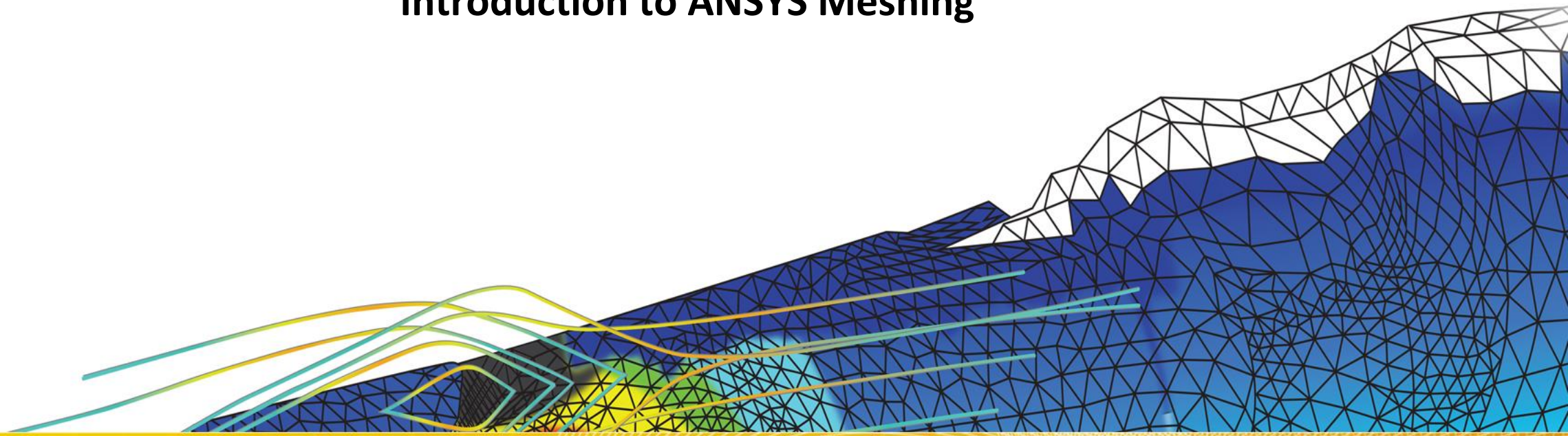
Realize Your Product Promise®

17.0 Release

ANSYS®

Tutorial 8: Local Mesh Controls

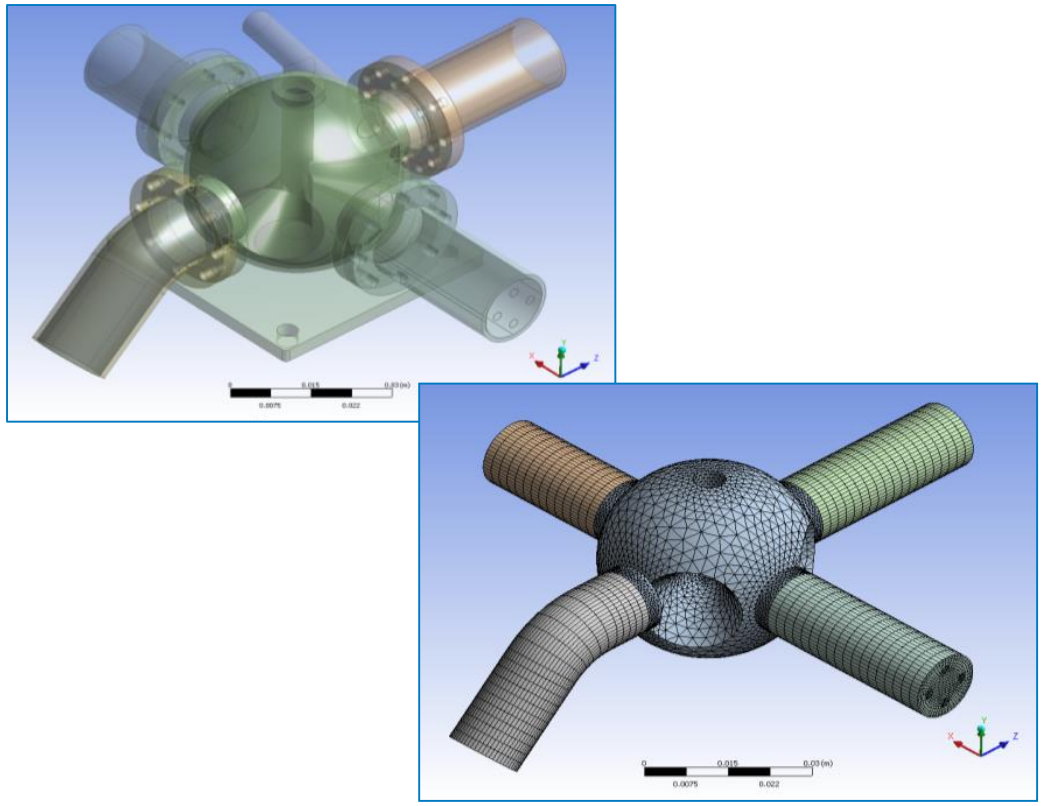
Introduction to ANSYS Meshing



Introduction

Background

- **This workshop will demonstrate how multiple methods and local controls can be combined to create a conformal hybrid mesh on a multibody part (valve geometry)**



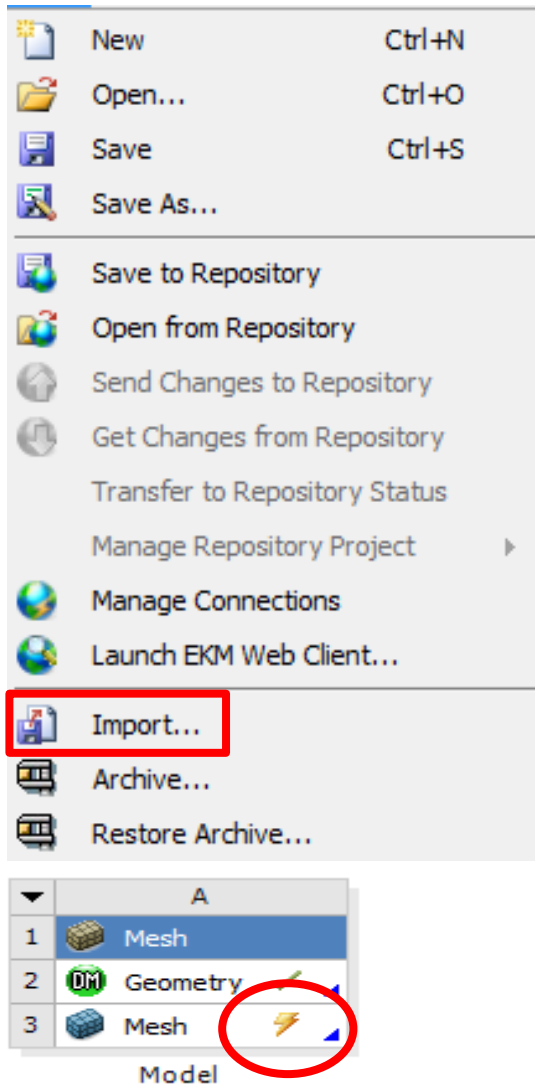
Objectives

- **Methods**
  - MultiZone, Sweep, Patch conforming Tetrahedrons
- **Local Sizing**
  - Edge & Face
- **Local Inflation**
- **Selective Meshing**

Starting Workbench

Create the Workbench Project:

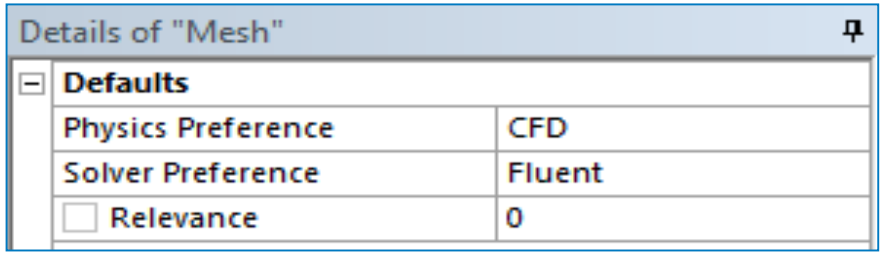
- **From the Workbench File Menu, select Import and browse to the file “valve.meshdat” located in the Meshing Workshops Input-Files folder and open it**
- **Drag a Mesh Component System and drop on Cell A2 of the Geometry System as shown**
  - This will attach the Mesh Component System to the Geometry System
- **Start ANSYS Meshing by double clicking on the Mesh Cell (A3) of the Mesh System**

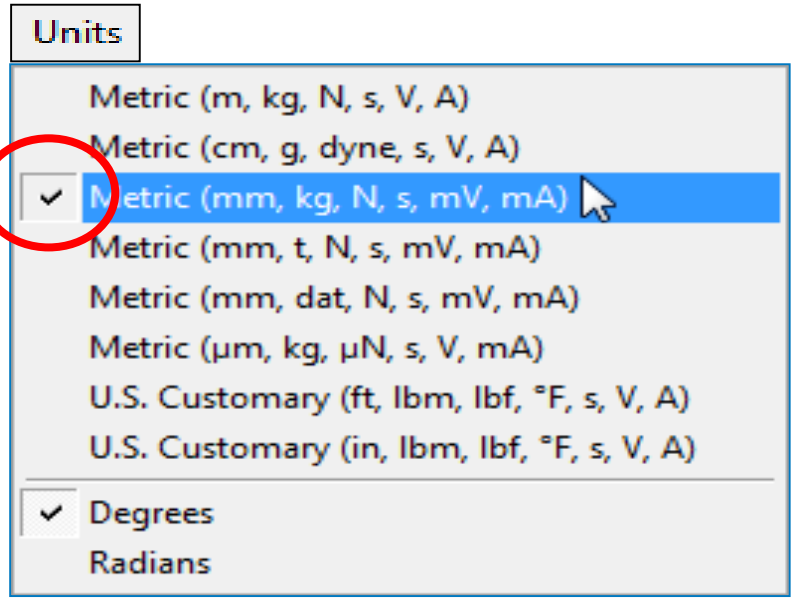


Units and Preferences

Set Global Meshing Options:

- Set Physics Preference to CFD
- Set Solver Preference to FLUENT



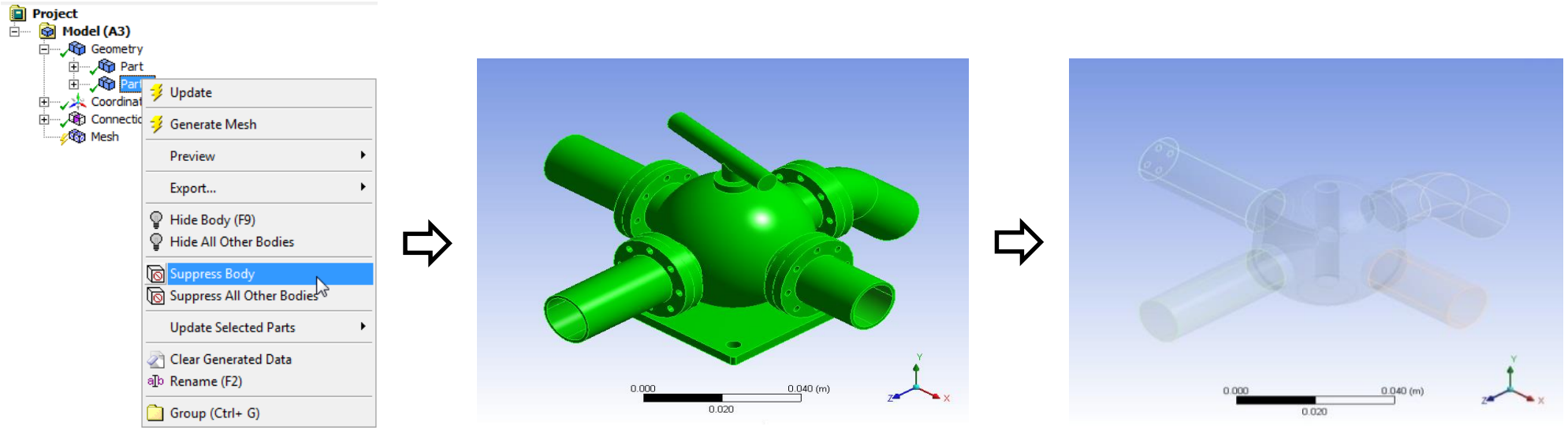


- In the Units menu set Metric (mm, kg, N, s, mV, Ma)

