LECCION 7 - EJERCICIO 9 (18.9) v.2005

▪ INICIO

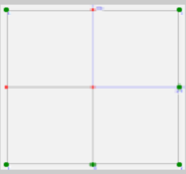
```
Off[General::"spell1"]
Off[General::"spell"]
```

```
SetDirectory[NotebookDirectory[]]
```

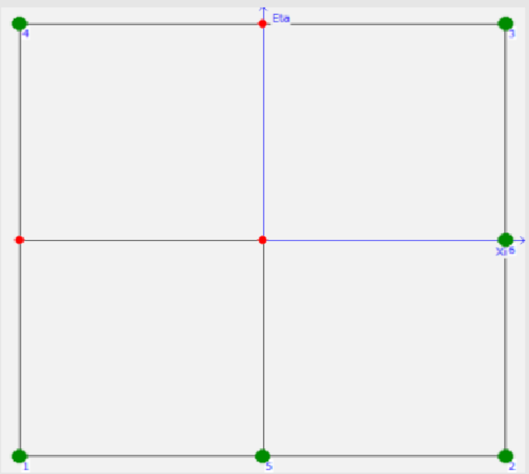
```
C:\#0-Modulos-M30x_MeF-10\#M306-m6-a3a-sws\08-Funciones-forma
```

▪ DEFINICION ELEMENTO CUADRILATERO DE TRANSICION DE 6 NODOS

▫ DEFINICION GRAFICA

CuaT6 =  ;

```
CuaT6r = Show[CuaT6, ImageSize → 250]
```



▫ COORDENADAS NATURALES NODOS

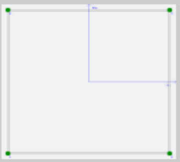
```
Cn = {{-1, -1}, {1, -1}, {1, 1}, {-1, 1}, {0, -1}, {1, 0}};
```

```
NNodos = Dimensions[Cn][[1]]
```

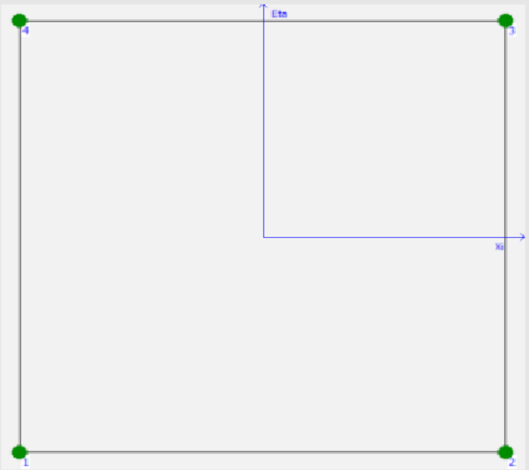
```
6
```

ELEMENTOS COMPLETOS NECESARIOS

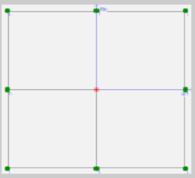
REGULAR DE 4 NODOS

CuaR4 = ;

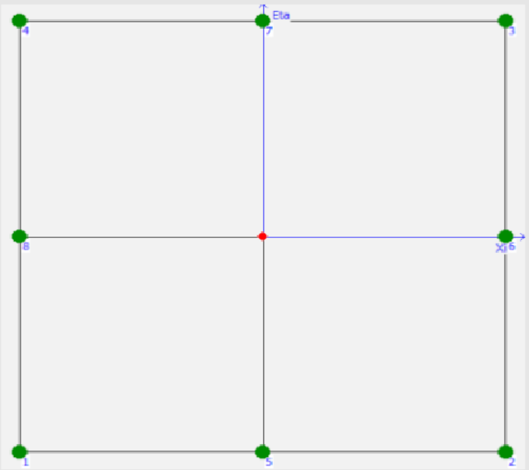
```
CuaR4r = Show[CuaR4, ImageSize → 250]
```



