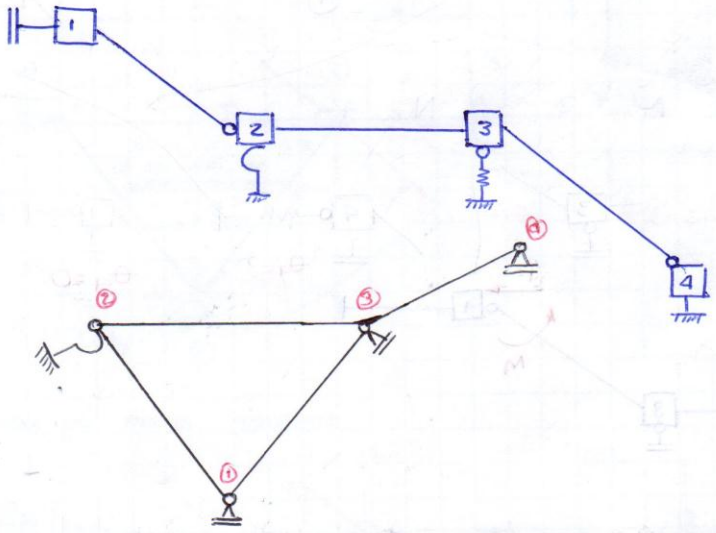


NUDO 1 NUDO 2 NUDO 3 NUDO 4

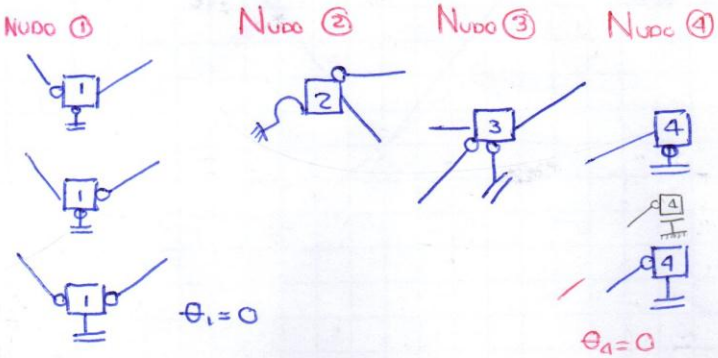


$\theta_4 = ?$ $\theta_4 = 0$

CONFIGURACION DE NUESTRA ESTRUCTURA.

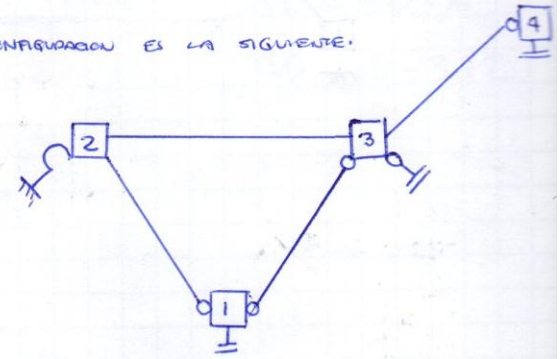


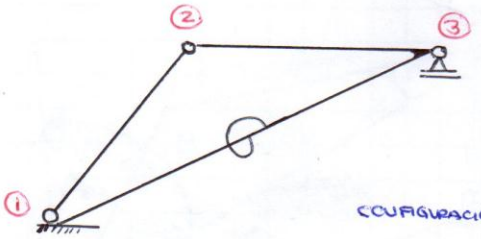
NUDO 1 NUDO 2 NUDO 3 NUDO 4



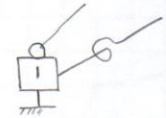
$\theta_1 = 0$ $\theta_4 = 0$

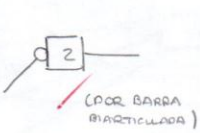
CONFIGURACION ES LA SIGUIENTE.



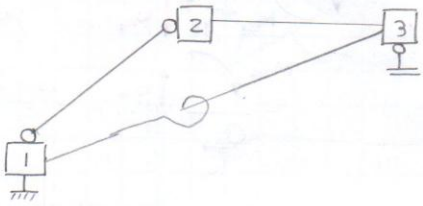


NUDO ① NUDO ② NUDO ③

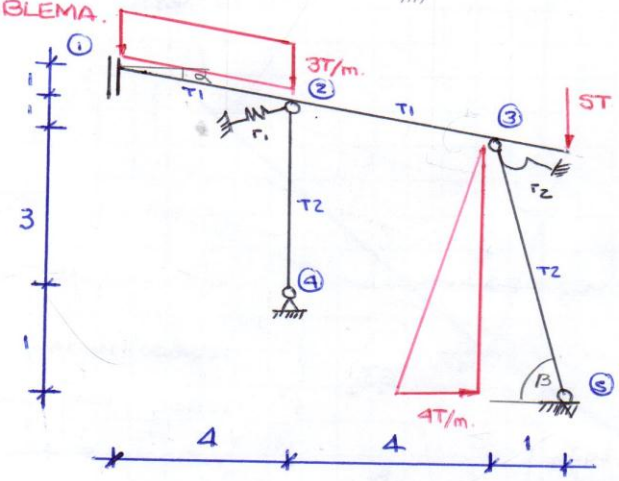




CONFIGURACION



PROBLEMA.



T1 → 20x35
T2 → 20x30
} E = 2.1ES (Kg/cm²)
E = 2.1E6 (Tn/m²)

$r_1 = 5E3$ T/m

$r_2 = 4E3$ T-m/rad.

