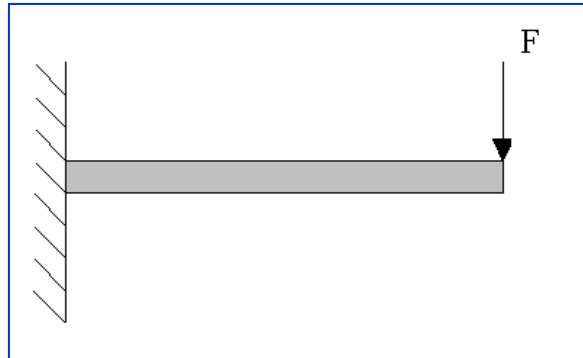


PRÁCTICA 1:
INTRODUCCIÓN AL MÉTODO DE LOS
ELEMENTOS FINITOS

Álvarez Caldas, Carolina

CONCEPTO DEL M.E.F.



$$\frac{du}{dx}$$



$$\sum a_i u_i = b_i$$

Se discretiza el sistema continuo en elementos interconectados



Se especifica el comportamiento de cada elemento mediante un conjunto finito de parámetros

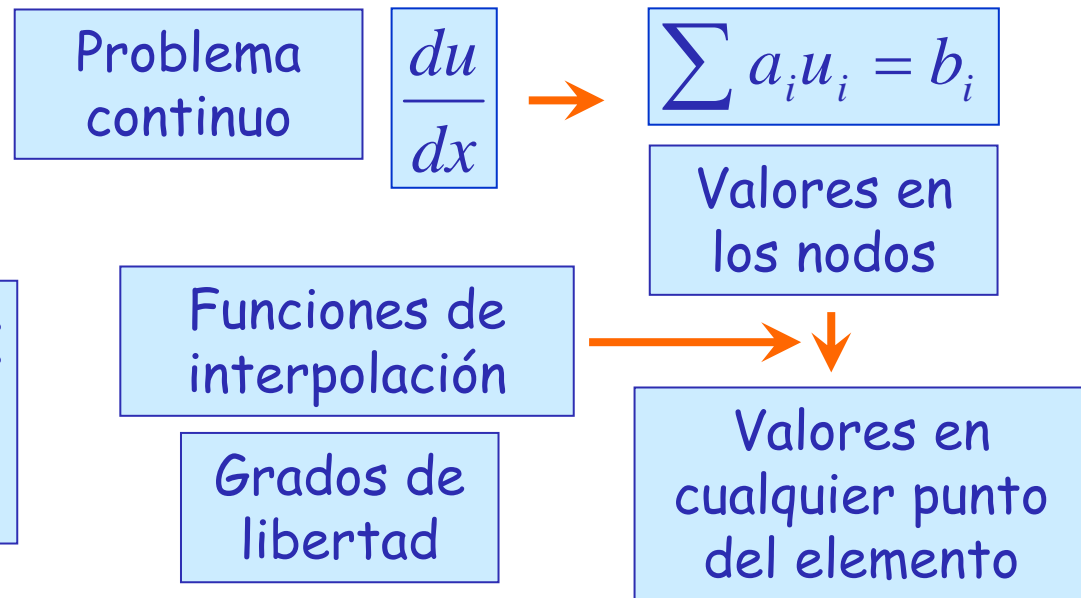
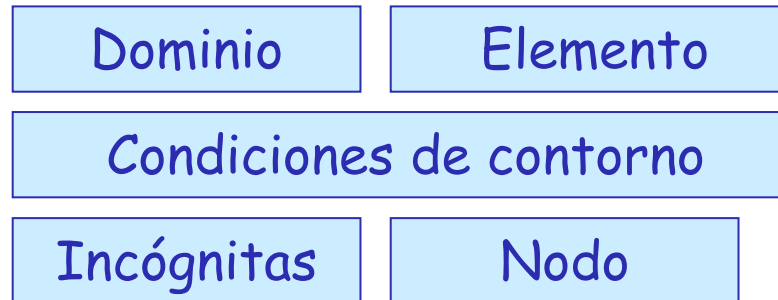
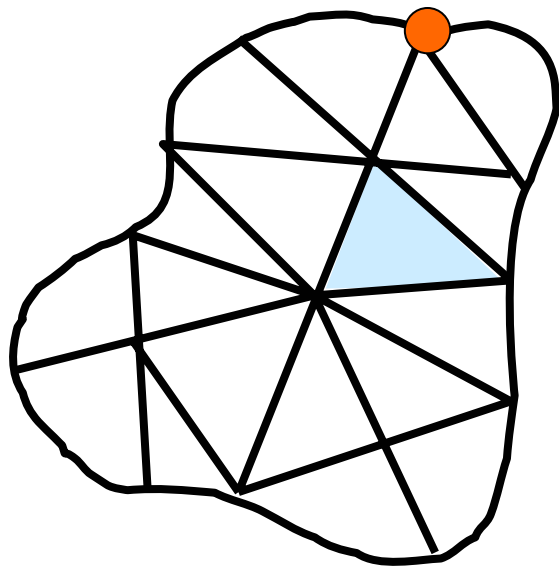


Se ensamblan los elementos



Se resuelve el sistema complejo

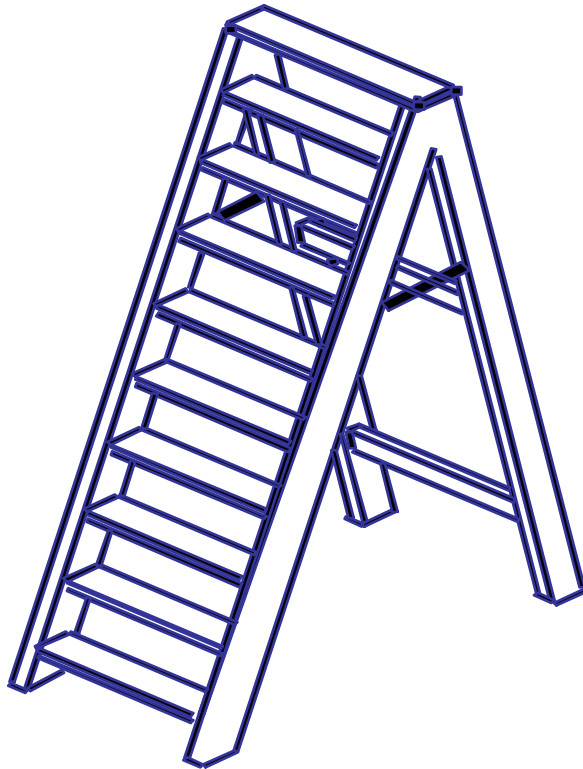
CONCEPTOS GENERALES DEL M.E.F.



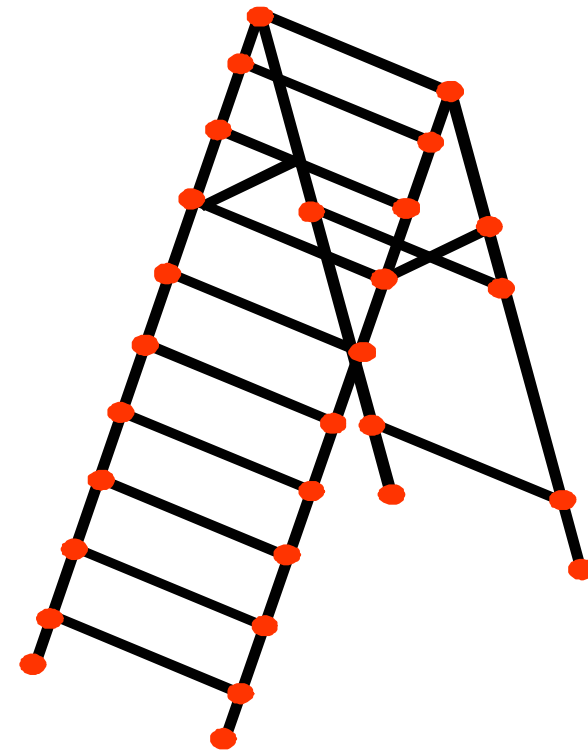
Elemento finito:
 (T, P_T, Σ_T)



Un modelo MEF es la idealización matemática de un sistema físico.

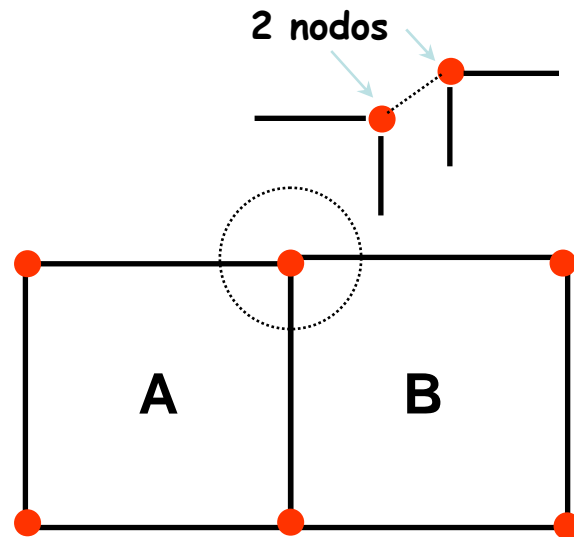


El sistema "real"

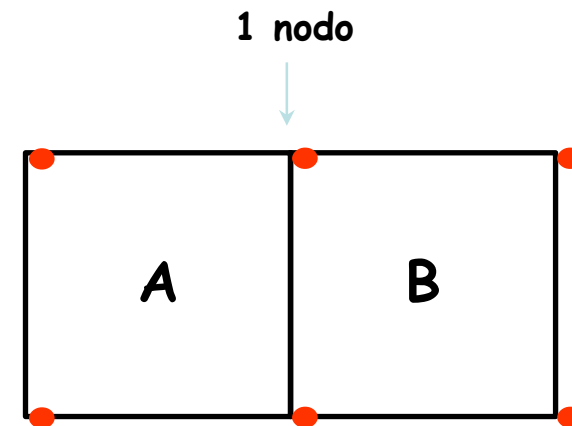


El modelo MEF

La información se transmite de elemento a elemento sólo a través de los nodos comunes.



