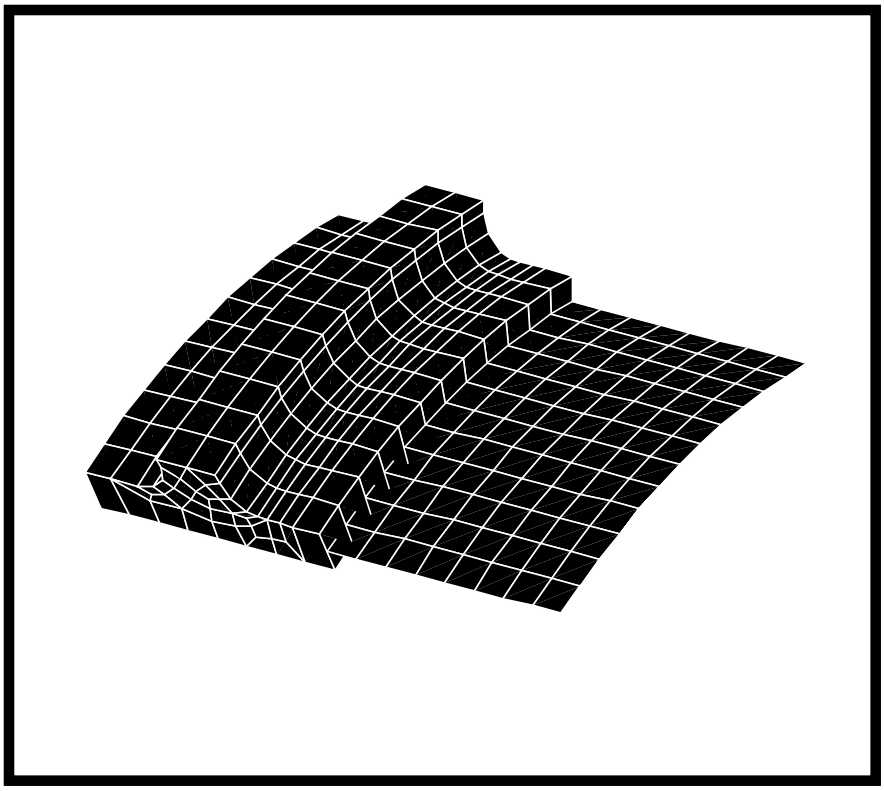
LESSON 9

Finite Element Model



Objectives:

- Build an initial surface mesh that will be used as a pattern to create the final 1, 2 and 3D mesh.
- Edit and smooth the mesh.
- Build a finite element model by sweeping a node, 1D and 2D elements in a 30^{o} arc.

Model Description:

In this lesson you will use the finite element construction method called mesh sweep to create your finite element model. This algorithm is different than the IsoMesh hexahedral mesher because it creates elements by sweeping existing elements, therefore no supporting geometry is required.

Suggested Exercise Steps:

- Open the old database **mpc.db**.
- Create a mesh seed of 3 elements per edge along the fillets, and 1 element per edge at the far right and left edges of the trimmed surface.
- Create a “base mesh” with a global edge length of 0.25 on the trimmed surface and the curve in your model.
- Modify some quads around the fillet on the right and where it is needed by splitting them into 3 smaller quads.
- Equivalence the model and smooth the mesh.
- Sweep the elements defining the base of the model in a 30^{o} arc about the cylindrical coordinate frame, to create 12 layers of hex, quad, and bar elements in the swept direction. Nodes should reference the cylindrical coordinate frame.
- Display the model in Element Fill render style.

Files:

All the files used in this exercise are listed below. Each listing includes the file, where it originated, its format (text/binary) and summary information as to how it relates to this exercise.

File	Supplied/Create	Description
mpc.db	Created in ex2	This is a PATRAN database (binary) created in Exercise 2. The geometry for the model was created in Exercise 2. The mesh for the model is generated in Exercise 6. Finally, multi-point constraints will be created in Exercise 7.

