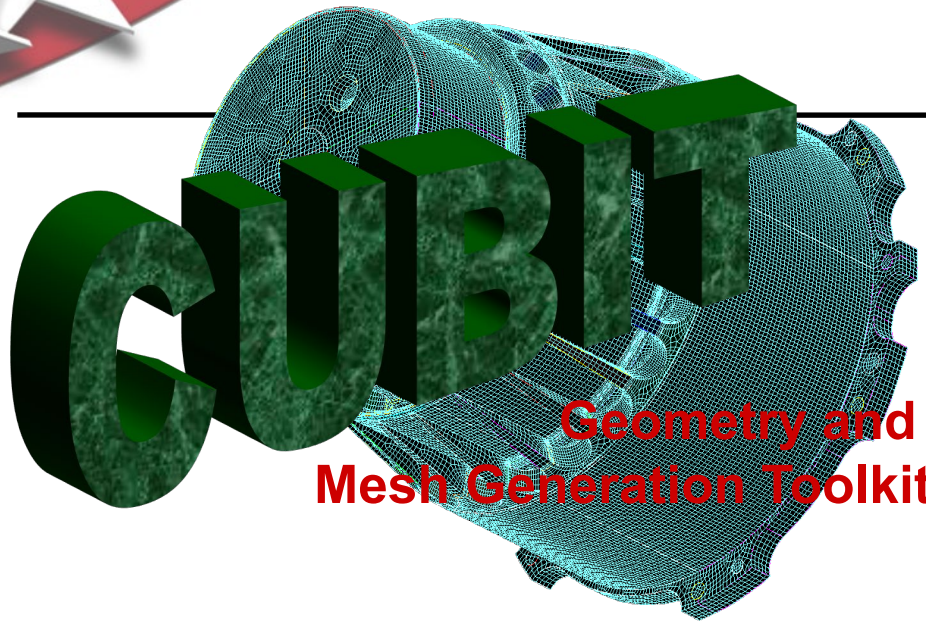

Simulation Modeling Sciences

CUBIT Fast-Start Tutorial

11. Mesh Control

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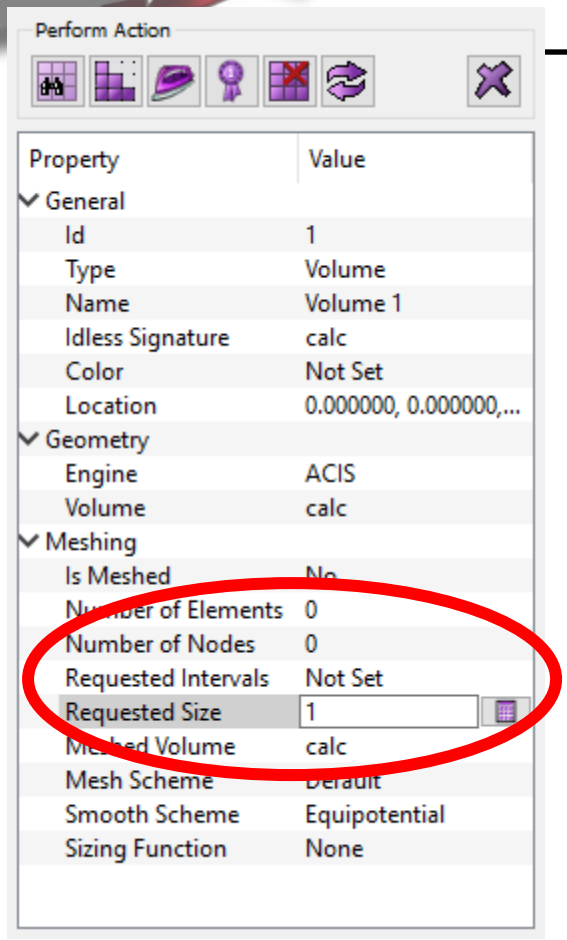
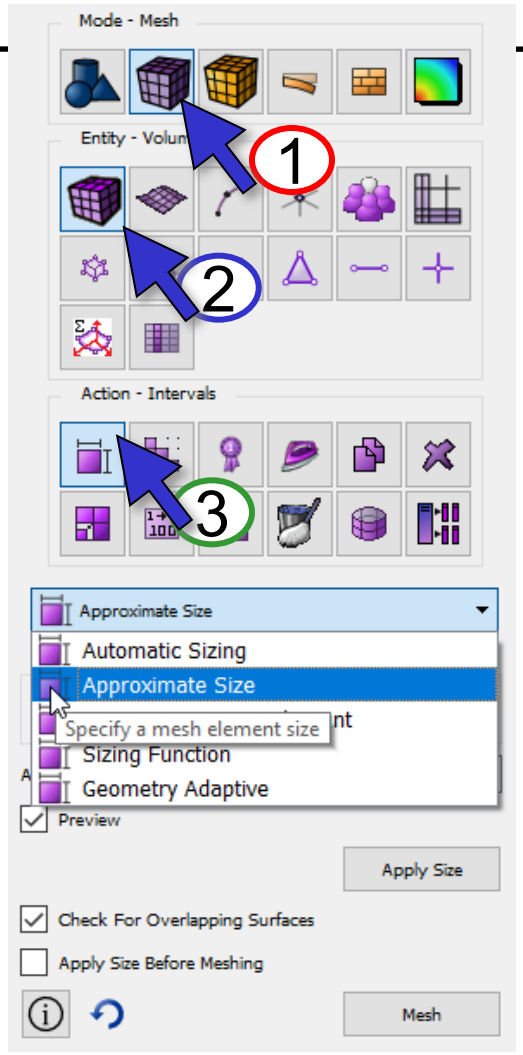
Mesh Sizing



Mesh size can be set on geometry entities from property panel



Mesh Size Command Panels

Simulation Modeling Sciences

Mesh size is an attribute of the geometry. Select entity then set attribute

Automatic Sizing: relative value
- 1 = fine mesh
- 10 = coarse mesh
- Good way to preview element sizes

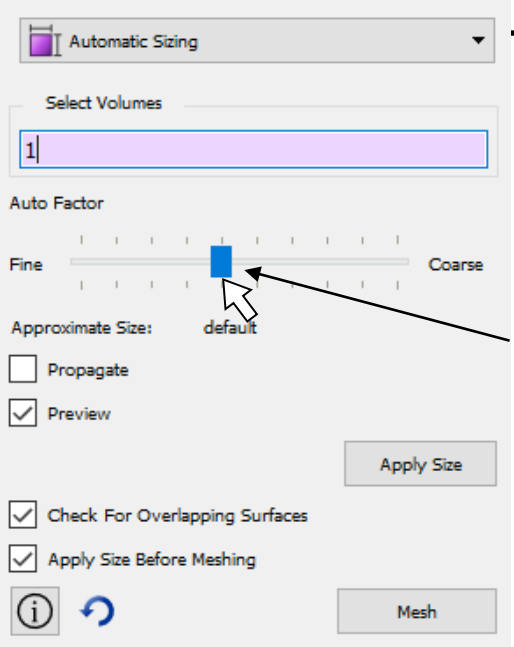
Approximate Size: mesh algorithms will try to maintain constant edge length

Approximate Interval Count: number of intervals on a curve. Will match approximately

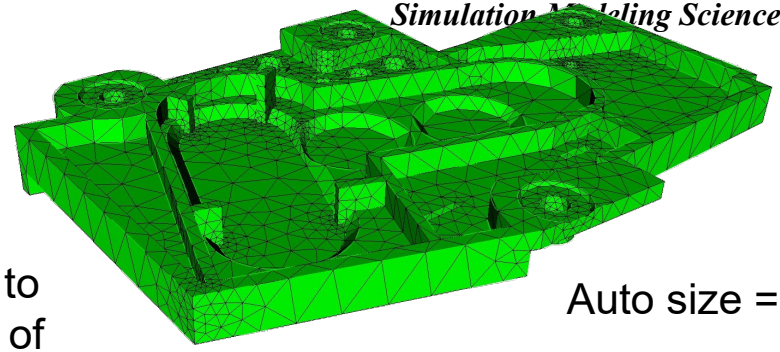
Sizing Function: Specify a sizing function.

Geometry Adaptive: Size based on geometry characteristics.

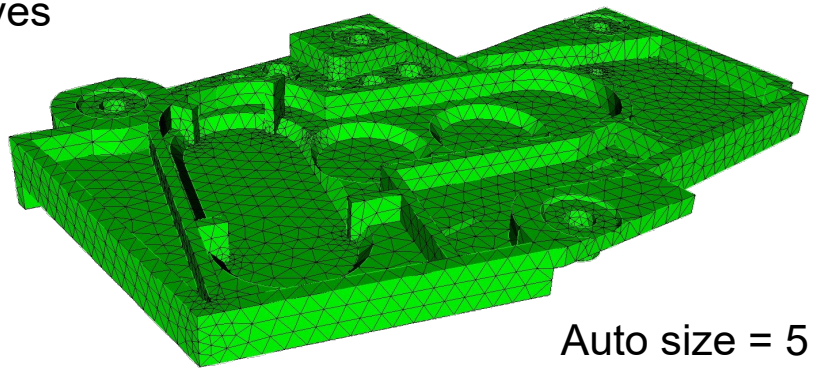
Auto Mesh Sizing



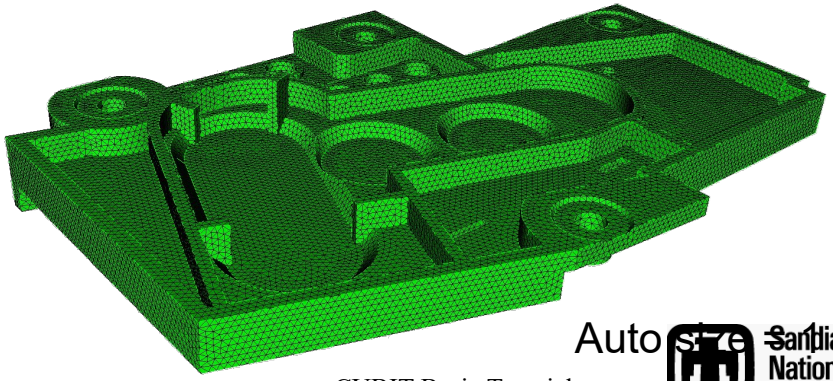
Move slider to see preview of mesh on curves