① CARACTERISTICAS DE LA ESTRUCTURA.

$L_{12} = L_{23} = \sqrt{1^2 + 4^2} = 4.123$ (m)

$L_{35} = \sqrt{4^2 + 1^2} = 4.123$ (m)

$\alpha = \tan^{-1}\left(\frac{1}{4}\right) = 14.036°$

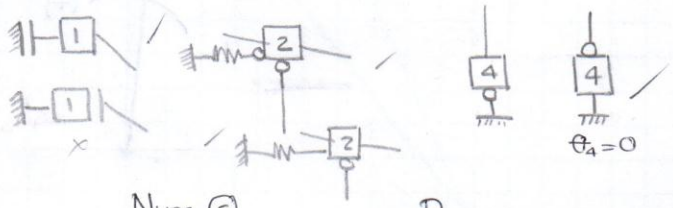
$\beta = \tan^{-1}\left(\frac{4}{1}\right) = 75.964°$

$EI_1 = 2.1E6 * \left(\frac{0.20 * 0.35^3}{12}\right) = 1500.625$ (T-m²)

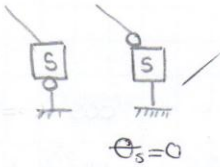
$EI_2 = 2.1E6 * \left(\frac{0.20 * 0.30^3}{12}\right) = 945.000$ (T-m²)

② CONFIGURACION DE VINCULES Y GRADO DE DESPLAZAMIENTO

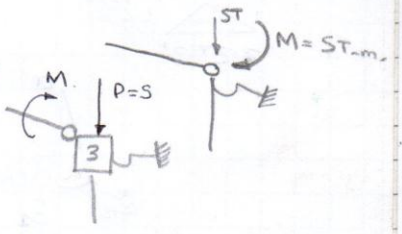
NUDO ① NUDO ② NUDO ④



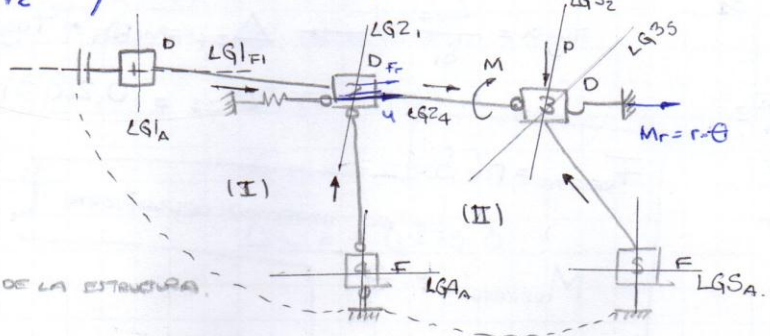
NUDO ⑤



PARA NUDO 3



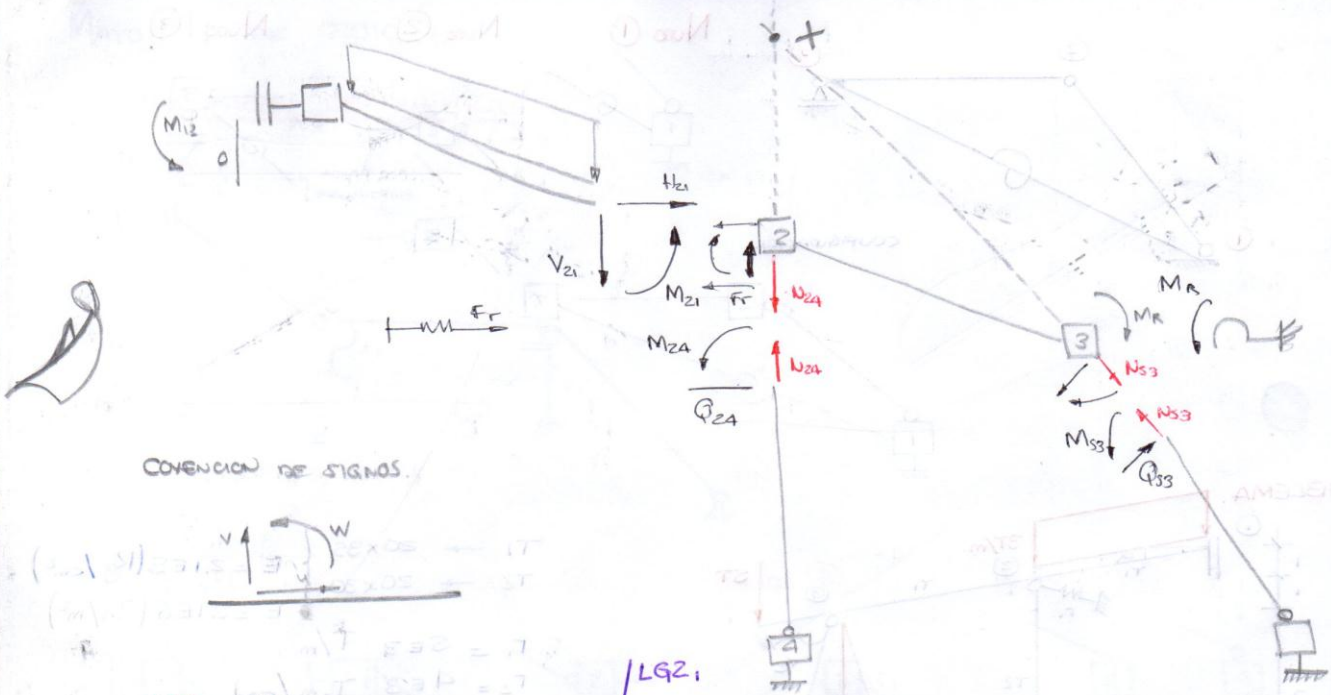
$\theta_1 = 0$
$\theta_2 = ? \rightarrow \Sigma M_2 = 0$
$\theta_3 = ? \rightarrow \Sigma M_3 = 0$
$\theta_4 = 0$
$\theta_5 = 0$
$\delta_1 = ? \rightarrow$ ECUACION DE LA ESTRUCTURA