Exercise Procedure:

1. Open the old database **mpc.db.**

2. Create a mesh seed of 3 elements per edge along the fillets, and 1 element per edge at the far right and left edges of the trimmed surface.

Create a Mesh Seed

First, for the fillet curves,

◆ **Finite Elements**

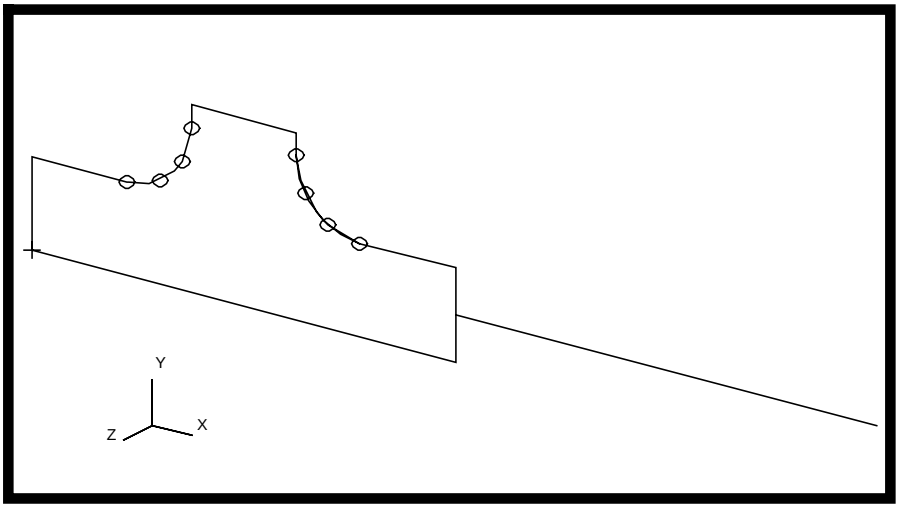
Action:	**Create**
Object:	**Mesh Seed**
Method:	**Uniform**

◆ **Number of Elements**

Number	**3**
Curve List	**Surface 1.4 1.8** (see figure below)

Apply

The current model is shown below.



Next, for the far right and left edges of the trimmed surfaces,

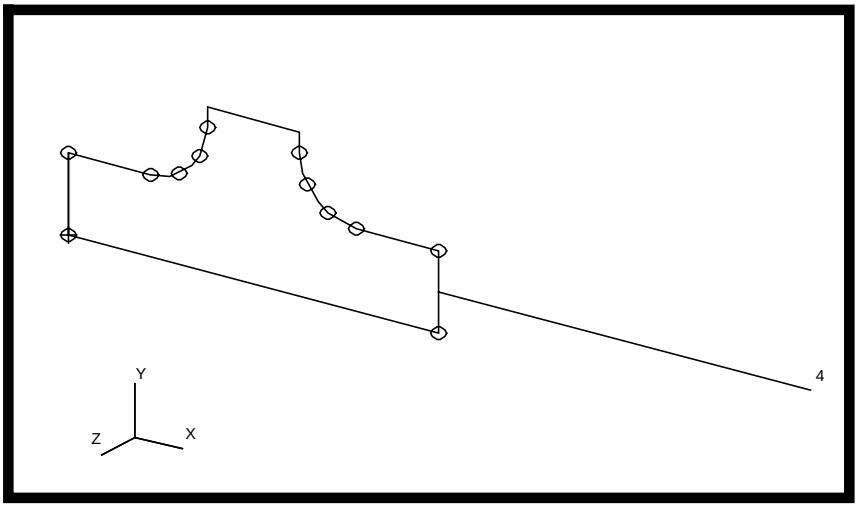
◆ **Number of Elements**

Number **1**

Curve List **Surface 1.2 1.10**

Apply

Your model should look like the one shown below.



Create a "Base" Mesh

3. Create a "base mesh" with a global edge length of 0.25 on the trimmed surface and the curve in your model.

To mesh the surface, enter the following:

◆ **Finite Elements**

Action:	**Create**
Object:	**Mesh**
Method:	**Surface**
Global Edge Length	**0.25**
Element Topology	**Quad4**
Mesher	**Paver**
Surface List	**Surface 1**

Now click the **Node Coordinates Frames** and a *Node Coordinate Frames* Menu will appear on the screen. Change the *Analysis Coordinate Frame* to the cylindrical coordinate frame.