Auto size = 7



Auto size = 5



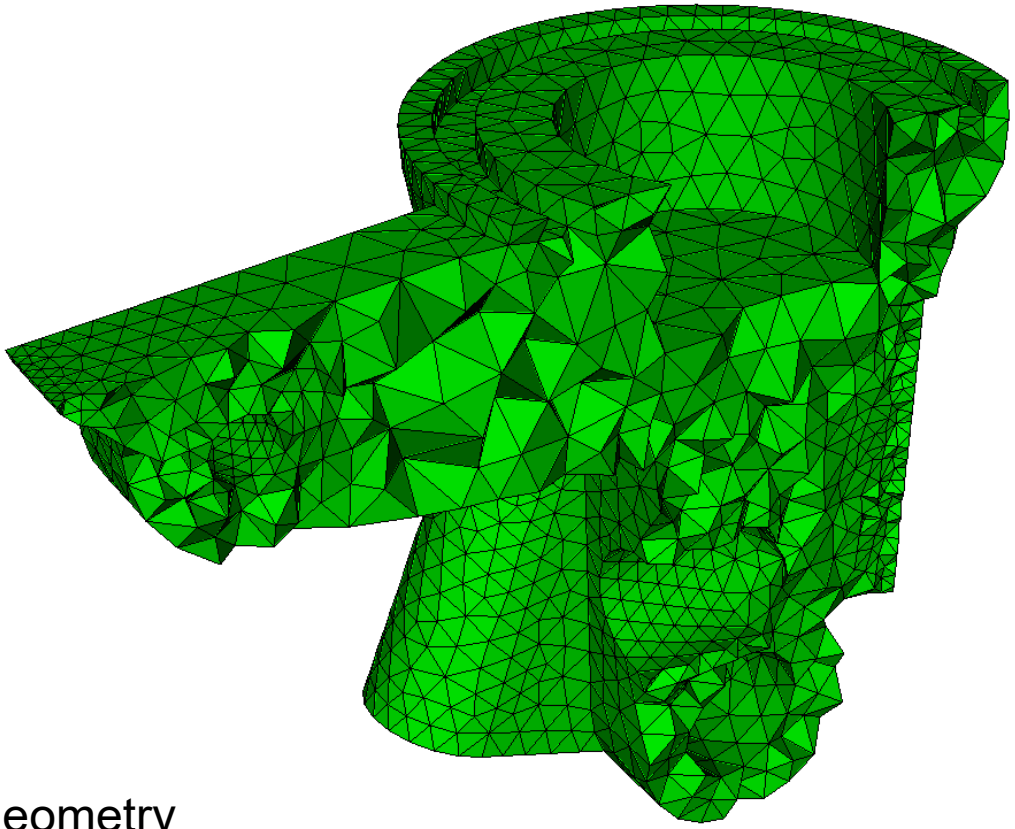
Auto size = 1

No need to know exact size of elements

Uses heuristic to compute size of element

If no size has been set, CUBIT will compute an auto mesh size=5

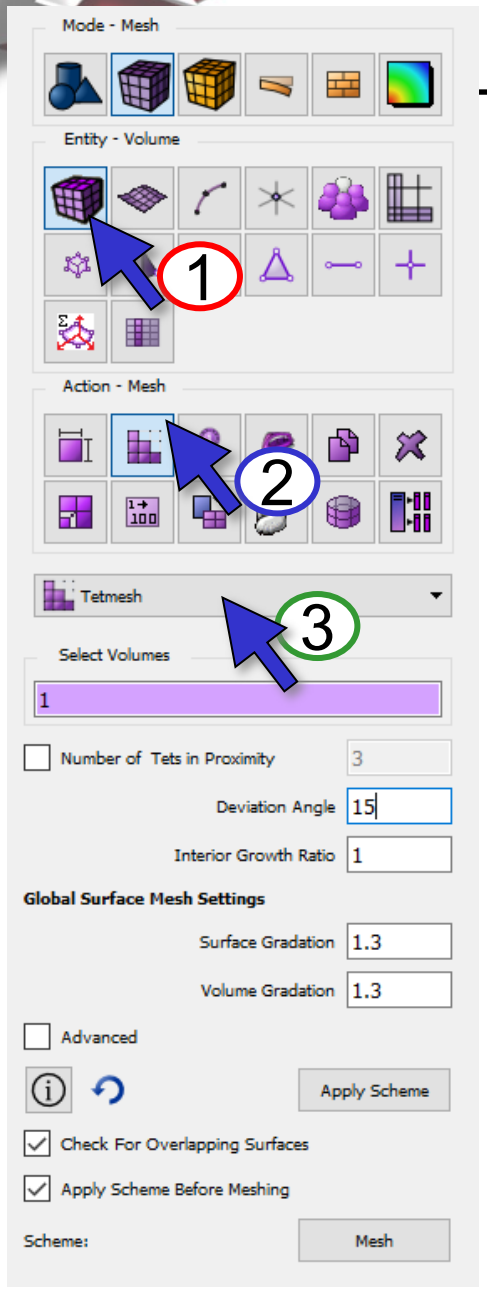
TetMesh Scheme

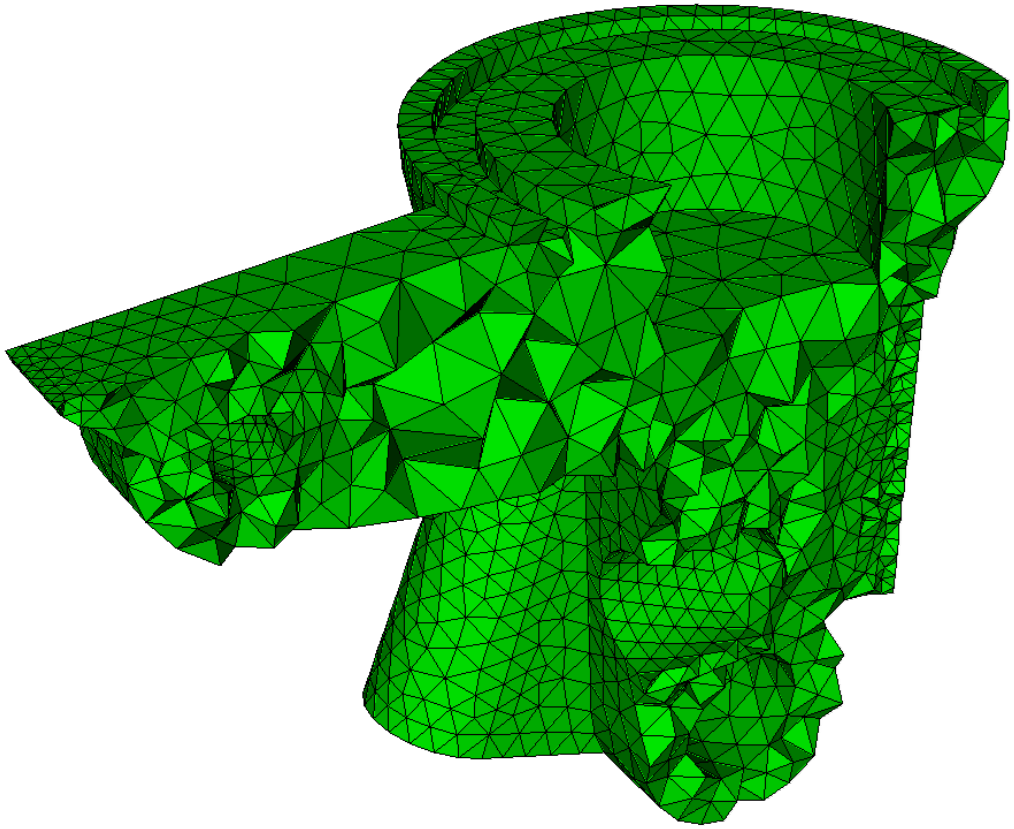


- Arbitrary geometry
- Mostly push-button/automatic
- May still require geometry clean-up

TetMesh Scheme

Simulation Modeling Sciences





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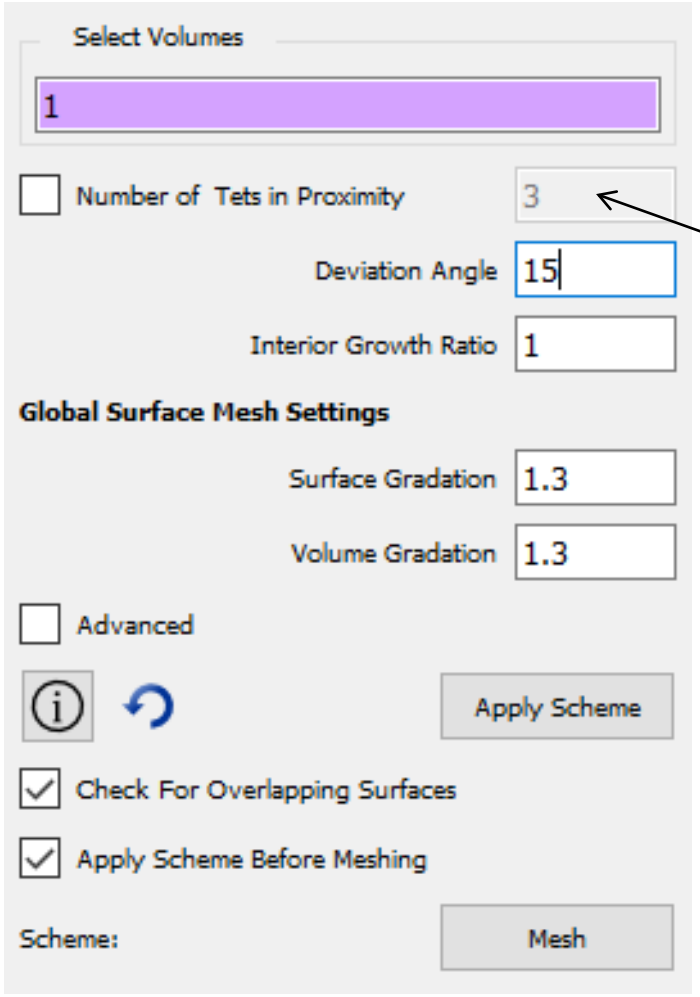
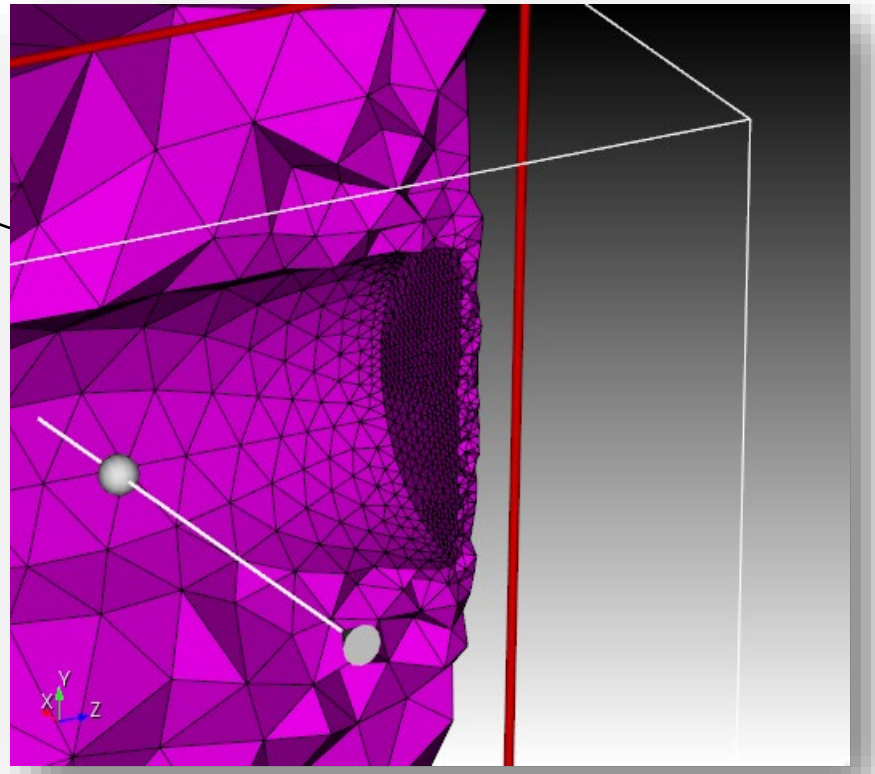
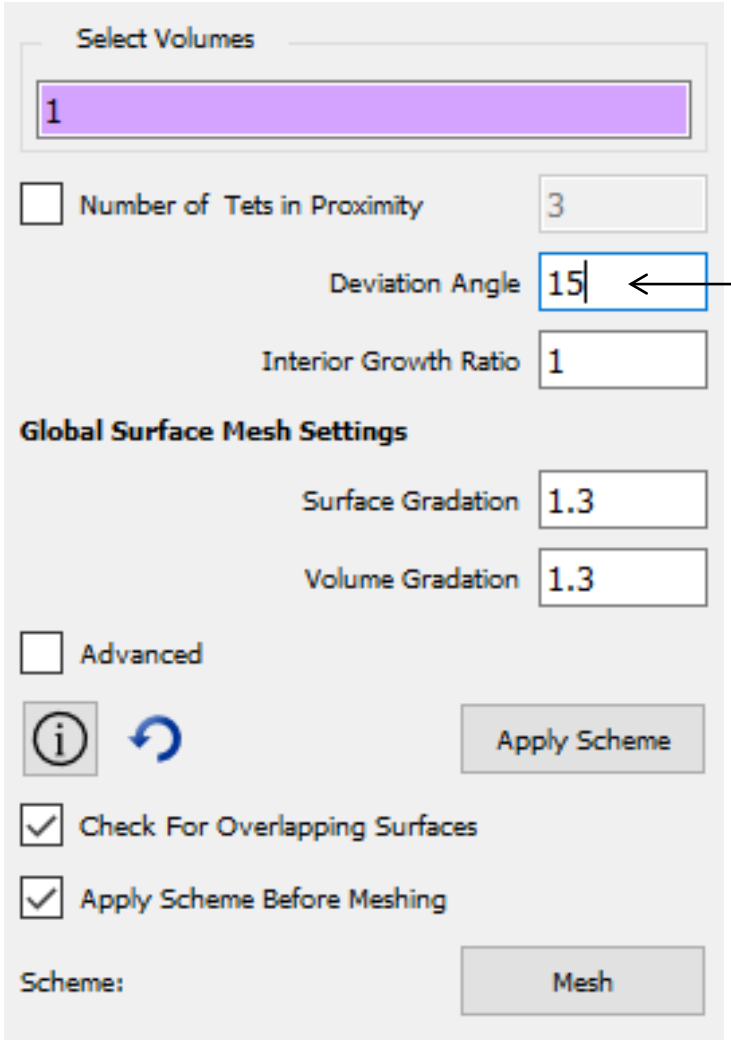
TetMesh Scheme

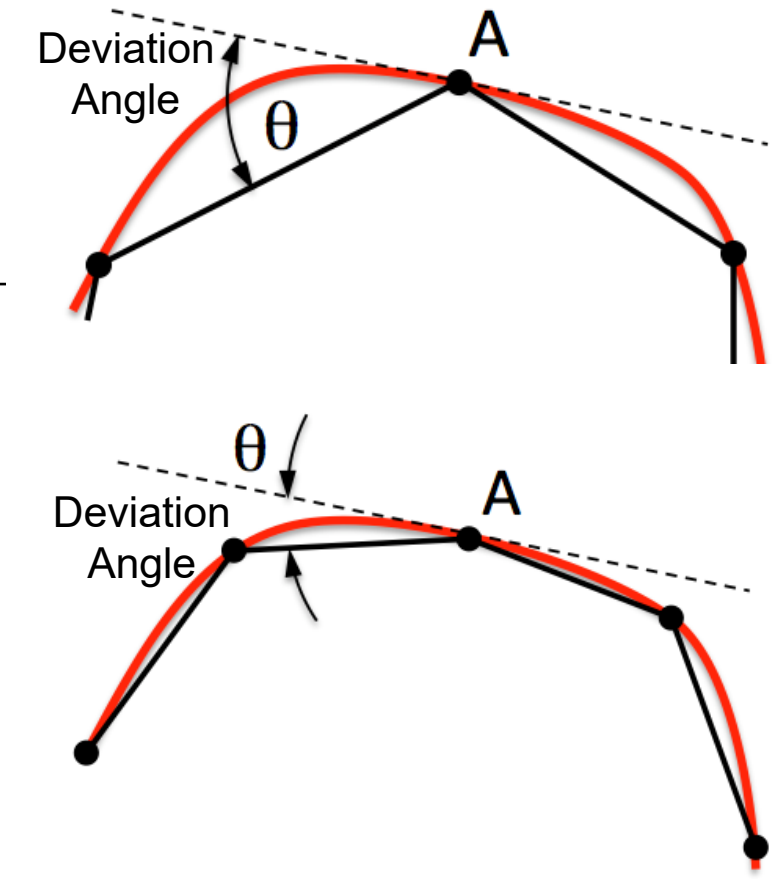




Number of Tets in Proximity

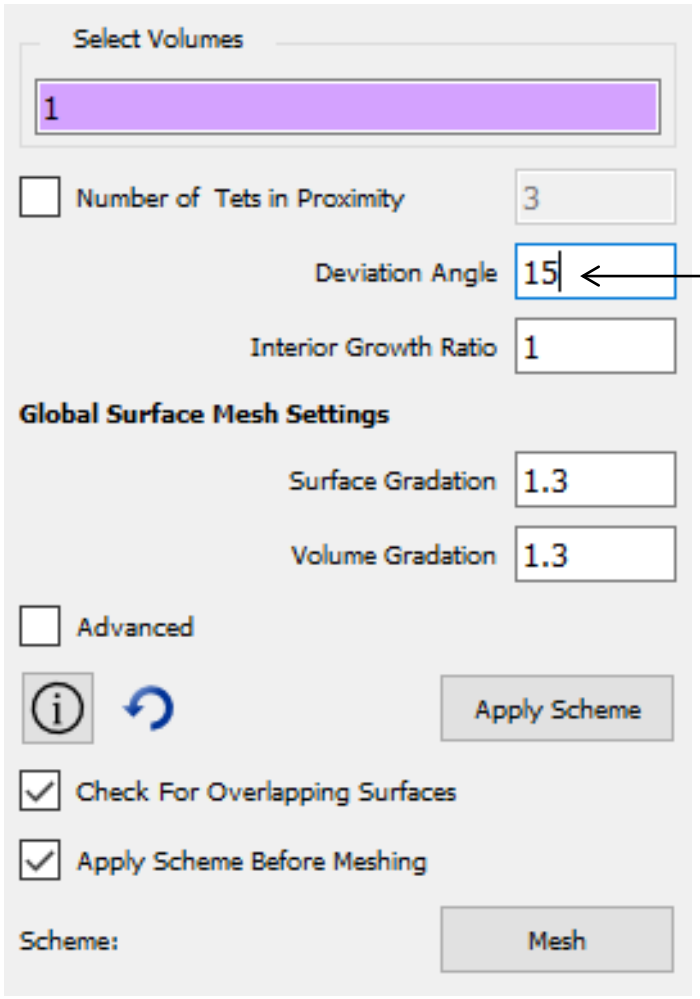
TetMesh Scheme

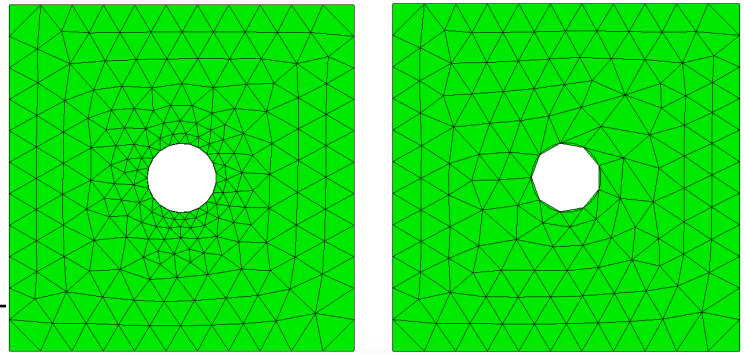


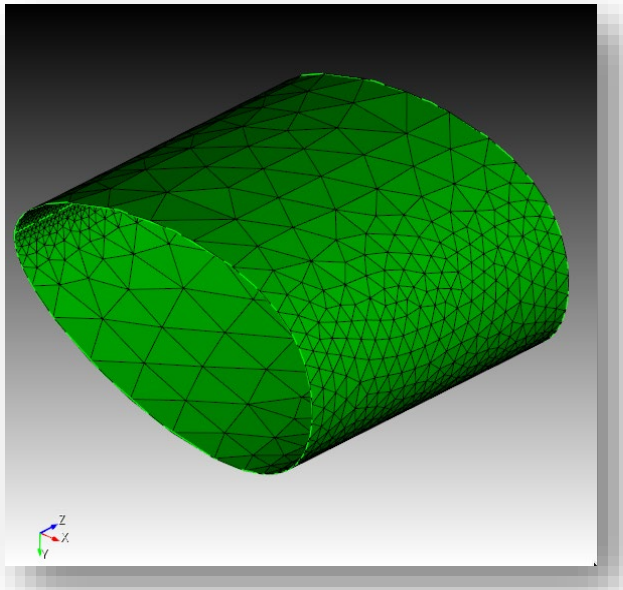


Deviation Angle (Geometry Approximation Angle)