Nodos separados aunque coinciden en el espacio.
Los elementos A y B no se "comunican".
Hay que "fundir" o "mezclar" los nodos

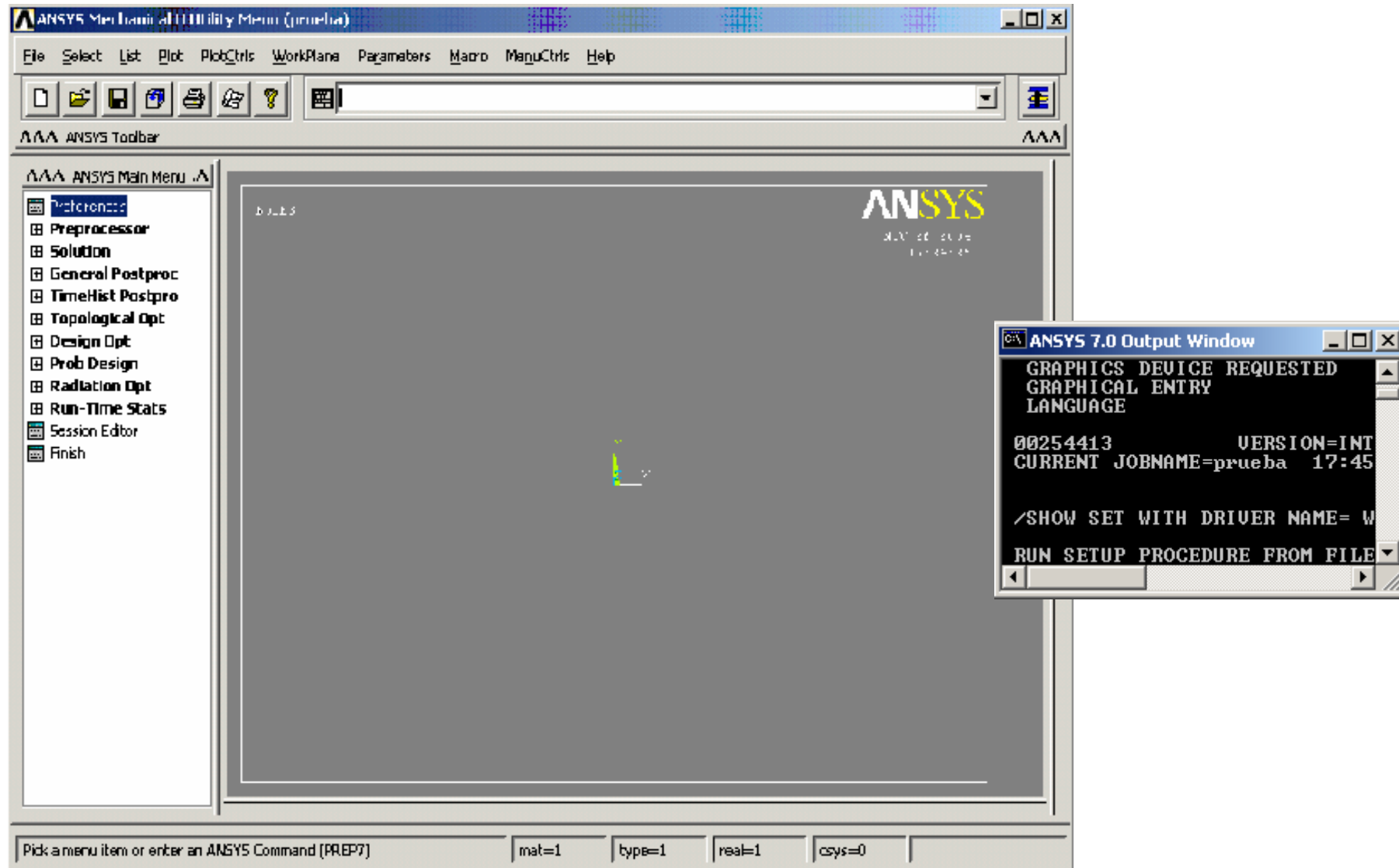


Nodos comunes.
Los elementos A y B se "comunican" entre sí

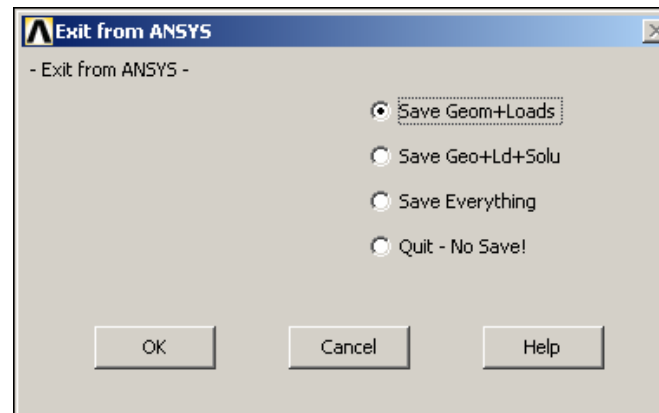
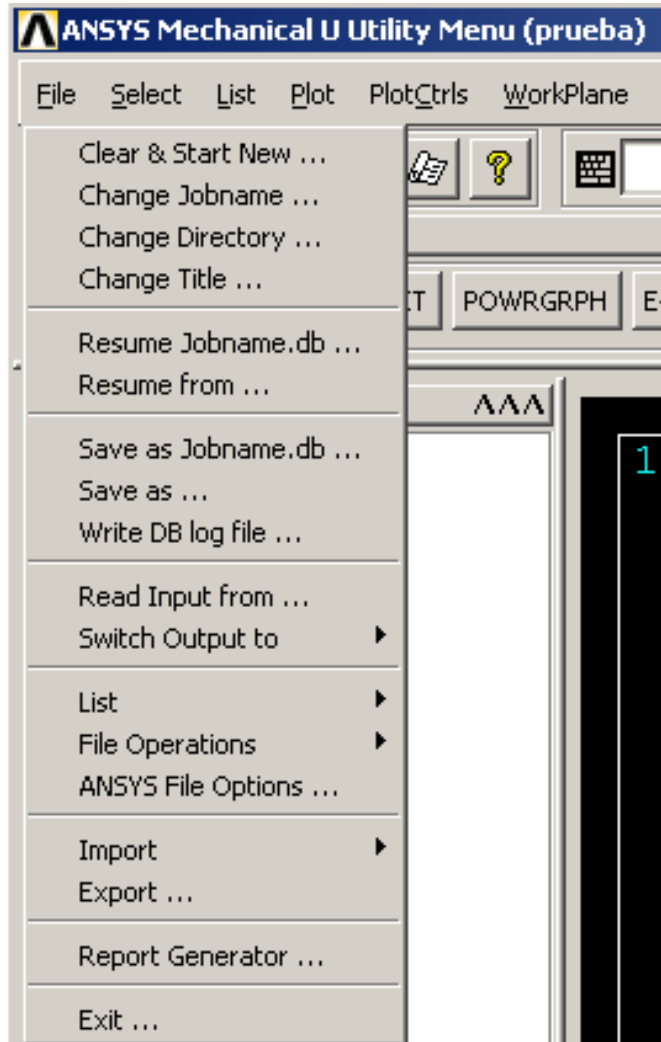
TRABAJO CON UN SOFTWARE DE E.F.

1. Selección del tipo de análisis
2. Diseño del modelo
 - 2.1. Dimensión
 - 2.2. Tipo de elemento y características
 - 2.3. Material
3. Creación de la geometría
4. Mallado
5. Aplicación de las condiciones de contorno
6. Aplicación de las cargas, presiones...
7. Resolución
8. Visualización y análisis de resultados

EL ENTORNO DE ANSYS



MANEJO BÁSICO DE FICHEROS



Ficheros creados por ANSYS

*.err

*.log

*.db

*.dbb

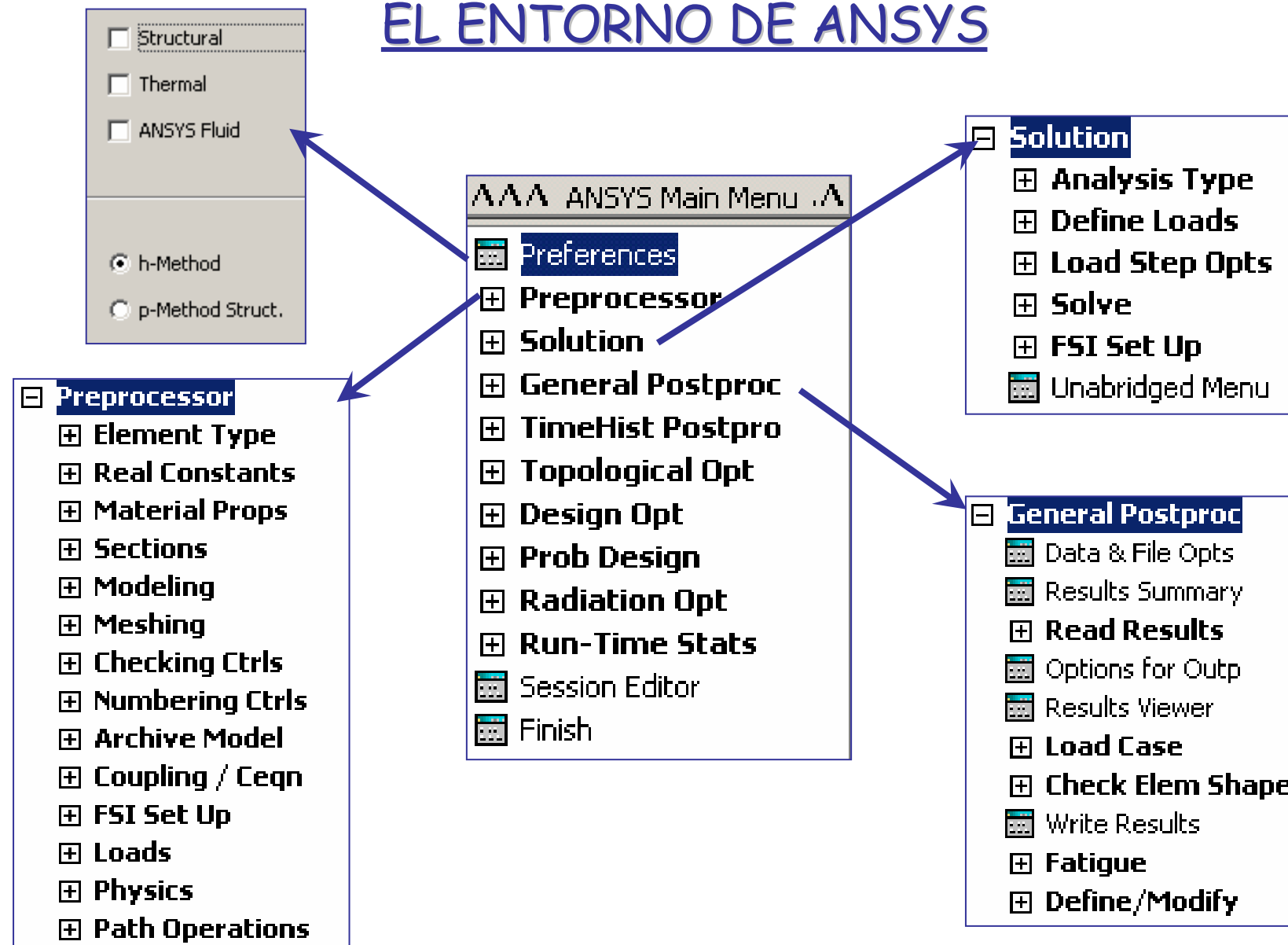
*.rst

*.esav

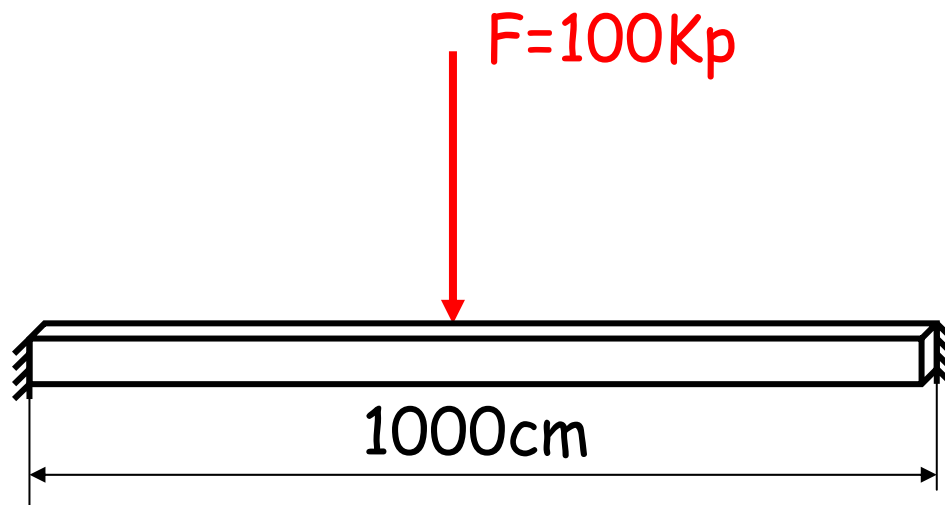
*.emat

*.tri

EL ENTORNO DE ANSYS



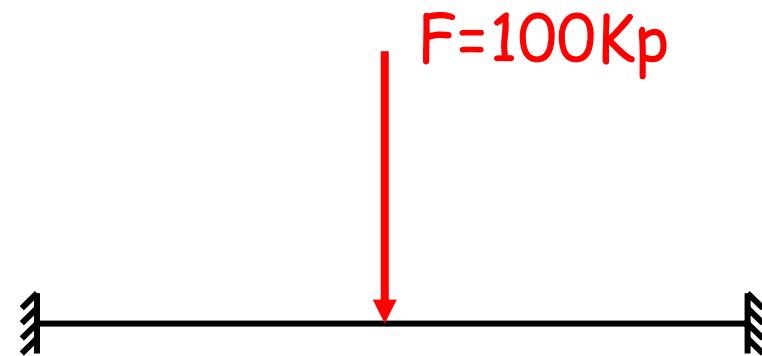
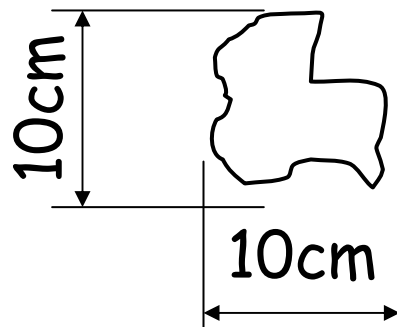
EJEMPLO: VIGA DOBLEMENTE EMPOTRADA