Node Coordinate Frames...

Analysis Coordinate Frame	**coord 1**

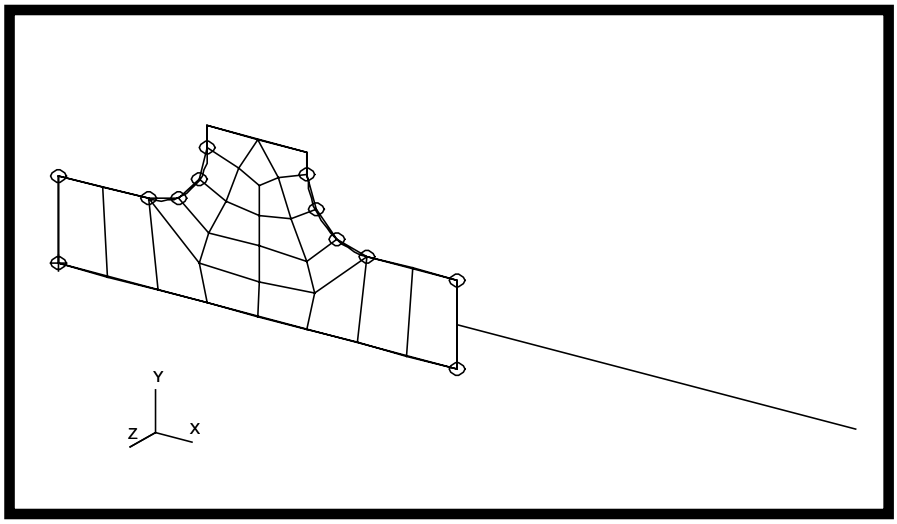
OK

Click **Apply** to create the mesh.

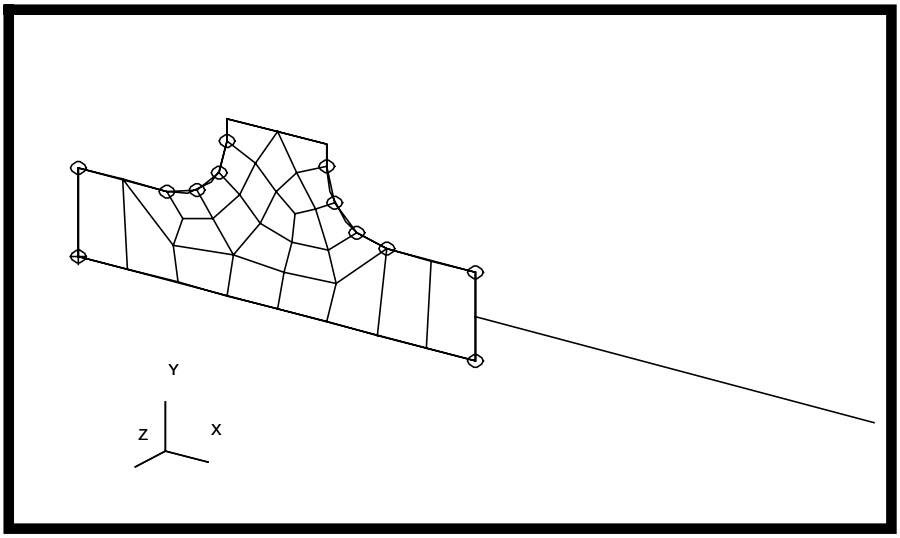
Apply

If you have the labels turned off and geometric display lines set to zero, your model should look like either one of the following:

Model with symmetrical mesh.



Model with unsymmetrical mesh.



Meshing by paver is dependent on a lot of geometric factors such as surface orientation, meshing direction and direction of surface normal etc. Therefore, different meshes may result even using the same meshing techniques.

(For your convenience, we will only show illustration and entity number for the unsymmetrical mesh model.)