GD = ND - A

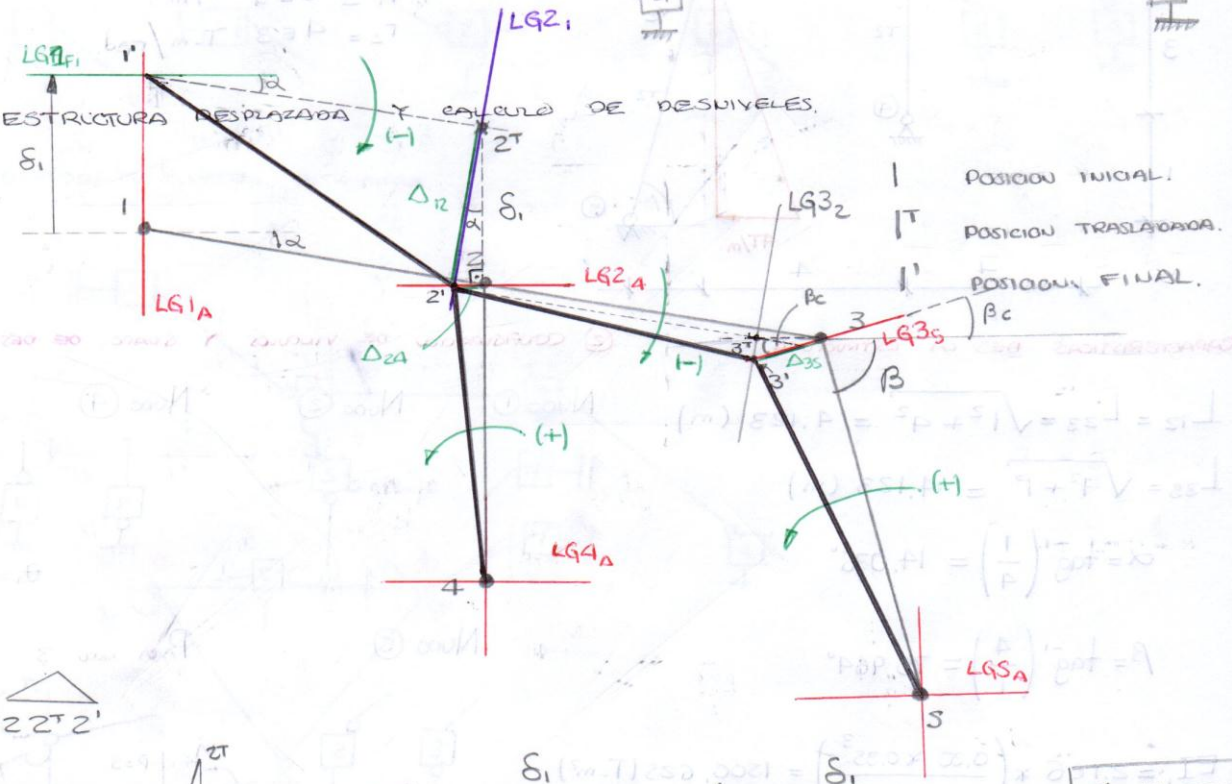
GD = 3 - 2 = 1

$F_r = r \cdot \Delta^r$

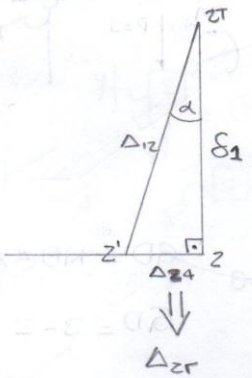


CONVENCION DE SIGNOS.

3. ESTRUCTURA DESPLAZADA Y CALCULO DE DESNIVELES.



1	POSICION INICIAL.
1T	POSICION TRASLADADA.
1'	POSICION FINAL.



$$\cos\alpha = \frac{\delta_1}{\Delta_{12}} \rightarrow \Delta_{12} = \frac{\delta_1}{\cos\alpha} \qquad \alpha = 14,036°$$

$$\Delta_{12} = 1,031\,\delta_1$$

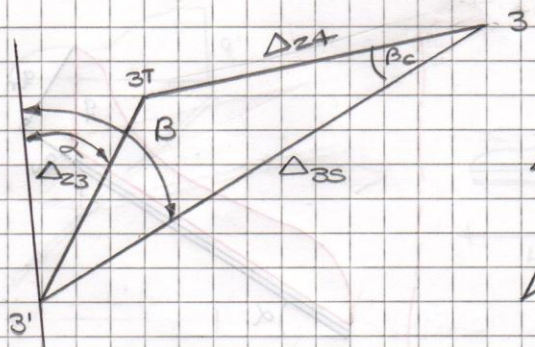
$$tag\,\alpha = \frac{\Delta_{24}}{\delta_1} \rightarrow \Delta_{24} = \delta_1 \cdot tag\,\alpha$$