$$E=2,1\text{E}6$$

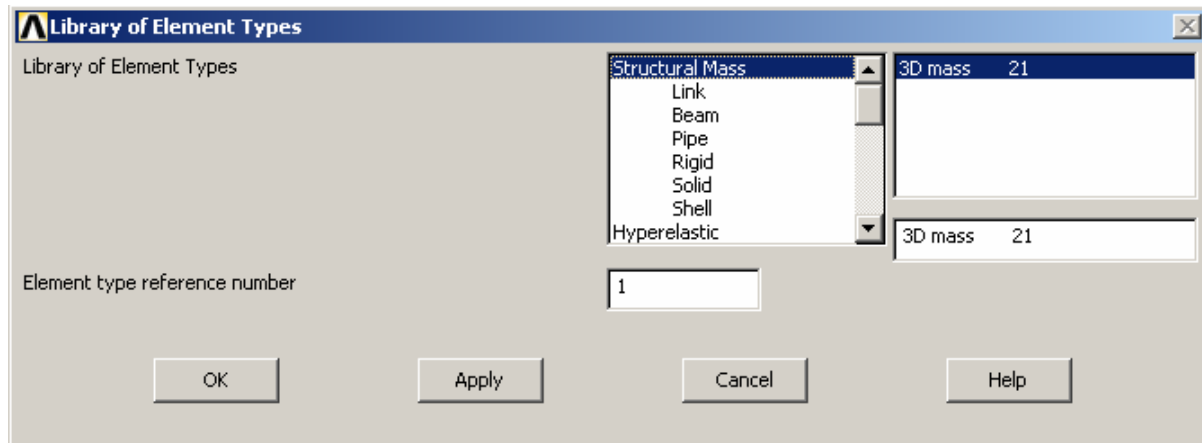
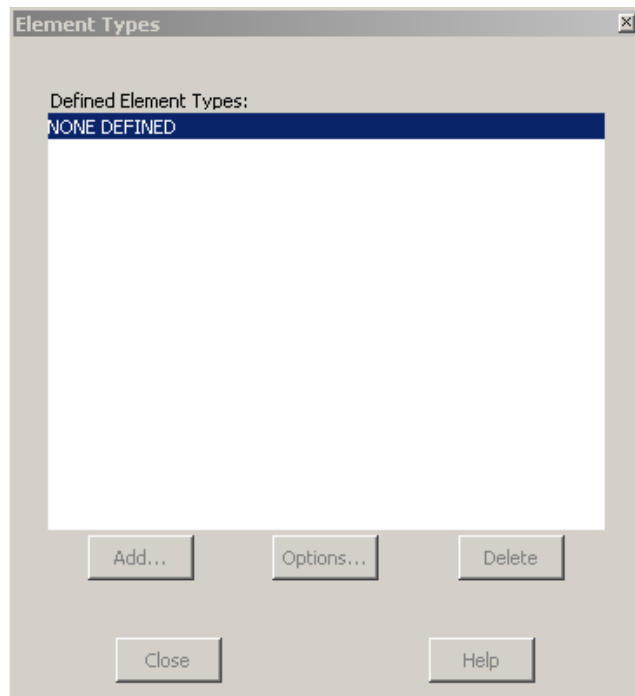
$$\nu = 0,3$$

$$I_{zz}=I_{yy}=171\text{ cm}^4$$



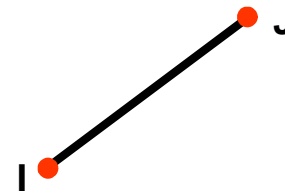
SELECCIÓN DEL TIPO DE ANÁLISIS Y DEL TIPO DE ELEMENTO

Preferences → **Structural**, Thermal, ANSYS Fluid...
Preprocessor → Element Type → Add/Edit/Delete

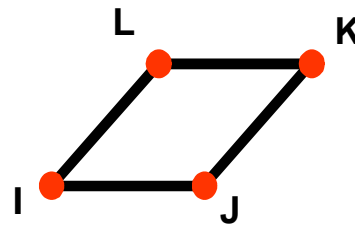


TIPOS DE ELEMENTOS

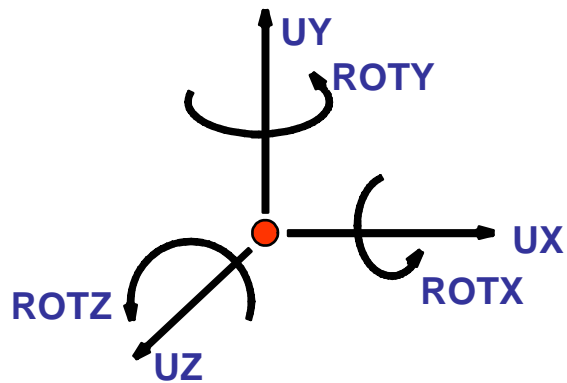
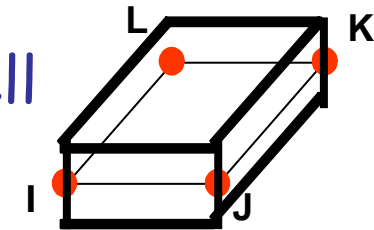
Elemento finito :
 (T, P_T, Σ_T)



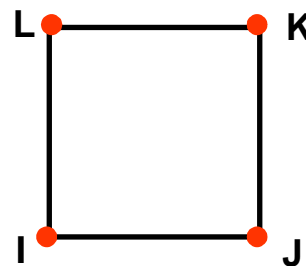
Structural Beam
2D, 3D



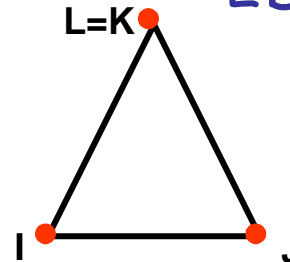
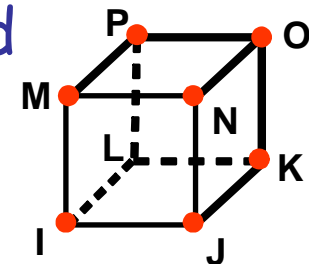
Structural Shell
2D, 3D



GDL estructurales



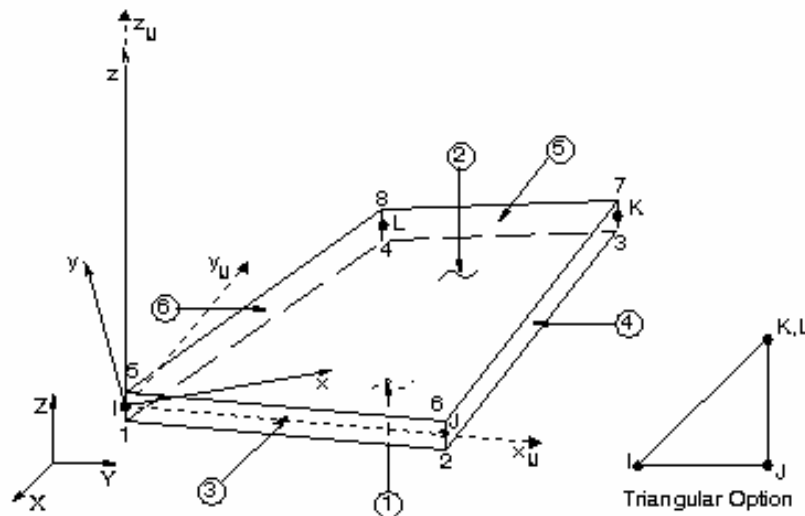
Structural Solid
2D, 3D



AYUDA: LIBRERÍA DE ELEMENTOS



Figure 63.1. SHELL63 Elastic Shell



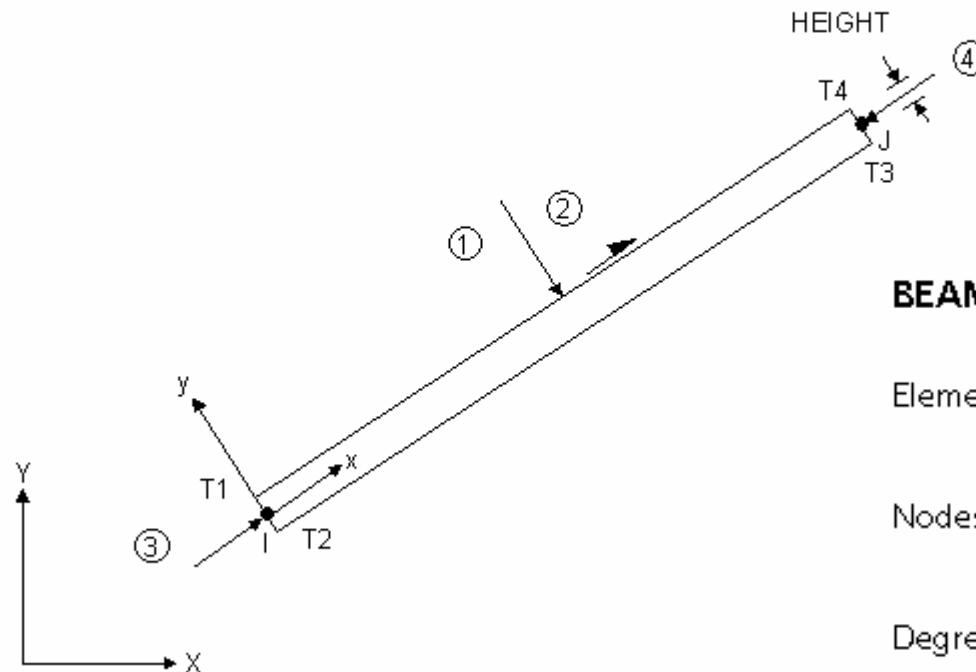
x_{ij} = Element x -axis if ESYS is not supplied.
 x = Element x -axis if ESYS is supplied.