Model

Review the Geometry

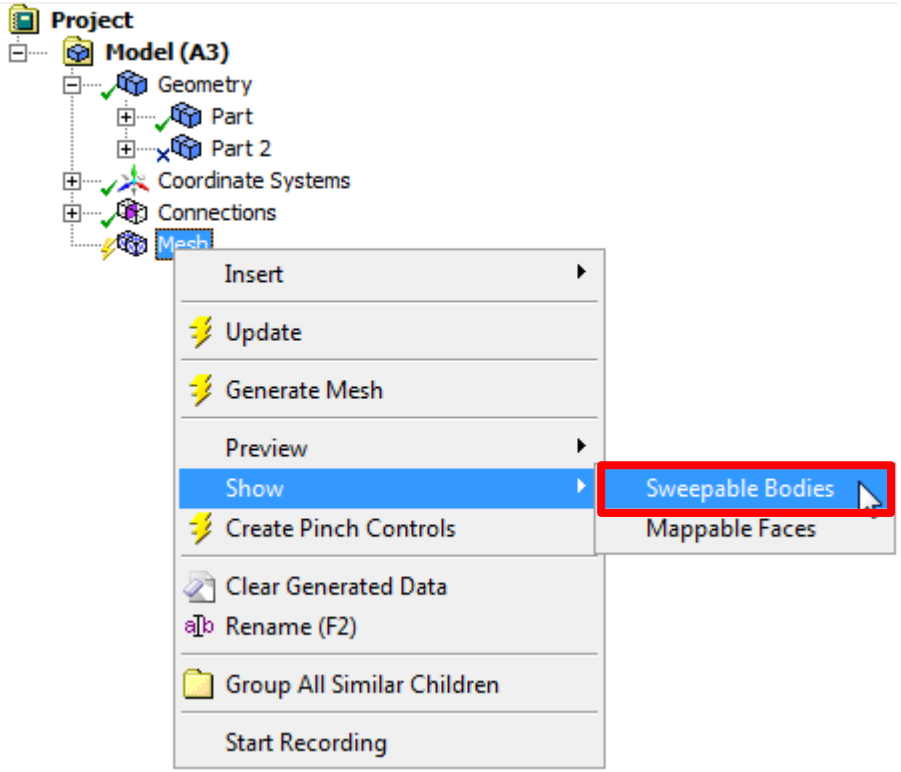
- The geometry represents a valve with one inlet distributed through a central spherical region to three outlets
  - **A mesh will be generated on the fluid region only in this workshop**
- In the Outline expand Geometry, right click on Part2 and select Suppress Body from the Context Menu as shown
  - **This will suppress all bodies contained within Part2 which represents the solid outer region in this case. The (transparent) fluid region will be displayed**



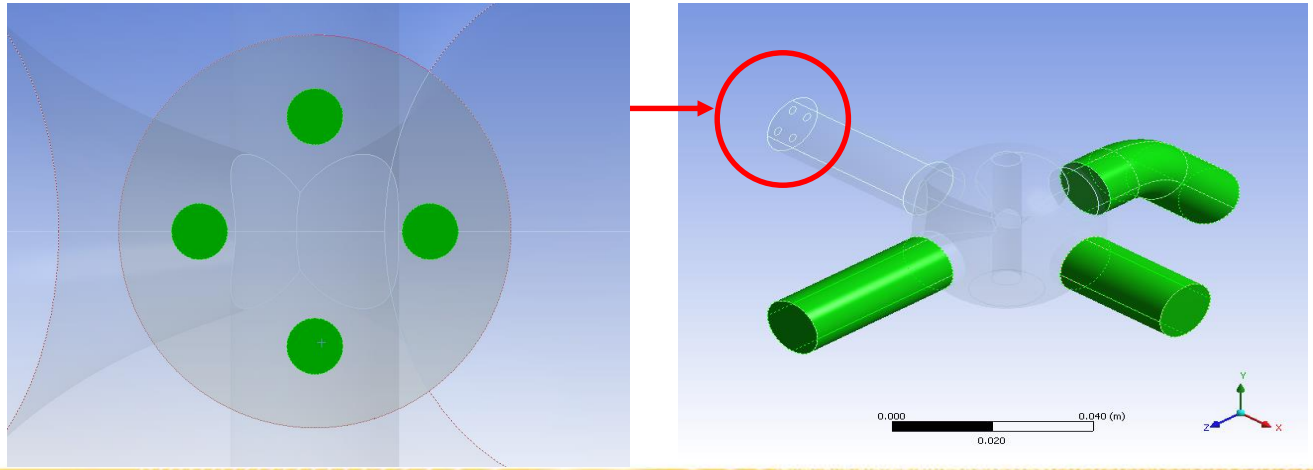
Preparation

Planning

- **In the Outline, right click on Mesh and select Show Sweepable Bodies**
  - Three of the five bodies could be meshed using the Sweep Method
  - The central region is complex and therefore will be meshed using the Patch Conforming Tetrahedral Method
  - The remaining body cannot be swept using the standard sweep method since it contains multiple source faces as shown
  - MultiZone will however be able to sweep this



In the Graphics Window , right click View → Left or click the –X Axis on the Triad to view



Set Global Mesh Options

Setup Advanced Size Functions:

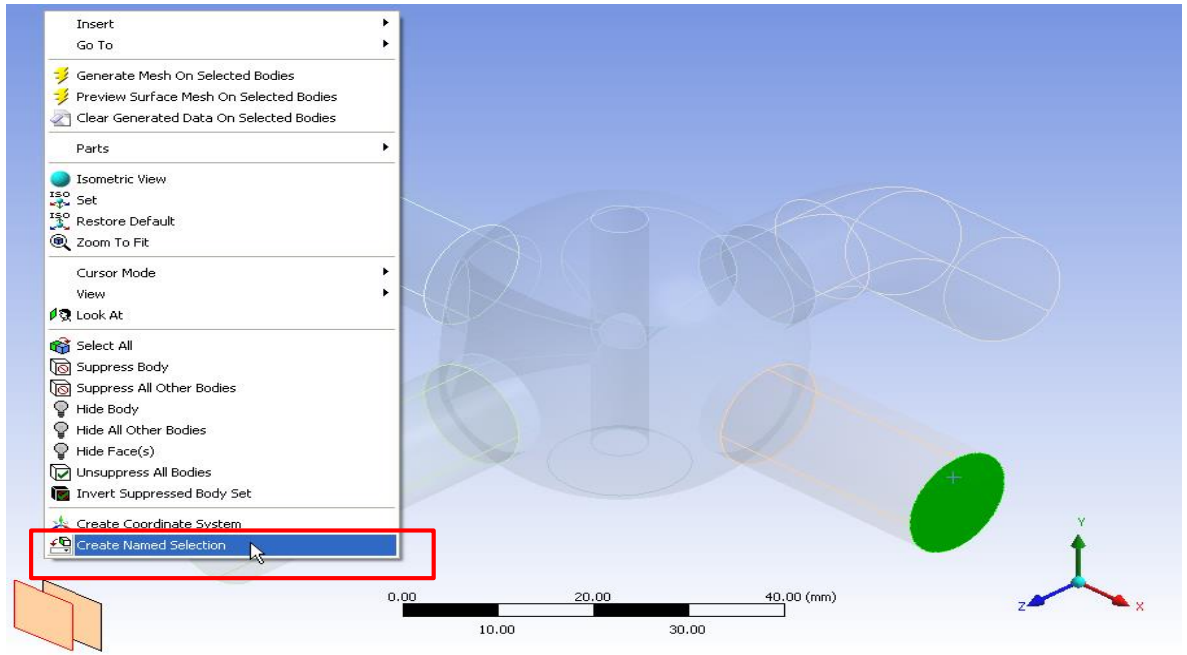
- To adequately capture the curved geometric features a Curvature Size Function will be used
- Leave all other options to default as shown

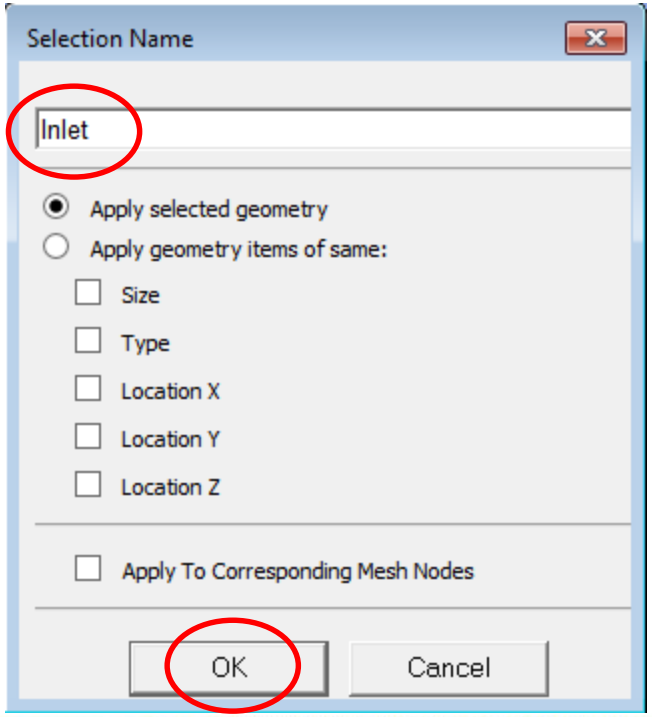
Details of "Mesh"	
⊞ Display	
⊞ Defaults	
⊟ Sizing	
Size Function	Curvature
Relevance Center	Coarse
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Slow
Span Angle Center	Fine
Curvature Normal Angle	Default (18.0 °)
Min Size	Default (8.4671e-002 mm)
Max Face Size	Default (8.46710 mm)
Max Tet Size	Default (16.9340 mm)
Growth Rate	Default (1.20)
Automatic Mesh Based Defeaturing	On
Defeaturing Tolerance	Default (4.2336e-002 mm)
Minimum Edge Length	0.132340 mm

Named Selections (1)

Create Named Selections:

- Switch the view to isometric and ensure the Selection Filter is set to Face 
- Select the face as shown, right click in the Graphics Window and select Create Named Selection from the Context Menu
- In the Selection Name Dialog Box set the name to “Inlet” and click OK

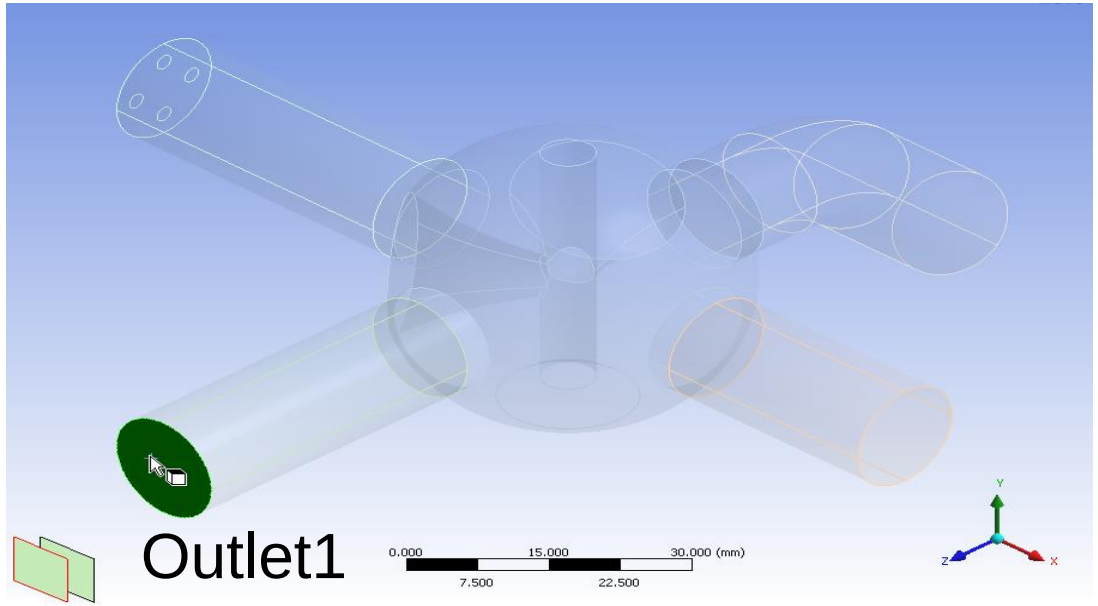


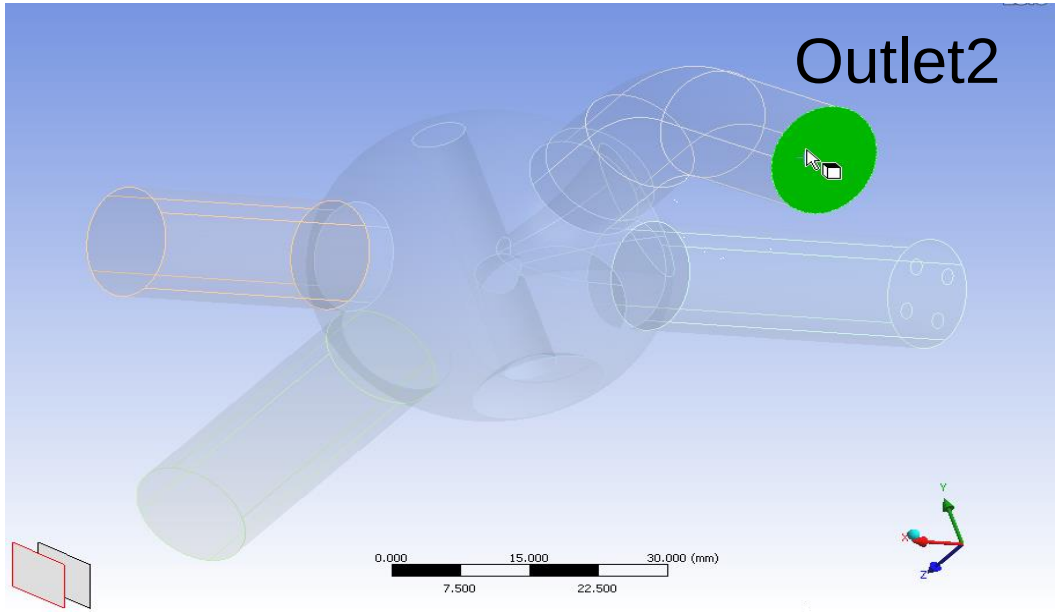


Named Selections (2)