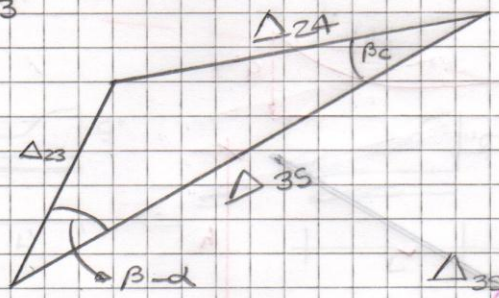
$$\Delta_{24} = 0,250\,\delta_1$$

$$\Delta_{2r} = 0,250\,\delta_1$$

$F_{RESCATE} = r * \delta$ → EN DIRECCION DEL RESORTE

$M_{RESCATE} = r \cdot \theta$

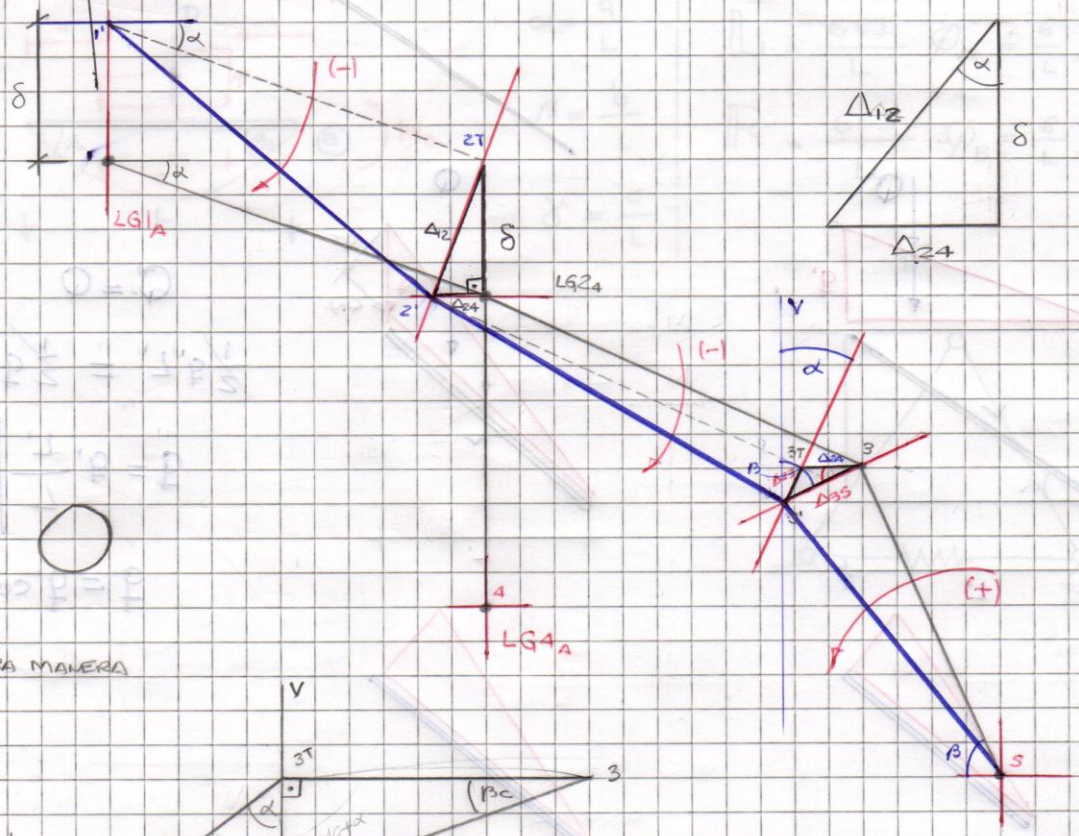




$\Delta_{35} = 0.275\,\delta$

$\Delta_{23} = 0,063\,\delta$

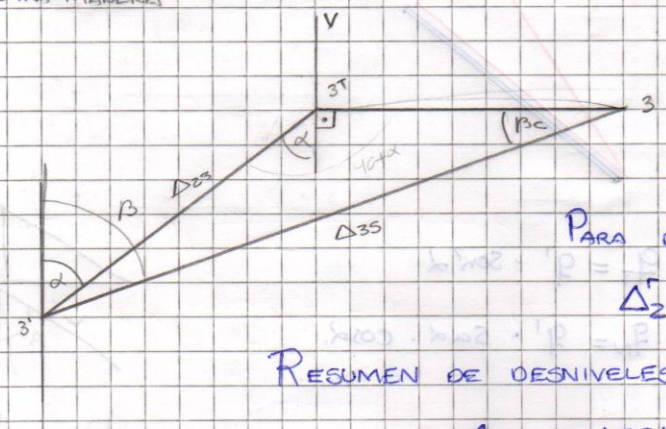
- 18 DE MAYO DE 2010



$\Delta_{12} = 1,031\,\delta$

$\Delta_{24} = 0,250\,\delta$

OTRA MANERA



PARA EE RESORTE

$\Delta_2' = \Delta_{24} = -0,250\,\delta$

RESUMEN DE DESNIVELES.