SHELL63 Input Summary

- Element Name
SHELL63
- Nodes
I, J, K, L
- Degrees of Freedom
UX, UY, UZ, ROTX, ROTY, ROTZ
- Real Constants
TK(I), TK(J), TK(K), TK(L), EFS, THETA, RMI, CTOP, CBOT,
(Blank), (Blank), (Blank), (Blank), (Blank), (Blank), (Blank), (Blank), (Blank), ADMSUA
- Material Properties
EX, EY, EZ, (PRXY, PRYZ, PRXZ or NUXY, NUYZ, NUXZ), ALPX, ALPY, ALPZ, DENS, GXY, DAMP
- Surface Loads
Pressures --
face 1 (I-J-K-L)(bottom, in +Z direction), face 2 (I-J-K-L)(top, in -Z direction), face
- Body Loads
Temperatures --
T1, T2, T3, T4, T5, T6, T7, T8
- Special Features
Stress stiffening, Large deflection, Birth and death

AYUDA: ELEMENTO DEL EJEMPLO

Figure 3.1. BEAM3 2-D Elastic Beam



BEAM3 Input Summary

Element Name

BEAM3

Nodes

I, J

Degrees of Freedom

UX, UY, ROTZ

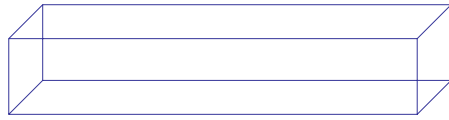
Real Constants

AREA, IZZ, HEIGHT, SHEARZ, ISTRN, ADDMAS

Material Properties

EX, ALPX, DENS, GXY, DAMP

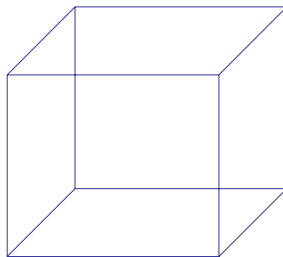
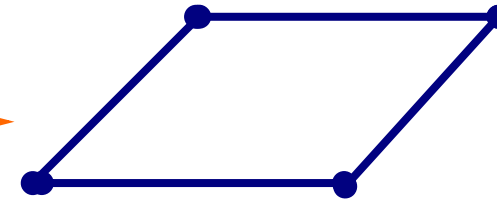
CONSTANTES REALES



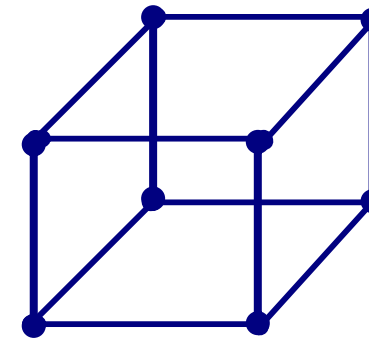
Barra



Placa

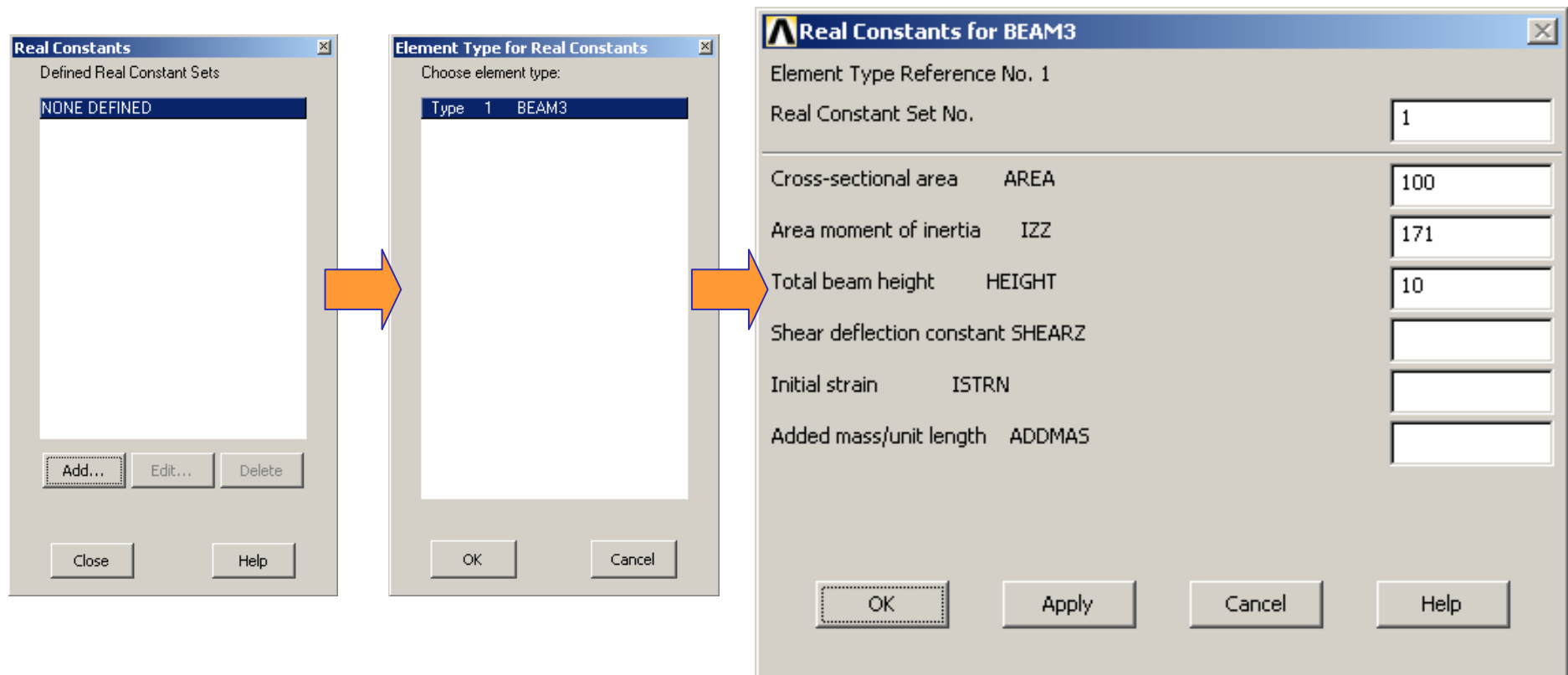


Volumen



CONSTANTES REALES

Preprocessor → Real Constants → Add/Edit/Delete



ELECCIÓN DEL MATERIAL

Preprocessor → Material Props → Material Models

- [-] **Material Props**
- [+] **Material Library**
- Temperature Units
- Material Models
- Convert ALPx
- Change Mat Num
- [+] **Failure Criteria**
- Write to File
- Read from File

The image shows two overlapping dialog boxes from the ANSYS software. The background dialog is 'Define Material Model Behavior', which has two panes: 'Material Models Defined' (containing 'Material Model Number 1') and 'Material Models Available'. The 'Material Models Available' pane is expanded to show 'Structural' > 'Linear' > 'Elastic' > 'Isotropic'. The foreground dialog is 'Linear Isotropic Properties for Material Number 1', which contains a table for material properties:

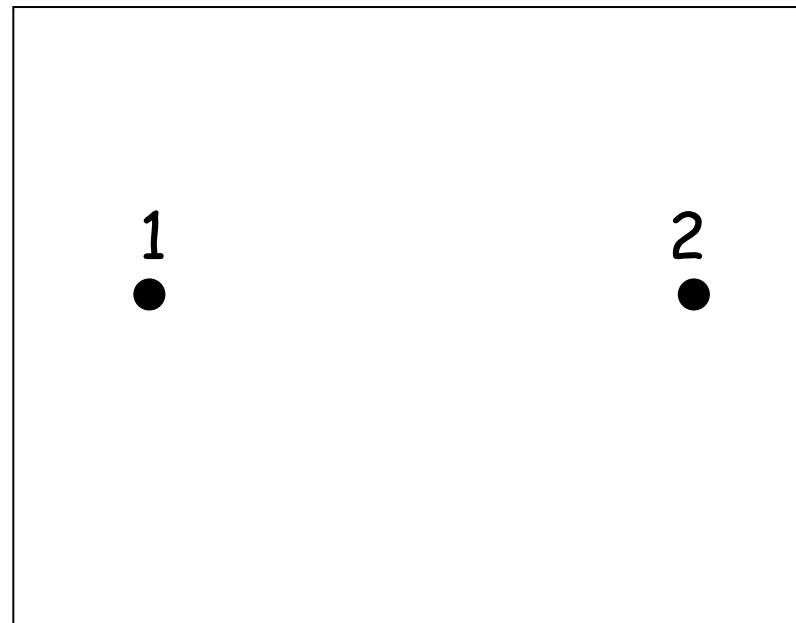
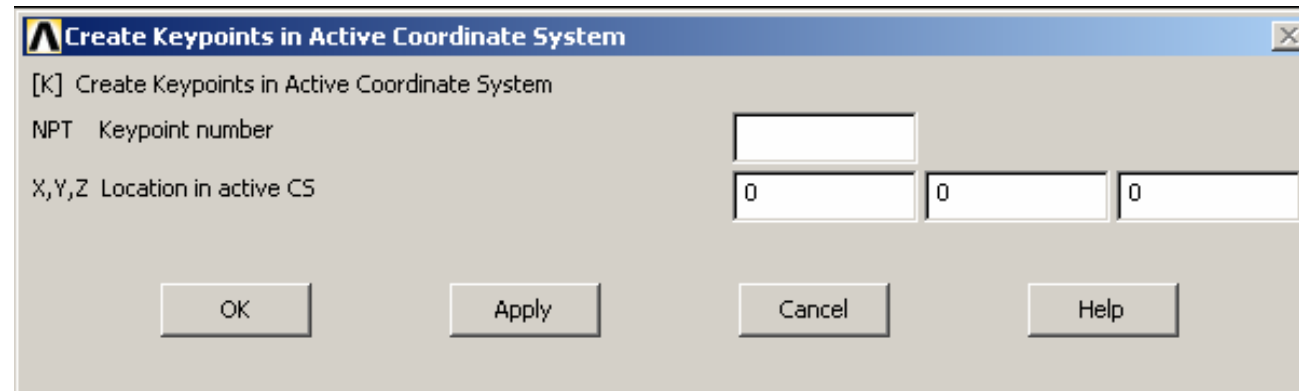
T1	
Temperatures	
EX	2.1e6
PRXY	0.3

Buttons at the bottom of the foreground dialog include 'Add Temperature', 'Delete Temperature', 'Graph', 'OK', 'Cancel', and 'Help'. Orange arrows point from the 'Material Library' menu item to the 'Define Material Model Behavior' dialog, and from the 'Isotropic' option in the 'Material Models Available' list to the foreground dialog.