TetMesh Scheme

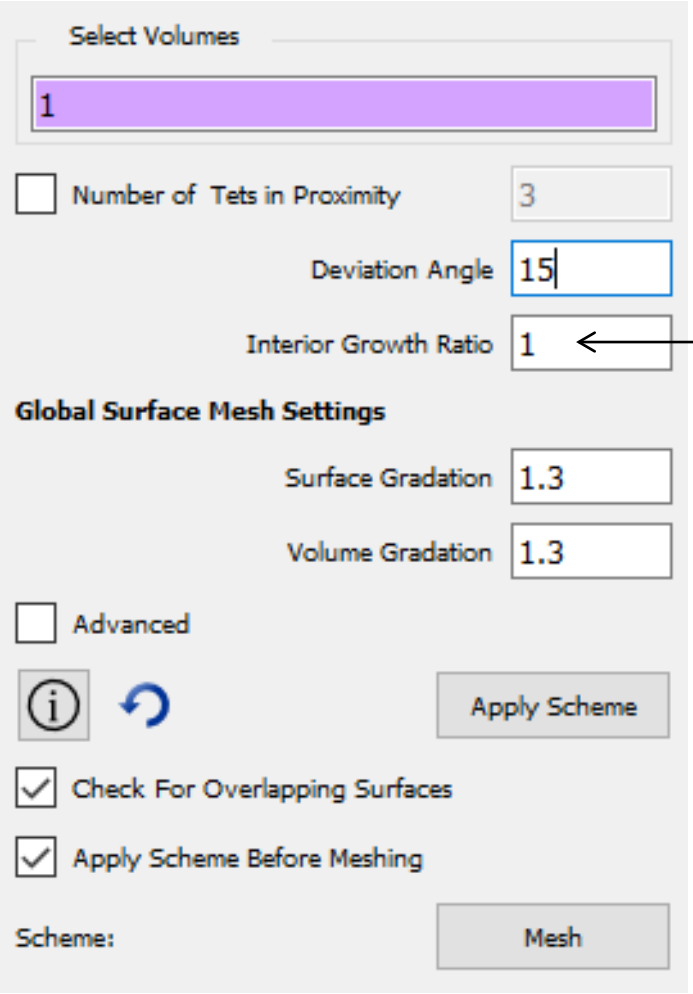


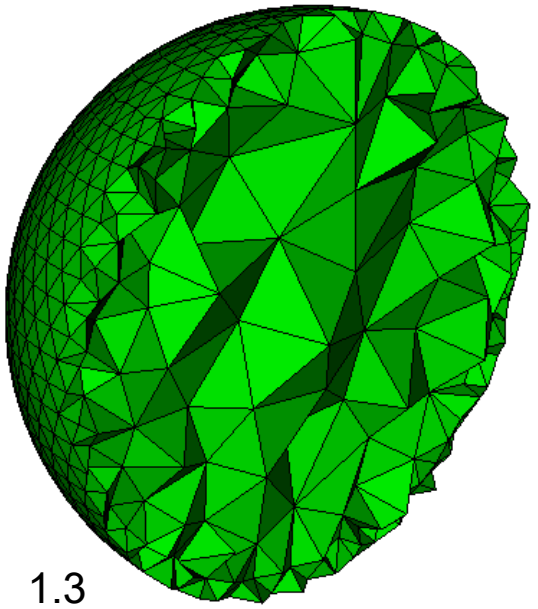




Deviation Angle (Geometry Approximation Angle)