$\Delta_{12} = -1,031\,\delta$

$\Delta_{23} = -0,069\,\delta$

$\Delta_{35} = +0,275\,\delta$

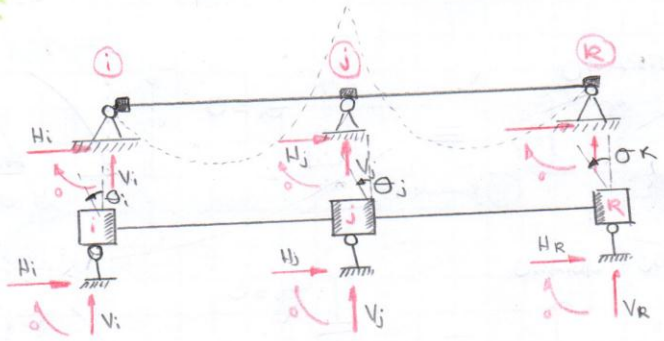
METODO ROTACIONES ANGULARES
(METODO DE RIGIDEZ)

- EST. ISOSTÁTICAS
- EST. HIPERESTÁTICAS

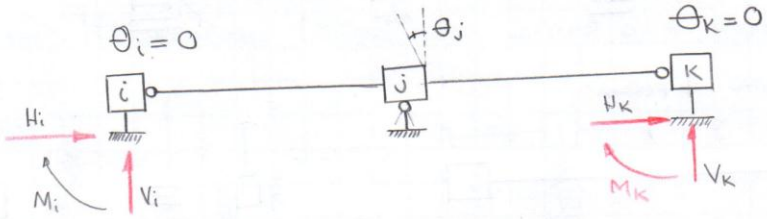
1. **BASE FUNDAMENTAL** INCOGNITAS SON DESPLAZAMIENTOS (LINEALES Y ROTACIONALES), DE PUNTOS O NUDOS DEFINIDOS POR DISEÑADOR.

1.1. **CONFIGURACION DE VINCULOS** ES EXPRESAR UN NUDO DE FORMA DIFERENCIAL AMPLIADA, CON LOS TIPOS DE LIBERTADES Y RESTRICCIONES QUE LA CONFORMAN.

EJEMPLO:



3 INCOGNITAS



1 INCOGNITA.

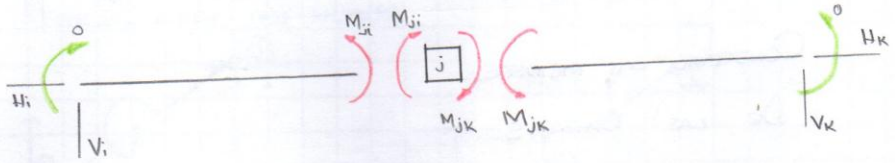
DATOS

$\theta_i = 0$
$\theta_K = 0$

INCOGNITAS.

$\theta_j = ?$

ANALIZANDO NUDO (j)



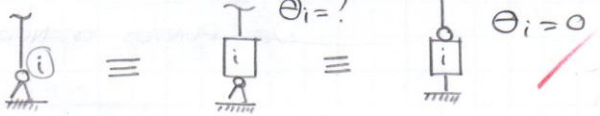
$$\Sigma M_j = 0 \qquad M_{ji} + M_{jk} = 0 \quad \ldots \quad (1)$$

$$M_{ji} = f(\theta_j)$$

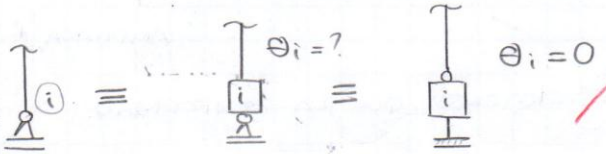
$$M_{jk} = g(\theta_j)$$

1.2. Tipos de Configuración de Vínculos.

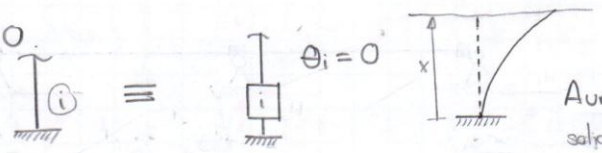
Apoyo Fijo



Apoyo Movil

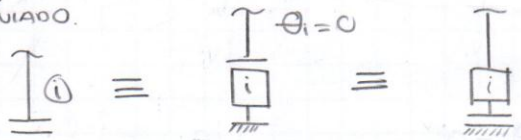


Apoyo Empotrado

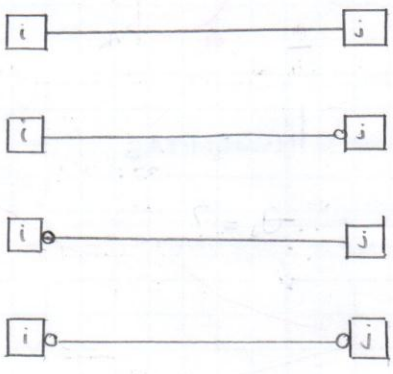


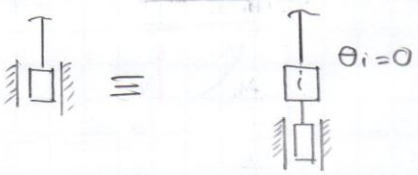
Aumenta en función a la solicitación interna (M_x)

Apoyo empotrado - Guiado.



Configurar de una de estas 4 formas

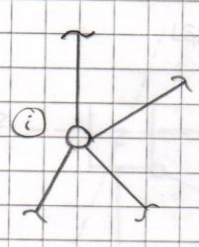


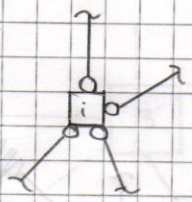


Conocemos las rigideces.

De las barras.

- UNION ARTICULADA.