Now to mesh the curve, apply the following:

◆ **Finite Elements**

Action:	**Create**
Object:	**Mesh**
Method:	**Curve**
Global Edge Length	**0.25**
Element Topology	**Bar2**
Curve List	**Curve 2**

Apply

Modify Quads

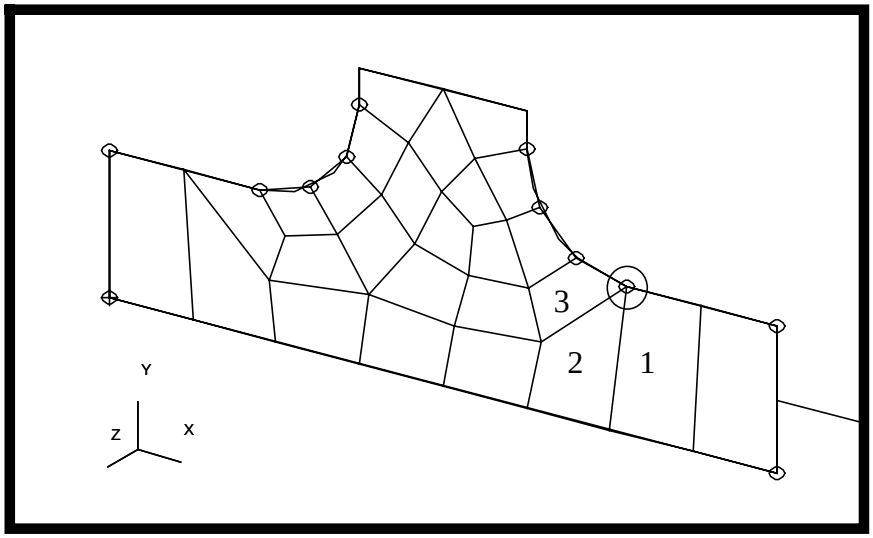
4. Modify some quads around the fillet on the right by splitting them into 3 smaller quads.

◆ **Finite Elements**

Action:	**Modify**
Object:	**Quad**
Method:	**Split**

Select the *Replacement Pattern* with three quads.

Then, screen select the three elements as shown below for the *Quad Element List*.



Quad Element List

Element #'s will differ with each mesh

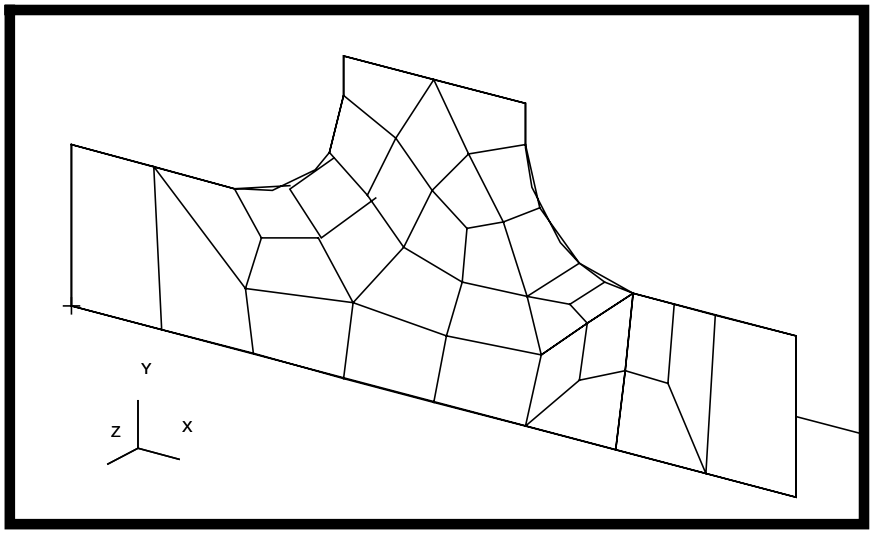
Click in the *Node List* databox and select the upper corner node (as shown above) that is common to these three elements three times.