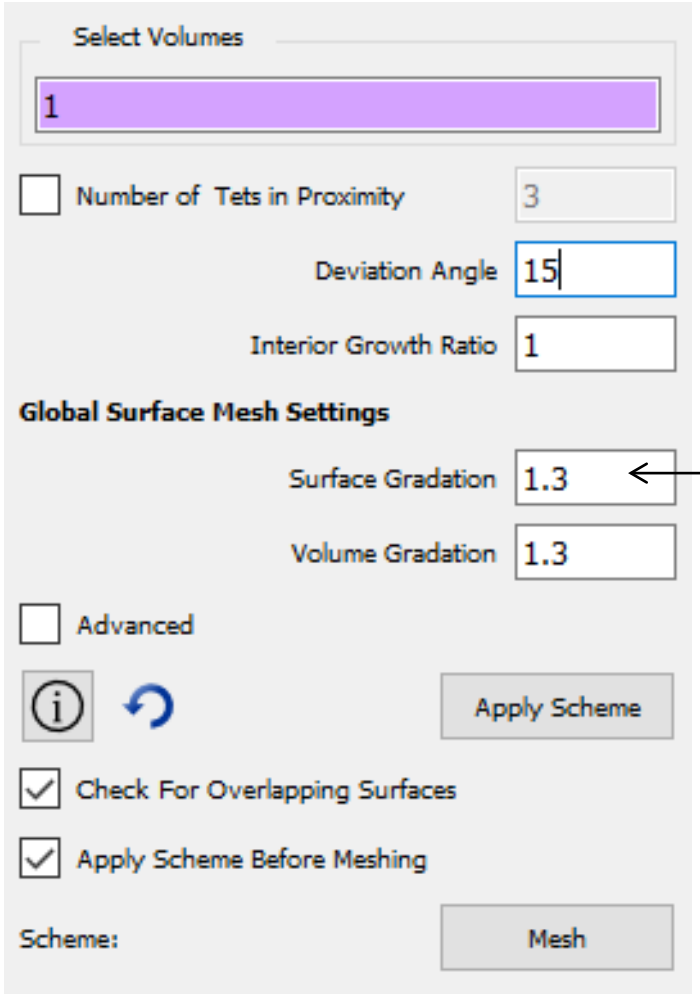
TetMesh Scheme

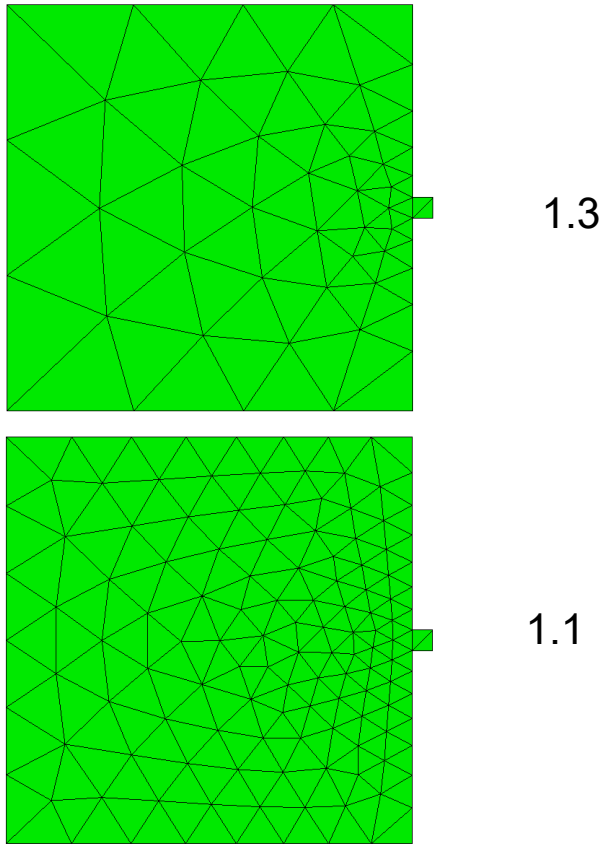




Interior Growth Ratio

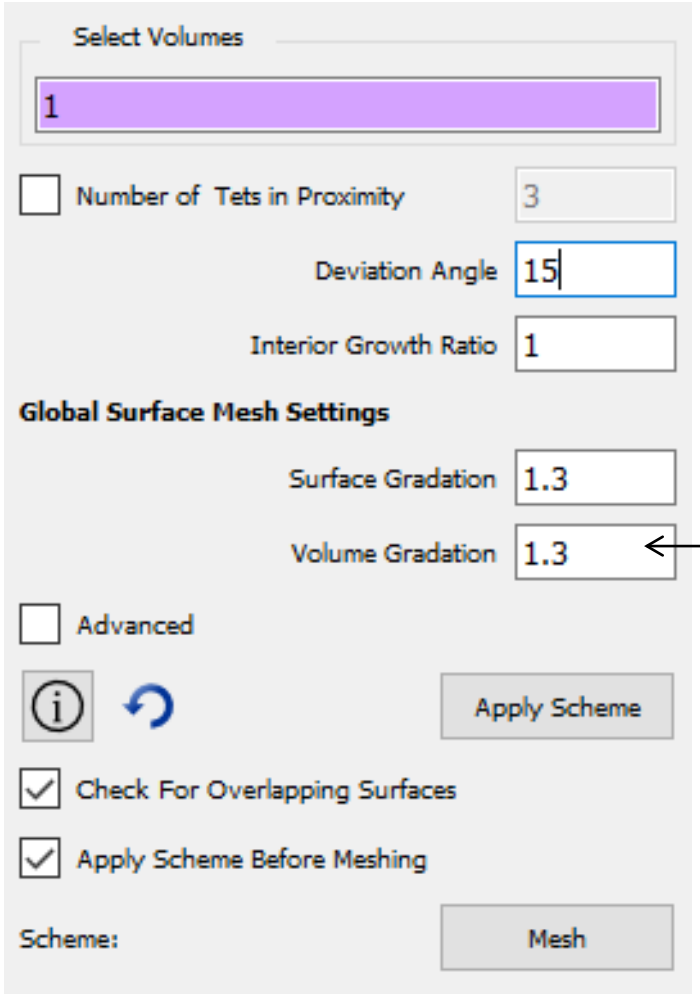
TetMesh Scheme

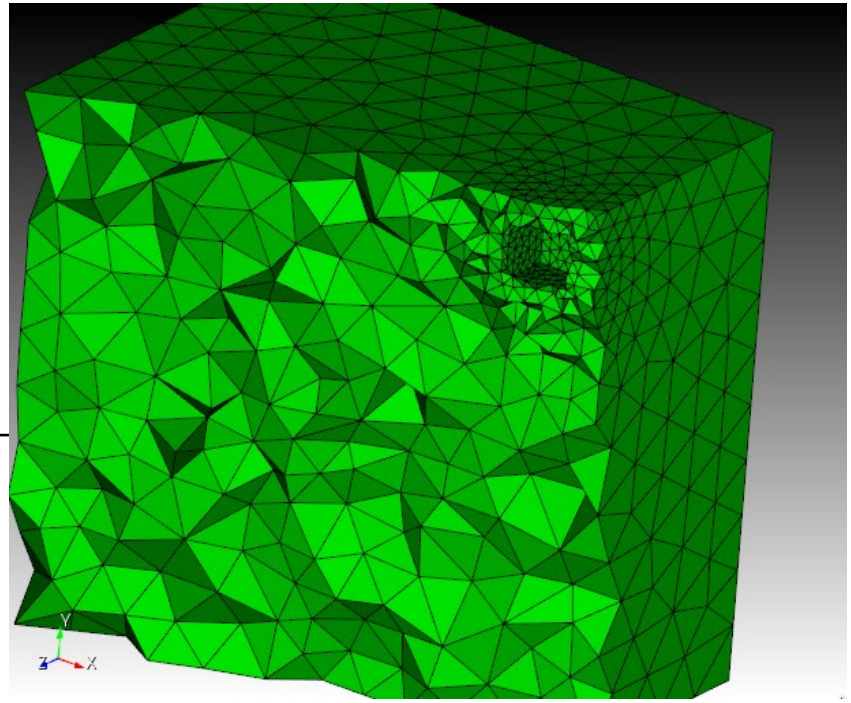




Surface Gradation

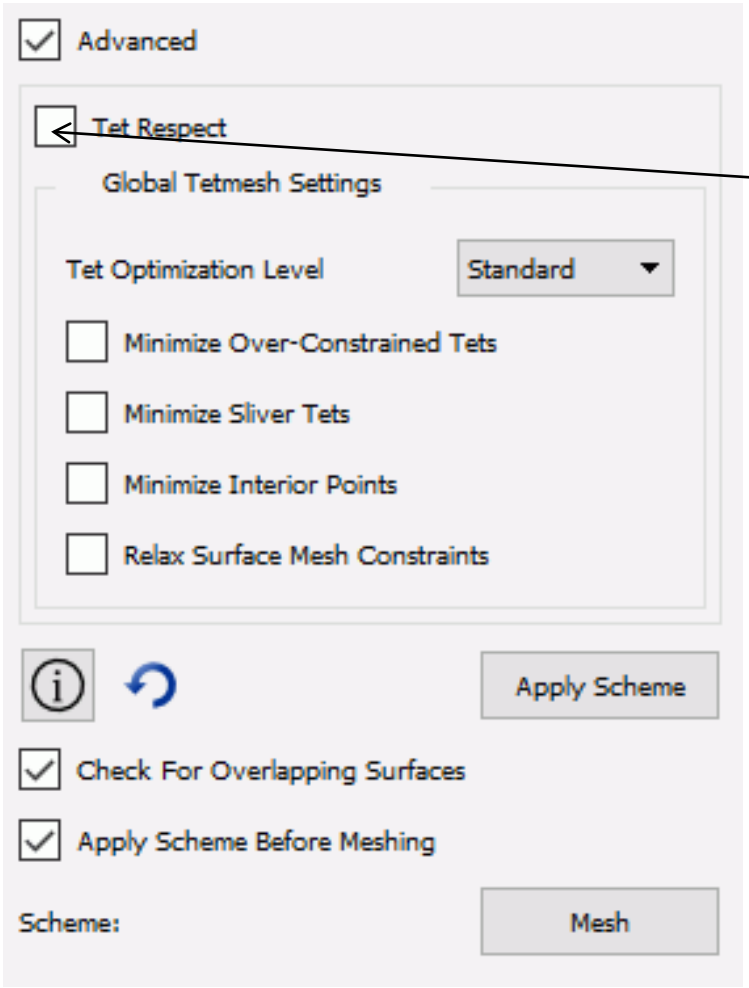
TetMesh Scheme





Surface Volume Gradation

TetMesh Scheme



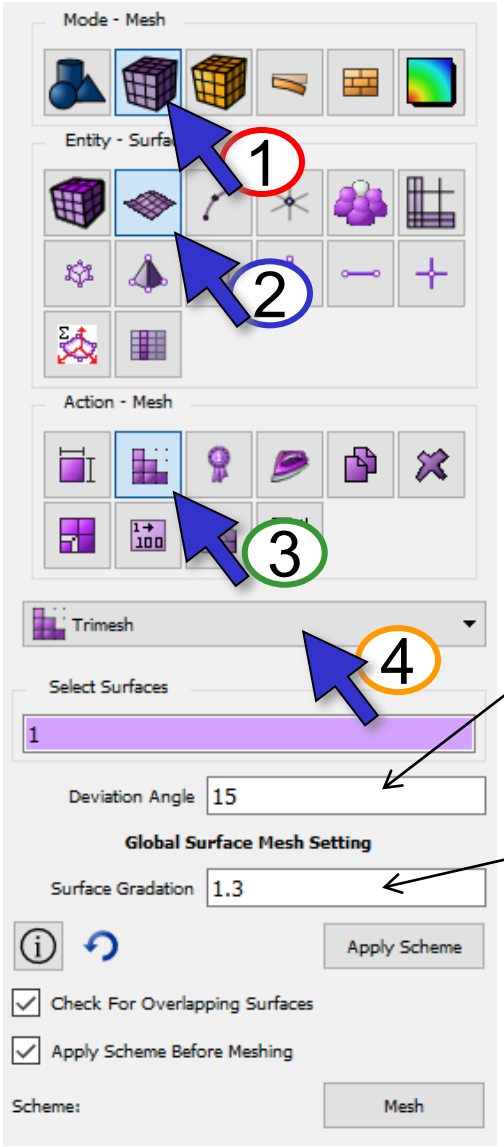
Tet Respect: Force TetMesh to conform to internal features (specified here)

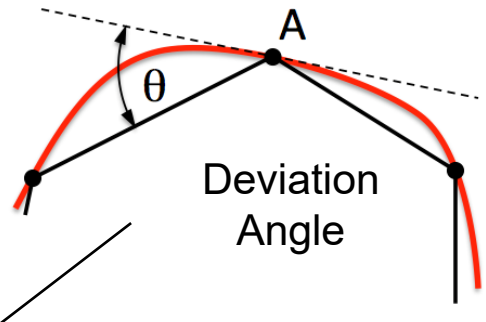
Tetmesh Global Settings
Mesh Optimization settings not normally changed

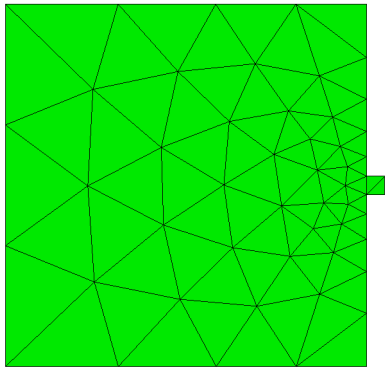
TriMesh Scheme

TriMesh Scheme: Settings on Volume (TetMesh Scheme) are by default propagated to surfaces

Normally no reason to set Trimesh Scheme separately

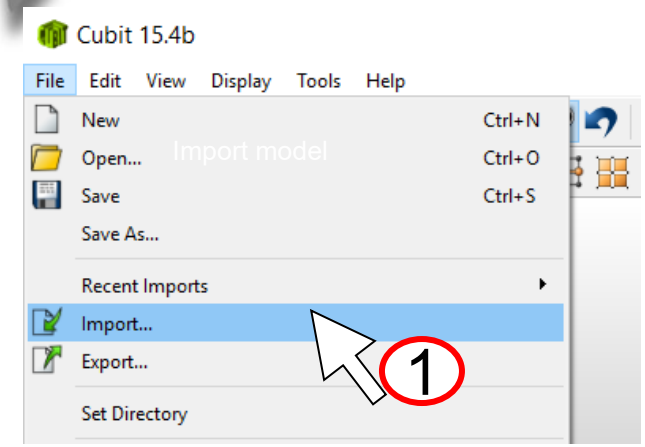




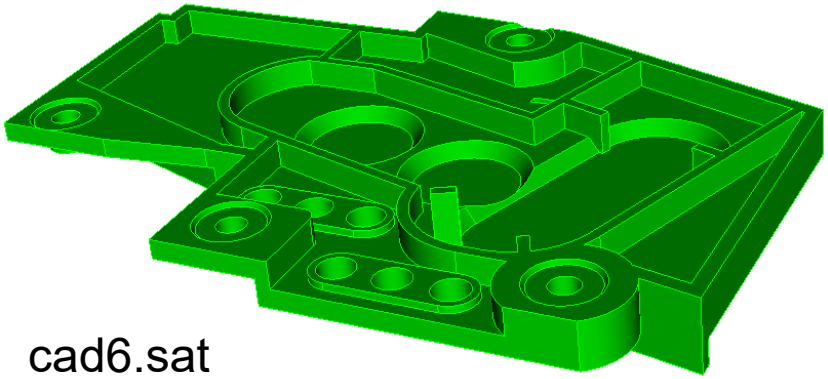


Surface Gradation

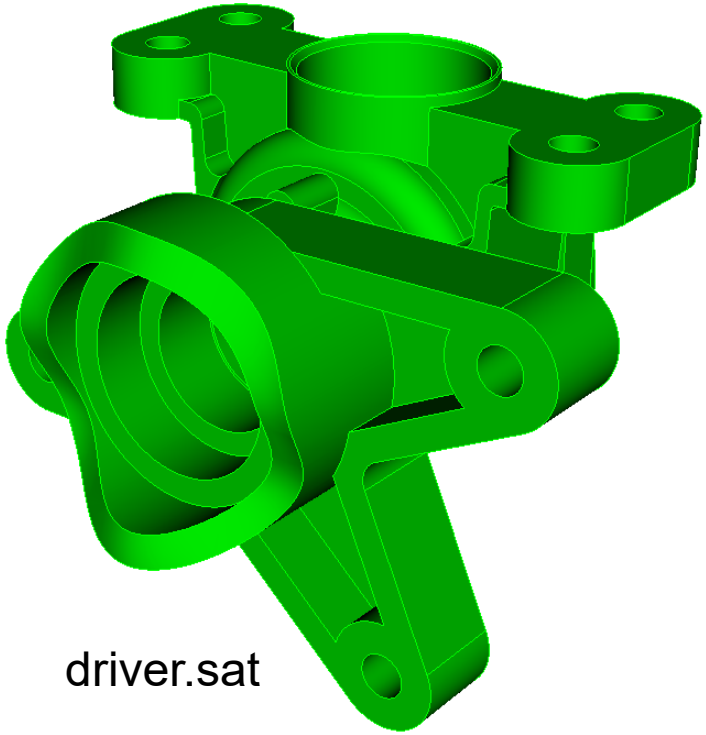
Exercise 1: Tet meshing



1 Import ACIS file driver.sat OR cad6.sat

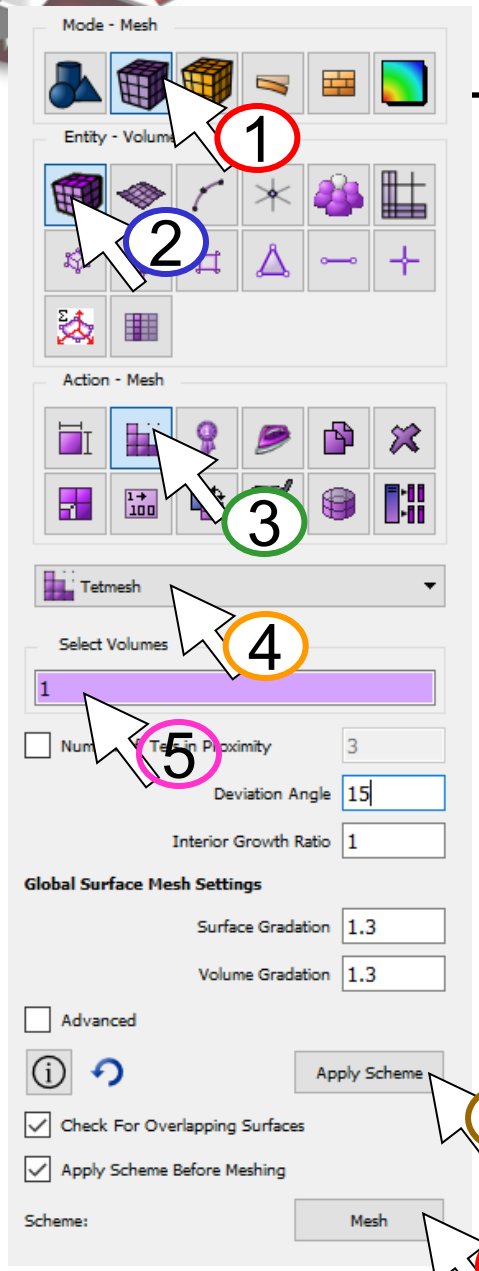


cad6.sat

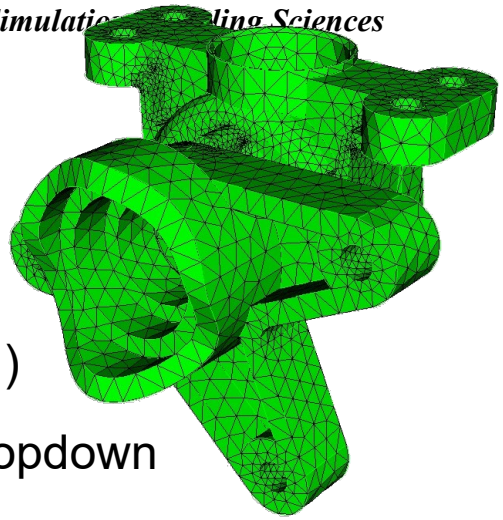


driver.sat

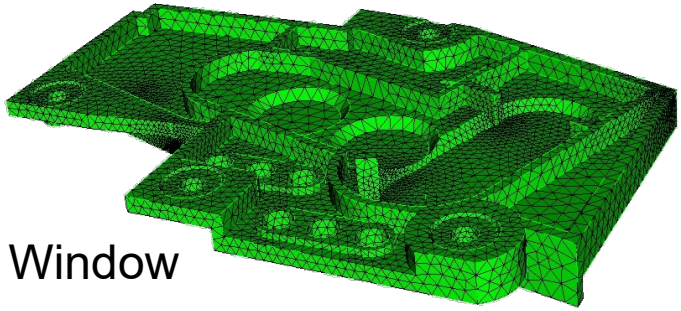
Exercise 1: Tet meshing



1. Mode - Mesh
2. Entity - Volume
3. Action - Mesh
4. Select Volume to Mesh (1)
5. Choose Tetmesh from Dropdown
6. Apply the Tetmesh Scheme
7. Click the Mesh Button



OR



From Cubit Command Window

Volume 1 scheme tetmesh

Mesh Volume 1

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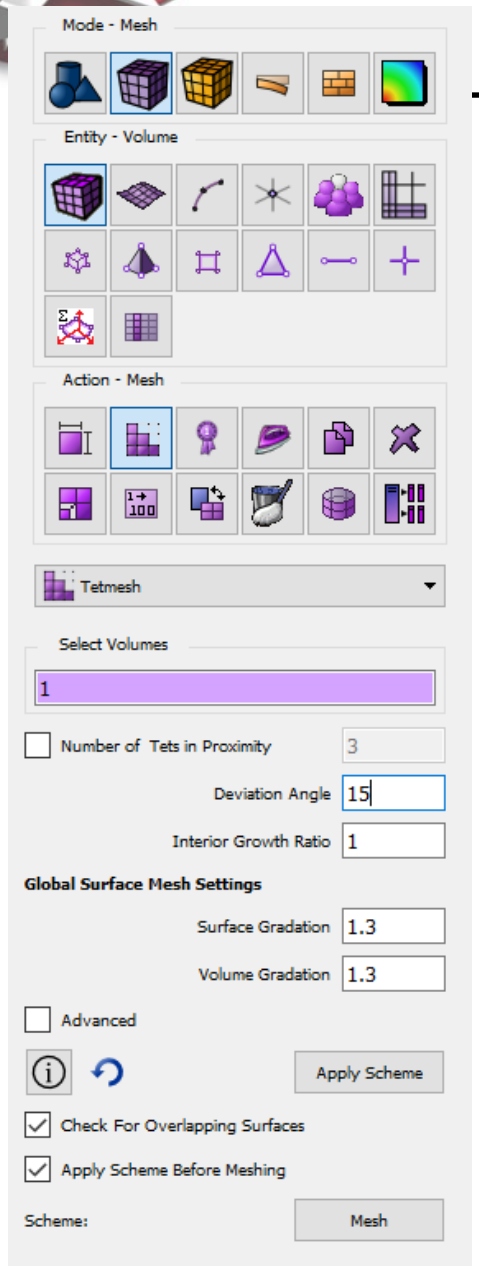
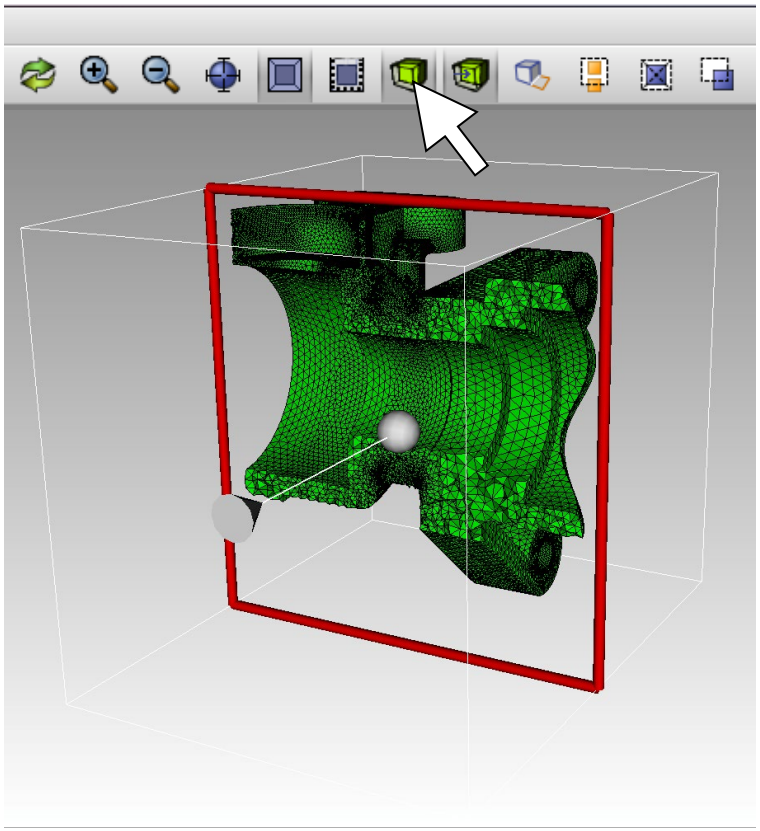
Exercise 1: Tet meshing