Modeling

- [-] Create
 - [-] Keypoints
 - On Working Plane
 - In Active CS
 - On Line
 - On Line w/Ratio
 - On Node
 - KP between KPs
 - Fill between KPs
 - ⊕ KP at center
 - ⊕ Hard PT on line
 - ⊕ Hard PT on area
 - ⊕ Lines
 - ⊕ Areas
 - ⊕ Volumes
 - ⊕ Nodes
 - ⊕ Elements
 - Contact Pair
 - ⊕ Piping Models
 - ⊕ Transducers
- ⊕ Operate
 - ⊕ Move / Modify
 - ⊕ Copy
 - ⊕ Reflect
 - ⊕ Check Geom
 - ⊕ Delete
 - ⊕ Cyclic Sector
 - Genl plane strn
 - Update Geom

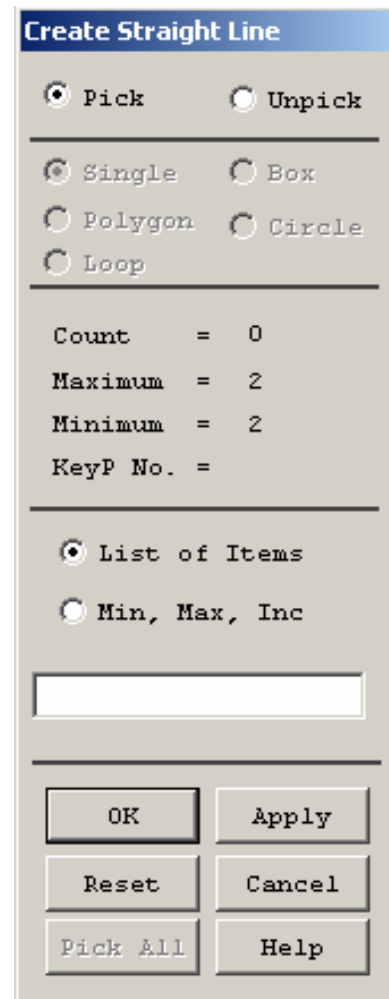
GENERACIÓN DE LA GEOMETRÍA: PUNTOS



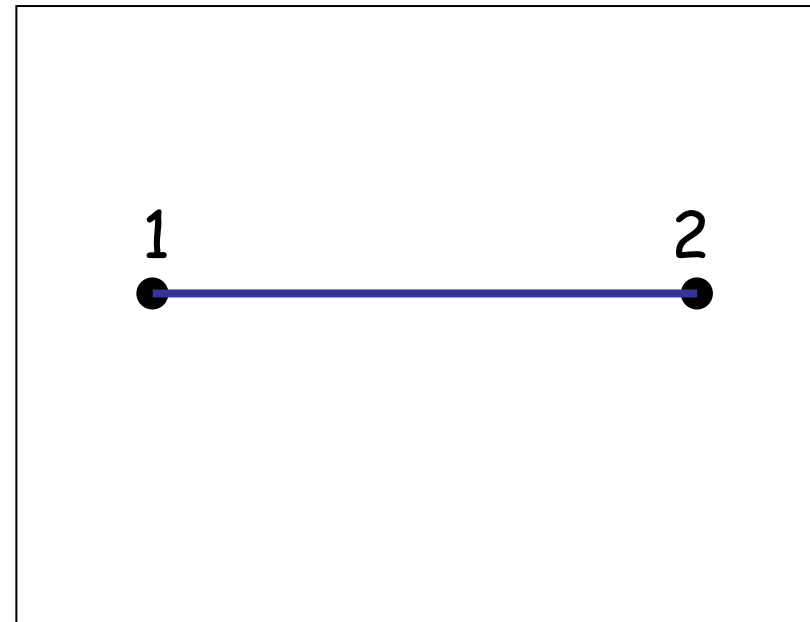
Modeling

- [-] Create
 - [+] Keypoints
 - [-] Lines
 - [-] Lines
 - [>] Straight Line
 - [>] In Active Coord
 - [>] Overlaid on Area
 - [>] Tangent to Line
 - [>] Tan to 2 Lines
 - [>] Normal to Line
 - [>] Norm to 2 Lines
 - [>] At angle to line
 - [>] Angle to 2 Lines
 - [+] Arcs
 - [+] Splines
 - [>] Line Fillet
 - [+] Areas
 - [+] Volumes
 - [+] Nodes
 - [+] Elements
 - [+] Contact Pair
 - [+] Piping Models
 - [+] Transducers
- [+] Operate
 - [+] Move / Modify
 - [+] Copy
 - [+] Reflect
 - [+] Check Geom
 - [+] Delete
 - [+] Cyclic Sector
 - [+] Genl plane strn
 - [+] Update Geom

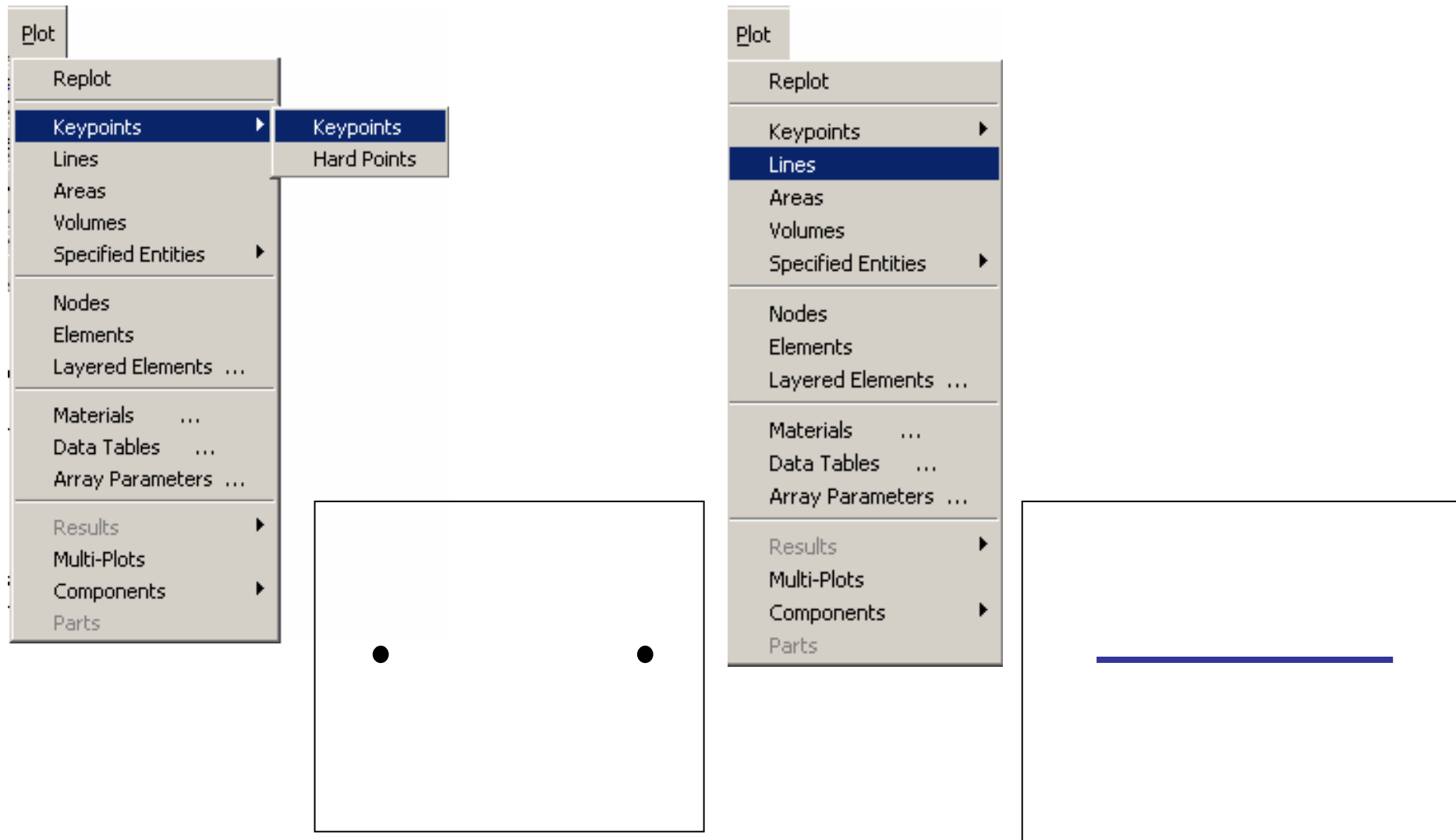
GENERACIÓN DE LA GEOMETRÍA: LÍNEAS



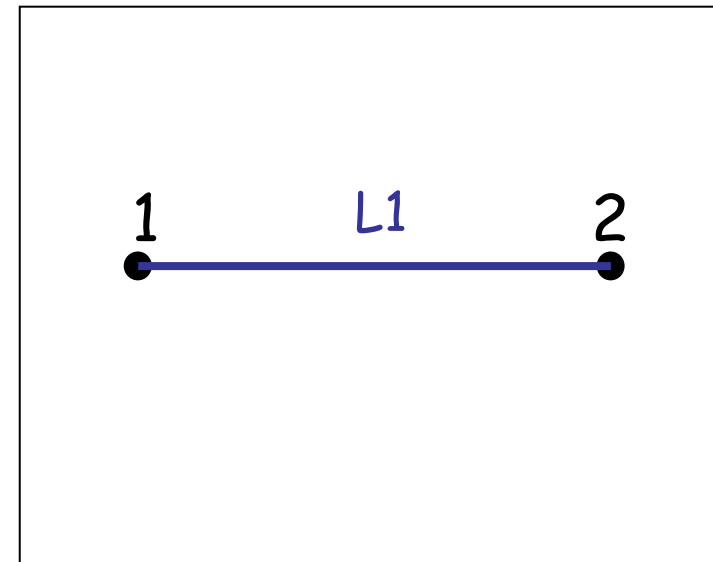
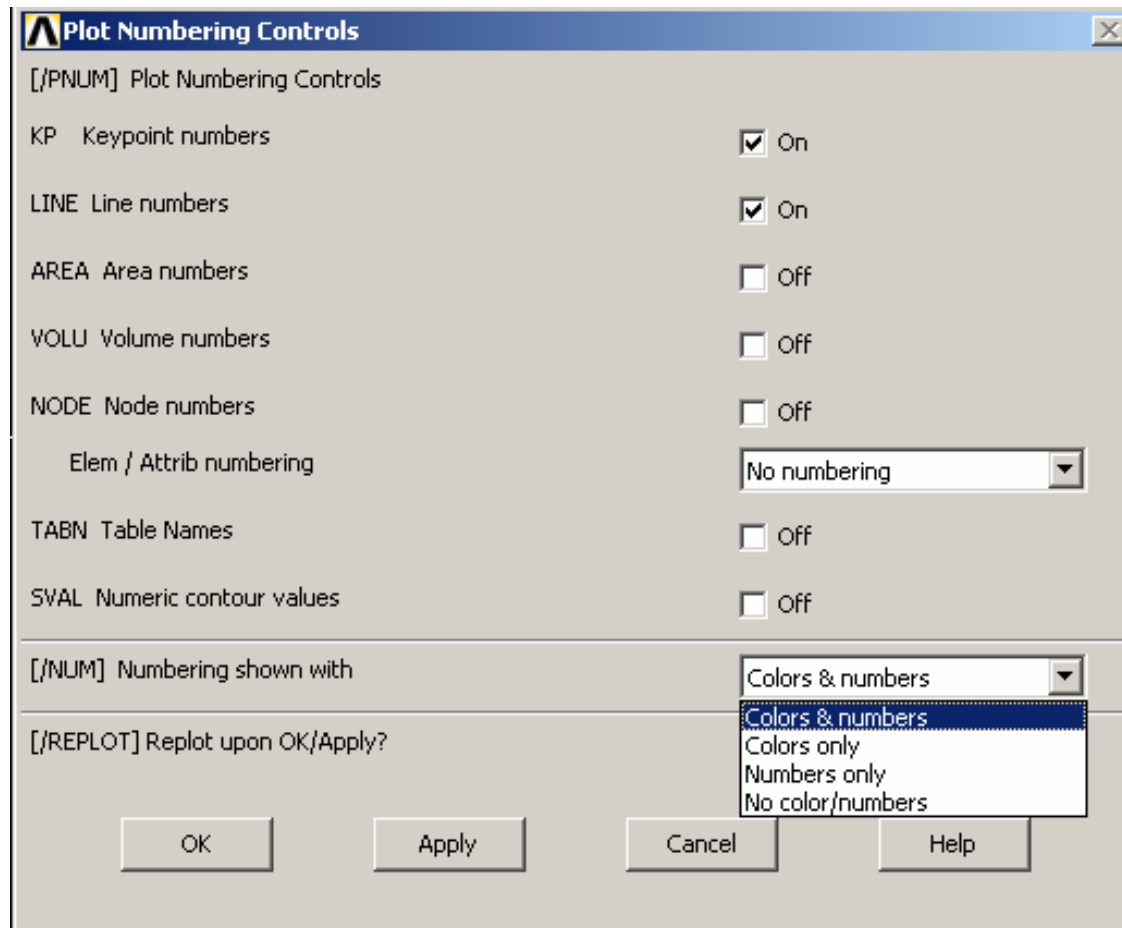
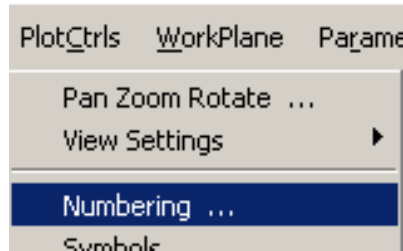
Cursor:
Seleccionar: ↑
Deseleccionar: ↓
(Alternar: Botón dcho. Del ratón)