Create Named Selections (Continued)

- Using the same procedure create Named Selections for the two faces as shown (Outlet1 & Outlet2)

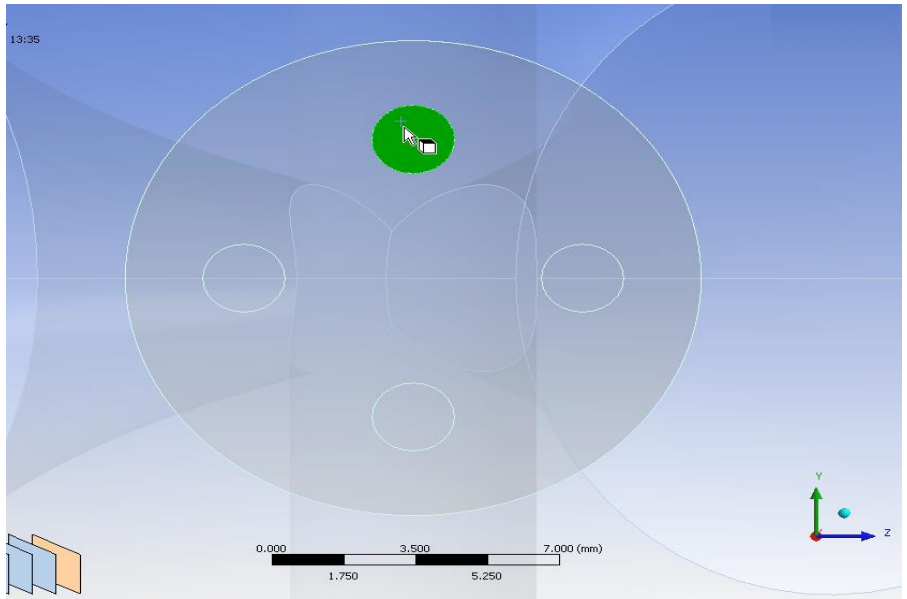


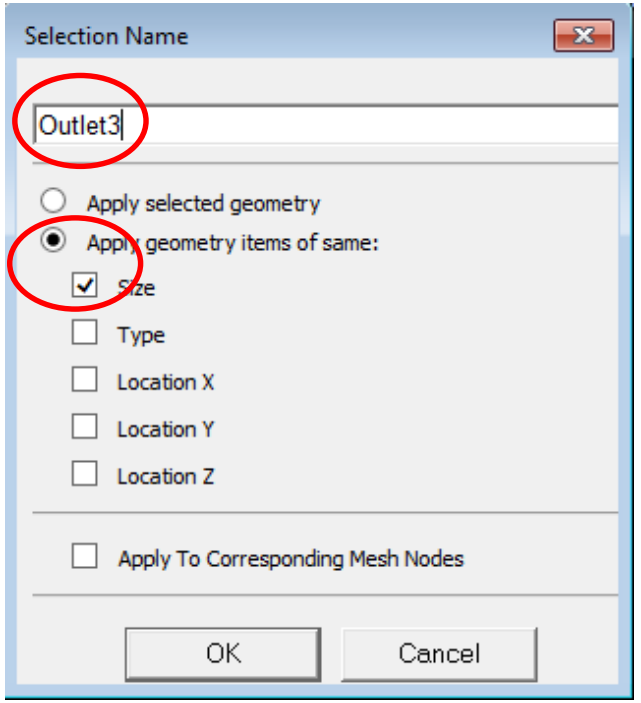


Named Selections (3)

Create Named Selections (Continued)

- In the Graphics Window, right click and select View → Left (or use the Triad -X). Zoom in as shown
- Select one of the four small circular faces, right click → Create Named Selection
- In the Selection Name Dialog Box set the name as “Outlet3” and select Apply geometry items of same → Size as shown. Click OK

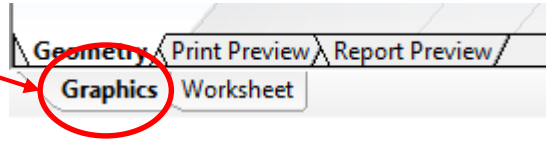




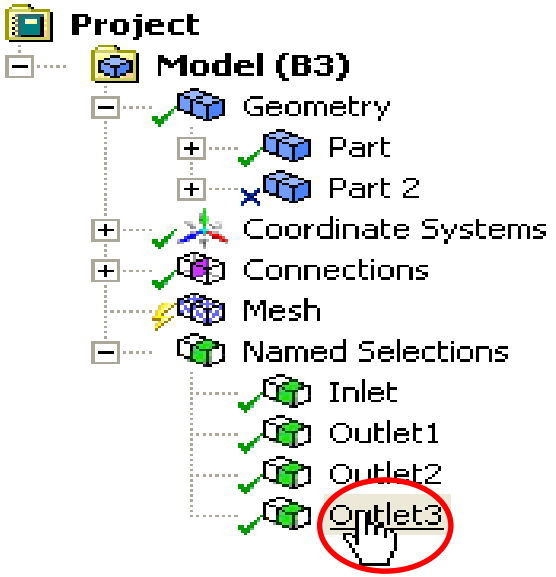
Named Selections (4)

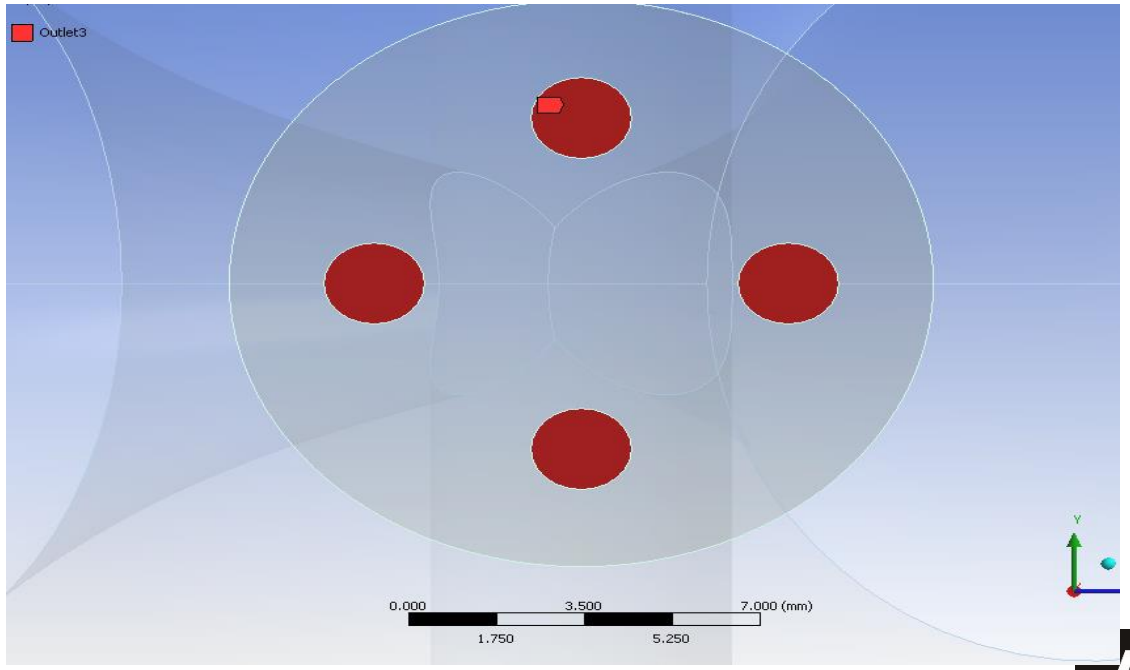
Create Named Selections (Continued)

- In the Outline, expand Named Selections and click on Outline3.
  - The worksheet details the method by which the Named Selection is scoped to faces – in this case by size. Switch to Graphics by clicking on the button



  - Note that the Named Selection contains all four identical faces

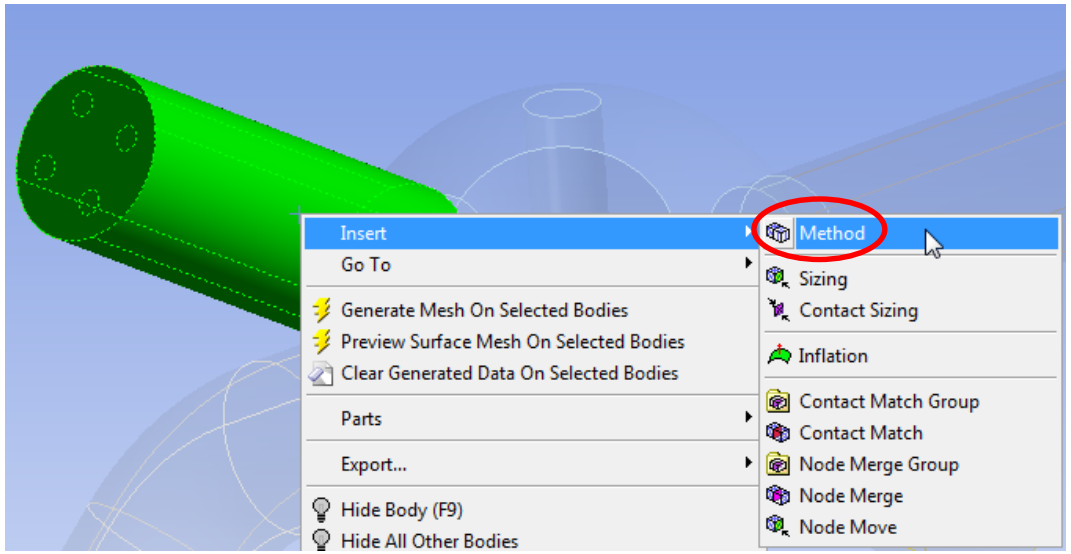




MultiZone Method

Setup MultiZone for the Non-Sweepable Body:

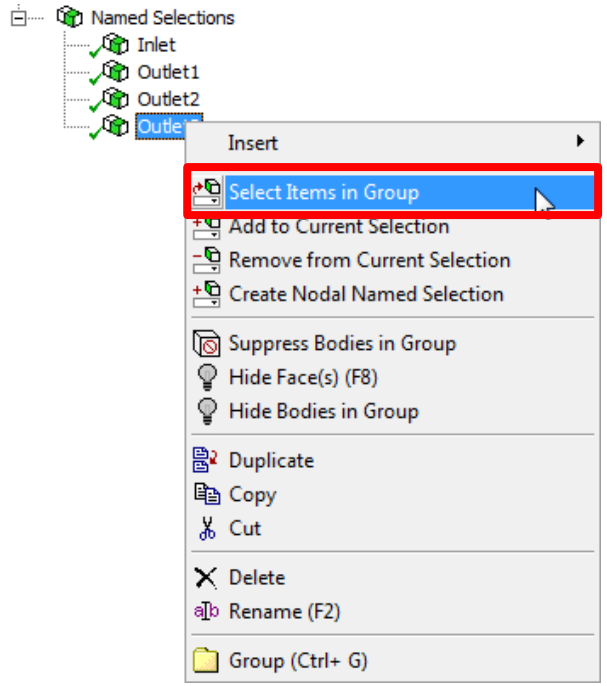
- Multizone method can be used to mesh cases where multiple source faces are there (Sweep supports only single Source face)
- Click Mesh in the Outline
- Switch the view to isometric , set the Selection Filter to Body and select the non sweepable body as shown
- Right click → Insert → Method
- Under Details of “Automatic-Method” change Method to Multizone
  - The Details view will now be named Details of “Multizone”
  - Set Surface Mesh Method to “Uniform”
- Leave all other settings to default as shown