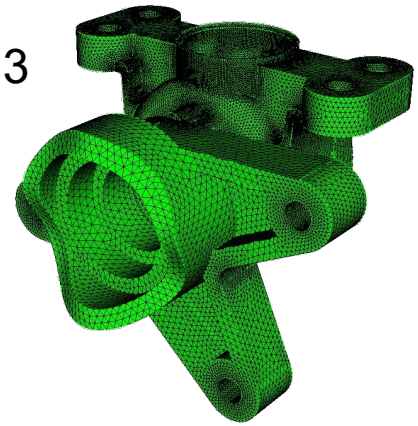
Simulation Modeling Sciences

Modify the following parameters and observe the changes to the mesh

1. Number of Tets in Proximity = 3
2. Deviation angle = 5
3. Surface Gradation = 1.2







Use the slice tool to see the interior of the mesh

From the command line:

draw tet all

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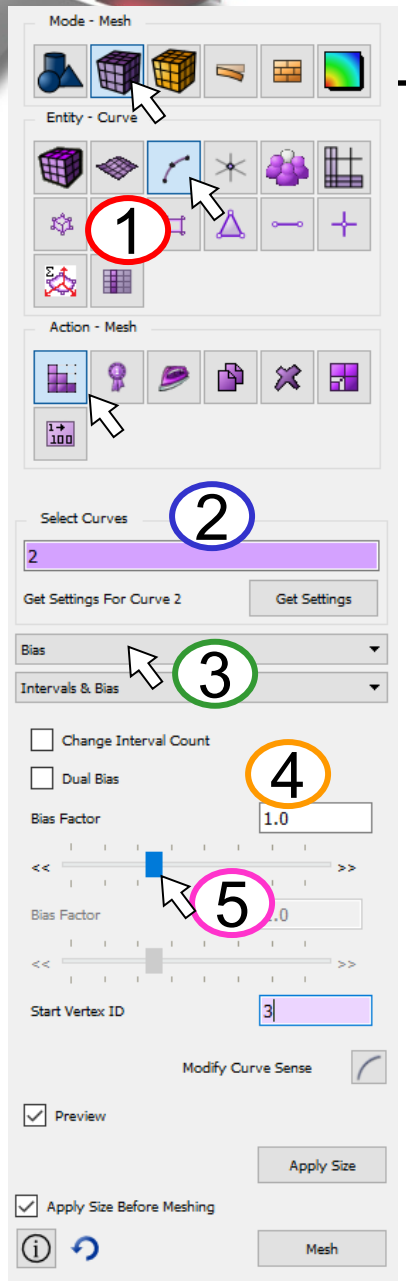
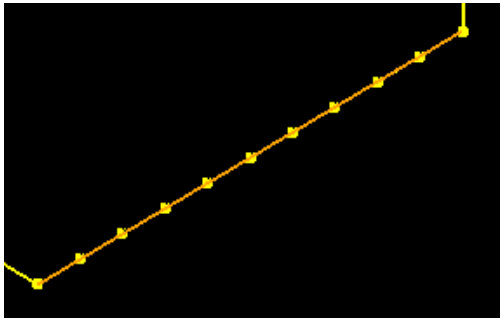
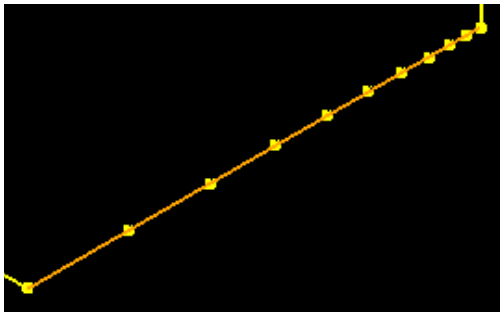
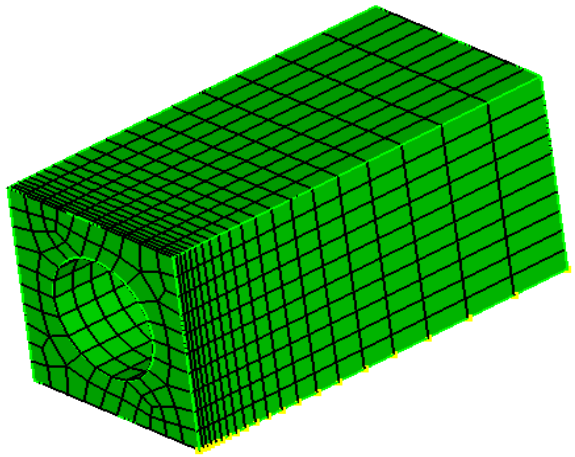
Curve Biasing



1. Navigate to Curve Bias Panel
2. Pick a Curve.
3. Select *Bias* and *Intervals & Bias*
4. Set number of intervals, start vertex, etc..
5. Adjust slide bar to preview







Propagate Curve Bias

Choose from Bias Scheme on GUI panel 3

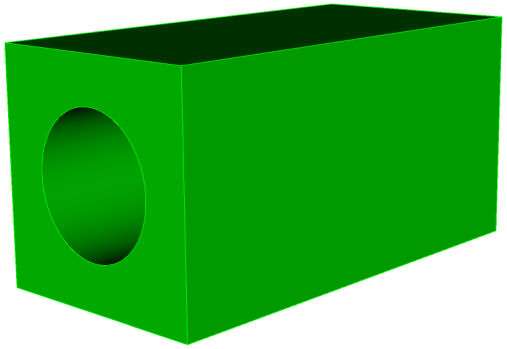
Mesh Control Exercise 2

1. Create the simple model shown using the GUI or command line

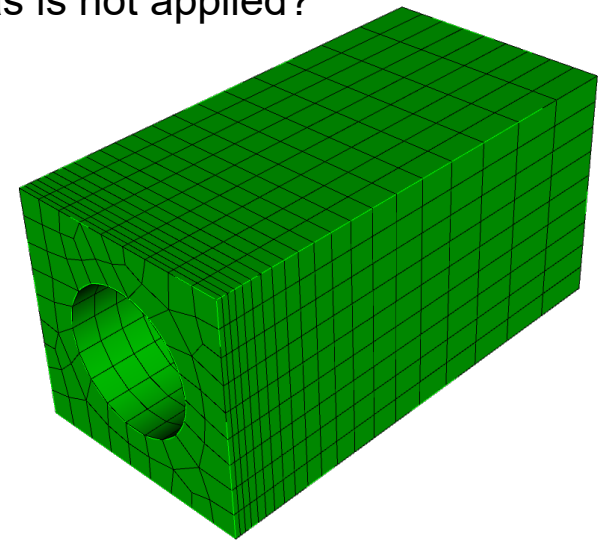
2. Use the procedure shown in the previous slide to generate a biased mesh

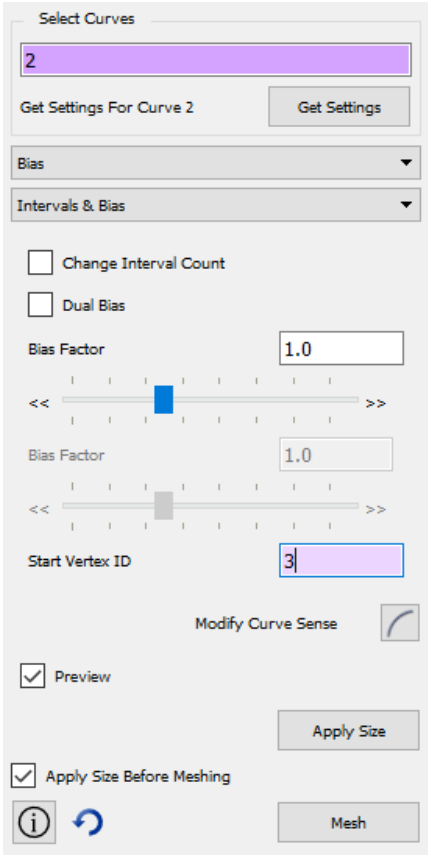
3. Experiment with different options of curve bias

Brick x 10 y 10 z 20
Create cylinder height 25 rad 3
Subtract vol 2 from vol 1



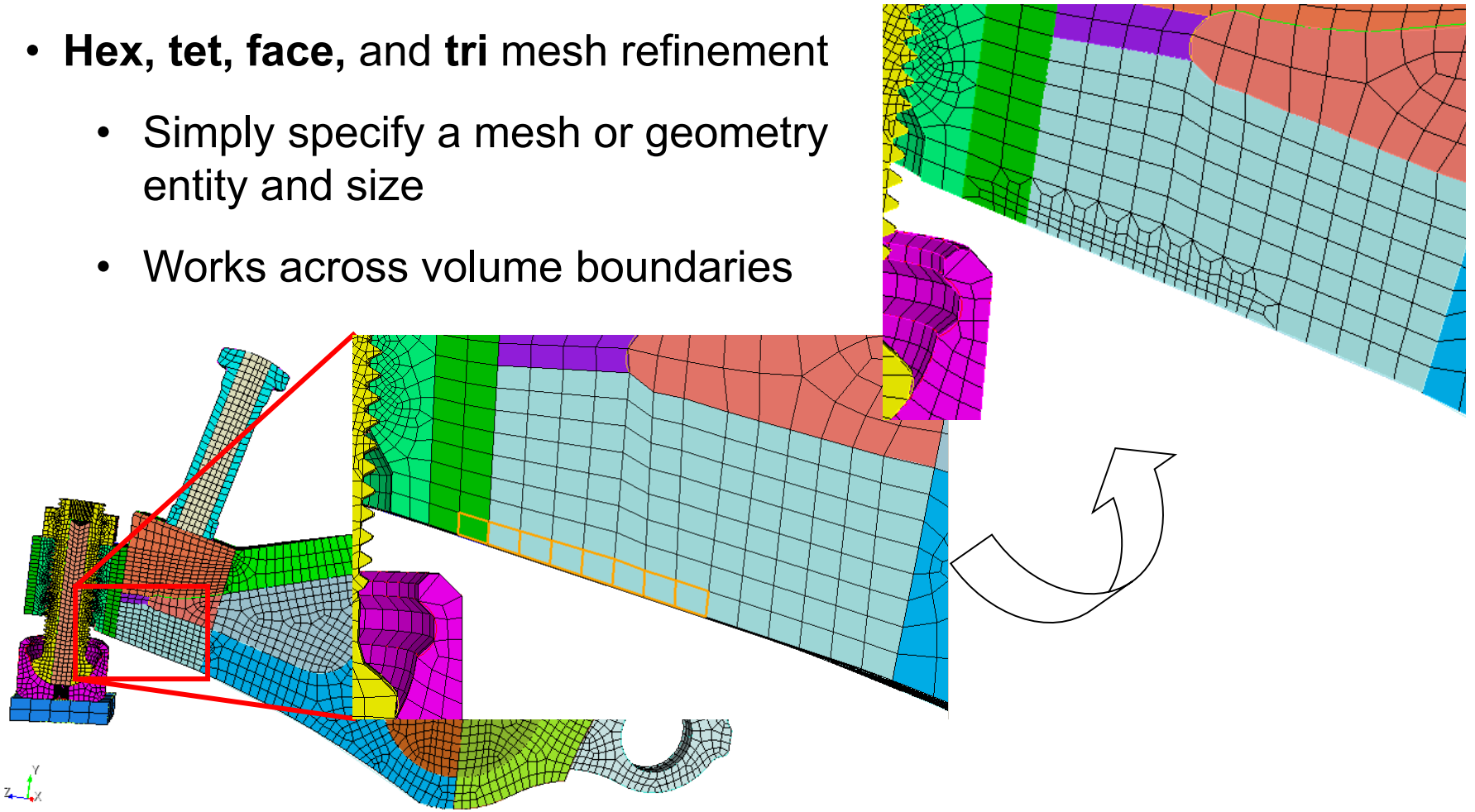
What happens if propagate curve bias is not applied?