Node List

Node #'s will differ also

Apply

Your model should appear as follows:



(You may want to apply the above procedure again to modify the quad elements in any other locations, such as the left side of the model shown above. It should be noted, that doing so may change the later node and element numbering.)

Equivalence and Smooth the Mesh

5. Equivalence the model and smooth the mesh.

First, to equivalence, perform the following:

◆ **Finite Elements**

Action:	**Equivalence**
Object:	**All**
Method:	**Tolerance Cube**

Apply

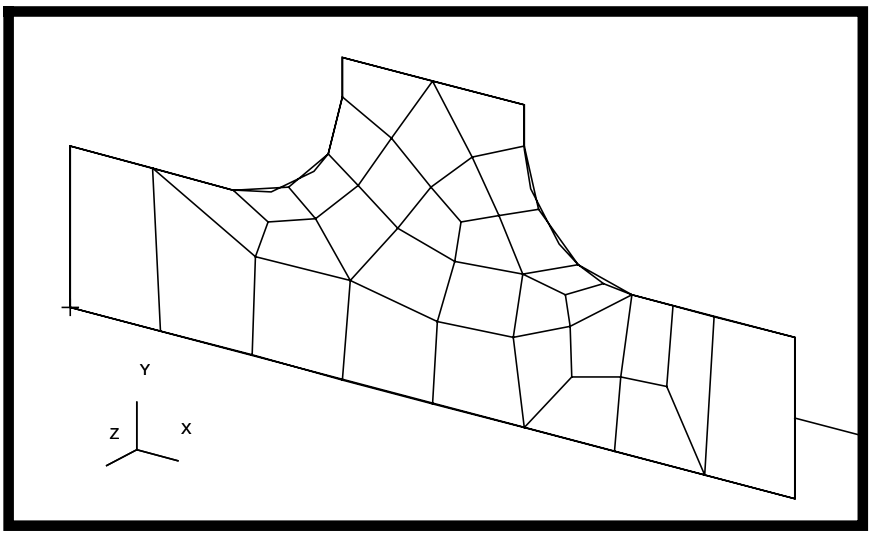
Then, to perform the mesh smoothing operation:

◆ **Finite Elements**

Action:	**Modify**
Object:	**Mesh**
Method:	**Surface**
Surface List	**Surface 1**

Apply

Your model should appear as shown below.



6. Sweep the elements defining the base of the model in a 30^o arc about the cylindrical coordinate frame, to create 12 layers of hex, quad, and bar elements. Nodes should reference the cylindrical coordinate frame.

Sweep Elements (Uniform Thickness)

◆ **Finite Elements**

Action: **Sweep**

Object: **Element**

Method: **Arc**

The *Mesh Control* form should automatically display. If it does not, then click on the **Mesh Control…** button. Enter the following in this menu:

Mesh Control

Method: **Uniform**

◆ **Number of Elements**

Number **12**

OK

Click on the **FE Parameters…** button. On the *Sweep FEM Parameters* form, you need to change the *Analysis Coordinate Frame* to the cylindrical coordinate frame, **Coord 1**.

FE Parameters

Analysis Coordinate Frame **coord 1**

OK

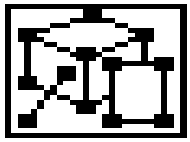
On the *Finite Elements* form, change the *Refer. Coordinate Frame* to **Coord 1** and then enter the *Axis* and *Sweep Angle* as follow:

Refer. Coordinate Frame **coord 1**

Axis **{[0 0 0][0 0 1]}**

Sweep Angle **30.0**

Click in the *Base Entity List* databox. On the *Select* Menu that appears, select the icon shown below to allow the selection of finite elements.



Now in that Select Menu select the icon for node,

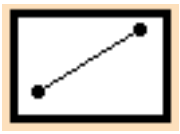
sweep your point element at the end of **Curve 2,** deleting the original element.