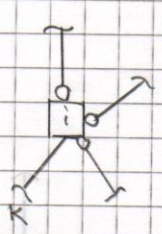




$\theta_i = ?$

$\Sigma M_i = 0$

$0 = 0$

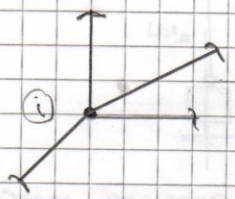


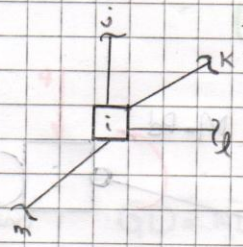
$\theta_i = ?$

$\Sigma M_i = 0$

$M_{iK} = 0$

- UNION EMPOTRADA.



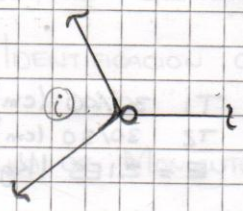


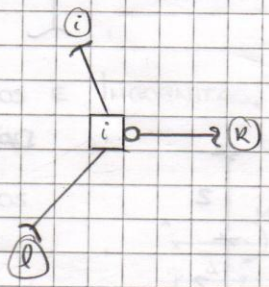
$\theta_i = ?$

$\Sigma M_i = 0$

$M_{ij} + M_{iK} + M_{il} + M_{im} = 0$

- UNION MIXTA



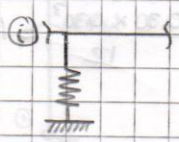


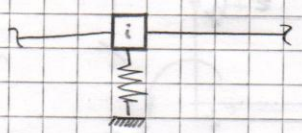
$\theta_i = ?$

$\Sigma M_i = 0$

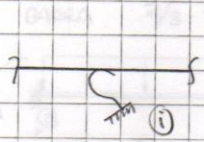
$M_{ij} + M_{il} = 0$

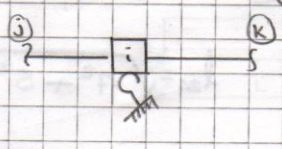
- RESORTE HELICOIDAL (100pre DEB LLEGAR A UN NUDO).





- RESORTE ESPIRAL



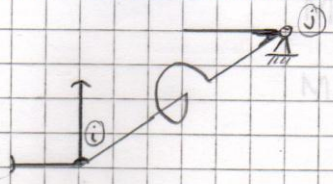


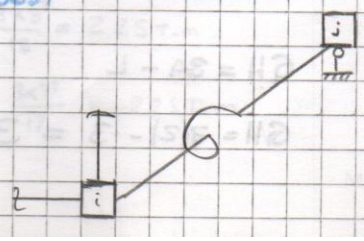
$\theta_i = ?$

$\Sigma M_i = 0$

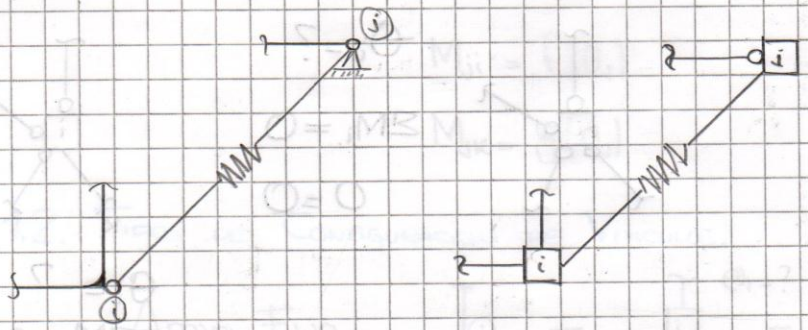
$M_{ij} + M_{iK} + M^r = 0$

- RESORTE ESPIRAL ENTRE DOS NUDOS.

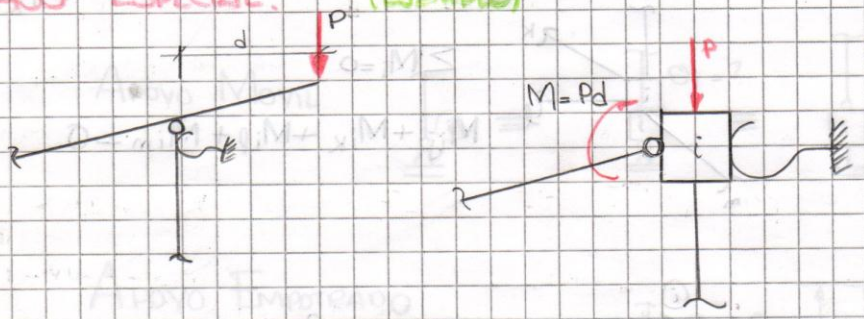




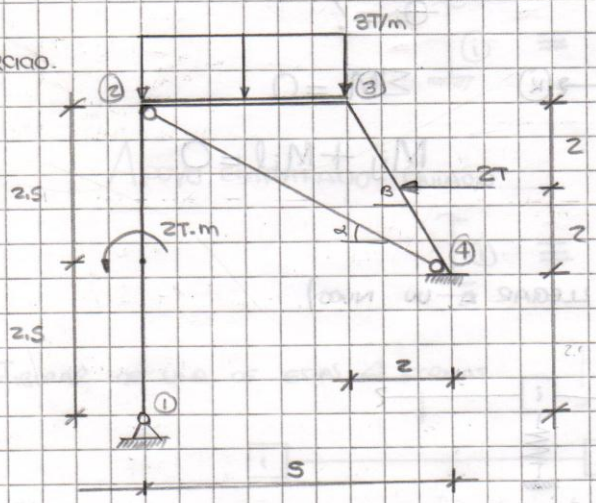
- RESORTE HELICOIDAL ENTRE DOS NUDOS.