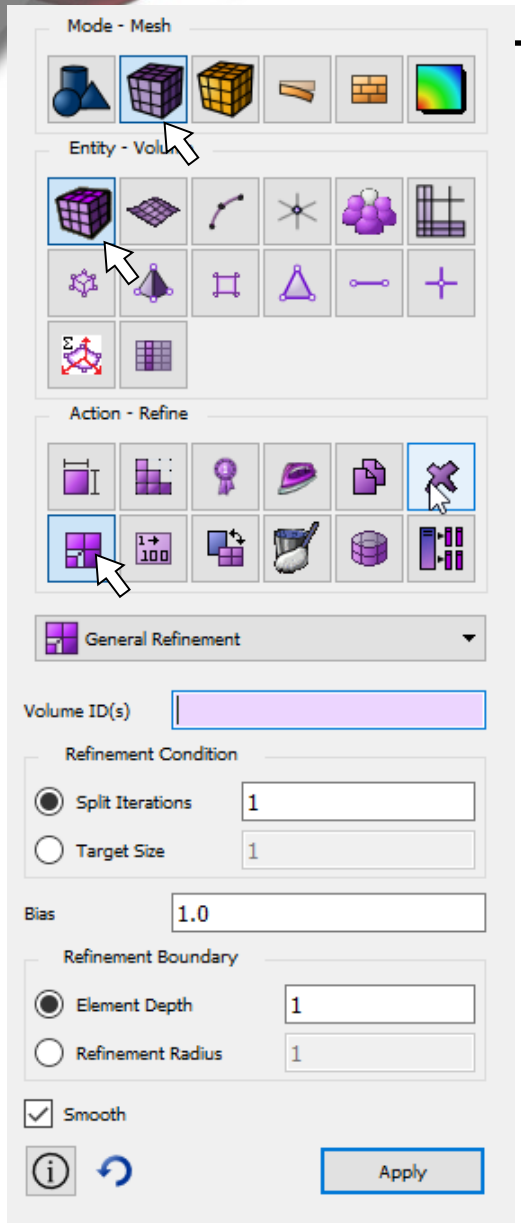


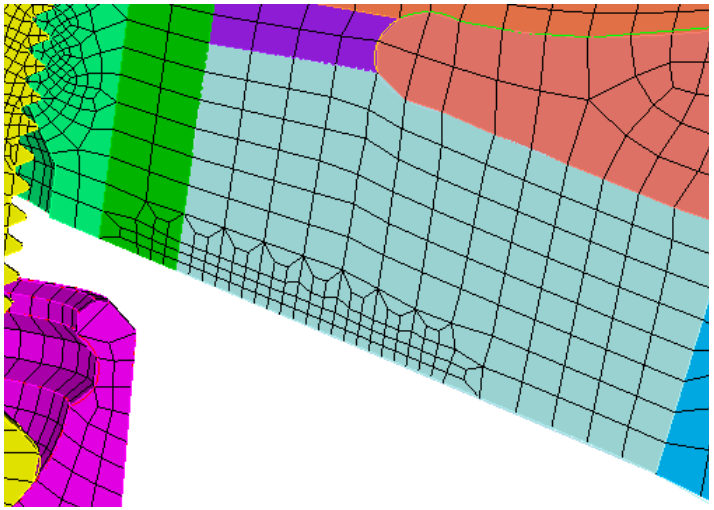
Mesh Refinement

- **Hex, tet, face,** and **tri** mesh refinement
  - Simply specify a mesh or geometry entity and size
  - Works across volume boundaries



Mesh Refinement





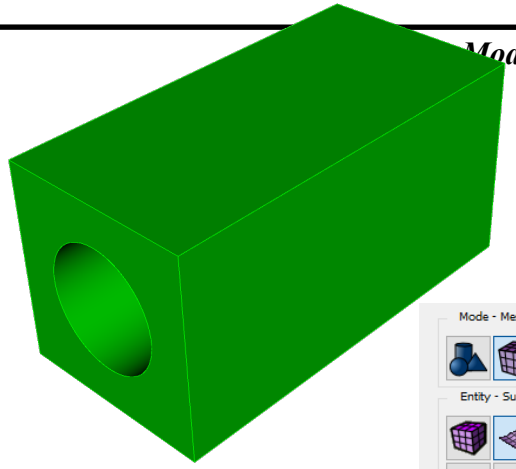
```
Refine {Node|Edge|Tri|Face|Tet|Hex}
<range>     [NumSplit <int = 1>|Size
<double> [Bias <double>]]     [Depth
<int>|Radius <double>] [Sizing_Function]
[no_smooth]

Refine {Vertex|Curve|Surface|Volume}
<range>     [NumSplit <int = 1>|Size
<double> [Bias <double>]]     [Depth
<int>|Radius <double>] [Sizing_Function]
[no_smooth]
```

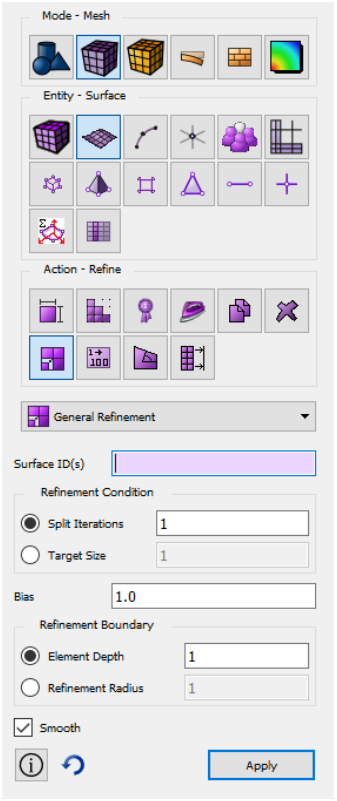
Mesh Control Exercise 3

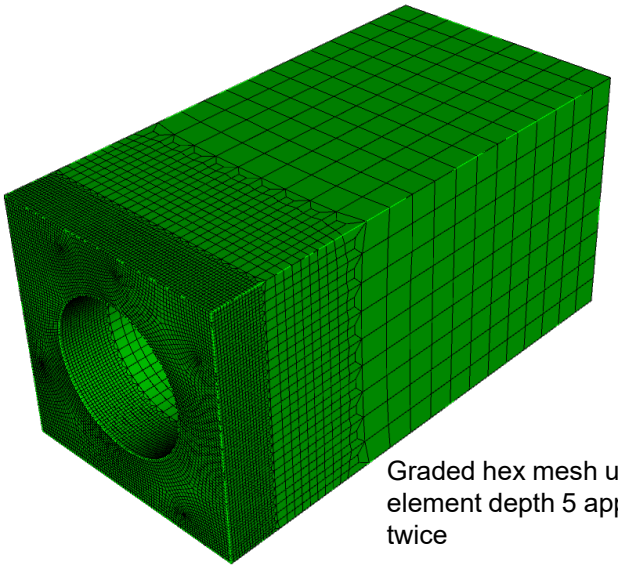
1. Use the same model you created for exercise 2 and reset the volume

2. Use the refine surface command panel to generate a graded hex mesh. Try an element depth of **5**.

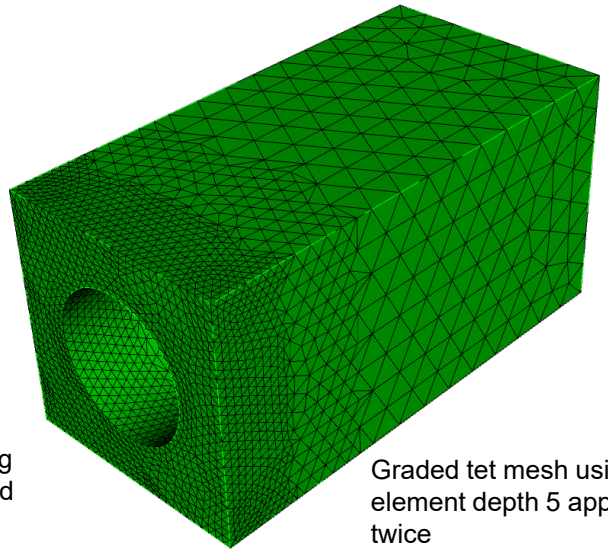
3. Reset the volume, generate a tet mesh and use the same tool to generate a graded tet mesh







Graded hex mesh using element depth 5 applied twice



Graded tet mesh using element depth 5 applied twice

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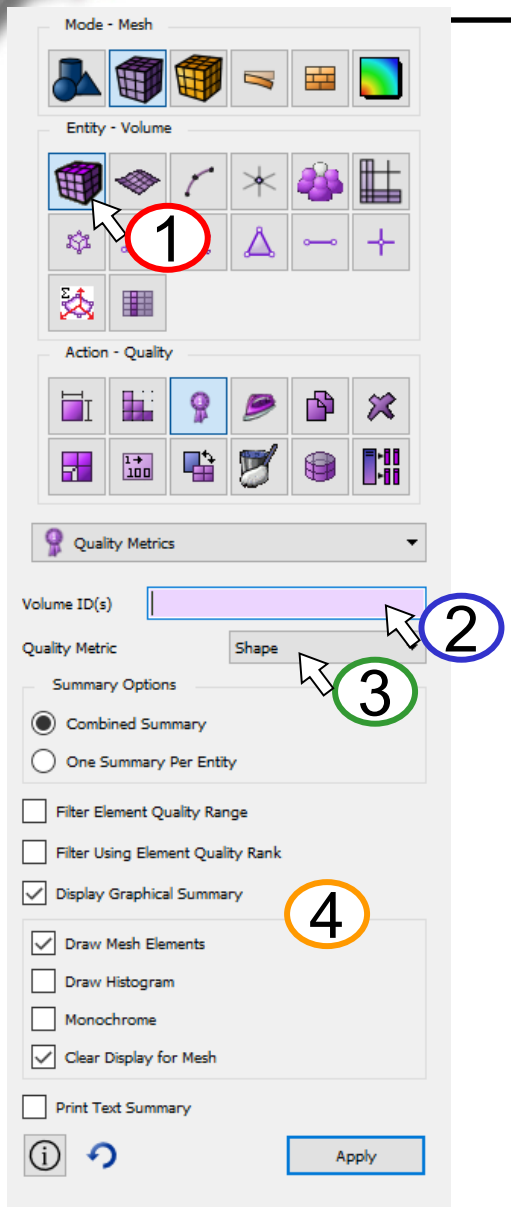
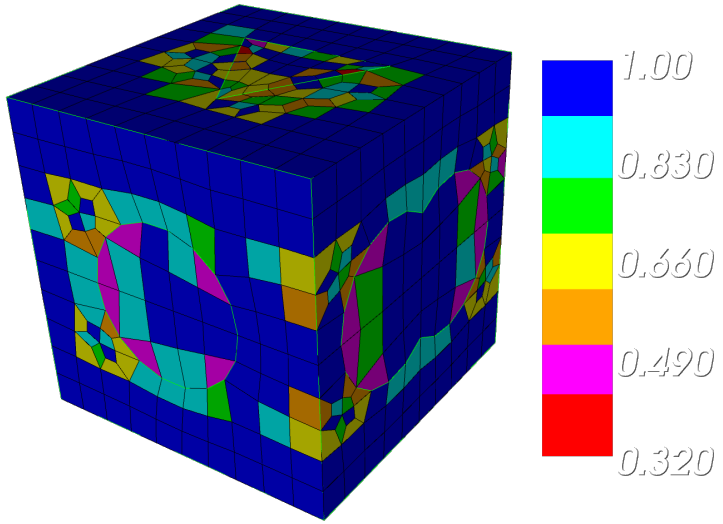
Mesh Quality Command Panel



1. Navigate to Mesh Quality Panel

Note that this panel is available for volumes, surfaces and elements

2. Select a meshed volume to examine
3. Select *a Quality Metric*
4. Select the options for displaying the metrics



Quality Metrics

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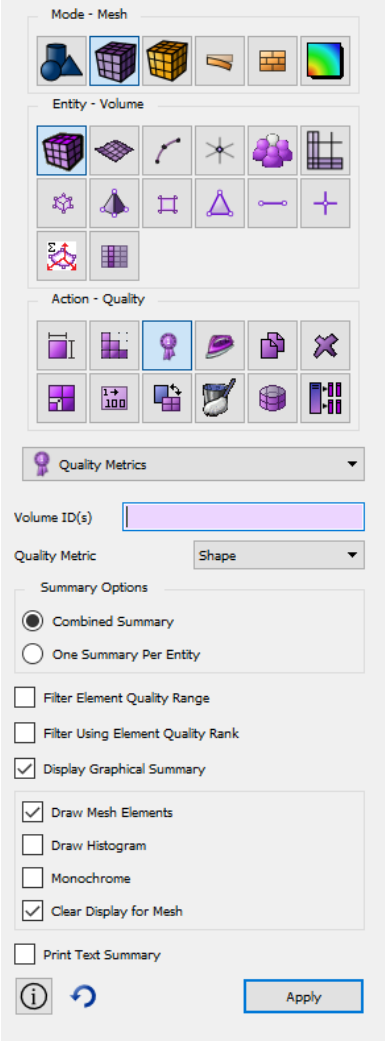
- **Definitions of the metrics are in the online documentation**
  - Go to the quality page and hit the F1 key

Function Name	Dimension	Full Range	Acceptable Range	Reference
Aspect Ratio	L^0	1 to inf	1 to 4	[5]
Skew	L^0	0 to 1	0 to 0.5	[5]
Taper	L^0	0 to +inf	0 to 0.4	[5]
Element Volume	L^3	-inf to +inf	None	[5]
Stretch	L^0	0 to 1	0.25 to 1	[6]
Diagonal Ratio	L^0	0 to 1	0.65 to 1	
Dimension	L^1	0 to +inf	None	[5]
Oddy	L^0	0 to +inf	0 to 20	[7][8]
Condition No.	L^0	1 to inf	1 to 8	[8]
Jacobian	L^3	-inf to +inf	None	[8]
Scaled Jacobian	L^0	-1 to +1	0.5 to 1	[8]
Shear	L^0	0 to 1	0.3 to 1	[9]
Shape	L^0	0 to 1	0.3 to 1	[9]
Relative Size	L^0	0 to 1	0.5 to 1	[9]



Automatic Mesh Quality Checks

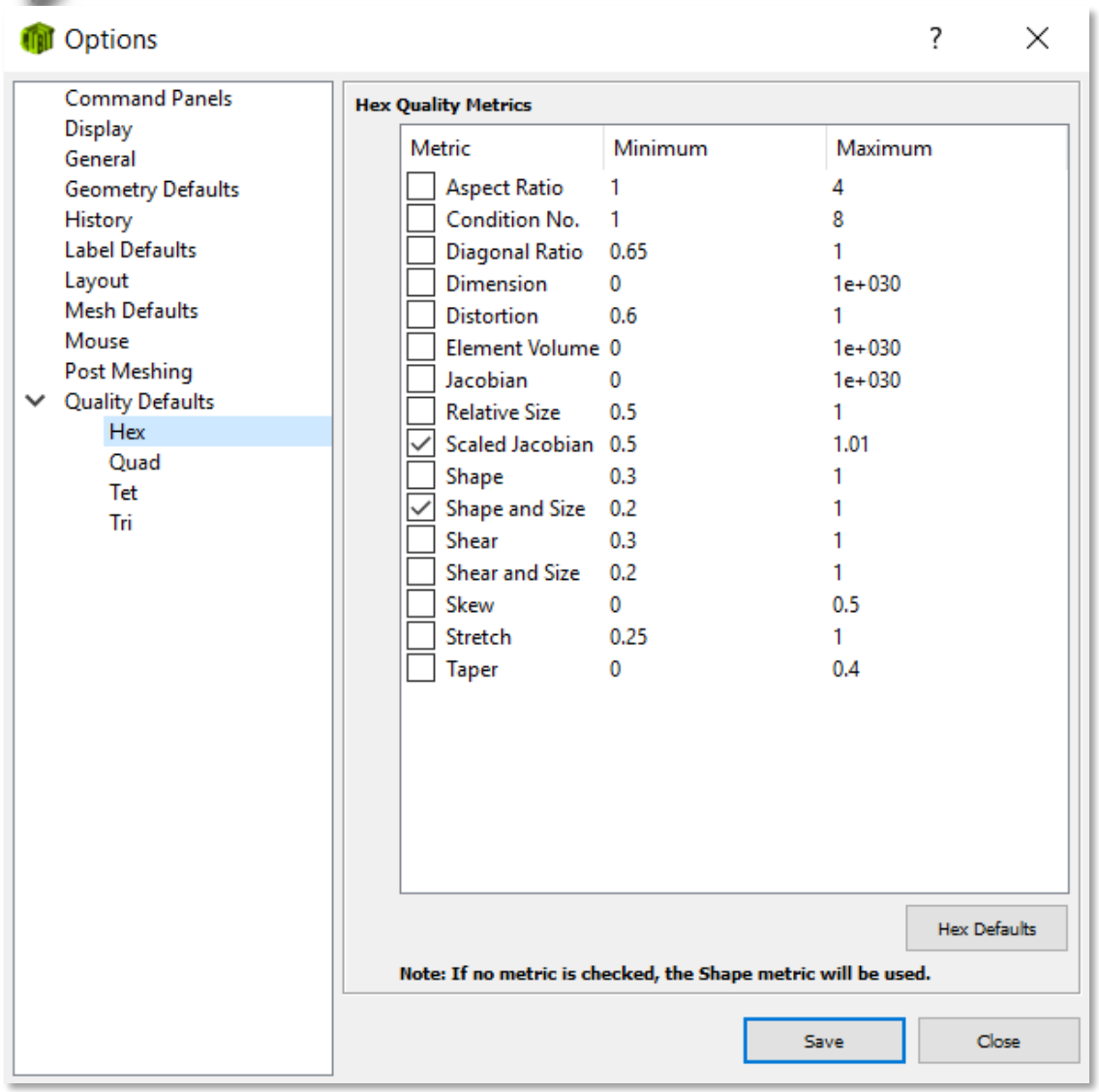
- **Quality is automatically computed after every meshing or smoothing operation**
- **Always check output window following meshing**

```
CUBIT> Mesh Volume 1
  ERROR: >>>> Negative Jacobian Hex Element Generated! <<<<<
  Check Mesh Quality.

CUBIT> Mesh Volume 1
  WARNING: >>>> Poorly-shaped Hex Element Generated! <<<<<
  Check Mesh Quality
```