■ **Delete Original Elements**

Base Entity List **Node 48**

Apply

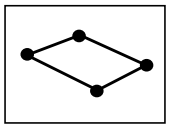
Next select the icon for **beam elements** and sweep the original bar elements along **Curve2.**



Base Entity List **Elm 27:34**

Apply

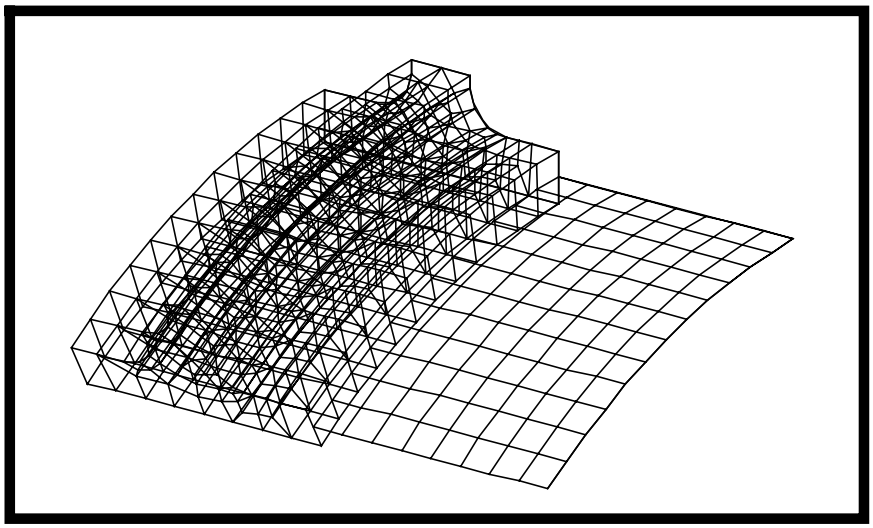
Finally, select and sweep the quad elements on **Surface 1** using the following icon for **quad element**.



Base Entity List **Elm 1:6 8:19 22:26 35:43**

Apply

The model should appear as shown below.



7. Equivalence the model.

◆ **Finite Elements**

Action: **Equivalence**

Object: **All**

Method: **Tolerance Cube**

Apply

8. Display the model in **Element Fill** Style.

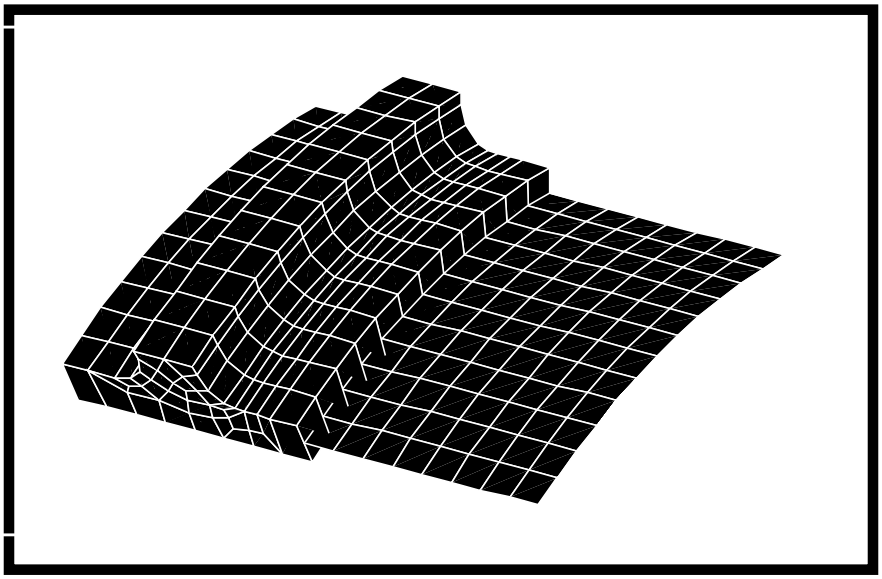
Display/Entity Color/Label/Render...

Render Style: **Hidden Line**

Hide All Entity Labels

Apply

Your model should appear as the one shown below.



Reset the *Render Style* back to **Wireframe**.

Render Style: **Wireframe**

Apply

Cancel

Close the database and quit PATRAN to complete this exercise.

File/Quit