SERENDIPITO DE 8 NODOS - 2 DIVISIONES POR LADO

CuaS8 = ;

```
CuaS8r = Show[CuaS8, ImageSize → 250]
```



FUNCIONES DE FORMA - METODO PRODUCTO DE CURVAS

CURVAS A CONSIDERAR

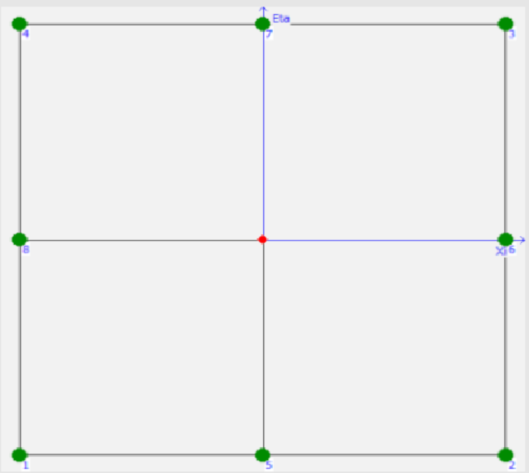
LADOS - CUADRILATERO REGULAR DE 4 NODOS

```
CuCR04N = Table[0, {i, 4}];
```

```
CuCR04N[[1]] = (η + 1); CuCR04N[[2]] = (ξ - 1); CuCR04N[[3]] = (η - 1); CuCR04N[[4]] = (ξ + 1);
```

LADOS Y MEDIANAS - CUADRILATERO SERENDIPITO DE 8 NODOS

```
Show[CuaS8, ImageSize → 250]
```




```
CuCS8N = Table[0, {i, 6 }];
```

```
CuCS8N[[1]] = (η + 1);
CuCS8N[[2]] = (ξ - 1);
CuCS8N[[3]] = (η - 1);
CuCS8N[[4]] = (ξ + 1);
```

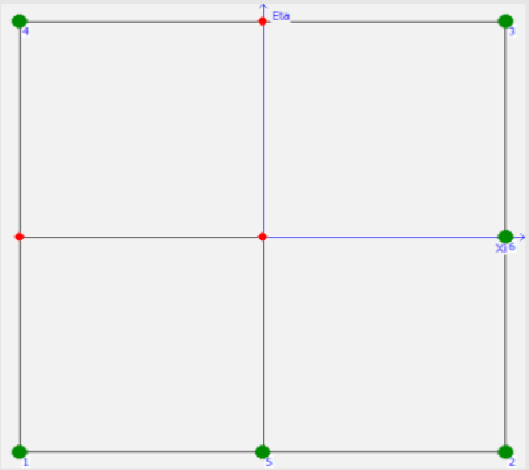
```
CuCS8N[[5]] = (ξ);
```

```
CuCS8N[[6]] = (η);
```

DEFINICION PRODUCTO DE CURVAS EN CADA NODO - NODOS NO ESQUINA

```
Nc = Table[{0, 0}, {i, NNodos}];
```

```
Show[CuaT6, ImageSize → 250]
```



Tipo 2 - LADOS

```
Nc[[5]] = CuCS8N[[2]] * CuCS8N[[3]] * CuCS8N[[4]];
```

```
Nc[[6]] = CuCS8N[[1]] * CuCS8N[[3]] * CuCS8N[[4]];
```

OBTENCION FUNCIONES DE FORMA - NODOS NO ESQUINA

```
Clear[Nf]
```

```
Nfp = Table[0, {i, NNodos}];
```

```
Nf = Table[0, {i, NNodos}];
```

```
Do[
  Nfp[[i]] = a * Nc[[i]];
  eq = 1 == Nfp[[i]] /. {ξ -> Cn[[i, 1]], η -> Cn[[i, 2]]};
  as = a /. Solve[eq, a][[1]]; Print["Nodo ", i];
  Nf[[i]] = Simplify[Nfp[[i]] /. {a → as}],
  {i, 5, NNodos}
 ];
```

```
Nodo 5

Nodo 6
```

```
MatrixForm[Nf]
```

$$\begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ \frac{1}{2}(-1+\eta)(-1+\xi)(1+\xi) \\ -\frac{1}{2}(-1+\eta)(1+\eta)(1+\xi) \end{pmatrix}$$

OBTENCION FUNCIONES DE FORMA - NODOS ESQUINA

Utilizamos las Funciones de Forma del Cuadrilatero de 4 Nodos.