Details of "MultiZone" - Method

Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Suppressed	No
Method	MultiZone
Mapped Mesh Type	Hexa
Surface Mesh Method	Uniform
Free Mesh Type	Not Allowed
Element Midside Nodes	Use Global Setting
Src/Trg Selection	Automatic
Source Scoping Method	Program Controlled
Source	Program Controlled
Sweep Size Behavior	Sweep Element Size
Sweep Element Size	Default
Advanced	

Local Sizing (1)



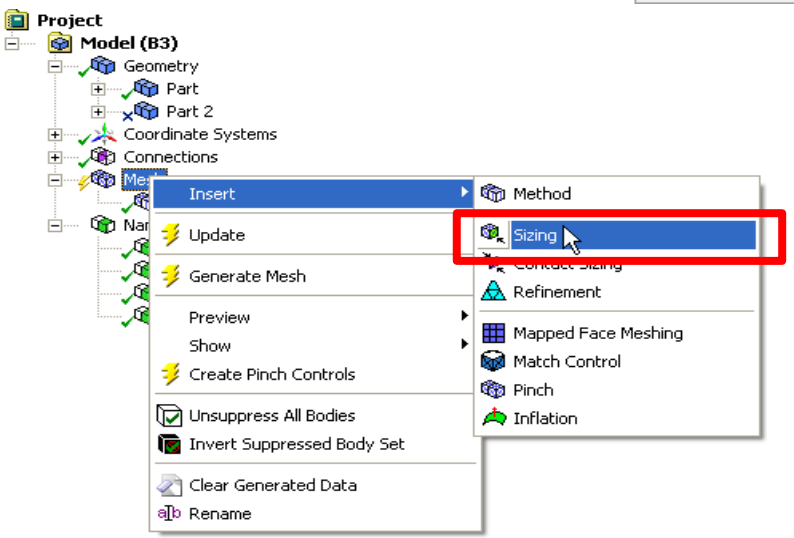
Insert Face Sizing:

- **In the Outline, under Named Selections right click on Outlet3 and click Select Items in Group**
  - **This will select all the faces contained within that Named Selection**
- **In the Outline, right click on Mesh and select Insert → Sizing**

  Note: that the Details of "Face Sizing" has the Geometry Selection populated with the 4 faces within the Named Selection. You can also use Named Selections directly under Scoping Method

  - **Set Element Size to 0.5mm**

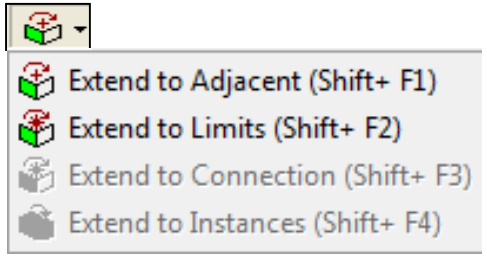
Details of "Face Sizing" - Sizing	
Scope	
Scoping Method	Geometry Selection
Geometry	4 Faces
Definition	
Suppressed	No
Type	Element Size
Element Size	0.5 mm
Behavior	Soft
Curvature Normal Angle	Default
Growth Rate	Default
Local Min Size	Default (8.4671e-002 mm)



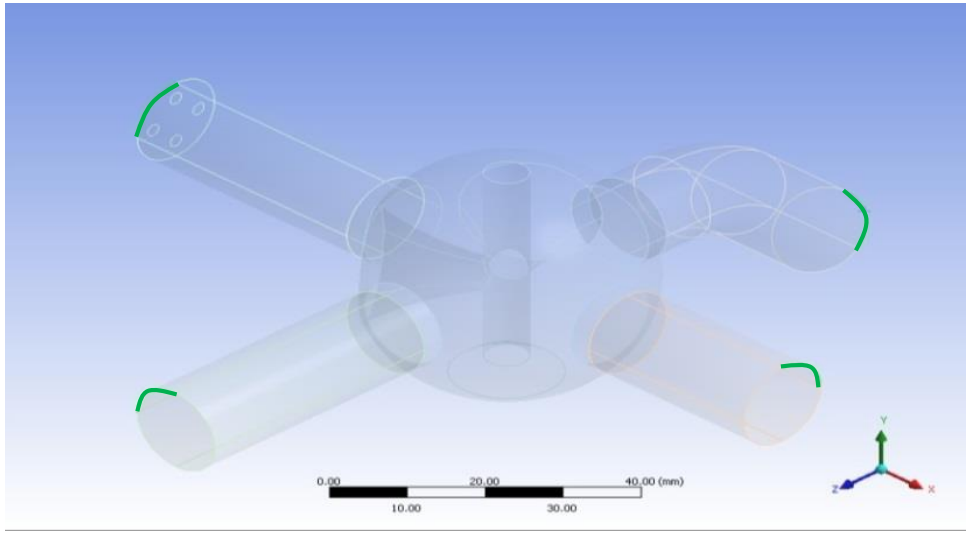
Local Sizing (2)

Insert Edge Sizing:

- **Select the Edge Selection Filter** 
- **The inlet and outlet faces are bound by four edges each**
- Select one edge on each of the four faces as shown (ctrl left click for multiple selection)
- **Select Extend to Limits to extend the selection to the complete edge loops**



- **In the Outline, right click on Mesh and select Insert → Sizing**
- **Check that Geometry contains 16 edges**
- **Set Element Size to 0.8mm as shown**

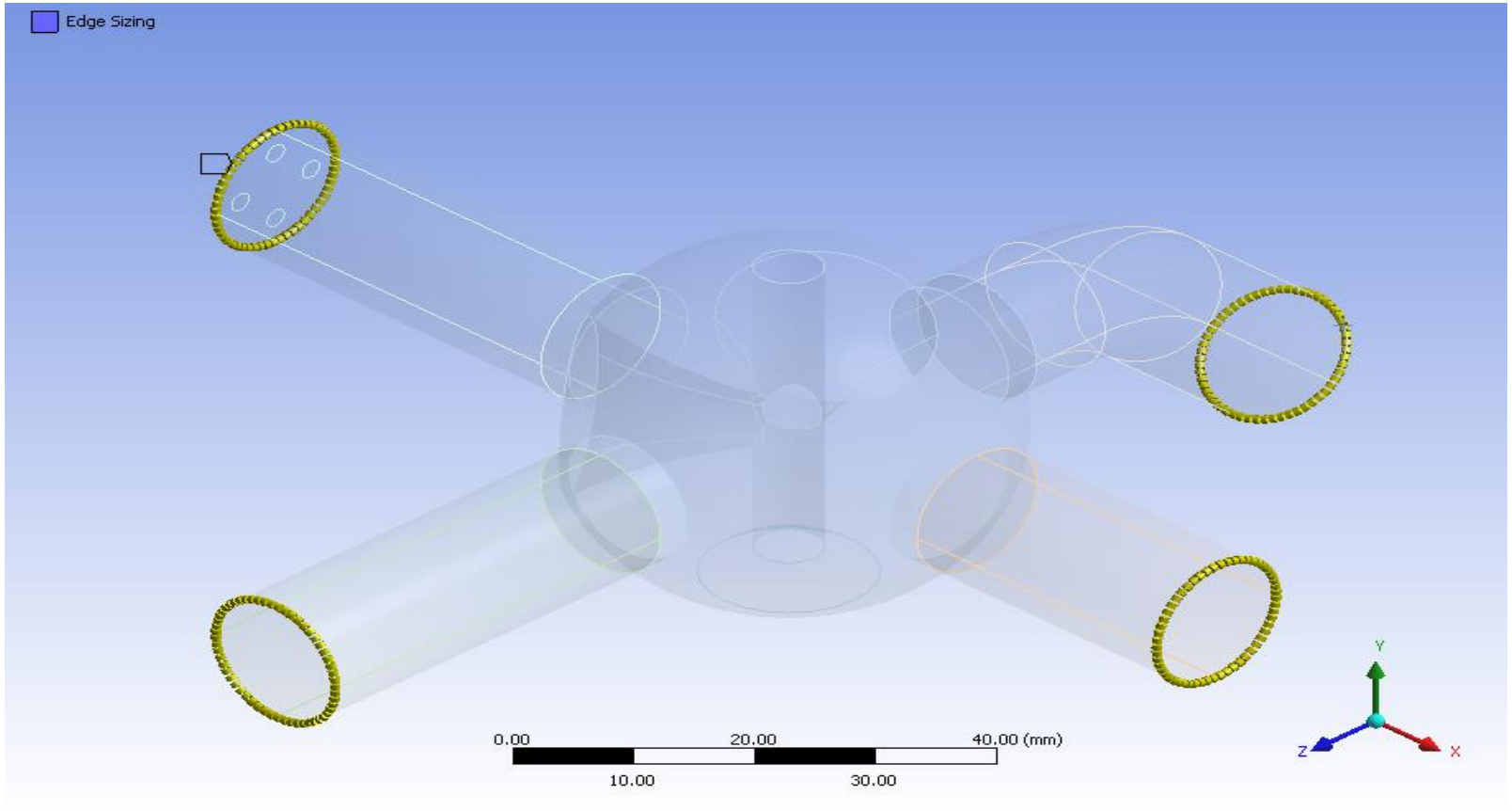


Scope	
Scoping Method	Geometry Selection
Geometry	16 Edges
Definition	
Suppressed	No
Type	Element Size
Element Size	0.8 mm
Behavior	Soft
Curvature Normal Angle	Default
Growth Rate	Default
Bias Type	No Bias
Local Min Size	Default (8.4671e-002 mm)

Local Sizing (3)

Insert Edge Sizing (Continued):

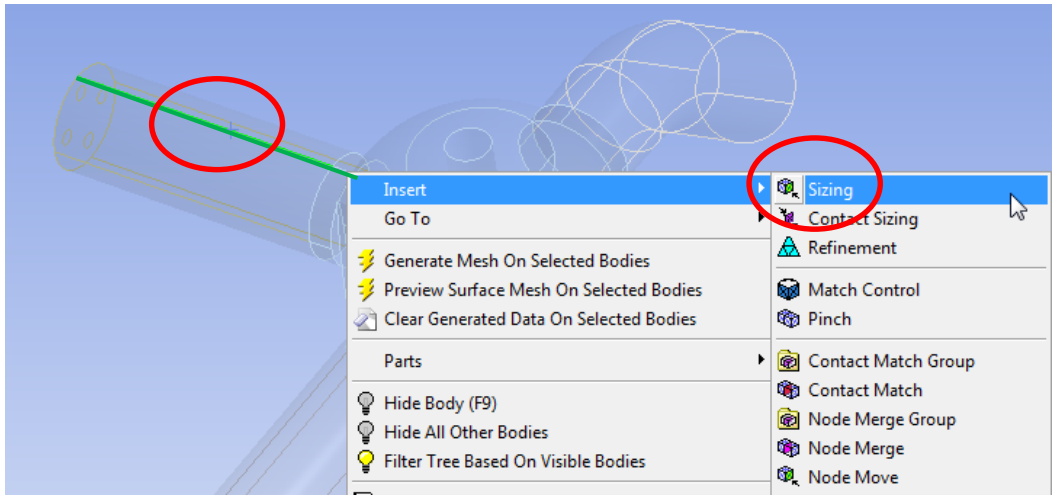
- A preview of the Edge Sizing will be displayed on the geometry



Local Sizing (4)

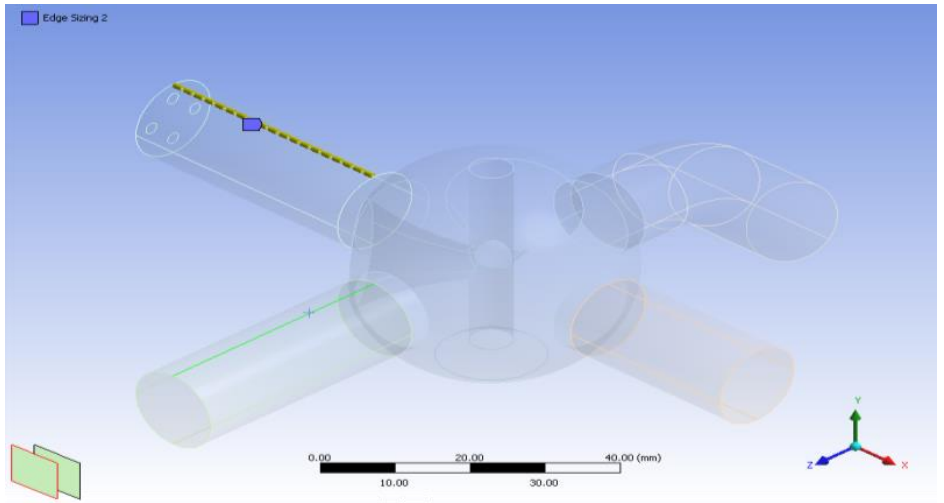
Insert Edge Sizing 2:

- Create another Edge Sizing this time to control the Multizone sweep
- **Select the edge as shown circled and insert sizing as previously**



Details of "Edge Sizing 2" - Sizing

Scope	
Scoping Method	Geometry Selection
Geometry	1 Edge
Definition	
Suppressed	No
Type	Element Size
Element Size	2. mm
Behavior	Soft
Curvature Normal Angle	Default
Growth Rate	Default
Bias Type	No Bias

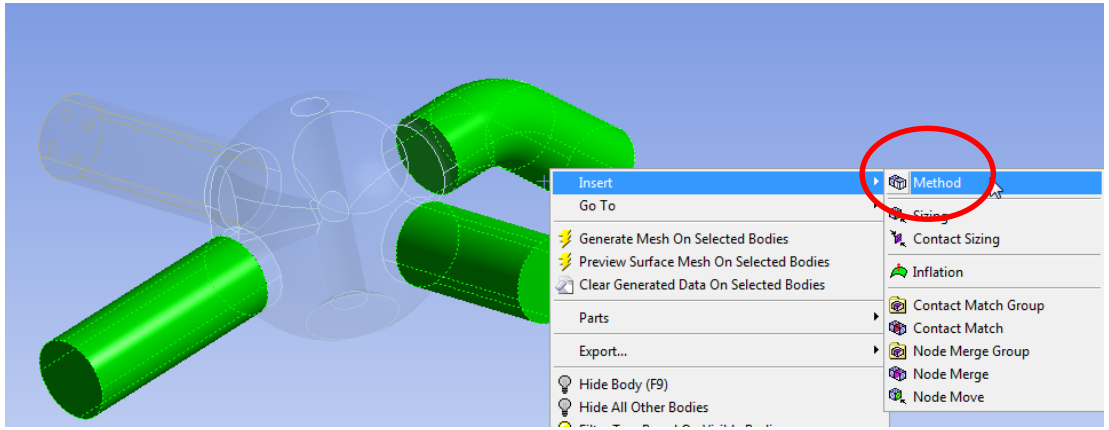


- **Under Details of "Edge Sizing 2" set Element Size to 2.0mm**

Sweep Method (1)

Insert a Sweep Method:

- The three remaining cylindrical bodies can be swept using the Sweep
- Set the Selection Filter to Body, select the three bodies as shown and right click → Insert → Method
- Under Details of "Automatic-Method" change Method to Sweep
  - The Details view will now be named Details of "Sweep Method"
- Set Type to Element Size and set Sweep Element Size to 2.0mm



Details of "Sweep Method" - Method

Scope	
Scoping Method	Geometry Selection
Geometry	3 Bodies
Definition	
Suppressed	No
Method	Sweep
Element Midside Nodes	Use Global Setting
Src/Trg Selection	Automatic
Source	Program Controlled
Target	Program Controlled
Free Face Mesh Type	Quad/Tri
Type	Element Size
Sweep Element Size	2. mm
Sweep Bias Type	No Bias
Element Option	Solid
Constrain Boundary	No

Sweep Method (2)

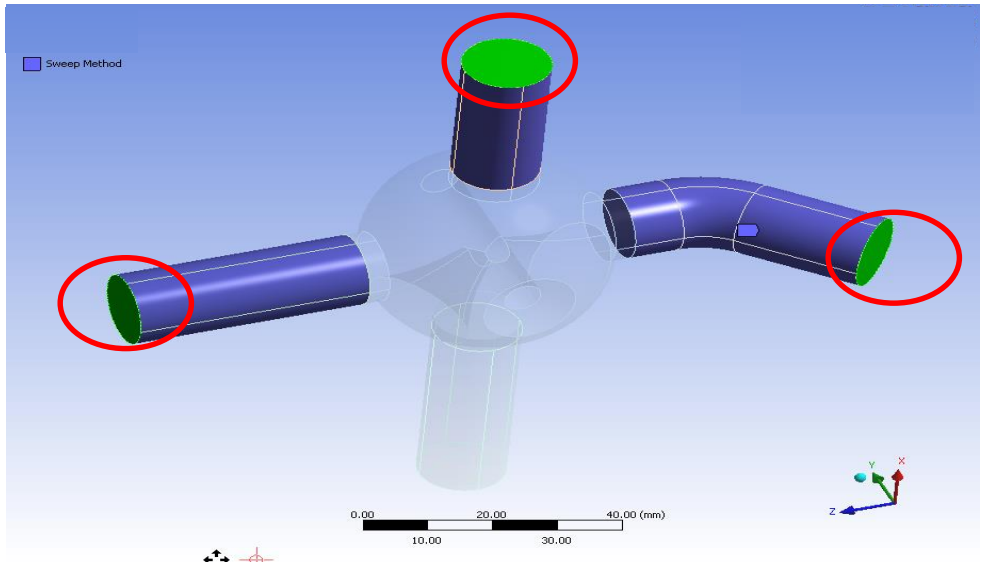
Insert a Sweep Method (Continued)

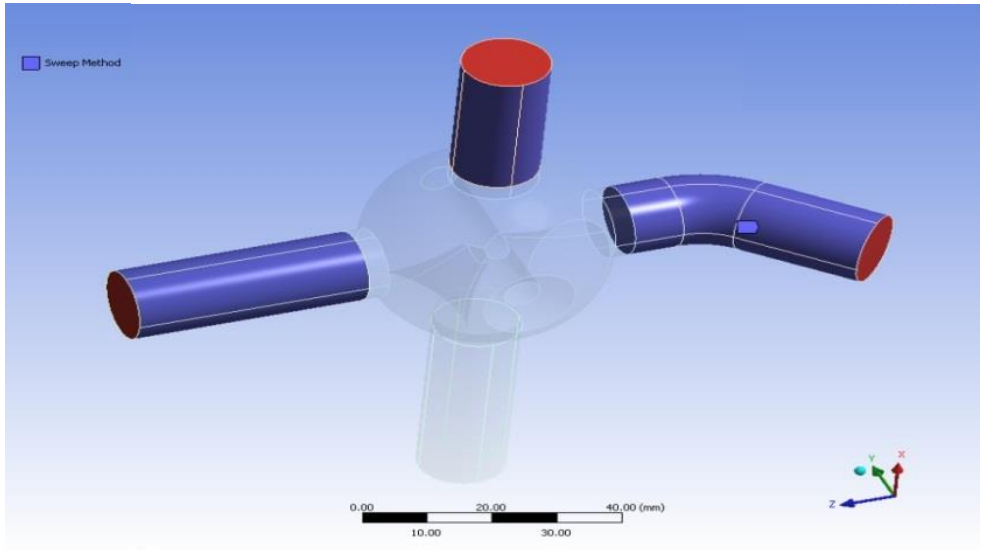
- Set the Source & Target Selection (Src/Trg Selection) to Manual Source
  - If the box adjacent to Source displays “No Selection” with a yellow background click in the yellow box to activate
- Select the three faces as shown and apply the selection in the box adjacent to Source

- Check the Details match those shown

Details of "Sweep Method" - Method

Scope	
Scoping Method	Geometry Selection
Geometry	3 Bodies
Definition	
Suppressed	No
Method	Sweep
Element Midside Nodes	Use Global Setting
Src/Trg Selection	Manual Source
Source	3 Faces
Target	Program Controlled
Free Face Mesh Type	Quad/Tri
Type	Element Size
Sweep Element Size	2. mm
Sweep Bias Type	No Bias
Element Option	Solid
Constrain Boundary	No

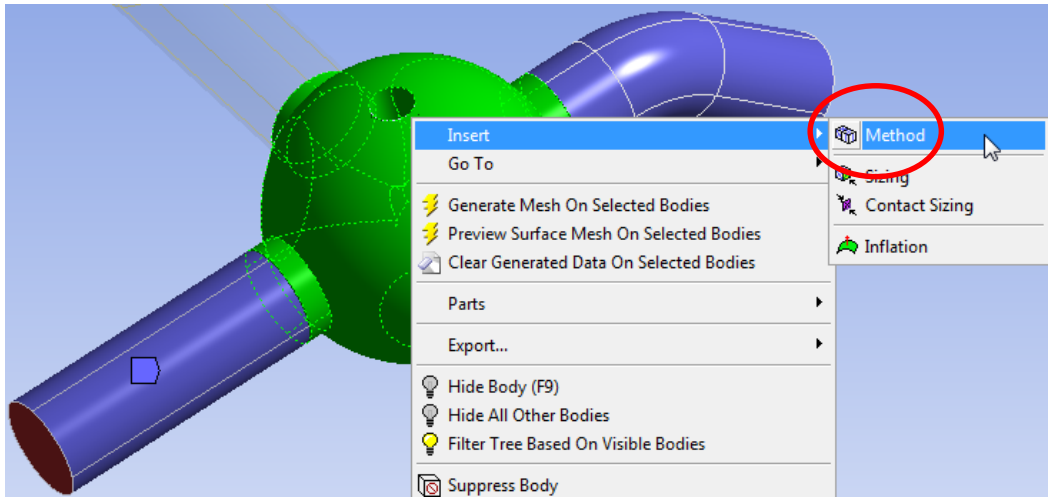




Patch Conforming Tetrahedral Method

Insert Patch Conforming Tetrahedral Method

- Use the Body Selection Filter to select the central body as shown
- Right click → Insert → Method
- Under Details of “Automatic-Method” change Method to Tetrahedrons
  - The Details view will now be named Details of “Patch Conforming Method”
- Ensure Algorithm is set to Patch Conforming



Details of "Patch Conforming Method" - Method

Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Suppressed	No
Method	Tetrahedrons
Algorithm	Patch Conforming
Element Midside Nodes	Use Global Setting

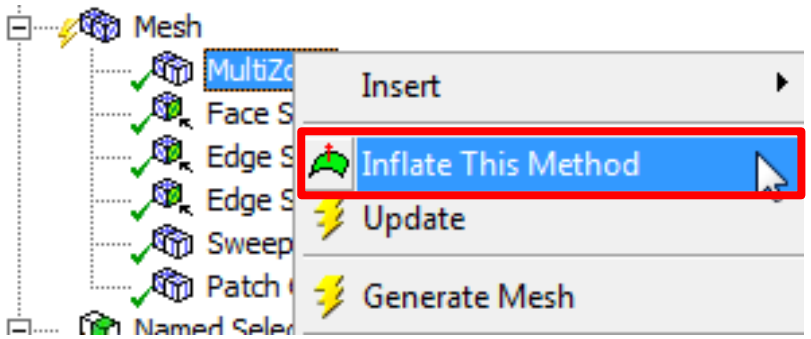
Inflation (1)

Inflate the MultiZone Method

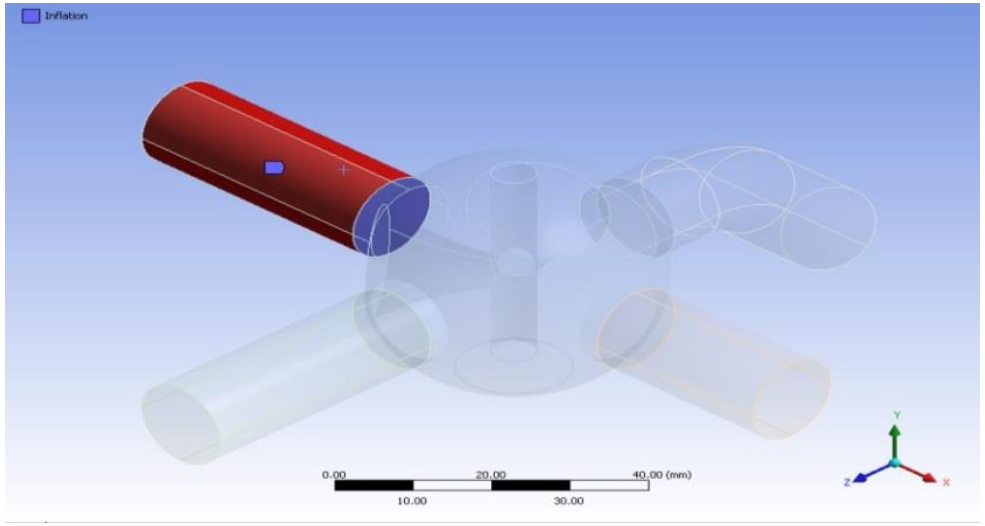
- **Right click on MultiZone in the Outline and select “Inflate This Method” from the Context Menu**

- **Under Boundary in Details of “Inflation” select the four faces bounding the MultiZone body and apply the selection**

- Set Inflation Option to Total Thickness, Number of Layers to 3 and Maximum Thickness to 1.25mm as shown