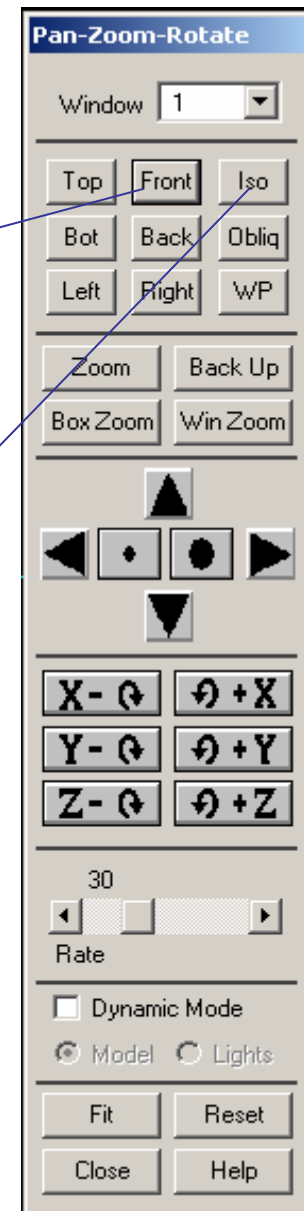
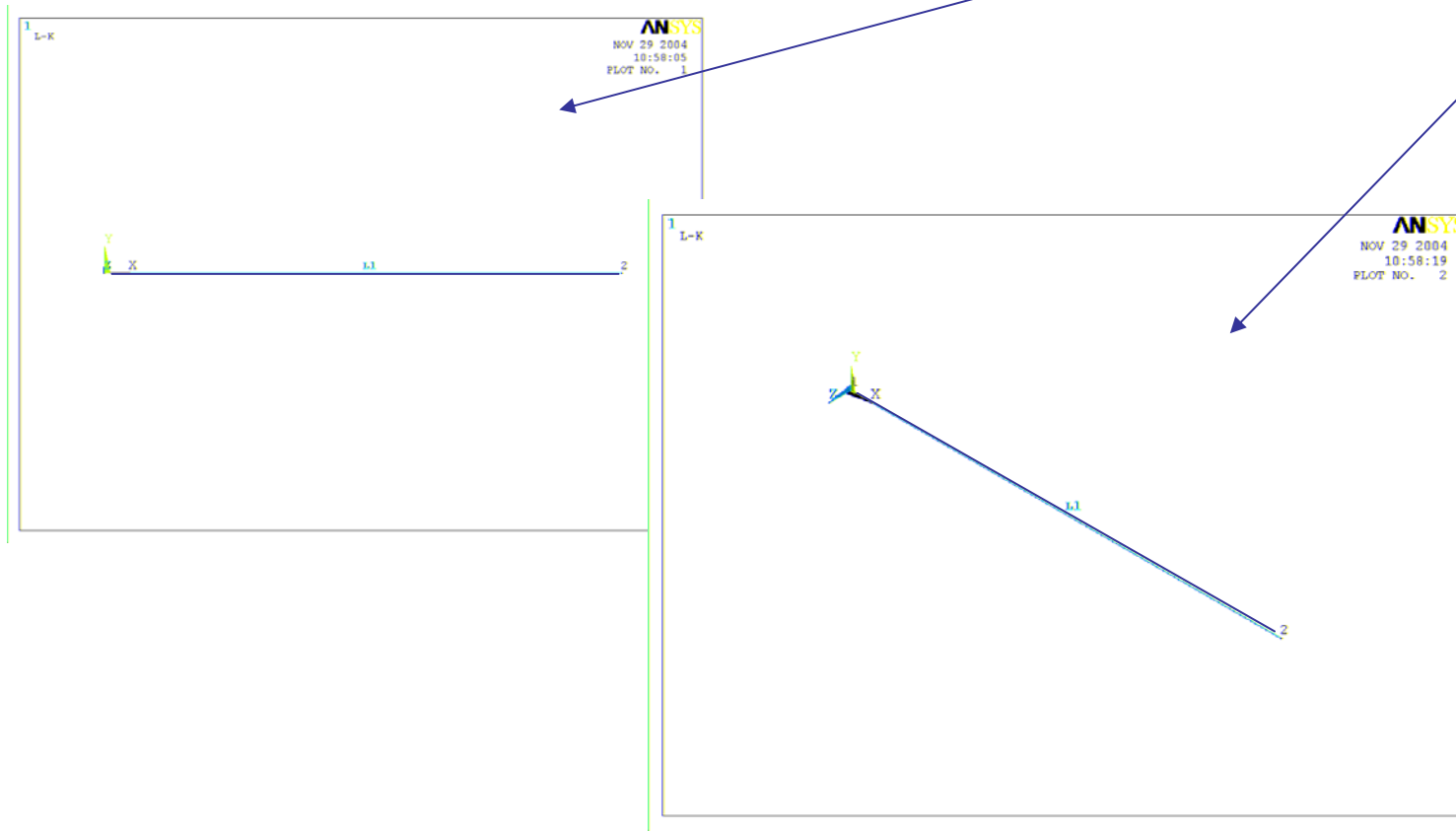
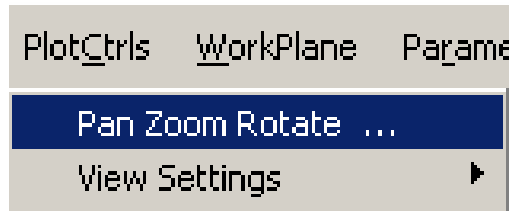
OPCIONES DE VISUALIZACIÓN



OPCIONES DE VISUALIZACIÓN



OPCIONES DE VISUALIZACIÓN



ELIMINAR ENTIDADES

- [-] Modeling
 - [+] Create
 - [+] Operate
 - [+] Move / Modify
 - [+] Copy
 - [+] Reflect
 - [+] Check Geom
 - [-] Delete
 - Keypoints
 - Hard Points
 - **Lines Only**
 - Line and Below
 - Areas Only
 - Area and Below
 - Volumes Only
 - Volume and Below
 - Nodes
 - Elements
 - Pre-tens Elemnts
 - [+] Del Concats
 - [+] Cyclic Sector
 - [+] Genl plane strn
 - [+] Update Geom

Delete Lines Only

Pick Unpick

Single Box
 Polygon Circle
 Loop

Count = 0

Maximum = 1

Minimum = 1

Line No. =

List of Items
 Min, Max, Inc

- Preferences
- Preprocessor
 - Element Type
 - Real Constants
 - Material Props
 - Sections
 - Modeling
 - Meshing
 - Mesh Attributes
 - MeshTool
 - Size Cntrls
 - Mesher Opts
 - Concatenate
 - Mesh
 - Modify Mesh
 - Check Mesh
 - Clear

MeshTool

Element Attributes:
Global [v] Set

Smart Size

Fine 6 Coarse

Size Controls:
Global [Set] [Clear] →
Areas [Set] [Clear]
Lines [Set] [Clear]
[Copy] [Flip]
Layer [Set] [Clear]
Keypnts [Set] [Clear]

Mesh: Lines [v]
Shape: Radio1 Hex/Wedge
 Free Mapped Sweep
3 or 4 sided [v]
[Mesh] [Clear] →

Refine at: Elements [v]
[Refine]

[Close] [Help]

MALLADO

Global Element Sizes

[ESIZE] Global element sizes and divisions (applies only to "unsized" lines)

SIZE Element edge length [0]

NDIV No. of element divisions - [10]
- (used only if element edge length, SIZE, is blank or zero)

[OK] [Cancel] [Help]

Mesh Lines

Pick Unpick

Single Box
 Polygon Circle
 Loop

Count = 1
Maximum = 1
Minimum = 1
Line No. = 1

List of Items
 Min, Max, Inc

[OK] [Apply]
[Reset] [Cancel]
[Pick All] [Help]

Plot - Elements



CONDICIONES DE CONTORNO

- Preferences
- Preprocessor
- Solution
 - Analysis Type
 - Define Loads
 - Settings
 - Apply
 - Structural
 - Displacement**
 - On Lines
 - On Areas
 - On Keypoints
 - On Nodes
 - On Node Components
 - Symmetry B.C.
 - Antisymm B.C.
 - Force/Moment
 - Pressure
 - Temperature
 - Inertia
 - Pretnsn Sectn
 - Gen Plane Strain
 - Other
 - Initial Condit'n
 - Load Vector
 - Functions
 - Delete
 - Operate
- Load Step Opts
- Solve
- FSI Set Up
- ADAMS Connection
- Unabridged Menu

Apply U,ROT on KPs

Pick Unpick

Single Box
 Polygon Circle
 Loop

Count = 0
Maximum = 2
Minimum = 1
KeyP No. =

List of Items
 Min, Max, Inc

Apply U,ROT on KPs

[DK] Apply Displacements (U,ROT) on Keypoints

Lab2 DOFs to be constrained

UX
 UY
 ROTZ

Apply as:

If Constant value then:
 VALUE Displacement value

KEXPND Expand disp to nodes? No

CONDICIONES DE CONTORNO

- Preferences
- Preprocessor
- Solution
 - Analysis Type
 - Define Loads
 - Settings
 - Apply
 - Structural
 - Displacement**
 - On Lines
 - On Areas
 - On Keypoints
 - On Nodes
 - On Node Components
 - Symmetry B.C.
 - Antisymm B.C.
 - Force/Moment
 - Pressure
 - Temperature
 - Inertia
 - Pretnsn Sectn
 - Gen Plane Strain
 - Other
 - Initial Condit'n
 - Load Vector
 - Functions
 - Delete
 - Operate
- Load Step Opts
- Solve
- FSI Set Up
- ADAMS Connection
- Unabridged Menu