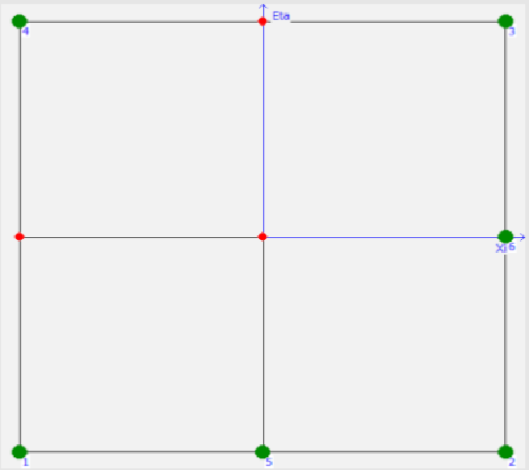
```
NfCR4 = {1/4 (-1 + η) (-1 + ξ), -1/4 (-1 + η) (1 + ξ), 1/4 (1 + η) (1 + ξ), -1/4 (1 + η) (-1 + ξ)};
```

NODO 1 - Desarrollo -

```
Clear[a5, a6];
```

```
Nf[[1]] = NfCR4[[1]] + a5 * Nf[[5]] + a6 * Nf[[6]];
```

```
Show[CuaT6, ImageSize → 250]
```




```
eq = 0 == Nf[[1]] /. {ξ -> Cn[[5]][[1]], η -> Cn[[5]][[2]]}
a5s = a5 /. Solve[eq, a5][[1]]
```

$0 == \frac{1}{2} + a5$

$-\frac{1}{2}$

```
Nf[[1]] = Simplify[Nf[[1]] /. {a5 → a5s}];
```

```
eq = 0 == Nf[[1]] /. {ξ -> Cn[[6]][[1]], η -> Cn[[6]][[2]]}
a6s = a6 /. Solve[eq, a6][[1]]
```

$0 == a6$

0

```
Nf[[1]] = Simplify[Nf[[1]] /. {a6 → a6s}];
```

```
Nf[[1]]
```

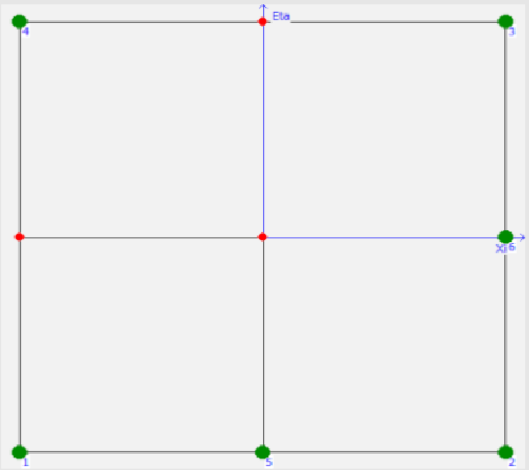
$-\frac{1}{4}(-1+\eta)(-1+\xi)\,\xi$

NODO 2 - Desarrollo -

```
Clear[a5, a6];
```

```
Nf[[2]] = NfCR4[[2]] + a5 * Nf[[5]] + a6 * Nf[[6]];
```

```
Show[CuaT6, ImageSize → 250]
```




```
eq = 0 == Nf[[2]] /. {ξ -> Cn[[5]][[1]], η -> Cn[[5]][[2]]}
a5s = a5 /. Solve[eq, a5][[1]]
```