CASO ESPECIAL. (EJEMPLO)



EJERCICIO.



DATOS T1 30/40 (cm)
T2 30/30 (cm)
E = 2.1ES (Kg/cm²)

$EI = \frac{2.1E6 \times 0.30 \times 0.40^3}{12} = 3360\ (T\text{-}m^2)$

$EI = \frac{2.1E6 \times 0.30 \times 0.30^3}{12} = 1417.5\ (T\text{-}m^2)$

SOLUCION.

1. CARACTERISTICAS GEOMETRICAS

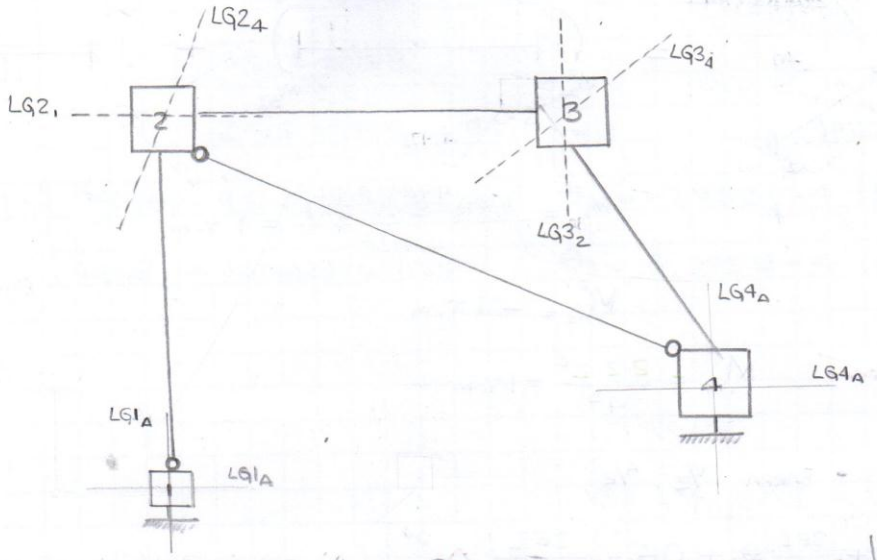
$\alpha = \text{arctg}\left(\frac{4}{5}\right) = 38.659$ $\quad l_{24} = \sqrt{4^2 + 5^2}$

$\beta = \text{arctg}\left(\frac{4}{2}\right) = 63.435$ $\quad l_{34} = \sqrt{4^2 + 2^2}$

2. GRADO DE HIPERESTATICIDAD $\quad GH = 3A - L$

$GH = 3(2) - 3 = 3$

3. Configuracion de Vinculos



3.1 Grado de desplazabilidad $GD = ND - A = 2 - 2 = 0$

No existe desplazamientos lineales en nestros nudos

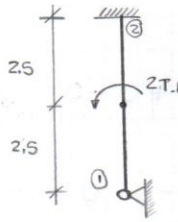
3.2 Lugares Geometricos

3.3 Identificacion de datos e Ingognitas.

Datos	Incognitas	
$\theta_1 = 0$	$\theta_2 = ?$	$\Sigma M_2 = 0$ ... ①
$\theta_4 = 0$	$\theta_3 = ?$	$\Sigma M_3 = 0$ ... ②

4. Calculo de Momentos Fijos.

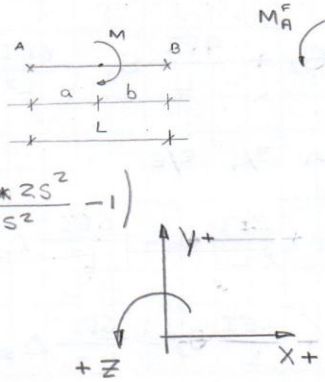
Barra 1/2 A/E.