- **Use smoothing, cleanup or modify the geometry to improve quality before using mesh with poor quality in an analysis**
- **Poor quality may be acceptable if located where physics is not as important. Engineering judgment needed.**

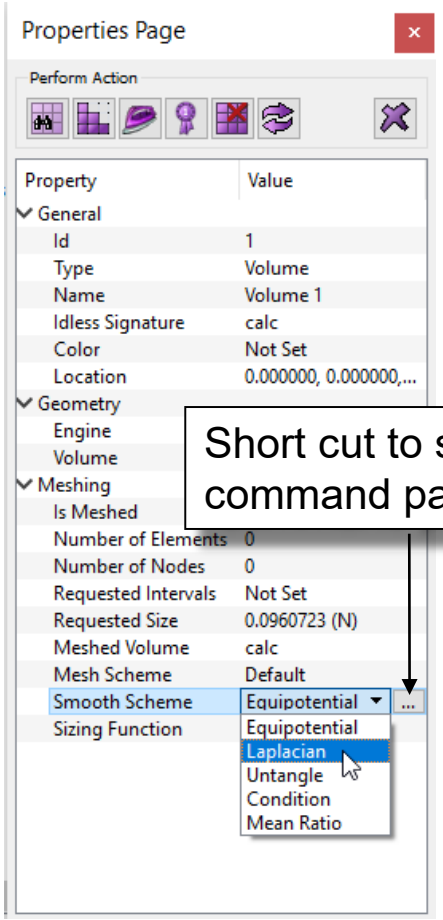
Mesh Quality



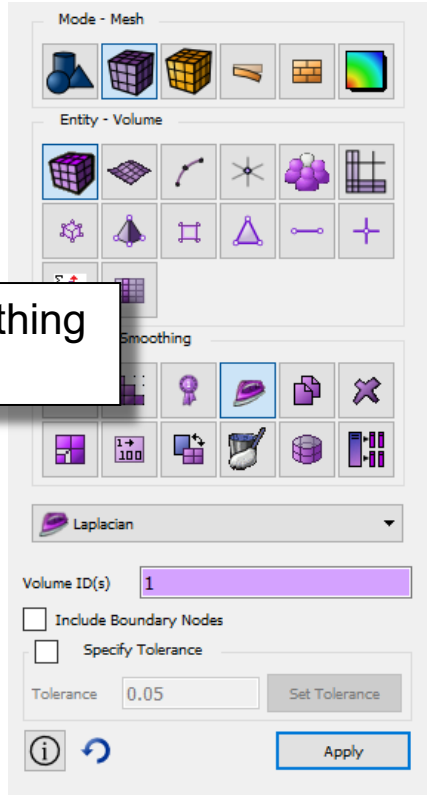
Select **Options** (or **Preferences** on Mac) menu to define quality metric(s) to use and the minimum and maximum criteria

Smoothing

Smoothing adjusts node locations without changing element connectivity.



Smooth scheme can be set from the property panel



Smooth scheme can also be set from the command panel

Many different smoothing schemes with different characteristics

Usually iterative algorithms that attempt to improve the local mesh quality

Smoothing schemes for surfaces and volumes

Smoothing schemes applied as an attribute, (similar to meshing scheme)

Surface and volume schemes are independent (unless free boundary option selected)

Smoothing

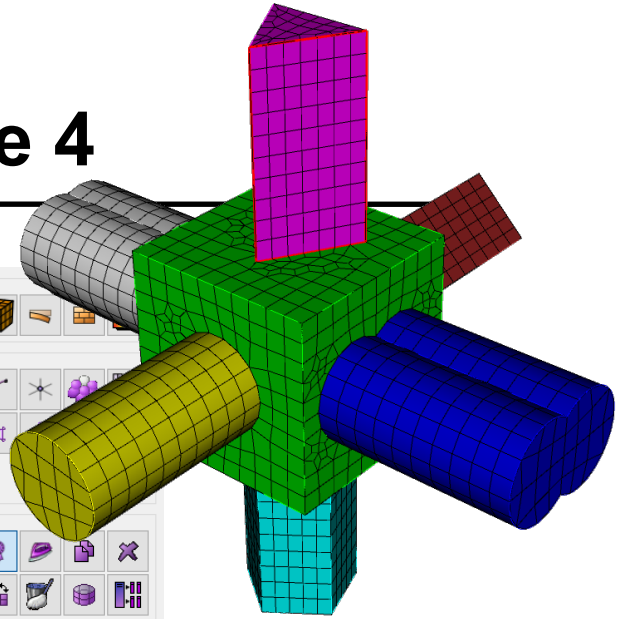
Surface Smoothing Schemes

- **Equipotential**
- **Centroid Area Pull**
- **Optimize Jacobian**
- **Winslow**
  - longtime favorite for structured meshes has been extended to unstructured in CUBIT - theoretical guarantee against mesh folding
  - fast and high quality, try first
- **Laplacian, centroid area pull (smart Laplacian)**
  - fast, poor near concave features
- **Untangle**
  - remove stubborn inverted elements
- **Condition number**
  - improve stubborn low-quality elements
  - must be non-inverted to start
- **Mean Ratio**

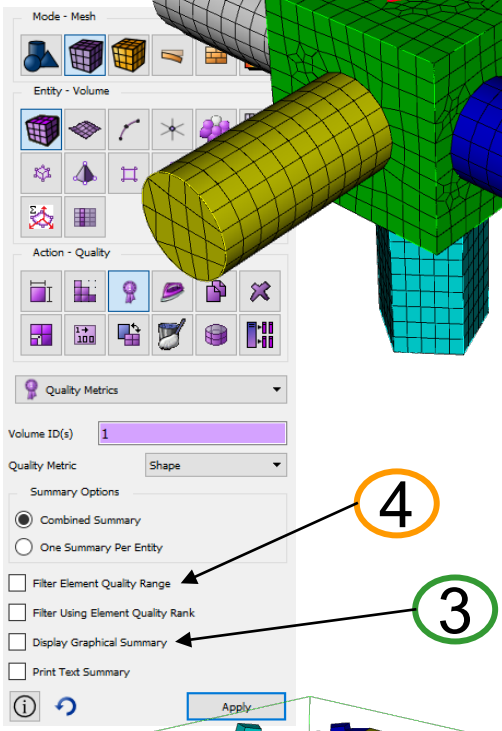
Volume Smoothing Schemes

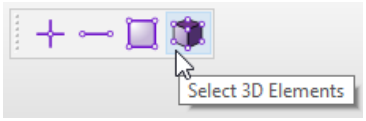
- **Laplacian**
  - fast, poor quality near concave features
- **Equipotential**
  - medium fast and medium quality
- **Untangle**
  - remove stubborn inverted elements
  - Can take a long time
  - Control time limit:
    Volume <range> Smooth Scheme Condition Number [beta <double=2.0>] [cpu <double=10>]
- **Condition number**
  - Guarantees the same or better quality
  - improve stubborn low-quality elements
  - must be non-inverted to start (runs untangle if inverted)
  - Can take a long time
  - Control time limit:
    Volume <range> Smooth Scheme Condition Number [beta <double=2.0>] [cpu <double=10>]

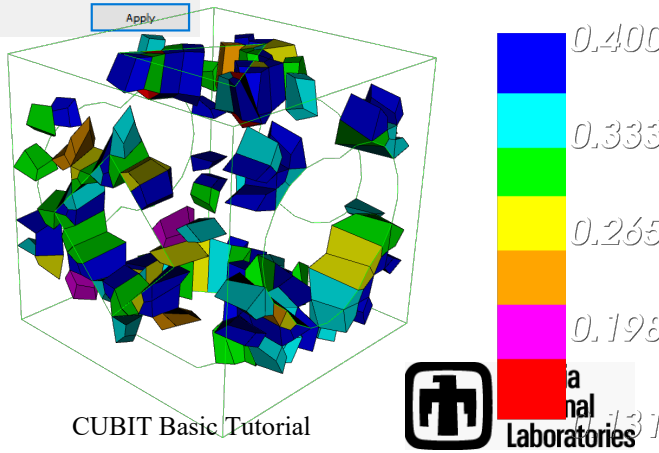
Mesh Control Exercise 4



1. Open cub file “**graft.cub**”
2. Navigate to the volume mesh quality panel
3. Draw the mesh quality of volume 1 using the *shape* metric.
4. Filter the mesh based on an upper limit of .4 and a lower limit of 0 and redraw the mesh.
5. Draw the shape quality histogram for volume 1.
6. Smooth volume 1 using *mean ratio*.
7. Draw the mesh quality of volume 1 using the shape metric and the same filter as before.
8. Set the 3D filter in the tool bar.
9. Select one of the poorly shaped elements and examine the properties panel.



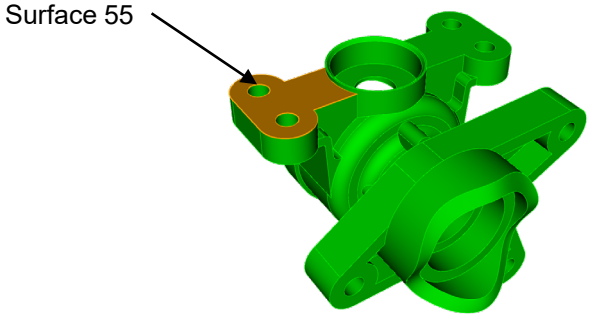


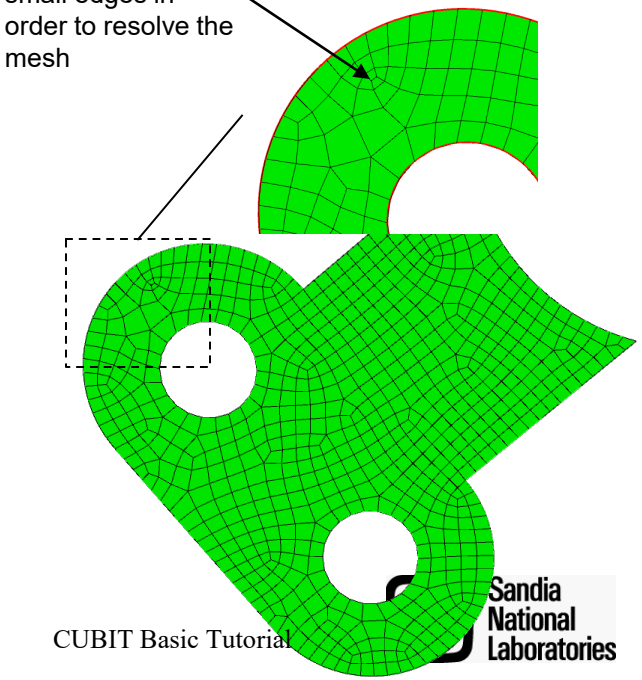


Mesh Control Exercise 5

Simulation Modeling Sciences

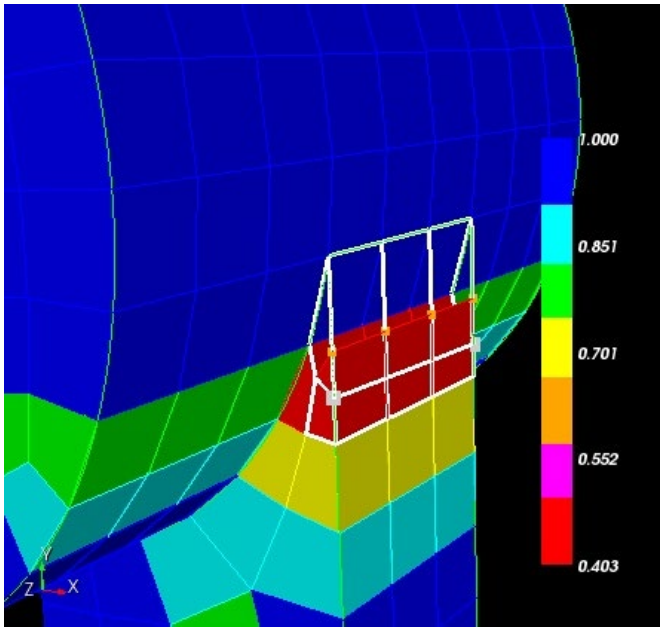
1. Import the acis file "**driver.sat**"
2. Draw surface **55**
3. Set the mesh size to **1.0** on surface **55**
4. Mesh surface **55** using the paving scheme
5. Check the *edge length* quality. Use the quality command panel  located under edge elements
6. What is the smallest edge length? Average edge length? Zoom to the smallest edge.
7. Use the *edge length* surface smoothing scheme to smooth surface 55
8. Check the edge length quality again for surface 55
9. Note any changes to the mesh What is the smallest edge length now?