$$0 == \frac{1}{2} + a5$$

$$-\frac{1}{2}$$

```
Nf[[2]] = Simplify[Nf[[2]] /. {a5 → a5s}];
```

```
eq = 0 == Nf[[2]] /. {ξ -> Cn[[6]][[1]], η -> Cn[[6]][[2]]}
a6s = a6 /. Solve[eq, a6][[1]]
```

$$0 == \frac{1}{2}\ (1 + 2\ a6)$$

$$-\frac{1}{2}$$

```
Nf[[2]] = Simplify[Nf[[2]] /. {a6 → a6s}]
```

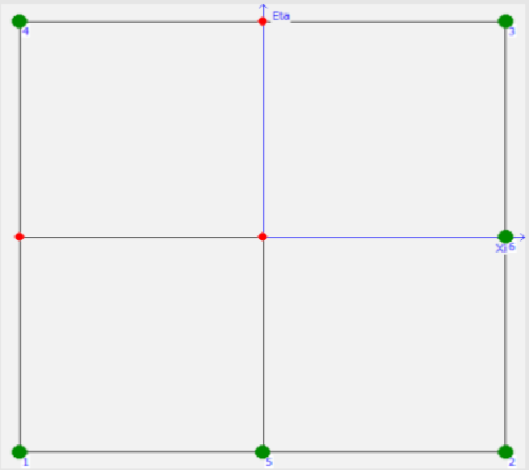
$$\frac{1}{4}\ (-1 + \eta)\ (1 + \eta - \xi)\ (1 + \xi)$$

NODO 3 - Desarrollo -

```
Clear[a5, a6];
```

```
Nf[[3]] = NfCR4[[3]] + a5 * Nf[[5]] + a6 * Nf[[6]];
```

```
Show[CuaT6, ImageSize → 250]
```




```
eq = 0 == Nf[[3]] /. {ξ -> Cn[[5]][[1]], η -> Cn[[5]][[2]]}
a5s = a5 /. Solve[eq, a5][[1]]
```

$0 == a5$

0

```
Nf[[3]] = Simplify[Nf[[3]] /. {a5 → a5s}]
```

$\frac{1}{4}\,(1 - 2\,a6\,(-1 + \eta))\,(1 + \eta)\,(1 + \xi)$

```
eq = 0 == Nf[[3]] /. {ξ -> Cn[[6]][[1]], η -> Cn[[6]][[2]]}
a6s = a6 /. Solve[eq, a6][[1]]
```

$0 == \frac{1}{2}\,(1 + 2\,a6)$

$-\frac{1}{2}$

```
Nf[[3]] = Simplify[Nf[[3]] /. {a6 → a6s}]
```

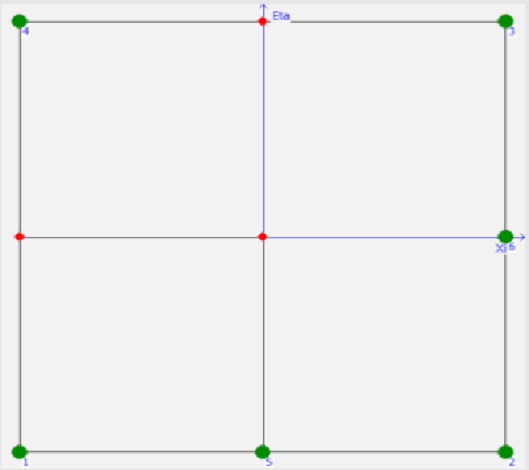
$\frac{1}{4}\,\eta\,(1 + \eta)\,(1 + \xi)$

NODO 4 - Desarrollo -

```
Clear[a5, a6];
```

```
Nf[[4]] = NfCR4[[4]] + a5 * Nf[[5]] + a6 * Nf[[6]];
```

```
Show[CuaT6, ImageSize → 250]
```




```
eq = 0 == Nf[[4]] /. {ξ -> Cn[[5]][[1]], η -> Cn[[5]][[2]]}
a5s = a5 /. Solve[eq, a5][[1]]
```