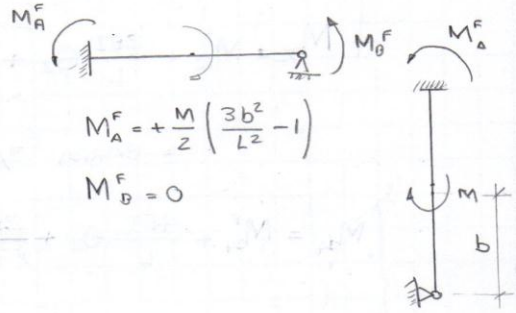


$$M^F_{21} = + \frac{(-2)}{2}\left(\frac{3 * 2.5^2}{5^2} - 1\right)$$

$$M^F_{21} = 0.25\ T.m$$

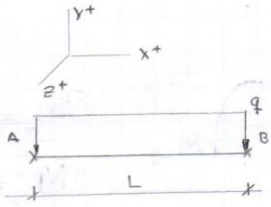
$$M^F_{12} = 0$$

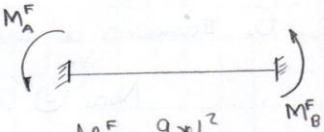




$$M^F_A = + \frac{M}{2}\left(\frac{3b^2}{L^2} - 1\right)$$

$$M^F_B = 0$$

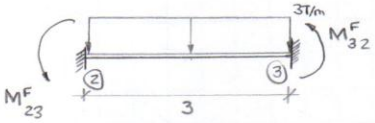




$$M^F_A = \frac{q * L^2}{12}$$

$$M^F_B = -\frac{q * L^2}{12}$$

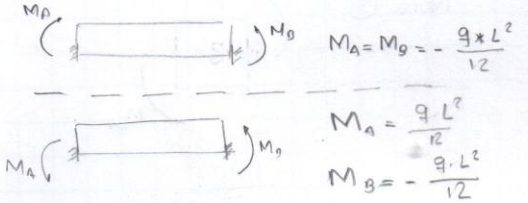
Barra 2/3 E/E



$$M^F_{23} = \frac{3 * 3^2}{12} = 2.25\ T.m$$

$$M^F_{32} = -\frac{3 * 3^2}{12} = -2.25\ T.m.$$

Bera cualquier

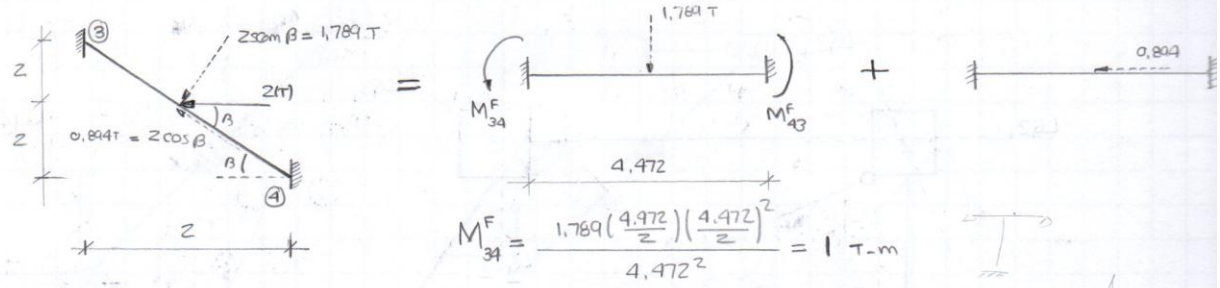


$$M_A = M_B = -\frac{q * L^2}{12}$$

$$M_A = \frac{q L^2}{12}$$

$$M_B = -\frac{q \cdot L^2}{12}$$

BARRA 3/4 E/E $L_{34} = 4.472\,(m)$



$$M^F_{34} = \frac{1.789\left(\frac{4.472}{2}\right)\left(\frac{4.472}{2}\right)^2}{4.472^2} = 1\ T\cdot m$$

$$M^F_{43} = -1\ T\cdot m$$

OTRA FORMA DE VERIFICAR $\quad M^F_{34} = \frac{2 \cdot 2 \cdot 2^2}{4^2} = 1\ T\cdot m$

5. MOMENTOS TOTALES • BARRA 1/2 A/E

$$\begin{cases} M_{21} = M^F_{21} + \frac{3EI}{L}\theta_2 + 0\theta_1 - \frac{3EI}{L^2}\Delta_{21} \\ M_{12} = 0 \end{cases} \qquad \begin{cases} M_{21} = 0.25 + 2016\,\theta_2 + 0 + 0 \\ M_{12} = 0 \end{cases}$$

• BARRA 2/3 E/E

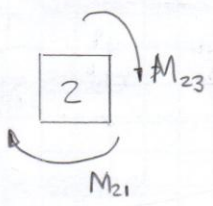
$$\begin{cases} M_{23} = M^F_{23} + \frac{4EI}{L}\theta_2 + \frac{2EI}{L}\theta_3 - \frac{6EI}{L^2}\Delta_{23} \\ M_{32} = M^F_{32} + \frac{2EI}{L}\theta_2 + \frac{4EI}{L}\theta_3 - \frac{6EI}{L^2}\Delta_{23} \end{cases} \qquad \begin{cases} M_{23} = 2.25 + 1890\,\theta_2 + 945\,\theta_3 - 0 \\ M_{32} = -2.25 + 945\,\theta_2 + 1890\,\theta_3 - 0 \end{cases}$$

• BARRA 3/4 E/E

$$\begin{cases} M_{34} = M^F_{34} + \frac{4EI}{L}\theta_2 + \frac{2EI}{L}\theta_3 - \frac{6EI}{L^2}\Delta_{34} \\ M_{43} = M^F_{43} + \frac{2EI}{L}\theta_2 + \frac{4EI}{L}\theta_3 - \frac{6EI}{L^2}\Delta_{34} \end{cases} \qquad \begin{cases} M_{34} = 1 + 1267.899\,\theta_3 + 0 - 0 \\ M_{43} = -1 + 633.945\,\theta_3 + 0 - 0 \end{cases}$$

6. ECUACIONES DE CONDICIÓN

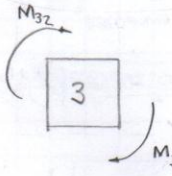
NUDO ②



$$\Sigma M_2 = 0$$

$$M_{23} + M_{21} = 0 \quad \ldots (1)$$

NUDO ③



$$\Sigma M_3 = 0$$

$$M_{32} + M_{34} = 0 \quad \ldots (2)$$

7. Calculo de Incognitas

$\Sigma M_2 = 0$ $\quad 2,25 + 1890\theta_2 + 945\theta_3$

$0,25 + 2016\theta_2$

$2,5 + 3906\theta_2 + 945\theta_3 = 0$

$\Sigma M_3 = 0$ $\quad -2,25 + 945\theta_2 + 1890\theta_3$

$1 \quad +1267,889\theta_3$

$-1,25 + 945\theta_2 + 3157,889\theta_3 = 0$

$$\begin{cases} 3906\theta_2 + 945\theta_3 = -2,5 \\ 945\theta_2 + 3157,889\theta_3 = 1,25 \end{cases}$$

$\theta_2 = -7,932E-4$ (rad)

$\theta_3 = 6,332E-4$ (rad)