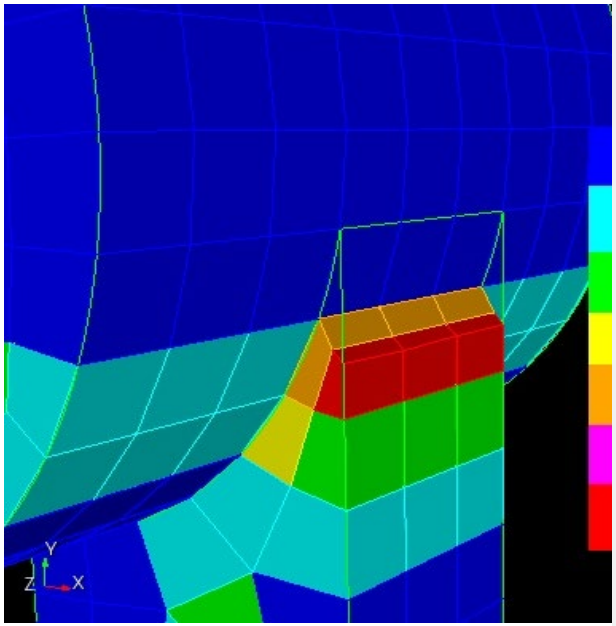


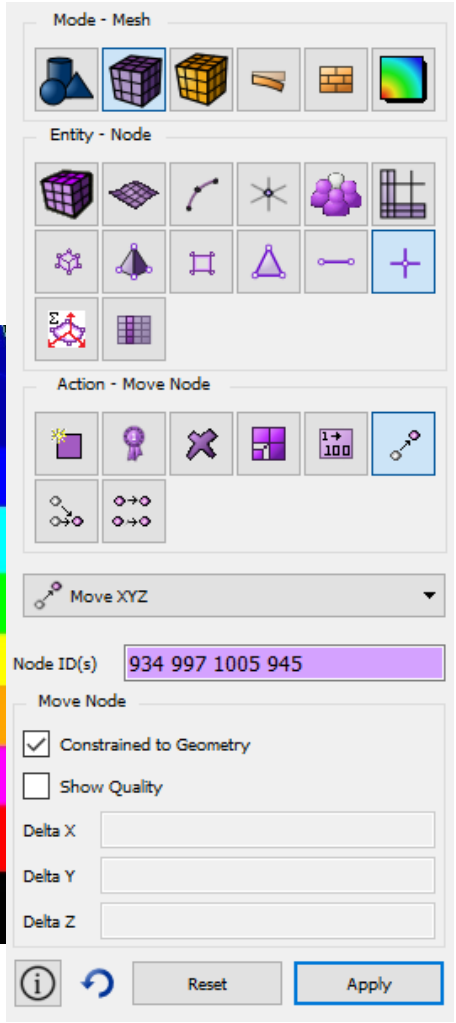


Interactive node editing

- **Select nodes to reshape elements**
  - Draws element outlines as nodes are moved.
  - Can display element quality as nodes move





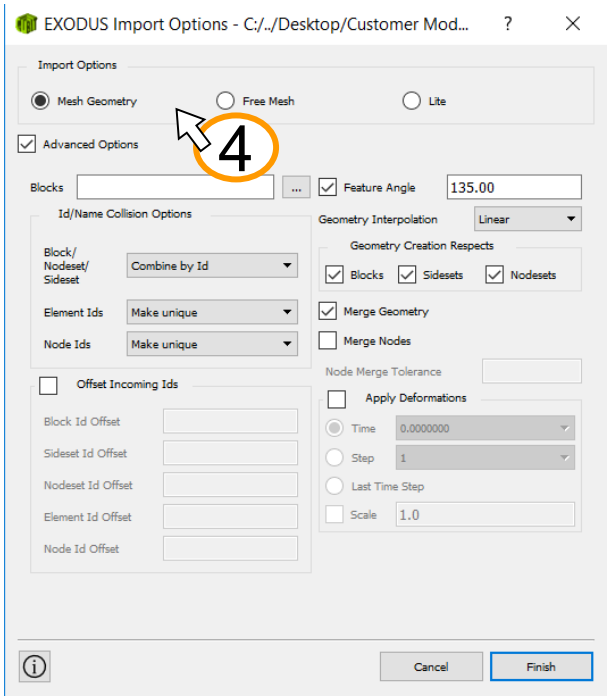


Mesh Import

Importing an existing mesh into Cubit

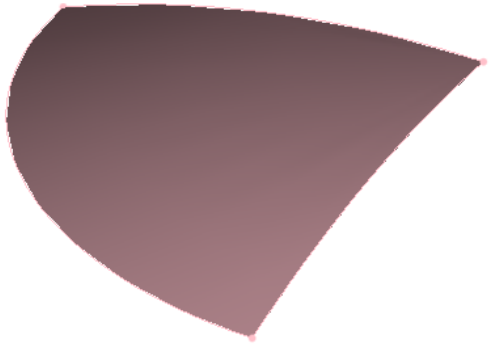
1. Select the File->import menu
2. Choose the Genesis/Exodus File Filter
3. Select a mesh file to import
4. Choose how you want Cubit to use the mesh

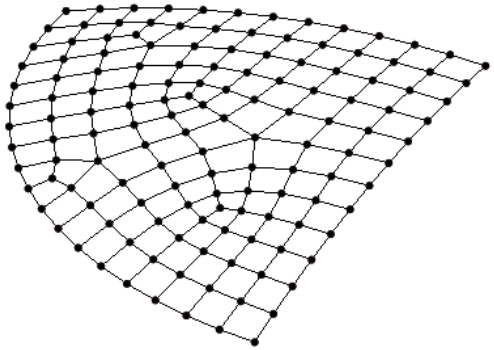
Note that in addition to Exodus, Patran, Ideas, Abaqus, Fluent and Nastran mesh file formats are also supported.



1. **Mesh Geometry**: A new “mesh-based” geometry definition is automatically created on import. Vertices, Curves, Surfaces and Volumes are generated from the boundary of the mesh.
2. **Free Mesh**: Imports the mesh with no geometry association
3. **Lite:** Imports a light-weight version of the mesh suitable for responsive display and a small set of operations.

Free Mesh

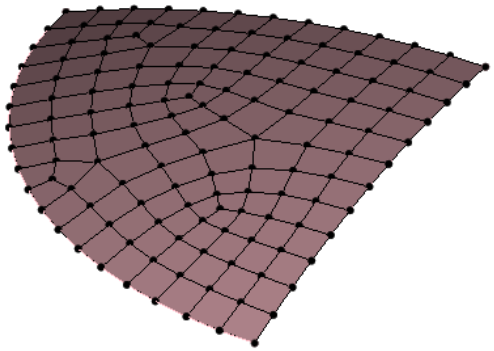




Geometry

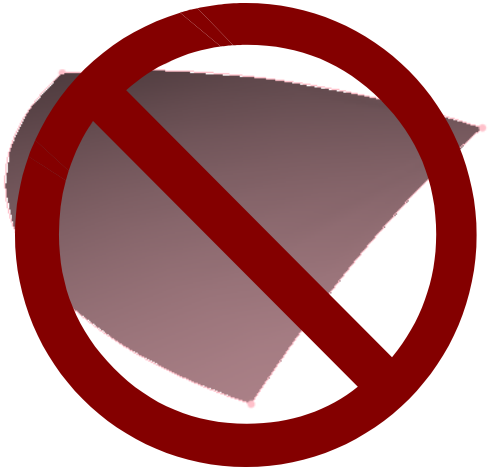
Mesh

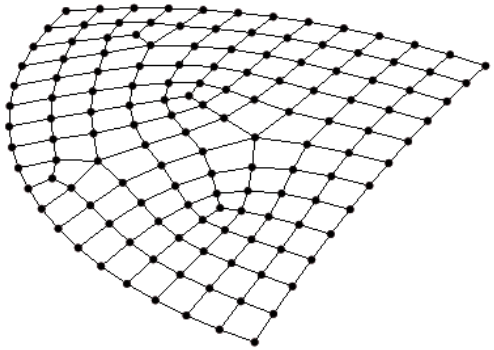
Mesh Owned
By Geometry



Traditionally this is the only way mesh could exist in CUBIT.

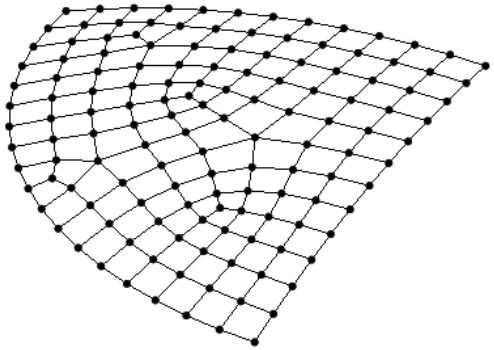
Free Mesh





Geometry

Mesh



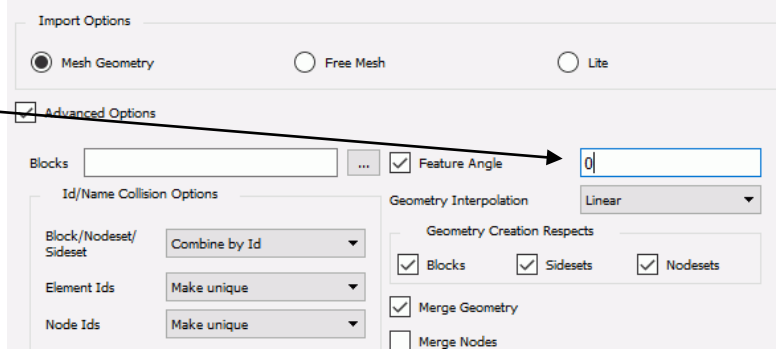
Mesh Not Owned By
A Geometric Owner
(“Free Mesh”)

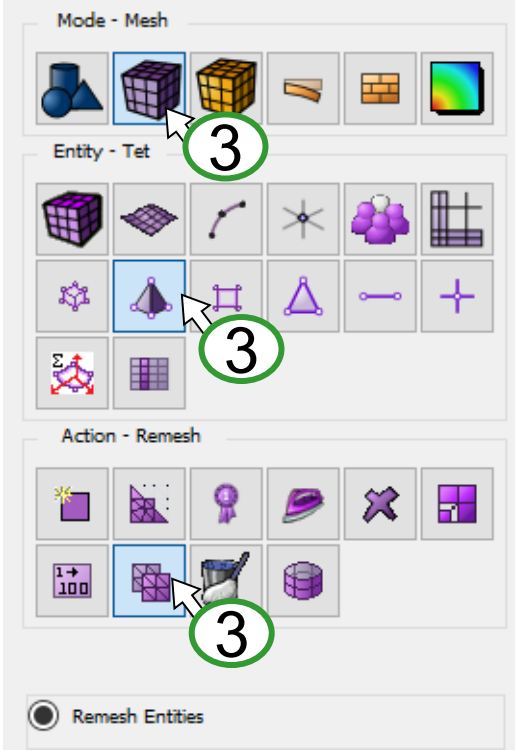
Now mesh can exist and be manipulated without a geometric owner.

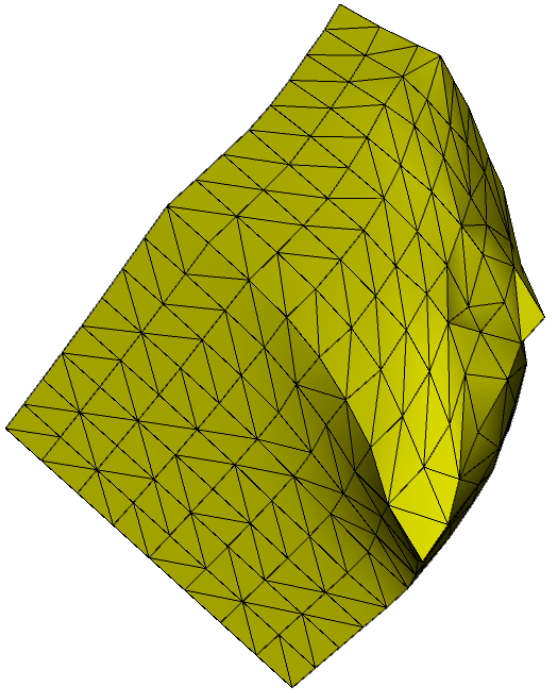
Mesh Control Exercise 6

Simulation Modeling Sciences

1. Import the exodus file "**crunch.e**" as a **mesh-based geometry**. Use a feature angle of **0**
2. Examine the mesh quality. What do you notice?
3. Navigate to the Remesh Tet Command Panel





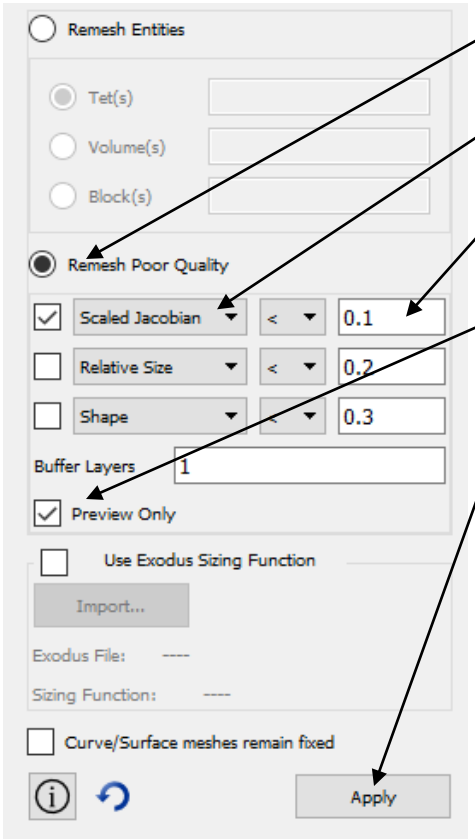


crunch.e

Tet mesh after deformations applied from an analysis

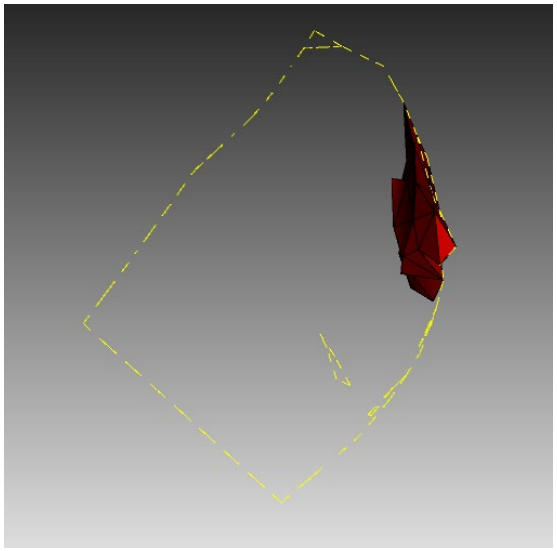
Sandia National Laboratories

Mesh Control Exercise 6 (con.)



4. Select *Remesh Poor Quality*
5. Select *Scaled Jacobian*
6. Use a value **< 0.1**
7. Select *Preview Only*
8. Click Apply

The elements in the mesh that meet the criteria of scaled Jacobian less than 0.1 will be displayed. These are the elements that will be remeshed. (The rest of the mesh will not be affected)



9. Uncheck the *Preview Only* Toggle
10. Click Apply
11. Examine the mesh quality.
    What do you notice?