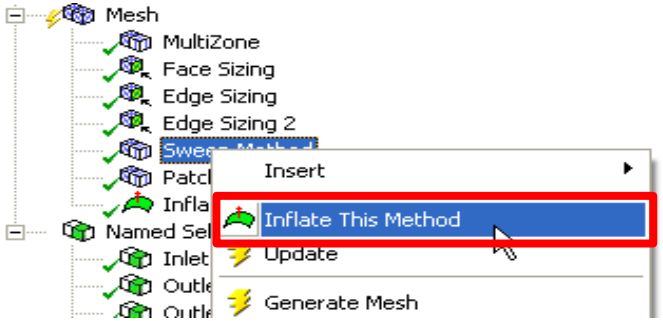
Details of "Inflation" - Inflation	
Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Suppressed	No
Boundary Scoping Method	Geometry Selection
Boundary	4 Faces
Inflation Option	Total Thickness
Number of Layers	3
Growth Rate	1.2
Maximum Thickness	1.25 mm
Inflation Algorithm	Pre

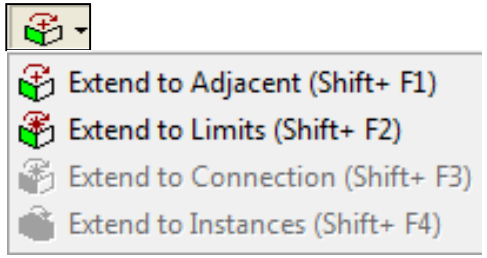


Inflation (2)

Inflate the Sweep Methods:

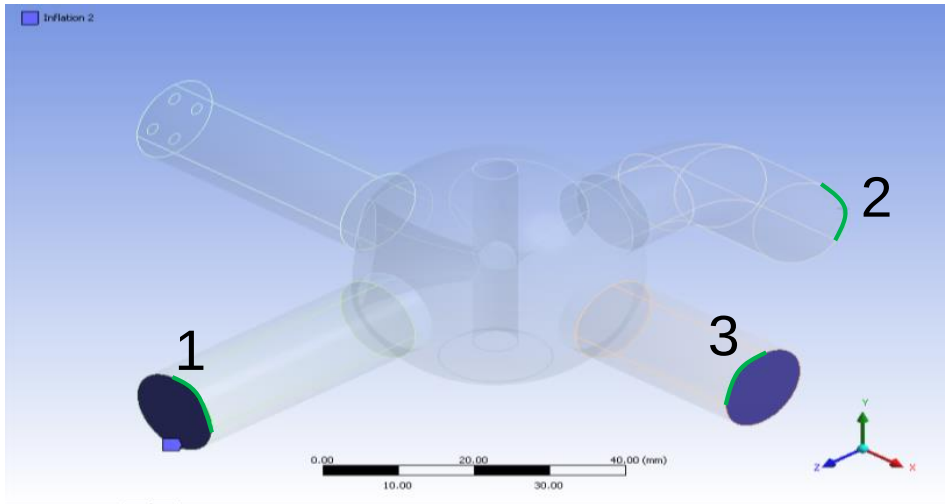
- **Right click on Sweep Method in the Outline and select “Inflate This Method” from the Context Menu**
- **Under Boundary in Details of “Inflation 2” select one edge on each of the three Source Faces as shown**
  - Use the Extend to Limits Tool again to complete the selection
  - Apply the selection and Set Inflation Option to Total Thickness, Number of Layers to 3 and Maximum Thickness to 1.25mm as shown





Details of "Inflation 2" - Inflation

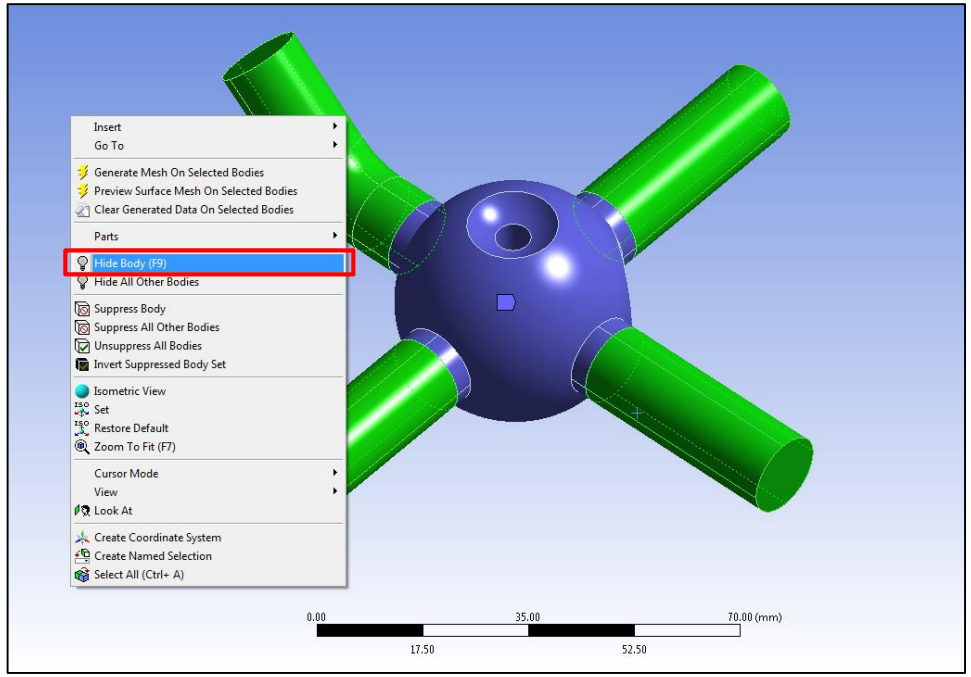
Scope	
Scoping Method	Geometry Selection
Geometry	3 Faces
Definition	
Suppressed	No
Boundary Scoping Method	Geometry Selection
Boundary	12 Edges
Inflation Option	Total Thickness
Number of Layers	3
Growth Rate	1.2
Maximum Thickness	1.25 mm
Inflation Algorithm	Pre

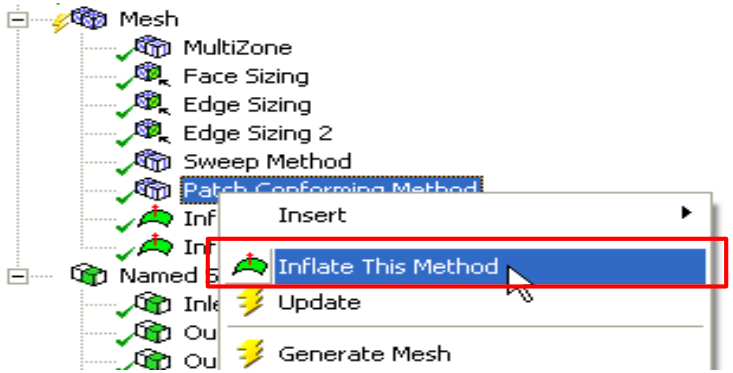


Inflation (3)

Inflate the Patch Conforming Method

- Select the four cylindrical bodies, right click in the Graphics Window and select “Hide Body” (or press F9)
  - This will make boundary selection easier in the next step
- Right click on Patch Conforming Method in the Outline and select “Inflate This Method” from the Context Menu
- Under Boundary in Details of “Inflation 3” all faces of the central body must be selected with the exception of those separating the four cylindrical bodies

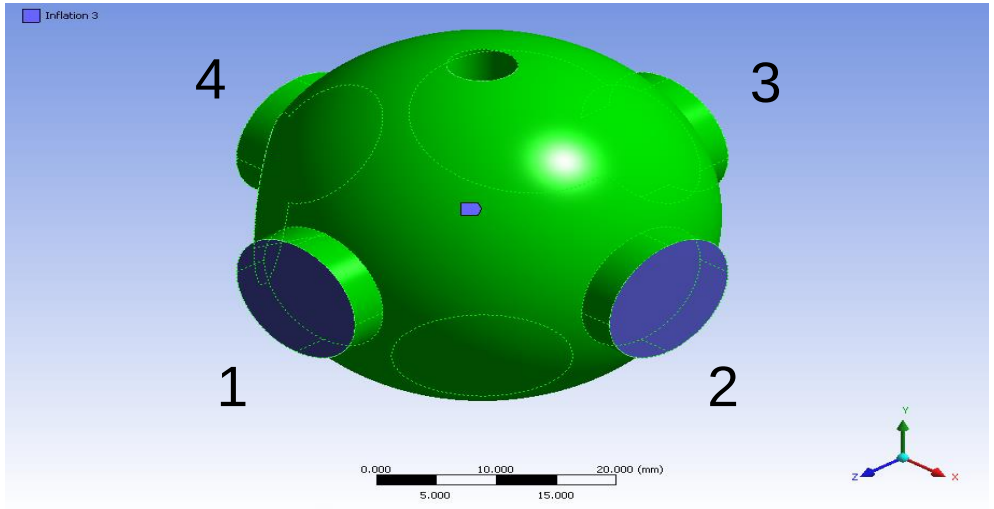




Inflation (4)

Inflate the Patch Conforming Method (Continued)

- **Under Details of "Inflation 3" activate the Boundary Selection Box**
  - Apply/Cancel buttons appear when active
- **In the Graphics Window right click and click Select All from the Context Menu**
  - All faces will be selected
- **Deselect the four faces as shown by clicking ctrl left click on each face**
  - **Faces will turn blue when deselected**
- **Apply the selection under Details of "Inflation 3" (check 25 Faces are selected)**
- **Set Inflation Option to Total Thickness, Number of Layers to 3 and Maximum Thickness to 1.25mm as shown**
- **In the Graphics Window right click → Show All Bodies**



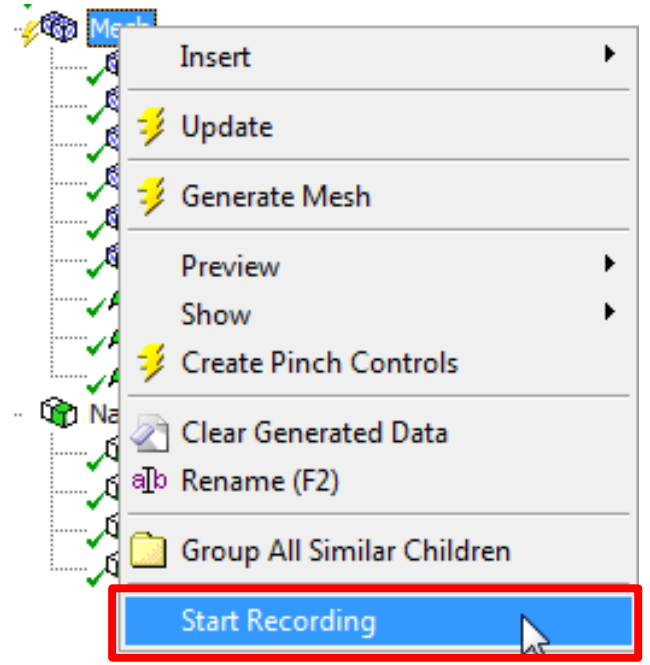
Details of "Inflation 3" - Inflation

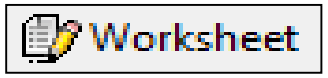
Scope	
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Suppressed	No
Boundary Scoping Method	Geometry Selection
Boundary	25 Faces
Inflation Option	Total Thickness
Number of Layers	3
Growth Rate	1.2
Maximum Thickness	1.25 mm
Inflation Algorithm	Pre

Selective Meshing (1)

Start Selective Meshing

- When combining multiple mesh methods the order in which the bodies are meshed may influence the final mesh characteristics
- Generating meshes one by one is called “Selective Meshing”
- It is therefore recommended that we record the body meshing order such that it can be repeated automatically
- Right click on Mesh in the Outline and select Start Recording from the Context Menu
- If the Worksheet is displayed switch it off using the worksheet Toggle button

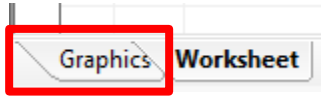




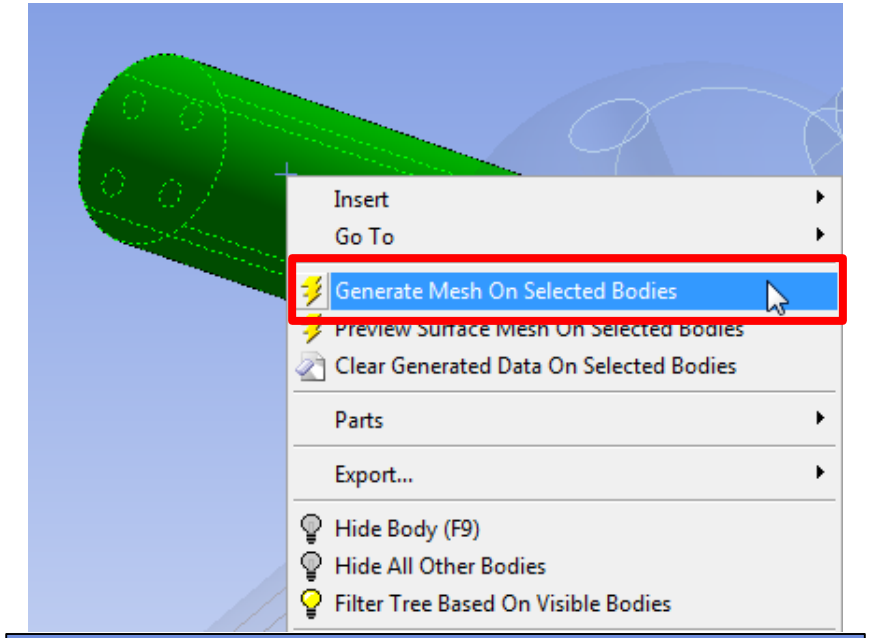
Selective Meshing (2)