Apply U,ROT on KPs

Pick Unpick

Single Box

Polygon Circle

Loop

Count = 0

Maximum = 2

Minimum = 1

KeyP No. =

List of Items

Min, Max, Inc

OK Apply

Reset Cancel

Pick All Help

Apply U,ROT on KPs

[DK] Apply Displacements (U,ROT) on Keypoints

Lab2 DOFs to be constrained

All DOF
UX
UY
ROTZ

Apply as Constant value

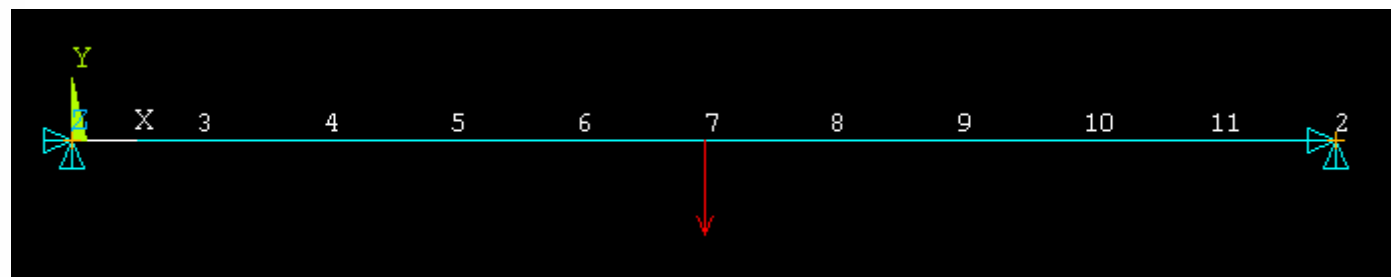
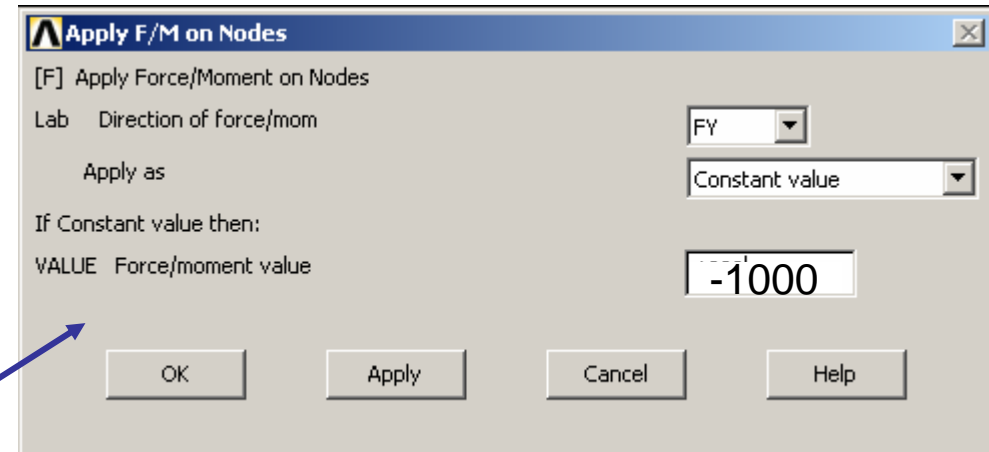
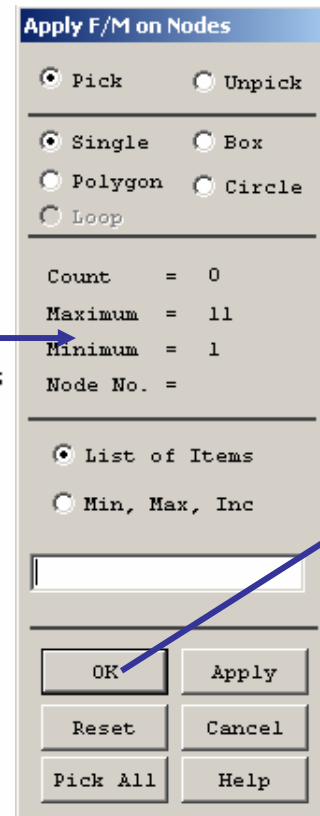
If Constant value then:
VALUE Displacement value

KEXPND Expand disp to nodes? No

OK Apply Cancel Help

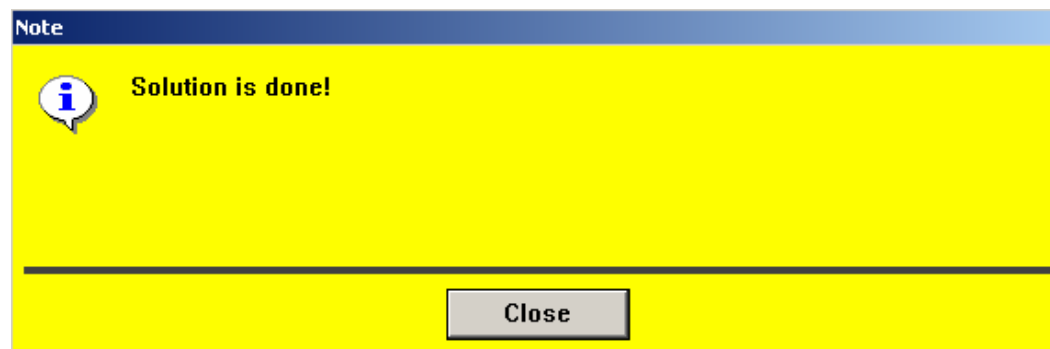
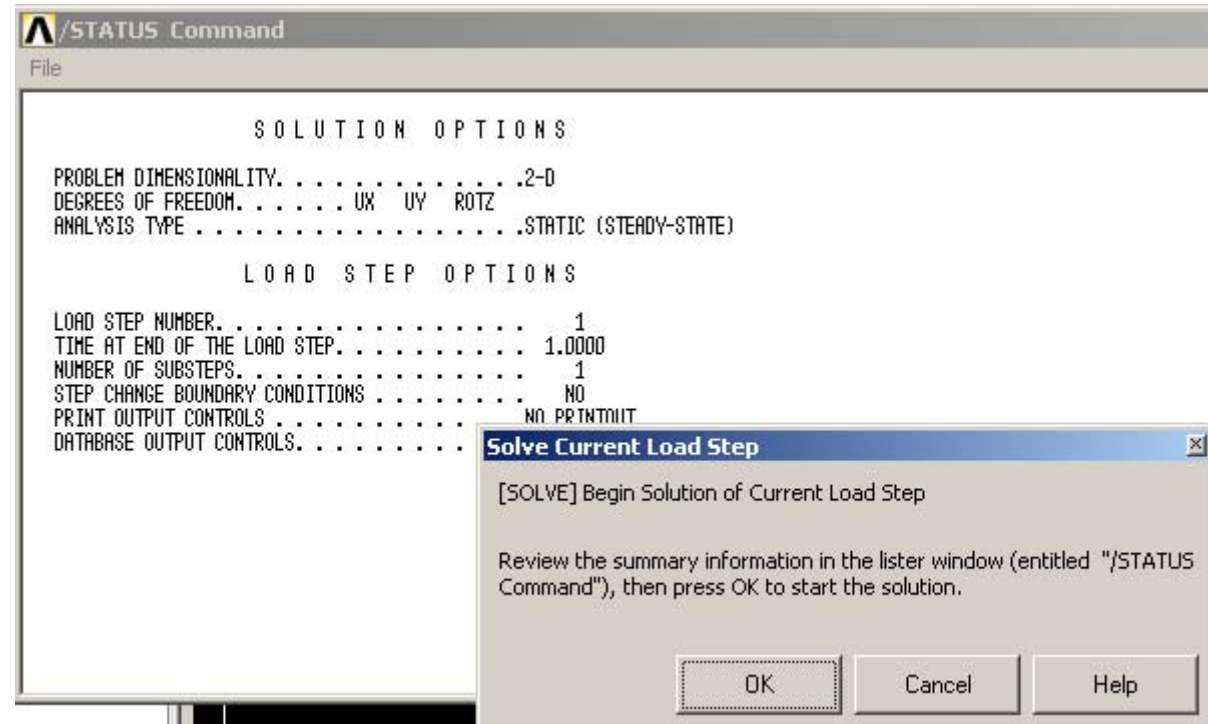
APLICACIÓN DE FUERZAS

- Preferences
- Preprocessor
- Solution
 - Analysis Type
 - Define Loads
 - Settings
 - Apply
 - Structural
 - Displacement
 - Force/Moment
 - On Keypoints
 - On Nodes
 - On Node Components
 - From Reactions
 - From Mag Analy
 - Pressure
 - Temperature
 - Inertia
 - Pretnsn Sectn
 - Gen Plane Strain
 - Other
 - Initial Condit'n
 - Load Vector
 - Functions
 - Delete
 - Operate
 - Load Step Opts
 - Solve
 - FSI Set Up
 - ADAMS Connection
 - Unabridged Menu



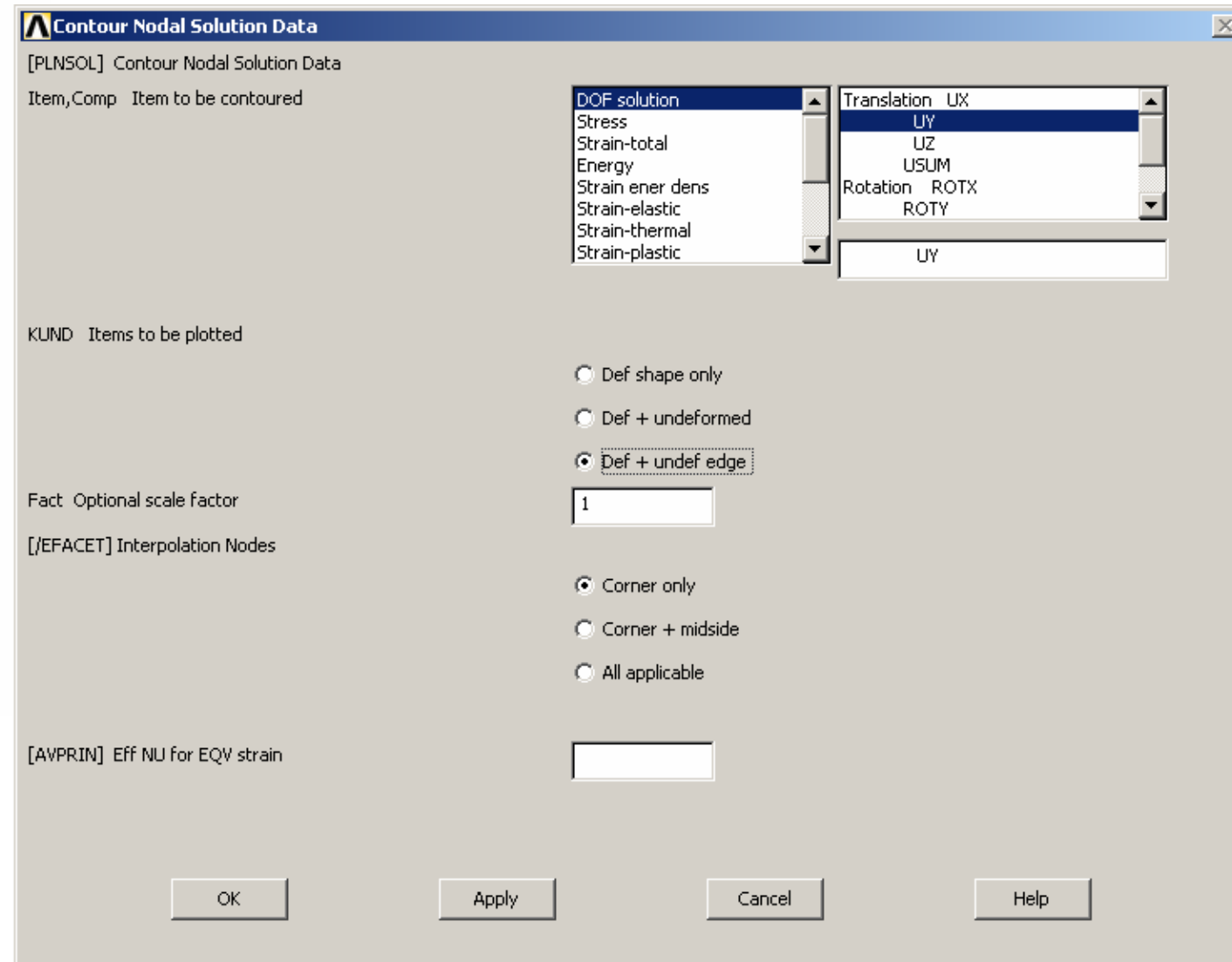
RESOLUCIÓN

- ☰ Preferences
- + Preprocessor
- Solution
 - + Analysis Type
 - + Define Loads
 - + Load Step Opts
 - Solve
 - ☰ Current LS
 - ☰ From LS Files
 - ☰ Partial Solu
 - + FSI Set Up
 - + ADAMS Connection
 - ☰ Unabridged Menu