0 == a5

0

```
Nf[[4]] = Simplify[Nf[[4]] /. {a5 → a5s}];
```

```
eq = 0 == Nf[[4]] /. {ξ -> Cn[[6]][[1]], η -> Cn[[6]][[2]]}
a6s = a6 /. Solve[eq, a6][[1]]
```

0 == a6

0

```
Nf[[4]] = Simplify[Nf[[4]] /. {a6 → a6s}]
```

$$-\frac{1}{4}(1+\eta)(-1+\xi)$$

Funciones de Forma de todos los Nodos.

```
MatrixForm[Nf]
```

$$\begin{pmatrix} -\frac{1}{4}(-1+\eta)(-1+\xi)\xi \\ \frac{1}{4}(-1+\eta)(1+\eta-\xi)(1+\xi) \\ \frac{1}{4}\eta(1+\eta)(1+\xi) \\ -\frac{1}{4}(1+\eta)(-1+\xi) \\ \frac{1}{2}(-1+\eta)(-1+\xi)(1+\xi) \\ -\frac{1}{2}(-1+\eta)(1+\eta)(1+\xi) \end{pmatrix}$$

Comprobación Suma Unidad -

$$\text{Suma} = \sum_{i=1}^{\text{NNodos}} \text{Nf}[[i]]$$

$$-\frac{1}{4}(1+\eta)(-1+\xi) - \frac{1}{4}(-1+\eta)(-1+\xi)\,\xi - \frac{1}{2}(-1+\eta)(1+\eta)(1+\xi) + \frac{1}{4}\eta(1+\eta)(1+\xi) + \frac{1}{4}(-1+\eta)(1+\eta-\xi)(1+\xi) + \frac{1}{2}(-1+\eta)(-1+\xi)(1+\xi)$$

```
Simplify[%]
```

1

OK - SE CUMPLE LA CONDICION DE COMPLETITUD

Proceso para comprobar Valor Funciones de Forman en Nodos - en caso de Error

```
Do[
  Print["NODO ", j];
  Do[
   Print[i, "   ", Simplify[Nf[[j]] /. {ξ -> Cn[[i, 1]], η -> Cn[[i, 2]]}]],
   {i, NNodos}
    ],
  {j, NNodos}
 ];
```

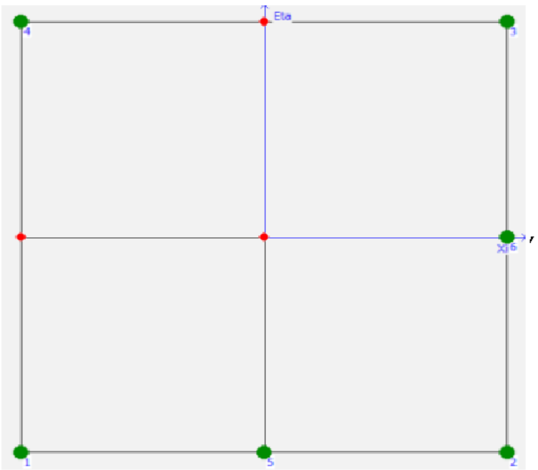
Representación Gráfica.

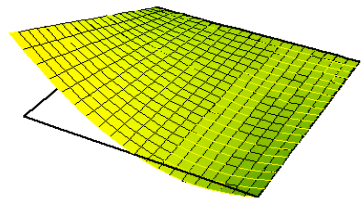
RESULTADOS INTERACTIVOS

```
Manipulate[{CuaT6r, Ng[[n]], Nf[[n]]}, {n, 1, Dimensions[Nf][[1]], 1}, {n, Range[Dimensions[Nf][[1]]]},
 FrameLabel → {"FUNCION DE FORMA EN NODO n - CUADRILATERO TRANSICION 6 NODOS"},
 SaveDefinitions → True]
```

n

n 1

{ 

, 
, $-\frac{1}{4}(-1+\eta)(-1+\xi)\,\xi$ }

FUNCION DE FORMA EN NODO n – CUADRILATERO TRANSICION 6 NODOS