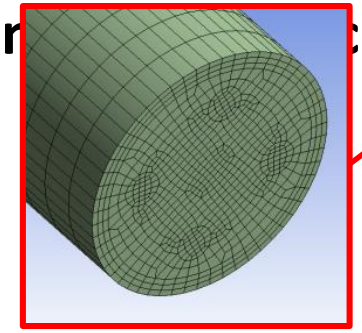
Generate the MultiZone Mesh

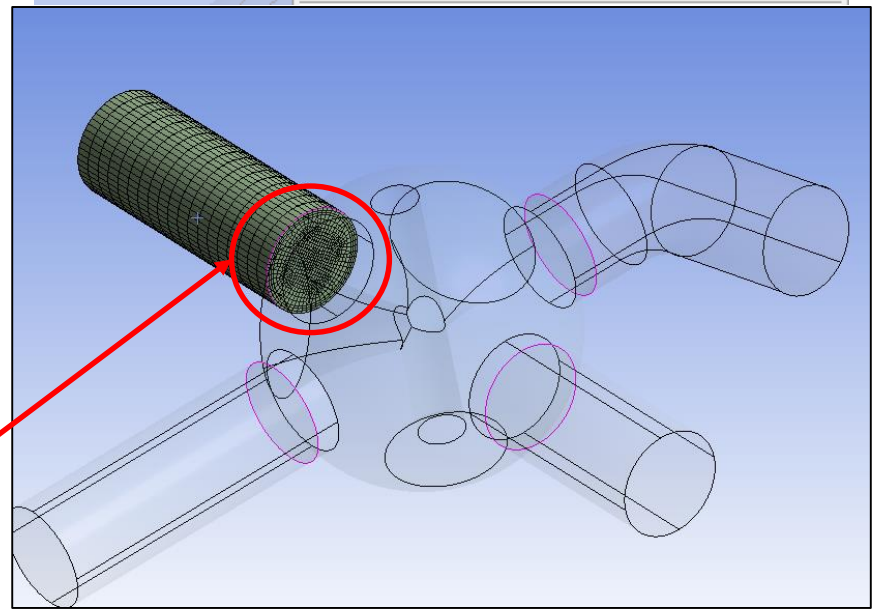
- Using the Body Selection Filter select the MultiZone body
- Right click and select “Generate Mesh on Selected Bodies”
- The Worksheet will record the operation as Step 1
- Switch off the Worksheet and view the mesh



- Note how MultiZone has imprin ce faces onto the target
- Press “Show Mesh”



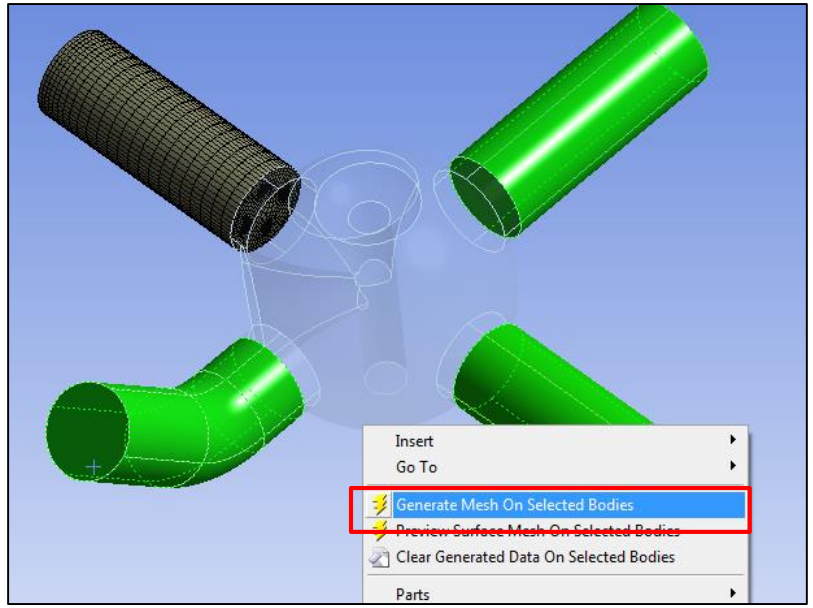


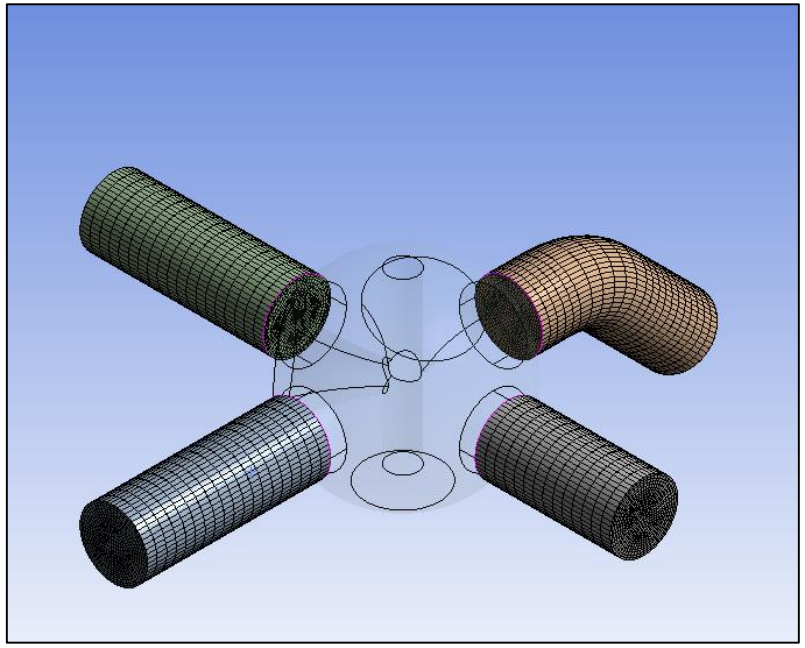


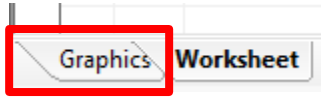
Selective Meshing (3)

Generate the Sweep Meshes

- Select the three Sweepable bodies
- Right click and select “Generate Mesh on Selected Bodies”
- This operation is again recorded in the Worksheet, this time as Step 2
- Switch to Graphics mode to view the Mesh



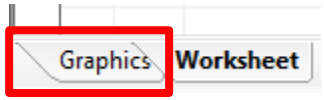


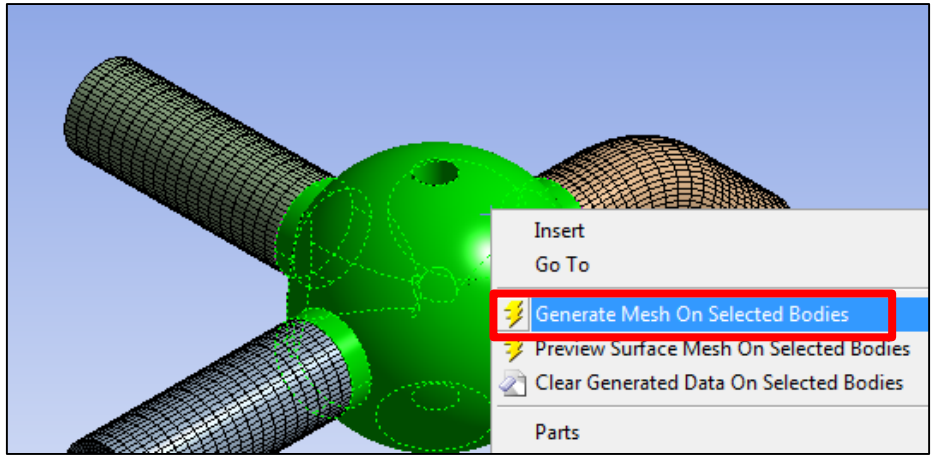


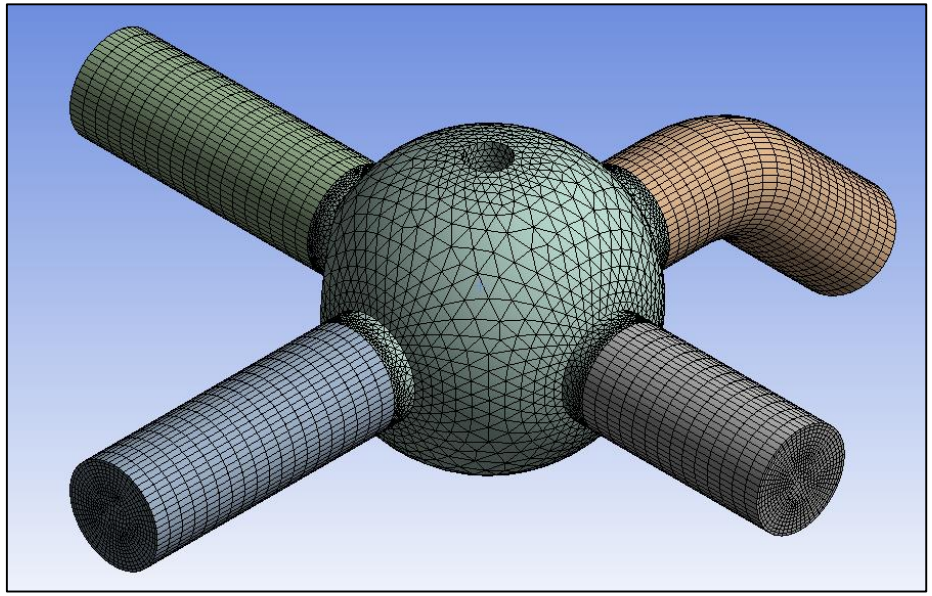
Selective Meshing (4)

Generate the Tetrahedral Mesh

- Select the central Tetrahedral mesh body
- Right click and select “Generate Mesh on Selected Bodies”
- All three steps are now recorded in the Worksheet





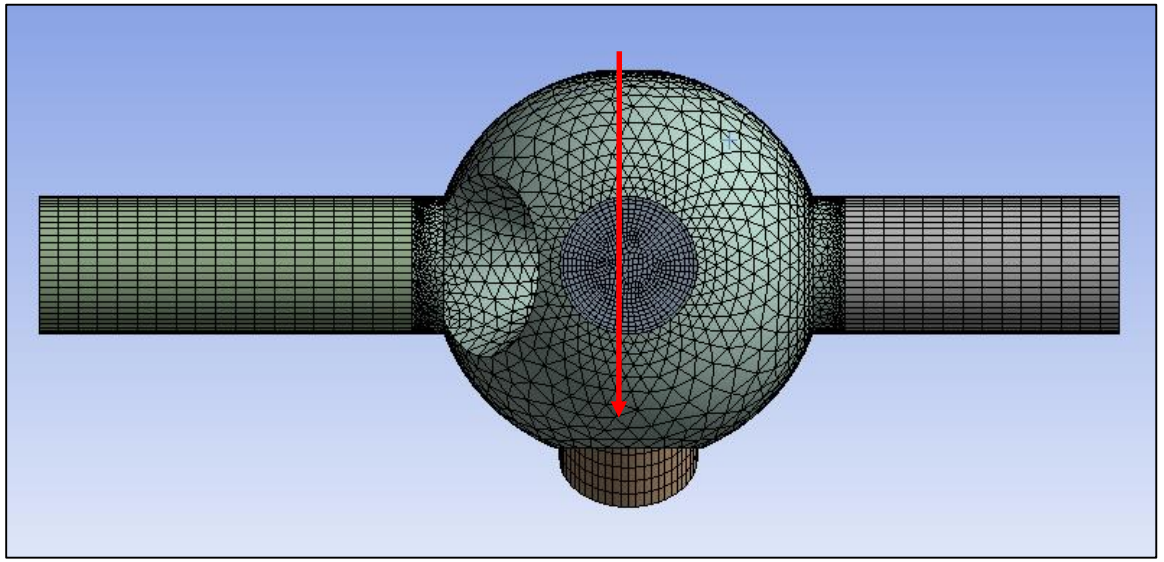


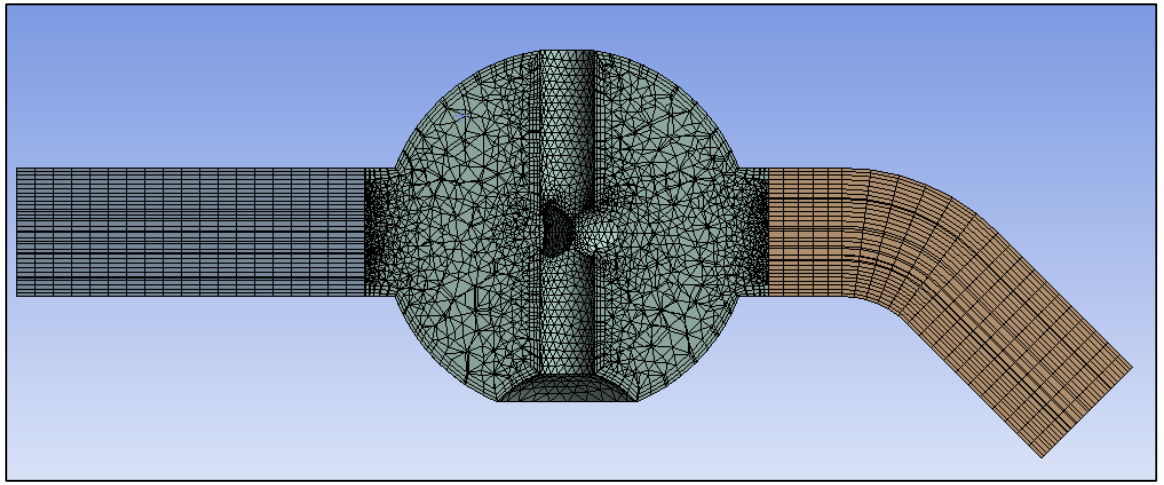
View Mesh Interior (1)