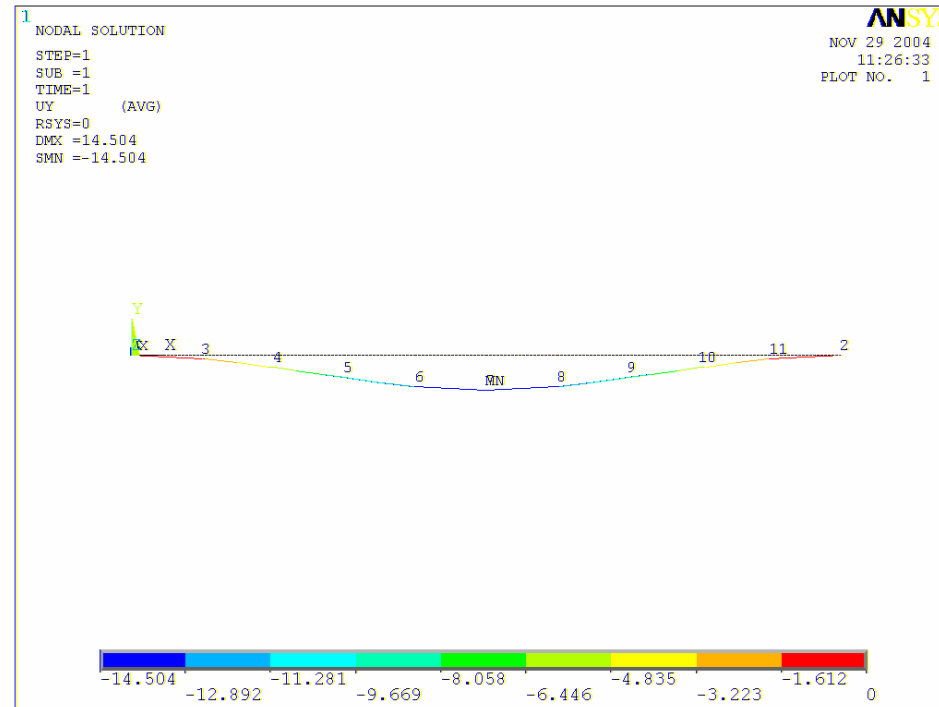
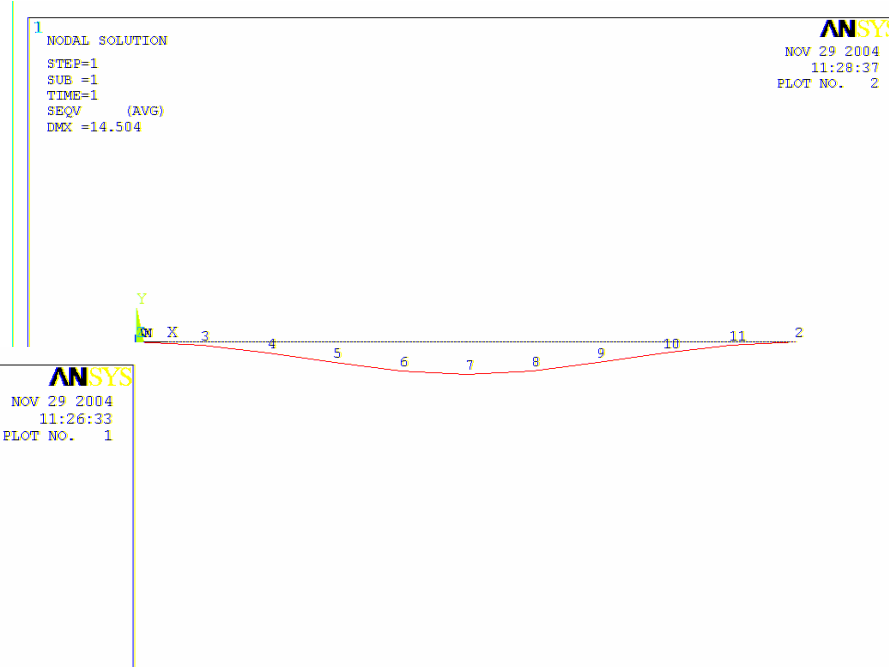
VISUALIZACIÓN DE RESULTADOS

- ☰ Preferences
- + Preprocessor
- + Solution
- ☰ General Postproc
 - ☰ Data & File Opts
 - ☰ Results Summary
 - + Read Results
 - + Failure Criteria
 - ☰ Plot Results
 - ☰ Deformed Shape
 - ☰ Contour Plot
 - ☰ Nodal Solu
 - ☰ Element Solu
 - ☰ Elem Table
 - ☰ Line Elem Res
 - + Vector Plot
 - + Plot Path Item
 - + Concrete Plot
 - + List Results
 - + Query Results



VISUALIZACIÓN DE RESULTADOS

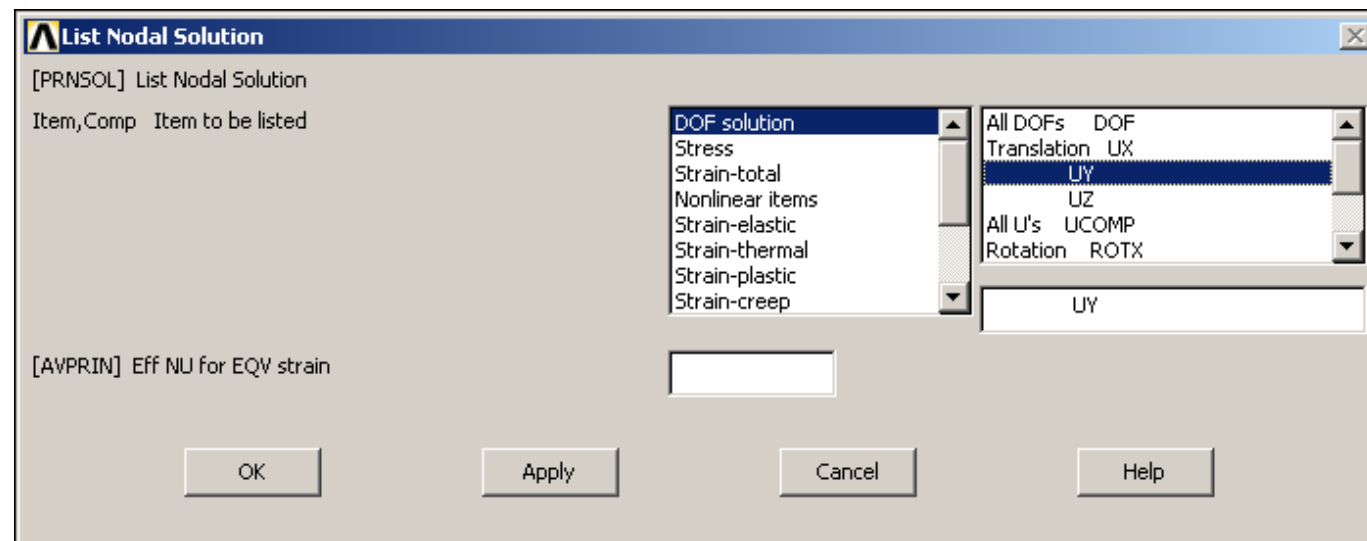
UY



TENSIÓN VM

VISUALIZACIÓN DE RESULTADOS

- ☰ Preferences
- + Preprocessor
- + Solution
- ☒ General Postproc
 - ☰ Data & File Opts
 - ☰ Results Summary
 - + Read Results
 - + Failure Criteria
 - + Plot Results
 - ☒ List Results
 - ☰ Detailed Summary
 - ☰ Iteration Summary
 - ☰ Percent Error
 - + Sorted Listing
 - ☰ **Nodal Solution**
 - ☰ Element Solution
 - ☰ Section Solution
 - ☰ Superelem DOF
 - ☰ Reaction Solu
 - ☰ Nodal Loads
 - ☰ Elem Table Data
 - ☰ Vector Data
 - ☰ Path Items
 - ☰ Linearized Strs
- + Query Results



VISUALIZACIÓN DE RESULTADOS

UY

```

PRINT U  NODAL SOLUTION PER NODE

***** POST1 NODAL DOF LISTING *****

LOAD STEP= 1 SUBSTEP= 1
TIME= 1.0000  LOAD CASE= 0

THE FOLLOWING DOF RESULTS ARE IN GRAPHICS

NODE   UY
 1  0.0000
 2  0.0000
 3 -1.5084
 4 -5.1054
 5 -9.3985
 6 -12.995
 7 -14.504
 8 -12.995
 9 -9.3985
10 -5.1054
11 -1.5084

MAXIMUM ABSOLUTE VALUES
NODE     7
VALUE -14.504
    
```

```

PRINT S  NODAL SOLUTION PER NODE

***** POST1 NODAL STRESS LISTING *****
PowerGraphics Is Currently Enabled

LOAD STEP= 1 SUBSTEP= 1
TIME= 1.0000  LOAD CASE= 0
NODAL RESULTS ARE FOR MATERIAL 1

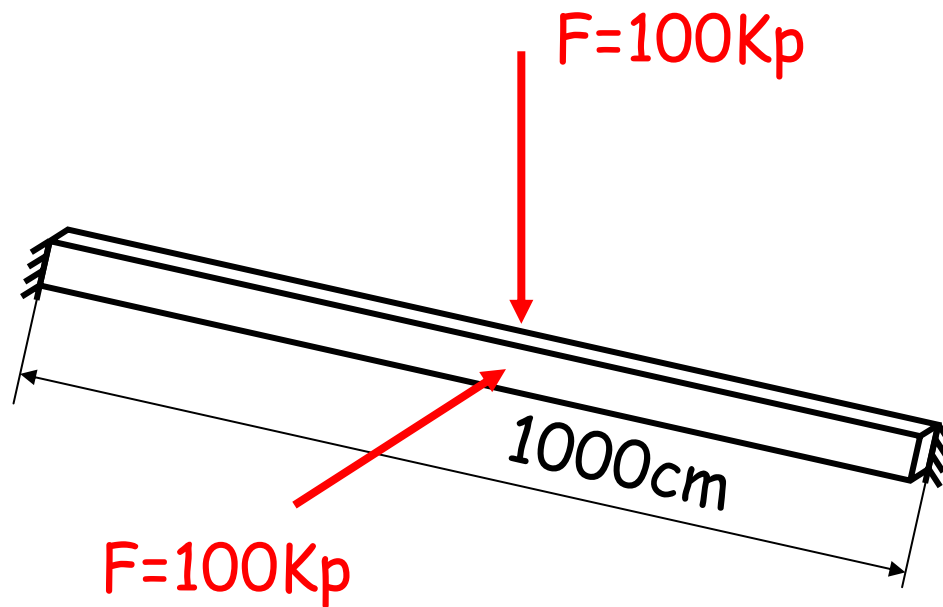
NODE   S1      S2      S3      SINT      SEQV

MINIMUM VALUES
NODE     1      1      1      1      1
VALUE  0.10000E+32 0.10000E+32 0.10000E+32 0.10000E+32 0.10000E+32

MAXIMUM VALUES
NODE     1      1      1      1      1
VALUE -0.10000E+32 -0.10000E+32 -0.10000E+32 -0.10000E+32 -0.10000E+32
    
```

TENSIÓN VM

EJERCICIO



$$E = 2,1E6$$

$$\nu = 0,3$$

$$I_{zz} = I_{yy} = 171 \text{ cm}^4$$