Create a Section Plane

- In the Graphics Window, right click and select View → Front to align the view to +Z Axis
- Click the New Section Plane button

- Click and drag the cursor through the model as shown from top to bottom
- Align the model to +X Axis (Right click View → Right)
- Note the continuous and conformal mesh & inflation between methods

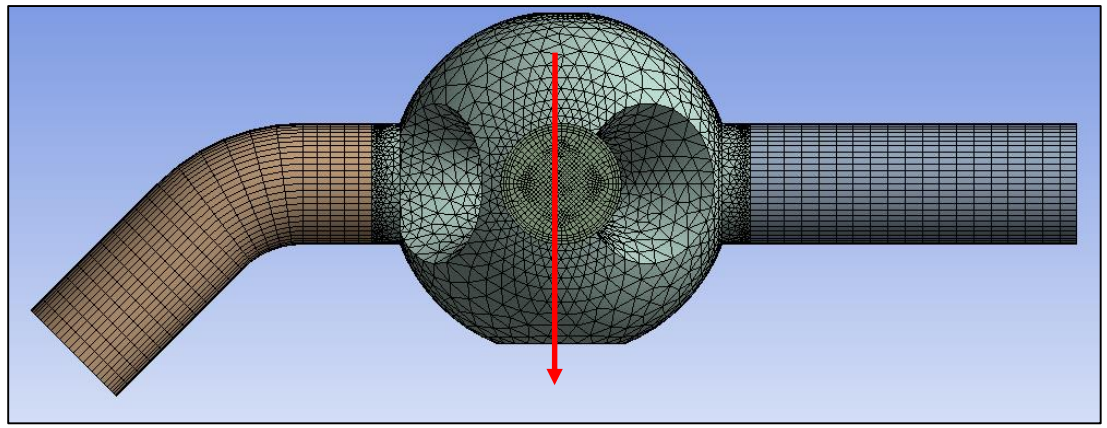


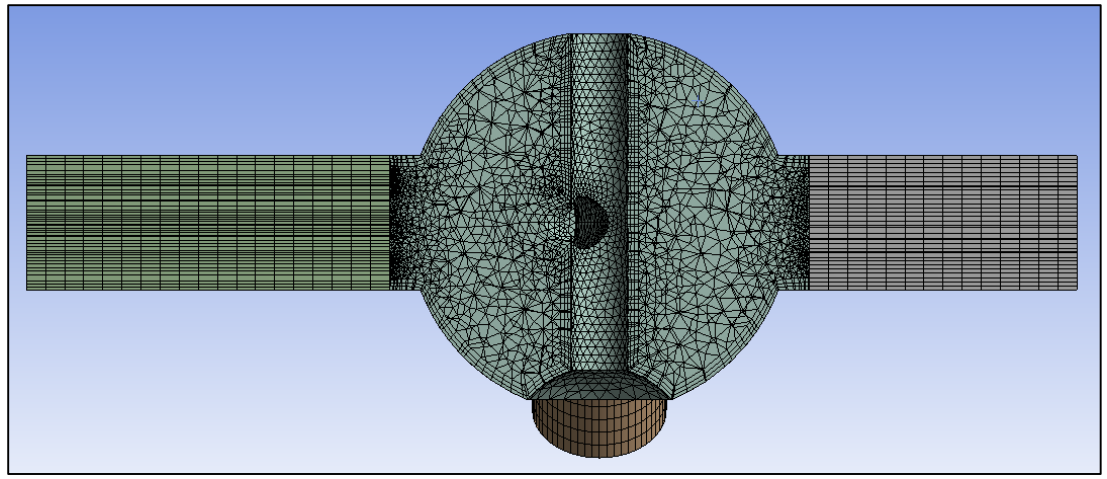


View Mesh Interior (2)

Create a Section Plane (Continued)

- Switch off Section Plane 1 and Align the model to -X Axis (Right click View → Left)
- Click the New Section Plane button
- Click and drag the cursor through the model as shown from top to bottom
- Restore the view to the +Z Axis (Front)
- Note the swept MultiZone mesh
- Switch off all Section Planes





Check Quality (1)

Set a Mesh Metric

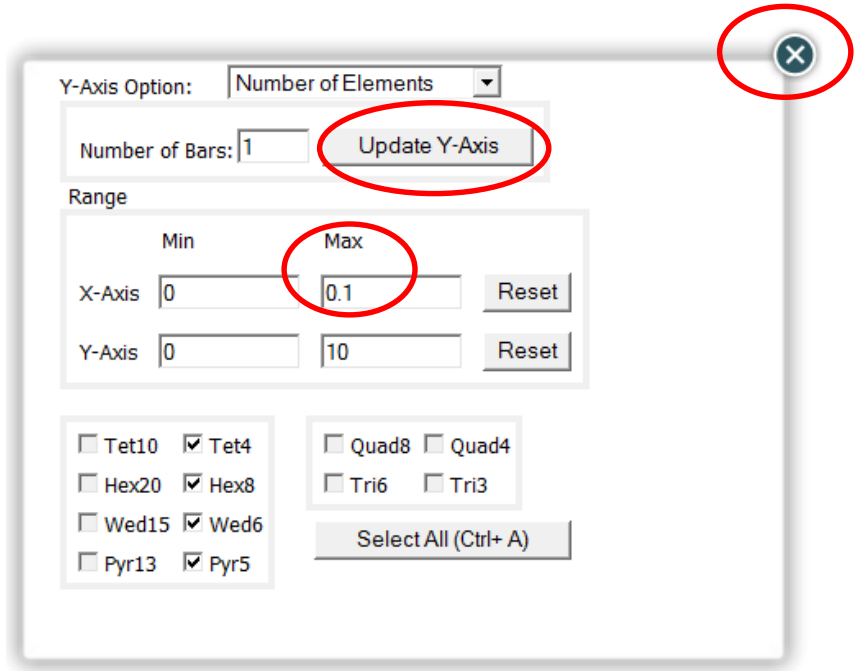
- Under Details of “Mesh” expand the Statistics Menu and set Mesh Metric to Orthogonal Quality
  - Note the value of Min Quality (your values may vary from values shown below)

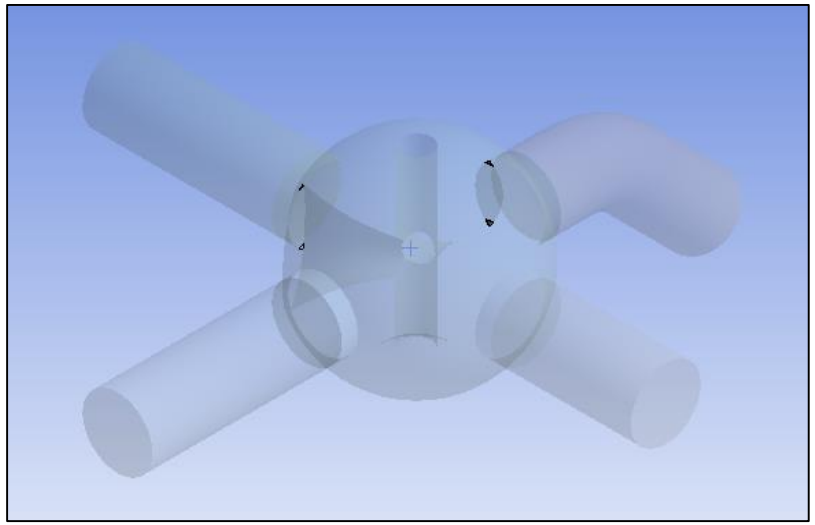
Statistics	
Nodes	86286
Elements	183878
Mesh Metric	Orthogonal Quality
Min	3.2921e-002
Max	0.99998
Average	0.87811
Standard Deviation	0.10804

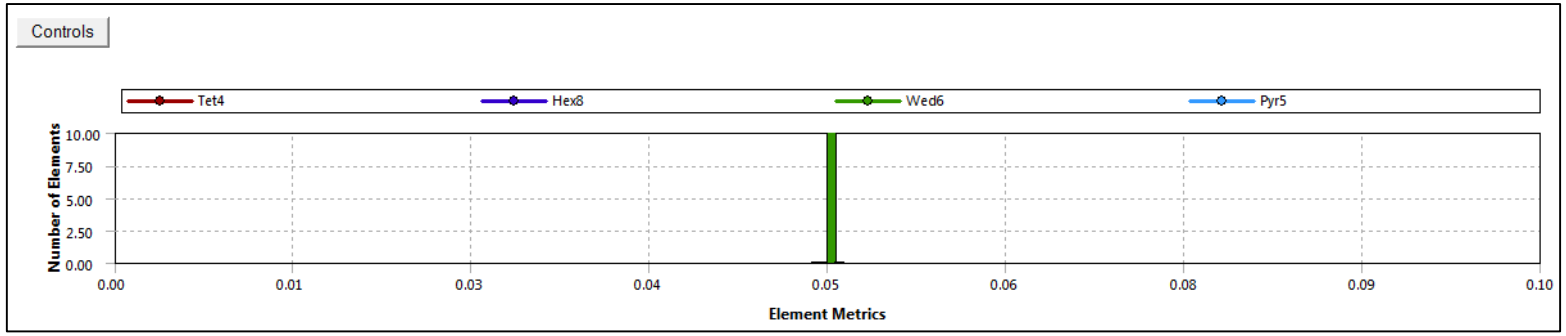
Check Quality (2)

Use the Mesh Metrics Graph to View Quality Ranges

- Click the Controls button in the Mesh Metrics Graph and set the Max value for the X-Axis to 0.1 and Number of Bars 1. Click Update Y-axis and exit the Controls Panel
- Select the bar in the Metrics Graph and view the Graphics Window to locate the small number of cells below a quality of 0.1 (Please note that you may have different results for Min & Max quality)







Improving Quality

- **On investigating the shown elements, it appears that the bad elements are in inflation layer near the sharp locations where some pipes meet central body**
- **We can change some Advanced options**
  - Under Inflation, select “View Advanced Options” to **Yes**
  - Change the Collision Avoidance method to “Stair Stepping” from “Layer Compression” and change the Max height to 0.7
  - This operation will delete the mesh (It will still be visible as Obsolete mesh in yellow color)
  - Now, from Meshing Worksheet, press Generate Mesh button This will recreate the mesh in meshing order as recorded earlier
  - Check Orthogonal Quality again. Min value is now above 0.1

Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	Yes
Collision Avoidance	Stair Stepping
Gap Factor	0.5
Maximum Height over Base	0.7
Growth Rate Type	Geometric
Maximum Angle	140.0 °
Fillet Ratio	1
Use Post Smoothing	Yes
Smoothing Iterations	5

Statistics	
Nodes	87314
Elements	186348
Mesh Metric	Orthogonal Quality
Min	0.13179
Max	0.99998
Average	0.87764
Standard Deviation	0.11448

Save the Project

- This completes the workshop
- From the main menu select File → Close Meshing
  - Workbench will save any application data

- From the Workbench Project Page use the file menu and save the project as “AMWS4.1_cfd.wbpj” to your working folder